A strategic overview of wild deer population dynamics in the Cairngorms National Park

Report to the Cairngorms National Park Authority

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Strath Caulaidh

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Standard caveats

- SCL have exercised reasonable skill, care and diligence in the preparation of this document, in accordance with the standards of a qualified and competent person experienced in carrying out work of a similar scope and complexity to the agreed services and current at the time when the services were performed.
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Specific caveats

- The report in places uses data sets created by other organisations and we cannot be held responsible for their accuracy.
- A range of other data available from private sector, third sector or other government organisations may be available to help the CNPA expand upon the findings of this project, but the scope of the project and timeline precluded contact being made.

ACKNOWLEDGEMENTS

- Mike Cottam and Pete Mayhew of CNPA identified the funds needed for the project.
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INTRODUCTION

1. The Cairngorms National Park (CNP) covers ~ 452,800ha of mountain, moorland, woodland and farmland in the north east of Scotland. A total of 18,000 people live within its local communities, and a wide range of businesses operate within its boundaries.

2. The Cairngorms National Park Authority (CNPA) has statutory duties in relation to planning and outdoor access within the park, but also provides a range of services to support business owners, landowners and local communities.

3. The CNPA also has an important strategic part to play in relation to land management[1]. Policies and support packages are in place to encourage active conservation of the park's iconic landscapes and valued semi-natural habitats, at the same time as promoting sustainable rural development through tourism and other forms of business activity (e.g. farming, forestry) where appropriate. The authority therefore has a particularly important role to play in relation to landscape-scale planning and co-ordination of land management activity.

4. Wild deer are present throughout the park. Red deer are thought to be the most abundant species, followed by roe deer. Sika deer and fallow deer are also present locally. Wild deer produce a range of impacts, both positive and negative, on the land and local communities present within the park. The two forms of impact need to be balanced, according to local and regional priorities. The CNPA therefore has a potentially important and useful strategic role to play in helping achieve this aim at regional scale.

5. A variety of data are currently available to underpin the CNPA's ability to deliver on its strategic deer management remit. This includes (i) helicopter count data of deer management group (DMG) areas supplied by NatureScot (NS), (ii) statutory cull returns provided annually to NS from landowners, (iii) habitat impact monitoring data gathered by NS or landowners and (iv) a range of monitoring data from woodland deer populations (e.g. dung counts, crop impact surveys). However, these data sets currently exist in multiple locations and in a variety of formats. As a consequence, there is no robust estimate of how many wild deer live within the Cairngorms National Park as a whole. Crucially, the CNPA has no strategic overview of their contemporary distribution - or their population density - in different areas and habitat types. Moreover, the CNPA also lacks a landscape-scale data set showing how habitat impacts vary across the park.

[1] The National Parks (Scotland) Act 2000 states that the aims of National Parks are to: (1) conserve and enhance the natural and cultural heritage of the area, (2) promote sustainable use of the natural resources of the area, (3) promote understanding and enjoyment (including enjoyment in the form of recreation) of the special qualities of the area by the public and (4) promote sustainable economic and social development of the areas' communities. However, where these aims conflict, the relevant National Park authority must prioritise the first of these aims.

6. The current absence of a strategic-scale overview of deer population dynamics means the CNPA's leadership team and staff face challenges in:

    a) Demonstrating clearly what progress has been made, to date, in delivering on key CNPA policies relating to deer management across the park.

    b) Establishing whether, based on the most up-to-date sets of data, the CNPA's policies on deer management and related issues seem likely to be fully deliverable in the near term.

    c) Determining whether their current delivery model (e.g. available CNPA support packages, current staff numbers etc) is sufficient to ensure that these policies will otherwise be successfully delivered in the longer-term.

    d) Understanding how contemporary deer distribution and densities at regional and local scale might impact on the current and future delivery of other key CNPA policies (e.g. on woodland expansion, on peatland restoration, on biodiversity, on supporting the fragile rural economy of the area).

7. It is possible, in principal, to bring available data sets together and analyse them to obtain the strategic overview needed by the CNPA. However, in practice there are technical challenges involved in ensuring the process is robust. In addition, a considerable amount of internal staff time would need to be employed in completing the task.

8. Therefore, in March 2020, the CNPA commissioned Strath Caulaidh Ltd (SCL) to compile and analyse available deer count and deer cull data, to help develop an improved strategic understanding of deer population dynamics in the Cairngorms National Park. In late 2020 the scope for the study was expanded to include compilation and review of contemporary herbivore impact survey data on open range habitats.

METHODS

HELICOPTER DEER COUNTS

9. Records of helicopter deer counts undertaken by NS were downloaded from 'Natural Spaces'. This included an ESRI-compatible shapefile of the locations, sizes and compositions of deer groups counted over the period 2004-2019 and a Microsoft Excel table containing data on the timing of each count.

10. The shapefile data were summarised by year and by DMG area in ArcGIS, and analysed to assess:

    a) Which parts of the CNPA area had deer count data available?

    b) When each available count data set had been obtained?

c) To what extent it was warranted to 'join' select data sets together, and treat them as a single unified data set, for the purpose of deriving a robust contemporary estimate of deer numbers across the CNP?

11. Initial inspection of the available data from Natural Spaces revealed a number of potential issues with obtaining a contemporary overview of deer abundance, deer density and deer distribution across the CNP area:

    a) NS helicopter count records relate to red deer only, whereas there are in fact four species of deer present in the CNPA area (roe, fallow, sika and red deer). Any estimate of the deer population using the park based on helicopter count data will be an under-estimate for this reason alone.

    b) Helicopter count data do not cover woodlands, as they are unreliable when undertaken in dense tree cover (Map 1). The lack of availability of corresponding, contemporaneous woodland count data from NS means there is further potential for bias in any deer abundance or density estimates derived for the CNP as a whole. Firstly, deer living permanently in these woodlands were unlikely to have been counted. Secondly, as the counts are often undertaken in snowy weather any open hill deer sheltering temporarily in the trees might be missed during helicopter counts.

    c) Counts tended not to cover the major areas of farmland in lowland settings (e.g. the Speyside section labelled 'Part of Cairngorms'; Map 1). This is in part because DMG's do not always include such places within their boundaries, but also in part as they are often partly wooded (Map 1).

    d) Significant areas of open range land in the CNPA area have no helicopter count data available at all (see Map 1), even though in principal they could be counted. These include:

        i) Areas out with an official DMG but coinciding with historic Deer Commission for Scotland zones used to record deer cull return data (e.g. Morven, Cabrach/Glenbuchat, Moray) (Map 1).

        ii) Areas not currently covered by DMG's.

            (1) These areas were often included within older DCS count areas, mainly under the 'Cairngorms' heading and hence included under the label 'Part of Cairngorms' (Map 1).

            (2) Another area was never historically included in a DCS count area but does fall within the CNPA boundary (referred to as Unassigned; Map 1).

        iii) A fragment of the Birse Parish DMG is included within the CNPA boundary (approx. 10ha).

    e) Some areas had a very recent count undertaken, but the area covered was relatively small in comparison with the size of the CNP (see Map 1). Examples included:

i) Places which are centrally-located within the CNPA area, but where deer movements between the count areas and adjacent land could be significant. The issue in using such data to synthesise a contemporary estimate of overall deer abundance or density is that adjacent areas were counted at markedly different times. Examples of these recently counted areas include East Grampian Sub-Group 1 DMG[2] counted in 2019 (as part of the current Caenlochan Section 7 Agreement) and parts of the East Grampian Upper Deeside & Donside DMG (counted variously in 2019 and 2020) (Map 1).

ii) Places on the periphery of the park, where only a small part of a much larger DMG is included in the CNPA area (e.g. Monadhliath, Mid-West Association, East Loch Ericht).

12. Having reviewed the available helicopter count data sets, the following conclusions were reached on which helicopter data sets to include in the CNPA-wide analysis of contemporary deer abundance and density:

a) The majority of the open range land in CNPA was covered by one of two landscape-scale deer counts. These data sets, which were gathered within a ~ 12 month period albeit over two winters, covered a majority of the CNPA area in the narrowest time window available:

i) January 2016: East Grampians South Deeside - North Angus DMG, East Grampians SG1 DMG.

ii) February 2017: East Grampians Upper Deeside & Donside, West Grampians DMG and Cairngorms & Speyside DMG.

b) The most recent available count from each of the peripheral DMG areas (Monadhliath, Mid-West Association, East Loch Ericht) was also included in the analysis of contemporary deer abundance and density. Despite each area being relatively small, the degree of mixing between each (and the other major count DMG's to the east) will be negligible. That said, the number of deer counted in each area, within the CNPA boundary itself, will not necessarily provide a reliable measure of abundance for the year as a whole:

i) The Monadhliath count was conducted in a warm spring (April 2019) when many deer had moved to higher ground. This count may, with all else equal, have under-estimated the number of deer that would have otherwise been present during a snowier winter count of the same sub-area. With deer free to move in and out of the CNPA boundary, as there is no deer fence in place at this point, the number of deer present will vary markedly through time.

ii) The other two counts (Mid-West, East Loch Ericht) were winter counts, but were of very small areas where deer numbers are likely to vary

[2] Recently re-named the South Grampian DMG, and with its boundaries now expanded, but referred to herein as EG SG1 in line with the historic data sets being analysed for this report.

markedly from week to week, in the same way as the portion of the Monadhliath included, depending on the weather.

c) The remaining areas (Morven, Unassigned, Cabrach/Glenbuchat, Moray, Part of Cairngorms) had no red deer helicopter count data available.

13. For the purposes of simplifying analysis and presentation, the CNPA area was split into several zones reflecting the nature of the count data available (Map 1):

a) East Grampians (Upper Deeside & Donside DMG, South Deeside & North Angus DMG, Sub-Group 1 DMG).

b) West Grampians (covering the WG DMG only).

c) Cairngorms (incorporating Cairngorms & Speyside DMG plus the 'Part of Cairngorms' areas previously included in old DCS count maps).

d) Monadhliath / Mid-West Association /East Loch Ericht DMG's (combined, as they are peripheral to the core CNPA area).

e) Birse/Morven/Cabrach/Moray/Unass' (covering all the areas not officially counted which lie on the east and north sides of the CNPA area).

HISTORIC DEER COUNT DATA

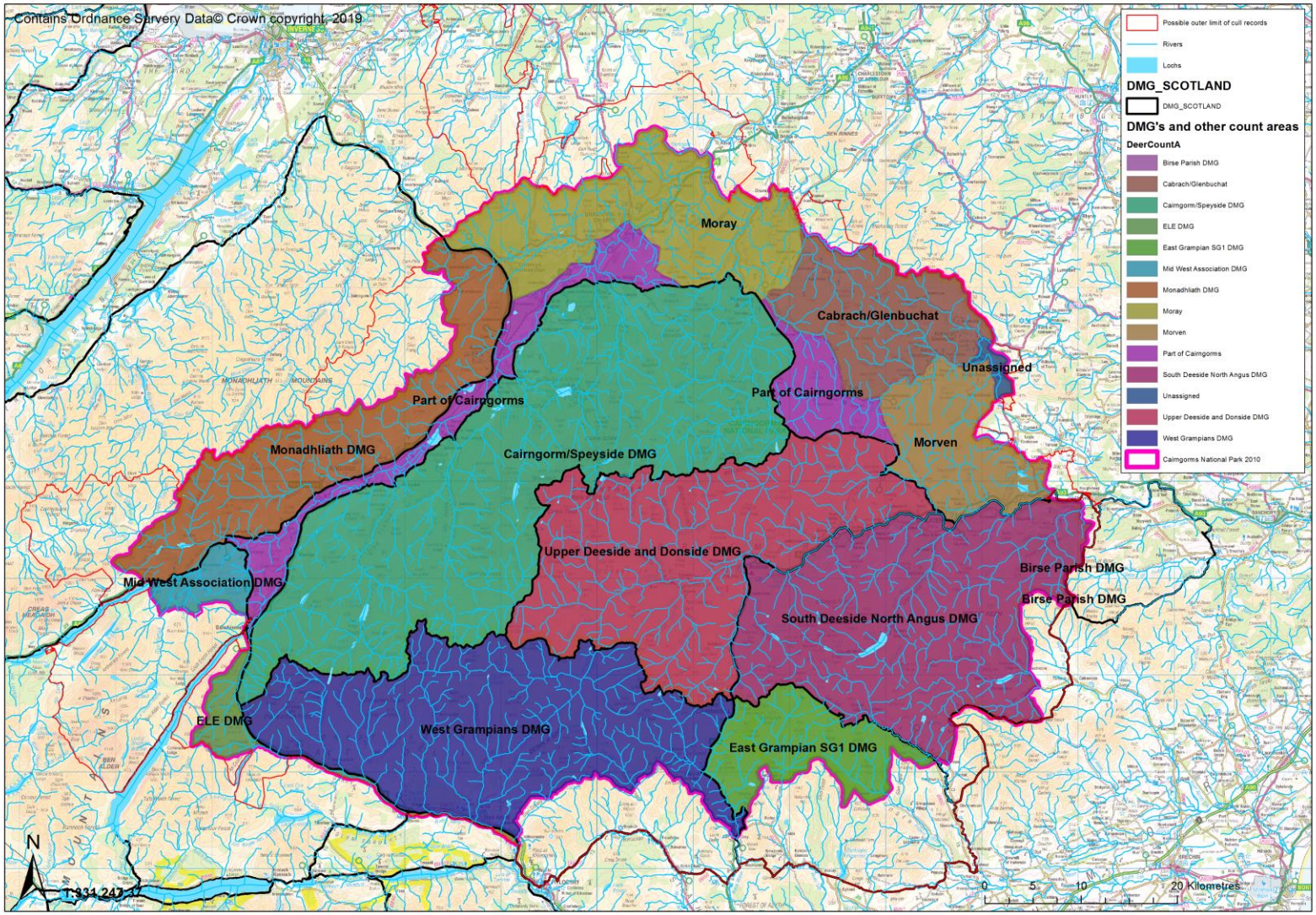
14. SNH made available a range of 'archive' deer counts as part of the project. The data set covered the period 1966-2004 inclusive. The data set comprises ground count data, gathered by the Red Deer Commission (RDC) and its successor Deer Commission for Scotland (DCS), as well as some early helicopter counts by DCS prior to them merging with Scottish Natural Heritage (SNH; later re-named NatureScot).

15. Additional 'historic' count data, covering the period 2005-2015, were contained in the main file downloaded from Natural Spaces. By summarising these two data sets a complete record of counts was available for analysis.

16. The two sets of count data (1966-2004, 2005-2015) were displayed on GIS and a search made to identify periods in time (ideally within 12-24 months) that large parts of the CNP had been counted. These data were analysed and presented in chart form to illustrate possible trends in deer abundance and density over time, across the CNP area as a whole, from the 1960's to date.

17. Upon inspection of the data it became apparent that only three parts of the CNP had been counted consistently, and in a manner that was worthy of detailed analysis[3]: Cairngorms & Speyside DMG, West Grampians DMG (previously called Tayside DMG) and the three main East Grampians DMG's: SDNA, UDD, SG1 (Birse Parish was only covered occasionally and in part).

[3] Monadhliath, East Loch Ericht and Mid-West DMG's were omitted because of the high likelihood that deer moved in and out of the CNP boundary regularly). All the other areas had little or no count coverage (e.g. Moray, Morven, Cabrach etc).



Map 1 Map showing the areas used for analysis in this report. DMG's are shown (heavy black lines), with some parts lying out with the CNPA area.

OTHER DEER COUNT DATA

18. A number of studies have been undertaken across the CNPA area using 'deer dung count' techniques. The authors of this current report have been involved in many of them, working on contract for the Forestry and Land Scotland (FLS) / CNPA / NatureScot over the period 2000-2019. Other similar data sets are thought to have been gathered in the CNPA, on select areas of private land, but the scope and budget of this project precluded a consultation being conducted with landowners to ascertain availability and negotiate access.

19. The locations dung-counted by SCL for publicly funded projects were compiled and presented on a map in this report to illustrate the degree of coverage obtained. Reference is also made in the report to some of the more noteworthy results obtained from recent studies, as they provide an insight into the possible dynamics of woodland deer populations in the CNP more widely.

DEER CULL RECORDS

20. SNH was asked by CNPA to provide outputs from the database in which they hold statutory annual cull return information sent by landowners across Scotland. A run of 30 years of data, stretching back to 1990, was requested for historical context.

21. The data provided included all four species of deer culled, and covered all types of land (woodland, agricultural land, open range).

22. The database was queried by SNH with the aim of providing data for the entirety of the CNPA but, in reality, the data sets provided have the following issues:

    a) Straddling of CNPA boundaries: data can be queried on an estate-by-estate basis. However, many estates straddle the boundaries of the CNPA area. As a result, the cull records provided cover an area of land somewhat larger than that of the CNPA area itself.

    b) Confidentiality: data were provided at regional scale and not by estate. This approach was acceptable for the purposes of the intended analysis but did create some difficulties in certain areas. For the southern-most DMG's (West Grampians and East Grampians Sub-Group 1) a portion of their land lies out with the CNPA but the outlying estates were not stripped out of the data supplied. The data for these areas therefore includes land out with the park.

    c) Completeness of coverage: some landholdings do not provide a return at all, although what proportion of the CNPA this applies could not be confirmed exactly by SNH. Some landholdings also fail to provide a return in certain years, because they shoot no deer or because they forget etc.

    d) Breakdown of data into land types: it appears from the data sets provided by SNH that 'agriculture' as a category was only introduced in the mid-2000's as an option on forms. SNH also commented that the breakdown by land type

more generally may not be entirely reliable. For example, some estates will put all cull figures into the one type (open range) depending on how they record culls.

e) Unrecorded culls: some culling will go unrecorded, for example because it relates to the illegal taking of animals (poaching).

f) Natural mortality: it is well documented that wild deer, and in particular red deer on open range in winter, die of natural causes within the CNPA area as well as being culled. There are no reliable park-wide records for how large the numbers might be, although anecdotally the number dying in hard winters (in the hundreds locally, and quite possibly in the thousands on a park-wide basis in some very severe winters) is sufficient to suppress deer numbers locally in the same way as culling does. The number of deer culled annually, as presented herein, is therefore likely to be different to the overall number of deer dying annually.

g) Deer-Vehicle collisions: similarly, a number of DVC's happen each year in the CNPA area. Some are recorded (by an SNH-sponsored project[4]) but many will go un-recorded. It is not known whether the number dying each year contributes significantly to suppression of the population.

23. The supplied cull data were analysed according to the five main count areas (see previous sub-section on helicopter count data), as follows:

    a) Data were analysed according to species and land use type.

    b) For analysis involving breakdowns by land use or deer species, only data from 2005 onwards was included as this is assumed to be more reliable.

SPATIAL ANALYSIS

24. A Geographic Information System (GIS) was built in ArcMap covering the CNPA area and its environs.

25. A wide range of data was input to the GIS including:

    a) CNPA boundary and DMG boundaries from SNH.

    b) DCS count area boundaries (where necessary to fill in gaps in DMG shapefile coverage; sketched from a PDF supplied by SNH so not guaranteed accurate) and sketched boundaries for remaining areas not covered by SNH.

    c) Helicopter deer count data from SNH (classified by deer group size and composition – stags, hinds & calves).

    d) Altitude and topography (Ordnance Survey Panorama), with the land area divided into 100m altitude bands for analysis.

[4] https://www.nature.scot/professional-advice/land-and-sea-management/managing-wildlife/managing-deer/deer-vehicle-collisions

e) Roads, rivers, lochs etc (OS Meridian)

f) Sites of Special Scientific Interest (SSSI) from SNH.

g) Land Cover Scotland (LCS) from James Hutton Institute (JHI), which describes the extent and types of habitat present across Scotland.

h) Soils (1: 250,000 scale) from Scottish Government, a data set describing the various types of soil present.

i) Land Capability for Agriculture (LCA) from James Hutton Institute (JHI), which identifies the various types of land across Scotland and its suitability for different agricultural activities.

j) National Forest Inventory (NFI) from Scottish Government, describing the extent and nature of woodland cover (all types).

k) Native Woodland Survey of Scotland (NWSS) from Scottish Forestry, describing the extent and nature of native woodland cover present and its condition.

26. Statistics were derived from the GIS to help:

a) Characterise the nature of the land present within the CNPA area

b) Show where deer had been counted in recent times, as well as which areas had no count data available.

DEER POPULATION MODELS

27. Records of the numbers of open range red deer counted in the West Grampian DMG, Cairngorms and Speyside DMG and East Grampians DMG's were available at regular intervals spanning several decades. In addition, cull records were available over an extended period from SNH's historic records. Population models were built using a selection of these data to establish whether contemporary populations could be predicted from a previous starting point. The following approach was employed:

a) Only a 'core area' was analysed, with two spatial scales being investigated:

i) Entire area: a single model including the records, and suitable parameters, for the combined land area of the Cairngorms & Speyside DMG, West Grampians DMG and East Grampians DMG's.

ii) Individual models: Cairngorms & Speyside DMG, West Grampians DMG and East Grampians DMG's.

b) Helicopter-count based data are only available from February 2005 onwards, so these data were used as the start point for the models. Two sets of repeat count data are available for each of the three regions also. These are both embedded within the model outputs for reader reference, as they were used

when attempting to balance the model by varying its parameters (see comments laterin this section).

c) All count outputs are for summer deer numbers and densities (i.e. spring counts plus recruitment). Therefore, the numbers included in the models will differ from the spring count data provided by SNH as an input to the models.

d) The models related to all land in each DMG with the exception of woodland. Land areas include any land lying out with the CNP, because cull data were supplied only at DMG scale.

e) Cull records relate only to open range and agricultural land (i.e. have woodland culls excluded).

f) Cull records should in general be considered a minimum given that SNH stated some smaller properties do not always submit records.

g) No allowance was made for poaching, as we assume the vast majority of the land (and therefore deer population) included in the models is unlikely to be affected.

h) Model outputs are run and presented to show the impact of a small over- and under-count, at the outset of the modelling period, in order to reflect potential uncertainty in input population size:

   i) Readers should note that the woodlands of the Cairngorms & Speyside DMG are entirely open to deer (no deer fences). Some of the woodlands in other DMG areas are also open to deer, either due to absence of fences or porosity of fences locally. Helicopter counts used as model inputs may, on balance, be underestimates of the true number of open hill red deer present during the main part of the year (e.g. some may have been sheltering in woodland at the time of the counts).

   ii) Similarly, some deer will have died of natural causes in the spring, after the count but before summer recruitment. Also, some deer may have been culled in the same intervening period. Both outcomes would have reduced the size of the input count used in the model, but no reliable records were available to make these adjustments for individual areas.

   iii) Evidently, these 'over-counting' biases may to some extent counteract biases arising due to the aforementioned potential for 'under-counting'.

i) The adult sex ratio for the start point of each model is generated from the February 2005 count data (with merged values used for the East Grampians DMG's model, as multiple DMG's are included in this).

j) Summer recruitment rates are estimated from long-term data obtained from spring counts, with a different value used for each region and a weighted value used for the overall model. The rate employed in models is the long-term % calves at foot in spring, but with 10% added on to the rate (e.g. 35% becomes 38.5%) to reflect the fact that summer calving rates are likely to be

higher than the rate evidenced by spring counts. The rate is held steady in each model, rather than varying annually. Whilst weather and changes in density are known to cause variations in rate, there are insufficient local data to derive such parameters with certainty for all areas and years. The modelled population trajectory over time may, as a consequence, be less variable than the real trajectory (i.e. natural perturbations would cause more variation between years; interactions between year and rate will not therefore be accurately represented).

k) No adult natural mortality is explicitly 'allowed for' in the models as insufficient records were available to derive reliable local parameters. Given this, the recruitment rates employed in the model can be considered 'net rates' (i.e. not gross rates, with mortality of juveniles and adults later deducted).

l) Models are run concurrently for stags, for hinds and for calves as well as for deer numbers overall. The outputs from the models reflect this, as do any repeat counts included for reference purposes.

m) When the model for the entire core area (all DMG's combined) was first run it failed to balance using the above parameters. Skewing survivorship appeared to improve the modelling outcomes. In the modelling framework employed herein, we achieved this by varying the'sex ratio at birth' parameter (53% female and 47% male, rather than 50: 50) to reflect differential survivorship. That does not mean the actual ratio at birth was skewed as no records are available to ascertain this. Rather, it is used as a proxy to ensure male mortality rates are higher than females overall in the model. It may also be taken to reflect broader differences in the way male and female populations operate more generally in the modelled area (e.g. some male deer may be 'lost' from the system due to emigration which could conceivably arise from stag movement out of the modelled area during the rut, and subsequent culling on a distant area).

n) In balancing the model for the entire core area, the key underpinning assumption was that the initial count and subsequent counts were accurate both in terms of overall numbers of deer present and breakdown into sex and age classes. Should numbers in fact have been higher or lower, then a different suite of parameters may result in model balance.

IMPACT DATA: HIA

28. The methods of MacDonald *et al* (1998)[5] have long been used by NS (and previously by SNH/DCS) to monitor the level of herbivore impacts on designated open range sites across Scotland. The method, based around the 'small-scale indicators' of MacDonald *et al*, is referred to as Herbivore Impact Assessment (HIA). DCS/SNH typically designed the surveys and identified plot locations then

[5] https://www.nature.scot/guide-upland-habitats-surveying-land-management-impacts-volumes-1-and-2.

asked independent contractors to undertake the work. Appendix 1 provides an overview of the method.

29. A campaign of surveying over the period 2005-2018 yielded a large volume of HIA data, parts of which cover the CNP. That said, upon inspection of the data sets available online at Natural Spaces and otherwise held directly, only some parts of the CNP were found to be covered by contemporary data (referred to hereon in as SNH HIA): Cairngorms SAC, most recently in 2015, and the Caenlochan Section 7 Area, most recently in 2018. Older HIA data are available for the CNP area but are not considered further in this report due to the restricted scope (i.e. to focus on reviewing impact data gathered over a similar time frame to contemporary counts).

30. Over a decade ago DCS/SNH developed a simplified approach to assessing herbivore impacts on key open range habitats, for estate staff and managers to use, as part of their Best Practice Guides (BPG) series. These guides are now overseen by a steering group (https://www.bestpracticeguides.org.uk/) comprising members of key industry organisations. In recent years the Association of Deer Management Groups (ADMG) has encouraged DMG's and their member estates to use the BPG impact survey protocols to assess the condition of dwarf shrub heath (DSH) and blanket bog (BB) habitats across upland Scotland.

31. CNPA staff confirmed that a considerable number of estates across the East Grampian DMG's areas and West Grampian DMG area had recently gathered data using the BPG protocols for DSH and BB habitat[6]. In autumn 2020 the CNPA input individual estate records into Excel for the purposes of this project. The following data (referred to hereon in as Estates HIA) were provided:

    a) West Grampian DMG: almost all estates provided data on both DSH and BB.

    b) East Grampians DMG's: a moderately high proportion of estates in provided data, but relatively little BB data were submitted.

    c) Cairngorms & Speyside DMG: some estates provided data, the majority of it being for BB.

32. Several issues were identified with the Estates HIA data which potentially complicate any analysis:

    a) Incomplete geographic coverage means it is more difficult to identify spatial trends in the data (e.g. in relation to deer density) across the regions of the CNP. Variability in the supply of data from each estate (i.e. DSH only, BB only or both data types) adds to the analytical challenge.

    b) The sampling strategy for gathering Estates HIA was not explicitly stated, but can in large part be inferred from the data provided. Larger estates (and

[6] Monadhliath DMG has been gathering HIA data as part of their Peatland Action project but the data are not yet compiled. Other DMG's / estates may have gathered HIA data but the park did not provide it and it was not available through SNH online.

otherwise small aggregations of estates) appear to have employed a fixed sample size of n=30 random quadrats spread across the land mass, but restricted to habitat type, for each habitat (DSH, BB). However, many variations on the theme are apparent (e.g. some have used n=15 DSH and n=15 BB, some have sampled n=30 in total and plots have fallen at random in DSH or BB etc).

c) The date of each survey was rarely stated, although it is believed most of the data were gathered in the period 2017-2019.

d) The timing of survey was not evident in most of the records provided (e.g. was data gathered in winter, spring, summer or autumn conditions?). This can have implications for how surveys need to be conducted to ensure accuracy of browsing data (see below).

e) Moreover, it was not evident from the data which heather shoots were assessed during browsing surveys: fresh summer growth, or previous years' growth[7]. Assessing the 'browsing class' (Low = < 33% shoots browsed, Moderate = 33-66%, High = > 66%) is the primary focus of the method and so the precise approach used for shoot identification during surveys is key.

f) Some surveys reported intermediate classes of browsing (e.g. LM, MH) but it is not clear what the basis for this is.

33. For the purposes of the analysis presented herein, we adopted the following approach for analysis of Estates HIA data:

a) All supplied data are assumed to be contemporary (i.e. relevant to the period of the contemporary count analysis).

b) The analysis focused on browsing class, being common to both the BB and DSH survey protocols, with other variables being omitted[8]. It was assumed that browsing assessments were all undertaken at an optimal time of year (i.e. just before the onset of fresh growth) and measured impacts on the previous years' shoots, and otherwise were undertaken in summer or early autumn but assessed the previous growth only.

[7] Deer eat heather relatively infrequently in summer when it is actively growing, but from autumn onwards they eat it increasingly frequently. This means the level of off-take (normally measured as % long shoots browsed) increases from a low point in early summer (fresh growth active) through the winter leading to a peak in late spring just before growth begins again. Assessment of browsing on the fresh growing tips, or otherwise in the late winter / early spring on hardened shoots, will lead to browsing off-take being under-estimated relative to a late spring survey at which time the impact level has peaked for the year (achievable also with a summer survey, if it focuses on the previous years' growing shoots only).

[8] Some additional analysis of other variables is possible, for example using vegetation height, but it is beyond the scope of this report. Other variables (e.g. heather stem trampling, moss trampling) were submitted in mixed data formats and it was not possible in the time available to consult with estates then try to standardise them all.

c) Where intermediate browsing classes (e.g. LM) are recorded we have preserved them as it was not clear how otherwise to treat them. However, it should be noted that many surveys did not use them.

d) Data were presented for three different regions, in line with main deer count analysis: West Grampians DMG, Cairngorms & Speyside DMG, East Grampians DMG. Data were un-weighted, when deriving regional statistics, given that (i) sampling intensities varied between estates and (ii) the area of each habitat present on each estate varied also. The area (ha) of each habitat on each estate was firstly estimated in ArcGIS using Land Cover Scotland data[9]. Regional statistics were generated in two ways: (i) an arithmetic average, ignoring differences in sampling intensity and habitat area between estates and (ii) weighted average, taking into account the % of habitat present on each estate in each region.

IMPACT DATA: OTHER FORMS

34. Various studies undertaken in the CNP area for public bodies by SCL have yielded other open range impact data worthy of mention, albeit coverage is not as extensive as the Estates HIA:

a) Detailed surveys of the Caenlochan Section 7 area in 2018 yielded several data sets of interest:

i) As well as repeating a SNH HIA study on previously established random co-ordinates, new HIA quadrats were also set up on a systematic sampling grid across the site using the methods of MacDonald *et al*. The new survey yielded data with a potentially useful spatial component, particularly so when overlain on a map showing how deer/sheep occupancy levels (derived from dung counts) varied spatially across the same site.

ii) Concurrently with the dung counts and HIA, SCL gathered additional quantitative impact data (e.g. % fresh heather shoots browsed in summer and % old browsed in spring) which was of interest to land managers when overlain on occupancy maps as it could help to explore in detail any spatial relationships evident between occupancy and impacts (termed herein Occupancy-Impact Assessment or OIA).

b) Other forms of impact data are gathered across the CNP area (e.g. crop impact data from forest re-stocking sites, tree regeneration assessments etc) but their compilation and analysis was out with the scope of this current report.

[9] DSH habitat was defined as the combined extents of LCS classes as follows: Dry heaths, Temperate shrub heathland and Wet heaths. BB was calculated from only the 'Raised and blanket bogs' category of LCS data (Blanket Bog complexes were virtually absent).

KEY FINDINGS

LAND CHARACTERISTICS

35. The CNP covers a land area of 452,810 ha, according to calculations made using available online data (Table 1).

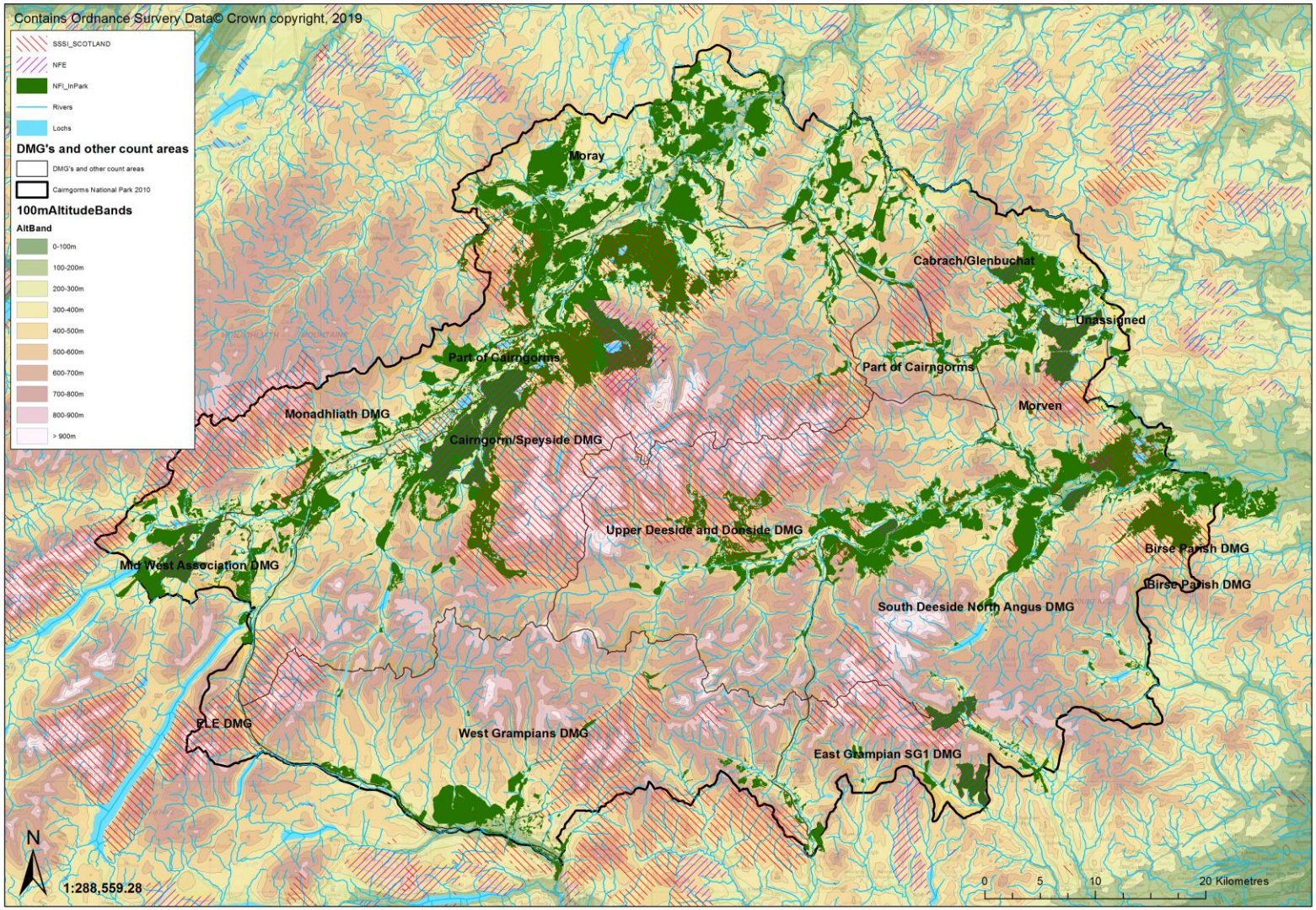
36. Relatively little land lies below 200m altitude (1.6% of the park area) (Table 1; Map 2). The majority of the land (64.1%) lies below the tree-line (approx. 600m altitude), but a considerable amount lies above it in the montane zone (35.9%). The majority of montane habitat lies in the centre or south of the park (West Grampians, East Grampians and Cairngorms zones within the CNPA).

37. A wide range of soil types are found within the park boundary. A high proportion of these are suitable for farming or forestry. Only 13.6% comprise peatlands, with a further 6.7% being classed as skeletal in some way (e.g. rankers). Peatlands and skeletal soil types are typically associated with the higher elevation areas of the West Grampians, East Grampians and Cairngorms zones of the CNPA.

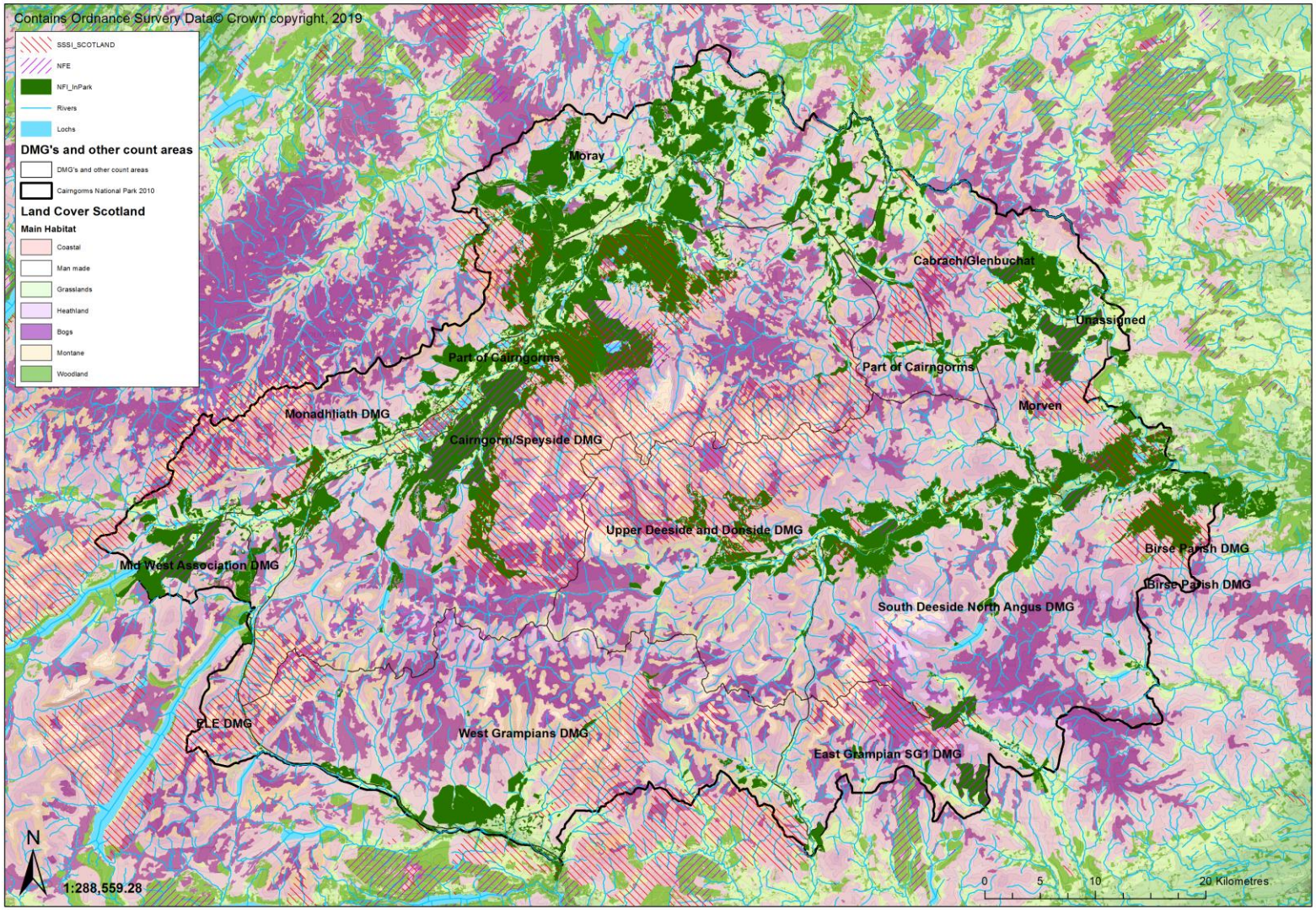
38. A detailed analysis using LCA data shows that approximately 9.3% of the park area is suitable for mixed agriculture (e.g. cereals), albeit there is no land in the highest (and most flexible) category (Arable Agriculture). Some of the land suitable for mixed agriculture is under woodland. The vast majority of this land is located either in the Cairngorms zone of the CNPA or otherwise in the eastern zone (Birse/Morven etc). Most of the remaining land in the CNPA is suitable only for rough grazing (72.9%), and this is typically associated with the higher areas of the West Grampians, East Grampians and Cairngorms zones.

39. Woodlands as a whole cover 74,448ha of the park (16%) (Map 3). Pure conifer woodland is the most common type (56.5%). Woodland cover is most prevalent in the Cairngorms zone of the CNPA along with the easternmost zone (Birse/Morven etc).

40. Native woodlands specifically cover 10% of the CNPA area, and are found mainly in the Cairngorms zone along with the East Grampians zone and the easternmost zone (Birse/Morven etc). Pinewoods and juniper scrub are the most common type (65.8%) of native woodland cover.



Map 2 The altitude range of land in the CNPA area along with woodland cover (National Forest Inventory) and the extent of SSSI's.



Map 3 Broad habitat types present in the CNPA area. The presence of grasslands (light green) is often, although not always, indicative of agricultural activity.

Table 1 Variation in the altitude range of land (metres above se-level) within the CNPA area.

Analysis Zone	0-100m	100-200m	200-300m	300-400m	400-500m	500-600m	600-700m	700-800m	800-900m	900-1000m	1000-1100m	1100-1200m	1200-1300m	1300-1400m	Sub-Total
West Grampians	-	1,089	1,690	6,511	12,104	11,760	11,216	12,231	6,504	1,268	144	8	-	-	64,524
East Grampians	-	1,105	6,829	16,589	23,333	27,333	29,115	17,646	11,030	5,159	2,569	994	258	3	141,964
Cairngorms & Speyside	-	717	22,201	18,818	20,153	19,124	18,866	13,047	7,401	4,434	2,085	1,061	260	1	128,168
Monadhliath/Mid-West/E Loch Ericht	-	31	5,988	11,401	8,810	6,177	4,736	3,667	2,499	329	5	-	-	-	43,643
Birse/Morven/Cabrach/Moray/Unass'	1	4,236	15,310	22,378	16,261	10,189	4,633	1,432	70	-	-	-	-	-	74,510
TOTAL	1	7,179	52,018	75,697	80,660	74,582	68,567	48,022	27,504	11,189	4,804	2,064	518	4	**452,810**
% TOTAL	0.0%	1.6%	11.5%	16.7%	17.8%	16.5%	15.1%	10.6%	6.1%	2.5%	1.1%	0.5%	0.1%	0.0%	**100%**

Table 2 Variation in the range of broad soil types within the CNPA area.

Analysis Zone	Standing Water	Peat (Blanket or Basin)	Gleys	Podsols	Rankers	Brown Earths / Alluvial etc	Sub-Total
West Grampians	118	12,937	7,557	35,661	4,007	4,244	64,524
East Grampians	498	25,353	4,059	91,943	11,451	8,659	141,964
Cairngorms & Speyside	1,240	15,277	3,514	89,739	11,236	7,161	128,168
Monadhliath/Mid-West/E Loch Ericht	178	5,028	3,724	29,967	3,271	1,474	43,643
Birse/Morven/Cabrach/Moray/Unass'	245	2,928	5,360	57,327	454	8,195	74,510
TOTAL	2,280	61,524	24,215	304,638	30,419	29,733	**452,810**
% TOTAL	0.5%	13.6%	5.3%	67.3%	6.7%	6.6%	**100%**

Table 3 Variation in agricultural land potential within the CNPA area

Analysis Zone	Mixed Agriculture	Improved Grassland	Rough Grazing	Other	Sub-Total
West Grampians	1,288	3,856	59,262	118	64,524
East Grampians	4,608	13,762	123,096	498	141,964
Cairngorms & Speyside	14,063	26,011	86,849	1,246	128,168
Monadhliath/Mid-West/E Loch Ericht	3,102	9,411	30,950	180	43,643
Birse/Morven/Cabrach/Moray/Unass'	19,173	25,351	29,729	257	74,510
TOTAL	42,234	78,391	329,886	2,299	**452,810**
% TOTAL	9.3%	17.3%	72.9%	0.5%	**100%**

Table 4 Variation in the woodland cover types within the CNPA area

Analysis Zone	Open / Failed	Broadleaf / Shrub	Mixed	Conifer / Wind blow	Other woodland	Felled / Cult' / Re-stocks / Young	Sub-Total
West Grampians	74	259	116	1,791	551	554	3,344
East Grampians	415	1,853	254	10,395	1,883	1,363	16,163
Cairngorms & Speyside	1,104	3,133	475	13,016	4,208	3,153	25,089
Monadhliath/Mid-West/E Loch Ericht	304	1,407	165	5,265	1,161	1,249	9,550
Birse/Morven/Cabrach/Moray/Unass'	450	2,952	274	11,563	1,991	3,072	20,302
TOTAL	2,347	9,603	1,284	42,029	9,793	9,391	**74,448**
% TOTAL	3.2%	12.9%	1.7%	56.5%	13.2%	12.6%	100%

Table 5 Variation in the range of native woodland types within the CNPA area

Analysis Zone	Pinewood / Juniper	Broad-leaved	Non Native	Other	Sub-Total
West Grampians	580	294	16	156	1,046
East Grampians	7,661	2,047	199	1,220	11,127
Cairngorms & Speyside	12,722	3,330	235	2,254	18,540
Monadhliath/Mid-West/E Loch Ericht	3,637	1,475	220	658	5,990
Birse/Morven/Cabrach/Moray/Unass'	6,638	3,061	125	964	10,789
TOTAL	31,238	10,207	796	5,251	**47,492**
% TOTAL	65.8%	21.5%	1.7%	11.1%	**100%**

Table 6 The extent of SSSI land within the CNPA.

Analysis Zone	Biological	Geological	Mixed	Sub-Total
West Grampians	4,268	14	7,763	12,045
East Grampians	12,328	141	18,428	30,897
Cairngorms & Speyside	6,971	754	38,247	45,973
Monadhliath/Mid-West/E Loch Ericht	15,297	20	182	15,499
Birse/Morven/Cabrach/Moray/Unass'	6,025	1	2,445	8,471
TOTAL	44,889	930	67,065	**112,884**
% TOTAL	39.8%	0.8%	59.4%	**100%**

CONTEMPORARY DEER COUNTS

41. None of the woodlands present in the CNPA area are counted by helicopter, and numerous areas of farmland and open range across the area are also omitted from annual count programs. Overall, it appears that 68% of the CNPA area has been counted by SNH using helicopters at some time in the last 5 years (Map 4). The corollary is that 32% of the CNPA land area has no helicopter deer count data available (16% woodland and 16% open habitats). Moreover, the helicopter count records do not include roe deer, sika deer or fallow deer.

Table 7 Overview of the CNPA area and the extent of helicopter deer count coverage.

Analysis Zone	Total land area (ha)	NFI Woodlands: heli counts ineffective	Open land not counted: not included in count program	Total land not counted (ha)	% Land not counted
West Grampians	64,524	3,344		3,344	5%
East Grampians	141,964	16,163		16,163	11%
Cairngorms & Speyside	128,168	25,089	17,944	43,033	34%
Monadhliath/Mid-West/E Loch Ericht	43,643	9,550		9,550	22%
Birse/Morven/Cabrach/Moray/Unass'	74,510	20,302	54,208	74,510	100%
TOTAL	452,810	74,448	72,153	146,601	
% CNPA TOTAL		16%	16%		32%

42. Using the 2016 data for the East Grampians & Cairngorms along with the 2017 data for the West Grampians and most recent data for the Monadhliath/Mid-West/E L Ericht areas (2017-2019), the compiled helicopter counts indicate a minimum spring population of 35,337 red deer (Table 8) on the open range within the CNPA[10] around that time:

    a) The count breaks down as 13,297 stags (38% of the total), 16,292 hinds (46% of the total) and 5586 calves (16% of the total) (Table 9; Map 5a).

    b) The vast majority of the deer were counted in the East Grampian and West Grampian areas (80% of the count total) (Map 5a).

[10] The total includes a small number of deer counted in 2018 within the Cabrach area, even though the count was mainly undertaken outside the CNPA boundary.

c) A high proportion (77.6%) of deer were counted below the tree-line (600m altitude) with 94.7% being counted below 700m (Table 8). This distribution is typical of winter time, and in particular snowy weather.

43. The density of red deer present in these open range areas can be calculated in a number of ways:

a) ENTIRE RANGE: The mean density of red deer on the open range land counted, calculated by dividing the total number of deer in spring by the total area in hectares, was 11.5 per km^2. Obviously, this density only applies to the area counted (i.e. it does not apply to the 32% of land not counted). It also excludes all other species of deer. Variation was apparent between zones, with the lowest 'entire range' density recorded in the Cairngorms zone (4.0 per km^2) and the highest in the West Grampians zone (20.2 per km^2) (Map 5b).

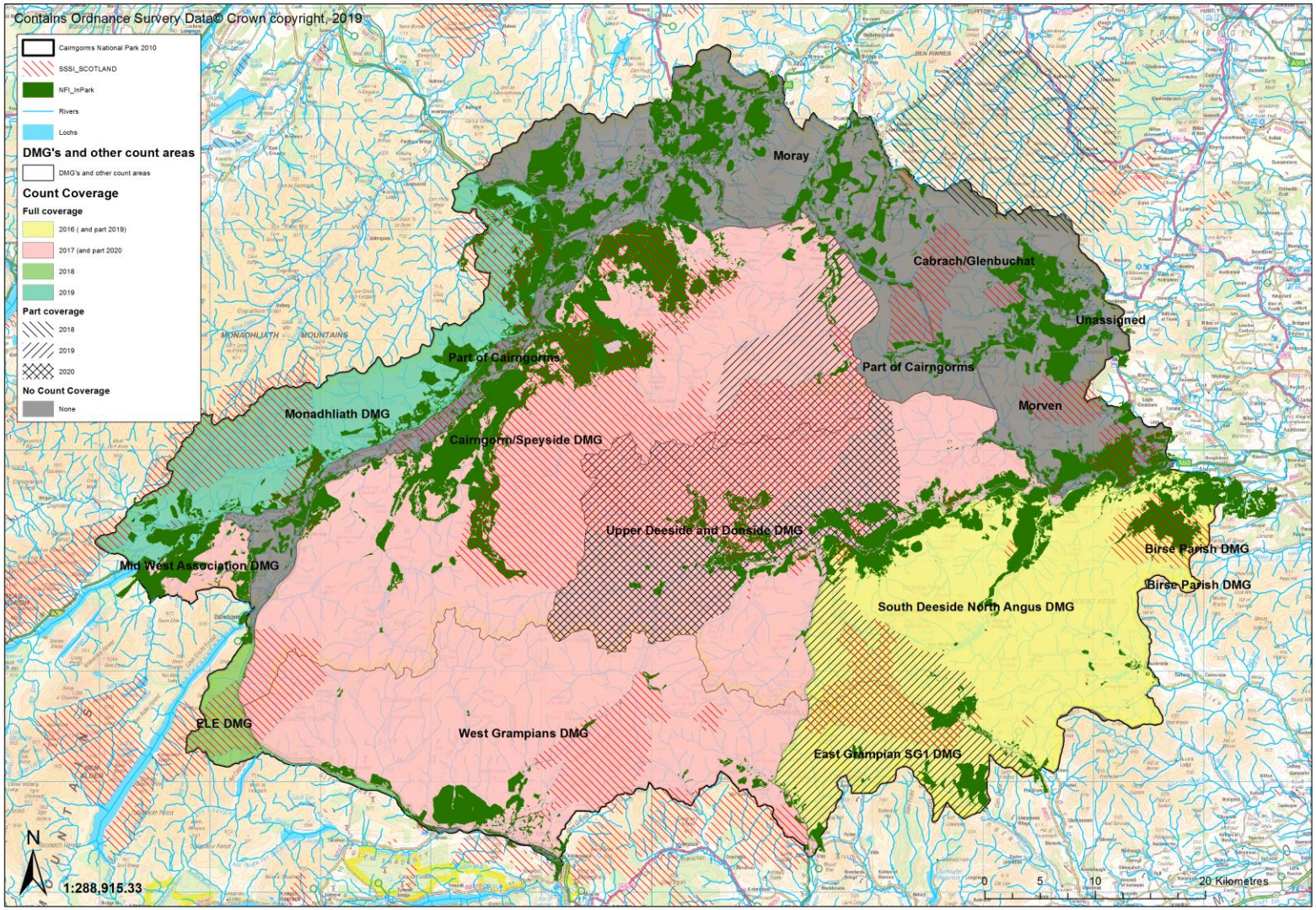
b) CORE WINTER RANGE: Deer spend much if not all of their time at lower elevations during typical winter weather. It can be useful to calculate the density of deer in their core winter range only, as this provides land managers with a truer reflection of the numbers of animals present locally (Map 5c). Taking the 700m contour as the upper limit of the typical winter red deer range in the CNPA (based on detailed analysis work undertaken using multiple winter counts from Caenlochan[11]) and using the spring count data sets available, the mean winter range density is calculated as 16.3 per km^2 (for those areas counted) based on the available records[12]. The same calculation for the Cairngorms & Speyside area is 5.8 per km^2 and for the West Grampians is 30.1 per km^2.Obviously, these figures does not apply to the 32% of land uncounted, and also exclude all other species of deer present. That said, the calculations do assume that all woodland < 700m is inaccessible and also that no open range red deer spend time above 700m in the winter. Neither assumption is entirely valid hence the quoted winter range densities are, with all else equal, arguably somewhat over-stated.

c) CORE SUMMER RANGE: Conversely, open range red deer in the summer spend much of their time at higher elevations. Summer count data are not available for much of the CNPA area, but a recent project by SNH at Caenlochan analysed the extensive summer deer count data sets available for the area and found that most of the red deer herd was located above 500m altitude[13] at the time of the counts (typically July). On this basis, the 'summer range' red deer densities within the CNPA – for those areas counted – averaged 19.4 per km^2 based on the available records (Map 5d). This density

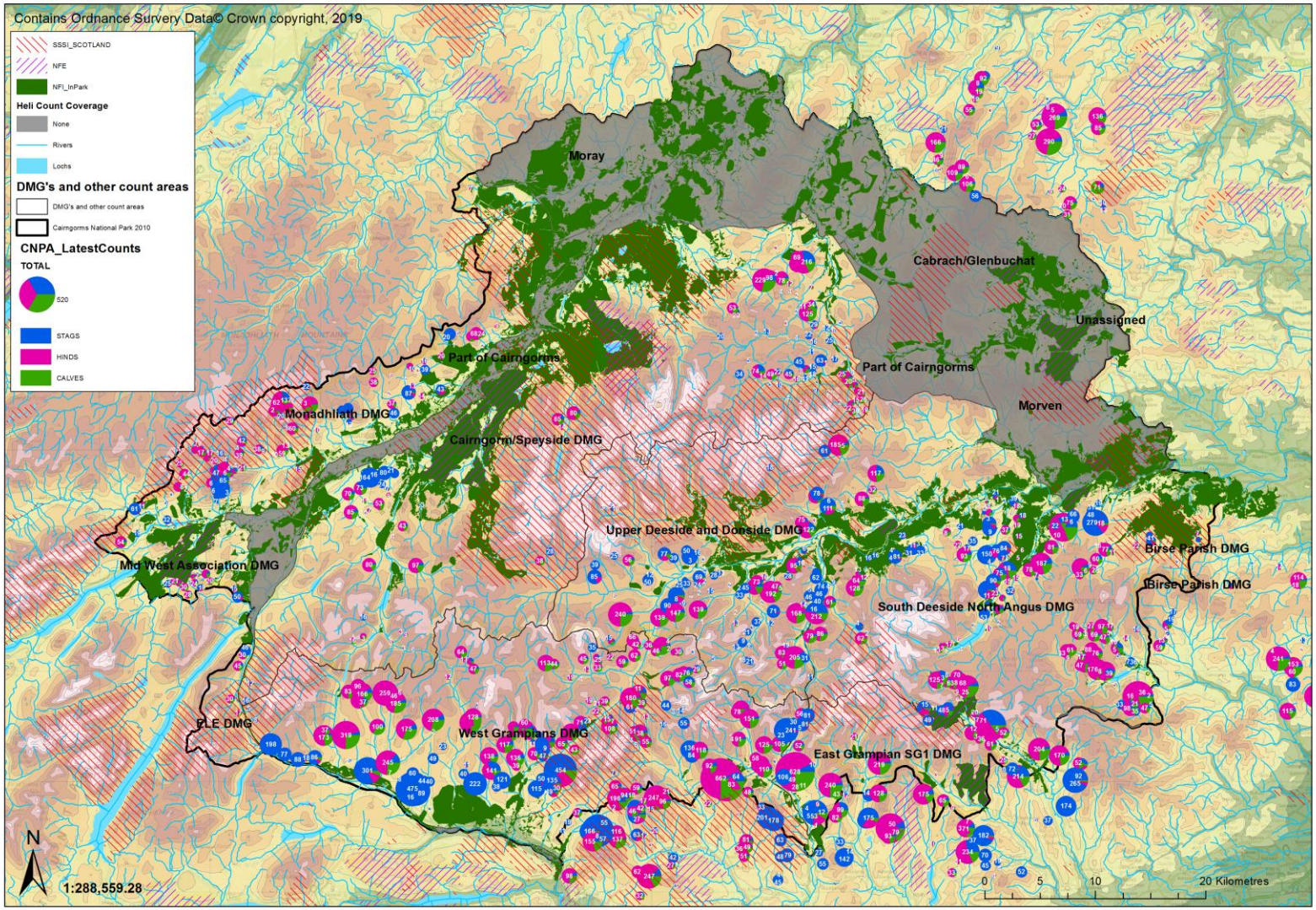
[11] The Caenlochan analysis showed that 91% of deer groups counted in winter over a 15-year period were below 700m.
[12] Calculation employs the full number of deer counted, divided by the winter range size in km^2.
[13] The Caenlochan analysis showed that 88% of deer groups counted in summer over a 15-year period were above 500m.

takes into account the likely level of recruitment[14] that would have occurred in the early summer following each spring count. That said, it also assumes that all woodland > 500m is inaccessible and that no open range red deer spend time below 500m in the summer. Neither assumption is entirely valid hence the quoted summer range density is, with all else equal, arguably somewhat over-stated. The same calculation for the Cairngorm & Speyside area is 6.8 per km^2 on average and for the West Grampians is 34.1 per km^2.

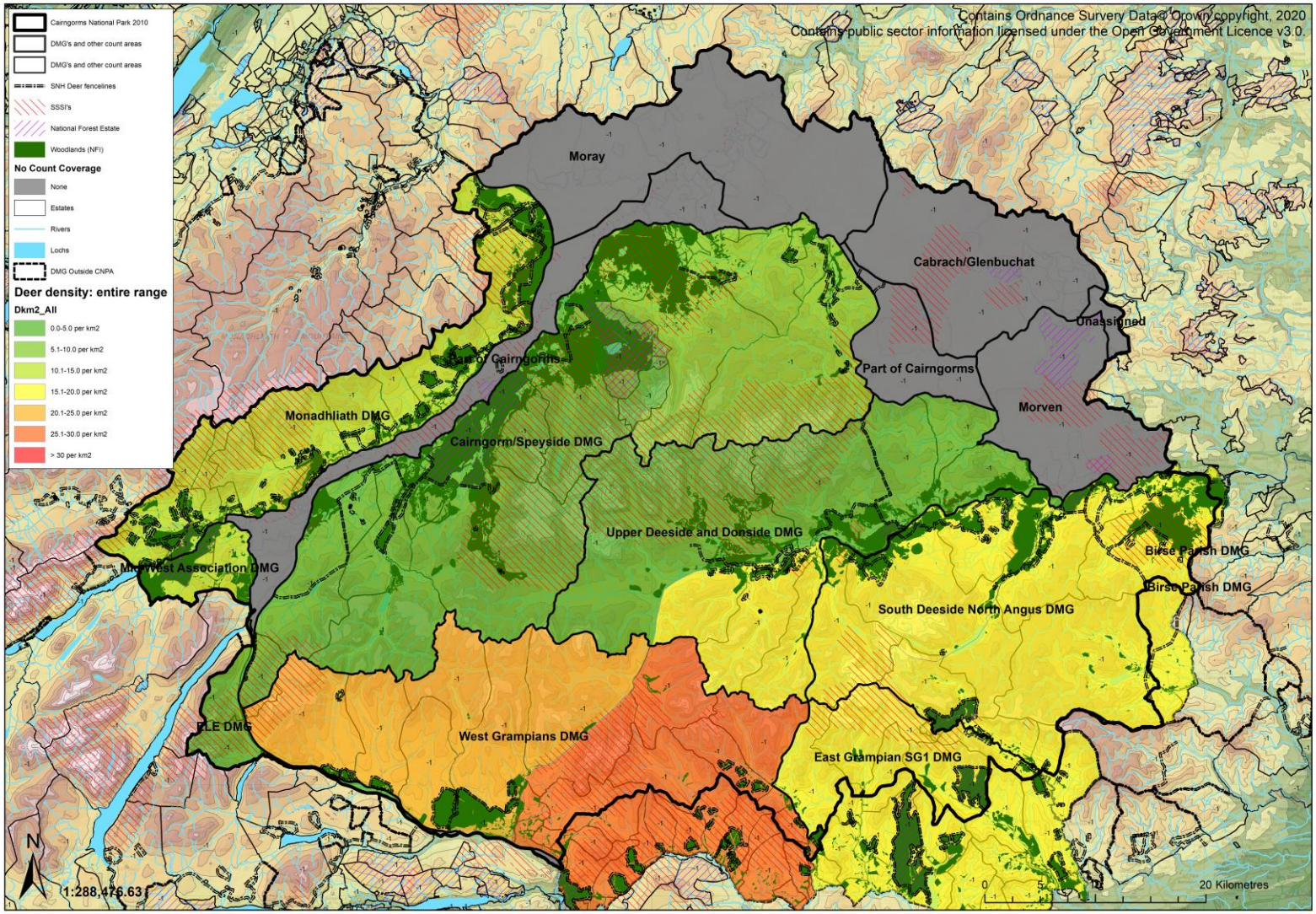
[14] Modelling of recruitment, for this part of the report, is based on a simple assumption that 35 calves are born for every 100 hinds, on average, across the park in the summer following each count. If anything, this value is an underestimate (see Methods section: Population Modelling).



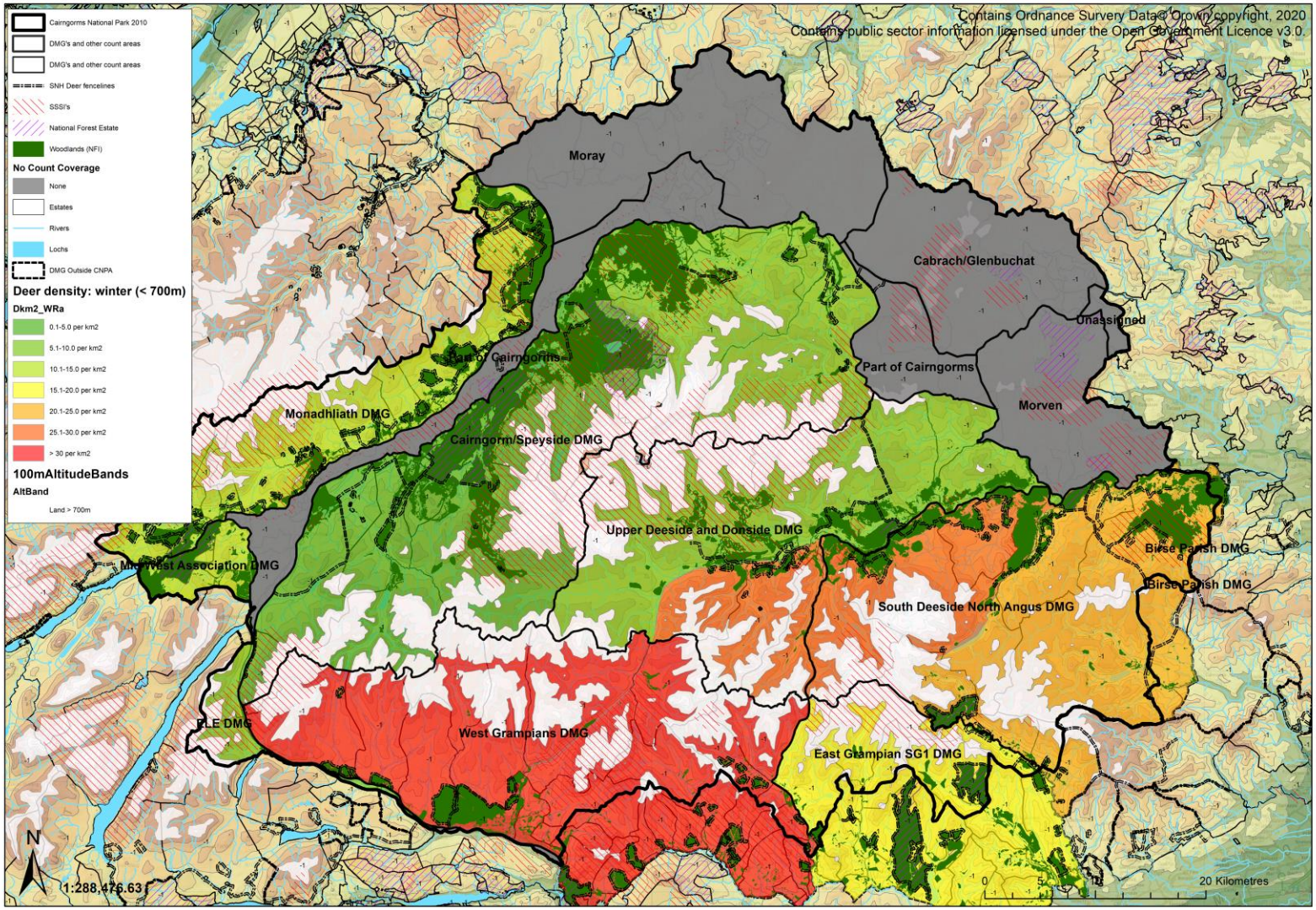
Map 4 Recent SNH helicopter count coverage across the CNPA area. Woodland areas are not counted. The grey region is also not counted by SNH.



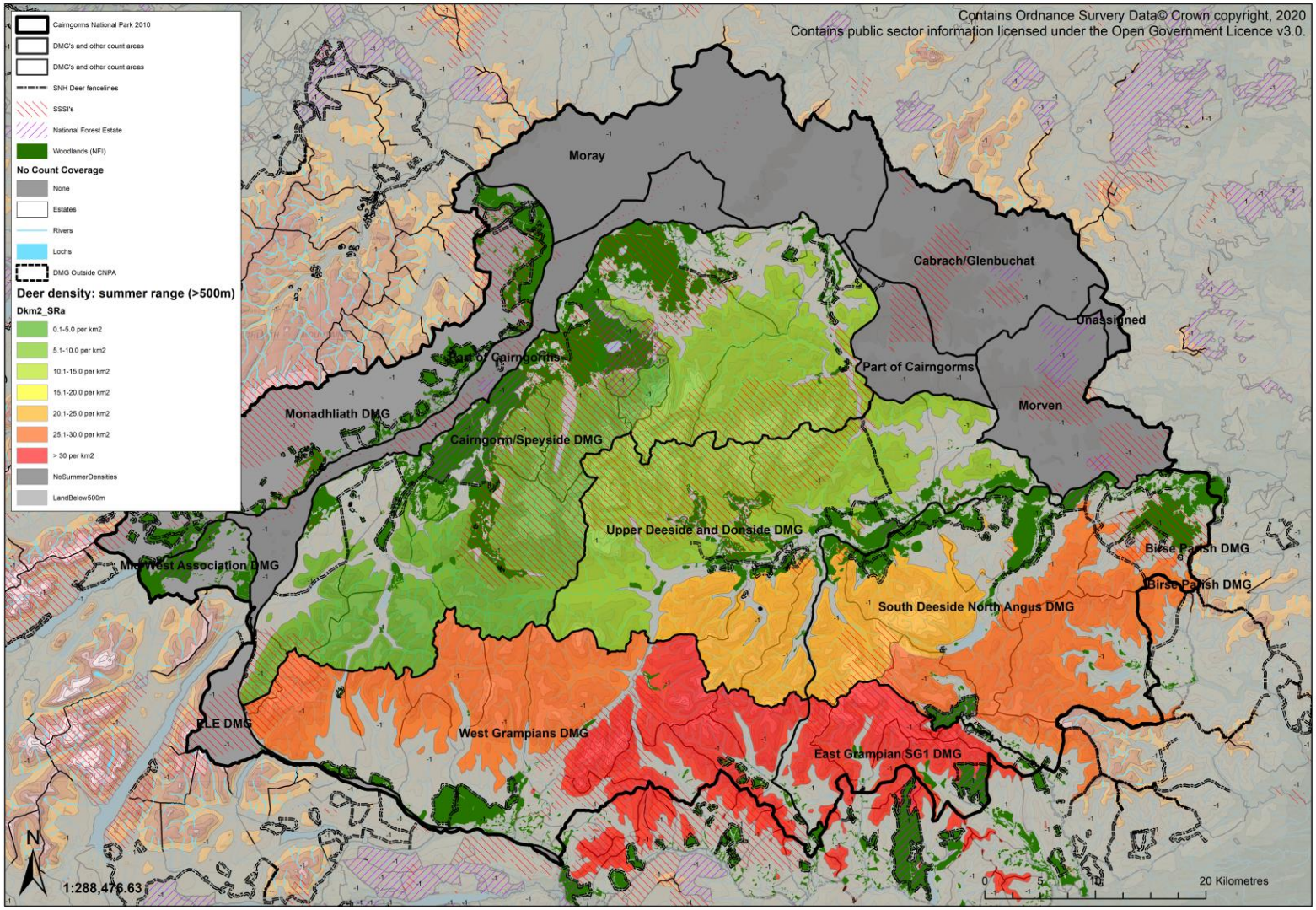
Map 5a Aggregated results of recent helicopter counts. The results from 'part coverage' counts in 2018/2019 and 2020 are not incorporated. White labels = total group size.



Map 5b Results of recent helicopter counts presented as deer density polygons for the main areas counted regularly within the CNP: 'entire range' deer densities.



Map 5c Results of recent helicopter counts presented as deer density polygons for the main areas counted regularly within the CNP: 'winter range' deer densities.



Map 5d Results of recent helicopter counts presented as deer density polygons for the main areas counted regularly within the CNP: 'summer range' deer densities.

Table 8 Variation in the number of red deer counted on open range by helicopter across the CNPA between 2016 and 2019. The counts are synthesised from a number of different sources, as each area was counted at a different time.

Analysis Zone	200-300m	300-400m	400-500m	500-600m	600-700m	700-800m	800-900m	900-1000m	TOTAL
West Grampians	-	715	3,598	4,937	2,704	402	-	-	12,356
East Grampians	117	2,146	6,791	4,722	1,820	417	28	5	16,046
Cairngorms & Speyside	344	226	716	1,390	681	69	2	-	3,428
Monadhliath/Mid-West/E Loch Ericht	53	306	621	567	846	668	284	-	3,345
Birse/Morven/Cabrach/Moray/Unass'	-	-	106	56	-	-	-	-	162
TOTAL	514	3,393	11,832	11,672	6,051	1,556	314	5	35,337
% TOTAL	1.5%	9.6%	33.5%	33.0%	17.1%	4.4%	0.9%	0.0%	100.0%

Table 9 The density of open range red deer counted by helicopter between 2016 and 2019 across the CNPA area: mean spring density across the CNPA as a whole (upper), mean winter range density on land below 700m altitude (middle) and mean summer range density on land > 500m (lower). The summer population was inflated to allow for recruitment in the early summer following each count. Ranges used in calculations omit any land not counted at all, and also omit woodland within count areas.

Analysis Zone	Total Area (ha)	Areas not counted (ha)	Counted area (ha)	Adjusted Area km²	Stags	Hinds	Calves	ALL	Stags / km²	Hinds / km²	Calves / km²	ALL / km²
West Grampians	64,524	3,344	61,180	611.8	4,791	5,573	1,992	12,356	7.8	9.1	3.3	20.2
East Grampians	141,964	16,163	125,801	1258.0	6,013	7,467	2,566	16,046	4.8	5.9	2.0	12.8
Cairngorms & Speyside	128,168	43,033	85,135	851.4	1,169	1,638	621	3,428	1.4	1.9	0.7	4.0
Monadhliath/Mid-West/E Loch Ericht	43,643	9,550	34,092	340.9	1,324	1,614	407	3,345	3.9	4.7	1.2	9.8
Birse/Morven/Cabrach/Moray/Unass'	74,510	74,510	-	0.0								
TOTAL	452,810	146,601	306,209	3,062	13,297	16,292	5,586	35,175	4.3	5.3	1.8	11.5

Analysis Zone	Land below 700m (ha)	NFI Woodland < 700m (ha)	Other land not counted (ha)	Land below 700m counted (ha)	Stags	Hinds	Calves	ALL (spring)	Stags / km²	Hinds / km²	Calves / km²	All - Winter / km²
West Grampians	44,370	3,341	0	41,029	4,791	5,573	1,992	12,356	11.7	13.6	4.9	30.1
East Grampians	104,305	16,159	0	88,147	6,013	7,467	2,566	16,046	6.8	8.5	2.9	18.2
Cairngorms & Speyside	99,878	25,089	15,295	59,495	1,169	1,638	621	3,428	2.0	2.8	1.0	5.8
Monadhliath/Mid-West/E Loch Ericht	37,142	9,550	0	27,592	1,324	1,614	407	3,345	4.8	5.8	1.5	12.1
Birse/Morven/Cabrach/Moray/Unass'	73,009	20,302	52,707	-								
TOTAL	358,704	74,440	68,002	216,262	13,297	16,292	5,586	35,175	6.1	7.5	2.6	16.3

Analysis Zone	Land above 500m (ha)	NFI Woodland > 500m (ha)	Other land not counted > 500m (ha)	Land above 500m counted (ha)	Stags (post-recruit')	Hinds (post-recruit')	Calves (35% recruit')	ALL (summer)	Stags / km²	Hinds / km²	Calves / km²	All - Summer / km²
West Grampians	43,131	187		42,944	5,787	6,569	2,299	14,655	13.5	15.3	5.4	34.1
East Grampians	94,107	1,575		92,532	7,296	8,750	3,063	19,109	7.9	9.5	3.3	20.7
Cairngorms & Speyside	66,280	867	5,409	60,004	1,480	1,949	682	4,110	2.5	3.2	1.1	6.8
Monadhliath/Mid-West/E Loch Ericht	Not applic'	428										
Birse/Morven/Cabrach/Moray/Unass'	No count	479										
TOTAL	203,519	3,536	5,409	195,480	14,563	17,268	6,044	37,874	7.4	8.8	3.1	19.4

DUNG COUNTS & ASSOCIATED SURVEYS

44. Dung counting has been used by SCL, and others, to estimate deer abundance, deer distribution and deer density in several parts of the park over the past 20 years (Map 6):

    a) The methods can be used to assess all deer species and are effective in all habitat types. That said the methods have sampling error associated with them which makes them less accurate than helicopter counts, with all else equal.

    b) The techniques have been used within the CNPA area in pure wooded areas (e.g. Bunzeach Forest in Aberdeen-shire), in mixed areas of woodland and open range where perimeter deer fencing is absent (e.g. as found in the Western Cairngorms) and on pure open range land (e.g. as is found at Caenlochan).

    c) Overall, only a relatively small portion of the woodlands in the CNPA (22% of woodlands; 3.6% of CNPA land area) have been 'dung counted' to date. A smaller portion (16% of woodlands; 2.6% CNPA) have been counted in the last 5 years.

45. Monitoring undertaken extensively in the Western Cairngorms showed the following:

    a) Occupancy levels & patterns:
        i) Summer deer densities varied between 1 and 20 per km^2. Map 7 shows the aggregate results of survey work undertaken in 2015 (NFE and SNH-owned land) and 2018 (RSPB and private land).
        ii) Roe deer typically accounted for 50-70% of activity recorded in each area sampled, but in some locations this proportion was as high as 90%.
        iii) Whilst deer in this area are in most cases free to use the open range or woodland as they wish, as there are no deer fences of note, the vast majority of deer activity (95%) was recorded within the woodland areas studied (as opposed to the adjacent open range areas also studied concurrently) over the period studied (early November to mid-July).
    b) Culling patterns & intensity:
        i) Roe deer culls averaged 50-60% of the total cull taken annually.
        ii) Annual cull intensities varied from 1 - 12 per km^2. Most of the variation was between areas, but some variation occurred over time (e.g. due to culls ramping up or declining in an area).
        iii) Between 25% and 40% of the deer present at the outset of the survey season (2015-16 or 2017-18) had been culled by the end of season, depending on area.
        iv) Annual recruitment rates, derived from cull records, varied from 45-85 juveniles per 100 adult females.

c) Population trends:
   i) A repeat of the surveys on the NFE and SNH-owned landholdings in 2019 yielded an updated data set for much of the survey area but the results have not yet been published (due spring 2021). In several areas densities had remained broadly stable since the time of the last assessment (2014/15) but in several places densities had declined dramatically as a result of sustained ongoing culls and, in places, markedly increased culls.
   ii) Actual recruitment rates may now be as high as 100 juveniles per 100 adult females in some locations as the deer densities have declined to low levels.

d) Conclusions: it would appear from the results of the Westerm Cairngorms study that deer populations in woodland and mixed environments, at least on this side of the Cairngorms, are highly dynamic. Also, their dynamics differ markedly from those populations residing exclusively on open range (see next sub-chapter analysing cull records).

46. The results of other woodland dung count studies undertaken previously in the wider CNPA area (e.g. in Aberdeen-shire) showed that summer deer densities vary from 5 – 25 per km^2, but with densities most commonly lying in the upper half of that range. The % annual cull taken from woodland populations is commonly in the range 15-25%.

47. Dung counts have also been used on open range habitat over the past decade. Deer densities on the areas studied have ranged from 1 per km^2 to over 50 per km^2.

48. Dung count studies have from time-to-time incorporated other animal species, which can provide useful additional insights particularly when studying relationships between herbivore density and impact levels:

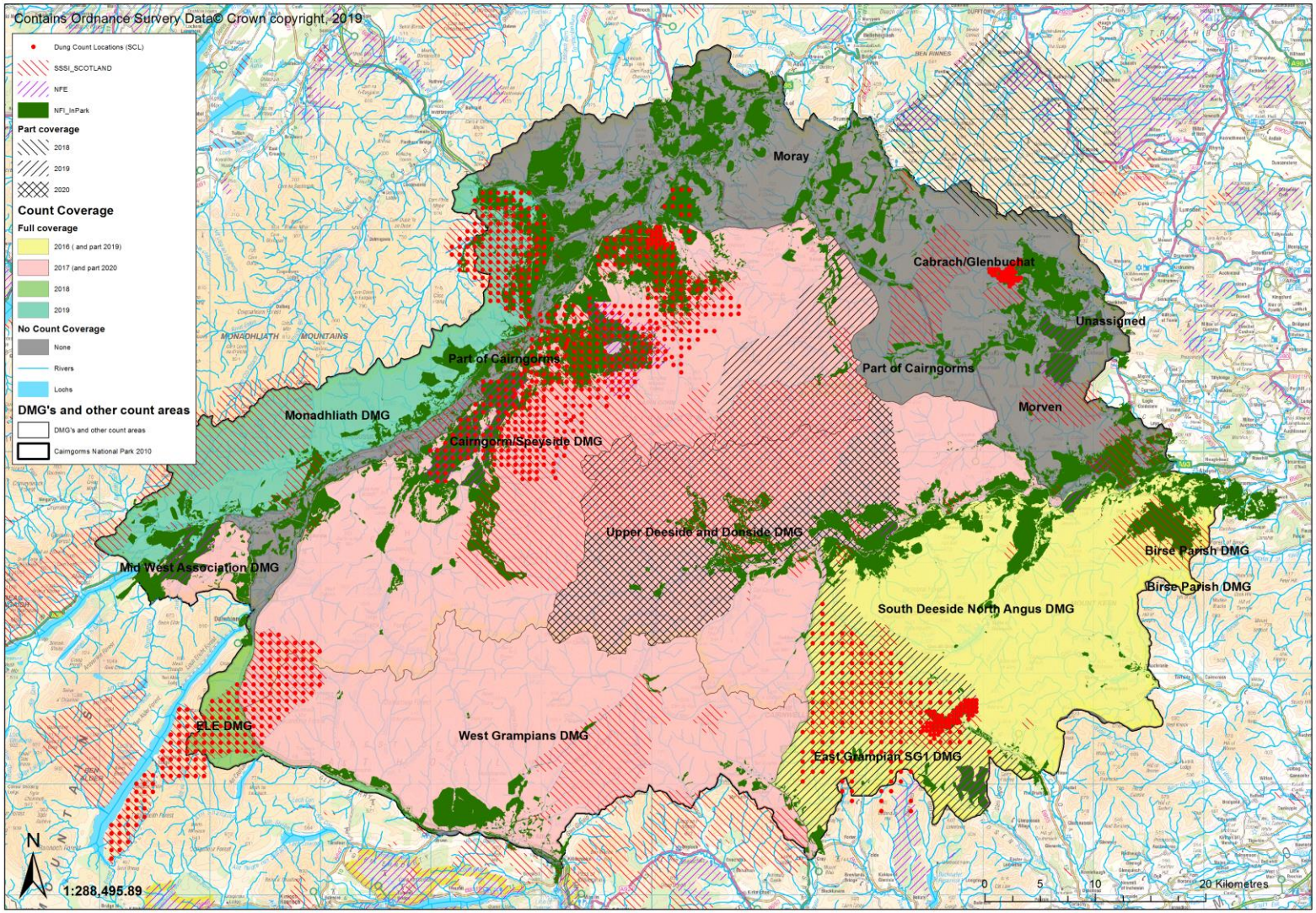
    a) In the Western Cairngorms the distribution and intensity of Capercaillie signs was assessed in parallel with deer dung over the period 2015-2019. Reindeer dung was also surveyed locally.

    b) At Caenlochan, the extent and intensity of mountain hare signs and grouse signs was also quantified. Attempts were made in this study to estimate the contribution of each species, alongside red deer and sheep, to the overall level of grazing pressure on the site.

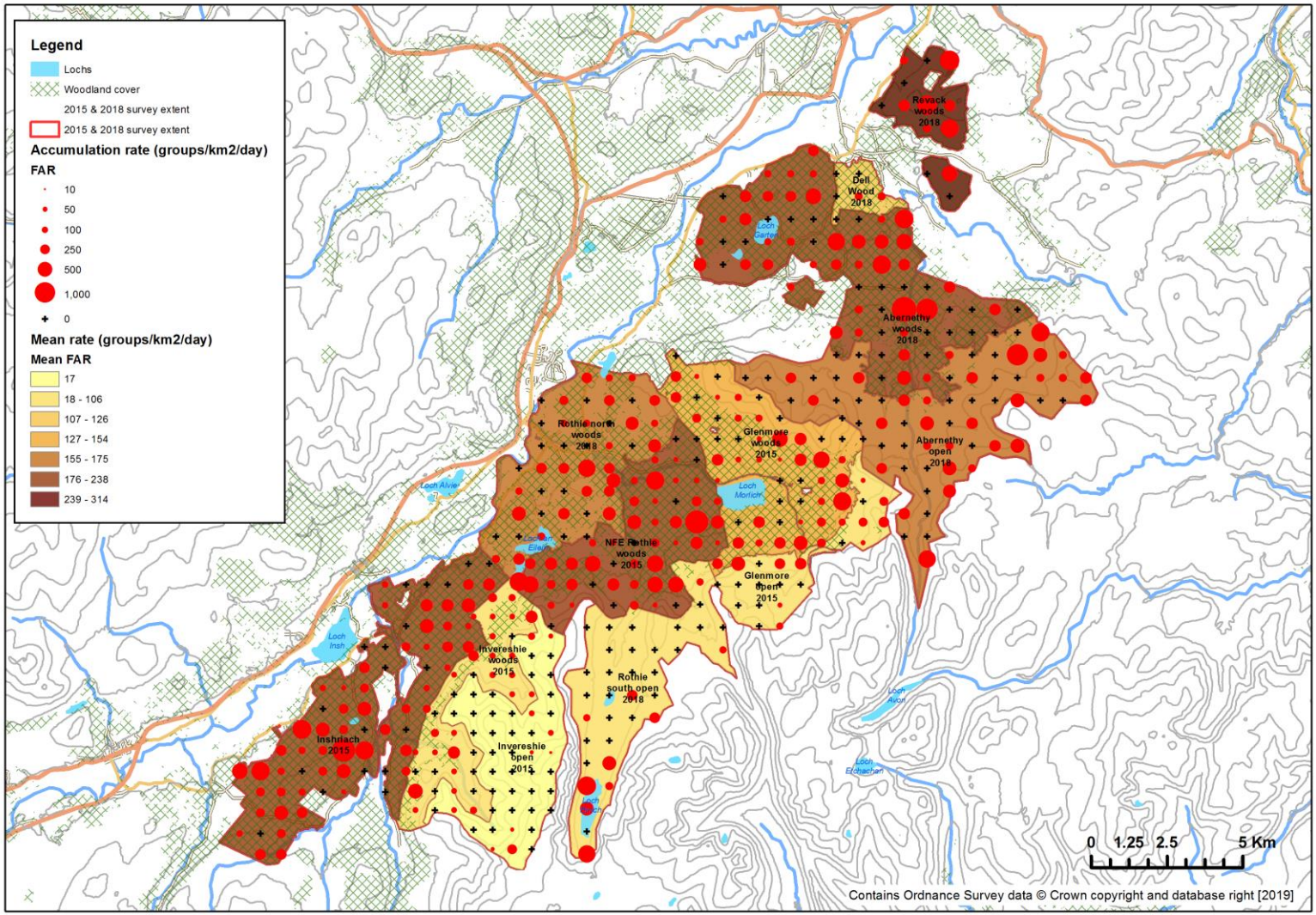
    c) In the western Monadhliath, albeit out with the CNPA boundary, feral pig signs have also been surveyed in parallel.

49. Over the past 15 years, many dung count surveys have involved assessment of deer impacts in parallel with deer occupancy levels (termed herein 'Occupancy-Impact Assessment or OIA):

    a) The approach employed is to quantify impact levels on the same transects as, and at the same time as, deer dung density is being measured. Impacts on open habitats and on woodlands can both be assessed.



Map 6 Locations at which deer occupancy levels have been assessed using dung counts (Monadhliath SAC and Bunzeach Forest still to be added).



Map 7 Dung count data for the Western Cairngorms across multiple ownerships. A recent repeat (results not yet published) shows marked declines have occurred locally.

b) Analysis can then be undertaken to look for any relationships apparent between occupancy levels and impact levels.

c) The results of the analysis can help land managers to identify the level of occupancy needed to deliver acceptable levels of impact on the habitats present. Select findings are presented later in this chapter, from the recent SNH study at Caenlochan, alongside other deer impact survey data from the CNP area.

CULL RECORDS

50. The cull records provided by SNH indicate that almost half a million deer (478,216) have been shot in the CNPA area since 1990. (Table 10).

51. In processing the data, SNH made us aware of several potential issues with the records. The records are likely to be an under-estimate of the true number of deer culled overall, because of a variety of factors such (i) some properties not being asked for a cull, (ii) non-returns of questionnaires and (iii) a degree of illegal culling (see Methods for further explanation). There is no easy way, within the remit of this project, of establishing the degree of bias at this juncture. It might be reasonable to assume records are under-estimated by 10% if not more.

52. Moreover, when broken down by land use type, the available records appear to have gaps in them: (i) consistently before 2005 for 'agriculture' and (ii) from time to time for 'woodland' prior to 2000 (Table 10). This is assumed to be due to a change in recording procedure rather than because deer culled in woodlands and agricultural land were not recorded at all. Under this assumption, the data were aggregated in order to examine trends in culls taken since 1990 (Table 11).

53. In the past 30 years, there was a distinct peak of culling activity from the early- to mid-2000's (24,728 deer shot in 2005-06). This period of elevated culls appears to coincide with several Section 7 agreements being put in place between SNH and landowners. Prior to this time, culls were typically somewhat lower. After this time the culls were also somewhat lower on average, although this may well be due to the reduced deer population that was then present. Moreover, in several of the most recent years the CNPA-wide cull has shown an upswing again.

54. The breakdown of the CNPA-wide cull by land use type and by species over the period 2005-2019 provides a useful insight into the relationship between the helicopter counts of open range red deer and the wider deer population (Table 12):

a) Overall, 5.2% of deer (12,147) were culled on agricultural land – these areas are not typically covered by helicopter deer counts.

b) A further 23.9% of deer (56,149) were culled in woodlands – these areas cannot be covered by the helicopter as deer cannot be counted reliably through the canopy.

c) Also, 8.6% of deer culled (20, 219) were roe, fallow or sika deer culled on the open range across the CNPA.

d) Moreover, a further 2.1% (5,033) were red deer were culled on open range in the outlying eastern and northern areas (Birse/Morven etc) which are not counted.

e) In total, according to SNH's records, 39% of deer culled in the CNPA area were culled in habitats or on land use types where deer are not counted routinely by helicopter (Table 13). This compares with a total of 32% of land area not covered (as per calculations in GIS of count coverage – see Table 1).

f) In terms of the distribution of deer between habitat types, 46.1% of deer culled on agricultural land are roe deer. This compares with 48.2% in woodland, which is similar, but only 11.8% of deer on open range. A similar pattern is apparent with fallow deer (0.5-0.6%) and sika deer (0.6-0.8%) on agricultural land and woodland in comparison with open range (0.1% and 0.3% respectively).

g) Overall, 22.3% of the CNPA-wide cull annually is roe deer with 0.2% being fallow and 0.4% being sika deer. The remainder (77.1%) is red deer. Overall therefore, species other than red deer account for 22.9% of all deer culled. In addition, a further 14.8% of red deer are culled on agricultural land or in woodlands. This implies that the red deer cull on open range accounted for only 62.3% of the CNPA-wide deer cull over the period.

55. The SNH cull records for 2005-2019, when viewed alongside area calculations in ArcMap, enabled an analysis of 'cull density' to be undertaken by land use and species (Table 14):

    a) The overall cull density over the period 2005-2019 was 4.6 deer per km^2 per year in woodlands across the CNPA, as compared with 2.8 per km^2 across open range and agriculture combined[15] (i.e. 60% higher in woodland).

    b) Roe deer were culled at a rate of 2.2 per km^2 in woodland as compared with 0.4 per km^2 in open range and agricultural land. Red deer were culled at a rate of 2.3 per km^2 in woodland compared with 2.4 per km^2 in open habitats.

56. Cull records were further analysed to examine evidence for variation in recruitment rates between species and land use types across the CNPA (Table 15):

    a) The % calves culled-at-foot of females averaged 34% across the CNPA for all species, land use types and areas combined.

    b) The % calves culled was consistently higher in woodlands (41% overall) than on open range (32%) with agricultural culls being intermediate (35%). Other notable findings include the higher rate in woodlands within the Cairngorms

[15] There is no robust way to map what is classed as agricultural land by estates, in relation to their cull returns, at this juncture.

and eastern/northern areas (c. 50%) and the consistently lower rates seen in the West Grampian area across all land use types.

c) Somewhat surprisingly, given roe deer are normally more fecund than red deer in most situations, the % calves-at-foot for red deer was consistently higher than (or otherwise similar to) roe deer across all land use types.

Table 10 Summary of the cull records provided by SNH broken down into the count zones employed in this report. Note the gap in agriculture data prior to 2005. Note also the relative lack of woodland data prior to 2000.

Habitat	Deer Count Area	1990-1991	1991-1992	1992-1993	1993-1994	1994-1995	1995-1996	1996-1997	1997-1998	1998-1999	1999-2000	2000-2001	2001-2002	2002-2003	2003-2004	2004-2005	2005-2006	2006-2007	2007-2008	2008-2009	2009-2010	2010-2011	2011-2012	2012-2013	2013-2014	2014-2015	2015-2016	2016-2017	2017-2018	2018-2019	TOTAL
Agriculture	West Grampians																67	45	85	120	81	124	111	52	56	156	122	88	143	77	1,327
	East Grampians																429	536	164	303	264	276	238	322	294	308	317	372	521	446	4,790
	Cairngorms & Speyside																99	152	56	173	122	134	145	167	112	146	220	217	252	160	2,155
	Monadhliath/Mid-West/E Loch Ericht																54	102	180	158	50	235	161	135	144	178	197	210	175	222	2,201
	Birse/Morven/Cabrach/Moray/Unass'																84	116	140	99	165	53	118	140	106	112	132	133	173	109	1,680
Sub-total		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	733	951	625	853	682	822	773	816	712	900	988	1,020	1,264	1,014	12,153
Open Range	West Grampians	2,808	2,929	4,375	3,182	2,907	3,215	2,487	2,751	2,833	2,957	2,905	3,282	2,901	3,107	3,696	3,511	3,293	2,914	1,553	2,723	3,259	3,198	2,661	2,724	3,094	3,171	2,579	3,445	2,521	86,981
	East Grampians	6,726	9,809	10,494	9,094	8,019	9,284	8,090	7,744	9,256	7,895	8,749	6,796	6,921	8,658	8,739	11,846	8,486	7,186	7,614	5,568	4,422	3,667	4,515	5,445	4,875	4,731	3,250	5,893	5,073	208,845
	Cairngorms & Speyside	1,499	1,294	1,681	1,321	1,227	1,117	1,281	1,381	1,619	1,465	1,730	1,486	1,293	1,902	1,220	1,962	1,185	773	1,238	1,138	1,036	368	776	899	1,222	1,426	457	1,289	827	36,112
	Monadhliath/Mid-West/E Loch Ericht	1,323	1,354	1,640	1,051	1,126	1,278	1,630	1,492	1,819	1,724	1,777	1,171	1,320	1,659	2,125	2,083	2,106	1,852	1,679	1,892	1,369	1,484	1,495	1,164	1,786	1,540	1,601	2,616	996	46,152
	Birse/Morven/Cabrach/Moray/Unass'	96	107	185	114	79	249	820	549	673	481	488	476	524	590	425	577	572	693	261	37	159	64	154	183	570	525	510	119	609	10,889
Sub-total		12,452	15,493	18,375	14,762	13,358	15,143	14,308	13,917	16,200	14,522	15,649	13,211	12,959	15,916	16,205	19,979	15,642	13,418	12,345	11,358	10,245	8,781	9,601	10,415	11,547	11,393	8,397	13,362	10,026	388,979
Woodland	West Grampians								15	483	463	501	271	75	50	45	237	206	160	133	117	170	73	135	179	167	206	317	374	223	4,600
	East Grampians						-	9	3	23	42	29	2,044	1,874	1,311	1,762	1,911	1,785	1,424	1,449	1,690	1,367	1,829	1,315	1,686	1,820	1,772	2,436	1,728	1,226	30,535
	Cairngorms & Speyside	62	56	62	43	86	64	46	75	122	130	79	1,128	1,248	1,219	1,672	940	1,567	1,696	1,019	780	1,140	1,125	1,203	1,013	2,465	2,548	1,619	1,939	1,565	26,711
	Monadhliath/Mid-West/E Loch Ericht						185	172	422	328	461	443	965	495	576	385	538	272	357	249	523	334	211	421	288	293	249	375	439	398	9,379
	Birse/Morven/Cabrach/Moray/Unass'												351	251	317	406	390	353	337	496	223	240	188	275	258	288	316	290	590	290	5,859
Sub-total		62	56	62	43	86	249	227	515	956	1,096	1,052	4,759	3,943	3,473	4,270	4,016	4,183	3,974	3,346	3,333	3,251	3,426	3,349	3,424	5,033	5,091	5,037	5,070	3,702	77,084
Total - ALL		12,514	15,549	18,437	14,805	13,444	15,392	14,535	14,432	17,156	15,618	16,701	17,970	16,902	19,389	20,475	24,728	20,776	18,017	16,544	15,373	14,318	12,980	13,766	14,551	17,480	17,472	14,454	19,696	14,742	478,216

Table 11 Summary of cull data for all species of deer combined, across all land use types, over the past 30 years. The records are assumed to be complete over the 30-year period, but the lack of certainty over the accuracy of the breakdown between habitat types means that historic trends over time are best assessed on an 'all habitats basis'.

SCL Count Area	1990-1991	1991-1992	1992-1993	1993-1994	1994-1995	1995-1996	1996-1997	1997-1998	1998-1999	1999-2000	2000-2001	2001-2002	2002-2003	2003-2004	2004-2005	2005-2006	2006-2007	2007-2008	2008-2009	2009-2010	2010-2011	2011-2012	2012-2013	2013-2014	2014-2015	2015-2016	2016-2017	2017-2018	2018-2019	Mean annual cull
West Grampians	2,808	2,929	4,375	3,182	2,907	3,215	2,487	2,766	3,316	3,420	3,406	3,553	2,976	3,157	3,741	3,815	3,544	3,159	1,806	2,921	3,553	3,382	2,848	2,959	3,417	3,499	2,984	3,962	2,821	3,204
East Grampians	6,726	9,809	10,494	9,094	8,019	9,284	8,099	7,747	9,279	7,937	8,778	8,840	8,795	9,969	10,501	14,186	10,807	8,774	9,366	7,522	6,065	5,734	6,152	7,425	7,003	6,820	6,058	8,142	6,745	8,420
Cairngorms & Speyside	1,561	1,350	1,743	1,364	1,313	1,181	1,327	1,456	1,741	1,595	1,809	2,614	2,541	3,121	2,892	3,001	2,904	2,525	2,430	2,040	2,310	1,638	2,146	2,024	3,833	4,194	2,293	3,480	2,552	2,241
Monadhliath/Mid-West/E Loch Ericht	1,323	1,354	1,640	1,051	1,126	1,463	1,802	1,914	2,147	2,185	2,220	2,136	1,815	2,235	2,510	2,675	2,480	2,389	2,086	2,465	1,938	1,856	2,051	1,596	2,257	1,986	2,186	3,230	1,616	1,991
Birse/Morven/Cabrach/Moray/Unass'	96	107	185	114	79	249	820	549	673	481	488	827	775	907	831	1,051	1,041	1,170	856	425	452	370	569	547	970	973	933	882	1,008	635
Total (all species & all habitats)	12,514	15,549	18,437	14,805	13,444	15,392	14,535	14,432	17,156	15,618	16,701	17,970	16,902	19,389	20,475	24,728	20,776	18,017	16,544	15,373	14,318	12,980	13,766	14,551	17,480	17,472	14,454	19,696	14,742	16,490

Table 12 Summary of cull data for all four species of deer across three main land use types, restricted to the period 2005-2019 when it is believed the records breakdown is most accurate. Total culls for this period are shown alongside mean annual culls and the % of mean annual culls.

		Total culled (2005-06 to 2018-19)					Mean annual cull (2005-06 to 2018-19)					% Mean annual cull (2005-06 to 2018-19)				
Habitat	**SCL Count Area**	Roe	Fallow	Sika	Red	All	Roe	Fallow	Sika	Red	All	Roe	Fallow	Sika	Red	All
Agriculture	West Grampians	315	62	1	949	1,327	23	4	0	68	95	2.6%	0.5%	0.0%	7.8%	10.9%
	East Grampians	1,828	1	3	2,958	4,790	131	0	0	211	342	15.0%	0.0%	0.0%	24.3%	39.4%
	Cairngorms & Speyside	1,428	-	20	707	2,155	102	-	1	51	154	11.8%	0.0%	0.2%	5.8%	17.7%
	Monadhliath/Mid-West/E Loch Ericht	820	-	40	1,337	2,197	59	-	3	96	157	6.7%	0.0%	0.3%	11.0%	18.1%
	Birse/Morven/Cabrach/Moray/Unass'	1,208	-	5	465	1,678	86	-	0	33	120	9.9%	0.0%	0.0%	3.8%	13.8%
Agriculture Total		5,599	63	69	6,416	12,147	400	5	5	458	868	46.1%	0.5%	0.6%	52.8%	100.0%
Open Range	West Grampians	2,062	23	7	38,554	40,646	147	2	1	2,754	2,903	1.2%	0.0%	0.0%	23.2%	24.4%
	East Grampians	11,392	93	-	71,086	82,571	814	7	-	5,078	5,898	6.8%	0.1%	0.0%	42.7%	49.6%
	Cairngorms & Speyside	2,565	-	-	12,031	14,596	183	-	-	859	1,043	1.5%	0.0%	0.0%	7.2%	8.8%
	Monadhliath/Mid-West/E Loch Ericht	703	-	414	22,482	23,599	50	-	30	1,606	1,686	0.4%	0.0%	0.2%	13.5%	14.2%
	Birse/Morven/Cabrach/Moray/Unass'	2,960	-	-	2,073	5,033	211	-	-	148	360	1.8%	0.0%	0.0%	1.2%	3.0%
Open Range Total		19,682	116	421	146,226	166,445	1,406	8	30	10,445	11,889	11.8%	0.1%	0.3%	87.9%	100.0%
Woodland	West Grampians	1,967	54	17	655	2,693	141	5	1	47	193	3.5%	0.1%	0.0%	1.2%	4.8%
	East Grampians	12,103	292	137	10,906	23,438	865	21	10	779	1,674	21.6%	0.5%	0.2%	19.4%	41.7%
	Cairngorms & Speyside	7,936	-	4	12,673	20,613	567	-	0	905	1,472	14.1%	0.0%	0.0%	22.6%	36.7%
	Monadhliath/Mid-West/E Loch Ericht	1,562	-	312	2,997	4,871	112	-	22	214	348	2.8%	0.0%	0.6%	5.3%	8.7%
	Birse/Morven/Cabrach/Moray/Unass'	3,510	1	1	1,022	4,534	251	0	0	73	324	6.3%	0.0%	0.0%	1.8%	8.1%
Woodland Total		27,078	347	471	28,253	56,149	1,934	25	34	2,018	4,011	48.2%	0.6%	0.8%	50.3%	100.0%
ALL	West Grampians	4,344	139	25	40,158	44,666	310	10	2	2,868	3,190	1.9%	0.1%	0.0%	17.1%	19.0%
	East Grampians	25,323	386	140	84,950	110,799	1,809	28	10	6,068	7,914	10.8%	0.2%	0.1%	36.2%	47.2%
	Cairngorms & Speyside	11,929	-	24	25,411	37,364	852	-	2	1,815	2,669	5.1%	0.0%	0.0%	10.8%	15.9%
	Monadhliath/Mid-West/E Loch Ericht	3,085	-	766	26,816	30,667	220	-	55	1,915	2,191	1.3%	0.0%	0.3%	11.4%	13.1%
	Birse/Morven/Cabrach/Moray/Unass'	7,678	1	6	3,560	11,245	548	0	0	254	803	3.3%	0.0%	0.0%	1.5%	4.8%
ALL		**52,359**	**526**	**961**	**180,895**	**234,741**	**3,740**	**38**	**69**	**12,921**	**16,767**	**22.3%**	**0.2%**	**0.4%**	**77.1%**	**100.0%**
Agriculture	ALL															5.2%
Open Range	ALL															70.9%
Woodland	ALL															23.9%

Table 13 Analysis of cull data using four species of deer across three main land use types, over the period 2005-2019, showing how the cull records break down between (i) species that are counted (red deer) or not (roe, sika and fallow deer) and land use types that are counted (open range) and not (agriculture and woodland).

SCL Count Area	Total cull: Roe	Total cull: Fallow	Total cull: Sika	Total cull: Red	Total cull: ALL	Woods & agric': Roe	Woods & agric': Fallow	Woods & agric': Sika	Woods & agric': Red	Woods & agric': ALL	Open range, but not counted: Roe	Open range, but not counted: Fallow	Open range, but not counted: Sika	Open range, but not counted: Red	Open range, but not counted: ALL	Culled (woods, agric or not counted) : ALL
West Grampians	4,344	139	25	40,158	44,666	2,282	116	18	1,604	4,020	2,062	23	7	N/A	2,092	6,112
East Grampians	25,323	386	140	84,950	110,799	13,931	293	140	13,864	28,228	11,392	93	-	N/A	11,485	39,713
Cairngorms & Speyside	11,929	-	24	25,411	37,364	9,364	-	24	13,380	22,768	2,565	-	-	N/A	2,565	25,333
Monadhliath/Mid-West/E Loch Ericht	3,085	-	766	26,816	30,667	2,382	-	352	4,334	7,068	703	-	414	N/A	1,117	8,185
Birse/Morven/Cabrach/Moray/Unass'	7,678	1	6	3,560	11,245	4,718	1	6	1,487	6,212	2,960	-	-	2,073	5,033	11,245
ALL	52,359	526	961	180,895	234,741	32,677	410	540	34,669	68,296	19,682	116	421	2,073	22,292	90,588
%						62%	78%	56%	19%	**29%**						**39%**

Table 14 Overview of mean annual culling patterns over the period 2005-2019, broken down by deer species and presented as cull intensity (per km^2) using area data obtained from GIS: woodlands (upper table) and open habitats (lower table; open range + agriculture). Note: land areas used in calculations include a considerable amount of land around the periphery of the CNP which had to be included because the cull summaries provided by SNH included deer shot in these areas also (e.g. parts of the Monadhliath Estates which are part in the CNP but part out of it, parts of the West Grampians DMG area which lie out with the CNP etc).

		Mean annual cull (2005-06 to 2018-19)					Mean 2005-2019		
Analysis Zone	NFI Woodlands (ha)	Roe	Fallow	Sika	Red	All	Roe	Red	All (incl fallow & sika)
West Grampians (incl. land ex CNPA)	5,511	141	5	1	47	193	2.5	0.8	3.5
East Grampians (incl. land ex CNPA)	24,519	865	21	10	779	1,674	3.5	3.2	6.8
Cairngorms & Speyside (incl Part of Cairngorms)	25,089	567	-	0	905	1,472	2.3	3.6	5.9
Monadh/Mid-West/E Loch Ericht (incl ex CNPA)	10,285	112	-	22	214	348	1.1	2.1	3.4
Birse/Morven/Cabrach/Moray/Unass' (incl ex CNPA)	22,474	251	0	0	73	324	1.1	0.3	1.4
TOTAL	87,878	1,934	25	34	2,018	4,011	2.2	2.3	**4.6**
% TOTAL CULL - WOODS		48%	1%	1%	50%	100%			

		Mean annual cull (2005-06 to 2018-19)					Mean 2005-2019		
Analysis Zone	Open range & farmland (ha)	Roe	Fallow	Sika	Red	All	Roe	Red	All (incl fallow & sika)
West Grampians (incl. land ex CNPA)	75,344	170	6	1	2,822	2,998	0.2	3.7	4.0
East Grampians (incl. land ex CNPA)	147,913	944	7	0	5,289	6,240	0.6	3.6	4.2
Cairngorms & Speyside (incl Part of Cairngorms)	103,079	285	-	1	910	1,197	0.3	0.9	1.2
Monadh/Mid-West/E Loch Ericht (incl ex CNPA)	57,261	109	-	32	1,701	1,843	0.2	3.0	3.2
Birse/Morven/Cabrach/Moray/Unass' (incl ex CNPA)	69,671	298	-	0	181	479	0.4	0.3	0.7
TOTAL	453,268	1,806	13	35	10,903	12,757	0.4	2.4	**2.8**
% TOTAL CULLS - OPEN/AGRIC'		14%	0%	0%	85%	100%			

Table 15 Mean % calves culled-at-foot of females over the period 2005-2019 across the CNP: all deer (upper), roe deer only (middle) and red deer only (lower).

	Agriculture			Open Range			Woodland			ALL		
SCL Count Area	Female	Calf	% Calves	Female	Calf	% Calves	Female	Calf	% Calves	Female	Calf	% Calves
West Grampians	279	50	18%	22,313	4,641	21%	1,039	305	29%	23,631	4,996	21%
East Grampians	1,520	422	28%	40,109	14,327	36%	10,001	3,537	35%	51,630	18,286	35%
Cairngorms & Speyside	926	327	35%	6,413	2,470	39%	7,200	3,496	49%	14,539	6,293	43%
Monadhliath/Mid-West/E Loch Ericht	719	409	57%	10,824	3,720	34%	2,023	828	41%	13,566	4,957	37%
Birse/Morven/Cabrach/Moray/Unass'	665	237	36%	2,258	981	43%	1,755	935	53%	4,678	2,153	46%
TOTAL	4,109	1,445	35%	81,917	26,139	32%	22,018	9,101	41%	108,044	36,685	34%

	Agriculture			Open Range			Woodland			ALL		
SCL Count Area	Female	Calf	% Calves	Female	Calf	% Calves	Female	Calf	% Calves	Female	Calf	% Calves
West Grampians	146	26	18%	1,061	237	22%	884	241	27%	2,091	504	24%
East Grampians	949	175	18%	5,652	1,427	25%	5,503	1,630	30%	12,104	3,232	27%
Cairngorms & Speyside	624	170	27%	995	394	40%	3,127	1,524	49%	4,746	2,088	44%
Monadhliath/Mid-West/E Loch Ericht	271	141	52%	289	107	37%	662	269	41%	1,222	517	42%
Birse/Morven/Cabrach/Moray/Unass'	499	153	31%	1,314	540	41%	1,396	752	54%	3,209	1,445	45%
TOTAL	2,489	665	27%	9,311	2,705	29%	11,572	4,416	38%	23,372	7,786	33%

	Agriculture			Open Range			Woodland			ALL		
SCL Count Area	Female	Calf	% Calves	Female	Calf	% Calves	Female	Calf	% Calves	Female	Calf	% Calves
West Grampians	110	23	21%	21,243	4,400	21%	120	58	48%	21,473	4,481	21%
East Grampians	570	247	43%	34,424	12,865	37%	4,356	1,802	41%	39,350	14,914	38%
Cairngorms & Speyside	295	154	52%	5,418	2,076	38%	4,073	1,972	48%	9,786	4,202	43%
Monadhliath/Mid-West/E Loch Ericht	435	263	60%	10,333	3,519	34%	1,249	503	40%	12,017	4,285	36%
Birse/Morven/Cabrach/Moray/Unass'	166	84	51%	944	441	47%	359	183	51%	1,469	708	48%
TOTAL	1,576	771	49%	72,362	23,301	32%	10,157	4,518	44%	84,095	28,590	34%

HISTORIC DEER COUNT DATA

57. A review of the NS deer count data provided for the period 1966-2015 identified the following challenges:

    a) All data contained within the records were understood to have been obtained from counts involving DCS or SNH, as opposed to being from estate-based staff counts. Therefore, we assumed (i) all data had been gathered according to standardised protocols and (ii) all had been was passed through some form of quality assurance.

    b) The data were of mixed provenance, with data up to the late 1990's being obtained almost exclusively via foot count. Data from the mid-2000's onwards were obtained exclusively from helicopter, with the period in between involving a mixture of methods. Various arguments can be put forward about the possibility of ground counts underestimating deer numbers relative to helicopter counts, for example because of a lack of complete coverage of the land. However, as there is no reliable way of retrospectively adjusting the data we assume, for the purposes of this analysis, no systematic bias exists.

    c) Inspection of the data revealed that there were certain points in time where extensive coverage of the main parts of the CNP was achieved, whereas at other times only select parts of the area were counted. The eventual area ('core area') targeted for historic count analysis comprised: West Grampians DMG, Cairngorms & Speyside DMG and East Grampians (SDNA, UDD and SG1 areas combined).

    d) Even where extensive coverage was apparent of some areas, counts often had to be merged across two years (and sometimes across three) to obtain the fullest possible coverage of the core area at a particular point in time.

    e) On one occasion (Feb'' 2005) it was apparent that one area had been omitted (Angus Glens). The count from Feb 2003 was used to 'patch in' this area.

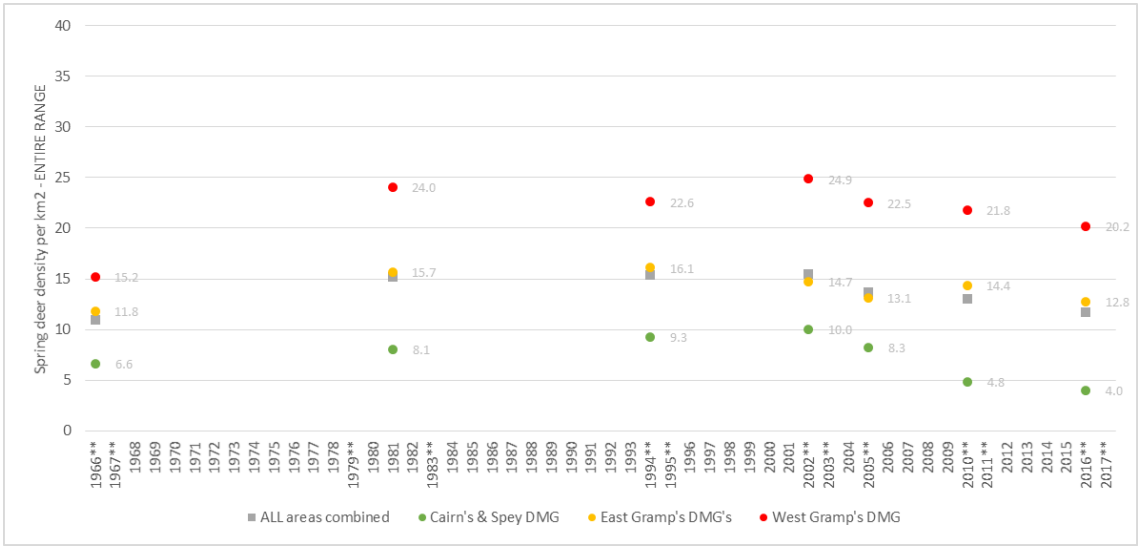
58. Compilation and analysis of selected historic counts (see Tables 16 & 17) suggests that open hill red deer densities in the core count areas of the park were at a relatively low level in the mid 1960's. Densities rose to a peak in the early 2000's before declining steadily in the period leading to the last region-wide counts in 2016 and 2017 (Figure 1 upper). Maps 6a, 6b & 6c compare the distribution and abundance of red deer in core count areas in 1966/67, 2001/03 and 2016/17.

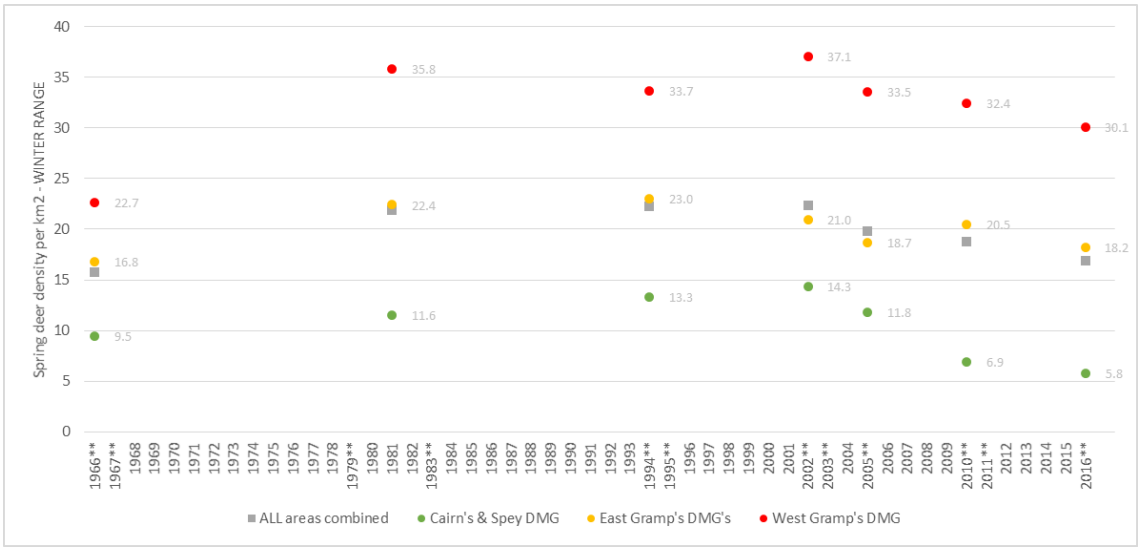
59. The lowest average deer densities have consistently been found in the Cairngorms & Speyside DMG area throughout the period, whilst the highest have consistently been found in the West Grampians DMG area (Figure 1 upper). Levels in the East Grampians DMG's area, as a whole, have remained intermediate between the other two areas.

60. The rate of increase in population density in the early part of the analysis period appeared to be slowest in the Cairngorms and fastest in the West Grampians;

similarly, the rate of decline in density in recent times appeared to be fastest in the Cairngorms and slowest in the West Grampians (Figure 1 upper).

Figure 1 Trends in deer density from 1966 to the present day, based on the sub-sets of count data provided by SNH which provided the fullest coverage of the areas in question. The upper chart shows spring deer density calculated using the entire land area, and the lower chart calculates the 'winter range' density (only land below 700m altitude used, rather than all open range land in the DMG). The underlying data that were used to generate the charts are presented in Table 16. Densities for each region are shown along with a combined density (all DMG areas merged). Asterisks denote the set(s) of count data used to derive the density estimate. Where more than one asterisk occurs, it denotes a density derived from two or more counts joined together.





61. Crucially though, any interpretation of deer densities must consider local effects as averaging the density of deer across large areas can be misleading:

    a) Figure 1 lower shows the impact of calculating spring deer densities using the actual area deer tend to use in winter (i.e. land < 700m) compared to calculating it using the overall range value. Use of the winter range figure arguably provides a more realistic measure of how many deer are occupying upland habitats during the period when the majority of browsing impacts arise (late autumn to late spring). Broadly, use of this approach increases the historic deer density values by 50% (e.g. in the latest counts, from ~ 4 per km^2 in the Cairngorms area to ~ 6 per km^2).

    b) Of course, the deer density locally within these areas will in places be much higher whilst in places will be much lower. A case in point is Glenfeshie where in the mid-2000's, prior to heavy culls being taken, a very high density of deer could be found in winter (perhaps 30-40 per km^2 or more) despite the overall density in the wider range (where few deer were present in winter) being relatively low at ~ 15 per km^2.

Table 16 Key statistics derived from historic count records of the core count areas that intersect the CNPA boundary. Note 1: land areas and statistics are derived only for those portions of the DMG areas lying within the CNP. Note 2: some counts (2005; 2010/11) were unclassified.

TOTAL COUNTS: INDIVIDUAL DMG'S & MERGED

CNPA Deer Count Area	1966 & 1967	1979 & 1983	1994 & 1995	2001 & 2003	2005	2010 & 2011	2016 & 2017
	Ground	Ground	Ground	Mix?	Heli'	Heli'	Heli'
Cairngorm/Speyside DMG	5,633	6,876	7,899	**8,537**	7,034	4,100	3,427
East Grampian SG1 DMG	1,299	1,512	3,136	3,760	**4,278**	3,822	2,201
South Deeside North Angus DMG	6,196	**9,655**	9,454	7,645	7,084	9,203	9,338
Upper Deeside and Donside DMG	7,336	**8,580**	7,664	7,088	5,135	5,041	4,507
West Grampians DMG	9,300	14,697	13,826	**15,206**	13,763	13,311	12,356
ALL	29,764	41,320	41,979	42,236	37,294	35,477	31,829

CNPA Deer Count Area	1966 & 1967	1979 & 1983	1994 & 1995	2001 & 2003	2005	2010 & 2011	2016 & 2017
	Ground	Ground	Ground	Mix?	Heli'	Heli'	Heli'
Cairngorm/Speyside DMG	5,633	6,876	7,899	8,537	7,034	4,100	3,427
East Grampians DMG's	14,831	19,747	20,254	18,493	16,497	18,066	16,046
West Grampians DMG	9,300	14,697	13,826	15,206	13,763	13,311	12,356
ALL	29,764	41,320	41,979	42,236	37,294	35,477	31,829

DEER DENSITIES: 'ENTIRE RANGE' (ALL LAND) AND 'WINTER RANGE' (LAND < 700M ONLY)

CNPA Deer Count Area	Entire range (ha) - ALL	1966 & 1967	1979 & 1983	1994 & 1995	2001 & 2003	2005	2010 & 2011	2016 & 2017
Cairngorm/Speyside DMG	85,135	6.6	8.1	9.3	10.0	8.3	4.8	4.0
East Grampians DMG's	125,801	11.8	15.7	16.1	14.7	13.1	14.4	12.8
West Grampians DMG	61,180	15.2	24.0	22.6	24.9	22.5	21.8	20.2
ALL	272,116	**10.9**	**15.2**	**15.4**	**15.5**	**13.7**	**13.0**	**11.7**

CNPA Deer Count Area	Winter range (ha) - ALL	1966 & 1967	1979 & 1983	1994 & 1995	2001 & 2003	2005	2010 & 2011	2016 & 2017
Cairngorm/Speyside DMG	59,495	9.5	11.6	13.3	14.3	11.8	6.9	5.8
East Grampians DMG's	88,147	16.8	22.4	23.0	21.0	18.7	20.5	18.2
West Grampians DMG	41,029	22.7	35.8	33.7	37.1	33.5	32.4	30.1
ALL	188,670	**15.8**	**21.9**	**22.2**	**22.4**	**19.8**	**18.8**	**16.9**

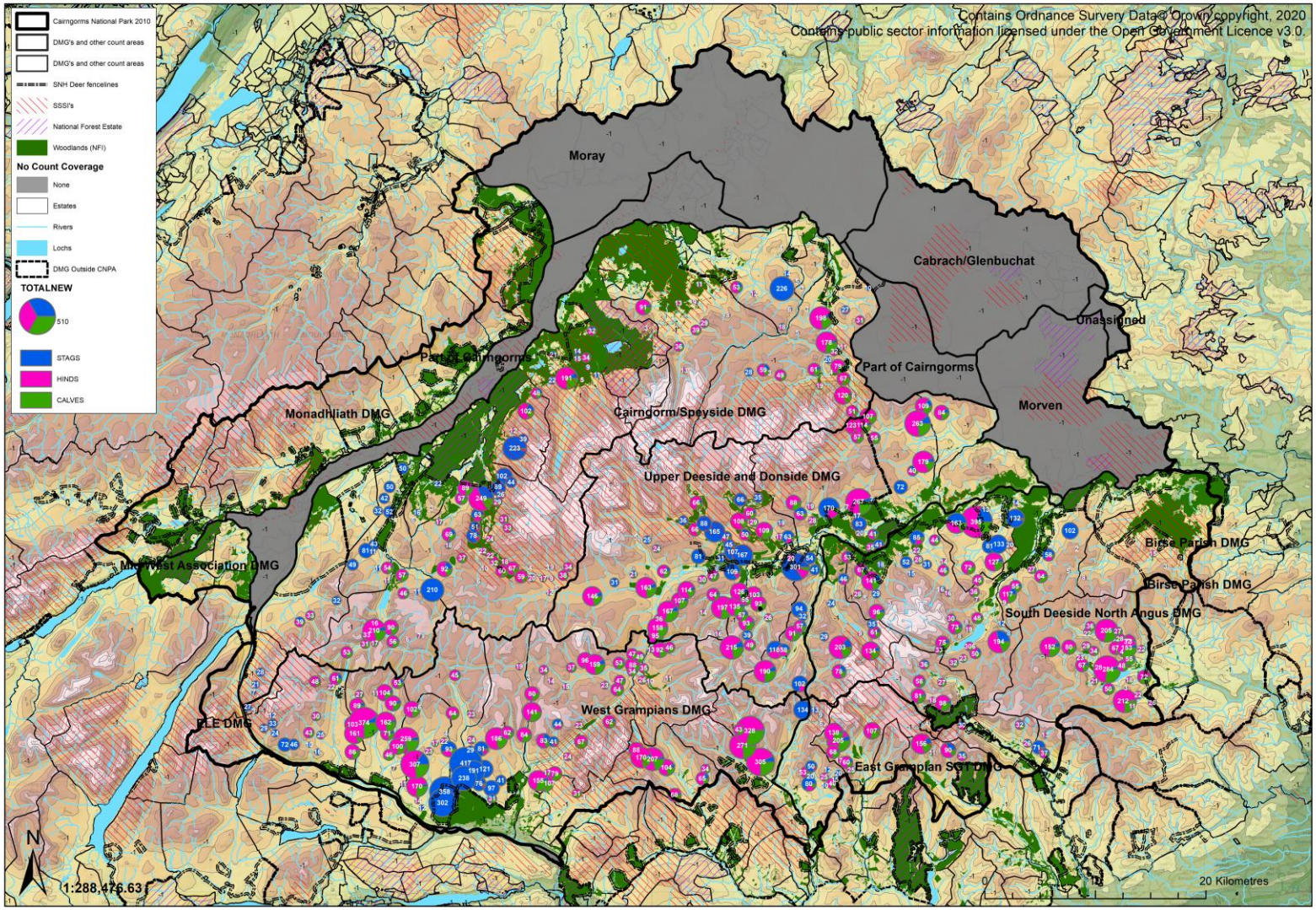
POPULATION STRUCTURE: HIND: STAG RATIOS & % CALVES RECORDED 'AT FOOT'

CNPA Deer Count Area	1966 & 1967	1979 & 1983	1994 & 1995	2001 & 2003	2005	2010 & 2011	2016 & 2017	
Cairngorm/Speyside DMG	1.14	0.97	0.87	1.13	U/C	U/C	1.40	
East Grampians DMG's	1.81	1.93	1.45	1.38	U/C	U/C	1.24	
West Grampians DMG	1.63	1.80	1.59	1.76	U/C	U/C	1.16	
ALL	**1.60**	**1.66**	**1.35**	**1.47**	U/C	U/C	**1.23**	

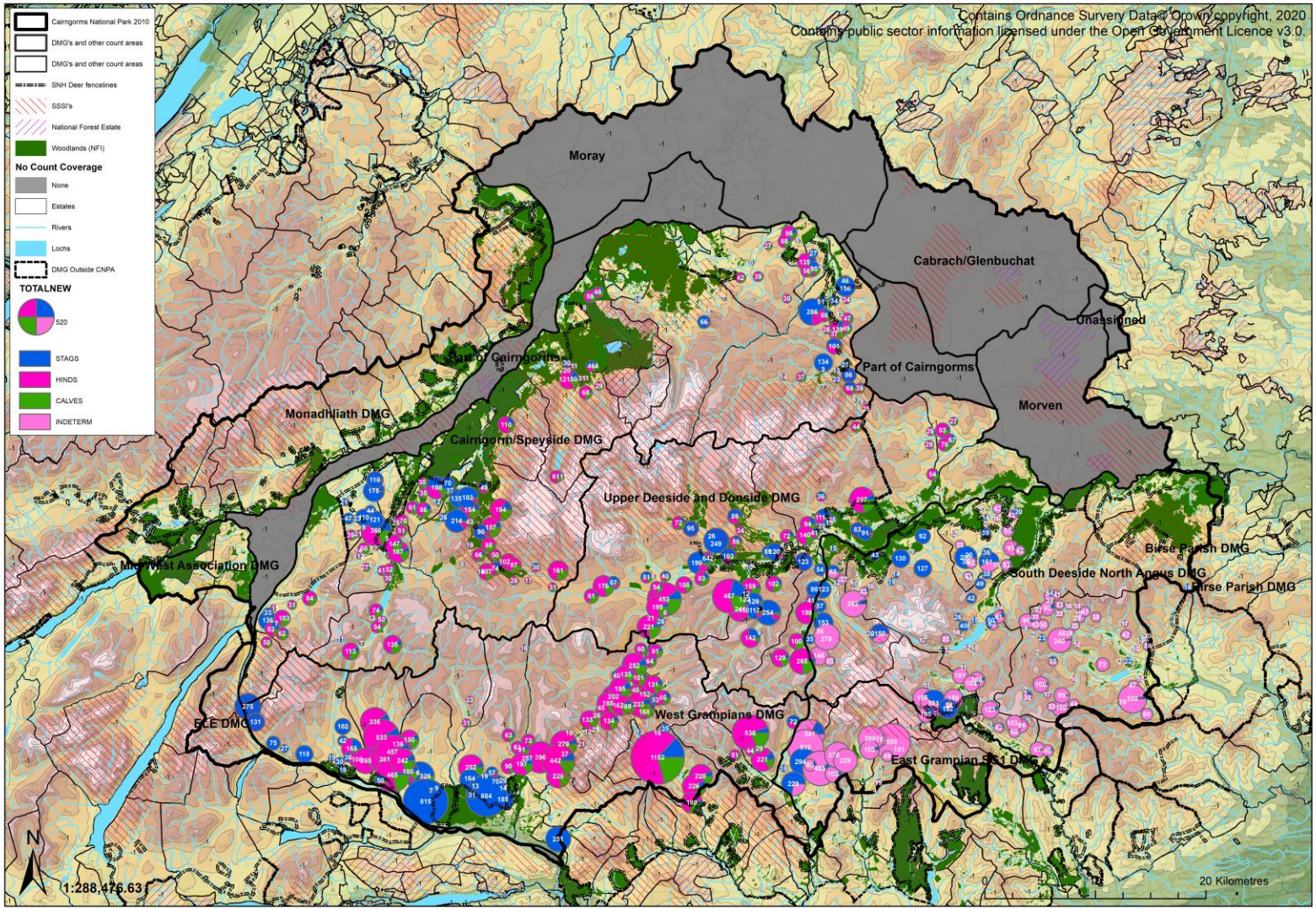
CNPA Deer Count Area	1966 & 1967	1979 & 1983	1994 & 1995	2001 & 2003	2005	2010 & 2011	2016 & 2017	Long-term mean
Cairngorm/Speyside DMG	34.4%	32.6%	32.9%	37.7%	U/C	U/C	37.9%	35.0%
East Grampians DMG's	36.9%	30.8%	24.8%	34.7%	U/C	U/C	34.4%	31.4%
West Grampians DMG	35.3%	31.9%	26.3%	29.2%	U/C	U/C	35.7%	31.1%
ALL	**36.0%**	**31.4%**	**26.6%**	**32.5%**	U/C	U/C	**35.3%**	**31.9%**

Table 17 Breakdown of historic count data by year, sex and age-class. Note: in some cases, counts were 'unclassified' (i.e. antlered stags were counted, but all other deer were grouped into one class).

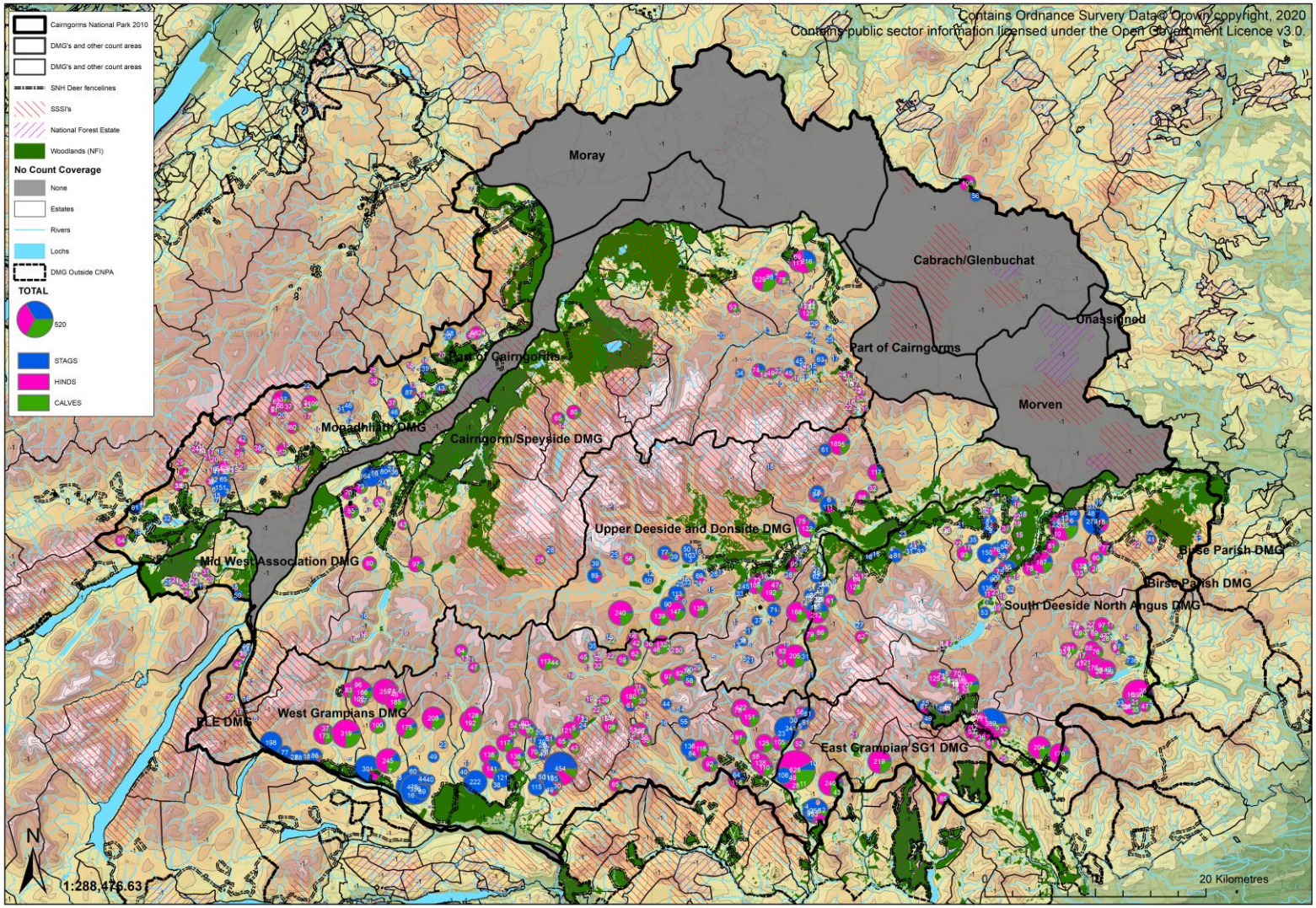
	Feb 1966 & Feb/Mar 1967					Mar 1979 & Feb 1983					Mar 1994 & Feb/Mar 1995					Feb 2001 & Feb/Mar 2003					Feb 2005					Jan 2010 & Jan 2011					Jan 2016 & Feb 2017				
	Foot count					Foot count					Foot count					Mix of foot & helicopter					Helicopter					Helicopter					Helicopter				
CNPA Deer Count Area	Stags	Hinds	Calves	Others	ALL*	Stags	Hinds	Calves	Others	ALL*	Stags	Hinds	Calves	Others	ALL*	Stags	Hinds	Calves	Others	ALL*	Stags	Hinds	Calves	Others	ALL*	Stags	Hinds	Calves	Others	ALL*	Stags	Hinds	Calves	Others	ALL*
Cairngorm/Speyside DMG	2,220	2,532	872	9	5,633	3,009	2,916	951	-	6,876	3,663	3,188	1,048	-	7,899	3,335	3,779	1,423	-	8,537	1,788	-	-	5,246	7,034	1,090	-	-	3,010	4,100	1,168	1,638	621	-	3,427
East Grampian SG1 DMG	315	726	258	-	1,299	646	657	209	-	1,512	1,029	1,692	415	-	3,136	622	-	-	3,138	3,760	325	-	-	3,953	4,278	696	-	-	3,126	3,822	662	1,134	405	-	2,201
South Deeside North Angus DMG	1,495	3,390	1,311	-	6,196	2,511	5,427	1,717	-	9,655	3,410	5,038	1,006	-	9,454	2,365	-	-	5,280	7,645	2,372	-	-	4,712	7,084	3,158	-	-	6,045	9,203	3,309	4,502	1,527	-	9,338
Upper Deeside and Donside DMG	2,454	3,604	1,278	-	7,336	2,452	4,725	1,403	-	8,580	2,768	3,722	1,174	-	7,664	2,483	3,418	1,187	-	7,088	1,897	-	-	3,238	5,135	1,507	-	-	3,534	5,041	2,042	1,831	634	-	4,507
West Grampians DMG	2,901	4,730	1,669	-	9,300	4,349	7,847	2,501	-	14,697	4,605	7,300	1,921	-	13,826	4,643	8,174	2,389	-	15,206	3,311	-	-	10,452	13,763	2,886	-	-	10,425	13,311	4,791	5,573	1,992	-	12,356
ALL	9,385	14,982	5,388	9	29,764	12,967	21,572	6,781	-	41,320	15,475	20,940	5,564	-	41,979	13,448	15,371	4,999	8,418	42,236	9,693	-	-	27,601	37,294	9,337	-	-	26,140	35,477	11,972	14,678	5,179	-	31,829



Map 6a Deer abundance and distribution within the CNPA area, derived by combining the results of foot counts from 1966 and 1967.



Map 6b Deer abundance and distribution within the CNPA area, derived by combining the results of foot/heli' counts from 2001 and 2003.



Map 6c Deer abundance and distribution within the CNPA area, derived by combining the results of heli' counts from 2016 and 2017 together (as per Map 5a).

POPULATION MODELLING

62. Initial attempts were made to model the red deer population counted on the open range across the entire area (Cairngorms & Speyside DMG, West Grampians DMG and East Grampian DMG's combined). However, they failed to produce a balanced model (i.e. where the model predictions match the repeat count data closely, both in terms of overall numbers – see Figure 2 - and sex/age-class breakdown – see Figure 3) despite using parameters derived from the actual counts in February 2005 and cull records supplied.

63. In the first instance, parameters were varied within believable limits to establish how sensitive the model was. Recruitment rates had to be increased greatly to achieve any semblance of balance, well beyond likely biological limits for red deer in this type of habitat. The adult sex ratio had to be skewed considerably more than the counts indicated was likely, to achieve balance. The alternative, and ultimately preferred, option settled upon was to skew survivorship. This was achieved by skewing the 'sex ratio at birth' in models for the reasons outlined in the Methods. This acted to increase the size of the breeding hind population, and thus the proportion of females annually in the population relative to males. A split of 53% females: 47% males produced a relatively well-balanced model that:

    a) Predicted the trend in overall deer numbers as evidenced by repeat counts whilst also;

    b) Matching the sex and age-class breakdown of repeat counts reasonably closely.

64. Other possible combinations of parameters could be used to produce broadly similar patterns of results but those settled on by the above process were considered the most biologically plausible. Adoption of this model enabled the second stage of modelling to proceed – production of regional models for the DMG areas.

65. The sub-models built for the individual regions (Cairngorms & Speyside DMG, East Grampians DMG's combined, West Grampians DMG) were run using all the same parameters as the Entire Area model, other than:

    a) Adult sex ratio: the initial ratio for each regional model was set using the count data from February 2005.

    b) Recruitment: the rate for each regional sub-model was set according to the long-term value for each region obtained from historic count data.

66. Despite using the same parameters, and despite covering such large areas in their own right, none of the regional models balanced. The WG model produced a rapid population increase as did the C&S model; on the other hand, the EG model rapidly ran out of deer. Of course, a variety of significant changes in the way deer were managed took place in the CNP during the period modelled and

these may have caused complex spatial and temporal interactions within and between areas – these include:

a) Markedly increased culls of red deer were taken in the western Cairngorms (e.g. Glenfeshie/Inshriach) in the mid 2000's, then later at Mar Lodge and in recent years in other areas (e.g. Wildland properties in Speyside more generally).

b) Very heavy culls were taken in the Caenlochan area as part of a Section 7 Agreement between DCS (at the time) and the owners. Culls were particularly intense in the period 2005-2007.

c) Several estates in the south of the Angus Glens are believed to have culled considerable numbers of deer around this time, whilst high altitude fences were also erected to prevent large-scale deer movements.

d) New deer fences were also erected around sizeable new woodland establishment schemes, which may also have affected movement/displaced deer.

e) Maps 6a, 6b and 6c provide a useful indication of how open hill red deer distributions changed in the CNP area from the 1960's to date (the latter two are particularly relevant).

67. Many possible combinations of new parameters could be introduced to try and help shed light on exactly how populations responded, in each regional sub-model area, to (i) these events as well as (ii) to general changes over time (e.g. in annual recruitment rates and annual patterns of winter die-off). However, this is deemed beyond the scope of the current report.

68. That said, for interest a second version of the Cairngorms & Speyside DMG regional model – and Entire Area model - was run again, but this time with the woodland red deer culls of the Cairngorms added to the recorded hill cull. This was to reflect the fact that large culls of red deer in the mid 2000's and beyond in the western Cairngorms were taken in and around unfenced woodland. The models both ran out of deer, quite possibly because compensation had not been made for an increased population size relating to red deer resident in the woods all year (not counted by helicopter; see sub-section on the results of dung counting).

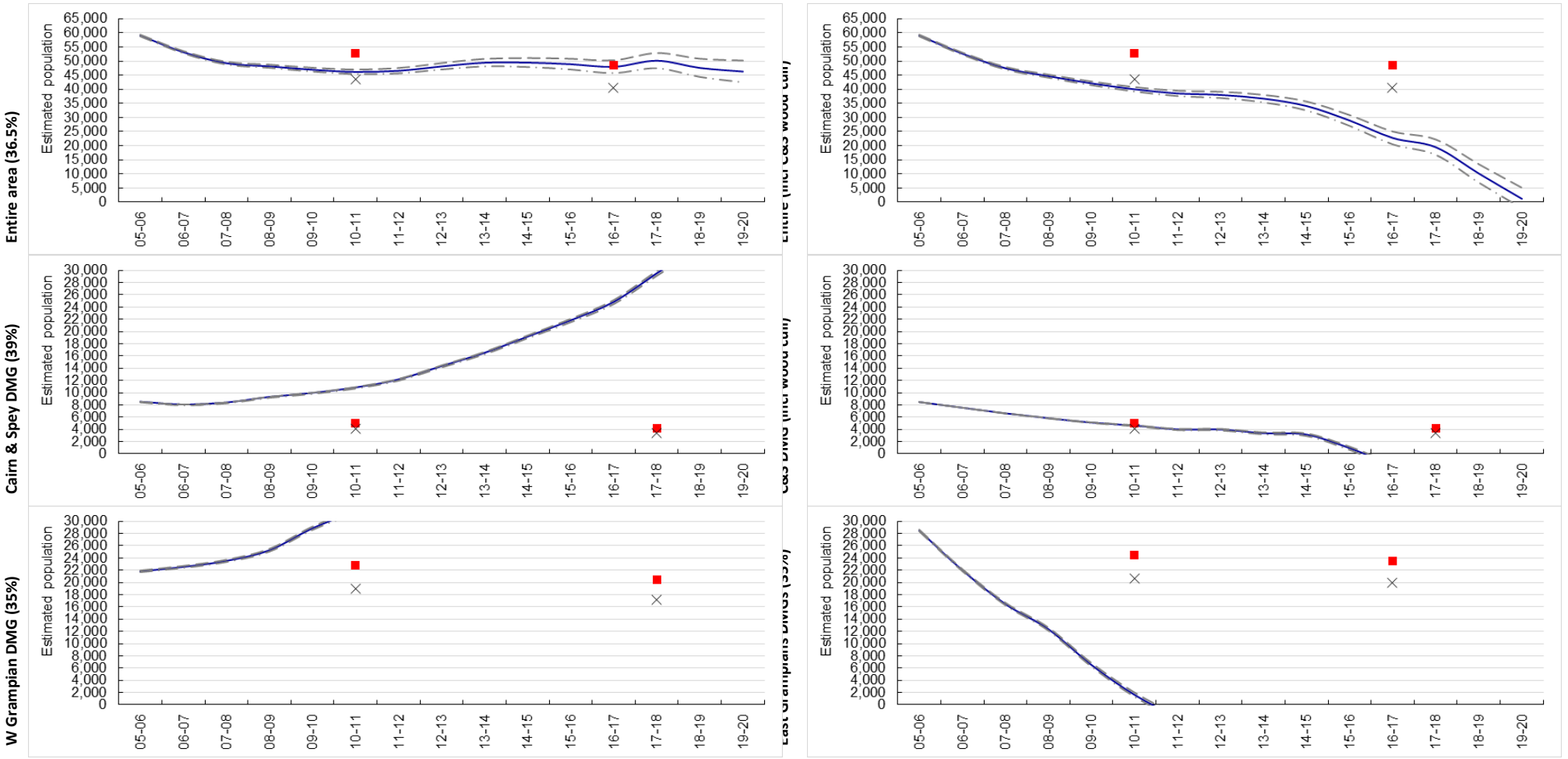


Figure 2 Population model outputs: summer deer numbers. Blue line – predicted population size. Dashed lines – prediction with +/- 0.5% difference in starting abundance. Cross – deer count. Red square – count inflated with recruitment. Note the difference in y-axis scale between the upper row (Entire Area) and the other rows (individual regional output). Column titles confirm the regions (e.g. West Grampian DMG) as well as the recruitment rate employed in the model (e.g. 35%). The rates and settings employed in the models for the Entire Area are weighted averages of the individual models (e.g. 36.5% recruitment overall -> derived from weighting the individual model values of 39% and 35%).

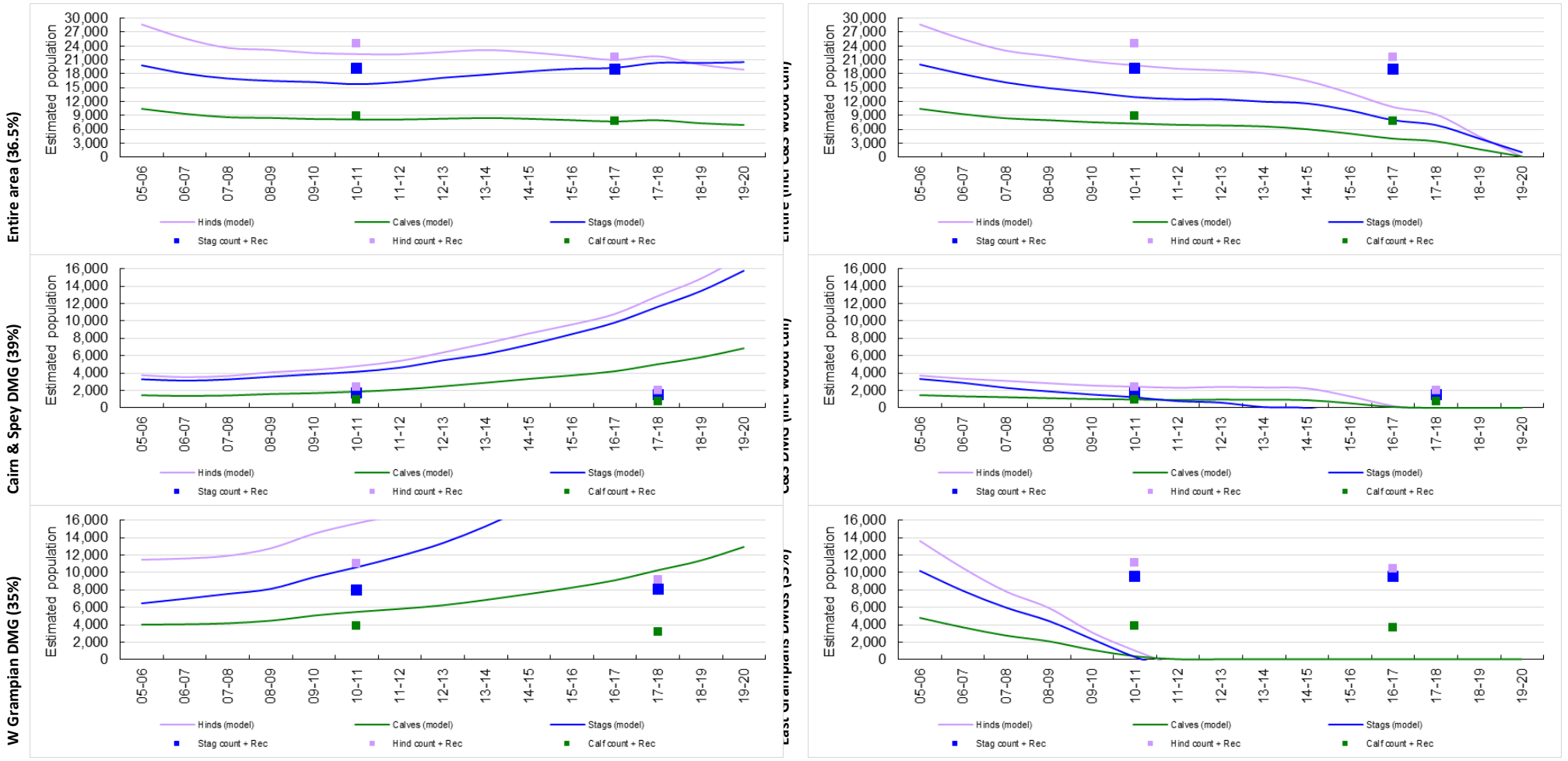


Figure 3 Population model outputs: breakdown of summer deer numbers. Blue line/square – predicted stags/counted + recruit'. Pink line/square – predicted hinds/counted + recruit'. Green line/square – predicted calves/counted + recruit'. Note the difference in y-axis scale between the upper row (Entire Area) and the other rows (individual regional output). Column titles confirm the regions (e.g. West Grampian DMG) as well as the recruitment rate employed in the model (e.g. 35%). The rates and settings employed in the models for the Entire Area are weighted averages of the individual models (e.g. 36.5% recruitment overall -> derived from weighting the individual model values of 39% and 35%).

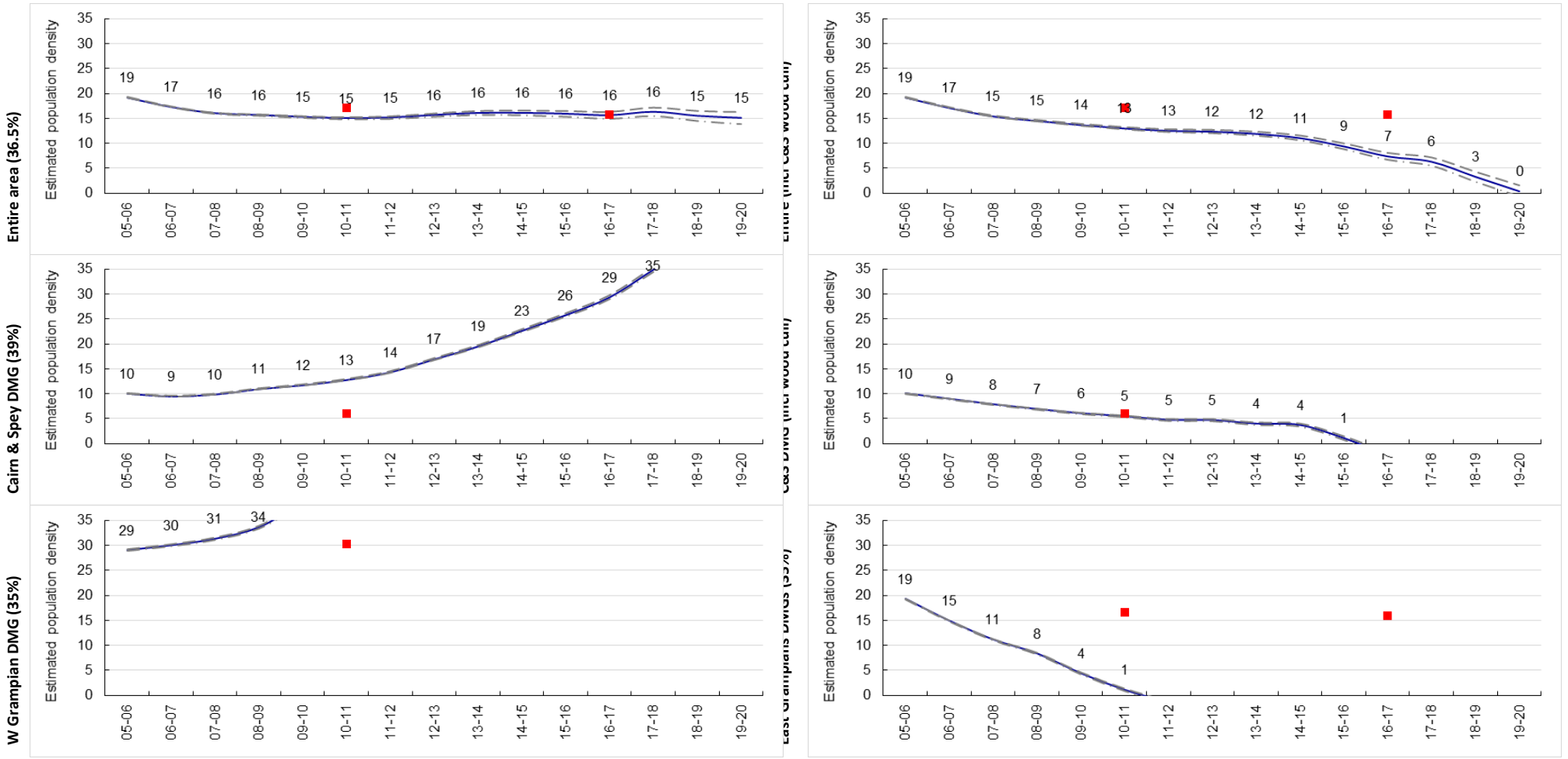


Figure 4 Population model outputs: summer deer densities. Blue line – predicted density. Dashed lines – prediction with +/- 0.5% difference in starting density. Cross – deer count. Red square – count inflated with recruitment. Note the difference in y-axis scale between the upper row (Entire Area) and the other rows (individual regional output). Column titles confirm the regions (e.g. West Grampian DMG) as well as the recruitment rate employed in the model (e.g. 35%). The rates and settings employed in the models for the Entire Area are weighted averages of the individual models (e.g. 36.5% recruitment overall -> derived from weighting the individual model values of 39% and 35%).

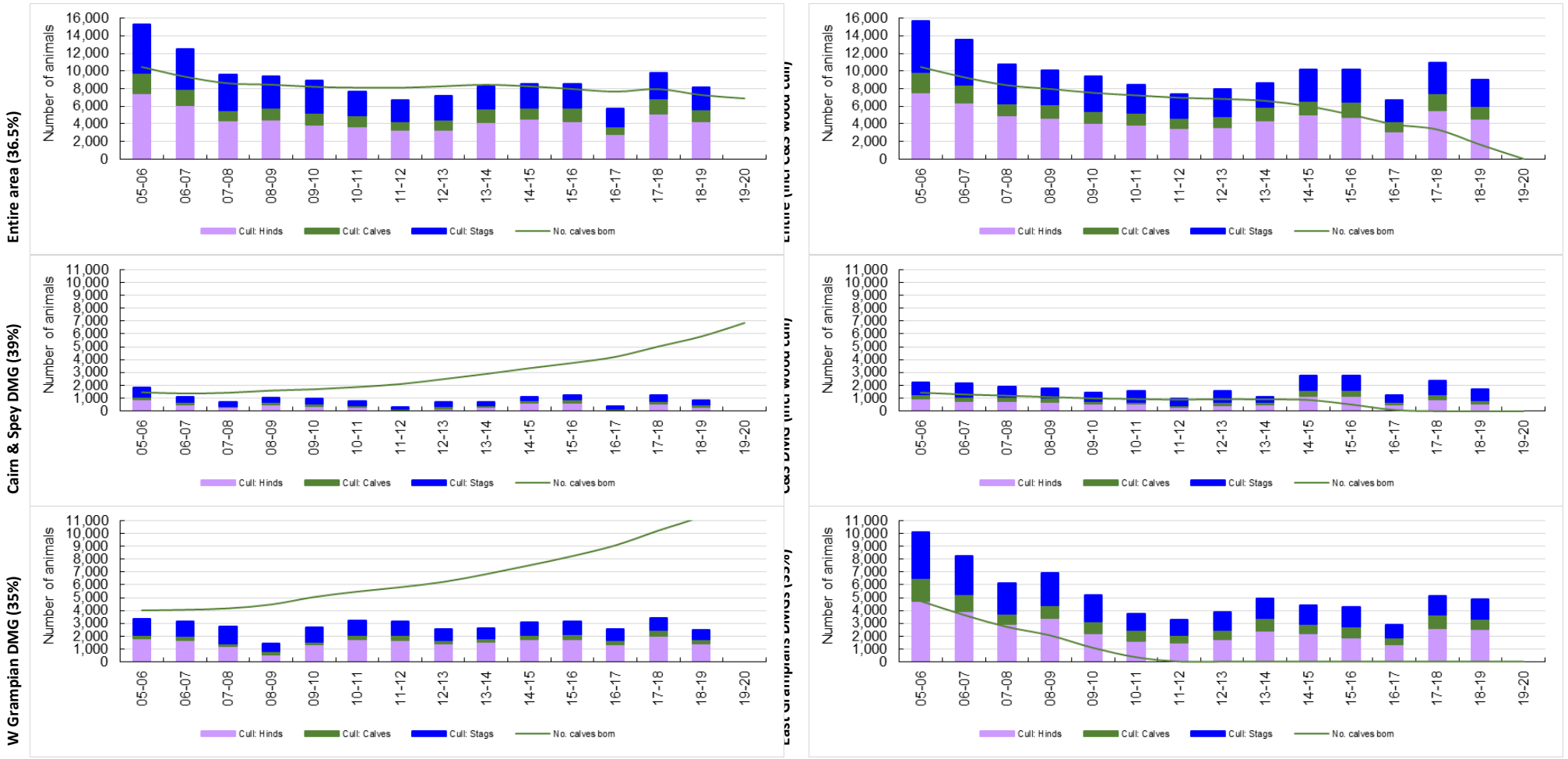


Figure 5 Population model outputs: deer culls, and predicted number of calves born. Blue bars – stags, Pink bars – hinds, Green bars – calves. Green line – predicted number of calves annually. Note the difference in y-axis scale between the upper row (Entire Area) and the other rows (individual regional output). Column titles confirm the regions (e.g. West Grampian DMG) as well as the recruitment rate employed in the model (e.g. 35%). The rates and settings employed in the models for the Entire Area are weighted averages of the individual models (e.g. 36.5% recruitment overall -> derived from weighting the individual model values of 39% and 35%).

IMPACT SURVEYS

69. The extent of Estates-HIA data coverage varies considerably between the three regions, meaning care has to be taken when appraising the results:

    a) 79% of available dwarf shrub heath habitat was sampled in the WG region as a whole compared with 50% in EG and 37% in CS. This compares with 90% of available blanket bog habitat in WG, 27% in EG and 38% in CS.

    b) Also, not all estates provided both types of survey data (DSH and BB), implying that locally some data sets are more representative of impact patterns than others. Participating estates in WG and EG covered 100% of available DSH habitat on their land whereas only 85% was covered on participating CS estates; on those same estates, 95% of BB habitat was covered in WG compared with 52% in EG and 78% in CS.

    c) In essence, the average impact statistics presented herein need to be treated with some caution. WG achieved the greatest coverage and so regional statistics, with all else equal, might be expected to be the most robust. Cover was markedly poorer in the other two regions (CS and EG) in comparison.

70. Recorded browsing impact levels on heather vary markedly between estates, DMG's and habitat types according to the Estates-HIA data (see overview in Table 18a, breakdown in Table 18b and Maps 6a/6b):

    a) De-weighting the scores, to adjust for differences in sampling intensity and sampled area between estates, generally resulted in higher levels of impact being ascribed to each region (e.g. 41% of sampled DSH plots had Low impacts in WG based on the arithmetic mean, but only 26% of plots based on the de-weighted mean).

    b) Higher levels of browsing impact were typically recorded on heather in dwarf shrub heath compared to heather on blanket bog, as shown by the greater % of plots achieving a Low impact score (e.g. 84% of BB plots compared to 72% of DSH plots in WG).

71. Relatively few HIA surveys have been undertaken in recent years by SNH – Table 19 summarises the results obtained for DSH and BB habitat types:

    a) The Cairngorms data set (2015) shows typically low impacts on BB (Table 19).

    b) The Caenlochan dataset, which was gathered for only part of the East Grampians area, shows high levels of impact on both habitat types (Table 19). The data can be viewed in association with a map of how deer/sheep occupancy varies across the site (Map 6c). It is also useful to understand how the actual level of impact on heather varies with density in sub-areas of the site (see Figure 3, which for interest shows the specific relationships derived for Caenlochan – other sites may have different forms of relationship).

Table 18a Overview of the Estates-HIA data provided by the CNPA. The data for each estate were split into two types: dwarf shrub heath (DSH) and blanket bog (BB) for analysis. Two types of calculation were produced: % plots, by browsing class, based on (i) arithmetic average and (ii) un-weighted average. The un-weighted average took account of differences in sampling intensity and sampled area between the different estates that contributed data, and is considered to provide a less biased reflection of impact levels as a whole. That said, coverage varied markedly - some DMG's have data for all estates whereas others only have data for selected estates.

		% Plots: Dwarf shrub heath						% Plots: DSH		% Habitat sampled: DSH	
Area	**Mean**	L	LM	M	MH	H	All	L	LM-H	Sampled Estates	Entire Area
Cairn's & Spey DMG	Arithmetic	84%	7%	6%	3%	0%	100%	**84%**	16%	85%	**37%**
E Gramp's DMG's: ALL	Arithmetic	66%	2%	17%	1%	14%	100%	**66%**	34%	100%	**50%**
W Gramp's DMG	Arithmetic	41%	23%	20%	7%	8%	100%	**41%**	59%	100%	**79%**
Cairn's & Spey DMG	Weighted	79%	6%	11%	4%	0%	100%	**79%**	21%	85%	37%
E Gramp's DMG's: ALL	Weighted	72%	1%	16%	1%	10%	100%	**72%**	28%	100%	50%
W Gramp's DMG	Weighted	26%	39%	18%	12%	5%	100%	**26%**	74%	100%	79%
		% Plots: Blanket bog						% Plots: BB		% Habitat sampled: BB	
Area	**Mean**	L	LM	M	MH	H	All	L	LM-H	Sampled Estates	Entire Area
Cairn's & Spey DMG	Arithmetic	92%	4%	3%	0%	1%	100%	**92%**	8%	78%	**38%**
E Gramp's DMG's: ALL	Arithmetic	92%	0%	7%	0%	1%	100%	**92%**	8%	52%	**27%**
W Gramp's DMG	Arithmetic	48%	26%	10%	3%	14%	100%	**48%**	52%	95%	**90%**
Cairn's & Spey DMG	Weighted	90%	4%	4%	0%	2%	100%	**90%**	10%	78%	38%
E Gramp's DMG's: ALL	Weighted	84%	0%	13%	0%	3%	100%	**84%**	16%	52%	27%
W Gramp's DMG	Weighted	31%	44%	12%	3%	10%	100%	**31%**	69%	95%	90%

Table 19 Overview of SNH-HIA results for surveys undertaken in recent years on designated sites, and their environs, within the CNP. Surveys at Caenlochan involved two approaches: (i) use of HIA on a pre-established network of random quadrats and (ii) use of a new grid-based systematic sampling framework based on 200 plots across a wider area than the designated site itself. Surveys in the Cairngorms SAC extended across the entire site. Other habitat types were sampled, but for the purposes of this report only DSH and BB habitats are present (in line with the BPG approach).

CAENLOCHAN SECTION 7 AREA

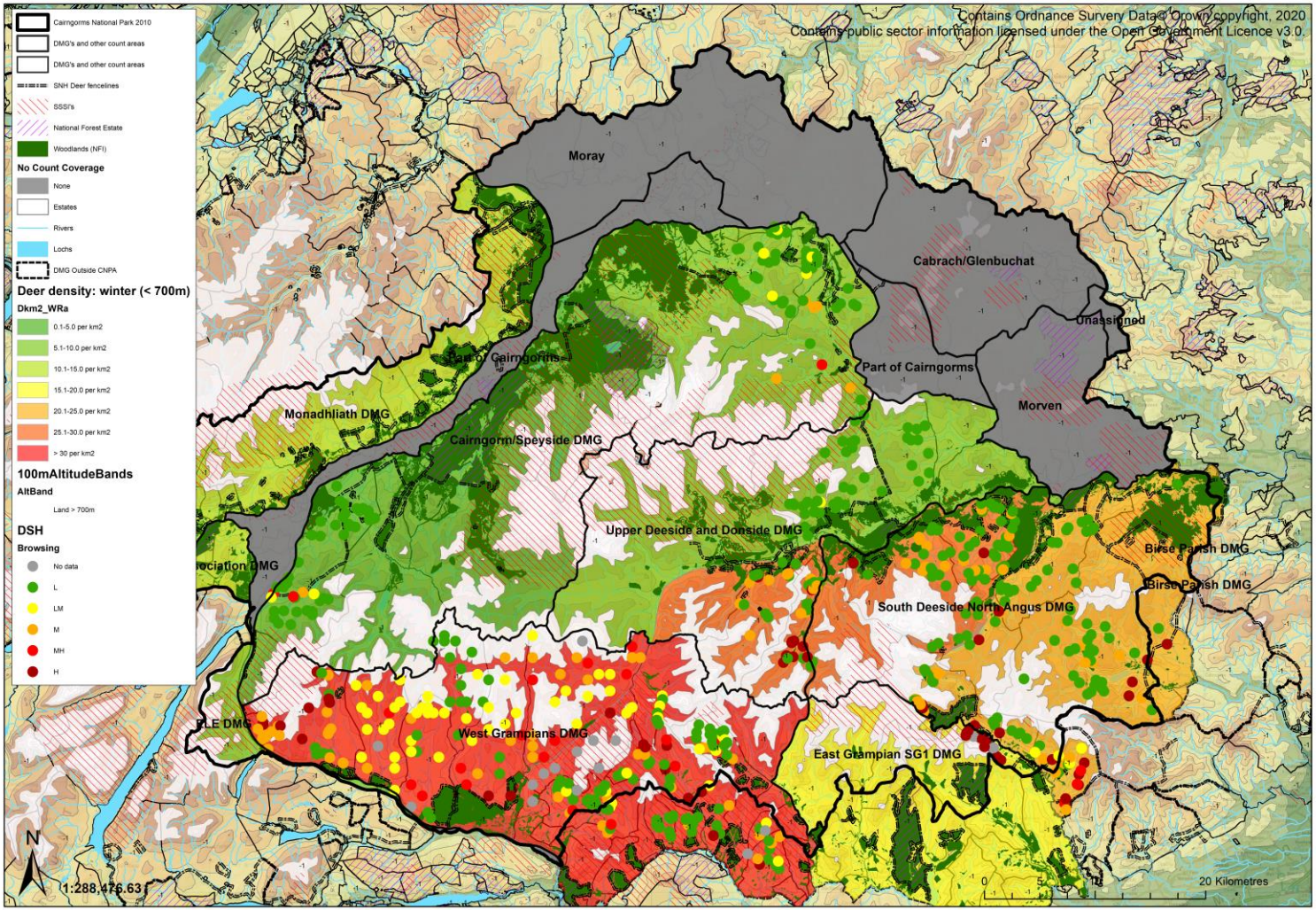
		% Plots: Dwarf shrub heath						% Plots: DSH	
Area	**Mean**	L	LM	M	MH	H	All	L	LM-H
Caenl' Sect 7 - 2018 - random	Arithmetic	0%	26%	47%	21%	5%	100%	**0%**	100%
		% Plots: Blanket bog						% Plots: BB	
Area	**Mean**	L	LM	M	MH	H	All	L	LM-H
Caenl' Sect 7 - 2018 - random	Arithmetic	6%	14%	33%	39%	8%	100%	**6%**	94%
		% Plots: Dwarf shrub heath						% Plots: DSH	
Area	**Mean**	L	LM	M	MH	H	All	L	LM-H
Caenl' Sect 7 - 2018 - grid	Arithmetic	9%	28%	41%	4%	19%	100%	**9%**	91%
		% Plots: Blanket bog						% Plots: BB	
Area	**Mean**	L	LM	M	MH	H	All	L	LM-H
Caenl' Sect 7 - 2018 - grid	Arithmetic	4%	7%	14%	61%	14%	100%	**4%**	96%

CAIRNGORMS SAC

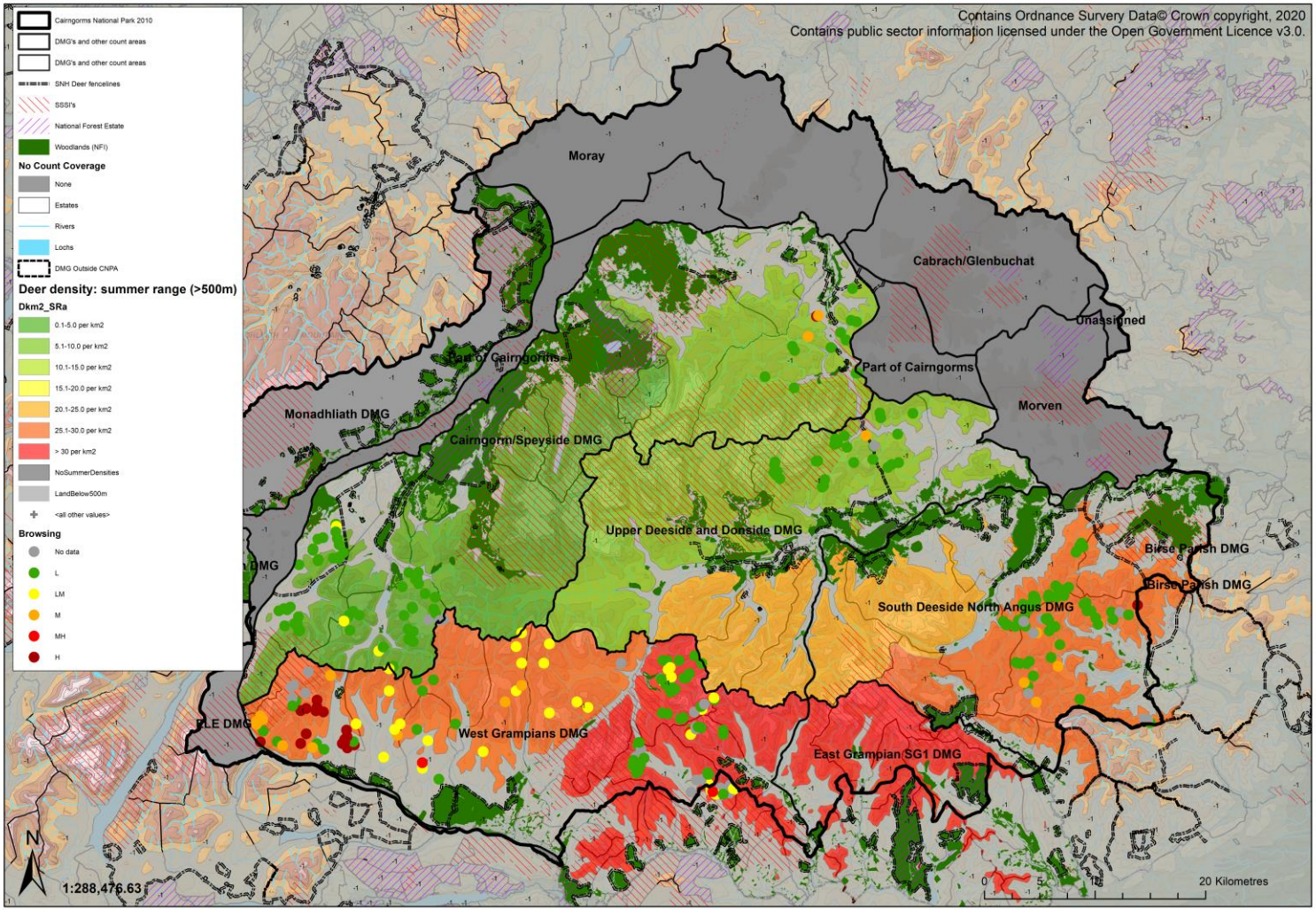
		% Plots: Blanket bog						% Plots: BB	
Area	**Mean**	L	LM	M	MH	H	All	L	LM-H
Cairngorms SAC - 2015	Arithmetic	72%	6%	10%	3%	10%	100%	**72%**	28%

Table 18b Breakdown of the Estates-HIA data provided by the CNPA, as summarised in Table 18.

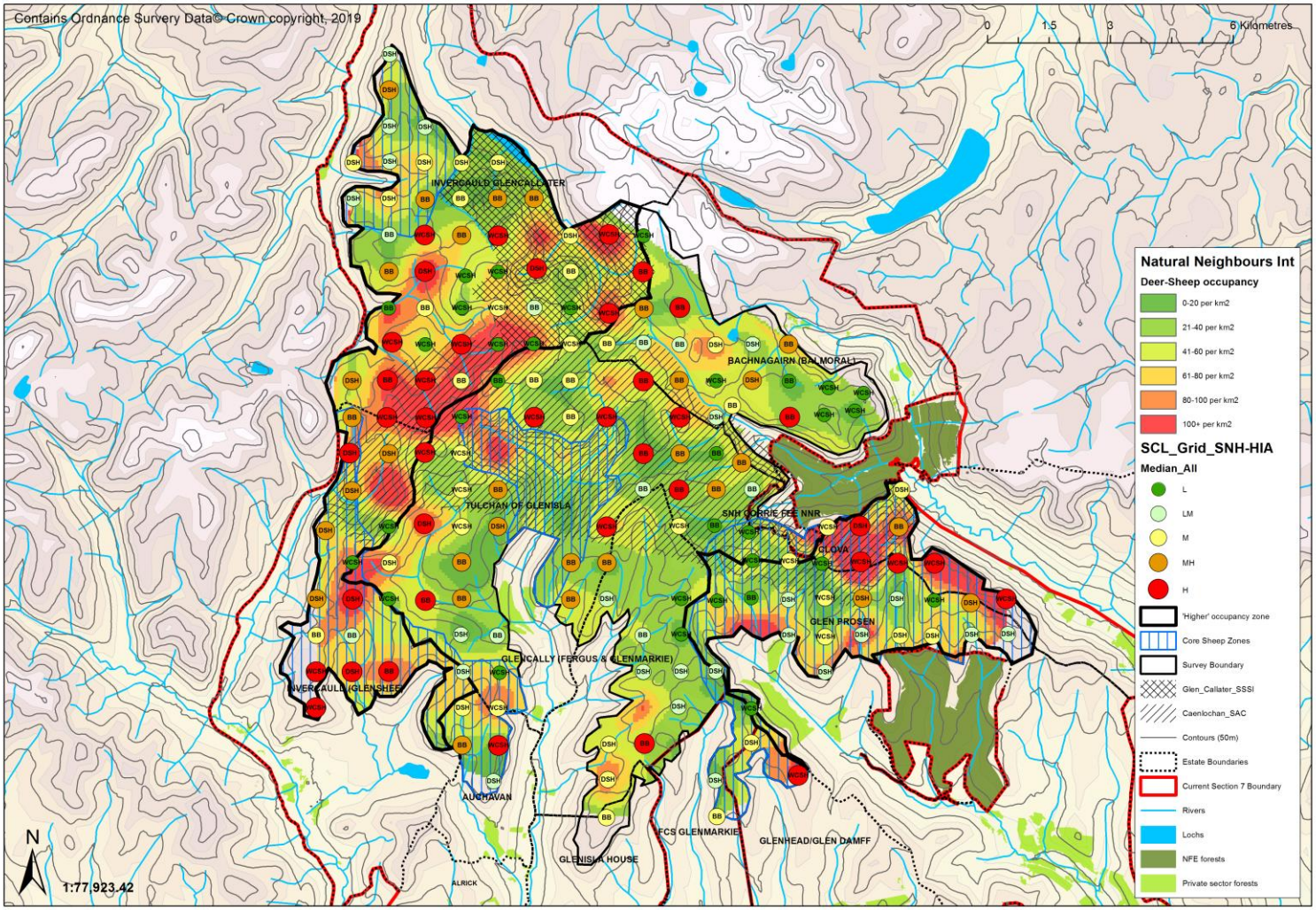
					% Browsing: DSH										% Browsing: BB						
Area	Estate	DSH Plots sampled	DSH Area ha	% DSH area sampled	L	LM	M	MH	H	No data	All (excl. No Data)	BB Plots sampled	BB Area ha	% BB area sampled	L	LM	M	MH	H	No data	All (excl. No Data)
Cairngorms & Speyside DMG	Delnabo	10	534	4%	8	2					10		304								0
Cairngorms & Speyside DMG	Dorback	28	3,188	21%	25	3					28		1,594								0
Cairngorms & Speyside DMG	Gaick		2,567								0	30	2,760	31%	25	2				3	27
Cairngorms & Speyside DMG	Glenavon	15	6,218	42%	9		5	1			15	15	4,305	48%	12		2		1		15
Cairngorms & Speyside DMG	Phones	30	3,498	23%	25	2	1	2			30	30	1,837	21%	29	1					30
Cairngorms & Speyside DMG	Ralia	16	1,495	10%	16						16		594								0
Cairngorms & Speyside DMG	ALL (sampled)	99	14,933	100%	83	7	6	3	0		99	75	8,902	100%	66	3	2	0	1		72
Cairngorms & Speyside DMG	% Plots by class				84%	7%	6%	3%	0%		100%				92%	4%	3%	0%	1%		100%
Cairngorms & Speyside DMG	**% Plots (de-weighted)**				**79%**	**6%**	**11%**	**4%**	**0%**		**100%**				**90%**	**4%**	**4%**	**0%**	**2%**		**100%**
East Grampians DMG's: SDNA	Abergeldie	37	2,543	6%	29		7		1		37		696								0
East Grampians DMG's: SDNA	Bachnagairn (Balmoral)	22	1,929	4%	10		10		2		22		772								0
East Grampians DMG's: SDNA	Balmoral	37	7,779	18%	25		9		3		37		2,603								0
East Grampians DMG's: SDNA	Clova	23	1,990	4%	7				13	3	20		45								0
East Grampians DMG's: SDNA	Glen Muick	22	3,512	8%	22						22	32	739	10%	32						32
East Grampians DMG's: SDNA	Invermark	38	9,752	22%	28		6		4		38	38	6,110	80%	25		5		1	7	31
East Grampians DMG's: SDNA	Rottal	20	2,290	5%	3	4	5	3	5		20		327								0
East Grampians DMG's: UDD	Invercauld (Baddoch)	29	1,980	4%	14		5		10		29		798								0
East Grampians DMG's: UDD	Invercauld (Corndavon)	10	3,362	8%	10						10		1,160								0
East Grampians DMG's: UDD	Invercauld (Home Beat)	31	5,684	13%	30	1					31	30	788	10%	28		1			1	29
East Grampians DMG's: UDD	Mar Estate	15	3,531	8%	8		6		1		15		534								0
East Grampians DMG's: ALL	ALL (sampled)	284	44,354	100%	186	5	48	3	39		281	100	7,637	100%	85	0	6	0	1		92
East Grampians DMG's: ALL	% Plots by class				66%	2%	17%	1%	14%		100%				92%	0%	7%	0%	1%		100%
East Grampians DMG's: ALL	**% Plots (de-weighted)**				**72%**	**1%**	**16%**	**1%**	**10%**		**100%**				**84%**	**0%**	**13%**	**0%**	**3%**		**100%**
West Grampians DMG	Ashintully	10	970	4%	5	1	3		1		10		0								0
West Grampians DMG	Atholl	104	13,677	53%	20	42	15	12	3	12	92	29	9,740	61%	6	18	3	1		1	28
West Grampians DMG	Balvarran	6	381	1%	2	1	1			2	4		64								0
West Grampians DMG	Dalmunzie	25	504	2%	17	4	3	1			25	10	571	4%	6	1		1		2	8
West Grampians DMG	Dalnacardoch	31	2,264	9%	5		18		8		31	35	2,829	18%	7		7		16	5	30
West Grampians DMG	Fealar	10	1,795	7%	4	4				2	8	30	1,878	12%	21	6				3	27
West Grampians DMG	Glenfearnate	30	2,646	10%	13	2	4	3	8		30	30	899	6%	15	5	1	1		8	22
West Grampians DMG	Lude	30	2,092	8%	19	4	5	2			30		477								0
West Grampians DMG	Straloch	6	835	3%	5		1				6		79								0
West Grampians DMG	Tarvie	10	574	2%	10						10		245								0
West Grampians DMG	ALL (sampled)	262	25,739	100%	101	58	50	18	20		247	134	15,917	100%	56	30	11	3	16		116
West Grampians DMG	% Plots by class				41%	23%	20%	7%	8%		100%				48%	26%	10%	3%	14%		100%
West Grampians DMG	**% Plots (de-weighted)**				**26%**	**39%**	**18%**	**12%**	**5%**		**100%**				**31%**	**44%**	**12%**	**3%**	**10%**		**100%**



Map 6a Estates-HIA data for dwarf shrub heath (overlain for reference on winter range deer density polygons, see Map 5d, given most of the heathland sampled lies at low to middle altitudes in the CNP).



Map 6b Estates-HIA data for blanket bog (overlain for reference on summer range deer density polygons, see Map 5d, given most peatland lies at higher altitudes in the CNP).



Map 6c SNH-HIA data for dwarf shrub heath and blanket bog (mixed in with other habitats – see key) gathered on a systematic sampling grid at Caenlochan in autumn 2018 (overlain on a summer deer/sheep occupancy model, obtained using dung counting and a Natural Neighbours interpolation in ArcGIS).

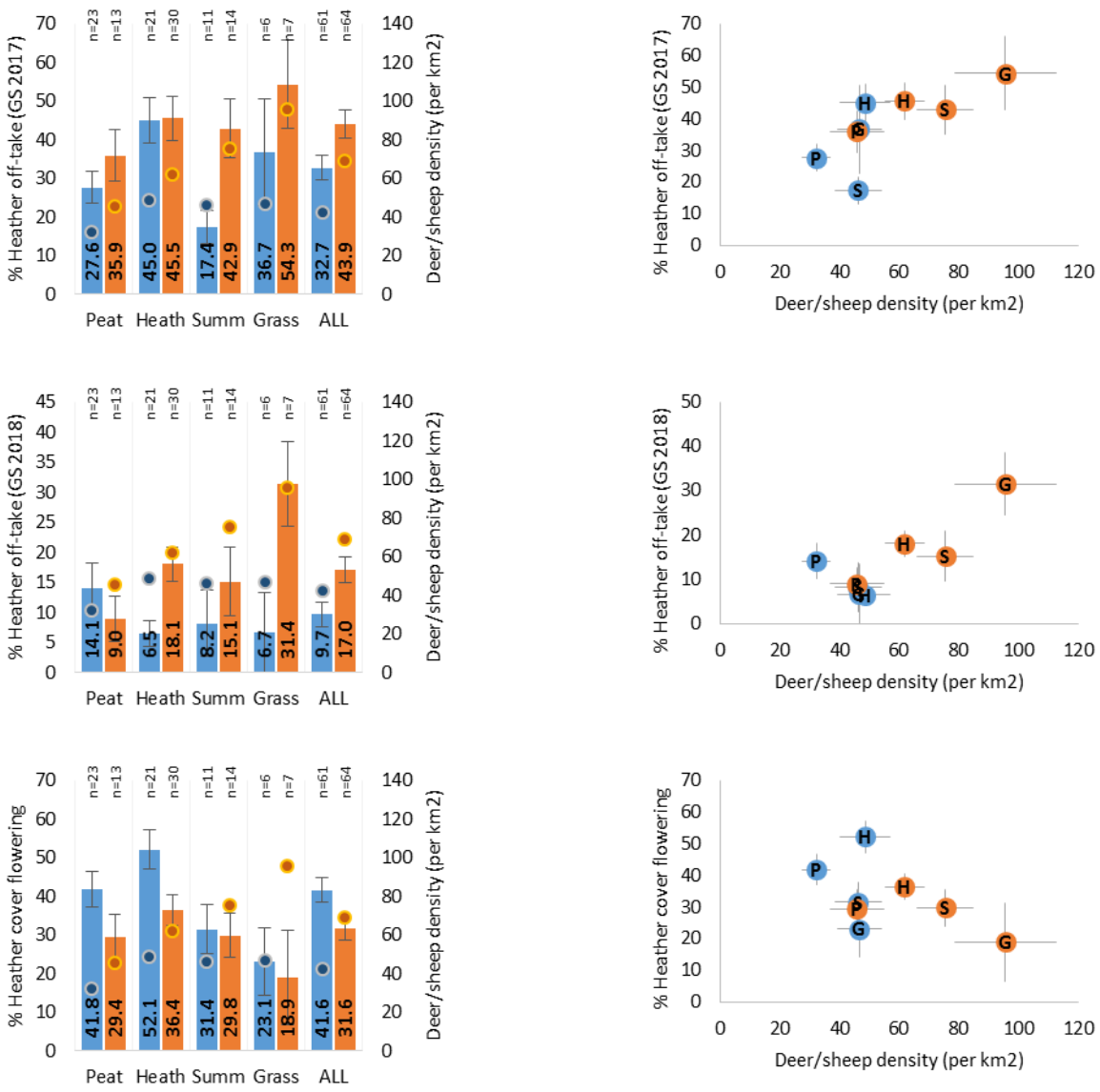


Figure 3 Quantitative impacts on heather recorded in the Caenlochan survey area in 2018, in tandem, with execution of the SNH-HIA surveys: mean % off-take of long shoots from the 2017 growing season (upper graphs), for growing season 2018 to date (middle graphs) and mean % plant canopy in flower in autumn 2018 (lower graphs). Blue = Lower occupancy zone and orange = higher occupancy zone (see Map 6c).

Notes: Left-hand column: bars display the main variate (+/- 1 Standard Error SE), the dots show the deer-sheep occupancy level and upper labels confirm the sample size of transects in the analysis. Right-hand column: scatter diagram showing relationship between the variate measured (+/- 1 SE) and the deer-sheep occupancy level (+/- 1 SE) in that habitat/zone combination. Peatland = P, Heathland = H, Summit communities = S and Grassland = G. Standard errors (SE) shown for deer-sheep occupancy in the right-hand column relate to pellet group density and not animal density. General note: sample sizes for Grassland are small so the results obtained should be treated with considerable caution.

INTERPRETATION

CONTEMPORARY DEER COUNTS

72. The Cairngorms National Park is an extensive area of farmland, forest, moorland and montane habitat centred round the Grampian Mountains in north-eastern Scotland. Around 16% of the area comprises mapped woodland. The vast majority of the rest is open range land used primarily for rough grazing, deer stalking, grouse shooting and recreation.

73. SNH runs an annual national helicopter count program focused on the open range areas, which includes land within the CNP. In recent years this program has covered 68% of the CNPA land area. The area counted includes all of the open range habitat within the park, with the exception of land in the east and north:

    a) Two surveys covered the vast majority of the open range area within 12 months of each other: the West Grampians DMG area, the Cairngorms and Speyside DMG area and the Upper Deeside & Donside section of the East Grampians were counted in 2016; the balance of the East Grampians DMG's were counted in 2017. With all else equal, these counts provide a relatively reliable basis for deriving a contemporary estimate of open range red deer numbers within the park as a whole.

    b) More recent counts of select parts of these same areas are somewhat less useful, when estimating contemporary abundance in the CNPA as a whole, because of the potential for significant numbers of deer to move in or out of them.

    c) Counts of the peripheral areas to the west (i.e. the Mid-West Association DMG, East Loch Ericht DMG, Monadhliath DMG) are arguably less reliable also. This is because the area lying within the CNP is small, and yet the deer populations in the small areas counted are highly mobile. It is difficult to be sure that the deer counted at the time are always present within the sub-set of the range counted.

74. The average density of deer in the CNPA in the spring of the relevant count years (2016-2019), in the areas counted, was approx. 11.5 per km^2 (35,175 red deer in 306,209ha). With a conservative level of recruitment added on to this figure[16], the density might have risen in the summer following counting to an average of approx. 12.5 per km^2 (37,874 red deer within the same area). However:

    a) These figures exclude any roe deer, fallow deer or sika deer present within the open range at the time of the counts. The overall deer density on the open range at the time of the count would thus, with all else equal, be underestimated.

[16] 35 new calves born in summer for every 100 hinds present.

b) The figures quoted relate only to those areas of open range area that were counted. Considerable areas of open range are not counted in the east, north-east and north of the park. The 2018 count of the Cabrach – albeit it was mainly undertaken in areas out with the CNPA - showed there were considerable numbers of red deer present therein. Therefore, there may also be considerable populations of red deer using the open range areas to the east and north-east of the park that have not been counted to date by SNH.

c) The main count data sets referred to were not captured in the same year. One potential issue is that a net flow of deer may have occurred from one count area to another, or *vice versa*, over the 12-month period between counts.

d) Moreover, the peripheral areas included within the western DMG's (e.g. Mid-West Association) include small mobile populations, hence the count figures on the day may not be entirely representative of population density generally. In the case of the Monadhliath count of April 2019, one of the components of the estimate, the weather had been atypically warm in the lead up to the count and deer had started moving to higher ground. A more typical, and hence comparable, winter or spring count may well have yield a higher density.

e) Crucially, it is also likely that densities of deer have changed in the period *since* the most recent landscape-scale counts were undertaken. Densities may have gone up or gone down due to culling pressure, due to natural mortality events or both. Perhaps the best example of this problem is the Caenlochan area where owners took a much larger than normal hind cull in 2018-19 following the results of a new count (this had suggested the population had grown considerably over a few years). However, not all of the local cull data needed to bring the counts fully up to date was available at the time of data being analysed for this report.

f) The available data are from spring helicopter counts, undertaken at a time of year when deer numbers are at or near their lowest ebb. However, late spring mortality can reduce them further, and also the annual cull may not be entirely complete when counts are undertaken. That said, the annual influx of new calves is yet to arrive at the time of the count. In a typical year, and on much of the area, the spring count might be expected to be a slight over-estimate of the final population at the end of the annual cycle but a distinct under-estimate of peak numbers in the early summer after calving.

75. Irrespective of the range of potential biases evident in the open range red count data presented, and how they balance out, the average density of red deer on open range across the CNPA area as whole is not a particularly useful statistic to quote. This is because wide regional and local differences in density are apparent when the data are examined in more detail:

    i) In general, densities of open hill red deer are relatively low in the north-west section of the park, albeit local variations are apparent. In

comparison, open hill red deer densities are relatively high in the south and south-east sections of the park. However, local variations are also apparent within these areas. There is no data available for the north-east section of the park but it is possible that high density populations exist locally.

ii) Specifically, the way the open range red deer density is calculated also has a bearing on how the data are interpreted:

(1) The mean spring density of deer in the latest set of landscape-scale helicopter counts was ~11.5 per km^2 (~12.5 per km^2 including summer recruitment). However, when this figure is broken down it is apparent that regional densities varied from 4.0 – 20.0 per km^2.

(2) Moreover, if spring densities are calculated for the core *winter range only* (i.e. for all land < 700m) then the average spring density across the CNPA area was in fact 16.3 per km^2 (range 6-30 per km^2 regionally).

iii) If these same data, having been inflated to allow for recruitment in the following summer, are used with the approximate core *summer range only* (i.e. mainly land > 500m) then the average density (including calves) in the areas as a whole was closer to 19.4 per km^2 (range 7-34 per km^2 regionally).

iv) Local deer densities are an important driver of ecological processes such as the rate at which naturally-regenerated tree seedlings grow and the size to which dwarf shrubs can grow.

76. Moreover, given the SNH count program focuses on open range there is no park-wide source of data available to estimate deer densities in woodlands (or associated farmland in the lowlands). If the figures for woodlands and farmland, where densities are potentially higher on average given the evidence available in the cull returns, were added in to any CNPA-wide estimate of density then the figure would likely increase.

77. Dung counting undertaken across a range of property types in the CNPA area, albeit mainly in the Western Cairngorms, can help us to understand something about the woodland areas not covered by helicopter counts:

a) Densities appear to vary widely across the areas studied to date, albeit with much of the variation appearing to be related to the intensity and duration of deer culling undertaken locally in each area.

b) Summer densities in the range 5-25 per km^2 have commonly been recorded, across all species combined, in wooded areas. That said, woodland densities in the upper half of the range appear to be somewhat more common across the CNPA as a whole.

c) It is also important to understand that estimates derived from dung counting have a lower level of confidence than open range counts (which are census based, albeit still potentially somewhat error prone). Dung count estimates of deer abundance often have a 95% Confidence Interval of +/- 25-40%.[17] Long term studies have tended to show that, following heavy culling for a number of years, densities tend if anything to be towards the upper end of the limits calculated. This may be because recruitment rates are commonly under-estimated (from cull records), because the sex ratio of the population is not equal (i.e. may have more females present), because of inwards immigration (common from open range, or other lightly-culled high density areas, into woodlands) or because the count method has inherent inaccuracies. A key potential inaccuracy arises from the need to employ an estimated rate of deer defecation in calculations. As the method is sample based, as opposed to being a census, sampling error itself is also a potential issue - low sample sizes produce less precise estimates than surveys using larger sample sizes, hence surveying larger areas with more transects produces better results.

78. As with dung counting studies, the cull records available from SNH can also help us to understand something more about deer population dynamics in the CNPA area as a whole:

    a) It appears that there are considerable populations of the other species (roe mainly, but also fallow and sika deer) present in the woodlands and farmland of the park. There also appear to be considerable populations of red deer in these areas. Moreover, there also appear to be considerable populations of roe deer using open range land – at least for part of the time – along with sporadic fallow and sika deer.

    b) 29.1% of deer are shot within the woodlands and farmland of the CNPA area. 22.9% of all deer shot in the CNPA area are roe deer, fallow deer or sika deer and not red deer. Overall, approximately 39% of all deer shot in the CNPA area either:

        i) Relate to species not surveyed by helicopter at all (roe deer, sika deer, fallow deer) or;

        ii) Are shot in areas (e.g. the north-east part of the CNPA) or in habitats (e.g. woodland, lowland farmland) not surveyed by helicopter.

79. Cull densities can be calculated using cull records and spatial data, to help us to understand yet more about deer population dynamics in the CNPA area:

    a) On average, 60% more deer are culled per unit area annually in woodlands (5.4 per km^2) than on farmland/open range (3.4 per km^2). This could indicate that deer densities are, on average, genuinely higher in the woodlands of the

[17] On the other hand, the precision of the pellet group density data used to derive abundance estimates is much better (95% CL's typically +/- 5-20%). These data provide a very powerful monitoring tool even though abundance estimation using them is more challenging.

CNPA as a whole. However, there are other factors that could contribute to the observed pattern - whether in isolation or combination – such as:

i) Culling is simply more intense due to the need to protect valuable timber crops.

ii) Immigration may occur from the open range in winter (e.g. when fences are breached by drifting snow).

iii) Recruitment rates are higher meaning a higher % of the population needs to be culled each year, even if the populations are numerically the same size prior to calving.

b) Woodland populations certainly appear to be more fecund than open range populations, as a general rule, given the evidence in the cull records. An average of 41 juveniles are culled annually per 100 adult females in woodlands compared with 32 on open range.

c) Surprisingly, red deer appear to be as fecund (or even slightly more so) as roe deer even in woodlands. In most of the woodlands SCL studies across Scotland, roe deer would be expected to produce more young than red deer. The reasons for this difference in the CNPA cull records are not entirely clear at this juncture. It may relate to differences in deer density, or to differences in the way some stalkers target hind-calf pairs for culling etc.

d) Open range fecundity appears to vary markedly between the different regions within the CNPA, based on the cull records provided. Red deer recruitment rates in the open range areas of the West Grampians, for example, appear to be more much lower (~20%) than those of open range red deer in the far eastern and north-eastern areas (~40%). That said, count data suggest there is much less variation than this (30-40%).

80. Whilst the cull records provide some potentially useful insights, they come with some significant caveats:

a) Not all areas of CNPA covered (SNH estimates 90-95% of land area is covered annually by returns).

b) Some records include parts of estates that lie out with park boundaries.

c) Some estates do not provide a record every year (e.g. due to administrative problems).

d) Deer die of other causes too (e.g. natural mortality, deer vehicle collisions, poaching) which are additive (i.e. more die each year than are culled, and all deaths ultimately contribute to regulation of the population in the long-term).

e) Stalkers might select deer to cull in different ways. In woodlands, the tendency will be to shoot ‘on sight’ more often – this is likely to result in a

more representative cull of hinds and calves taken. On the open range, more selective practices are likely to be adopted in places.

HISTORIC POPULATION TRENDS

81. Various historic analyses have been presented in this report: as well as the analysis of long-term deer cull records, a review of historic deer count data was also undertaken. Both of these data sets were then brought together to help parameterise a set of deer population models covering the period 2005-2017. The value of all these outputs lies in their ability to shed light on how the dynamics of open hill red deer populations within the CNP have varied over time, which could in turn help us to better predict likely changes in population dynamics in the future.

82. Population densities of red deer generally appear to have been at their lowest in the CNP in the 1960's, rising to a peak in the late 90's to early 2000's. However, in the period since they have declined.

    a) The rise in populations seemed to occur over a similar period of time in all three regions analysed, but the rates of increase varied somewhat. In part this was likely due to each area having a distinctly different density at the outset. However, it may also in part be due to culling policies operating at that time (records were not made available this far back, so it is not possible to be sure).

    b) The rate of decline has also varied between regions, presumably in large part because of the marked differences in the level of culling activity locally.

83. Under the assumption the counts of the 1960's and the present day are equally accurate, which is not possible to test robustly, it would appear that deer densities were ~ 40% lower in the Cairngorms & Strathspey DMG section of the CNP in 2016/17 than in the mid-1960's whereas they are now 10% higher in the East Grampians section and ~ 30% higher in the West Grampians DMG section. However, overall densities are now ~ 10% lower in comparison with the 1960's count data. That said, relative to the *peak* recorded densities (mid 1990's to early 2000's in each region) a marked decline appears to have occurred in all areas (60% in C&S, 23% in EG and 19% in WG; 25% less overall).

84. Regional deer densities have consistently remained highest in the West Grampians DMG section of the park (spring values across the entire range of 15-25 per km^2) throughout the period counts have been undertaken, whilst remaining lowest in the Cairngorms & Speyside DMG section (4-10 per km^2). That said, densities vary widely at the sub-regional scale (< 5 per km^2 to > 30 per km^2). Areas of seasonally high or very high local density (> 50 per km^2) can in fact be found locally in parts of all the regions.

85. Population models built to understand regional population dynamics in more detail yielded some potentially useful insights also:

a) In the core area, which includes all three regions (Cairngorms, East Grampians, West Grampians) merged into one, it was reasonably easy to create a balanced model for the period 2005-2017. This implies the vast majority of deer reside permanently within the modelled area. Population density was shown, via deer counts, to have declined gradually over the period. Reasonable agreement was obtained by modelling using a suite of parameters generated from count and cull data, where available, and otherwise estimated within realistic biological limits. That said, the model predicted a faster decline - followed by a longer period of relative stability – when compared to the trend in count data. Further work on model parameters, explored in consultation with local estate staff and NS staff, might be expected to improve the level of agreement because the model used a static annual recruitment rate which, in effect, ignored annual variations in birth rates/natural mortality rates despite them being likely.

b) However, when the model for the Entire Area was divided into three regional models (Cairngorms & Speyside, East Grampians, West Grampians) the models failed to balance when compared to the repeat deer count data. Some regional models ran out of deer rapidly whilst others yielded exponentially expanding populations[18]. The regional models used most of the same parameters as the main model, with variations only introduced to reflect differences in the initial adult sex ratio and long-term recruitment rate apparent from the records provided. These outcomes may be the result of poor regional model parameterisation, but it is thought that flows of deer between regions are also likely - at least in part - to be responsible for the lack of agreement between predicted abundance in models and actual counts undertaken.

c) Major changes in deer management are known to have occurred over the modelling period, including a sequence of very large culls being taken in some locations in the mid to late 2000's and erection of new strategic deer fences in other areas. These changes could have driven net inflows of deer from one region to another. The unexpected modelling results could be explained in a number of different ways. Differences in the level of culling pressure could lead to a number of changes arising. In some parts of the modelled area, heavy culling will have caused densities to decline rapidly – the vacated grazings might later on have become re-occupied by other animals from higher-density areas in the wider environment that found the vacated grazings more attractive. Equally, heavy culling pressure could have changed the distribution of deer regionally – some deer may have permanently moved, or otherwise had their seasonal movement patterns disturbed. Patterns of recruitment might also have changed; in the short-term, social structures may have been disrupted and birth rates declined in high density culling areas, whereas in the long-term rates may have risen as a result of reduced densities and improved grazing therein.

[18] Carrying capacity was not incorporated into the models, whereas in reality this would quickly act to slow then halt such increases.

d) One final point to consider is the primary aim of the modelling presented herein. Modelling was undertaken in order to explore whether trends observed in the historic count records tallied with the patterns of historic culling and recruitment at two different spatial scales. The intention of the models was not to generate an accurate prediction of how many deer are now present in 2021. A different exercise would need to be undertaken to generate such figures, but this activity is out with the scope of this report

IMPACTS OF DEER ON OPEN RANGE HABITATS

86. The scope of this report was extended in autumn 2020 to include compilation and review of available data on the impacts of red deer on key open range habitats. In extending the scope of the work the CNPA was interested to see how impact levels varied (i) across the park generally as well as (ii) specifically in relation to deer density.

87. Two main sets of data were reviewed: HIA data gathered by SNH contractors using the methods of MacDonald *et al*, and HIA data gathered by the estates/contractors using Best Practice Guidance protocols. Some additional data gathered for SNH at Caenlochan, as it is the most recent major open range habitats study, was also considered.

88. Geographic coverage of the CNP was most complete in the estate-based data, with the other data sets providing local information only. That said, even the estates data still only covered part of the red deer range. Also, more estates data were available for the dwarf shrub heath habitat than for blanket bog. Moreover, the estates-based data (2017-19) and Caenlochan data (2018) were the only relatively recent data gathered over the period relevant to the analysis of count data; the only other SNH data gathered in recent years was for the Cairngorms SAC in 2015.

89. The available Estates-HIA data suggest that recorded levels of impact vary markedly within and between areas. Whilst coverage is not complete enough to provide entirely robust statistics for all the three regions covered, the available data suggest that impact levels are highest in the West Grampians and lowest in the Cairngorms & Speyside DMG area with intermediate levels of impact recorded in the East Grampians as a whole. That said, survey coverage in the latter two areas is relatively limited meaning the statistics derived therein need to be treated with considerable care. Further caution needs to be exercised as it is unclear from the records supplied how % browsing on heather was actually assessed on each estate (i.e. was it by looking at fresh growth, or the previous years' growth?).

90. The SNH-HIA data typically show higher levels of impact present, but the sites assessed are not directly comparable to the Estates-HIA data set. The Caenlochan survey site is much smaller than those areas covered by the regional statistics; the Cairngorms survey site is larger but the overlap with the estates-based HIA is limited. Moreover, the method employed in the SNH surveys is

markedly different to that employed by the estates - and the timing of the SNH Cairngorms survey is also very different.

91. The detailed additional data gathered at Caenlochan by SCL on behalf of SNH in 2018, albeit it is obtained from a relatively small area, is helpful in confirming that impacts locally can be high within the CNP area even if impacts regionally are on average lower. In addition, the Caenlochan data provide a useful contrast as they are gathered using a different system:

    a) The main analysis in this report employs helicopter-based winter counts of red deer on the open range, which confirm the distribution of deer on the day in question. They are compared with impact data typically gathered in summer conditions – normally in a different year. The impact data are placed into browsing 'classes' (e.g. L, M) which are very broad (e.g. L = 0-33%, M = 34-66%).

    b) The Caenlochan data set is gathered from a common sampling framework (fixed point trabnsects) and relate to a similar period of time in the year. The dung count data set covers most or all key mammalian herbivores (all deer species, sheep, hare; in the example presented herein hare are omitted). A wider range of impact data were gathered, including quantitative data. The data were gathered using a grid-based framework which provides more opportunities for spatial analysis. The quantitative data offer the chance to undertake analyses with markedly higher levels of sensitivity, compared to the class-based data, and this it should be easier to detect change between monitoring visits.

CONCLUSIONS

92. On the basis of the data available to the project, and in light of the analyses undertaken to date, we conclude the following on overall deer abundance and density levels with the CNP:

    a) Currently, there are insufficient data available to quantify the overall number of wild deer, the actual distribution of deer across all habitat types or the density of deer in each region of the CNPA with a high level of confidence.

    b) That said, on the basis of the data available currently - and given the range of caveats made clear within the body of the report - an attempt can be made to estimate a possible range of values:

        i) Population size in summer – lower end estimate[19]: ~50,000 (~11 per km^2).

[19] Density for all open range land set to be below the level calculated from available contemporary count data, to allow for the possibility that uncounted areas in the NE of the CNP have a markedly lower density (even taking into account non-red deer species, as well as recruitment of calves in summer). Woodland density set according to the typical level recorded in the Western Cairngorms as a whole, over the past decade, although culling has been relatively intense in these areas over that

ii) Population size in summer – upper end estimate[20]: ~80,000 (~17 per km^2).

Land Type	Area (ha)	Est. peak summer deer density per km^2 (incl. recruitment)		Estimated summer deer abundance (rounded)	
		Lower end	Upper end	Lower end	Upper end
Woodland	74,448	15	30	11,200	22,300
Open range / agric' / other	378,362	10	15	37,800	56,800
ALL	452,810	11	17	**49,000**	**79,000**

93. However, we would argue that accurately ascertaining the total abundance of deer in the CNP, and the mean density of deer present within it, are of relatively limited value to CNPA land managers. Rather, the emphasis should be placed on how population densities and dynamics vary across the CNP and why.

94. This study has shown that the dynamics of deer populations using the Cairngorms National Park appear to be highly complex:

    a) Marked historic changes in deer numbers, density and distribution have clearly occurred over the past 50 years. These changes have played a role in determining the present dynamics of the deer populations, at a variety of spatial scales.

    b) Considerable contemporary differences in population dynamics are apparent regionally (e.g. north vs south of the CNP), locally (e.g. glen to glen), between habitat types (open range vs woodland) and between deer species (e.g. red vs roe vs sika deer).

    c) These differences in the historic and contemporary dynamics of deer populations with the Cairngorms National Park are likely to have contributed to the present patterns of, and trends in, upland habitat condition across the region whether currently improving, stable or declining.

95. The extensive range of deer management data presented in this report has helped to shed some light on the ways in which deer population dynamics have changed over time, and how they might vary in future, within the CNP. However, considerable gaps in the knowledge base remain. In order to improve the CNPA's understanding of the number of wild deer, distribution of deer and density of deer within the park area – as well as the relationships apparent between herbivore density and impacts - a number of recommendations are made.

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time meaning that if anything densities in the wider area of CNP woodland may well be higher. Note: estimates in the tables are rounded.

[20] Densities in the uncounted area to the NE of the CNPA unlikely to be much higher than the historic peak of the recently counted areas (16 per km^2 before calving, in the early 2000's). Densities in the contemporary counted area may in recent years have declined slightly from 2016/7 albeit an extended analysis of cull data and extension of modelling is needed to ascertain this with certainty (records not all available at the time this analysis was undertaken in summer 2020). Woodland densities are often found to be as high as 50-60 per km^2 in unmanaged populations, more widely in Scotland, but a high proportion of the woodlands in the CNP are known to be culled to some extent.

RECOMMENDATIONS

COUNTS

96. Woodlands and associated agricultural land should ideally be given more prominence when planning deer abundance assessments across the CNPA in future:

    a) This is especially the case given that these are the places where economic damage to crops tends to occur.
    b) It is also where public safety concerns (e.g. vehicle-deer collisions, tick bites) are more likely to arise given the degree of interaction (i.e. high levels of recreation, majority of the road network etc)

97. Roe, sika and fallow deer should ideally be included in any planned assessments in future across the CNPA, whether via direct counting on the open range (possible in theory, albeit more time-consuming) or as part of dung counts (as already happens).

98. Assessments which systematically cover entire landscapes, irrespective of which land use and habitat type is present, would ideally be used anywhere that effective perimeter deer fences are absent around woodlands (and especially where woodland deer densities are suspected to be high). This is because it would reduce the risk of two separate assessment types (e.g. helicopter and dung counts) overlapping or underlapping significantly in time and space:

    a) Where enumeration of the deer population is the sole objective, and perimeter fences are present around major woodlands, helicopter or ground counts would be preferred over dung counts, on grounds of cost and accuracy, on open range sites.
    b) That said, if impact surveys are also needed by deer managers – an open range HIA, for example - then the choice is less clear cut. Helicopter count data would need to be complimented by a ground-based survey. A dung count can however be used to deliver an impact survey (e.g. an HIA) concurrently.
    c) Should wider survey data be needed also, then the choice is less clear cut again:
        i) Dung count techniques can also be used to assess the distribution and density of smaller mammals (e.g. mountain hare) or grouse species (e.g. red grouse, Capercaille). Additional data like this can help the manager identify places where hare grazing (for example) is important in comparison with deer grazing, or how deer density affects Capercaillie distribution.
        ii) When on the ground, other types of formal survey can also be combined with dung counts (e.g. peatland restoration feasibility, Site Condition Monitoring).

iii) Multi-faceted studies, involving many types of survey delivered at once, have recently been undertaken in the Western Cairngorms (CNPA) as well as at Caenlochan (SNH). These have delivered an increased level of insight to land managers, in particular on the relationship between deer occupancy level and the level of impact on a range of common habitat types. This is made possible by all the different forms of data being gathered in the same place at the same time, which normally does not happen.

99. Budgets available from public bodies such as SNH and CNPA or FLS might ideally be aggregated in future to maximise deer monitoring efficiency:

a) At the very least, future plans should be discussed between public bodies to identify potential synergies in the timing of different count activities.
b) Ideally any available private sector funding should be identified and combined with public budgets, where possible, to allow greater or more frequent coverage at reduced public cost.
c) Where grant aid is being provided to the private sector in relation to deer or livestock management more generally, this could also be considered in terms of CNPA-wide deer count planning (for example, Scottish Forestry offers grants for dung counting in woodlands where timber crops are being re-stocked and private owners wish to reduce deer densities to low levels).

100. Ideally, a multi-year program to assess deer abundance, distribution and density should be formulated so that all parties can contribute to its planning, if not also its funding and or execution, to maximise opportunities for synergy. Ideally, any such plan should seek to produce the most useful and most robust monitoring results possible – with the widest range of synergies delivered - for any given level of public investment.

101. Certain parts of the Cairngorms National Park might be considered priority over others, in terms of a multi-year count program, depending on what is considered important by the CNPA (and by its key stakeholders: e.g. SNH, FLS, private owners, 3rd sector owners, Police Scotland, National Farmers Union, Community Councils etc):

a) Habitats where less is known about the deer population could be prioritised, such as woodlands, to help ensure a clearer understanding is developed of park-wide deer densities as soon as possible. The same could be said for places where roe, sika and fallow deer are more numerous, given the relative lack of knowledge about them (albeit these species tend to be most numerous in woodland and on associated land anyway).
b) 'Time since last survey' is another factor to consider. If an area has never been counted, or not counted for a long time, this might be worthy of earlier inclusion in a new program.
c) Owner engagement is another key consideration. The CNPA must work with landowners to manage deer at a strategic scale within the national park.

Some owners may be keener to obtain data than others, for example because their area has no existing survey data or because the data they hold is 'out-of-date'. The CNPA may have a potentially important role to play here in helping co-ordinate larger-scale surveys (e.g. the recent one in the Western Cairngorms) where individual owners benefit from a wider survey but no individual is necessarily able to spend the time needed to organise it or find funding for it.

d) Prevention of damage by deer - as defined in the Deer (Scotland) Act - is an obvious consideration. Areas where significant concerns are being reported – or otherwise might be expected to arise - might be prioritised over others, with all else equal. This might include locations where vehicle-deer collisions or tick densities are relatively high, where damage to forest or agricultural crops is high or where woodland and open range habitats are in 'unfavourable' or otherwise 'declining' condition. It may also include areas which are 'sources' of deer which, from time to time, move onto other land and cause damage therein.

EXAMPLES OF AREAS WHERE NEW SURVEY WORK MIGHT YIELD USEFUL STRATEGIC INSIGHTS

- (1) Areas of open range in the east and north-east of the park, not currently counted by helicopter, may be useful to include in any future count program (see Map 4). Data would be relatively easy to gather, and would quickly 'complete the picture' in relation to red deer on open range within the CNPA. The woodlands in this area would also be useful to include in any future study (FLS will likely sample their land in the next 12 months). Being mainly deer fenced, to one degree or another, it is possible that dung counting could be used in isolation and then the results of the two types of survey combined. There are many agricultural and forestry interests in this area, hence the combined approach could be very useful.
- (2) Detailed studies of deer occupancy and impact levels have been recently undertaken in the Western Cairngorms (2018 & 2019) on woodland as well as associated open range. Woodland is expanding south from this area, hence it could be useful to study the land onto which woodland is expanding (or where expansion is otherwise planned). Land to the west of the current study area, in the Spey valley, should also ideally be included in a future survey program.
- (3) In 2019, a study of deer occupancy and impact levels on open range habitats was undertaken at Caenlochan. This study helped owners to quantify the relationships evident between deer occupancy and impacts, meaning that a progressive dialogue could be opened with SNH about how best to manage red deer on the site to deliver favourable condition on designated features. The open range land to the west of Caenlochan is part of the West Grampians DMG. It ultimately joins with the Western Cairngorms study area (see 2 above) and like Caenlochan contains several designated sites, as well as some farmland and woodland to the south. A similar piece of work could prove useful here, albeit that the area is easily counted by helicopter and hence it would depend on what other survey work might be undertaken in tandem to drive synergies.
- (4) Extensive areas of woodland exist along the A93 corridor from Aboyne to Braemar, including many areas of native woodland. There is also farmland present within this corridor. It may be that a landscape-scale dung-count survey of this area could prove useful.
- (5) West of the A93 corridor (see 4 above) lie a number of estates who 'march' with the Western Cairngorms area (see 2) and West Grampians area (3). This area might at some stage be assessed given there is a mix of woodlands and open range present, and plans are in place to expand woodlands markedly. A mix of approaches could be employed, or dung counts used solely, depending on the objectives and range of survey data desired.

CULLS

102. It would be useful to ensure in the future that all properties in the CNPA area return information on deer culls annually, whether or not they have applied for an 'authorisation' to shoot deer from SNH.

103. Cull data would be much easier to interrogate and analyse if it were digitised at property scale by SNH and made available to interested parties online.

104. Accurate division of the cull returns into the three main land use types (woodland, farmland and open range) should be encouraged across all ownership types, if exact location data are not provided, as analysis of this data provides potentially useful insights.

POPULATION MODELS

105. Local and regional population models could be developed using the count data obtained from a new multi-year count program, where not currently available. Examples of the types of model required have been presented herein. Such models could be used to help owners predict whether planned cull levels are sufficient to meet strategic-scale park objectives, as well as local objectives, at a range of spatial and temporal scales.

106. Each year, population models could be updated with new evidence as it comes to light (e.g. updated counts, new cull records etc). The results could be made available to all parties, as a form of 'common currency' for land management planning. This is currently done each year in the Monadhliath DMG area.

SUPPORTING STUDIES

107. Systematic records of the level of natural mortality (primarily winter-spring mortality) would be useful to obtain on an annual basis from across the park, to help ensure population models used for management planning are as accurate as possible.

108. Recruitment rates could usefully be estimated each year across the park, perhaps from questionnaires sent to local DMG's, for the same reason. Cull records could also be analysed, along with any evidence from new deer counts, to corroborate the findings when available.

109. Data gathered on potentially damaging impacts could usefully be compiled and analysed spatially for the CNPA area, in the same way that helicopter and cull data were for this report. This would include, for example: vehicle-deer collisions, agricultural damage, forest damage, data on the condition of native woodlands and additional open range impact data. Overlaying all the data – in tandem with HIA data already available - may yield greater insights into how the

deer population interacts with the (i) physical and biological environment of the park, as well as (ii) the human population living in and using it.

110. New data sets might also be usefully gathered as a compliment to the above process. The most obvious potential gap relates to the risk of catching Lyme Disease. Systematic sampling of ticks from culled carcasses from across the park could be organised, as well as being sampled directly during surveys in areas where culling is limited (if needed), and the results compiled annually to help monitor trends.

ENGAGEMENT WITH LAND MANAGERS

111. The current project has provided an indication of where substantive gaps in strategic information exist in relation to deer population dynamics in the Cairngorms National Park. It is evident that compilation of existing data, and new analysis of it, has been helpful in identifying the gaps for CNPA staff. However, new analyses such as these are most helpful if they are in turn used by land managers. Similarly, the gaps could only be filled if land managers are engaged in any subsequent process of information gathering catalysed by the CNPA. In the first instance, it would be useful for the CNPA to engage with land managers within the park to understand whether they also see the knowledge gaps identified in this report as being important to address, and if so how?

112. A raft of deer management plans were prepared, with SNH support, in the mid 2010's. Many are due to be renewed in the coming 12 months. The key findings of this report, and of any subsequent work that is catalysed by the CNPA and its stakeholders, may be useful to share with the key parties involved in future deer management planning at a local as well as regional scale.

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APPENDIX 1 – SNH HIA

The methods of MacDonald *et al* (1998) were originally developed to provide a rapid means of characterising land management impacts across large tracts of the Scottish uplands. The original method involved assessment of a variety of impacts including: herbivore grazing, herbivore browsing, herbivore trampling, land drainage/drying, muirburn and peat cutting. The assessment was undertaken for a range of broad habitat types – dwarf shrub heath, blanket bog, bracken etc – in recognition of the fact that some impacts only occurred in some areas, and also that impacts had different effects on each habitat.

The assessments were undertaken at two scales: landscape scale (Phase 1; using 'large scale' indicators) and local scale (Phase 2; using 'small-scale' indicators and 'trend indicators'). Phase 1 work was done by eye from a distance, or using binoculars, and helped the surveyor gain a general appreciation of whether land management impacts were noticeably high from a distance or not. They then proceeded, if required as part of the contract scope, to undertake a Phase 2 assessment.

The original method for Phase 2 was designed to be applied during a structure walkover to areas of homogenous habitat (more latterly to each 1 km square in a survey area). In each, the surveyor would assess 10 points (of c. $1m^2$) in each habitat type then record a result based on an average of the conditions they observed. Each area or (square) was assessed by the observer as 'Low', Moderate' or 'High' impact based on a range of indicators (e.g. level of browsing on heather, level of disturbance to bare peat etc). The aggregate result for each mapped area was arrived at from the most common of the indicator scores recorded (e.g. 5 indicators scored L, L, L, M, H so the most common was L). Most indicators related to current impacts (e.g. % heather long shoots browsed) but some related to longer-term impacts (termed 'chronic'or trend indicators e.g. growth form of heather plants present).

The result of the assessment would be a map, showing each area or square coloured according to the impact level assigned (e.g. High = red; Moderate= orange; Low = yellow). A map would either be produced for each habitat, or results integrated for all habitats. The idea was to produce an 'at a glance' picture of where impacts were highest on large sites. Whilst the original authors had suggested the system could, in principal, be employed to monitor sites the original design was not developed with this purpose in mind.

An evolution of the system occurred in the early 2000's when SNH began to deploy it on a fixed plot basis (typically 2x2m quadrats) when surveying 'Priority Sites' (in essence, designated sites with high deer densities). The idea was that observers could return to the same place several years after a baseline assessment and try to detect any difference in impact levels apparent. This revised approach was termed Herbivore Impact Assessment (HIA).

The approach commonly adopted was to use the Phase 2 assessment technique, but on a random set of ~ 30 fixed locations in each feature of interest (e.g. a set of 30 random quadrats in Wet Heath, a set in Flushes etc). The plots were photographed for follow up, and sometimes marked.

Subsequent iterations of the HIA approach, designed to improve the system further, involved:

1. Gathering additional 'quantitative' indicators' from the same plot. For example, the original 1998 system asked observers to categorise heather browsing as < 33% of shoots, 33-66% of shoots or > 66% (relating to L, M or H impact respectively). The quantitative system adds to the qualitative assessment and asks observers to record the actual % measured (e.g. 27%) so that a more refined analysis might later be undertaken and future change might be more likely to be detected.

2. Amending the methods for DCS 'Best Practice Guidance' publications, whereby the approach employed in the field was revised to make it quicker for estate gamekeepers to use (Best Practice Guides 2008).

A key issue with the HIA method (as with other open range methods) identified by the authors in the original text of 1998 is that the functional significance of many of the indicators used was not well understood. The response of heather to browsing by sheep and deer was heavily studied in the 1970's and 1980's, due to its importance for upland agriculture. Therefore, relationships between grazing off-take and heather cover, for example, were relatively well understood. However, the functional significance of other indicators such as the 'level of moss uprooting' were much less well understood. Attempts were made latterly to 'weight' the HIA analysis towards the 'better understood' indicators but ultimately SNH decided against this approach due to concerns over subjectivity in the choice of weightings used.

As the system of 'small-scale indicator' assessment is somewhat complicated, it is worth briefly explaining here how it works. The method, at the quadrat scale, involves an examination of a wide suite of indicators of Grazing or Trampling on each plot, assuming the plant (or physical feature) relevant to the assessment is present and hence the indicator is applicable. Each habitat type has its own set of 'small-scale indicators' and its own set of 'trend indicators'. Each indicator is assessed as being in one of three classes (Low, Moderate or High; sometimes there is an option to use LM or MH as intermediates). An example set for some of the Blanket Bog assessment has been copied below, from the original handbooks of MacDonald *et al* (1998) or interested readers to examine.

There are different ways of analysing the data, but common ways include using the most common or the middle class as a value for the plot (e.g. 15 Low values and 3 Moderate values from a plot would be classed as a Low score overall) for that plot. The data from each plot are often mapped, to assess spatial variations in impact, and

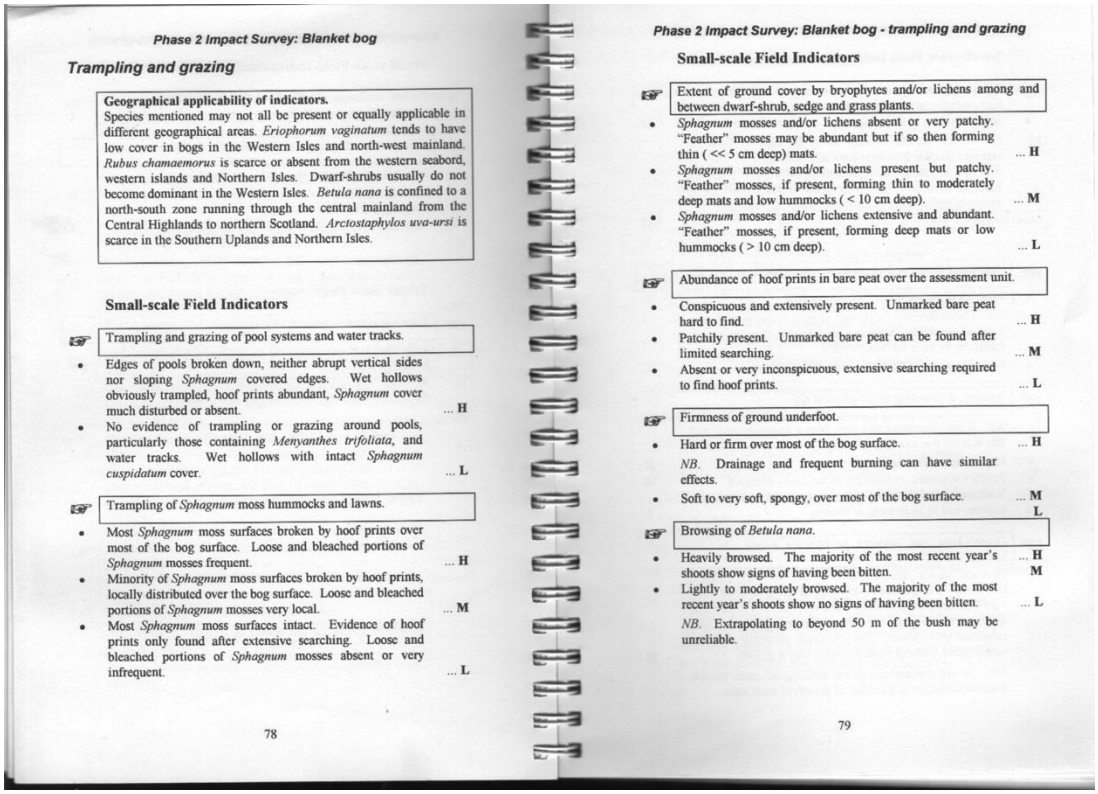
are also often presented in tables or graphs which show the % of plots in a feature which were recorded as Low, Moderate or High overall.

Trampling and grazing

Phase 2 - Small-scale Indicators	**H**	**M**	**L**
Pool systems and water tracks			
Sphagnum hummocks and lawns			
Cover of *Sphagnum* and/or lichens vs "feather" mosses			
Hoof prints in bare peat			
Firmness of ground underfoot			
Browsing of *Betula nana*			
Signs of browsing of less palatable dwarf-shrubs (*Auu, En, Et, Vvi*)			
Amount of flower and fruit on *Rubus chamaemorus*			
Amount of flower and fruit on *Eriophorum*			
Growth form and signs of browsing of *Myrica*			
Browsing of *Calluna* and/or *Vaccinium myrtillus*			
Dung			

Trend	**I**	**CH**	**CM**	**D**	**CL**
Changes in growth-form of dwarf-shrubs					
Height of *Myrica*					
Height and cover of dwarf-shrubs vs graminoids					
Abundance and vigour of *Juncus squarrosus*					
Presence of "grassland" species (*Ac, Ac, Ao, Df, Fo, Ns*)					
Abundance of *Carex panicea* on drier "ridge" areas					

Image 1. Blanket bog small-scale and trend indicators presented in a format that field surveyors can use (Copyright of SNH). They then need to refer to a set of descriptions and definitions to know which option to tick (see below).



Phase 2 Impact Survey: Blanket bog

Trampling and grazing

Geographical applicability of indicators.
Species mentioned may not all be present or equally applicable in different geographical areas. *Eriophorum vaginatum* tends to have low cover in bogs in the Western Isles and north-west mainland. *Rubus chamaemorus* is scarce or absent from the western seabord, western islands and Northern Isles. Dwarf-shrubs usually do not become dominant in the Western Isles. *Betula nana* is confined to a north-south zone running through the central mainland from the Central Highlands to northern Scotland. *Arctostaphylos uva-ursi* is scarce in the Southern Uplands and Northern Isles.

Small-scale Field Indicators

☞ Trampling and grazing of pool systems and water tracks.

- Edges of pools broken down, neither abrupt vertical sides nor sloping *Sphagnum* covered edges. Wet hollows obviously trampled, hoof prints abundant, *Sphagnum* cover much disturbed or absent. ... H
- No evidence of trampling or grazing around pools, particularly those containing *Menyanthes trifoliata*, and water tracks. Wet hollows with intact *Sphagnum cuspidatum* cover. ... L

☞ Trampling of *Sphagnum* moss hummocks and lawns.

- Most *Sphagnum* moss surfaces broken by hoof prints over most of the bog surface. Loose and bleached portions of *Sphagnum* mosses frequent. ... H
- Minority of *Sphagnum* moss surfaces broken by hoof prints, locally distributed over the bog surface. Loose and bleached portions of *Sphagnum* mosses very local. ... M
- Most *Sphagnum* moss surfaces intact. Evidence of hoof prints only found after extensive searching. Loose and bleached portions of *Sphagnum* mosses absent or very infrequent. ... L

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Phase 2 Impact Survey: Blanket bog - trampling and grazing

Small-scale Field Indicators

☞ Extent of ground cover by bryophytes and/or lichens among and between dwarf-shrub, sedge and grass plants.

- *Sphagnum* mosses and/or lichens absent or very patchy. "Feather" mosses may be abundant but if so then forming thin (<< 5 cm deep) mats. ... H
- *Sphagnum* mosses and/or lichens present but patchy. "Feather" mosses, if present, forming thin to moderately deep mats and low hummocks (< 10 cm deep). ... M
- *Sphagnum* mosses and/or lichens extensive and abundant. "Feather" mosses, if present, forming deep mats or low hummocks (> 10 cm deep). ... L

☞ Abundance of hoof prints in bare peat over the assessment unit.

- Conspicuous and extensively present. Unmarked bare peat hard to find. ... H
- Patchily present. Unmarked bare peat can be found after limited searching. ... M
- Absent or very inconspicuous, extensive searching required to find hoof prints. ... L

☞ Firmness of ground underfoot.

- Hard or firm over most of the bog surface. ... H

NB. Drainage and frequent burning can have similar effects.

- Soft to very soft, spongy, over most of the bog surface. ... M L

☞ Browsing of *Betula nana*.

- Heavily browsed. The majority of the most recent year's shoots show signs of having been bitten. ... H M
- Lightly to moderately browsed. The majority of the most recent year's shoots show no signs of having been bitten. ... L

NB. Extrapolating to beyond 50 m of the bush may be unreliable.

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Image 2. An excerpt of the blanket bog small-scale indicators, as presented in the SNH handbook (Copyright of SNH). Surveyors read through the options then decide, based on conditions on the ground, which class is most applicable.