Epping Forest and Buffer Lands

Deer Management

Strategy Review Summary

23/03/20

Client – Epping Forest, City of London Corporation.

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Executive Summary

"The City of London Corporation acts as the Conservators of Epping Forest under the Epping Forest Acts 1878 and 1880 as a charitable trust charged with the management and regulation of Epping Forest. The Epping Forest Acts specifically charges the Conservators with a series of statutory obligations including a responsibility to manage deer as a 'natural ornament' of the Forest."

The management of deer on the Epping Forest estate by City of London Corporation (CoL) is a complex undertaking. The review considers these complexities and draws upon modern understanding of landscape-scale deer management issues, as well as past management recommendations and practices, to offer a strategy for the future. We consider that the management of wild deer and their impacts is an issue of growing importance which will need to be accepted as a long term commitment to protect the deer and the natural capital value of the landholding, keeping deer impacts and negative human-deer interactions to acceptable levels.

Deer management on the CoL estate cannot be undertaken in isolation as deer are present in high densities in the surrounding landscape. Actions taken by CoL must consider the ebb and flow of deer across its boundaries, where collaboration might benefit deer management efforts and how future agri-environmental and woodland support mechanisms may influence the motivations of landowners to manage deer in the future.

As this review highlights, there are currently limited practicable or cost-effective options to manage wild deer in the absence of natural predators other than the use of legal, lethal control methods. There is significant peer-reviewed evidence that other methods of protection or population control are not only ineffective but can actually lead to negative animal-welfare outcomes and further detriment to habitats and public safety.

Long term and large scale population management of wild deer requires a strong evidence base and a management framework which can be used to justify actions, withstand scrutiny, and set rigid professional standards by which to operate. Management will need to consider public sentiment and perceptions. Human-deer encounters are often valuable experiences and the public often feel a degree of "ownership" of wild deer. The degree to which the management of deer is integrated into wider objectives such as long-term habitat sustainability or protection of woodland birds and invertebrates should be made clear in any management plans and publicity material.

Those who are engaged as the deer management practitioners need to be selected carefully to ensure that they have the correct aptitude as well as adequate skills and knowledge to build and maintain public confidence when undertaking their role. The benefits of using directly supervised operatives (either employed staff or closely supervised contractors) to undertake this sensitive work have been highlighted as being more cost effective and more likely to be acceptable to the wider public than other models. Close control of staff minimises business and reputational risk significantly and makes it easier to add value to the role through additional responsibilities such as education. Using dedicated staff to deal with deer vehicle collisions and other deer welfare incidents allows for a rapid and efficient response and can reduce burdens on other public services.

Management needs to be well evidenced and undertaken professionally, sensitively and humanely and CoL needs to explains how this management helps it to meet its wider multiple objectives. Management of wild deer within Epping Forest and its Buffer Lands has, in addition to humane dispatch of road casualties and other injured deer when required, already included some level of culling by since 2001. The level and distribution of deer culls undertaken since that time have helped to reduce the rate of population increase to below what it would have been otherwise. However, such culling has been restricted in its coverage to the exclusion of significant sections of the main Forest and been insufficiently consistent year to year to

achieve relatively stable and sustainable fallow and muntjac populations and levels of detrimental impacts. While a new 20 year Management Strategy has been created as part of this review, the strategy should be adaptive, subject to a regular audit process and be revised as circumstances dictate.

The future of the Birch Hall deer sanctuary should be considered in terms of its value as an asset to inform, educate and to positively influence public opinion as well as in terms of its current cost and perceived liability.

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1. Project Brief

Following a public tender process, Deer Initiative Ltd was awarded the contract by City of London Corporation (CoL) to comprehensively review the current Deer Management Strategy for Epping Forest and adjoining agricultural estates of Copped Hall Park; Great Gregories; Warlies Park and Woodredon estates collectively known as the Epping Forest Buffer Land. The Review has revisited the findings of previous studies, specifically the review produced for CoL by Langbein in 1996 as well as collating current impact, activity and historic cull data in order to make recommendations for future management options including a framework for a 20 year management strategy. The review makes recommendations for future management of wild deer to include health and welfare considerations, conservation objectives, economic impacts and public safety deer vehicle collision mitigation and the enclosed population within the Birch Hall Sanctuary.

1.2 Project Outcomes

The project brief set out a number outcomes to be delivered including;

1. *Assess the impact of deer grazing and browsing on both Epping Forest and the Epping Forest Buffer Land indicating at what densities/stocking levels deer grazing and browsing might positively contribute to a conservation grazing programme, alongside the impact of rabbits and cattle.*
2. *Evaluate the purposes and viability of the Birch Hall Park Deer Sanctuary.*
3. *Produce a best practice assessment for reducing deer vehicle collisions on the local highway network.*
4. *Develop a 20-year Deer Management Strategy for Epping Forest and its Buffer Lands 2019 – 2029.*
5. *Propose a future monitoring programme for Epping Forest and Buffer Land deer populations;*
6. *Advise on the need for a Wild Animal Welfare Policy for Epping Forest.*

The review supported its findings and recommendations with information from a wide range of sources including previous reviews, surveys, data collected from local and national sources and research from numerous peer-reviewed papers.

This summary document captures the key outcomes and findings of the full review and in particular provides recommendations to support future management of deer on CoL land in the Epping Forest and Buffer Lands.

2. Proposed 20 year deer management strategy for Epping Forest and Buffer Lands.

2.1 Aims and Objectives

In order to bring clarity to the aims and objectives of any deer policy it is imperative to understand and clearly state what these are, both for the landscape in which the deer live, and for the deer themselves.

These aims and objectives for deer management are set in the broader context of ensuring that the qualifying features of the Epping Forest Special Area of Conservation (SAC) are maintained or restored to favourable conservation status and the favourable condition of the Site of Special Scientific Interest (SSSI) is also maintained or restored. For the SAC it is the favourable conservation status of the Beech forest habitat and the two types of heathland that are absolutely key to the measurement of the success of any deer management. For the SSSI, in addition to these specific habitats, the broader balance between grass, heath and wooded areas, the habitat mosaic, with its structural and species diversities must be sustained. However, other factors that influence the favourable conservation status and condition, such as air pollution and visitor pressure, must inevitably be taken into account in any assessment of success.

In summary, the management of the SAC and SSSI, as well as the wider Forest and Buffer Lands landscape, is focused on maintaining or increasing the width of the transitions between habitats (the ecotones), the length of these edges (e.g. scrub zone length) and increasing the structural complexity of each component habitat (e.g., dwarf shrubs and tussocky grass intermixed with short turf). This focus on enhancing structure, edge and transition is set within the management framework of protecting all ancient pollards and all existing distributions of scarce and protected species. Some more details of these habitat and species objectives are outlined in the main report above and are encapsulated in the first bullet point below.

The CoL wishes, as far as practicably possible, to:

1. Ensure that fallow deer remain in the Epping landscape in perpetuity whilst managing the wood-pasture habitat mosaic, of which they are part, to maintain or restore its structural and species diversity.
2. Assure and monitor the welfare of all species of deer
3. Minimise Deer Vehicle Collisions
4. Minimise impact by all species of deer to the CoL Estate with a view to long term sustainability (Including the SAC/SSSI designated areas, woodland and habitat succession, and biodiversity, food production, climate change)
5. Minimise impacts by deer on other species and human interests (Public safety, health and Public good) within the CoL deer range

Assuming these aims, the project team recommend:

2.2 Deer Species

Fallow deer are regarded as the key Epping species, because of their historic association with the establishment of the Royal Forest in the 12th Century and subsequent protection after disafforestation under the Epping Forest Act 1878. Most of the discussion and recommendations in this report relate to Fallow and they must be regarded as a permanent and desirable feature of the area. Muntjac deer have been increasing in number over recent years and as that trend continues

their presence is becoming more significant. For example, in more heavily visited areas of the Forest, especially its southern compartments south of Chingford and Loughton, and in the oak-hornbeam wood-pasture areas their browsing has more of an impact than that of Fallow. Where practicably possible Muntjac, or any other novel or invasive, non-native deer species that become established, should be minimised in number and need not necessarily be considered permanent.

2.3 Extent and Sub-division of Deer Management Area

Recommendations were made in the 1996 deer report as to the extent of the proposed deer management area and these are pertinent today, these are:

The bulk of the Fallow Deer Range i.e. the area approximately bounded by the Lee valley to the West, the conurbations of Roydon and Harlow to the North, the M11 to the East and the conurbations of Loughton and Chingford to the South. See red boundary, map 1 below.

Map 1, reproduced from Langbein 2009

Within the above area, three zones:

1. South of the M25, Epping Forest plus, where possible, land outside of Forest ownership.
2. North of the M25, The Epping Forest Buffer lands.
3. North of the M25, where possible, any area within the adjacent deer range, not included in the Epping Forest "Buffer lands" ownership

2.4 Deer management

1. Deer numbers must be actively managed across all three zones. Currently the only viable means of achieving this is by legal culling.
2. A viable minimum population of Fallow deer should be assured in both zones 1 and 2, consistent with overarching aims and objectives for Epping Forest and Buffer Lands.
3. With regard to the above:

- We suggest that for zones 2 and 3 together, a notional fallow population of 6-8/ Km2 (150-200) head (50 head on the Buffer lands) be sought initially[1]. Muntjac should be kept to the

minimum number realistically possible. Over the course of time, cull levels should be dictated according to a dynamic review of available data and at least annually. Model 8 in Appendix D gives a general indication of the effort required to achieve this objective.

- cull targets for zone 1 should relate to avoiding the danger of any deer species reaching a density at which it will become difficult to control, given the practicalities of achieving a large-scale cull. To this end, maintain a notional maximum population of 3-5/Km2 (50-80 head) Fallow within the woodlands, if possible[2]. Muntjac should be kept to the minimum number realistically possible. Again, over the course of time cull levels should be dictated according to a dynamic review of available data and at least annually. Model 7 in Appendix D gives a general indication of the effort required to achieve this objective.

4. Deer should be managed by operatives directly managed by CoL. In terms of staff time, it is estimated that at least 2 Full Time equivalents (FTEs) would be required during the culling season with additional help on team culling events. 1 person should be available all year to deal with deer related issues.
5. Landscape scale deer management of herding species such as Fallow is more likely to succeed if there is collaboration between neighbouring landowners. Where opportunities exist, CoL should engage with neighbours regarding deer management.

2.5 Monitoring and reporting (See Appendix C)

1. Progress towards objectives must be monitored, recorded, reported, and reviewed at least annually in an effective and consistent way ("evidence-based management") using as many data sources as is realistic e.g. Impact/Activity assessment, Habitat assessment, Exclosure plots, Crop impacts, Cull and count records, DVC records, anecdotal/incident records.
2. Progress will be considered "sufficient" when the data as a whole indicate trends in the right direction. Cull targets will be considered as dynamic even within season and deer counts will not be relied on as the sole predictor of cull levels ("Adaptive management").
3. A public facing mechanism for providing information and allowing feedback is developed to demonstrate the CoL evidence-based approach and to encourage acceptance.

2.6 Deer Vehicle Collisions (DVCs) (See Appendix E).

1. It is recommended that measures are adopted for dealing with injured deer at roadside that include a formal Police/local Authority endorsed scheme incorporating compulsory training and assessment for participants.

2. Further develop means of consistently recording DVCs to contribute to monitoring
3. Expand areas under speed restrictions; consider additional permanent or seasonal signage.
4. Continue to take advice on means of mitigating DVCs

2.7 Animal Welfare, (See Appendix F)

Animal welfare considerations were and outcome of the report and a review of current understanding and best practice regarding the welfare of wild deer has been produced to inform current and future management.

2.8 Birch Hall Deer Sanctuary (See Appendix G)

1. Despite the lack of evidence to demonstrate their genetic uniqueness, consider options to retain deer within the Birch Hall deer sanctuary for educational purposes and to develop messaging regarding the impact of deer on the environment.
2. Manage the sanctuary deer according to best practice and deer welfare principles.

References:

[1]Barnett, 2012 (Deer Management Plan for CBDMG) (12 pages)

[2]Putman, R.J., Langbein, J., Green, P. and Watson, P. (2011) Identifying threshold densities for wild deer in the UK ab

Appendix A; Deer impact and activity.

As part of the review, deer impact and activity assessments were carried out on the 4th and 5th October following the protocol laid out in the Best Practice Guide "Deer Impact and Activity Assessment", methodology *Ref;* http://www.thedeerinitiative.co.uk/best_practice/associated_information.php This assessment is widely used for assessing the impact and activity of deer in woodland areas including supporting Countryside Stewardship, other grant aided schemes and work on designated sites.

The survey was designed in such a way as to provide as comprehensive and representative assessment of the Forest as possible. The survey areas were selected to encompass representative habitat types and within each compartment, Forest area or woodland, the actual route taken provided representative coverage. A summary of the Deer Impact and Activity survey results in addition to maps showing areas surveyed, levels of activity, impact and species present are attached at appendix B.

The optimum window for undertaking these surveys is the end of winter, enabling deer impacts on vegetation the woodland structure to be fully assessed at the point at which they show maximum seasonal impact and activity signs and prior to the end of winter dormancy. To meet the Project schedule this survey was undertaken at a time of year directly following spring and summer growth, when food availability (for deer and other browsing animals) was still relatively high and impact and activity signs were less obvious.

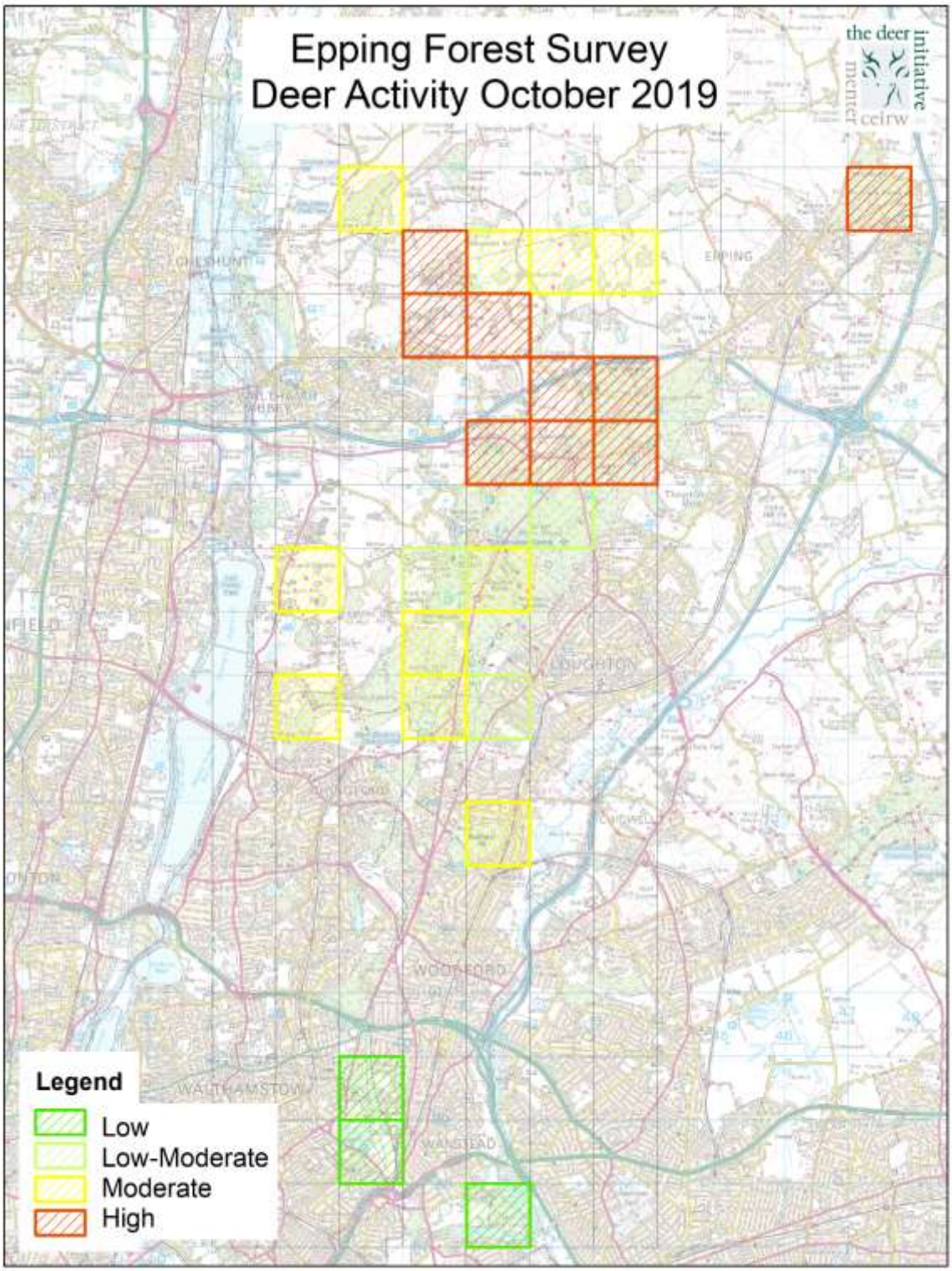
During this late autumn and winter period, food availability is declining therefore, it can be expected that impacts will continue to increase as the winter progresses and that . with higher levels of deer activity in search of food, signs are likely to increase.

Appendix B; Deer impact and Activity survey results Summary October 2019

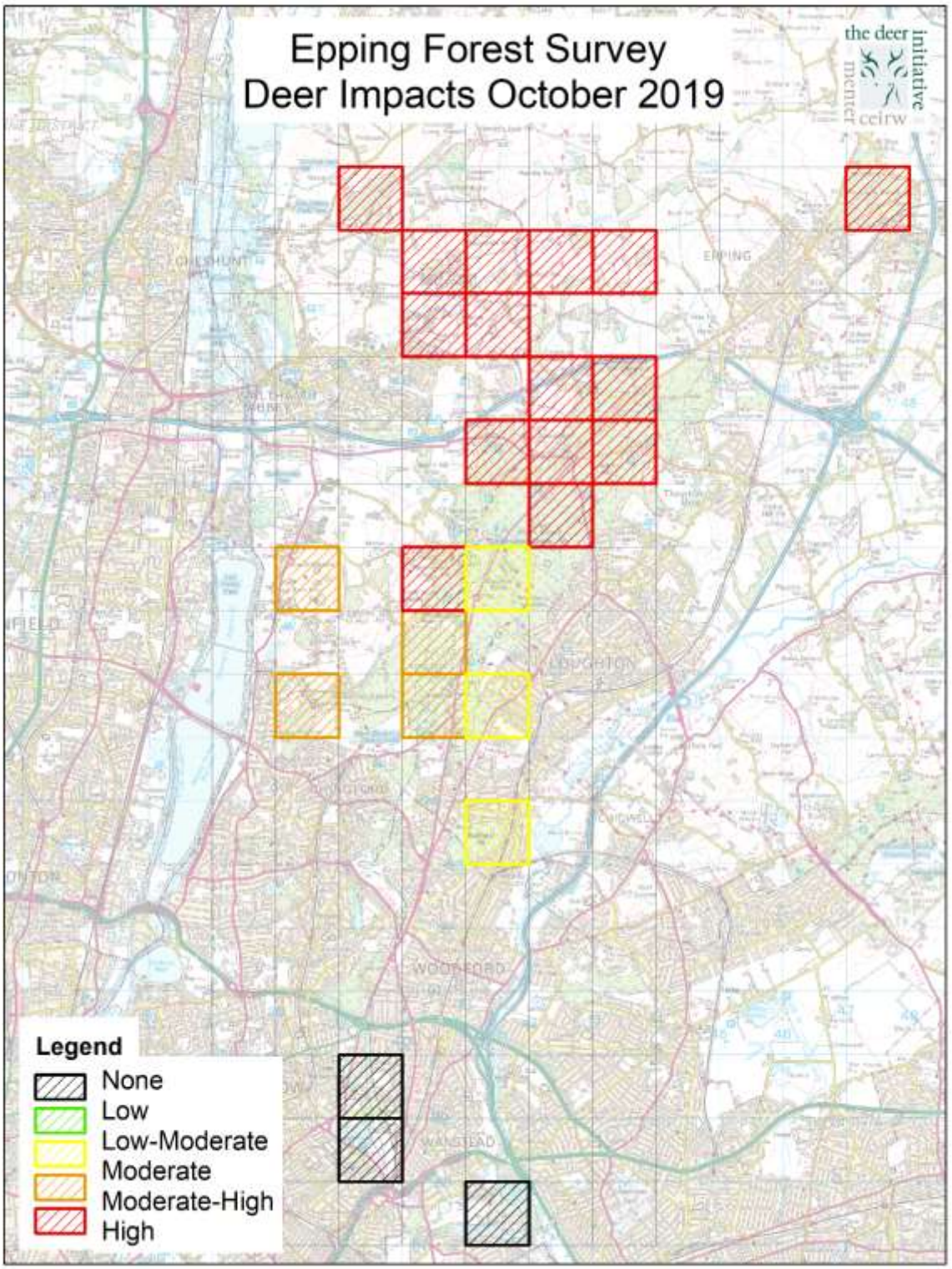
Appendix B.1; Impact and Activity Survey Results table;

Wood area name	Activity score	Impact score	Fallow present	Muntjac present	Numbers seen
Leyton Flats /Snaresbrook	Low	No impact	No	Yes	
Gilberts Slade	Low	No impact	No	Yes	
Wanstead	Low	No impact	No	Yes	
Loughton Camp	Low	Low	Yes	Yes	
Hill Wood (South of Café)	Low - Moderate	High	Yes	Yes	1 muntjac
Warren Hill	Low - moderate	Moderate	Yes	Yes	26 does, 6 bucks, 1 muntjac
Great Monk Wood	Low-moderate	High	Yes	Yes	1 fallow buck
Galleyhill Wood and Monkhams	Moderate	High	Yes	Yes	12 fallow, 3 muntjac
Fernhall Wood	Moderate	High	Yes	Yes	6 fallow
Rookery Wood	Moderate	High	Yes	Yes	
Little Rookery Wood	Moderate	High	Yes	Yes	
Yardley Hill / Hawk Wood	Moderate	Moderate High	Yes	Yes	
Fern Hills	Moderate	Moderate / High	Yes	Yes	
Pear Tree Plain	Moderate	Moderate High	Yes	Yes	
Lord's Bushes and Knighton Wood	Moderate	Moderate	No	Yes	1 muntjac
Fitches Plantation	Moderate - high	High	Yes	Yes	5 fallow
Eighteen Acre	Moderate - high	High	Yes	Yes	1 muntjac
Spratts Hedgerow Wood	High	High	Yes	Yes	12 fallow
Oak Hill Copley Plain	High	High	Yes	Yes	5 does, 2 bucks
Pauls Nursery	High	High	Yes	Yes	6 does, 1 buck
Holly Lane Quarter	High	High	Yes	Yes	5 fallow
ST. Thomas's Quarter	High	High	Yes	Yes	26 does, 6 bucks
Breach Barn	High	High	Yes	Yes	40 fallow
The Lower Forest / Wintry Wood	High	High	Yes	Yes	5 does, 1 buck, 1 Muntjac
Deer seen on route to breach barn 2 fields north of Waltham Abbey (Abbey View Nursery)					12 fallow
					177 fallow
Anecdotal numbers present within the natural range of deer in this area					
Lee Valley Country Park					30- 40 fallow
Royal Gunpowder Mills					30 + fallow
Parndon Woods					20-30 fallow
Jacks Hatch					100 fallow
Lower Forest					100 fallow
Copped Hall (New Farm) area					100 fallow
Warren Plantation, Woodredon, Epping Thicks					100 fallow
					c. 400 fallow

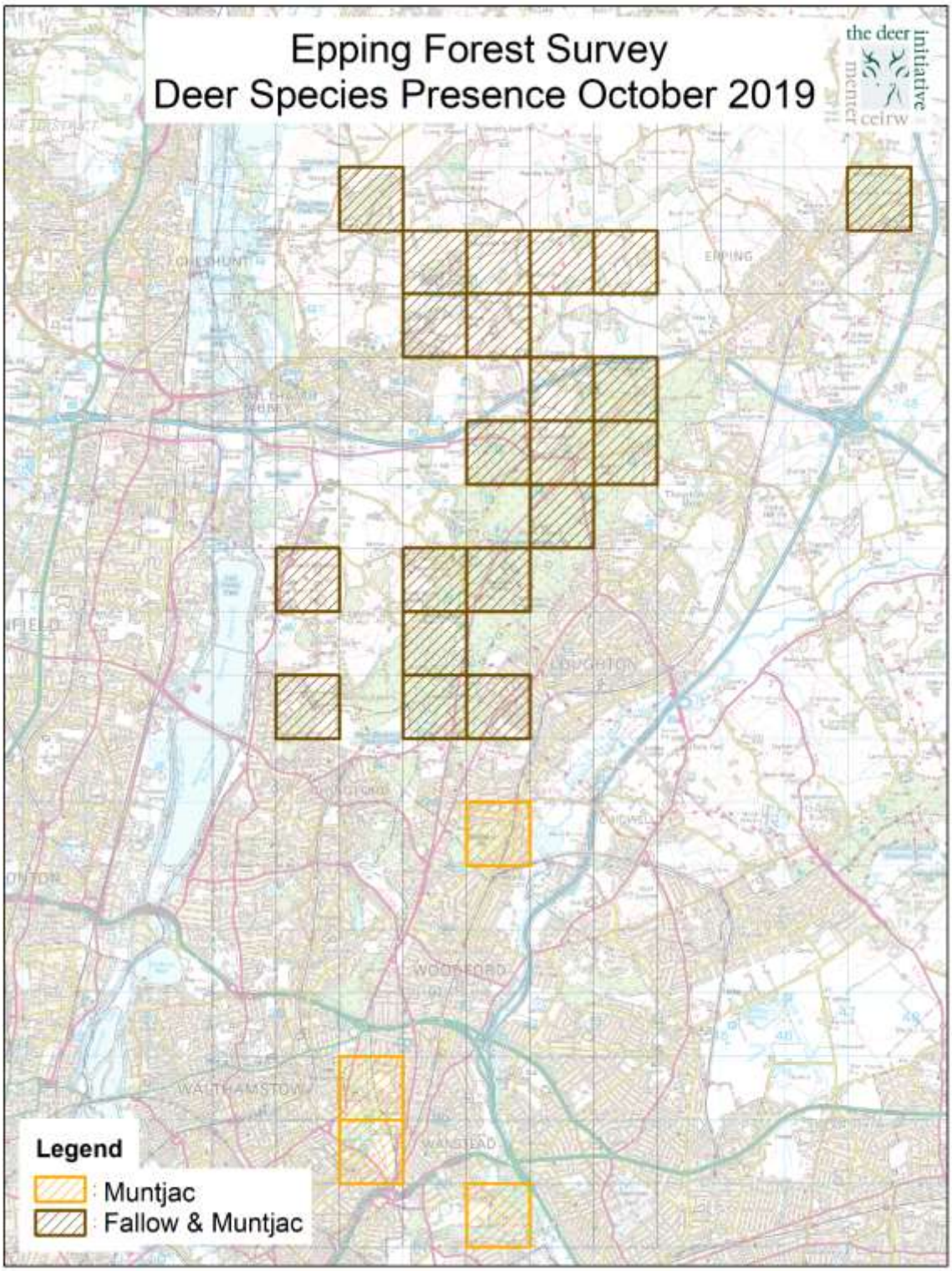
Appendix B.2; Activity Survey results



Appendix B.3; Impact Survey results



Appendix B.4; Species Presence Survey results



Appendix C; Population and Impact monitoring and subsequent data analysis.

Introduction and Scope

Deer management at Epping should be evidence-based.

The landscape management objectives across the Epping Forest and the Bufferlands are complex and varied. The effect that deer have (largely through browsing) throughout the estate, is likely to significantly compromise objectives. Thus, it is important that, concurrent with measuring progress towards objectives, the deer situation is also monitored to establish the effect of deer management.

Monitoring should be applied across these three zones:

1. South of the M25, Epping Forest, plus, where possible, land outside of Forest ownership.
2. North of the M25, The Epping Forest Bufferlands.
3. North of the M25, where possible, any area not included in the Epping Forest "Bufferlands" ownership

Counts

It is important to understand the purpose and limitations of counting deer, for example:

Most realistically applicable counting methods cannot yield highly accurate estimates of deer numbers. However, provided each animal counted was indeed a unique individual (i.e. no "double counting"), counts can indicate reliable minimum figures and, if realistic error margins are applied, can hint at possible actual totals.

Simple totals, provided there is consistency in methodology/deer environment /deer behaviour, can be useful as trend indicators over a sufficient period of time (min 5 years).

Simple totals alone are of no use when attempting to model populations forwards in time, or to set cull programmes. For this, some understanding of the population structure is required, e.g. sex and age class. Such details can sometimes be estimated from more detailed count techniques, from cull records, of from experience of herds in similar situations but there will always be a degree of uncertainty.

For these and other reasons it is strongly recommended that although counts are an essential tool, they should never be used on their own as the sole measure of the effects of deer management or as the sole source of information for cull planning.

Because providing count data is a long term undertaking, it is important to establish from the start a robust, consistent survey methodology and recording system. Successive counts should follow the same methodology to provide consistency in the data provided. If new methods of assessing populations are employed historic surveys should be maintained to provide an overlap, and consistency in surveying. New methods once proven to be effective can then be used, following this period of dual monitoring.

While every attempt must be made to provide robust count evidence, incidental (e.g. from deer impact surveys, or anecdotal evidence from reliable sources can be a useful addition, but always treated with caution. Within the Buffer lands and Forest complex there is considerable movement of groups of fallow deer, these movements may be from resting to feeding areas, or due to disturbance

by dog walkers, mountain bikes, fungi pickers and other general users of the Forest, counts must take these into consideration.

The project team recommend that:

All zones are included as comprehensively as possible in the collection of count data and that CoL staff coordinate and or carry out counts.

Count data should be generated from a combination of

1. Walk counts
2. Thermal imaging
3. Aerial survey

These can overlap but the application and area covered by each must be consistent over time

In addition, data should be gathered during deer impact and activity assessments and breakdowns of deer seen during stalking outings.

The interval of counts should be at least annual plus during every stalking outing

Records should where possible include tallies of totals, and a breakdown by sex and age class (fawns and adults). Records should be collated on a spreadsheet by a staff member assigned to the task

Analysis and Review must be carried out consistently and regularly by a team most likely to have a comprehensive view of the overall situation.

Impact and Activity surveys

There is a need to more closely monitor impacts and activity both on the Bufferlands and the Forest in respect of the biodiversity landscape management objectives. It is essential that habitat monitoring continues. This can be undertaken with equal validity both by deer impact and activity survey or by botanical surveys designed to measure habitat or plant assemblage "success" provided the latter also includes a measure of correlation with deer activity.

Arable impacts are a concern for many of the landowners in this area. This too will need to be monitored closely, with a more formal approach to recording actual impacts here.

Assessments of deer impacts should be made on the Forest, open heathland, arable and other land to give a broader understanding of overall impact and activity levels, where these impacts are occurring, and which assets are most vulnerable. This will help to establish how deer are utilising the wider landscape and how they are impacting upon it.

Where possible, survey routes should incorporate both exclosure plots[1] and fixed-point photography points[2]. Data from both of which can be compared with the timing, extent and type of management in place. Both should take in a variety of habitat types throughout the Forest.

The project team recommend that:

All zones are included as comprehensively as possible in the collection of impact data and that trained personnel staff coordinate and or carry out surveys.

Impact and activity data should be generated from a combination of

4. Deer Initiative DIA methodology
5. Formal agronomist surveys
6. Fixed point photography (sample sites only)
7. Exclosure plots

The interval of surveys should usually be annual or biannual (usually March-April but potentially additional other times for special sites or for specific plants or plant assemblages). For instance, impact surveys during the early autumn can establish whether Spring regeneration remains viable, prior to browsing in the winter months before the next regular survey.

Records should be collated on a spreadsheet by a staff member assigned to the task

Analysis and Review must be carried out consistently and regularly by a team most likely to have a comprehensive view of the overall situation.

[1]*Ideally exclosure plots should be erected adjacent to an unfenced "control" area and the exclosure moved after every three growing seasons, leaving the previously fenced area newly exposed. This can yield valuable information, not only about the current effect of protection, but about the vulnerability of previously protected areas.*

[2]*Annual fixed-point photography can provide long term photographic evidence of habitat change.*

Cull data

Each animal culled should be viewed as an important source of data, this is easily lost if a sampling routine is not established.

The project team recommend that for each animal culled a record is kept of a minimum of:

Date, location (digitally mappable e.g. via an app), species, sex, age (in years), standardised weight, female reproductive status, destination of carcass. Records should be collated on a spreadsheet by a staff member assigned to the task

Analysis and Review must be carried out consistently and regularly by a team most likely to have a comprehensive view of the overall situation.

DVC data

The project team recommend that for each animal culled a record is kept of:

Date, location (digitally mappable), species, sex, age (in years), destination of carcass. Records should be collated on a spreadsheet by a staff member assigned to the task

Incidents

A formal record of deer incidents relevant to CoL should be kept by a member of CoL staff in order to assist with enquiries and to feed into an annual Deer management plan review.

Deer Management Plan (DMP)

A robust method of collating available data, reviewing it, and then making forward management decisions is essential.

The project team recommend that the Deer Initiative DMP template is a good starting point.

Appendix D; Forward looking models based on best estimates of current population numbers and structure

As part of the 20 year strategy recommendations the following two models were produced to give indicative scenarios based on estimates of the current fallow deer situation drawn from available records and consultation. It must be emphasised that the starting figures and parameters are notional only and drawn from a wide range of possible realities. The models do illustrate however, general principles, an indication of potential culling effort, and a potential direction of travel.

It must be emphasised that , whatever the practical start point and whatever a model might appear to indicate for the future, in reality the concept of "Adaptive Management" must be employed i.e. using evidence to guide the culling programme towards achieving objectives, rather than adhering strictly to the model indicators.

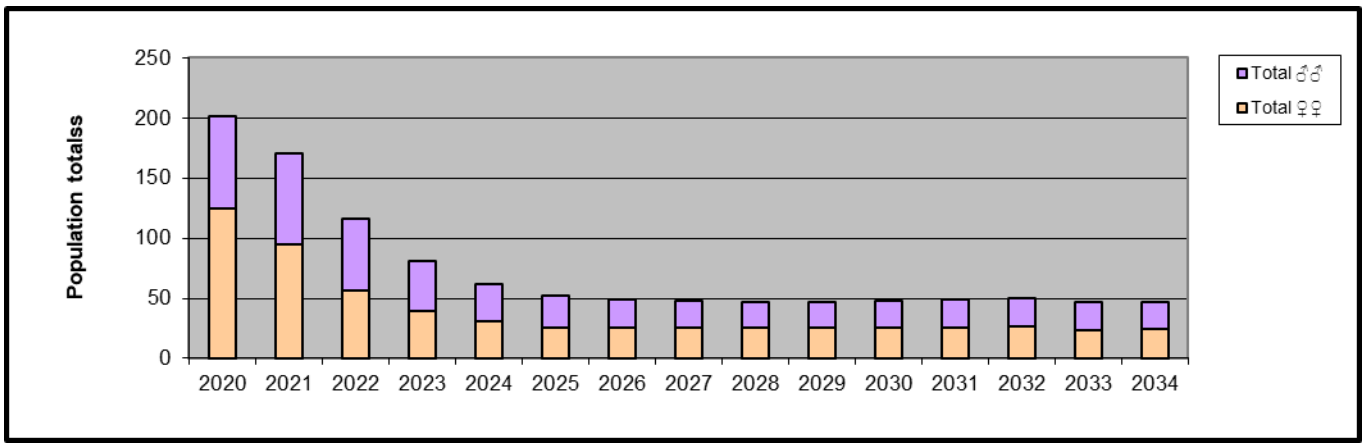
For both models the parameters are:

	Natural Mortality rate %	Fertility Rate %
Adult Females >2 years	2 (for each year class)	85
Yearling Females 1-2 yr.	2	30
Female Young <1 year	10	0
Adult Males >2 years	5 (for each year class)	
Yearling Males 1-2 yr.	10	
Male Young <1 year	10	
Max Age Males	12	Starting Adult Male: Female sex ratio, 1:4
Max Age Females	12	Equivalent to overall sex ratio of 1:1.8

The models show post fawning i.e. Autumn figures, a count taken in April (pre-fawning), would show a total approximately 22% less).

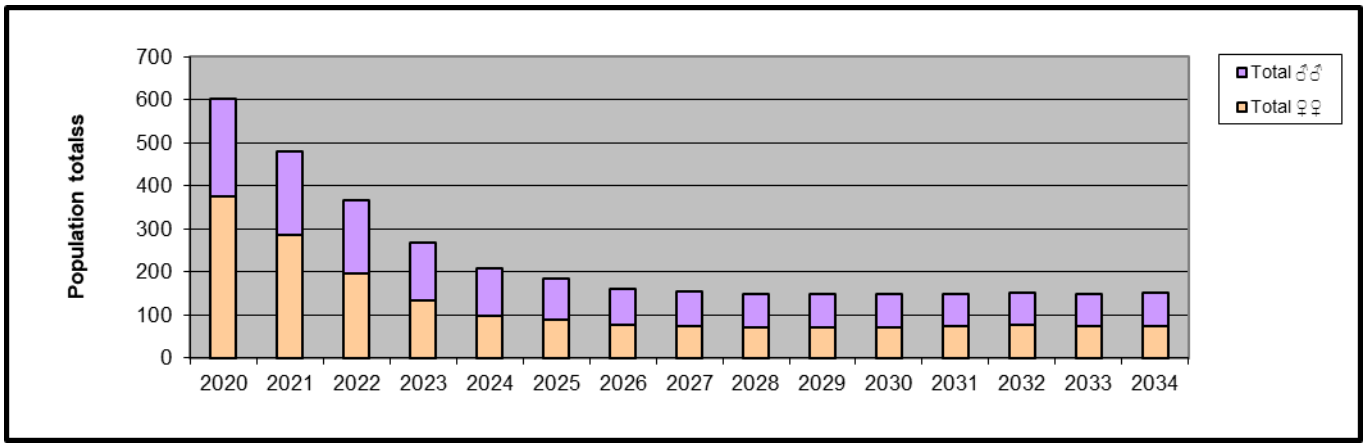
Note that the culls include DVCs i.e. the cull, as it proceeds, must take into account those known to have died in DVCs.
Although the initial and subsequent culls are achievable numerically, it must be recognised that conditions on the ground may mitigate against the actual achievement of the cull. This model takes no account of the obstacles to culling success that may be present due to weather, changes in deer behaviour, and so on.

Model 7. For Epping Forest woodlands South of the M25. A notional fallow population estimate of 200 on 1600ha (12/km^2), with a target population of 50 (3/km^2) (Extrapolated from historic CoL survey data).



This model illustrates a notional scenario whereby a population of 200 has been reduced to 50 and at the same time the overall male:female ratio has been changed from 1:1.6 to 1:1.
Reducing the population at the rate indicated required an initial cull of around 56 (32 does) reducing to 12(4 does) by 2025. When stabilised at 50 head (2027), the cull total is approx. 10 provided at least half are does.

Model 8. For the Epping Forest Buffer lands and adjacent land North of the M25. A current fallow population estimate of 600 on 2400ha (24/km^2), with a target population of 150 (6/km^2).



This model illustrates a notional scenario whereby a population of 600 has been reduced to 150 and at the same time the overall male:female ratio has been changed from 1:1.7 to 1:1.

Reducing the population at the rate indicated required an initial cull of around 212 (130 does) reducing to 47 (24 does) by 2025. When stabilised at 150 head (2027), the cull total is approximately 30 provided at least half are does.

Note that the culls include DVCs i.e. the cull, as it proceeds, must take into account those known to have died in DVCs.

Although the initial and subsequent culls are achievable numerically, it must be recognised that conditions on the ground may mitigate against the actual achievement of the cull. This model takes no account of the obstacles to culling success that may be present due to weather, changes in deer behaviour, and so on.

Appendix E; Recommendations of DVC measures to be considered as part of the overall Epping Forest deer management strategy

On the basis of this review of the scale and distribution of past DVCs in and around Epping Forest and of the suitability of particular mitigation measures in the local context, the following measures are recommended as part of the overall deer management strategy.

8. Reduce deer populations and then aim to maintain them within agreed sustainable target levels set separately for fallow and muntjac, and for north and south of the M25.
9. Consult with the highway authority to provide vehicle-speed activated digital deer signage targeted at road sections leading through selected DVC hotspots.
10. Consult with highways authority and parish council on reducing speed limits for B1393 & B181 along The Lower Forest; and/or else consider an animal activated signage system.
11. Maintain verges to prevent them from becoming overgrown and impeding sight lines.
12. Regularly inspect motorway deer fence and liaise with HE to correct issues promptly.
13. Provide large-scale (billboard type) signage at key entrances to the Forest to re-enforce the reasons for speed limits on all Forest roads.
14. Improve recording of DVCs including species involved and map locations of incidents, to ensure effectiveness of all measures taken can be assessed objectively.
15. Review and consult with Essex Police on possible improvements to callout scheme for attendance by CoL staff and others to deal with injured deer at the roadside.

Several of the above measures, not least those at the roadside, will inevitably require consultation and close working with the local highway authority to progress. Limited extra discussion is provided below on each of the measures regarding e.g. types of signage and provisional or highest priority locations.

16. Reduce deer populations and then aim to maintain them within agreed sustainable targets levels set separately for fallow and muntjac, and for north and south of the M25.

The avoidance of any further increase and localised reduction of deer numbers, of both muntjac and fallow, are an important prerequisite for any other DVC measures proposed to be cost-effective. In other words, if deer numbers continue to increase, any positive effects of enhanced signage and other mitigation measures will quickly become diluted.

An issue to be wary of is that focussing control of deer numbers predominantly on fallow, without also adequate effort made at keeping muntjac numbers under control, risks that both the number of DVCs overall and other impacts from muntjac will continue to rise even once a decline in fallow impacts is achieved.

17. Consult with highways authority to provide vehicle-speed activated digital deer signage at selected DVC hotspots.

Speed vehicle-activated signage, such as shown in Image 2 (centre) below, as used on a number of roads in the Scottish Highlands, can help to enhance the warning to drivers when they are driving in excess of the advised limit. Such signage would be best positioned to either side of road sections with known DVC hotspots (see Figure 11.3). In the first instance we would suggest such signage be considered for use at a number of locations approaching and leaving the Wake Arms roundabout, and also for the B1393 and B181 roads past the Lower Forest. The precise locations for such hot-spot signage should be discussed further in detail with those CoL callout teams who have dealt with DVCs over the last five years, to help refine locations identified in the present hotspot maps (see above); i.e. as those maps have been produced using past data where locations have not always been recorded very precisely.

Image 1

Image 3

The type of dynamic sign shown in Image 2 (centre) is powered using a solar panel above, and thus does not necessarily require mains supply where this would be costly to provide. They also tend to have options to be active continuously or only at certain times of the day and year when risk is considered greatest, as well as facility for automated recording of times and frequency of activation to assist, e.g. with monitoring speed reduction achieved over time.

While fixed signs left in situ throughout the year would be recommended at a small number of the worst DVC hotspots, in addition temporary seasonal virtual message signs (Image 3 – right) could also help to re-enforce speed limits and alert drivers to times for heightened risk of deer crossing at a wider range of sites across the Forest. However, whilst a prominent peak of fallow DVCs tends to occur during October & November in most years, muntjac DVCs peak later into winter and a significant proportion are spread out throughout most other months. Ideally therefore, if dynamic signage is employed, this should **not** be focussed solely on the late autumn period.

18. Consult with highway authority & parish council on reducing speed limits for B1393 and B181 Lower Forest; and/or else consider speed or animal activated dynamic systems.

DVC hotspots on the east and west side of the Lower Forest along B181 and B1393 have been the most longstanding and still remain among the highest problem locations in the Epping Forest district. Two additional contributing factors here are that a) by contrast to most Forest roads south of the M25 where 40mph speed limits apply, most of B-road sections past / through the Lower Forest are currently either 50mph or 60mph, and b) no regular culling of deer is undertaken within the Lower Forest, making it to some extent a sanctuary area for deer when culls are on-going elsewhere. A reduction of the speed limit from 60mph to 40mph or lower on the majority of roads through Epping Forest resulted in 2011 after public consultation on the second Forest Transport Strategy developed, together with Essex County Council, by the CoL Conservators. Consideration should be given to whether similar measures may be possible to introduce to the above roads north of Epping Town. Either as an alternative to permanent dynamic signage (see II above), or in addition, reducing and then (re)-enforcing the speed limit to ideally 40mph there has high potential to reduce

the total number of deer hit along those roads as well as lowering the risk and severity of injuries sustained in DVCs.

Other alternatives such as fencing along the B1393 at Lower Forest (likely feasible on one side only) would be problematic at these locations without risk of creating new hotspots at end-runs. Irrespective of whether lowering of the speed limits can be agreed with Essex County Council and locally, vehicle activated signage as at (II) above should be considered in the first instance for at least the B1393 in both directions, as well as B181 if resources permit. Consideration could also be given to a more advance *animal-activated* system that triggers dynamic deer warning signs when deer pass through (laser or radar) sensors arranged parallel to the verge. However, further investigation and a localised feasibility assessment of appropriate animal- activated systems would be required if wishing to explore this latter (likely more costly) option.

19. Maintain verges to prevent them becoming overgrown and impeding sight lines.

The prevention of verges from becoming overgrown is also an essential part of minimising DVCs, by ensuring good forward visibility for drivers and animals approaching the roadside. For the most part verges along roads through the Forest are already subject to twice-yearly cutting back by the highway authority but only to a limited flail width. CoL augments this cutting regime where felt needed. The removal of woody scrub and not allowing other dense high vegetation to develop within 5 metres of the verge is of greatest priority and in particular near bends and other sections of road with impaired forward visibility for driver. Creation of wider verges of 10 metres or more in DVC hotspots to further improve sight lines for both drivers and wildlife may also be valuable to assist in a number of locations, but would require careful site specific survey to help ensure that any benefits gained from creation of better sight lines do not become off-set by attracting deer to graze increasingly on the verges. Re-sowing any areas where wider verges are to be created with special seed mixtures of mainly native grasses and herbs of relatively low nutritional value could help negate the latter issue.

20. Regularly inspect motorway deer fence and liaise with HE to correct issues promptly.

Maintenance of deer fencing along the M25 is generally the responsibility of Highways England. It was not possible to inspect the fence for the present review but inspections in the recent past have revealed gaps breachable by fallow, roe and muntjac in some sections. In view of the potential seriousness of deer, especially large deer like fallow, passing through, CoL staff should inspect the M25 fence line from the outside at least every two or three months, and report any deer-porous gaps to the HE's management agent for the M25 corridor.

21. Provide enhanced (billboard type) signage at key entrances to main Forest.

A form of large (billboard) type of signage, such as the example Image 1 from the New Forest, is suggested for use at main routes into Epping Forest, to inform drivers that they are about to enter into an area where large animals are prevalent. Providing better information in this manner on the reasons for the Forest-wide 40 mph maximum speed is likely to aid greater compliance with that limit. If this recommendation is progressed, it would seem appropriate to adapt the design to be as 'Epping Forest' specific as possible, with emblems to signify presence of fallow deer, as well as muntjac and cattle. Provisional locations suggested would be a) at B1393 Bell Common heading south b) A104 near Warren Wood heading north, c) A121 Honey Lane heading west, and d) A121 nr Theydon Bois heading east.

22. Improve recording & collation of all reported DVCs including actual map locations and species.

Recording of DVCs by CoL staff and EFDC has been somewhat inconsistent across years and has frequently lacked the detail necessary to identify localised hotspots with a sufficient degree of accuracy. Contemporary technology makes it very simple to record accurately incidents attended by CoL staff, using either a) a GPS enabled phone to take a photo of the animal that automatically located the location or b) the new British Deer Society phone app, which is freely available and can be used to report deer sighting by species including specifically DVCs, and will return a copy of submissions made by email. OS grid references are not easily understood or recorded by everyone, but simple phone apps such as 'What Three Words' can also provide any locations in situ to within 5 m accuracy provided a GPS signal is available. CoL should decide on a standardised system of complete recording of every DVC which comes to its attention. Logged data should include precise location, date / time / species / sex / person or authority who informed CoL and the outcome (i.e. found or not found; and whether passed on to EFDC for collection). All those involved in DVC callouts should be trained and made to use the system, including office staff, field staff and volunteers. The purpose of more consistent and more detailed logging of DVCs is recommended not merely to assess DVC locations more precisely, but required also to enable objective assessments of the effectiveness (including cost-effectiveness) of such mitigation measures as are taken, and furthermore as valuable indicators of changes in the proportion and distribution of muntjac and fallow deer across the Forest.

23. Review and consult with Essex Police on possible improvements to callout scheme for attendance by CoL staff and others to deal with injured deer at the roadside.

Dealing with deer-vehicle collision road casualties: Dead deer are the responsibility of the local highway authority or else Highways England in case of trunk roads and motorways. Live injured deer, however, may require to be dealt with by specialists to first attend to animal welfare issues, which in most cases means euthanising the injured animal in a safe and humane manner, an approach supported by most vets and the RSPCA. Historically, throughout the UK, injured deer at roadside have been dealt with largely by volunteers (with deer culling experience) with a varying degree of support from Police Forces, Local Authorities and other NGOs. Organisations such as the RSPCA will also attend but have limited resources and often need to refer requests onward to the Police or local vets. In the case of Epping Forest, CoL staff have over the decades been directly involved and have attended to a high proportion of deer injured on roads leading through Epping Forest and the surrounding area. The same is true also of many other community forests, such as e.g. Ashdown Forest in East Sussex, where their rangers alone for many years have needed to deal with over two hundred DVCs a year.

With the increasingly widespread occurrence of DVCs, in some Counties (usually concurrent with Police Force areas) various "formalised" schemes have evolved whereby vetted volunteers (vetted by the Police) are called via a Police Force control room to deal with injured deer, where possible, with a Police presence. Volunteers are expected to operate only in possession of a Police incident number that should act as authorisation to use a firearm at roadside if required. More recently, a number of Forces (Hampshire, Thames Valley, Sussex) and Local Authorities (East Sussex) have required compulsory training and assessment as well as Police vetting to ensure a thorough understanding of roadside risk assessment issues. Organisations in situations similar to Epping Forest have adopted and now work as part of such wider schemes (e.g. the Ashdown Forest rangers). Outside of formal schemes, voluntary training is available from organisations such as the British Deer Society. It is recommended that CoL reviews and consults on their own measures for dealing with injured deer at roadside working with Police and local Authority and ideally includes compulsory training and assessment for all those involved.

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Appendix F; Safeguarding the welfare of wild deer

The welfare of free-living wildlife has attracted increasing attention from conservationists, veterinarians, animal behaviourists, philosophers and more recently legislators since it was first proposed in the peer-reviewed literature as an issue more than twenty-five years ago by Kirkwood Sainsbury and Bennett (1994).

The ubiquitous effect of human activity upon wild animals is set out by Czech (2013), who argues that the drive for economic growth, with concomitant habitat destruction, urbanisation, agricultural intensification, mining, logging and other extractive sectors leaves few parts of the globe free of an impact upon wild animal welfare. Recently the Netherlands and the Scottish Parliaments have enshrined into law a public duty of care for the welfare of wild animals, although these jurisdictions currently stand alone with such law in the developed world (WANE 2011, Putman 2008, Ohl and Putman 2013). In fact, the Animal Welfare Act (2006) and the Animal Health and Welfare (Scotland) Act (2006) specifically exclude wild animals from the obligations to exercise a duty of welfare care, unless the individual animal is "under the control of man" and specifically "not living in a wild state". Within these statutes, the consideration of animal welfare is framed almost exclusively in terms of the individual animal, not populations or socio-familial groups. The same is true of the Wild Mammals (Protection) Act (1996) and the English and Welsh Deer Act (1991).

None the less, increasing public awareness of animal welfare issues has drawn some attention to the welfare of animals perceived to be vulnerable or generally popular, including wild deer. This is especially the case where the deer live on land in public ownership or land available for public recreation, such as Epping Forest, the Royal Parks of London and the deer parks of the National Trust.

Current concepts of the welfare of wild animals have moved away from definitions of welfare constructed around absence of negative impacts (freedom from pain, freedom from hunger and thirst etc.) that have been applied to pets and domesticated animals for more than 50 years towards definitions that reflect the promotion of positive states of welfare (Ekesbo 2011, Appleby Weary and Sandoe 2014, Sandoe and Jensen 2012, Ohl and van der Staay 2012). This approach emphasises that welfare should be considered as a continuum, not a 'good or bad', or 'positive or negative' state. These current concepts of welfare refer to the ability of the animal or group of animals to adapt to challenges that might potentially be harmful and therefore define poor or negative welfare in terms of the inability of the animal to alter its state and adapt to such challenges. Conversely positive welfare describes the state in which an animal has the freedom to react and adapt adequately to the prevailing circumstances or challenges. These more current ideas about animal welfare emphasise that welfare cannot properly be assessed at a single point in time, since the welfare of the animal or group of animals is a reflection of how it or they react, respond and adapt to challenge. Wild animals must therefore, by definition, be given the time to demonstrate whether they can adapt or whether they have the freedom to make the necessary adaptation to mitigate the challenge.

For wild deer, examples of deer moving into a more positive state of welfare would be evidence that when they are cold or subject to inclement weather, they can both seek and find adequate shelter; that when they are hungry, they can both seek and find sufficient nutritious food. They would move into more negative states of welfare when they were unable to find shelter or sufficient food. By these principles, it is clear that the deer themselves may contribute to a decline in their welfare: if over-abundant deer populations consume most of the available forage and strip the woodland of its ground cover and understory, there will be less shelter and less available food. The Scottish WANE

Act (2011) addresses this point specifically, making landowners responsible for deer management so that over-abundance of deer does not impact adversely upon deer welfare.

Although no such legal constraints apply to the City of London Corporation in respect of Epping Forest and the buffer lands, CoL staff will be able to answer enquiries about the welfare of the deer on the estate if they are familiar with these concepts.

Objective assessments of wild deer welfare must rely upon observation and, where available, examination of deer culled in routine deer management. If culling is practiced, an element of welfare will be the humaneness of the lethal rifle shot.

Green (2016) provided to the Scottish Government nine objective indicators that may usefully be employed by landowners and deer managers to assess the welfare of free-living wild deer. They apply equally to lowland deer in England. These are:

24. The bodily condition of yearling animals based upon a visual pelvic condition score scale of 1-5, where 1 is emaciated with severely sunken pelvic soft tissues and 5 is obese. If many or most of the yearlings score low (pelvic BCS 2 or below), herd and individual welfare is likely to be more negative. Yearlings in pelvic BCS above 2, especially in winter, indicate positive welfare. (Yearlings provide the most consistent cohort of animals that may be compared between groups of deer and between seasons).

25. The appearance of normal mobility and freedom from any debility, or the presence of obvious disease or injury that disables the deer over time and limits movement and feeding.

26. The mortality rate of the deer. Death in the rut from fighting and limited death of fawns and kids in their first winter are normal in UK fallow deer and muntjac deer and does not necessarily indicate negative welfare in the group. The sudden death of unexpected numbers of deer of varying ages is an indicator of declining welfare in the group. (This includes unacceptable deaths from deer-vehicle collisions).

27. The behavior and activity of the deer when undisturbed. Unusually depressed or sluggish behaviour (unusual for the deer under observation) suggests declining

welfare.

28. The toleration of close approach or handling. Wild deer in a positive welfare state are cautious of human presence and flee attempts to approach or handle them. Deer that

permit close inspection or even handling are likely to be in a severely negative state of welfare.

29. The social interaction of the deer when undisturbed. Deer in a healthy, positive welfare state are usually settled, relaxed and may show evidence of playfulness, sparring, grooming or inquisitive behaviours. Increased agitation, bullying, squabbling or increased milling around in groups of deer that are usually settled is an indicator that welfare is declining.

30. Foraging behaviour and appetite: Manic or grossly abnormal appetite or food choice indicates declining welfare.

31. The assessment of carcass condition of yearlings based upon the presence or absence of both renal and cardiac coronary groove fat deposits. Absence of any fat at these sites is an indicator of more negative welfare, especially in combination with very poor bodily

condition. Fat around the kidneys and in the coronary groove indicates that the welfare state of the deer at the time of death was not unacceptably negative.

32. The bullet placement in carcasses in the larder. Carcasses with multiple bullet wounds, especially to the limbs and abdomen, should be unusual. There should be evidence of single, fatal wounds in most of the carcasses, indicating that death was humane and swift and that welfare was not unacceptably compromised. The presence of several carcasses with multiple wounds is highly suggestive that welfare of the deer before death was unreasonably reduced and that this was a pattern of effect across the group.

When observing live deer, these indicators are best used as dynamic indicators, assessed over several days. For postmortem indicators, patterns of findings over the cull period are most useful. Similar parameters may be applied to free-living deer in parks, which are likely to be more visible for dynamic assessments of living deer and for which the artificial provision of supplementary winter feeding is usually essential (Green 2017).

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Appendix G; The current status, purpose and future of the Birch Hall deer sanctuary

The history of the sanctuary

The enclosed deer sanctuary at Theydon Bois, Epping dates from the late 1950s and early 1960s. According to Langbein (2011) at that time there was concern that the survival of the distinctive black fallow deer of Epping Forest might be at risk (cf. 3 below). Increasing vehicular traffic and human disturbance within the Forest were considered to be a threat to the deer. This is confirmed by Whitehead (1964) who reports that in some years, deer numbers in the whole Forest were below 100 in the early and mid-1950s and that, as he was writing in 1963/4, up to thirty deer were being killed on the roads annually. He also states that '*in some years also, there are heavy casualties in the spring due to scouring and on occasions some twenty to thirty fawns have been killed by poaching dogs moving through the Forest in June. It will be realised therefore, that should there be a combination of all these evils occurring in one year, the herd might well be decimated beyond recall*'.

Whatever the reasons for the establishment of the sanctuary, an area of open wood pasture and meadow in the Birch Hall area of Theydon Bois was enclosed with deer fencing and provided with deer leaps to capture local deer with the sanctuary. The original manor house of Birch Hall lay between Birch Hall Farm and the present mansion of Birch Hall (Theydon Hall). The estate was purchased in 1901 by Gerald Buxton and subsequently inherited by the Verderer Lt Col Edward North Buxton, the author of the standard reference book about the Forest (Buxton 1885).

Records and evidence from the current CoL staff suggest that deer numbers before culling have been maintained at between 100 and 200 for the past 30 years. Langbein (2011) records that he has made deer management recommendations in respect of the sanctuary in 1996, 2004, 2007 and 2011. A veterinary assessment and audit of the deer in the sanctuary was provided by Green (2010), which revealed suspicion of a sub-clinical copper deficiency, but no other concerns about health or welfare.

The current status and management of the sanctuary

The sanctuary extends to some 44 ha of undulating land, gently sloping from 90m to 60m above sea level in a northwest/southeast direction. Approximately 30 ha of the sanctuary is open permanent pasture interspersed with mature deciduous trees, mostly oaks arranged along the line of a drain and earlier hedgerow; the remaining 14 ha is mature deciduous woodland with some understory and a shallow lake of just under one hectare. There is the remnant of an old deer catching corral on the northern boundary, a legacy of live sales from the sanctuary in the 1980s. The northeastern and eastern boundaries adjoin the gardens of local residences; the southeastern boundary adjoins the remnants of Gaunts Wood and Red Oak Wood from which the deer are excluded.

The Birch Hall deer sanctuary (from Epping Forest. The Official Map 2019)

The deer are relatively undisturbed, since there are no public rights of way through the sanctuary. In recent years, day-to-day management of the deer has been undertaken by CoL staff, who have inspected the deer for evidence of injury, provided the supplementary food in season and culled the deer to maintain numbers at agreed levels. A pre-rut cull of males has been undertaken in the past, in common with best practice for deer park management, but this cull has not occurred in 2019. Guided walks and group visits to the sanctuary have been undertaken by CoL staff in the past, but these have ceased. Cast antlers from the sanctuary are sold for a modest profit.

The sanctuary was visited on October 1st 2019. Present at the site visit were CoL staff, Consultant Dr Jochen Langbein and Consultant Dr Peter Green MRCVS.

The deer were more flighty than had been the case when Jochen Langbein and Peter Green last inspected them (in 2011 and 2010 respectively). The CoL staff stated that there were between 160 and 170 deer in the herd; it was impossible to confirm this. Subsequent scrutiny of photographs suggests that there may have been slightly more than this, but an accurate count was not possible. At the time of the visit, carrots were being provided; supplementary forage and deer-specific concentrates (Monarch Deer Nuts) would be provided later in the winter.

Inspection of the deer through binoculars indicated that they were in good condition, with pelvic body condition scores throughout the herd of 3 (out of 5) or above. There were several small late fawns, a testimony to late conceptions. All the deer were of the melanistic variety.

The fallow deer herd at the Birch Hall deer sanctuary on October 1st 2019 (photograph © J Langbein)

There was significant browsing of the nettles and creeping thistle in the sanctuary, which is an unusual feature of early autumn deer parks and indicates a degree of late summer forage deficiency. The central meadow area had only recently been mowed and CoL staffs conceded that pasture management had been delayed this season. The recent mowing should have been in time for an autumn flush of aftermath. The acorn and mast crop were considered to be no better than average.

Culling would begin when the rut had subsided and when the female season opened on November 1st.

Apart from the slight concern about summer forage and pasture management and the disappointment that the deer appeared more timid and flighty than in the past, the visit on October 1st gave no reason for the consultants to be concerned for the welfare of the deer. The CoL staff were clearly knowledgeable about park deer management and were enthusiastic about the deer and the sanctuary.

The character and value of the deer in the sanctuary

There has been a considerable focus upon the importance of the sanctuary in maintaining the bloodlines of the 'black' (melanistic) fallow deer that are believed to be characteristic of Epping Forest and to be traceable back to at least the early 17th century when James I is said to have brought black fallow deer of Danish origin to both Epping and Windsor (Buxton 1885, Chapman & Chapman 1975). The source of this information is not clear, since both Buxton, in later editions, and Chapman refer to Fisher (1887). Careful reading of both Fisher and Cox (1905) does not support this as an established fact.

Fisher actually states that "*the word 'fallow' refers to the usual reddish-brown colour of the species, but the Essex deer are of an almost uniform dark-brown tint. These were introduced into the Forest, it is said, by James I; but Mr Harting produces evidence of the existence of this variety in Windsor Forest in 1465*" (Fisher 1887 p 196). Whitehead (1964) also questions the folklore about the black fallow of Epping, again quoting Harting in his *Essays on Sport and Natural History 1883*, who evidently shows that there were dark coloured fallow deer at Windsor as early as 1465 and quoting Leyland's Itinerary of 1533, which refers to dark fallow deer in England.

The origin of all the received wisdom about James I and the black fallow deer appears to be Thomas Bewick who published his children's book *History of Quadrupeds* in 1790, in which he remarks that James I brought black fallow deer to Scotland and then to England because he had '*observed their hardiness in bearing the cold*' (quoted by Shirley 1867).

Irrespective of the origin of the melanistic fallow deer that came to predominate in the Epping Forest area in the 18th and 19th centuries, there is universal agreement that fallow deer were present in the Forest, together with red deer, long before the time of James I and at least as early as the 12th century (Fisher 1887, Cox 1905, Whitehead 1964). Red deer became scarce in the early 19th century, after the abandonment of stag hunting with hounds, and the few remaining red deer were netted and taken to Windsor in 1820. Roe deer were introduced to Epping Forest by Buxton in 1883 but lasted only until the outbreak of the First World War (Buxton 1887, Whitehead 1964).

Contemporary genomics indicates that there is less genetic diversity amongst modern northern European fallow deer than between other wild deer species. This is almost certainly because translocations of fallow deer in small numbers have been responsible for their spread throughout Europe and succeeding genetic bottlenecks have eliminated most deleterious alleles and narrowed the genetic footprint. Work in the 1980s and 1990s based upon protein electrophoresis suggested that there was virtually no polymorphism in disparate populations of fallow deer, which gave rise to the thesis that there was no value in safeguarding given populations of fallow deer or particular deer parks herds because they were all fundamentally identical.

Such a perspective has been undermined in more recent years with the advent of much more advanced genomics. This shows that populations of fallow deer, isolated for sufficient numbers of generations, exhibit predictable genetic drift and become somewhat distinct. Examples of such investigations have been undertaken in Hungary, Germany and Australia (Kuszas et al 2018, Ludwig et al 2012, Webley et al 2007). In effect, these studies show that isolated fallow deer populations can begin to assume characteristics equivalent to 'breeds' within domesticated livestock.

The deer of Epping Forest have themselves been restricted in the past to severe genetic bottlenecks, with as few as 10 deer remaining in the Forest before multiplying again (Chapman & Chapman 1975). It is likely therefore that the deer are characteristic of the region and will vary in certain phenotypic expressions from, say, the fallow deer of the New Forest or of Shropshire. But this is far

from suggesting that they are unique or 'valuable' in terms of the genetic material they carry or that they represent bloodlines lost elsewhere.

In 2011, Arts and Humanities Research Council funded a project titled '*Dama International: fallow deer (Dama dama dama) and European society 4000 BC - AD 1600*', a multi-disciplinary project that aimed to trace the movement of European fallow deer (*Dama dama*) by people through time and space. One arm of this project involved generating new DNA sequence data to produce baseline information to determine the genetic structure and diversity of this species across its contemporary range (see Baker et al., 2017). In this context, 10 samples were sent to the project's geneticist (Dr Karis Baker, Durham University, Biological sciences) from Epping Forest.

Three of the samples received from Epping Forest were processed alongside 200 other samples retrieved from a diversity of European and worldwide populations along a 683 base stretch of the maternally inherited mtDNA control region (a base is defined as a DNA nucleotide A, C, G or T).

Thirty-six unique DNA sequences (known as haplotypes) were identified across the 203 fallow deer samples examined by Dr Baker. The sharing of mitochondrial haplotypes can provide information about possible shared ancestry down the maternal line. All 3 samples examined from Epping Forest, belonged to the same haplotype, indicating shared inheritance, which is not unexpected in deer herds. The haplotype found at Epping was also shared with 4 other fallow deer individuals from 3 of the other sampled locations: one individual from Stetchworth in Cambridgeshire, one individual from Whipsnade Zoo and two individuals from Schleswig-Holstein, Plön in Germany. This haplotype shows a relatively low frequency (7/203; 0.034) across total sampled populations.

The result from the Epping deer should be interpreted with care since the sample size (n=3) is extremely low and the result is being interpreted only from a very small portion of mitochondrial DNA. An increased sample size from Epping could unveil further useful information (e.g. unique or other shared haplotypes). However, the result shows that the three Epping fallow deer sampled were all of the same maternal line and that this maternal line is also present elsewhere in the UK and on the Continent. It appears to be a relatively uncommon maternal line, but is not unique to Epping. The connection with Whipsnade is unsurprising since melanistic deer were taken from Epping to the zoo in the 1960s when concerns were raised that the Epping strain of fallow deer might be at risk of extinction.

('We are grateful to Dr Karis Baker, University of Durham, for providing details of her research into the genomics of the fallow deer at Epping'.)

The melanistic phenotype is considered by some park managers to be rather dominant in herds that have a mix of colours and the emphasis upon fallow deer of Epping Forest appears to have been at its most enthusiastic the turn of the 20th century. This was a time when the majority stud books and breed societies were formed with great enthusiasm in domesticated livestock and pet circles. Breed standards were set according to fashion and to the perceived 'original types. Animals not conforming to these standards were culled or neutered. Buxton (1887) is extremely disparaging about fallow deer of other colours, describing the menil fallow of the New Forest as '*washy spotted mongrels*' (quoted by Whitehead 1964). It seems likely therefore, that fallow deer of other colours were culled when they appeared and the preponderance of the dark lines arose because of a combination of selection and breeding dominance, as much as from ancient or unique origins.

Buxton also makes much of the diminutive size of the wild Epping Forest fallow deer, comparing them with larger park deer that, he says, have more favoured grazing. In fact, he is mistaken in this viewpoint, since park deer are almost invariably smaller in frame and lighter in weight than free-living fallow deer in the open landscape of the UK.

In summary, there is little or no evidence that the dark fallow deer of the Birch Hall deer sanctuary are especially valuable or unique in terms of their genetics. They are, however, representative of the predominant type of fallow deer present in Epping Forest for at least 200 years, even if this preponderance may have been the result of anthropogenic influences.

There is currently no risk to the survival of fallow deer in the Epping Forest and south Essex areas, indeed, keeping populations under control is proving to be challenging. The sanctuary therefore has no purpose in terms of maintaining or salvaging a population

The possible purposes and benefits of the sanctuary

The deer sanctuary currently falls outside most of the recognised purposes for enclosed deer herds in the UK.

It is not a deer farm, since there are no facilities for handling deer, youngstock is not weaned for fattening and the main purpose of the deer herd is not the production of venison.

It is not a heritage deer park with a long history of emparkment from either royal or monastic origins, since it was created some sixty years ago on the site of a former private residence. It might be argued that it represents the last vestige of the former royal hunting forest of Waltham, but other royal chases that have evolved into deer parks (Richmond, Bushy, Hampton Court, Windsor etc.) have extensive and abundant public usage.

It is not a public amenity deer park, since there is no public access and the deer herd is maintained in seclusion from most of the residents of Epping Forest and the surrounding area. With the exception of the CoL staff who enter the enclosure, only the adjoining property owners have regular sight of the deer through the fence from their gardens.

It is not a landscape amenity designed to enhance the attraction of the parkland surrounding a great house, in the style of the National Trust deer parks, or private parks such as Longleat, Woburn, Houghton or Powderham.

It is not a zoological collection, conserving an endangered species or offering public exhibition.

At best, it currently constitutes a private deer herd maintained by and for almost the exclusive benefit of the City of London Corporation. It is difficult to justify the maintenance of the enclosed herd on this basis. Fallow deer are not endangered in the immediate area. The original purpose of the sanctuary, to safeguard and preserve some deer when extinction from the Forest was anticipated, has proven to be unnecessary.

This is not to say that the deer sanctuary could not fulfil a valuable purpose in the future; the disparkment of the fallow deer herd would be a major undertaking, not least in terms of public acceptance given the media coverage of the deer culling on the wider estate in the autumn of 2016.

There is no doubt that the deer herd in the sanctuary could be used more for educational purposes: although deer are abundant and form an important part of the local ecosystem, they are usually only glimpsed by local residents. School children and adults would benefit enormously from greater access to the deer herd, in conjunction with organised and professional educational input. Such models for public educational value work well in many peri-urban deer parks, both private and public. The Epping Forest Act of 1878 was framed for "*the preservation and management of the uninclosed* (sic) *parts thereof as an Open Space for the recreation and enjoyment of the public*" and it might be argued that public education about the deer of the Forest is an essential role of the Epping Forest Committee constituted under the Act.

As this review is also considering deer management on the wider Epping Forest estate and the buffer lands, on which deer culling by rifle is the only realistic population control tool, the preservation and promotion of the deer in the sanctuary might usefully mitigate any public outcry about the killing of deer. The City of London Corporation could profitably use the sanctuary as an example of how deer are supported and preserved by their staff, whilst acknowledging that in other areas of the Forest deer need to be culled. Such a public promotion of the sanctuary would only be valuable if there were a genuine increase in public access and education in and around the sanctuary.

Should the Corporation decide that the deer sanctuary is no longer necessary and fulfils no useful purpose, very careful consideration must be given to the way in which the disparkment of the sanctuary area is undertaken. At a time when the Corporation and Committee are seeking to justify deer culling on the landscape holdings, the culling of the enclosed deer in the sanctuary would do nothing to settle pubic disquiet about the need for such measures. Rational and logical discussion about the adverse impacts of free-living wild deer on the Forest habitat, on deer vehicle collisions, on adjoining commercial farmland and upon the deer themselves would be undermined if the deer in the sanctuary were to be culled at the same time as landscape scale deer management was being justified. Informed and intelligent objectors to deer culling would quickly appreciate that the reasons for culling wild deer do not apply in the same way to the deer in the sanctuary.

If the deer are removed by either netting or other capture techniques, stress and casualty rates are likely to be high and any destination for a large number of deer would require approval by Defra and Natural England.

It seems obvious that until one of the principal findings of this review (that deer culling is essential) is accepted by the public and is proving to be uncontroversial, or minimally controversial, in the media, it would be foolish on the part of the Epping Forest Committee to do away with the deer sanctuary. If the sanctuary is to remain, at least in the foreseeable future, it also seems obvious that it should be used more, and more publicly, for promotion of the Epping Forest deer.

Regular visits by groups, regular human activities in the sanctuary and regular supplementary feeding will soon habituate the deer to close human presence and attention. Indeed, this has been demonstrated in the past and can easily be achieved in the future. If the sanctuary is to be retained, the deer management plans and regime proposed by Langbein 2011 still applies and should be implemented. Regular veterinary input and written welfare endorsement has also proved useful in the face of enquiries to other public deer parks including the Royal Parks.

Conclusion

The deer sanctuary at Birch Hall is not necessary for the purpose for which it was originally created: the preservation of the Epping Forest deer. The fallow deer in the sanctuary are not especially valuable or unique. In its current form and usage, the sanctuary serves little purpose, but it has great potential as a public amenity and educational facility. Removing the deer at a time when deer management on the wider City of London estate is under public scrutiny would be damaging to efforts to justify and explain why active deer management by culling is essential.

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Appendix H; Glossary

Adaptive management; A structured, iterative process of robust decision making in the face of uncertainty, with an aim to reducing uncertainty over time via system monitoring.

Alleles; Each of two or more alternative forms of a gene that arise by mutation and are found at the same place on a chromosome.

Dichromatic vision; the state of having two types of functioning colour receptors, called cone cells, in the eyes which may improve an animal's ability to distinguish colours in low light.

Ecotone; An ecotone is a transition area between two biomes. It is where two communities meet and integrate. It may be narrow or wide, and it may be local (the zone between a field and forest) or regional (the transition between forest and grassland ecosystems).

Empark; To enclose the land with a wall, hedge or fence and to establish a captive herd of deer within,

Genetic drift; Variation in the relative frequency of different genotypes in a small population, owing to the chance disappearance of particular genes as individuals die or do not reproduce.

Genomics; the branch of molecular biology concerned with the structure, function, evolution, and mapping of genomes.

Haplotype; A haplotype is a group of genes within an organism that was inherited together from a single parent. The word "haplotype" is derived from the word "haploid," which describes cells with only one set of chromosomes, and from the word "genotype," which refers to the genetic makeup of an organism.

Mast; The highly variable annual production of fruit by a population of trees and/or shrubs. These intermittent pulses of food production drive ecosystem-level functions and forest dynamics.

Mitochondrial DNA; The small circular chromosome found inside mitochondria. These organelles found in cells have often been called the powerhouse of the cell. The mitochondria, and thus mitochondrial DNA, are passed almost exclusively from mother to offspring through the egg cell.

Natural capital; The world's stocks of natural assets which include geology, soil, air, water and all living things. It is from this natural capital that humans derive a wide range of services, often called ecosystem services, which make human life possible.

Phenotype; The term "phenotype" refers to the observable physical properties of an organism; these include the organism's appearance, development, and behaviour. An organism's phenotype is determined by its genotype, which is the set of genes the organism carries, as well as by environmental influences upon these genes.

Pollard; A pruning system involving the removal of the upper branches of a tree, which promotes the growth of a dense head of foliage and branches. Traditionally, people pollarded trees for one of two reasons: for fodder to feed livestock or for wood.

Polymorphism; In biology and zoology, polymorphism is the occurrence of two or more clearly different morphs or forms, also referred to as alternative phenotypes, in the population of a species.

Rut/Rutting; The mating season of certain mammals, which includes ruminants such as deer, , The rut is characterized in males by an increase in testosterone, exaggerated sexual dimorphisms and increased aggression and interest in females. The males of the species may mark themselves with mud, undergo physiological changes or perform characteristic displays in order to make themselves more visually appealing to the females. Males also use olfaction to entice females to mate using secretions from glands and soaking in their own urine.

Scouring (of animals/livestock); Suffer from diarrhoea.

Understory; The underlying layer of vegetation in a forest or wooded area, especially the trees and shrubs growing between the forest canopy and the forest floor. Plants in the understory comprise an assortment of seedlings and saplings of canopy trees together with specialist understory shrubs and herbs.

Ungulate; A members of a diverse group of primarily large mammals with hooves. These include odd-toed ungulates such as horses and rhinoceroses, and even-toed ungulates such as cattle, pigs, giraffes, camels, deer and hippopotamuses, , and, as well as sub-ungulates such as elephants. Most terrestrial ungulates use the tips of their toes, usually hoofed, to sustain their whole body weight while moving.

Wood-pasture; An area of grazing land with trees. Traditionally, the trees are cut periodically for fuel and/or for additional fodder for the livestock. Under this form of management, the trees are cut and maintained as pollards, so that the new growth develops above the reach of the browsing animals.