



Scottish
Environment
LINK

Saving Scotland's Rainforest: managing the impact of deer

**Appendix to summary report:
Scottish deer populations**

AND

**Patterns of Scottish rural land use and
landownership**

Introduction

This appendix to the report *Saving Scotland's Rainforest: managing the impact of deer* contains additional informative and important material to accompany the summary report. Included is information that is the product of original research and information that has been informed by interviews with over 30 people who, taken together, have knowledge in all aspects of deer management in Scotland. Specifically, this appendix provides map data, covers estimated deer numbers, deer behaviour and impacts on woodland and in Scotland's rainforest, information on land ownership in the rainforest zone.

1: Scottish deer populations

Rising deer numbers

The history of the fall and rise of deer populations in Scotland is summarised in the Deer Working Group's (DWG) 2020 report [1] to the Scottish Government. It describes how "loss of tree cover and pressure from hunting meant that wild red and roe deer only survived north of the Highland Boundary Fault by the 18th century." After that, their numbers started to rise, with roe deer benefitting from the spread of lowland tree planting and red deer adapting to the open range and increasing in numbers due to the adoption of sport shooting on private estates.

Figure 1: Estimated rise in Scottish red deer numbers since 1945 (From S. Pepper, 2016)	
Year	Approx. no. of red deer
After 1945	100,000
1959	150,000
1965	180,000
1978	270,000
1988	300,000
2013	360,000 to 400,000

By the beginning of the 20th century, red deer were beginning to re-colonise woodland, with the first report being the colonisation of Water Board plantations in Cowal, i.e., within the rainforest zone. At around the same time sika deer first escaped or were released from several locations and now can be found in much of the rainforest zone. Fallow deer were introduced to Scotland in the 13th century but their populations remain isolated and only locally significant. Figure 1 shows the current distribution of the four deer species.

Based on a 2016 LINK Forest Policy Group article by Simon Pepper, *A brief history of 'the deer problem' in Scotland*, Figure 1 outlines the estimated rise in red deer numbers in

Scotland since 1945. In addition to the estimated 360,000 to 400,000 red deer in 2013, the estimated population of roe deer was 250,000 to 350,000 and the population of sika deer was 25,000 - giving an estimated 2013 total population of all species, excluding fallow deer, of 635,000 to 775,000.

However, estimates vary according to the source, as illustrated in Figure 6 of the DWG report. In 2021, Forest and Land Scotland estimated the total deer population (of all species including fallow deer) to be "around a million", up from 500,000 in 1990, a 100% increase in 31 years.

Box 1 illustrates the rise in deer numbers in an upland part of the rainforest zone where there are several surviving Caledonian pinewoods and land management is dominated by mixed estates with a sport shooting component. Though deer numbers (mostly red deer) appear much reduced from their peak in 1875 when sport shooting was the dominant land use, they remain high.

Box 1: Historic accounts of deer in the rainforest zone

The Marchioness of Breadalbane, writing in 1907 states "It is believed that at the opening of the last century not more than a hundred deer were to be found in what is now the Black Mount Forest" (Breadalbane, 1907). At an area of 32,000ha, this gives a deer density of one deer to every 323ha.

During the 19th century, Blackmount was increasingly managed for sporting purposes, managed for deer, and we can see a dramatic increase in deer numbers during this time. The change in area between the centuries reflects changes in land ownership, but broadly covers the same area. It is unusual to have any sort of record of changing deer numbers for this period, and their use is not meant to highlight any particular approach to deer management in the area.

Date	Overall numbers	deer	Area (ha)	Deer density per 100ha
C1800	100		32,000	0.3
1836	1,040		32,000	3.2
1845	2,600		32,000	8
1854	5,000		32,000	15.5
1875	18,000		32,000	55.5
2015	2,517		25,168	10

At the height of Victorian sporting mania, Sporting Agents produced hardback guides to promote the various letting opportunities available. Robert Hall's "The Highland Sportsman" second edition of 1883 gives details for 53 properties in Argyll. Many of the highlighted game species that are now only available in limited areas or are absent from Argyll (for example capercaillie, black game, ptarmigan, grouse, rabbit and hare). However, deer are most notable by their absence. 21 of the properties did not offer deer shooting at all, with red available on 21 properties and roe on 17. For example, the 9,000acres of Glenmorven on Morvern offered no red and only "occasionally roe deer."

Improving our knowledge of deer populations

Improving the accuracy of our knowledge about current deer populations and cull rates was one of the DWG recommendations: "Scottish Natural Heritage [now NatureScot] should more accurately report the basis of national population estimates for wild deer which it publishes; and that Scottish Natural Heritage should make clear that the national cull statistics which it publishes are based only on the numbers reported through cull returns."

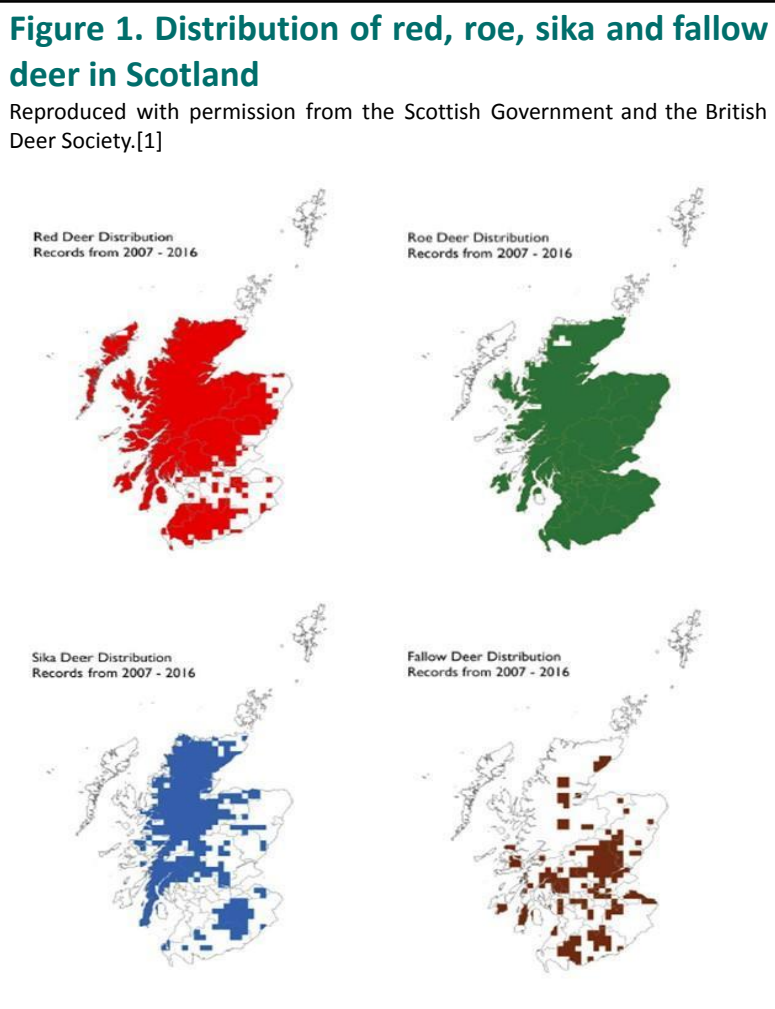
On the level of individual landholdings, determining deer numbers and thus a target cull can be tricky. To set a cull, the deer manager must first have an estimate of the number of deer. The traditional methods of determining this use either foot, or helicopter, counts of individual animals or use assessments of the density of dung pellet groups on the ground. Both these methods, although referred to in the FGS guidance notes for deer management plans, can be unreliable. Deer counts do not work well in wooded areas where deer cannot easily be seen. Furthermore, they only provide a snapshot of the number of deer present on the day of the count. Dung counting provides an estimate of the 'effective' density of deer using an area over a period of time (usually around three months over winter), however the dung may be produced by many deer using the area over a short time or few deer over a longer time. As such, neither method is ideal for providing a baseline population size nor for setting culls and monitoring progress.

Recent developments in survey methodology, such as using drones with mounted cameras to take visual or infra-red video, make it easier to count deer in woodland and, since they are relatively easy to carry out, could, in theory, produce better estimates of deer density. Drone counts, however, still only produce an estimate of the number of deer present on the day of the count. Despite this, they have been able to provide evidence in many places of the, often high, number of deer that are present in woodland that have not previously been counted. The technology is in its infancy and cost reductions and more refinements will no doubt follow.

With a combination of new and old counting methods, it should be possible to obtain an estimate of the population of deer using an area. Assuming no movement of deer into or out of the area, population dynamics models can then be used to determine how many deer will need to be culled, over how many years, to bring the deer density down to the target level. Assumptions of deer recruitment and mortality rates have to be made for each deer species to run population models so this, too, introduces uncertainty into the process of setting culls. Once culling is in progress, however, using standard methods to assess deer impacts on woodlands and other vegetation types will provide feedback to deer managers on whether culls need to be increased or not.

The nature of deer in Scotland

Currently, red and roe deer have the most widespread distribution within the rainforest zone, being found throughout the zone (see fig.1). Sika deer are also widespread and are almost certainly still spreading. By contrast, fallow deer have a more restricted distribution, with concentrations in areas where they were originally introduced.

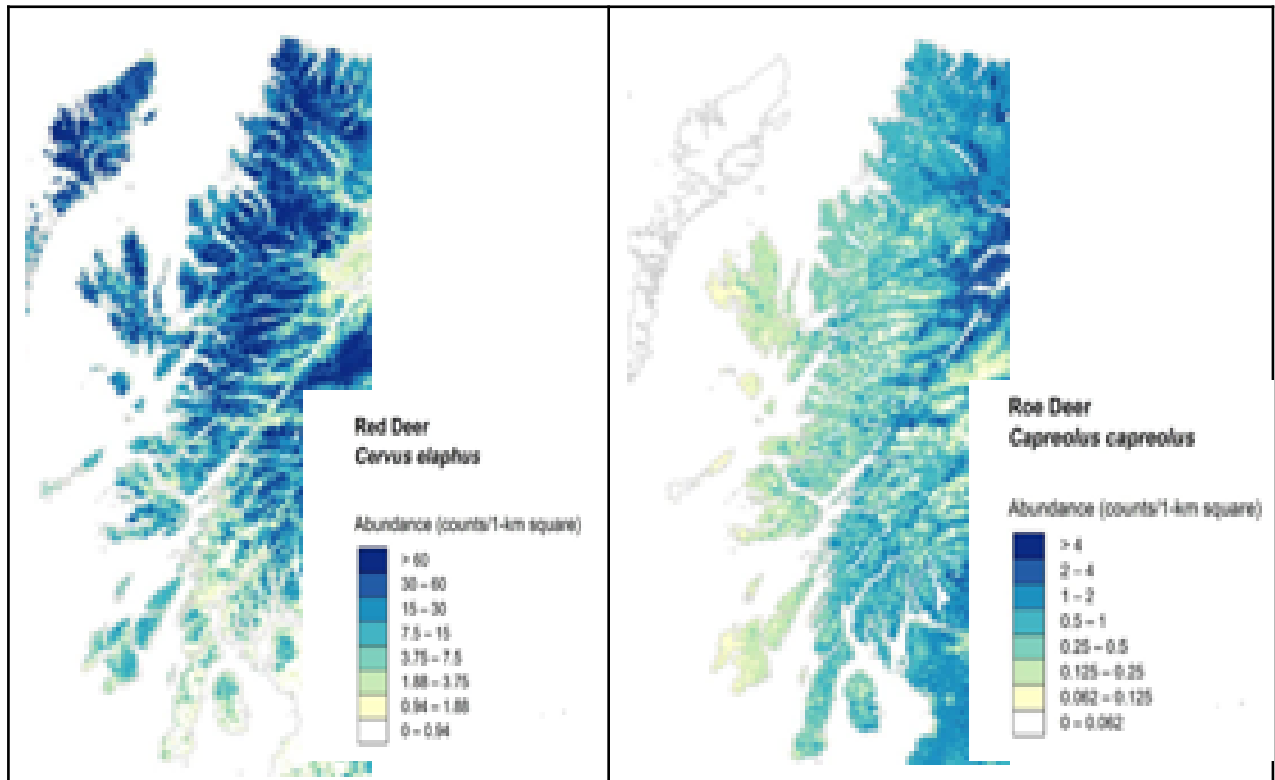


Densities of red deer are especially high in the northern half of the rainforest zone. Those of roe deer are generally recorded as lower than those of red deer (Fig. 2).

Habitat preferences

Red deer are found both on the open hill and in woodlands however they prefer woodland habitats, especially in winter when they benefit from the shelter. Roe deer are restricted largely to woodland or to areas where there is a patchwork of woodland and fields. Sika deer are found mostly in and around native woodland or commercial conifer plantations. They hybridise freely with red deer and, as a result, many deer that appear to be Red or sika are genetic hybrids [1]. Fallow are generally found in woodland or in mixtures of woodland and agricultural land in more lowland areas.

Figure 2: Estimated density of red deer (left) and roe deer (right) in Scotland in 1 km squares



Note that 'abundance' estimates are for relative abundance and do not represent absolute deer abundance. Figures are reproduced with the kind permission of the British Trust for Ornithology [2].

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Impacts on trees and shrubs

All deer species can browse on the shoots of trees and shrubs that are within reach. They also graze on woodland understorey vegetation.

High impact levels

Persistently high levels of browsing can kill both seedlings and saplings, as well as killing any shoots that are sprouting from the base of trees. or from trees that have fallen over but are still living. If this level of browsing is maintained over many decades, tree regeneration will not be possible and, as the mature trees senesce and die, the woodland will become more

open, eventually turning into open ground. When the woodland disappears, many of its associated plant and animal species will also disappear.

Medium impact levels

When browsing levels are less extreme, the browsing preferences of deer become apparent. At these intermediate browsing levels, seedlings and saplings of the least palatable tree species may be unbrowsed, or lightly browsed, whilst those that are more palatable may still be killed by heavy browsing. In general, the relative palatability of different tree and shrub species is similar for all deer species (Table 1). If intermediate levels of browsing persist over many decades, the diversity of tree species found in a woodland can be reduced, sometimes to the point where there is a complete absence of the more palatable tree species.

Table 1. Relative palatability (innate attraction) to deer of the shoots of different tree species.

Tree species have been put into a category from 1 (most palatable) to 6 (least palatable). Note that relative palatability can change with season and can differ, to some degree, between sites and between deer species. Adapted from Armstrong, Black, Holl, & Thompson, 2020 [3]

1	Aspen, Ash, Elder, Willow
2	Elm, Hazel, Holly, Oak, Rowan
3	Blackthorn, Douglas Fir, Gean, Hawthorn, Larches, Sycamore, Yew
4	Birch, Beech, Lodgepole Pine, Scots Pine
5	Bird cherry, Juniper, Norway Spruce, Western Hemlock
6	Alder, Rhododendron, Sitka Spruce

Low impact levels

At low levels of browsing impact all tree species will be able to freely regenerate. At these levels of browsing there may still be areas that are more heavily browsed as well as some that are lightly browsed. When browsing impact is very low, or absent, there may be an initial flush of dense regeneration as young trees that have been suppressed by browsing finally have the chance to ‘get away’. In hazel woods, a complete lack of browsing can result in a flush of new growth from hazel basal stems. This can hasten the death of older central stems [4]. Over time, if there continues to be no browsing, tree regeneration rates may decline as open areas ‘fill in’ thereby reducing the amount of light that reaches the woodland floor. The density of the ground vegetation may also increase, potentially leading to a lack of regeneration ‘niches’ for tree seedlings.

Impacts on other plants

Vascular plants

Deer browsing also affects the non-tree vegetation in woodlands. When browsing impacts are high the ground layer vegetation is short and most plants rarely have the chance to flower or set seed. There is also a lack of climbing plant species, such as honeysuckle and ivy, and there is no, or a sparse, shrub layer (Armstrong, Black, Holl, & Thompson, 2020)[3] (Holl,

2017)[5]. The lack of fruits, seeds and an understorey in the wood can lead to a low availability of food and habitat and for many invertebrate, bird and mammal species. High browsing impacts can therefore lead to reduced biodiversity overall, although some species thrive in open woodland with little understorey, and this applies especially to some of the non-vascular plant species such as those that are characteristic of Scotland's rainforests. Even amongst these species, however, there is a wide range of requirements.

Rainforest specialists

Each of the moss, lichen, liverwort, fungus and vascular plant species (largely filmy ferns) that are characteristic of rainforests has its own requirements for light, substrate type and humidity levels (Averis, 2022). Deer browsing, by influencing the species composition, age structure and density of trees, has the potential to affect the distribution, and abundance, of these different habitat 'niches' within a woodland. So, even if deer browsing levels are not high enough to completely prevent tree regeneration, deer can have a major effect on the mix of specialist rainforest species present in a woodland. Where deer are absent, a dense vegetation ground cover can develop that can suppress rainforest specialists both on the ground and lower tree trunks. Dense ivy is also an issue for these specialists in South West England. Deer impacts on woodlands can extend beyond the effects of browsing and grazing, with heavy trampling creating bare ground along heavily used tracks. Carpets of ground-living bryophytes can also be dislodged by hooves.

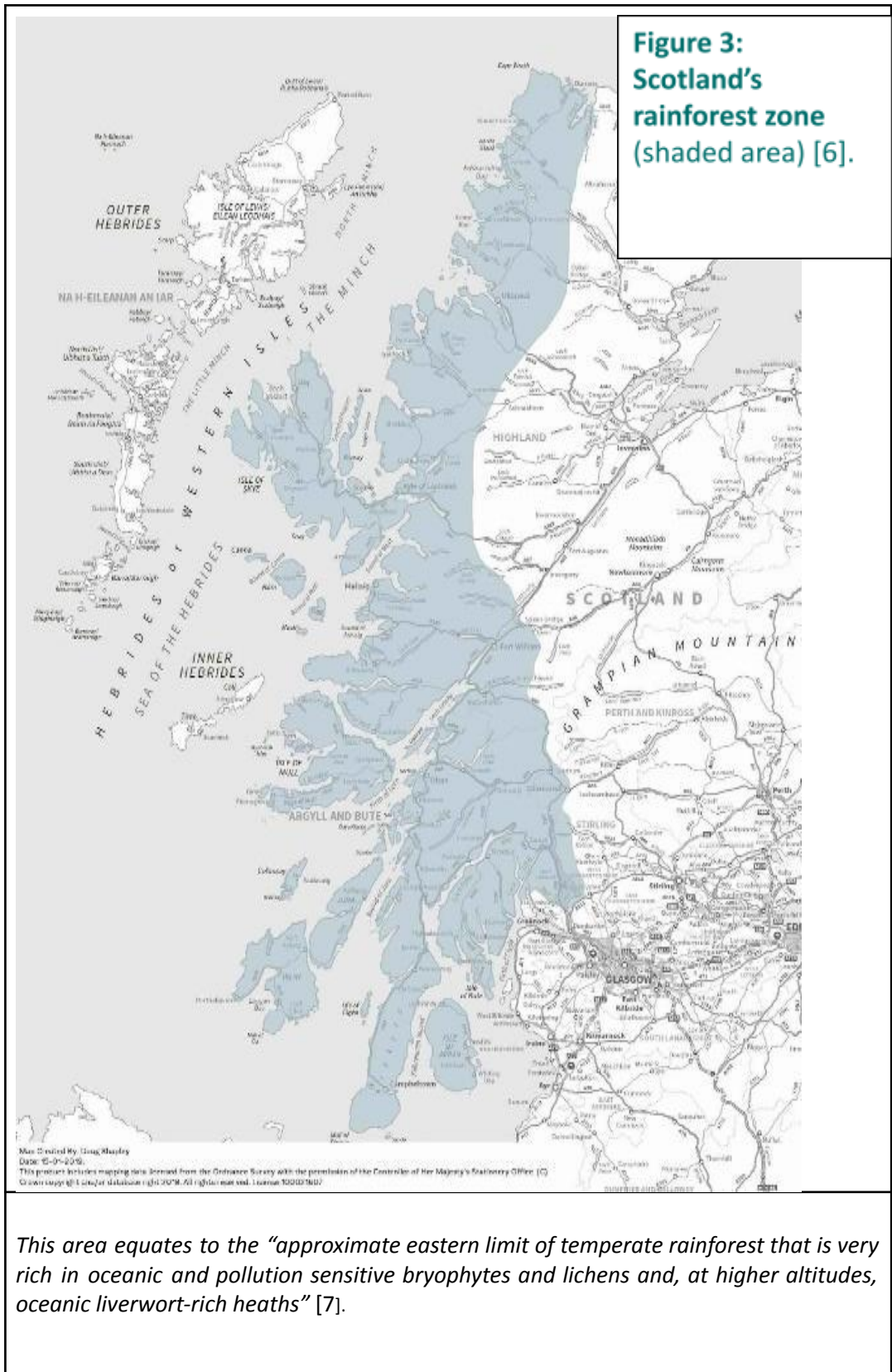
The fragmented state of Scotland's rainforest

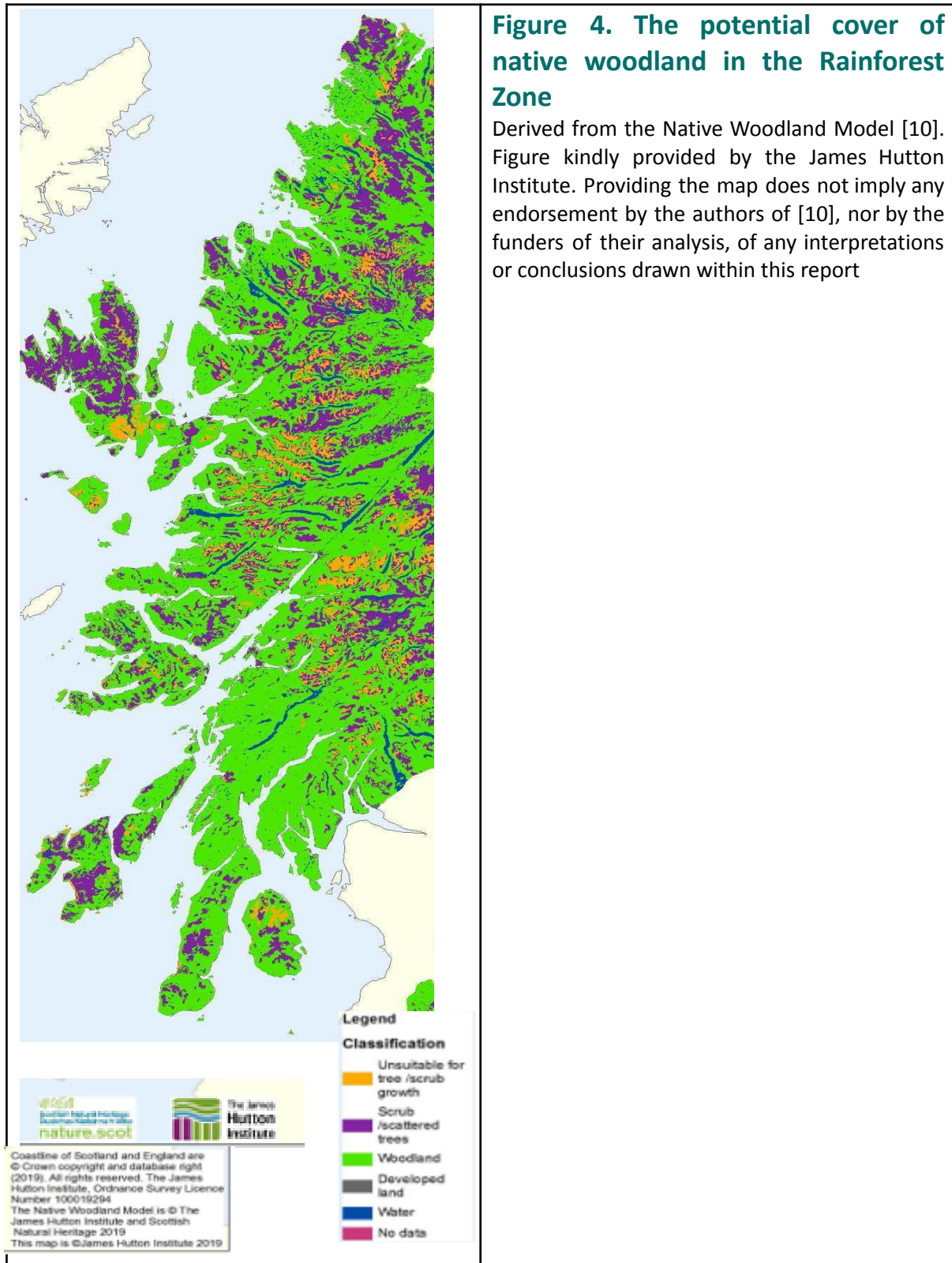
Although all Scotland's native woodlands tend to be of high biodiversity value, those in the north-west of Scotland are particularly valuable (Fig.3). The high rainfall, cool summers and mild winters found here foster a type of woodland found in very few other parts of the World: temperate rainforest (Fig.3).

Temperate rainforest is special because it hosts many species, especially lichens, mosses, liverworts and fungi, that can only thrive in the climatic conditions found in the temperate rainforest zone [7]. Many of these species are internationally rare and some are found only in Scotland [8].

Within Scotland's rainforest zone, 63% of the land area has the potential to support woodland, with a further 28% being able to support scattered trees and scrub (Fig. 4). As such, Scotland has the potential to host more temperate rainforest than any other country in Europe. Despite this, native woodland covers just 4.8% of the rainforest zone and 17% of this native woodland is PAWS (Fig. 5) [8]. Of this native woodland (excluding PAWS), only 41% (29,500ha) been classed as 'mature' [9] and so is most likely to be relatively intact ancient woodland. This represents less than 2% of the total area of the rainforest zone.

As well as covering a very small total area compared to its potential, native woodland in the rainforest zone is also very fragmented with a median size of just 25ha [8] (Fig.5). Most of these fragments are facing multiple threats to their ecological health and ability to regenerate and expand and one of the most serious of these threats is heavy browsing by deer [8] [11].





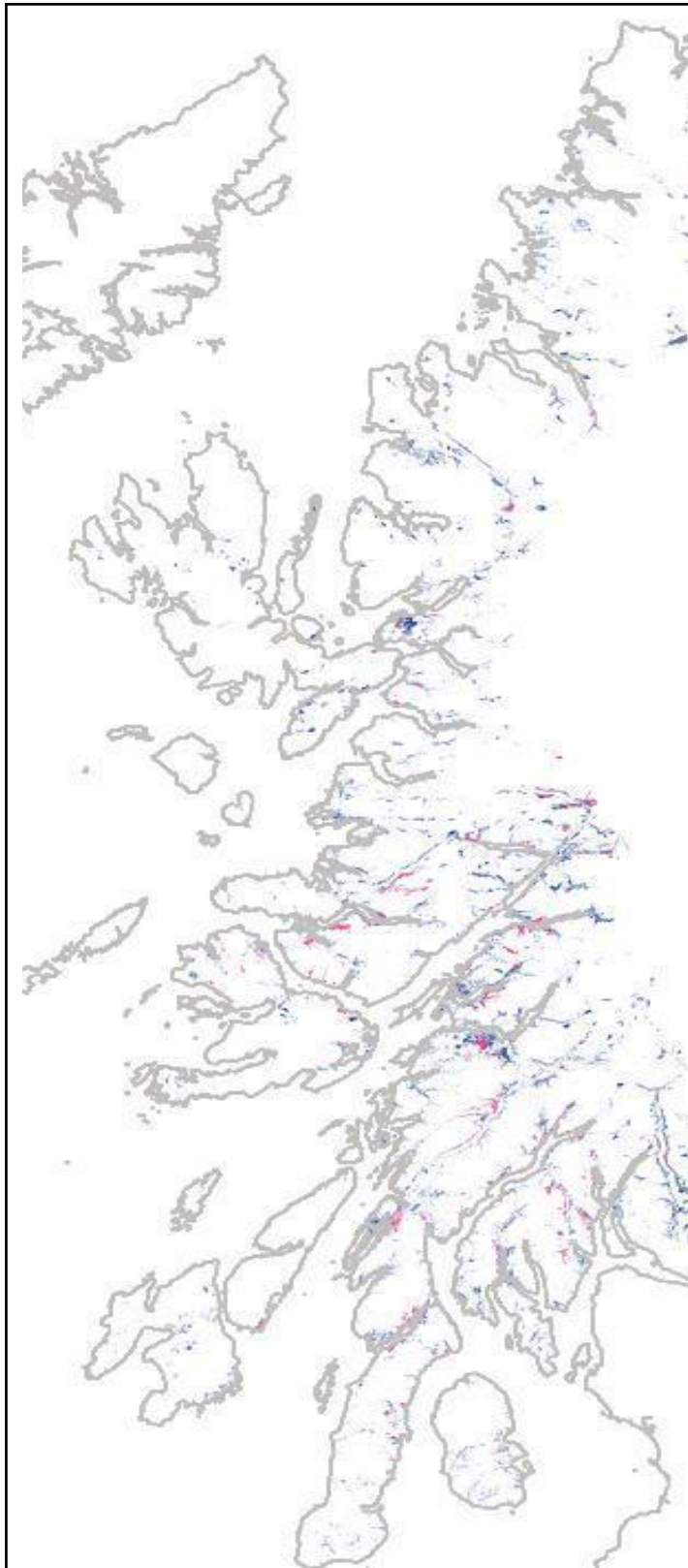


Figure 5. The distribution of native woodland (dark blue) and Plantations on Ancient Woodland Sites (PAWS; pink) within Scotland's rainforest zone.

The native woodland area shown includes some areas of 'nearly native' woodland. Some PAWS sites are in conversion back to native woodland. Data are from the Native Woodland Survey of Scotland [9].

2. Land use and land ownership

Land ownership

Although wild deer legally belong to no-one, the right to shoot deer is vested with the owner of the land on which deer are present at any one time. Effective deer management is therefore linked to who owns land and their land management objectives. Across Scotland, more than 80% of rural land is owned privately and, in 2014, half of this private land was owned by only 432 landowners [12]. This represents a more concentrated pattern of land ownership than is found in any other country in the world [12]. Private land encompasses land owned by a range of entities including private individuals, family trusts, private companies, investment trusts, community trusts, crofting trusts or charities.

The split between public and private land ownership is similar in the rainforest zone to that in the rest of Scotland with around 16% of the land area being publicly owned (Table 2). The majority of the publicly owned land in the rainforest zone, as in the rest of Scotland, is managed by Forestry and Land Scotland (FLS) with smaller areas being managed by NatureScot and the Rural Payments and Inspections Division of the Scottish Government (RPID) (Table 2, Fig.6). An additional 4.3% of the land area of the rainforest zone is owned or managed by environmental Non-Governmental Organisations (NGOs).

Table 2. Area of land in Scotland's rainforest zone owned and managed by public bodies or owned or managed by environmental NGOs.

Organization	Area (ha)	Percentage of rainforest zone
Forestry and Land Scotland	203,757	11.2
NatureScot	18,058	1.0
Rural Payments and Inspectorate Division	69,815	3.8
National Trust for Scotland	30,370	1.7
John Muir Trust	23,070	1.3
Scottish Wildlife Trust	12,762	0.7
Royal Society for the Protection of Birds	6,918	0.4
Woodland Trust Scotland	4,656	0.3
Total	36,9405	20.3

Figure 6. Land owned or managed by public bodies and environmental Non-Governmental Organizations in the rainforest zone.

Also shown are Deer Management Unit (DMU) boundaries, downloaded from the Scottish Natural Heritage (now NS) website in 2016. Despite DMU's not always co-inciding with ownership boundaries, there being some inaccuracies in the data and the likelihood that some boundaries will have changed since 2016, the data provide an indication current ownership boundaries

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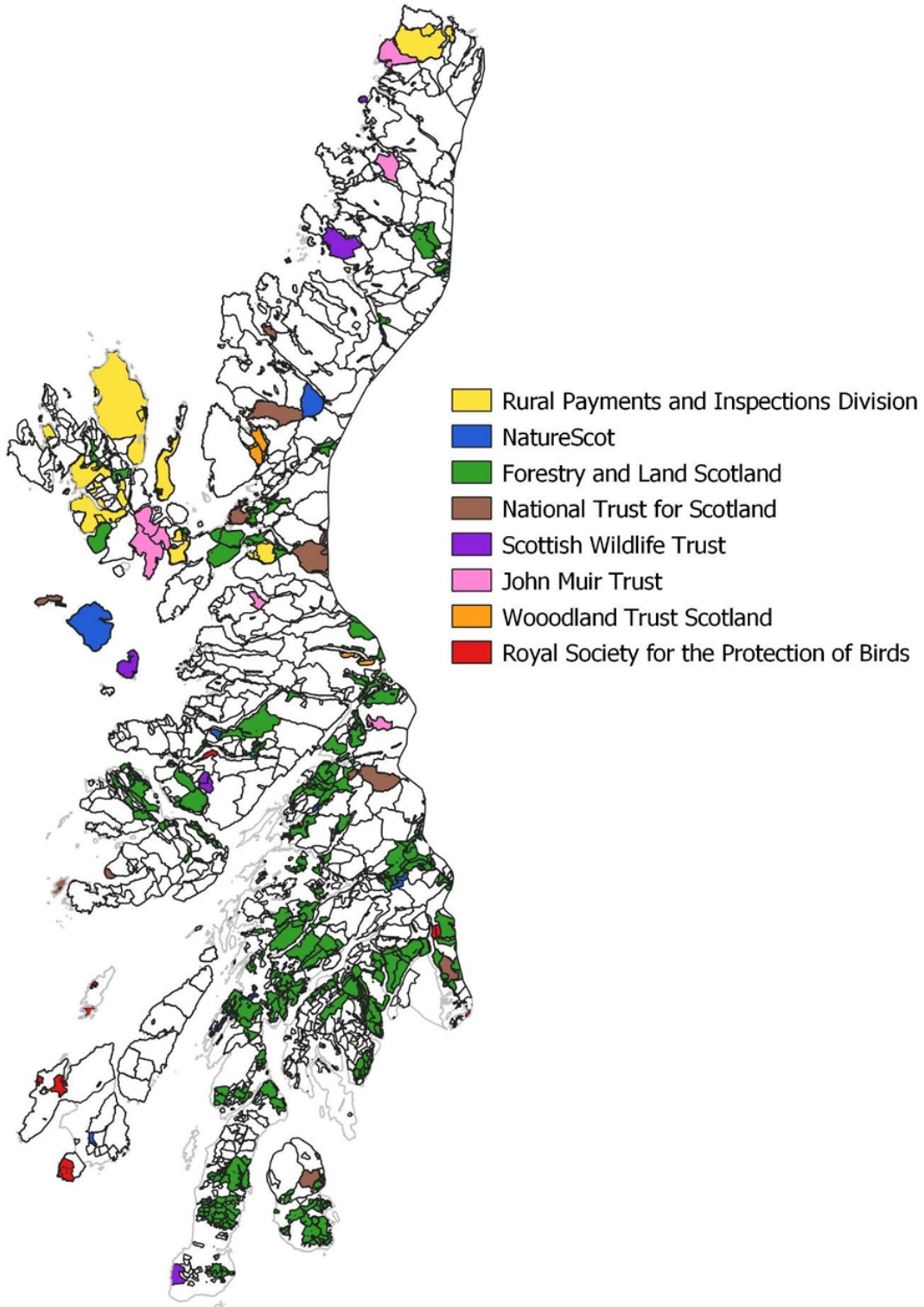
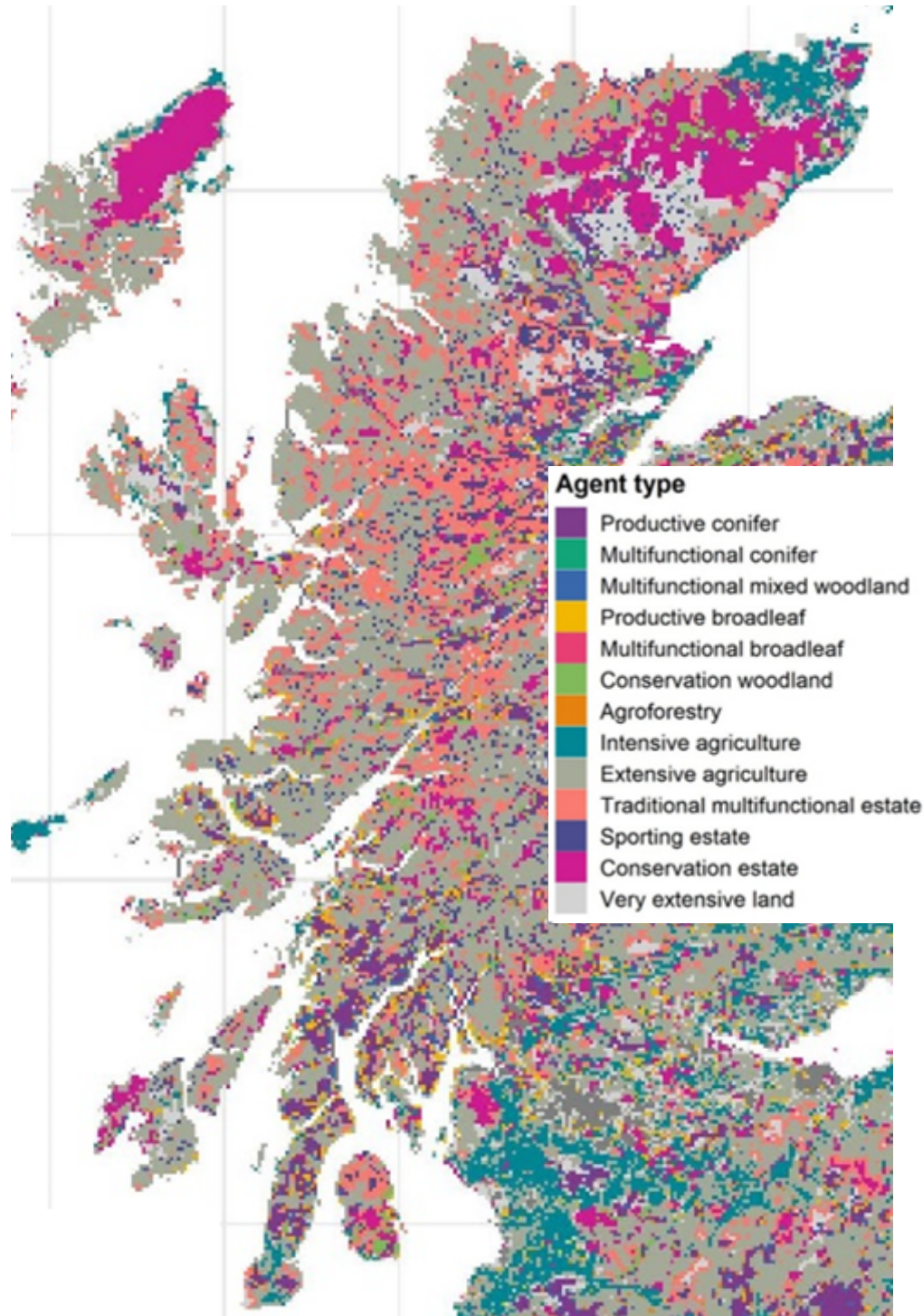


Figure 7. Indicative map of land use in Scotland's Rainforest [13].

The map is based on publicly available spatial datasets of land and woodland cover, nature conservation designations, deer density, deer management units and publicly owned land. Each 1 km² was characterised according to its most likely land use. Grid squares denoted as being part of an 'estate' were wholly, or partly, within a privately owned Deer Management Unit. Those estates denoted as 'Traditional multifunctional' contained a wide range of land cover types, those denoted as 'Sporting' had a high heather moorland cover and a high deer density and denotes as 'Conservation' had more than 50% of the square designated for its nature conservation value [13]. Note that this latter characterization does not necessarily mean that the land was managed primarily for nature conservation. Figure kindly provided by Vanessa Burton



Land use

Burton [13] used land cover and land ownership information to predict the spatial distribution of different land uses in Scotland (Fig. 7). Within the rainforest zone, extensive agriculture (largely hill sheep farming) and traditional multi-functional estates were predicted to cover most land area, with productive conifer forestry covering a large area in Argyll. Much of the latter is land managed by FLS (Figs 6,7). It can reasonably be assumed that the relatively small area of land owned by the environmental NGOs in the rainforest zone, as well as that owned by NatureScot, (Figs. 6,7) is being managed primarily for nature designated very little land in the rainforest zone as 'sporting estate', most of the traditional multi-functional estates will be managed for a range of uses, often including sport shooting conservation. The public land that is managed by RPID (Fig.6) is largely crofting land that is mainly managed for extensive agriculture (usually hill sheep farming). Although Burton of red deer as well as forestry and extensive agriculture. Some, especially those hosting designated sites, may also be managing at least part of their land for nature conservation.

Recent changes in land ownership

Recent years have seen a significant change in how rural land in Scotland is owned and managed. No landowner will be immune to the constant news about the need to reverse biodiversity loss and check the growth in carbon emissions and, in many cases, this is filtering through into adjustments in, if not a re-ordering of, management priorities.

Other changes are happening. As well as the traditional sporting and mixed land-use estates and the rise in conservation-oriented private estates, there has been a marked increase in land sales to investment companies and other corporate interests that are seeking a substantial financial return from their investment.

The importance of land and land ownership has been recognised throughout history. Land gives its possessor political influence and social significance, the right to charge rent and pursue land-based recreation, including sporting activities – and for 200 years the latter has been a particularly attractive feature of Highland land ownership for those who possess land and those with the money to buy it.

But in recent decades, wealth in the UK and elsewhere has become increasingly concentrated in a few hands and increasingly dominated by territorially mobile corporate interests. This wealth has been looking for a new home. Land doesn't go away and there is no more of it, so demand for it, and thus its value, is unlikely to decrease for the foreseeable future, making it a very attractive investment opportunity. And now land ownership has been made even more attractive by a grant system that financially encourages investment in new forestry projects, by high timber prices and by the emergence of a market in carbon credits (and potential biodiversity credits) promising additional long-term revenue streams.

The result is increased competition for land ownership by those with deep pockets - and a rapid increase in its price. In Scotland this increase has been dramatic, with consequent social and economic impacts. Research on behalf of the Scottish Land Commission has calculated a 31.2% rise in the price of farmland in 2021 alone.

These changes can have far-reaching social and economic impacts on local communities. Some of these impacts are negative, such as those resulting in local job losses and the loss of social cohesion, or those making it more difficult for local communities or conservation bodies to raise the capital to buy land. Impacts of a change in land ownership on deer management will vary depending on the land use objectives. An estate turned over to forestry is most likely to control deer just enough to safeguard the investment. This means moderately high deer numbers where Sitka spruce is involved, as is often the case in the south of the rainforest zone, with the broadleaved element that is required by regulation and grant assistance protected within a deer-fenced enclosure.

However, the attitude to deer control is likely to vary from one corporate entity to another. The decision-makers within the organisation may be unfamiliar with land-based issues and will come to land management decisions without fixed ideas and open to advice from land-based professionals. They may also be keen to establish good relations with the local community and they may have the money to help this along. They are likely to be interested in the potential for increasing the natural capital of their land, and they will certainly want to take advantage of Scottish Government grants and other financial incentives. So, the picture is likely to be mixed and there may be opportunities to steer these new landowners in the direction of sustainable land use and sustainable deer control.

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