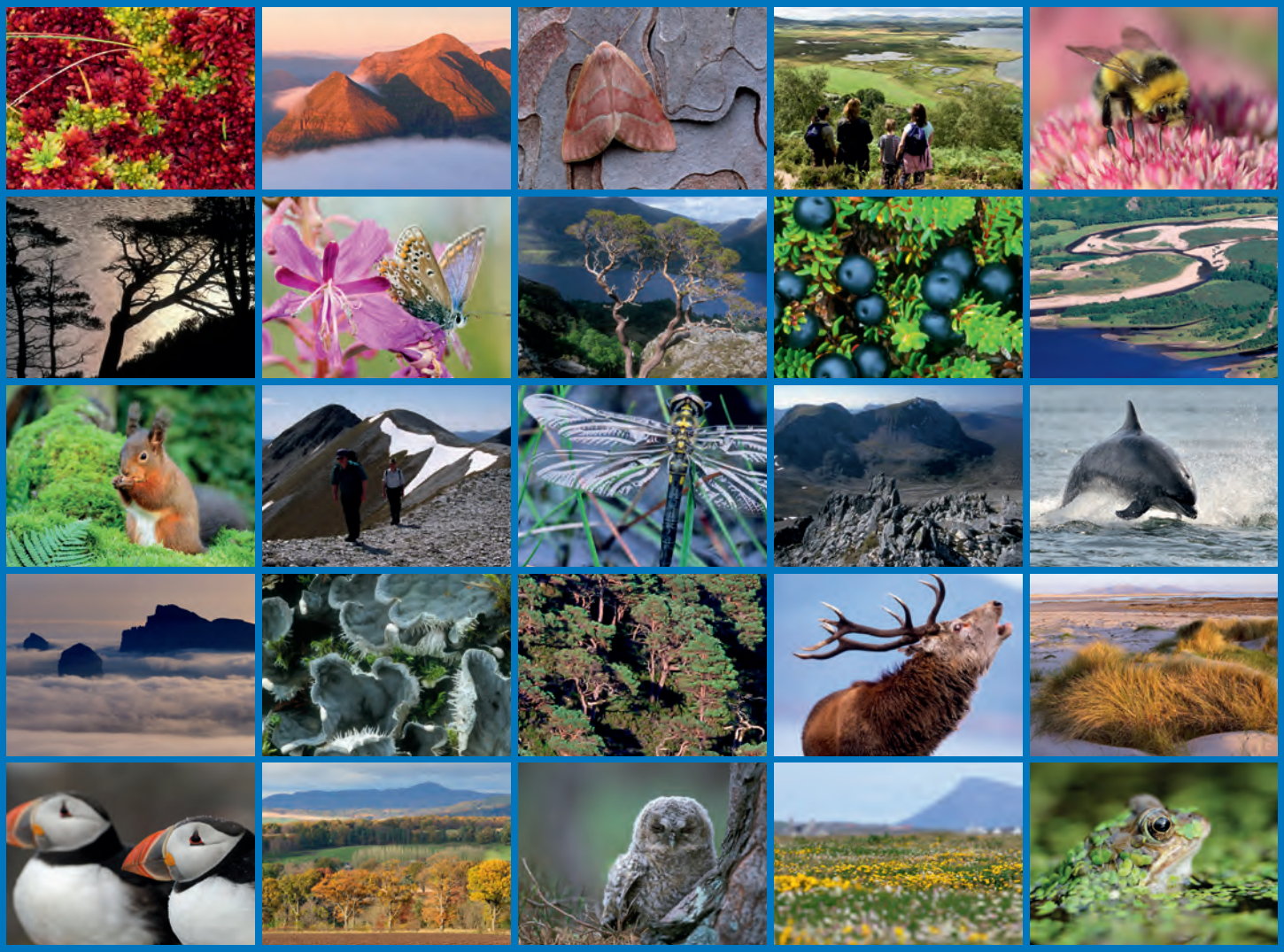
Scottish Natural Heritage
Research Report No. 1179

A woodland profile survey and assessment of herbivore impacts within the Ardgour Pinewoods Site of Special Scientific Interest (SSSI)



Scottish Natural Heritage
Dualchas Nàdair na h-Alba
nature.scot

RESEARCH REPORT

Research Report No. 1179

A woodland profile survey and assessment of herbivore impacts within the Ardgour Pinewoods Site of Special Scientific Interest (SSSI)

For further information on this report please contact:

Lorraine Servant
Scottish Natural Heritage
Torlundy
FORT WILLIAM
PH33 6SW
Telephone: 01463 701648
E-mail: lorraine.servant@nature.scot

This report should be quoted as:

Headley, A.D. 2020. A woodland profile survey and assessment of herbivore impacts within the Ardgour Pinewoods Site of Special Scientific Interest (SSSI). *Scottish Natural Heritage Research Report No. 1179.*

RESEARCH REPORT

Summary

A woodland profile survey and assessment of herbivore impacts within the Ardgour Pinewoods Site of Special Scientific Interest (SSSI)

Research Report No. 1179
Project No: 117137
Contractor: Alistair Headley
Year of publication: 2020

Keywords

Ardgour Pinewoods SAC; Caledonian forest; Lochaber; herbivore impact assessment; HIA; East Loch Shiel DMG.

Background

Ardgour Pinewoods SSSI has been identified as potentially 'at risk' from herbivore impacts and has therefore merited further investigation. Excessive browsing of seedlings and saplings can prevent the population of trees to from regenerating. This survey was designed to assess the age-structure of the population of all species of tree as well as to assess the levels of browsing on seedlings and saplings.

Main findings

The diameter of all species of tree within 49 sample plots chosen at random throughout the protected area was measured in April 2018. The numbers of seedlings and saplings, both small and large, were counted in the same plots and whether they were browsed or not was recorded. A total of 198 live trees and 28 dead trees were measured giving an overall stem density of live trees of 33 stems per ha. A total of 876 seedlings and 721 saplings were counted giving a densities of 381 seedlings per ha and 339 saplings per ha. The main findings are as follows:

- Scots pine is the most abundant species of tree with two-thirds of all live trees being of this species. The trees are widely scattered with an average density of 55 stems per ha or an average spacing of 13 metres.
- Downy birch is the second most abundant species of tree making up 33% of all live tree with an average stem density of 25.8 stems per ha.
- It appears that the regeneration is not limited due to seed supply and niches for seedling establishment as tree seedlings were found in 78% of the sample plots.
- The growth of the seedlings through to young trees appears to be limited at the sapling stage. This is because large saplings were found in much fewer plots (24%) than those with small saplings (69%) and the fact that the densities of large saplings is much lower (284 per ha) than for small saplings (43 per ha).

- The lack of significant regeneration has been occurring for some time as the combined densities of young reproductive and pole stage trees is lower (26 stems per ha) than that for mature trees (36 stems per ha).
- Browsing of tree seedlings was high with 63% of Scots pine, 92% of downy birch, 94% of rowan and all of the alder seedlings being browsed.
- The browsing of the small saplings of Scots pine, downy birch and rowan was 48%, 32% and 79%, respectively.
- Successful regeneration of Scots pine and downy birch trees is only occurring within deer exclosures and the browsing of saplings by red deer is considered to be the main reason for the poor regeneration of trees within the area surveyed.

For further information on this project contact:
Lorraine Servant, Scottish Natural Heritage, Torlundy, Fort William, PH33 6SW.
Tel: 01463 701648 or lorraine.servant@nature.scot
For further information on the SNH Research & Technical Support Programme contact:
Research Coordinator, Scottish Natural Heritage, Great Glen House, Leachkin Road, Inverness, IV3 8NW.
Tel: 01463 725000 or research@nature.scot

Table of Contents **Page**

Acknowledgements

I would like to thank the Conaglen estate for giving permission and help with access to the Ardgour Pinewoods SSSI. I want to also thank all the members of the survey team (Tom Edwards, Fraser Milne and Gus Routledge) for their efforts in completing the survey, and to Graeme Taylor of Scottish Natural Heritage in the helpful management of the contract.

Nomenclature

The scientific names of vascular plants follows that of Stace (2010).

1. INTRODUCTION

The Ardgour Pinewoods Site of Special Scientific Interest (SSSI) is located in the Lochaber district of the Highland region of Scotland between Lochs Shiel, Eil and Linnhe. There are three separate parts to the SSSI with the largest part of the SSSI in Cona Glen (NGR NM960730) and the two smaller areas of native pinewood, one located near Craigag Lodge (NGR NM915798) and the other at Allt na Teanga Duibhe (NGR NN921766) (see Figure 1). The whole of the SSSI covers 1,486.66 ha of which 329 ha is native pinewood. The Ardgour Pinewoods is also designated as a Special Area of Conservation (SAC) under the European Union Habitats Directive and it is listed for:

- 'Caledonian forest'; and
- 'Alder woodland on floodplains' features/habitats.

The Ardgour Pinewoods SSSI has been designated for the following features:

- native pinewood;
- beetle assemblage;
- chequered skipper butterfly (*Carterocephalus palaemon*); and
- reptile assemblage.

The Conservation Objectives for the Ardgour Pinewoods SAC are to ensure that the following are maintained in the long term:

- Extent of the habitat on site
- Distribution of the habitat within site
- Structure and function of the habitat
- Processes supporting the habitat
- Distribution of typical species of the habitat
- Viability of typical species as components of the habitat
- No significant disturbance of typical species of the habitat

The condition of the native pinewood habitat was last assessed in May 2008 as part of a rolling programme of surveys of qualifying habitats within protected sites. In this survey the native pinewood habitat was assessed to be in 'favourable maintained' condition, but the woodland is considered to be 'at risk' from the impacts of large herbivores, in particular deer.

Within the Site Management Statement for the Ardgour Pinewoods SSSI there are specific conservation objectives. The objectives that have been identified to maintain the woodland habitat in favourable condition are:

- continue to manage cattle grazing appropriately
- continue to restrict deer /sheep grazing
- continue to remove non-native coniferous species and other non-native plants from the woodland
- to safeguard against fire

To maintain the populations of beetles, reptiles and chequered skipper in favourable condition the objectives are to:

- continue to maintain open glades within the woodland;
- to avoid significant disturbance to the site; and
- to leave dead trees and fallen timber *in situ*.

1.1 Aims

The key aim of this survey is to implement a fit for purpose baseline survey on the existing woodland profile in terms of life-class, especially of seedlings and saplings, and the relative nature and extent of current herbivore impacts on the populations of trees within the SSSI. This will provide the data necessary to assess the long-term viability and future of the woodland habitat and, if there is a poor age-structure to the population of trees, to identify the likely causal factors that may be resulting in any lack of regeneration in the population of trees.

2. METHODS

2.1 Woodland profile

The criteria for the condition assessment were determined by SNH using the 'Common Standards Monitoring' (CSM) guidance. These standard criteria are available at http://jncc.defra.gov.uk/pdf/CSM_woodland.pdf. The additional site specific target that is relevant to this survey is:

- Signs of seedlings growing through to saplings to young trees at sufficient density to maintain canopy density over a 10 year period (or equivalent re-growth from coppice stumps).

For any healthy self-sustaining population of organisms there must be more individuals in the younger generations than the older generations, otherwise the population will die out. Although there may be spatial variation in the distribution of older and younger trees within a woodland, for a woodland to sustain itself there must be more younger trees, especially seedlings and saplings, than older trees. The direct measurement of the age of trees is both time consuming and potentially damaging to trees as it requires the removal of a core of the tree in order to count the number of annual growth rings. A much quicker and less invasive approach is to measure the diameter of the trees at a standardised height that is 1.3 m above the ground, and this is called diameter at breast height or dbh. However, due to significant variations in rates of growth between trees, a method of classifying trees into age-classes using the size, shape, proportion of dead branches and other physiognomic characteristics was devised by Clifford *et al.* (2004). The characteristics used to place trees into each of these life-classes are given in Annex 3. The life-classes can be summarised as follows:

- Seedling – plants that are no more than 1.3 m tall and usually within the field layer (mainly herbaceous perennials)
- Small sapling – plants that are between 1.3 and 3 m tall
- Large sapling – plants that are between 3 and 5 m tall and usually have a dbh less than 5 cm
- Pole stage tree – dense stands of young reproductive trees more than 5 m tall with dbh 5 to 20 cm, but still not reached full canopy height and spread
- Young reproductive tree – lone young reproductive trees that have dbh values 5 to 20 cm that have still not reached full canopy height and spread
- Mature tree – healthy trees that have reached full height and have a spreading canopy
- Over-mature tree – trees with a spreading canopy that have some dead or dying branches (between 10 and 50% of the canopy)
- Senescent tree – trees where more than 50% of the canopy is dead.
- "Phoenix" trees – trees where the main bole is dead or procumbent and new vigorous shoots coming from the base or from the main trunk
- Dead trees – include standing dead trunks, dead trunks lying on the woodland floor and stumps

2.2 Sampling strategy

Approximately 0.7% of the native pinewood habitat was sampled by taking a total of 49 plots. The sample plots were taken at random within areas known to have some trees present within the SSSI and the location of these plots is shown in Figure 2. Each plot covered an area of either 500 m^2, and was circular in outline.

2.3 Field survey

2.3.1 Woodland profile

The survey was carried out on the 17th, 18th and 20th April 2018 by up to four surveyors. The surveyors navigated their way to the sample plot locations using maps and hand-held GPS receivers (typically Garmin GS12s). No sample plots had to be discarded due to problems of access, but a number had to be moved a certain distance so that they were accessed safely. In every instance the grid reference at the centre of the plot was recorded. The centre of the plot was marked with a wooden post with a numbered tag. Forty three of the 49 sample plots were within 10 metres of the randomly selected grid reference, i.e. within the margin of error for single hand-held GPS receivers working within woodland. Three of the plots were between 10 and 20 metres of the grid reference supplied and only three sample plots were between 20 and 50 metres away (A1, A29 and A39).

Each plot was centred on the marker post and a 12.6 metre rope was used to mark out a 25.2 m diameter circular plot that had an area of 500 m^2. However, for two plots (A34 and A37) plots with a 5.6 metre radius were used due to the high density of trees (Kerr *et al.*, 2002). The Forestry Commission guidance on monitoring even-aged stands of trees suggests that at densities of more than 300 stems per hectare a 11.2 m diameter plot is used, i.e. 100 m^2. Where the densities are between 150 and 300 stems per hectare, a 16 m diameter plot is used, i.e. 200 m^2. Within these plots the diameter of each tree that had a diameter of at least 5 cm was measured 1.3 metres above the ground (dbh) to the nearest centimetre with either a forestry tape or a tailor's tape measure. The Forestry Commission NFI Survey Manual for measuring tree diameters was followed (FC NFI 15.0). Where a tree had multiple stems at 1.3 m above the ground each one was measured separately and assigned to the tree. The species of tree and its life-class was also noted using the classes described by Clifford *et al*. (2004) (see Annex 3 for details of life-classes). The total area of all the plots surveyed for trees amounts to 2.364 ha.

Each plot was searched for seedlings, small saplings and large saplings and the number that were browsed or unbrowsed, as defined above, were counted within the whole of the 25.2 m diameter plot, unless there was a high density of these life-classes. Where there were more than 100 seedlings and/or saplings per 25.2 m diameter plot, a smaller plot size of 11.2 m radius centred on the same post was used. It was only necessary to reduce the area used for counting the number of seedlings and samplings at six plots (A2, A6, A14, A22, A34 and A37). The total area of the plots surveyed for seedlings and saplings amounts to 2.244 ha.

If a plot was located within a deer fenced area this was noted. A total of ten plots were within extant deer exclosures and another eight plots were in a former deer exclosure (Figure 2). Although deer fences were noted, this does not necessarily mean that they were totally effective and it was not possible to tell from the survey whether they completely enclosed the area in question.

One or two photographs of the sample plots were taken with a digital camera and the direction of the photograph recorded with a compass.

2.4 Herbivore impacts

As browsing on seedlings and saplings is considered to be an important factor in the apparent lack of tree regeneration, the level of browsing on seedlings and saplings was assessed. This was done by counting the number of seedlings and saplings where the leading shoot was browsed or un-browsed. Where the leading shoot was browsed the plant was classed as being browsed, but some seedlings and many saplings had two or more leading shoots. Also for the larger saplings, especially the saplings of downy birch, there was no clear leading shoots. In

these instances a plant was classed as being browsed if more than half the shoots were browsed.

As several plots did not have any or very few seedlings or saplings on which to assess the level of browsing, the level of browsing on basal shoots and epicormic shoots of mature trees and preferentially browsed species in the sward was also assessed using the criteria in Armstrong *et al*. (2014). The indicators and thresholds for the different levels of browsing are given in Annex 3.

If the indicator was absent 'NP' was recorded. Where there were too few epicormic shoots, basal shoots, seedlings or saplings then a 'U' was recorded to show that the indicator was uninformative. If the indicator was considered to be inappropriate a 'NA' was recorded.

2.4.1 Quality control

Before the assessment was started Dr Headley spent at least one day with each of the other field surveyors (Tom Edwards, Fraser Milne and Gus Routledge) to clarify the methods, the interpretation of the various indicators and the standardisation of the various threshold levels to assign each impact level. Initially several plots were assessed together. When there was a high level of harmonisation, further sample plots were assessed individually and the results compared. Where appropriate, discrepancies were discussed and adjustments made by the surveyors to their interpretation or judgement of the indicators.

The data was recorded in the field, either on to tablets or paper pro-forma recording sheets. Some trees with dbh values more than 6 cm in diameter were placed in the small or large sapling life-class by one surveyor. These were re-classed as young reproductive trees if they were of downy birch or rowan, or pole stage trees if they were Scots pine.

2.5 Data analysis

2.5.1 Analysis of structure

The numbers of individual plants in each life-class were totalled for each species and then divided by the total area of the plots surveyed to obtain the number of plants per ha. The number of trees in different size classes, i.e. different dbh values, was also calculated using the size classes used by the Forestry Commission (Kerr *et al.*, 2002), as shown below:

- Small trees 5 to 25 cm diameter
- Medium trees 25 to 40 cm diameter
- Large trees 40 to 55 cm diameter
- Very large trees more 55 cm diameter

A minimum diameter of 5 cm was used for small trees as two trees in the pole or young reproductive life-classes had diameters of 6 cm.

The basal area (m^2 per ha) for each species was also calculated from the individual measures of all stem diameters that were at least 5 cm in diameter. Basal area is used as an indication of the level of shading.

2.5.2 Calculation of browsing impacts

The levels of grazing on the sward and the levels of fraying/bark stripping were not used in the calculations as they do not relate to the levels of browsing on the trees. An overall browsing impact was calculated from each of the individual indicators by ranking the values and taking the median score. To calculate the median value, the number of indicators falling in each impact category was calculated and the central one was taken when these values are ranked

in ascending order. For example, if there were five indicators available the value of the 3rd indicator when placed in rank order was taken as the impact category for the sample plot as a whole. When there was an even number of indicators available the mid-point between the two indicators either side of the mid-point was used. In some cases this fell between two categories, such as Moderate and Low. In this instance an impact of Moderate/Low was taken.

2.5.3 Statistical analysis

Although averages and standard deviations were calculated for each variable, as the data is not normally distributed the inter-quartile range (25th and 75th percentiles) and median values were also calculated for the data. The median shows the central tendency in the data and is the central value when all values are ranked in increasing order. The 25th and 75th percentiles are the respective 25th and 75th values when placed in rank order and the difference between these two values shows the variation in the data. This is called the inter-quartile range (Sokal & Rohlf, 1969). Logarithmic transformations of the data were calculated so that a comparison of values between plots within (old and new) and those outside deer exclosures using analysis of variance (ANOVA) for the stem density and basal area.

As the browsing levels on seedlings and saplings are expressed as percentages, this data requires arcsine transformation before means are calculated. The means and standard deviations are these values when transformed back in to percentages. Comparisons between plots within and outside deer exclosures were made by carrying out an ANOVA on the arcsine transformed data.

The herbivore impact data is categorical and a chi-square test was used to compare the number of plots with Very High, High, High/Moderate, Moderate, Moderate/Low and Low categories. A correction, subtraction of 0.5 from the chi-square value for each cell with fewer than 5 expected plots for any single combination of herbivore impact and type of deer exclosure, was applied, e.g. High impact within new deer exclosure.

3. RESULTS

3.1 Overall number of trees, seedlings and saplings

The overall density of live seedlings, saplings and lives trees was 808 per ha (Table 1). One or more seedlings were found in 78% of the plots whilst some small and large saplings were found in 69% and 24% of the plots, respectively (Figures 11, 12 and 13). A total of 876 seedlings were counted giving an overall density of 397 seedlings per ha (Table 1). A total of 626 small saplings and 95 large saplings were recorded and this gives a total density of 327 saplings per ha (Table 1).

3.2 Extent of woodland habitat

Although this survey was not designed or intended to survey the extent of woodland habitat, it was clear from the survey that the cover of trees was low with 13, or 27% of the 49 plots not having a single live tree within them (Table 2). The median density of live trees was only 60 per ha (Table 2).

3.3 Species composition

Overall, Scots pine (*Pinus sylvestris*), downy birch (*Betula pubescens*) and rowan (*Sorbus aucuparia*) are the most abundant species within the Ardgour Pinewoods SSSI (Figure 3). The total live stem density, including seedlings and saplings, of these species is between 215 and 287 stems per ha (Table 1). Alder (*Alnus glutinosa*), holly (*Ilex aquifolium*), sessile oak (*Quercus petraea*), grey willow (*Salix cinerea*), beech (*Fagus sylvatica*) and European larch (*Larix decidua*) are relatively minor components of the woodland making up only 5.2% of all the live seedlings, saplings and trees (Figure 3).

3.4 Woodland structure

The comparison of the different life-classes of tree shows that the densities of seedlings and small saplings were significantly higher than those found for all the other life-classes of tree (Figure 4). Young reproductive trees of downy birch and rowan were found in only six plots and ten plots had pole stage Scots pine trees. Mature trees are only represented by Scots pine and downy birch. The Scots pine population is dominated by the seedling stage, but there are also peaks in the densities of pole stage and mature/over-mature life-classes (Figure 4). In contrast the downy birch population is dominated by small saplings (Figure 4).

There were high densities of rowan seedlings and small saplings, and the only trees of rowan were one each of a pole stage and over-mature tree present in all of the plots surveyed (Table 1). Alder, holly, sessile oak, grey willow and beech were all present as either seedlings and/or saplings, but there were no trees in any of the other life-classes (Table 1).

The plots with the highest seedling densities are scattered across much of the SSSI (Figure 5). Some of the plots with the highest pine seedling densities (>500 per ha) were found within the deer exclosure to the west of the Allt an t-Sluichd and one plot to the south of Corrlarach, again in an old deer exclosure (Figure 6). Birch seedling densities were highest around Doire na Sleaghaich, which is in a different part of the SSSI (Figure 7). The spatial distribution of rowan seedlings is different again, but with some similarities to those of birch with high densities around Doire na Sleaghaich (Figure 8). Most of the rowan seedlings were found in plots with large mature trees where, presumably, species of thrush and other species of songbird perch after feeding on rowan berries.

The highest densities of small saplings were found on the south side of the Cona Glen and to the west of Coire Coile Losal (Figure 9). Some of these plots are within deer exclosures, but some are not (Figures 2 and 9). The highest densities of large saplings were mostly in new or

old deer exclosures (Figures 2 and 10). The higher densities of small and large saplings in the older deer exclosures were found to be statistically significant (Figures 23).

Pole stage and young reproductive trees were mostly, but not exclusively, found in the main area of woodland south of the Cona River in the deer exclosures (Figure 11). Mature trees were found in more plots (21), but they were still absent from 57% of the sample plots. The plots with mature trees are scattered throughout the SSSI (Figure 12). Over-mature trees were found in 16 sample plots and they were at their highest densities around Doire na Sleaghaich and close to the Cona River towards the eastern end of the SSSI (Figure 13).

Senescent and “phoenix” trees were found in three and one plot, respectively. The three plots with senescent trees are very close to one another at the eastern end of the SSSI on the south side of the Cona River, whilst the single “phoenix” birch tree was at the western end of the same glen (Figure 14).

Overall the densities of all live trees were generally higher in the older deer exclosures and this difference was found to be statistically significant (Figure 23). This is due to the Scots pine and downy birch trees being at higher densities in the old deer exclosures (Figures 24 and 25). All life-stages of downy birch, i.e. seedlings, small saplings, large saplings and live trees had higher densities in the old deer exclosures (Figure 25). The densities of small and large saplings as well as trees of Scots pine are higher in the deer exclosures, but it is only statistically significant for the trees and large saplings (Figure 24).

3.5 Size/age distribution

The diameter of trees at breast height give a rough indication of the age of a tree and the size classes are those given in section 2.4.1 (pages 12 and 13) above. As mentioned above, the Scots pine population is dominated by the seedlings, but there are peaks in the number of trees in the small and very large tree size classes with very few in the large sapling and medium size tree categories (Figure 15).

In contrast the downy birch population is dominated by small saplings (Figure 16). Generally there is a decrease in the numbers of downy birch trees with increase in size class of the trees (Figure 16). It is not surprising that there are relatively few large or very large birch trees.

The rowan population is dominated by seedlings and the only trees that were present were both small (Figure 17).

There is a lot of variation in the distribution of different sized Scots pine and downy birch trees over relatively short distances (Figure 18). Large or very large Scots pine trees were not necessarily concentrated in any particular part of the SSSI, but only a few plots had particular concentrations of small Scots pine or downy birch trees (Figure 18).

3.6 Basal area

Those plots with a basal area greater than 25 m^2 per ha have the potential to affect regeneration of Scots pine and other light demanding species of tree (Hale, 2004). Only seven plots had a total basal area of live trees greater than 25 m^2 per ha. The average basal area of all live trees across all plots surveyed was 9.41 m^2 per ha (Table 3). This represents less than 0.1% of the ground occupied by the trunks of trees. The median basal area across the 49 plots is 3.4 m^2 per ha and the inter-quartile range is between 0 and 11.76 m^2 per ha (Table 3). Therefore, significant shading of the woodland floor by mature and over-mature trees is only occurring in 14% of the woodland.

Scots pine is the dominant component of the basal area measurement and as this is an evergreen species the shading it casts will be throughout the year (Figure 19).

There is a high level of spatial variation in the basal area of live trees over relatively short distances (Figure 20).

3.7 Herbivore impacts

Across all the species surveyed 81% of the seedlings were browsed and 52% of the small saplings were browsed (Table 5). Levels of browsing on rowan, downy birch and alder seedlings were higher than that on the Scots pine seedlings (Table 5). Browsing on the small saplings was between 32 and 56% for all species, except for rowan which had the highest browsing level of 79% (Table 5). Browsing on the large saplings was low with only 5% of the 95 large saplings having more than half of the branches browsed.

When the browsing levels are analysed across individual plots the inter-quartile range for browsing on seedlings is between 50 and 100% with the median browsing level being 87% (Table 5). The median browsing level on small saplings is 70% and the inter-quartile range is between 16 and 100%. Four of the six plots where browsing of seedlings was below 20% were in new deer exclosures (Figure 21). Some plots within the deer exclosures had high levels of browsing on seedlings (Figures 2 and 21). Browsing levels on seedlings in the new deer exclosures is much lower than those outside deer exclosures or within old deer exclosures and these differences are highly significant (Figure 26). The browsing levels on saplings within new deer exclosures are significantly lower than the browsing levels on saplings within old deer exclosures and these are lower than those outside deer exclosures (Figure 26).

Browsing levels on epicormic and basal shoots could not be assessed in the majority of sample plots because they were absent (Table 6). The herbivore impacts assessed vary considerably between different indicators, but the levels of browsing/grazing were generally highest on preferentially grazed species (Table 6). This includes plants such as blaeberry and bog myrtle. Fraying and bark stripping was rarely observed. Overall the levels of browsing/grazing were in the Moderate to High categories (Table 6).

All of the sample plots within current deer exclosures have Low overall herbivore impacts whilst 25 of the remaining 40 sample plots outside the deer exclosures or within old exclosures had High or Very High overall herbivore impacts (Figures 2 and 22). The much lower overall herbivore impacts in the new deer exclosures are statistically highly significant (Figure 27).

3.8 Herbivores

The herbivores that are present within the Ardgour Pinewoods SSSI that contribute to the levels of browsing on the tree seedlings and/or saplings are largely deer. Although mountain hares could contribute to some of the browsing of the smaller seedlings, the way in which the shoot tips were browsed suggests that it was not carried out by mountain hare. Large herds of red deer were seen in Cona Glen at the time of the survey, especially towards the lower end of the glen where supplementary feed had been put out.

The counting of deer dung pellet groups in the large plots was found not to be sufficiently consistent to provide any meaningful data. The presence of deep heather cover meant that deer dung pellet groups could easily be over-looked, especially in those areas within deer exclosures.

3.9 Potential for tree regeneration

All areas of the Ardgour Pinewoods SSSI that were surveyed have the potential to support tree regeneration. There are plenty of seed sources and there are more than enough niches

for tree seedlings to establish as shown by the abundance of seedlings found in this survey. Shading by older trees is low, as indicated by the low basal area, and there is, therefore, no reason for seedlings and saplings not to become young reproductive trees.

4. DISCUSSION

4.1 Conservation objectives

4.1.1 Viability of typical species as components of the habitat

One of the conservation objectives for Ardgour Pinewoods SAC is the viability of typical species as components of the habitat. For any population of organisms to remain viable there must be more young individuals than adults because, in the case of trees, a proportion of the seedlings and saplings will die before they get to be a mature reproductive tree (Begon, Townsend & Harper (2006). In this survey 32% of the 198 live trees were in the pole or young reproductive life-classes. Of the remaining 136 live trees 131 were mature or over-mature. When the number of individuals in different cohorts is plotted the resultant graph for trees is normally an inverted J-shaped curve (Gao *et al*., 2017; Edwards & Mason, 2006). For the Scots pine and downy birch populations across all the plots surveyed within the Ardgour Pinewoods SSSI they have only part of this type of curve in the frequency of different sized trees (Figures 15 and 16). In the case of the Scots pine, large saplings were present in only 12 sample plots even though small saplings and seedlings were present in 34 and 38 sample plots, respectively. This shows that Scots pine are producing sufficient seed for seedlings to establish, but their establishment through to the large sapling and young reproductive trees is largely being prevented. The data from this survey indicates that 71% seedlings are surviving to the young sapling stage, but only 15% of the young saplings appear to survive through to the large sapling stage.

The populations of Scots pine and downy birch are only effectively regenerating within the deer exclosures (Figures 24 and 25). The older deer exclosures have on the whole higher densities of downy birch saplings, especially large saplings. This may in part be due to them being in place for longer, but also due to the higher densities of downy birch trees within these exclosures (Figure 25).

It is not possible to make much comment on the viability of the alder population as very few or no sample plots were within the ‘Alder woodland on floodplains’ feature. However, 37 seedlings and 11 small saplings were found in two plots (A42 and A43), which are located very close to the Cona River (Figure 2). No alder trees were present in either of these two plots or in plot A46, which were within 30 metres of the Cona River. This feature is restricted to a short narrow strip either side of the Cona River and may not extend to the 14.81 ha given on the Natura 2000 data form published on the JNCC website for this particular protected area.

4.1.2 Extent of the habitat

As mentioned above this survey was not designed or intended to assess the change in extent of the Caledonian pinewood habitat. An examination of current aerial imagery of the woodland within the Ardgour Pinewood SSSI shows that the woodland is less extensive than it is shown on the historical Ordnance Survey maps. It would be best if current aerial imagery is compared with historical aerial photography as well as old Ordnance Survey maps to assess whether the extent of woodland has shown a detectable decline.

4.2 Common Standards Monitoring

The assessment of the condition of features listed for SACs and SSSIs is made against the generic Common Standard Monitoring (CSM) targets and attributes published by the Joint Nature Conservation Committee (JNCC). The main targets in the CSM for woodland habitats relevant to this survey are:

1. At least current area of recent semi-natural stands maintained.

2. Understorey (2-5m) present over at least 20% of total stand area.
3. Canopy cover present over 30 - 90% of stand area.
4. At least three age classes spread across the average life expectancy of the commonest trees.
5. Some areas of relatively undisturbed mature/old growth stands or a scatter of large trees allowed to grow to over-maturity/death on site.
6. A minimum of three fallen lying trees more than 20 cm diameter per ha and four trees per ha allowed to die standing.
7. Signs of seedlings growing through to saplings to young trees at sufficient density to maintain canopy density over a 10 year period.

Targets 4 and 5 listed above are certainly met at the Ardgour Pinewoods SSSI. Although the target number of four standing dead trees per ha was easily achieved with just over seven standing dead trees per ha found across the 49 sample, the number of fallen dead trees was below the target density of three per ha with only four found in all 2.364 ha of ground surveyed. The extent of semi-natural woodland habitat has largely been covered in section 4.1.2 above. The understorey cover includes all large saplings as well as the taller small saplings. As mentioned in section 3.4 large saplings were very scarce and only present in 18% of the 49 sample plots and the cover of these woody understorey plants amounts to much less than 1% of the woodland area.

The cover of live trees across the woodland habitat may be less than 30%. This is because at a median density of 60 live trees per ha the average area covered by the canopy of the mature trees, including downy birch and rowan, would have to be 50 m^2 per tree to achieve this target. There are a sufficient number of seedlings growing through to the large sapling stage to maintain canopy density (cover) over a 10 year period within deer exclosures, but this is certainly not the case outside of deer exclosures.

4.3 Site Management Objectives

4.3.1 Non-native species coniferous trees and other non-native plant species

The only non-native species of coniferous trees found in this survey was one small European larch (*Larix decidua*) tree in plot A22 (Figure 2). This plot is within an area of commercial forestry plantation. No Sitka spruce (*Picea sitchensis*) saplings or trees were found during this survey within the SSSI.

Three beech (*Fagus sylvatica*) seedlings were found in plot A42 next to the Cona River. These beech seedlings are not expected to establish due to the nature of the soils and browsing levels.

4.3.2 Conservation objectives for beetles, reptiles and chequered skipper

The maintenance of the appropriate habitats for the beetle and reptile assemblages and the chequered skipper populations are being met as there are plenty of open glades within the woodland habitat and there is no significant disturbance to the site. Dead and fallen timber is *in situ* and there is a plentiful supply of standing and fallen dead trees as this survey recorded 7.2 and 1.3 stems, respectively.

4.4 Causes for lack of tree regeneration

The four factors most likely to prevent the establishment of tree seedlings and saplings are:

- insufficient seed source/production;
- browsing by large herbivores;
- insufficient light; or

- disease.

There was no evidence that plant pathogens had resulted in the death of any of the Scots pine seedlings and saplings.

Low light levels can result in the death of light demanding species of trees, such as Scots pine. The basal area of trees can be used as a surrogate for the amount of light likely to reach the floor of conifer plantations and whether natural regeneration of trees will occur (Hale, 2004). Scots pine requires about 35% of ambient light to establish and this relates to a basal area of 25 m^2 ha^{-1} (Hale, 2004). Only seven of the 49 sample plots had basal areas greater than 25 m^2 ha^{-1}. However, this threshold should only be used as a guide as it is based on conifer plantations where the spacing of the mature trees is very even. The Ardgour Pinewoods are semi-natural woodlands where the spacing between trees is not regular and varies a good deal over short distances. Consequently there will be some areas of the woodland floor which receive more light than others. Therefore, the use of the guideline numbers in the Forestry Commission Information Note (Hale, 2004) need to be treated with caution. This conclusion is supported by the presence of seedlings and saplings in at least one of the sample plots (A30) where the basal area of mature trees was 40 m^2 ha^{-1}. Also, the average basal area within the Ardgour Pinewoods SSSI is between 39% and 55% of that observed in four other Scottish native pinewoods where there is good regeneration occurring (Edwards & Mason, 2006).

The abundance of Scots pine and birch seedlings in certain plots suggests that there is no shortage of a seed source from which the populations of these two species can re-establish. There are also plenty of large mature Scots pine trees from which seeds can be produced over most of the Ardgour Pinewoods SSSI.

Given the lack of evidence for insufficient seed source, shading and disease for preventing the regeneration of Scots pine within the Ardgour Pinewoods SSSI it only leaves browsing as the most likely factor. Browsing damage by large herbivores is a more likely culprit as conifers are largely unable to recover if the leading shoot is browsed as they are usually unable to effectively produce side shoots. The browsing on the Scots pine seedlings and saplings was 63% and 48%, respectively (Table 3). This is similar to the levels of browsing observed on the Scots pine seedlings at Abernethy Forest (72%) before the RSPB started a significant cull (Beaumont *et al.*, 1995). Also eight of the 12 plots where there were small, and presumably young Scots pine trees, were within new or old deer exclosures. The analysis of the data across the plots within and outside of deer exclosures shows that the only significant regeneration of Scots pine and downy birch seedlings and saplings was within the deer exclosures (Figures 24 and 25). The installation of the relatively recent exclosure on the west side of the Allt an t-Sluichd has resulted in the establishment of a significant number of Scots pine seedlings and saplings. On average there are 488 seedlings, 608 small saplings and 100 large saplings per ha across the three sample plots (A17, A38, A40) located within this exclosure. These densities are far higher than the average obtained in this survey where the woodland is open to free-ranging deer. This exclosure has been successful in facilitating adequate regeneration of trees, especially Scots pine.

Significant regeneration of Scots pine has been achieved within parts of the Cairngorms SAC where the numbers of red deer have been reduced very significantly (Beaumont *et al.*, 1995; Rao, 2017).

The impact of any loss in tree cover on the other features listed for the SSSI (beetles, chequered skipper butterfly and reptile assemblage) are unknown.

5. CONCLUSIONS

- The populations of Scots pine, downy birch and rowan are only currently viable within the deer exclosures.
- There is no evidence that a lack of seed source, shading or disease is inhibiting the regeneration of Scots pine or other species of tree.
- Browsing levels on seedlings and small saplings of Scots pine, downy birch, rowan and alder are high outside the new deer exclosures.
- Browsing by red deer is considered to be the only viable explanation for the lack of adequate regeneration of Scots pine, downy birch and other species of tree outside the deer exclosures.
- If current levels of browsing on tree seedlings and saplings persist in the open woodland, the extent of woodland will decrease as the existing tree cover is reduced and fragmented and not replaced.

6. REFERENCES

Armstrong, H., Black, B., Holl, K. & Thompson, R. 2014. Assessing herbivore impact in woodlands: a subjective method. Forestry Commission, Edinburgh.

Beaumont, D.J., Dugan, D., Evans, G. & Taylor, S. 1995. Deer management and tree regeneration in the RSPB reserve at Abernethy Forest. *Scottish Forestry,* July 1995, letters.

Begon, M., Townsend, C.R. & Harper, J.L. 2006. Ecology: from individuals to ecosystems. 4th edition. Blackwell Publishing, Oxford.

Clifford, T., Collier, L., & Clifford, B. 2004. *Woodland Profile Survey, Zone 1 - Feshie Catchment Section 7 Control Agreement Area.* A Report to the Deer Commission for Scotland, Inverness.

Edwards, C. & Mason, W.L. 2006. Stand structure and dynamics of four native Scots pine (*Pinus sylvestris* L.) woodlands in northern Scotland. *Forestry*, 79(3), 261-277.

Gao, W.Q., Ni, Y.Y., Zue, Z.M., Wang, X.F., Kang, F.F., Hu, J., Gao, Z.H., Jiang, Z.P. & Liu, J.F. 2017. Population structure and regeneration dynamics of *Quercus variabilis* along latitudinal and longitudinal gradients. *Ecosphere*, 8(4), 1-15.

Hale, S. 2004. *Managing light to enable natural regeneration in British conifer forests.* Information Note 63. Forestry Commission, Edinburgh.

Hamilton, G.J. 1975. *Forest mensuration handbook*. Forestry Commission Booklet 39. HMSO, London.

Kerr, G., Mason, B., Boswell, R. & Pommerening, A. 2002. *Monitoring the transformation of even-aged stands to continuous cover management.* Information Note. Forestry Commission, Edinburgh.

Rao, S.J. 2017. Effect of reducing red deer *Cervus elaphus* density on browsing impact and growth of Scots pine *Pinus sylvestris* seedlings in semi-natural woodland in the Cairngorms, UK. *Conservation Evidence,* 14, 22-26.

Sokal, R.R. & Rohlf, F.J. 1969. *Biometry: The principles and practice of statistics in biological research*. Freeman & Co., San Francisco.

Stace, C. 2010. *New Flora of the British Isles.* 3rd edition. Cambridge University Press, Cambridge.

ANNEX 1: TABLES

Table 1. The stem density (stems per ha) of each life-class for each species of tree surveyed across the Ardgour Pinewoods SSSI.

Species of tree	Life stage										
	Seedlings	Small saplings	Large saplings	Pole stage	Young reproductive	Mature	Over-mature	Senescent	"Phoenix"	**Total Live**	Dead
Scots pine	153.4	49.0	7.7	22.8	0.0	18.6	12.7	1.3	NA	**265.5**	5.9
downy birch	35.8	135.7	17.7	0.0	2.5	17.3	6.3	0.4	0.4	**216.3**	3.8
rowan	175.1	93.0	17.7	0.0	0.4	0.0	0.4	0.0	0.0	**286.7**	0.4
alder	16.8	5.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	**21.8**	0.0
holly	14.5	0.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	**15.4**	0.0
sessile oak	0.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	**0.5**	0.0
grey willow	0.0	0.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	**0.5**	0.0
beech	1.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	**1.4**	0.0
European larch	0.0	0.0	0.0	0.4	0.0	0.0	0.0	0.0	0.0	**0.4**	0.0
unknown species	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	**0.0**	1.7
All species	**397.5**	**284.0**	**43.1**	**23.3**	**3.0**	36.0	19.5	**1.7**	**0.4**	**808.3**	11.8

Table 2. Summary statistics for the density (per ha) of seedlings, small saplings, large saplings and all live trees collected from each of the 49 sample plots surveyed.

Species	Life-class	Statistic						
		Mean	s.d.	Min.	25%tile	Median	75%tile	Max.
Density of all plants of all species (per ha)	Seedlings	440	793	0	40	140	541	4,238
	Small saplings	695	1753	0	0	80	301	8,829
	Large saplings	105	511	0	0	0	0	3,532
	Pole stage	41	153	0	0	0	0	1,015
	Young reprod'	4	16	0	0	0	0	100
	Mature	35	66	0	0	0	60	380
	Over-mature	19	49	0	0	0	20	280
	Senescent	1	5	0	0	0	0	20
	"Phoenix"	0	5	0	0	0	0	20
	All live trees	99	172	0	0	60	120	1,115
	All dead trees	11	19	0	0	0	20	80
Scots pine	Seedlings	142	477	0	0	0	60	3,128
	Small saplings	102	324	0	0	0	40	2,030
	Large saplings	17	88	0	0	0	0	609
	All live trees	72	153	0	0	20	80	1,015
downy birch	Seedlings	76	309	0	0	0	20	2,030
	Small saplings	313	905	0	0	0	80	5,583
	Large saplings	69	435	0	0	0	0	3,045
	All live trees	28	52	0	0	0	40	280
rowan	Seedlings	185	388	0	0	0	102	1,804
	Small saplings	255	834	0	0	0	80	4,872
	Large saplings	32	176	0	0	0	0	1,218
	All live trees	1	4	0	0	0	0	20
alder	Seedlings	15	106	0	0	0	0	740
	Small saplings	4	22	0	0	0	0	120
holly	Seedlings	13	38	0	0	0	0	160
	Small saplings	1	4	0	0	0	0	20
sessile oak	Seedlings	0	3	0	0	0	0	20
grey willow	Small saplings	0	3	0	0	0	0	20
beech	Seedlings	1	9	0	0	0	0	60

Table 3. The basal area (m^2 per ha) of each life-class for each species of tree surveyed across the Ardgour Pinewoods SSSI.

Species of tree	Life-class							
	Pole stage	Young reproductive	Mature	Over-mature	Senescent	"Phoenix"	**Total Live**	Dead
Scots pine	0.252	NA	4.180	3.553	0.152	NA	**8.137**	0.760
downy birch	0.000	0.012	0.692	0.536	0.005	0.019	**1.264**	0.006
rowan	0.000	0.002	0.000	0.011	0.000	0.000	**0.013**	0.032
European larch	0.002	0.000	0.000	0.000	0.000	0.000	**0.002**	0.000
Unknown species	0.000	0.000	0.000	0.000	0.000	0.000	**0.000**	0.030
All species	**0.255**	**0.014**	**4.872**	**4.100**	**0.157**	**0.019**	**9.417**	**0.828**

Table 4. Summary statistics for the basal area (m^2 per ha) for each species and for all live trees from the 49 sample plots surveyed.

Species	Statistic						
	Mean	s.d.	Min.	25%tile	Median	75%tile	Max.
Scots pine	7.93	12.96	0.00	0.00	1.76	10.94	54.94
downy birch	1.47	3.28	0.00	0.00	0.00	0.95	13.83
rowan	0.00	0.02	0.00	0.00	0.00	0.00	0.10
European larch	0.00	0.02	0.00	0.00	0.00	0.00	0.12
All	9.40	13.81	0.00	0.00	3.39	11.76	55.73

Table 5. The number of unbrowsed and browsed seedlings, small saplings and large saplings for each species of tree surveyed within the Ardgour Pinewoods SSSI as well as the descriptive statistics for browsing on these life-classes.

Species of tree	Seedlings			Small saplings			Large saplings		All seedlings & saplings	
	Un-browsed	Browsed		Un-browsed	Browsed		Un-browsed	Browsed		
		number	%		number	%		number	number	% browsed
Scots pine (*Pinus sylvestris*)	126	212	63	48	60	56	12	5 (29%)	**463**	**60**
downy birch (*Betula pubescens*)	6	73	92	204	95	32	39	0	**417**	**40**
rowan (*Sorbus aucuparia*)	22	364	94	43	162	79	29	0	**620**	**83**
alder (*Alnus glutinosa*)	0	37	100	5	6	55	0	0	**48**	**90**
holly (*Ilex aquifolium*)	13	19	59	1	1	50	0	0	**34**	**59**
sessile oak (*Quercus petraea*)	0	1	100	0	0	NA	0	0	**1**	**100**
grey willow (*Salix cinerea*)	0	0	NA	1	0	0	0	0	**1**	**0**
beech (*Fagus sylvatica*)	3	0	0	0	0	NA	0	0	**3**	**0**
All species	**170**	**706**	**81**	**302**	**324**	**52**	**90**	**5 (5%)**	**1597**	**65**

Life-class	Statistic							
	n	Mean	s.d.	Min.	25%tile	Median	75%tile	Max.
All seedlings	38	68.4%	36.3%	0%	50%	87%	100%	100%
All small saplings	34	58.6%	40.1%	0%	16%	70%	100%	100%
Large saplings	12	7%	24%	0	0	0	0	83%

Table 6. The number of sample plots with different levels of herbivore impact for each of six indicators in the vegetation within the Ardgour Pinewoods SSSI.

Vegetation Indicator	Level of herbivore impact							Uninformative/ Not applicable
	Very High	Very High/High	High	High/Moderate	Moderate	Moderate/Low	Low	
Basal shoots	0	0	6	0	2	0	2	39
Epicormic shoots	0	0	1	0	0	0	1	47
Seedlings and saplings	4	5	13	1	7	3	8	8
Preferntially grazed spp.	1	0	24	2	4	0	9	9
Sward	0	0	12	0	8	0	12	17
Bark Stripping	1	0	2	1	3	0	29	13
Overall Impact	**2**	**0**	**23**	**2**	**10**	**1**	**11**	**0**

Table 7. The results of Analysis of Variance comparing the differences in various variables generated from this survey between plots within old and new exclosures with those outside these deer exclosures.

Fvar = variance ratio, df = degrees of freedom and P = the probability of the Fvariance ratio being due to chance. Significant Fvar values are highlighted in bold and red type.

Variable	Fvar	df	P (%)
Seedling density	0.27	2/46	76.7
Small sapling density	**10.14**	2/46	**0.02**
Large sapling density	**7.43**	2/46	**0.16**
Pole density	2.73	2/46	7.57
Young reproductive density	**4.05**	2/46	**2.40**
Mature tree density	2.72	2/46	7.68
Over-mature tree density	0.78	2/46	46.3
Senescent tree density	0.91	2/46	41.2
“Phoenix” tree density	2.35	2/46	10.7
All live trees density	**5.99**	2/46	**0.49**
Dead tree density	1.47	2/46	24.2
% browsing on seedlings	**8.89**	2/35	**0.08**
% browsing on saplings	**4.83**	2/31	**1.49**
Scots pine seedling density	2.72	2/46	7.67
Scots pine small sapling density	2.37	2/46	10.5
Scots pine large sapling density	**5.02**	2/46	**1.07**
All live Scots pine tree density	**4.01**	2/46	**2.50**
Downy birch seedling density	**4.69**	2/46	**1.40**
Downy birch small sapling density	**12.94**	2/46	**0.003**
Downy birch large sapling density	**5.77**	2/46	**0.58**
All live downy birch tree density	**6.51**	2/46	**0.32**
Rowan seedling density	0.75	2/46	47.7
Rowan small sapling density	1.67	2/46	19.9
Scots pine small tree density	3.11	2/46	5.41
Scots pine medium tree density	0.80	2/46	45.4
Scots pine large tree density	0.90	2/46	41.2
Scots pine very large tree density	1.03	2/46	36.5
Downy birch small tree density	3.09	2/46	5.48
Downy birch medium tree density	2.23	2/46	11.9
Downy birch large tree density	**5.36**	2/46	**0.81**
Downy birch very large tree density	0.28	2/46	75.6
Basal area	**3.84**	2/46	**2.88**

ANNEX 2: FIGURES

Figure 1. Map showing the boundary of the Ardgour Pinewoods SSSI.

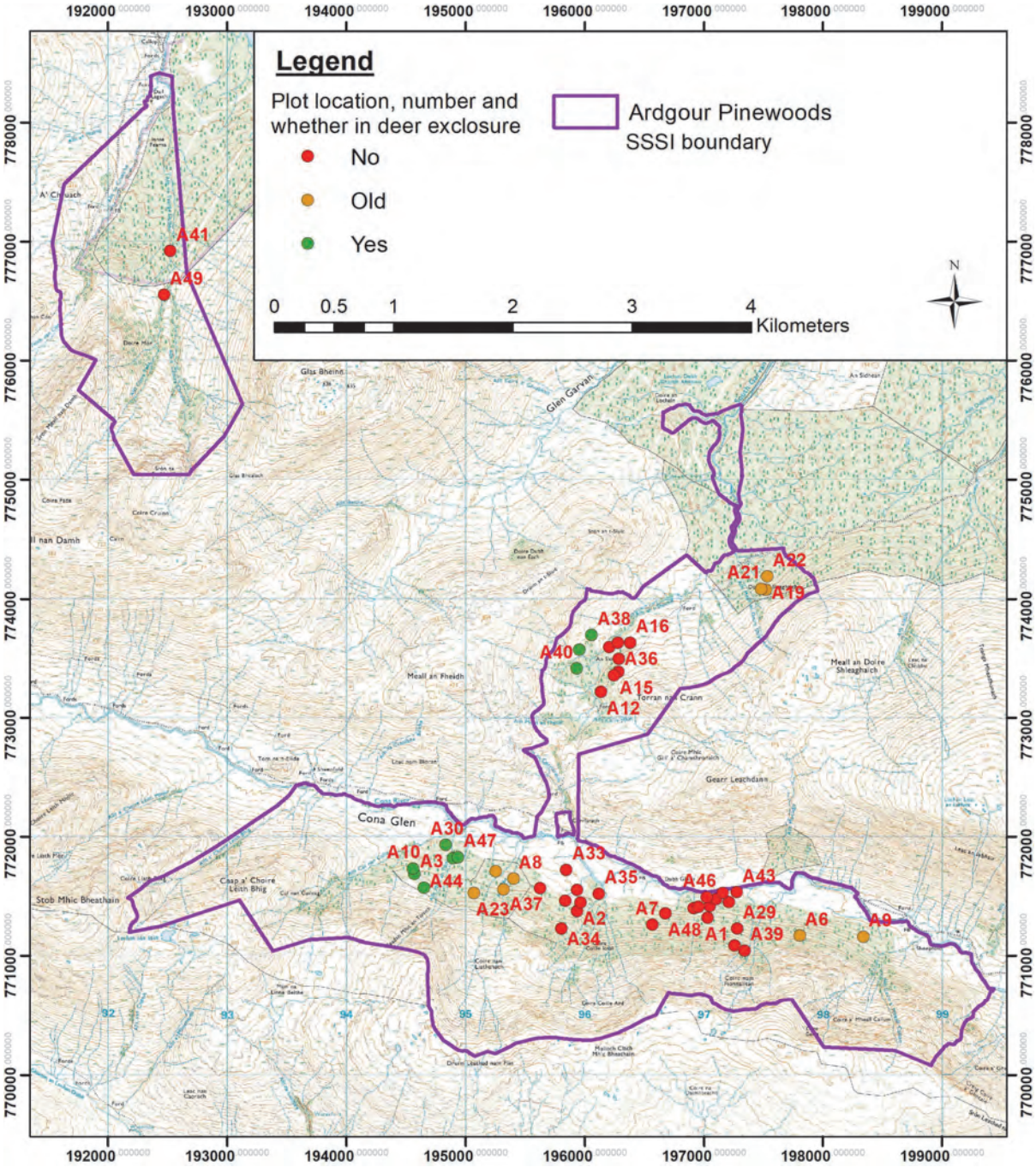


Figure 2. Map showing the location of the sample plots taken to describe the structure and assess the herbivore impacts on the pinewood habitat within the Ardgour Pinewoods SSSI. © Crown copyright and database right 2018. Ordnance Survey 100017908.

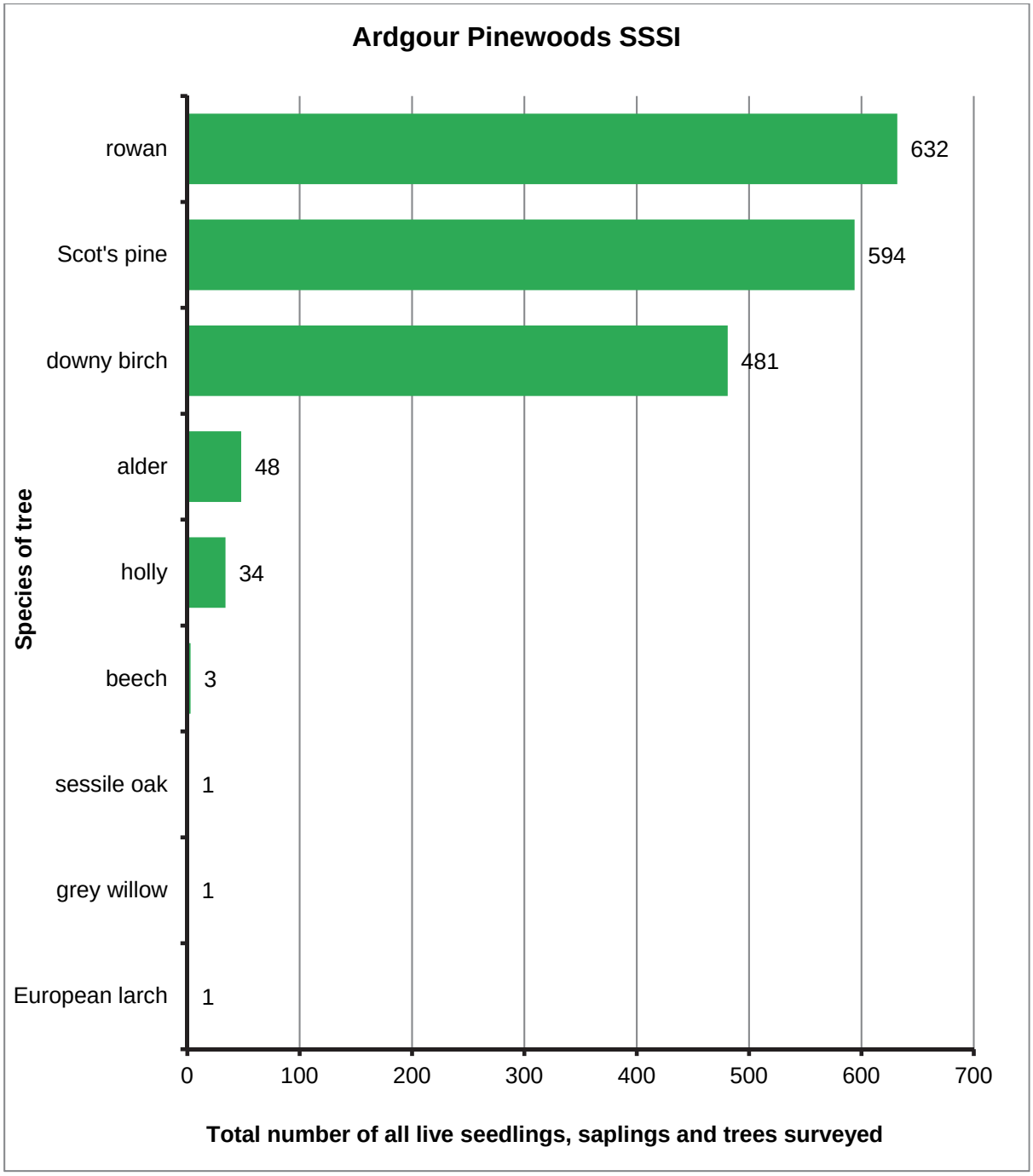


Figure 3. The total number of live trees, seedlings and saplings measured and counted for each species of tree.

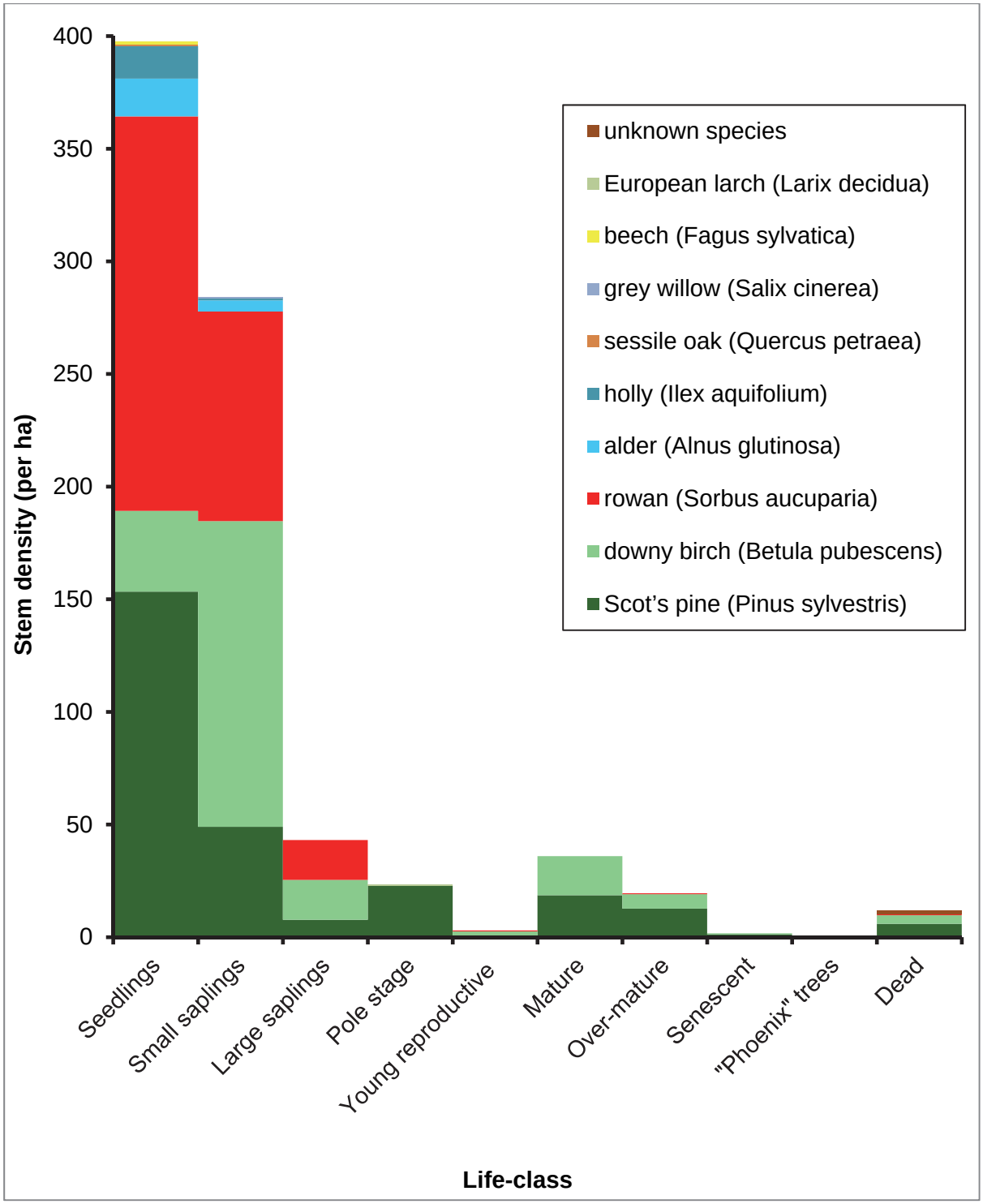


Figure 4. The stem density (per ha) for each life-class of each species of tree found in the 49 plots surveyed within the Ardgour Pinewoods SSSI.

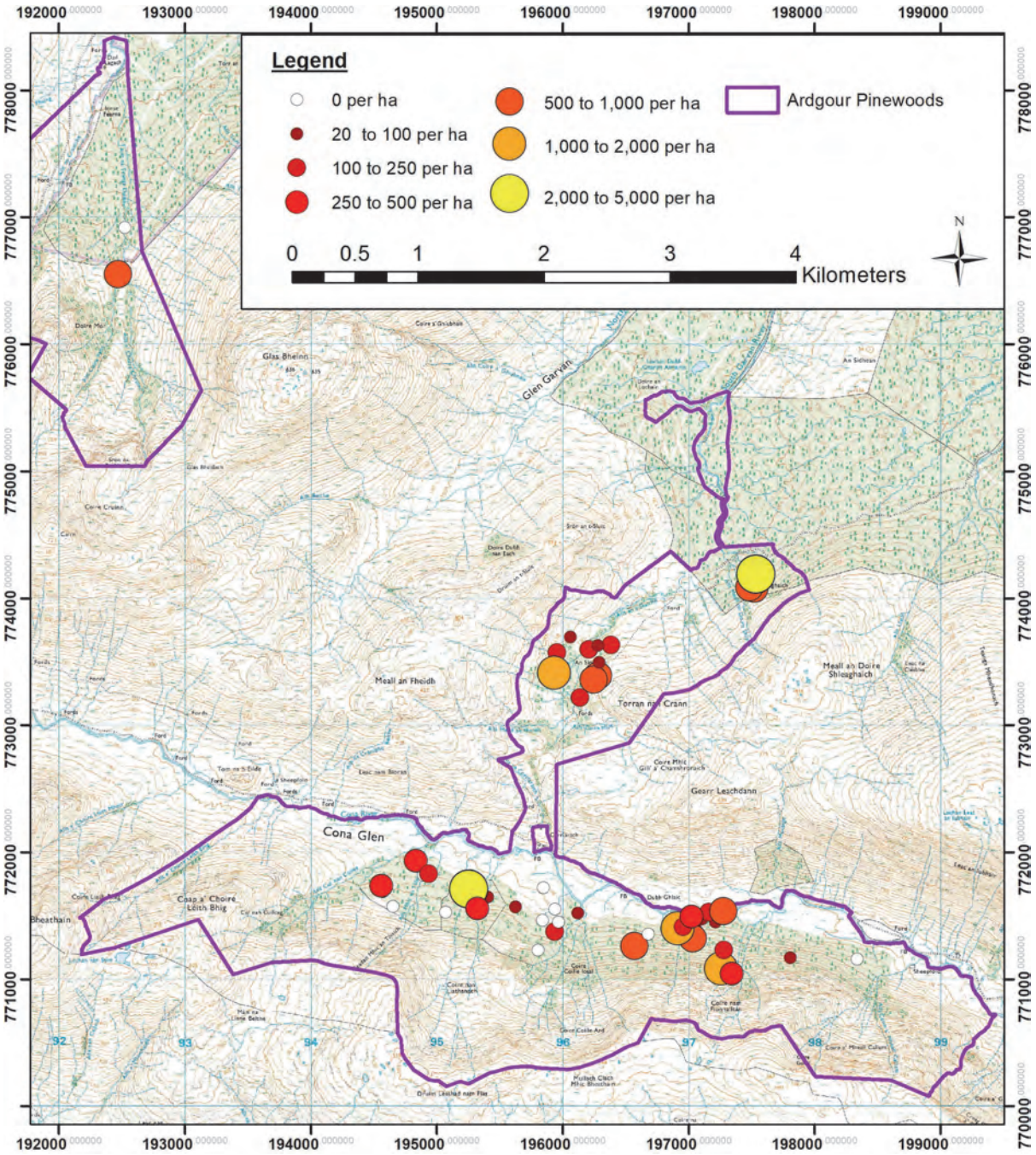


Figure 5. The density of all seedlings (per ha) in the plots surveyed across the Ardgour Pinewoods SSSI. © Crown copyright and database right 2018. Ordnance Survey 100017908.

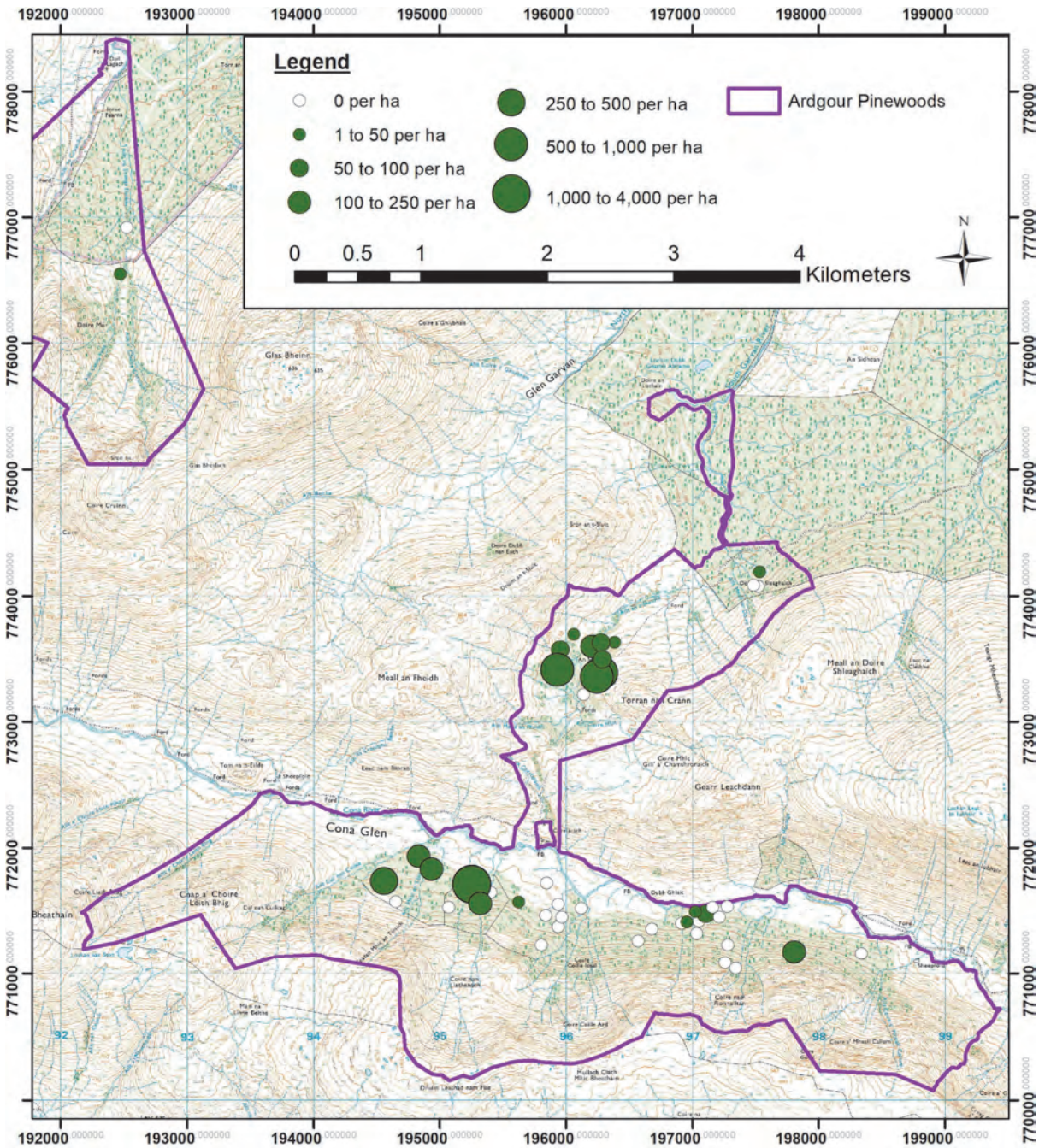


Figure 6. The density of Scots pine seedlings (per ha) in the plots surveyed across the Ardgour Pinewoods SSSI. © Crown copyright and database right 2018. Ordnance Survey 100017908.

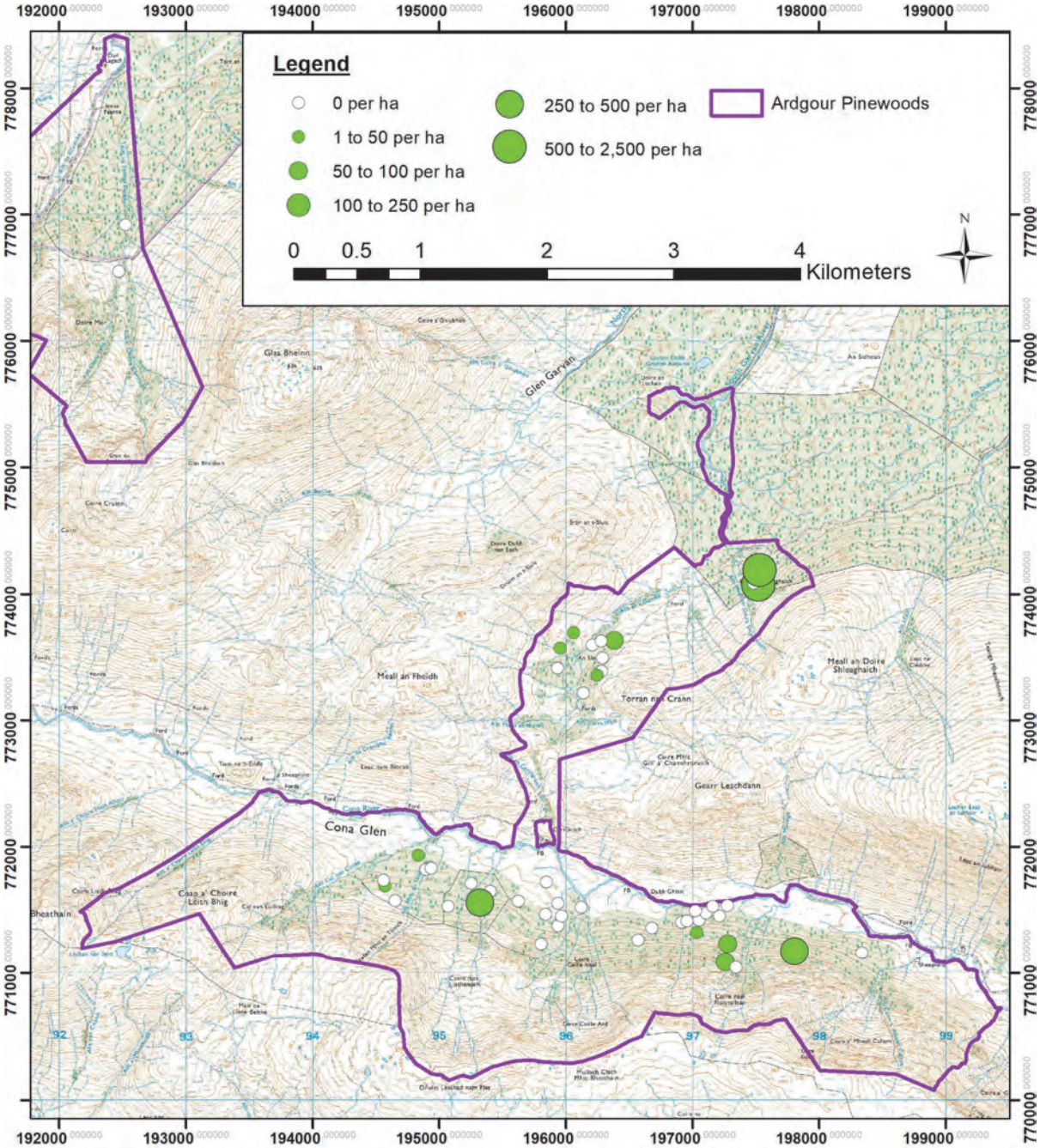


Figure 7. The density of downy birch seedlings (per ha) in the plots surveyed across the Ardgour Pinewoods SSSI. © Crown copyright and database right 2018. Ordnance Survey 100017908.

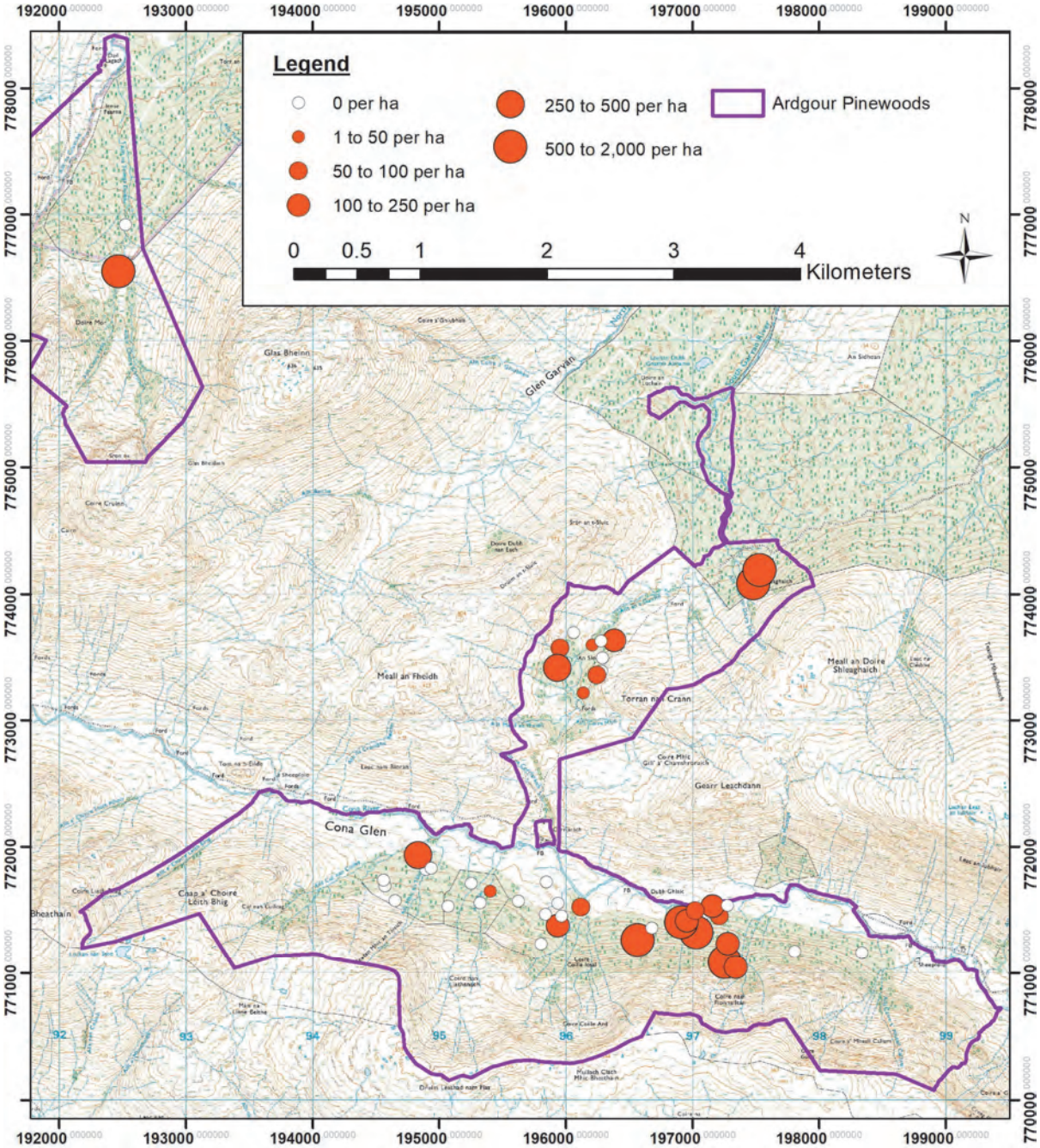


Figure 8. The density of rowan seedlings (per ha) in the plots surveyed across the Ardgour Pinewoods SSSI. © Crown copyright and database right 2018. Ordnance Survey 100017908.

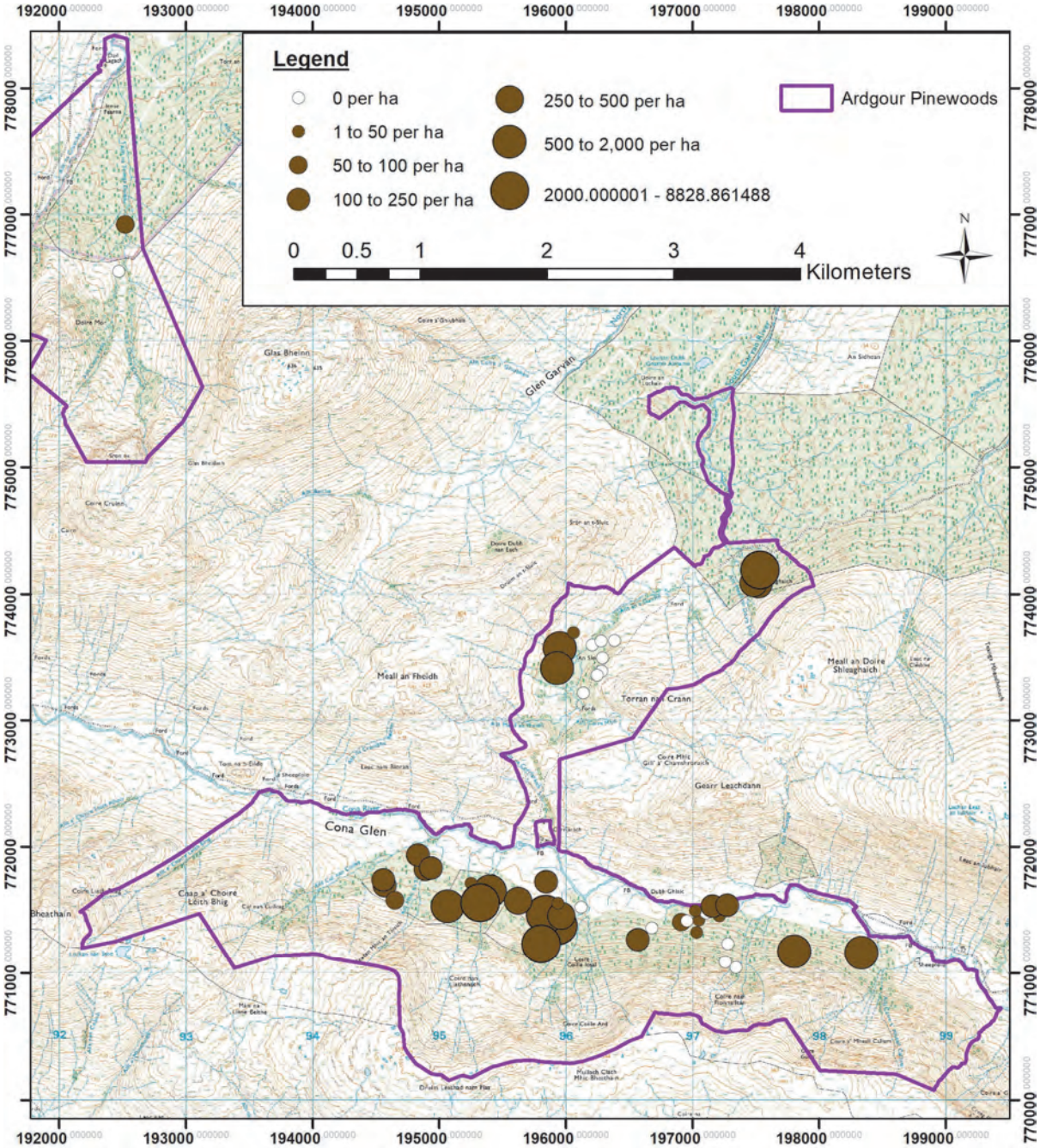


Figure 9. The density of all small saplings in the plots surveyed across the Ardgour Pinewoods SSSI. © Crown copyright and database right 2018. Ordnance Survey 100017908.

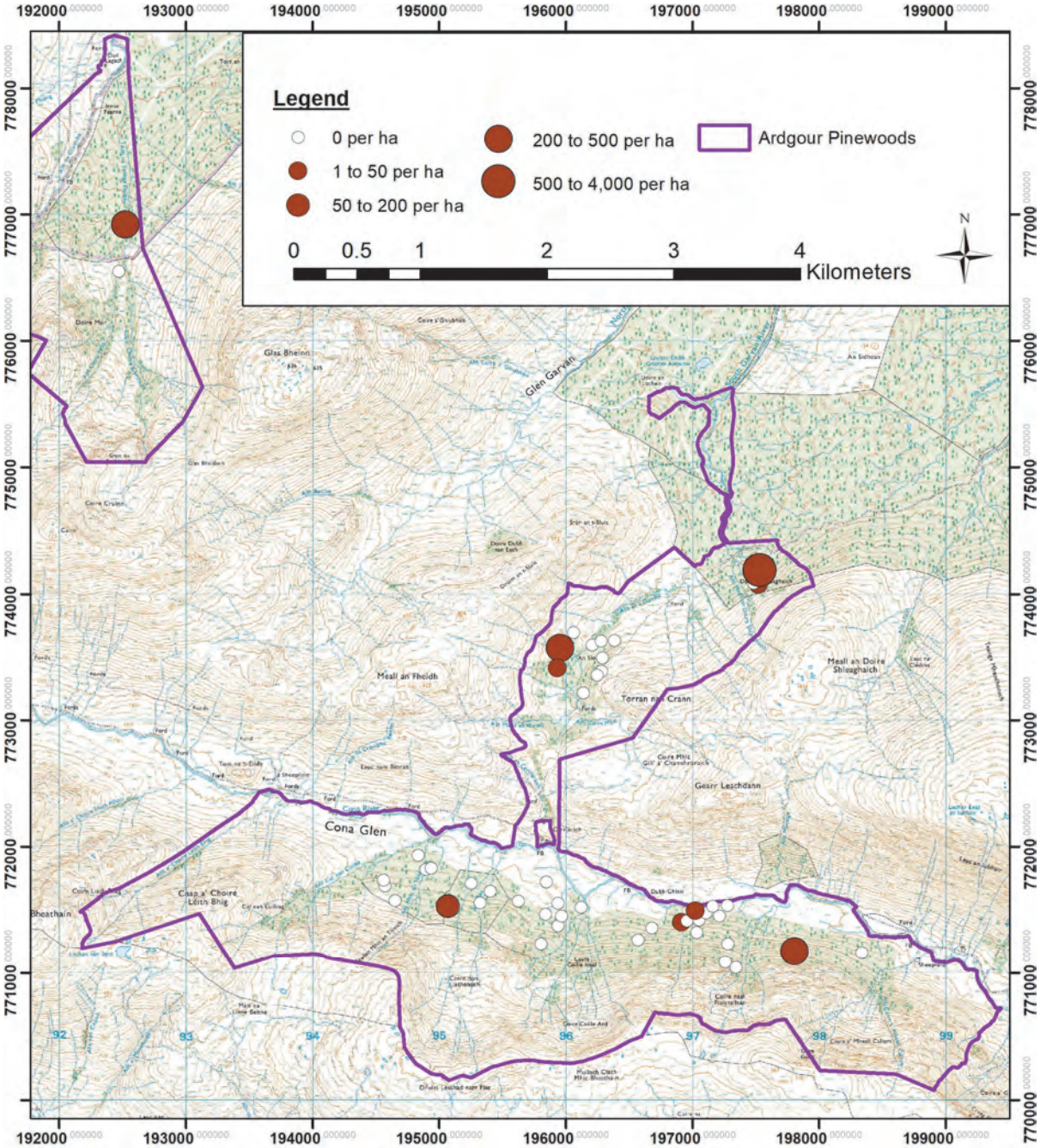


Figure 10. The density of all large saplings in the plots surveyed across the Ardgour Pinewoods SSSI. © Crown copyright and database right 2018. Ordnance Survey 100017908.

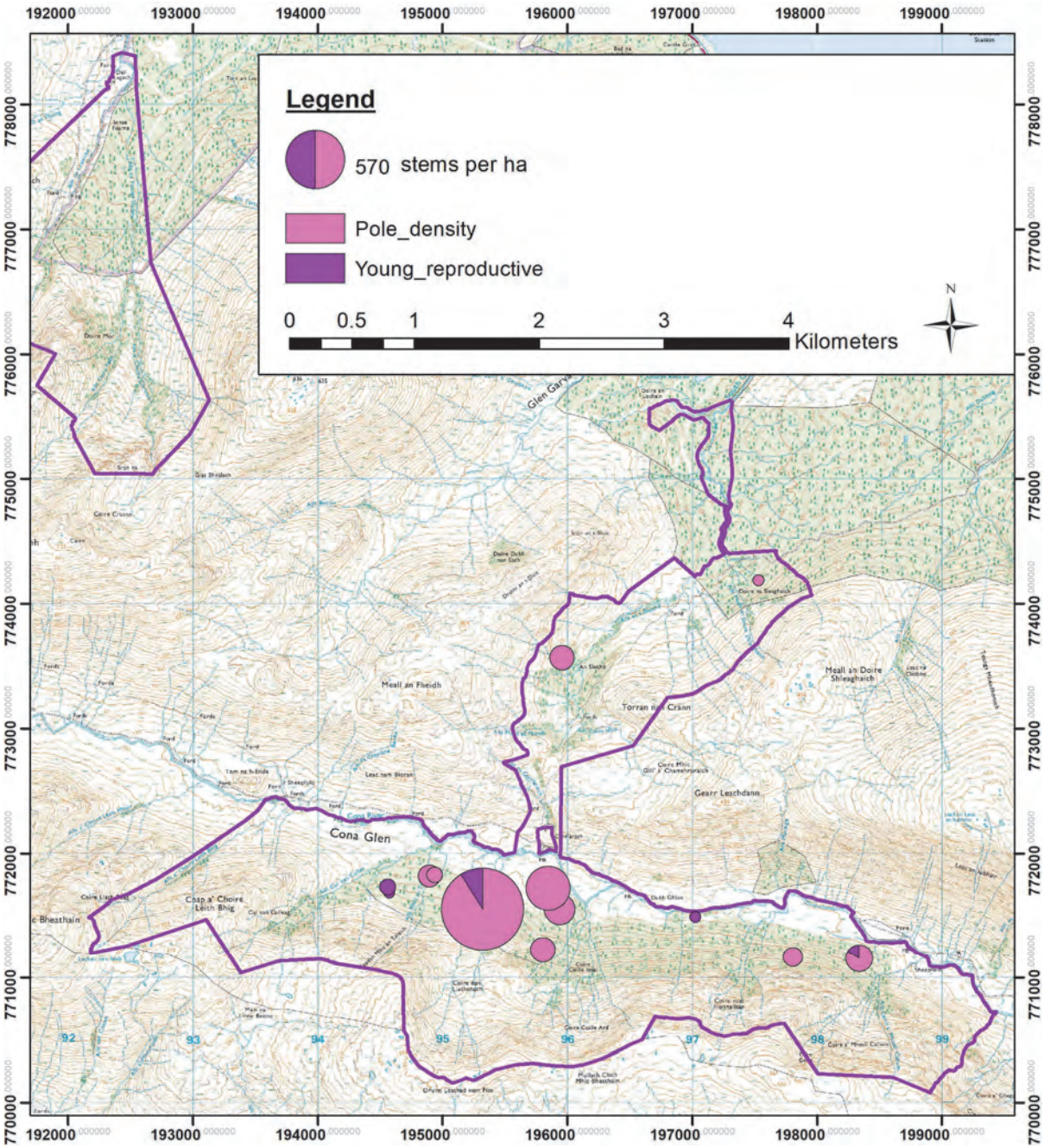


Figure 11. The density of all pole stage and young reproductive trees in the plots surveyed across the Ardgour Pinewoods SSSI. The area of the circles is proportional to the sum of the density for the pole stage and young reproductive life-classes. © Crown copyright and database right 2018. Ordnance Survey 100017908.

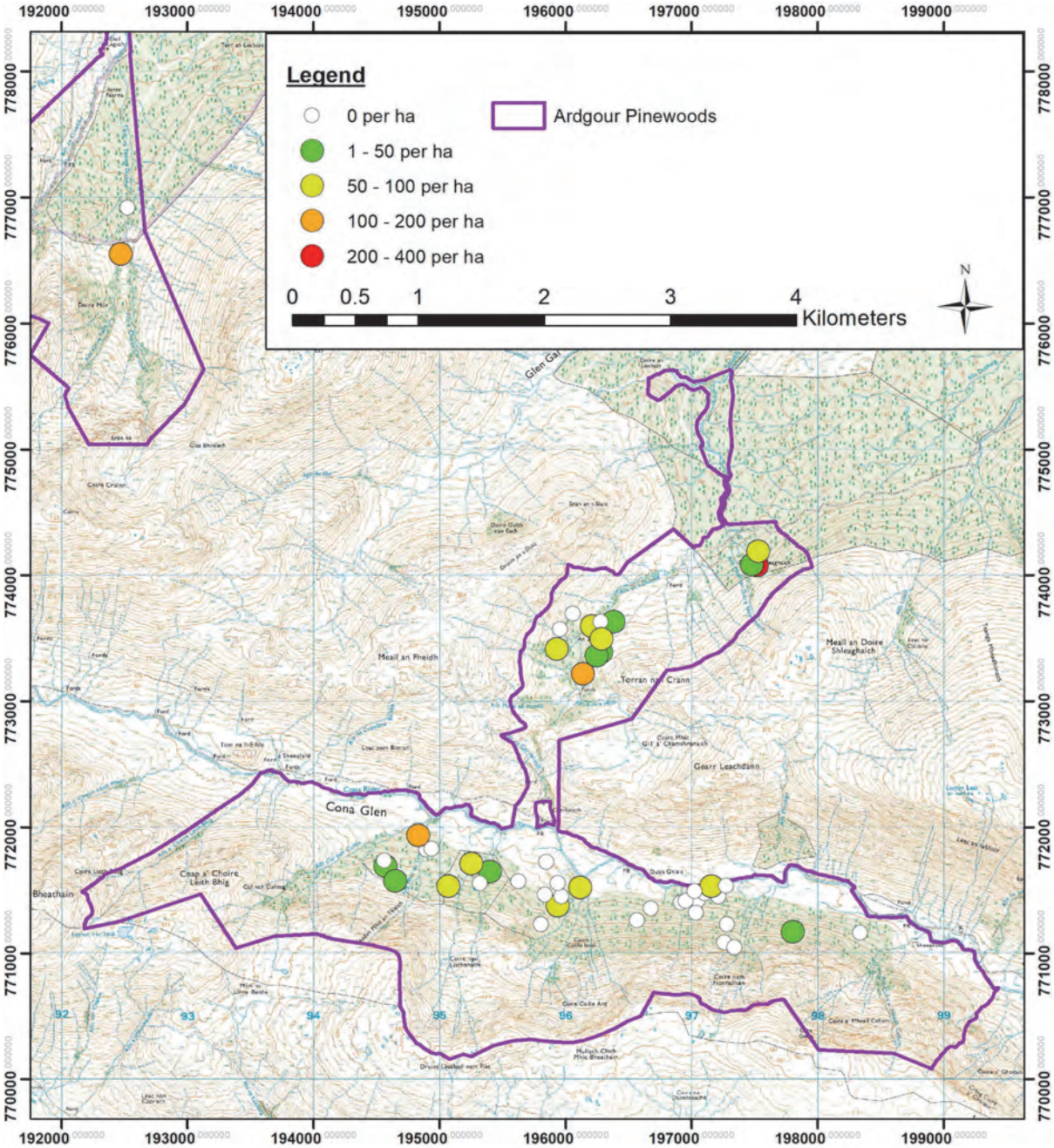


Figure 12. The density of all mature trees in the plots surveyed across the Ardgour Pinewoods SSSI. © Crown copyright and database right 2018. Ordnance Survey 100017908.

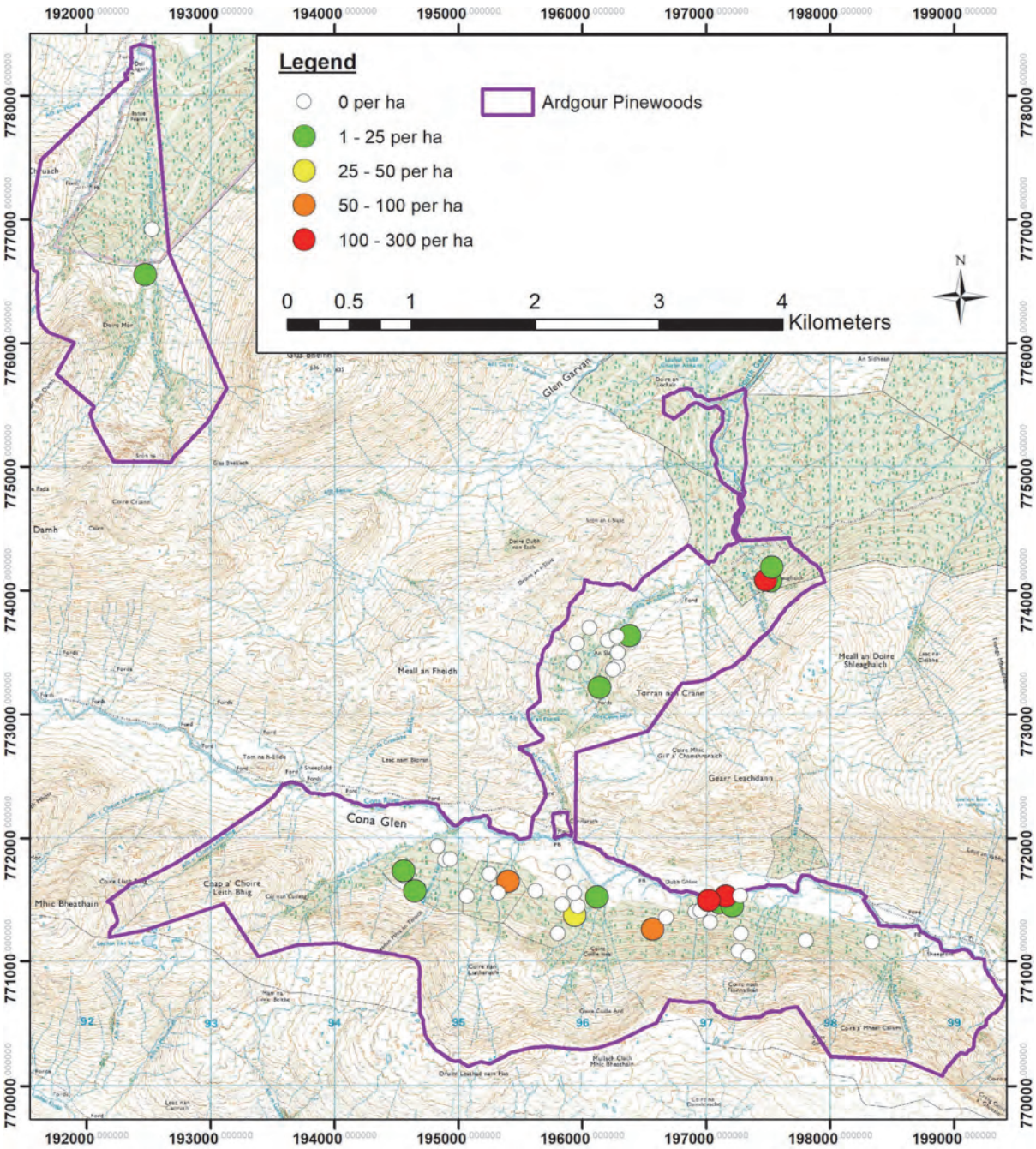


Figure 13. The densities of all over-mature trees in the plots surveyed across the Ardgour Pinewoods SSSI. © Crown copyright and database right 2018. Ordnance Survey 100017908.

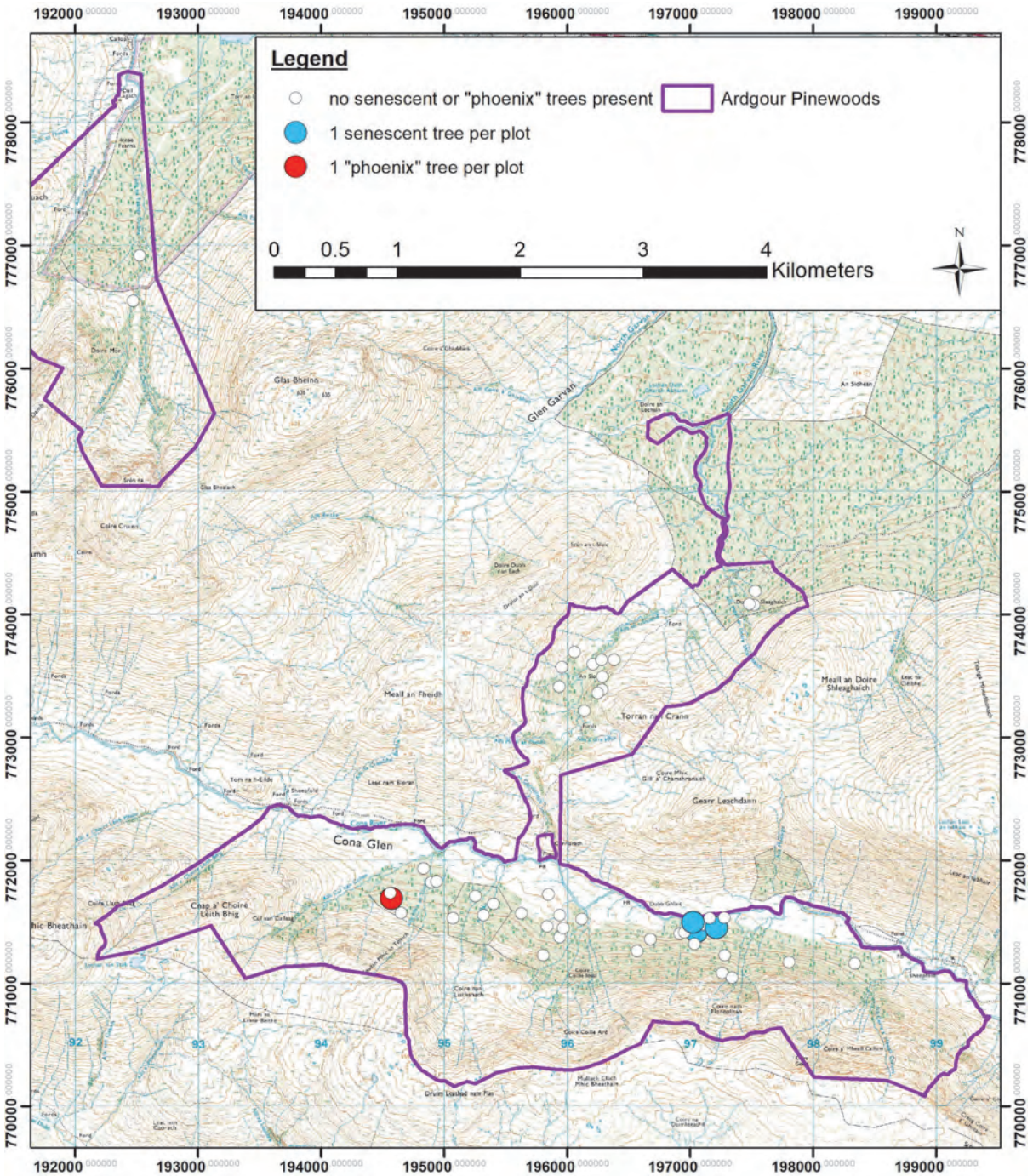


Figure 14. The location of the plots where all the senescent and "phoenix" trees were found in the 49 sample plots surveyed across the Ardgour Pinewoods SSSI. © Crown copyright and database right 2018. Ordnance Survey 100017908.

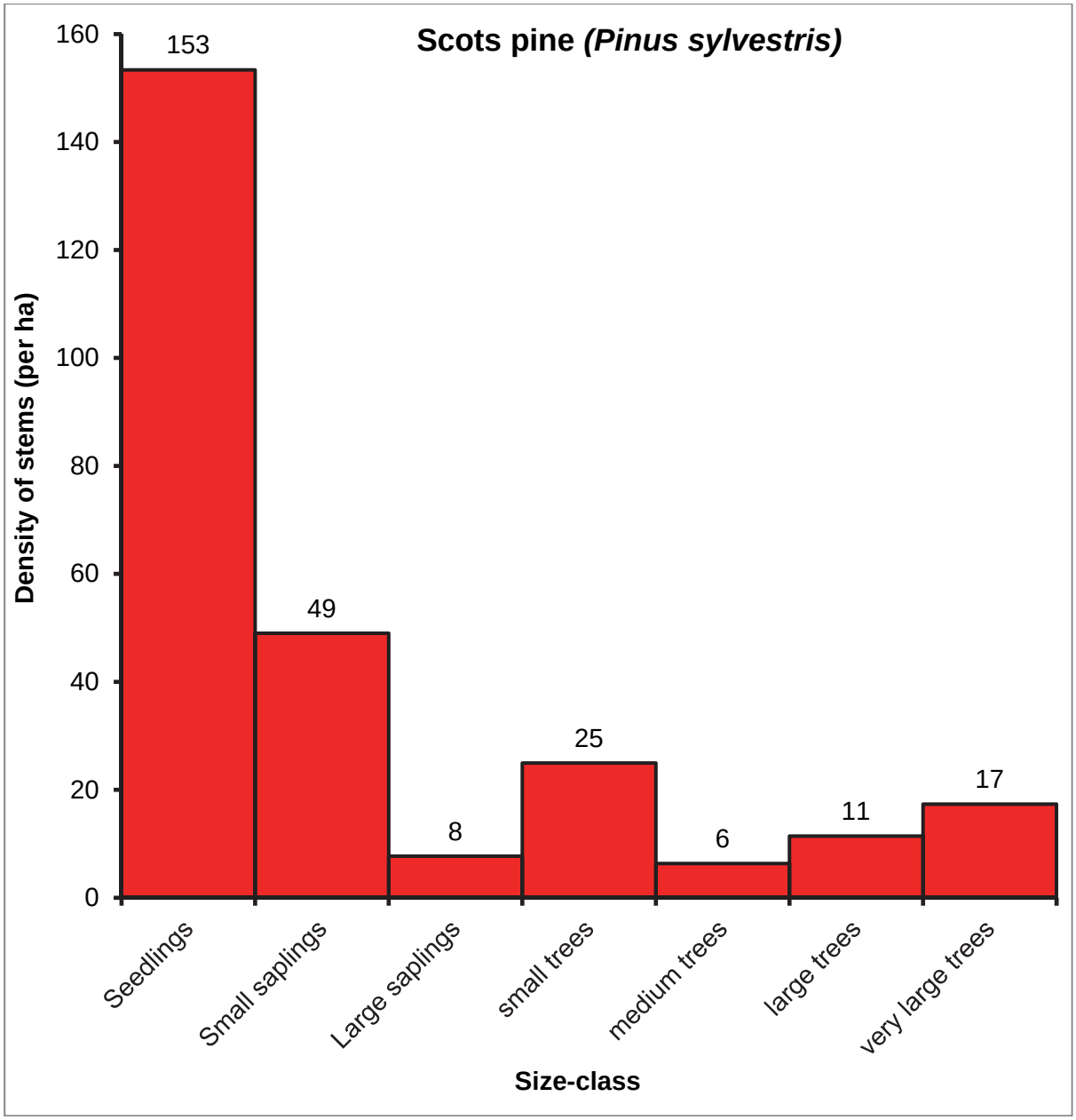


Figure 15. The size distribution of the Scots pine population surveyed within the Ardgour Pinewoods SSSI.

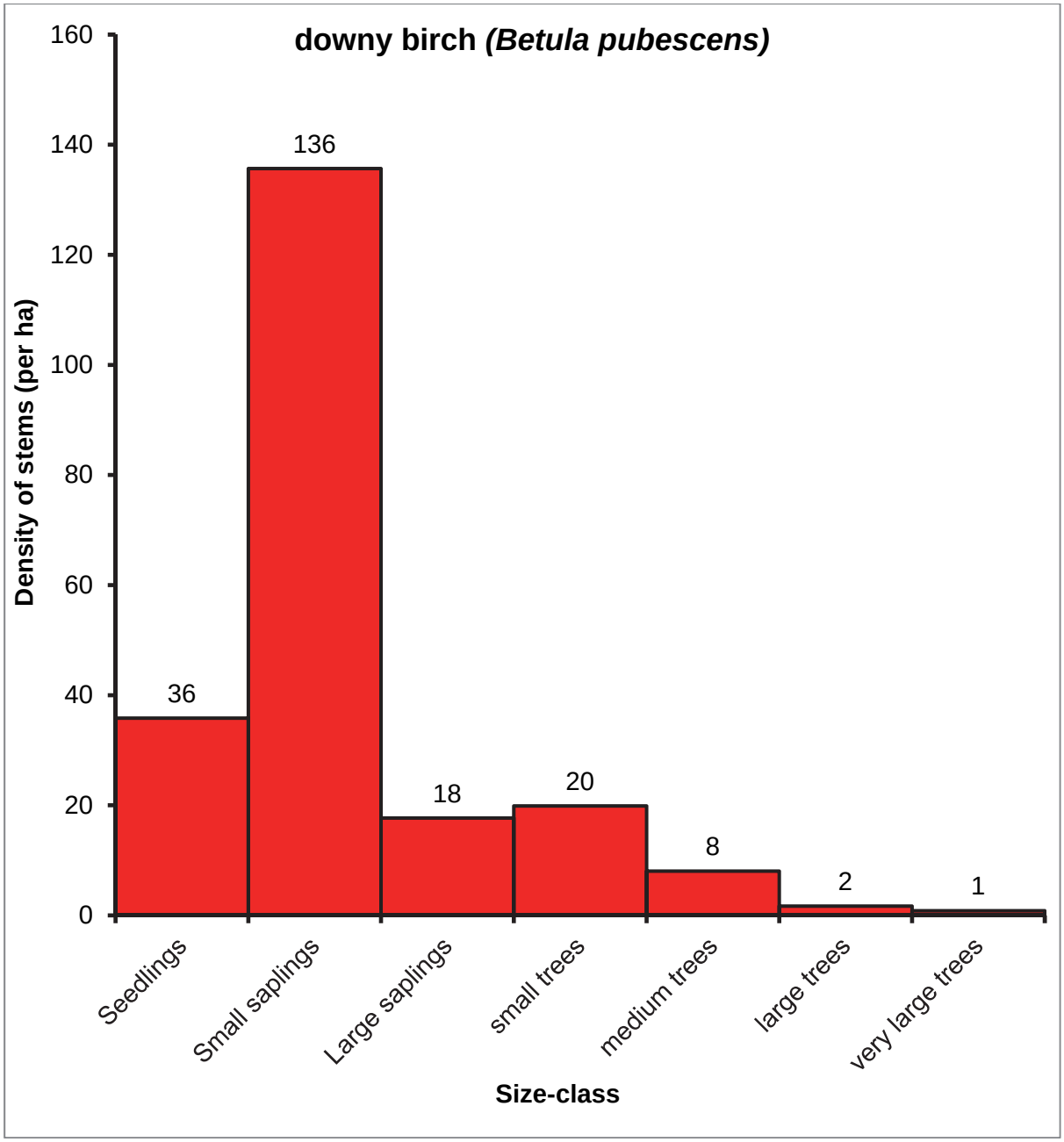


Figure 16. The size distribution of the downy birch population surveyed within the Ardgour Pinewoods SSSI.

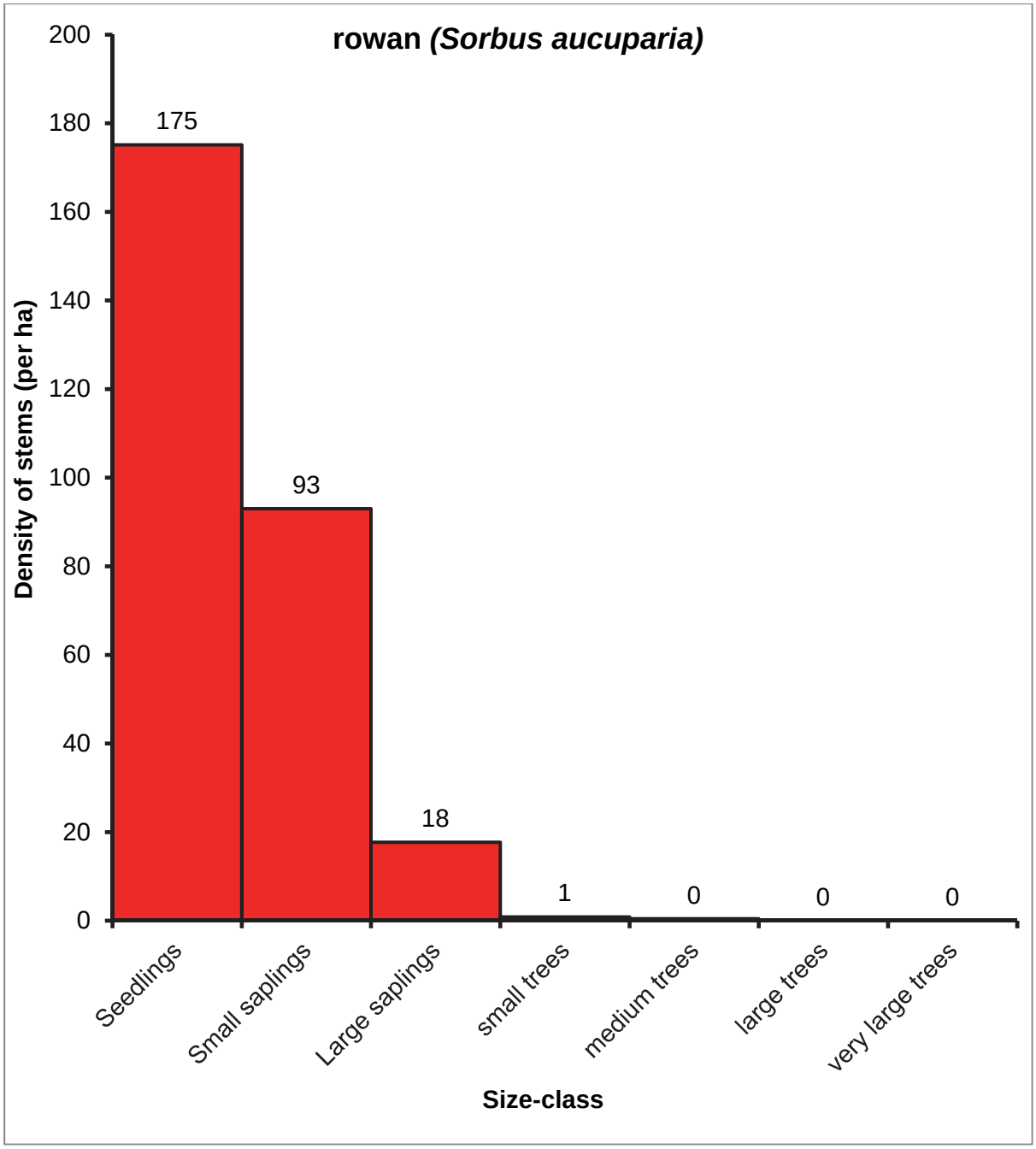


Figure 17. The size distribution of the rowan population surveyed within the Ardgour Pinewoods SSSI.

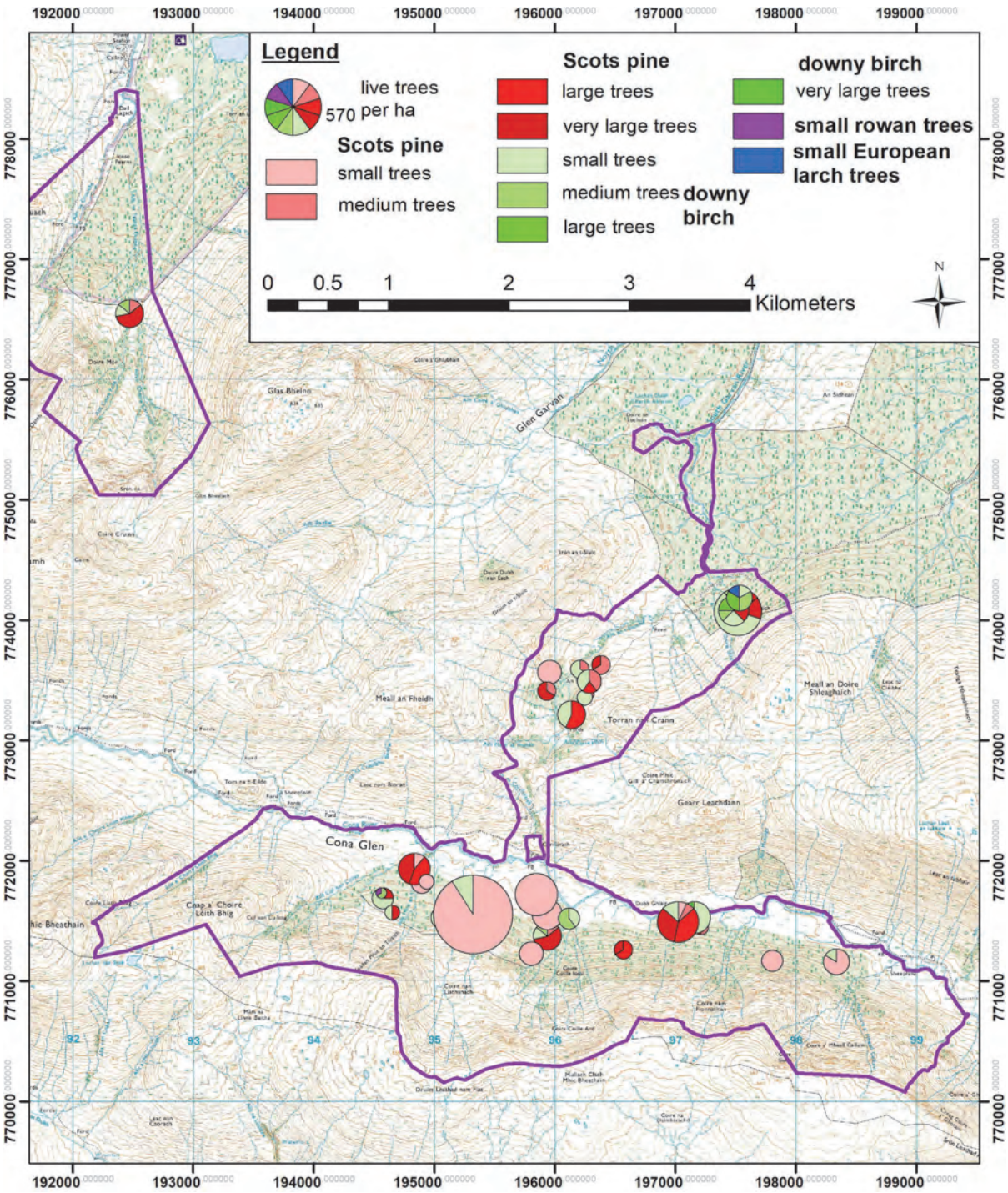


Figure 18. The density of different size classes of tree in individual plots surveyed across the Ardgour Pinewoods SSSI. The diameter of the pies is proportional to the sum of the densities of live trees in each size class. The diameter of the trees at breast height (1.3 metres) for each of the class intervals is as follows: small trees 5 to 25 cm; medium trees 25 to 40 cm; large trees 40 to 55 cm; and very large trees more than 55 cm. © Crown copyright and database right 2018. Ordnance Survey 100017908.

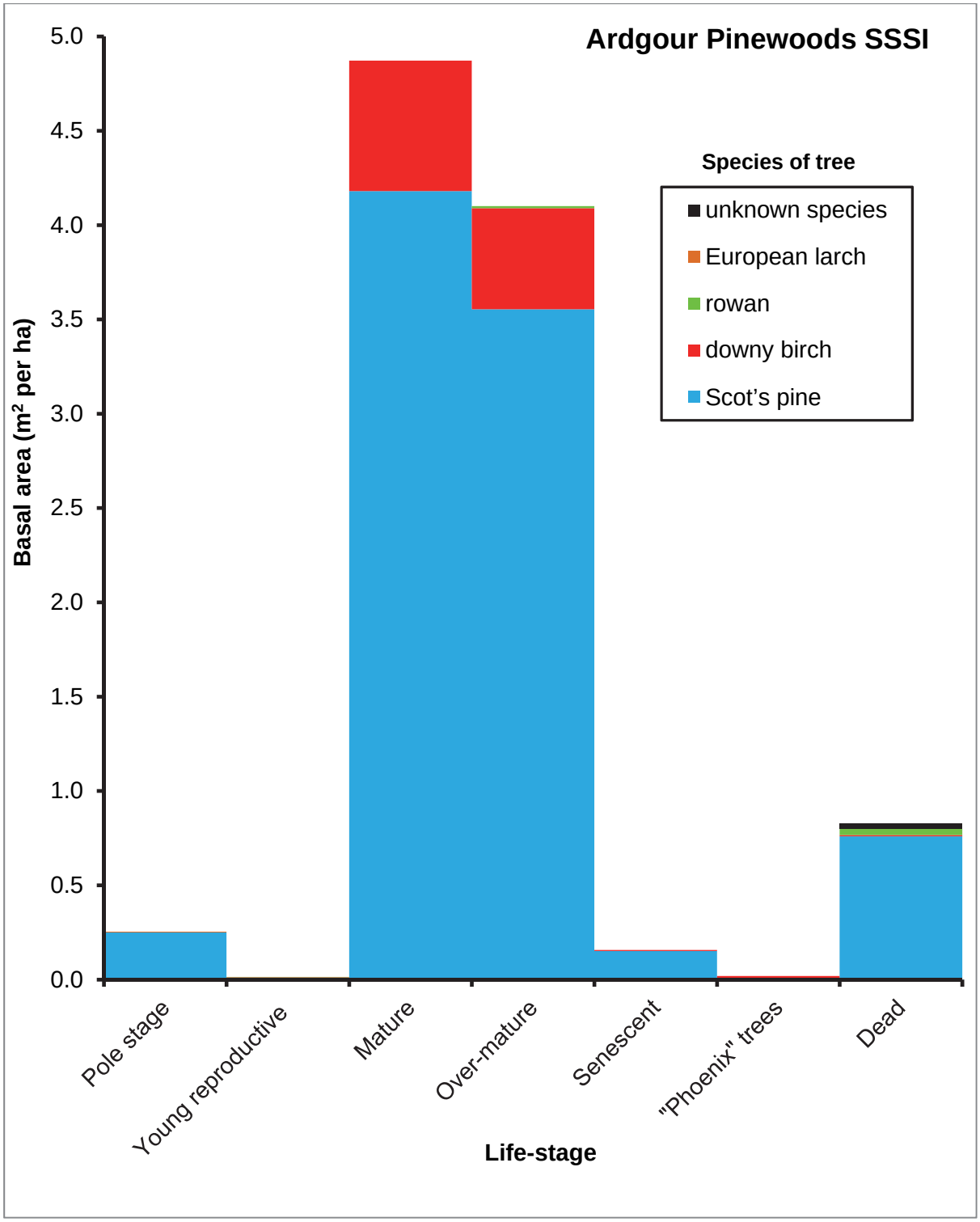


Figure 19. The basal area (m^2 per ha) of each life-class and each species of tree which had a diameter of at least 5 cm.

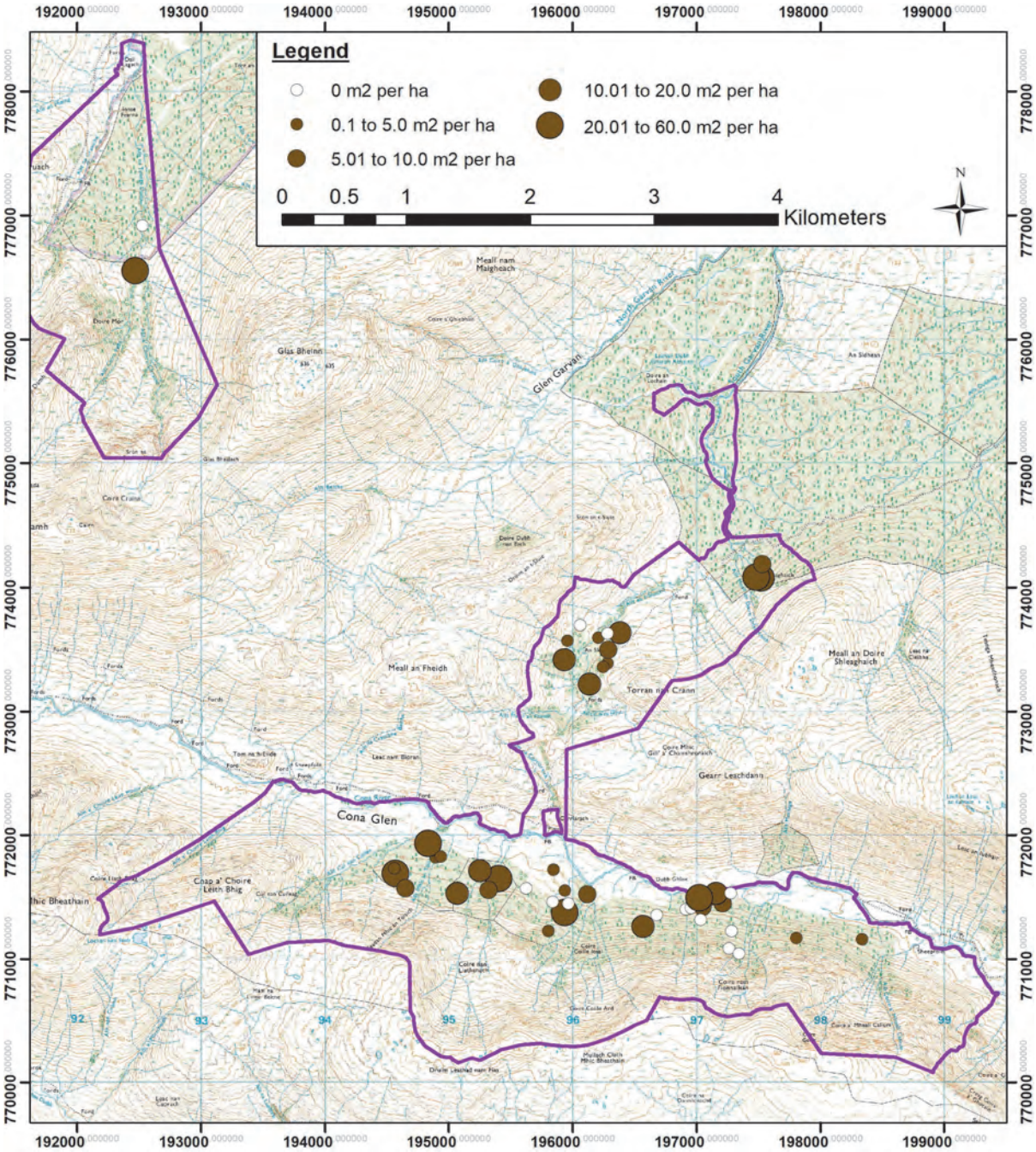


Figure 20. The total basal area (m^2 per ha) of all live trees with a diameter of at least 5 cm within the Ardgour Pinewoods SSSI. © Crown copyright and database right 2018. Ordnance Survey 100017908.

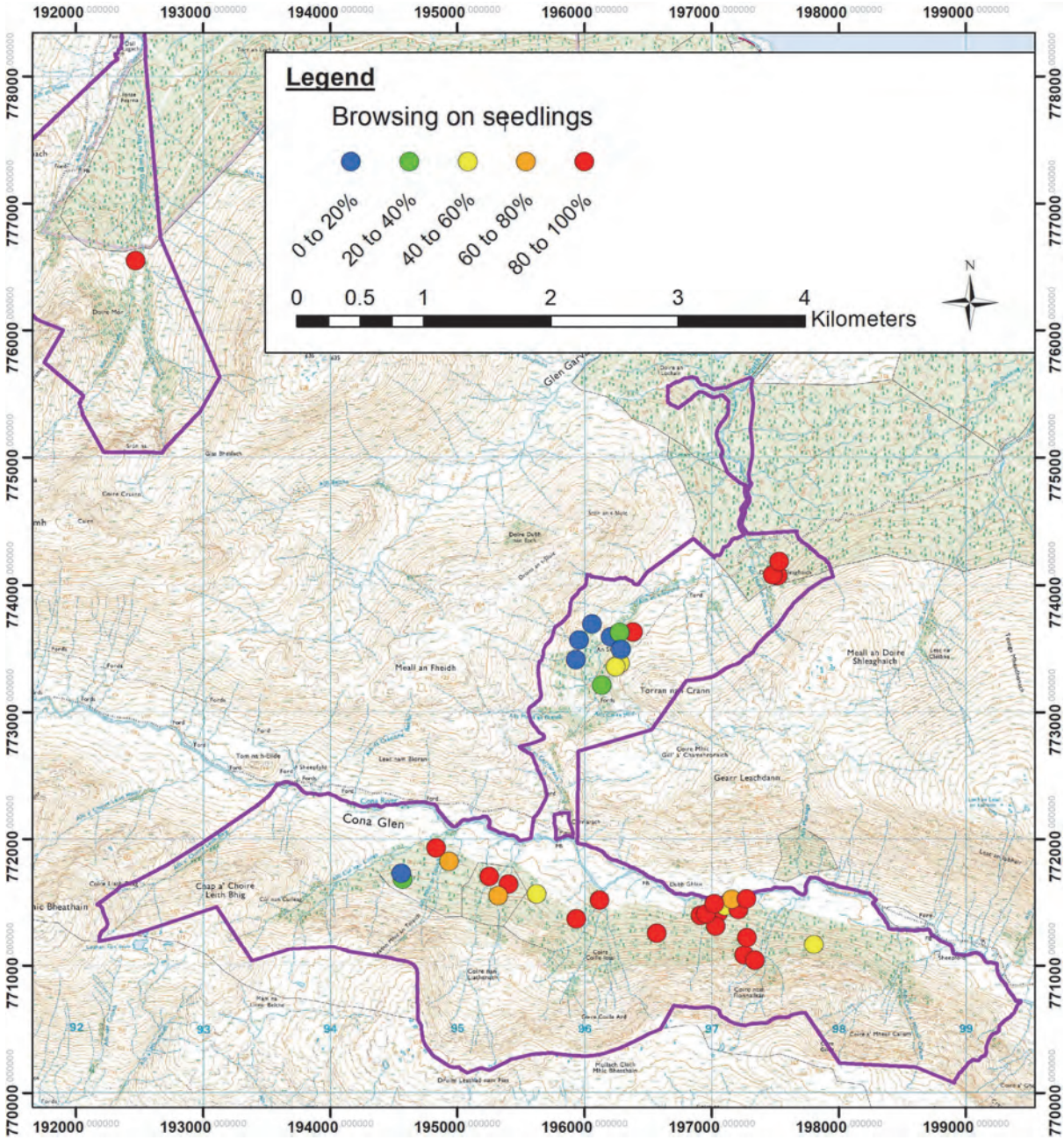


Figure 21. The level of browsing (%) of seedlings in the 38 sample plots where seedlings were found within the Ardgour Pinewoods SSSI. © Crown copyright and database right 2018. Ordnance Survey 100017908.

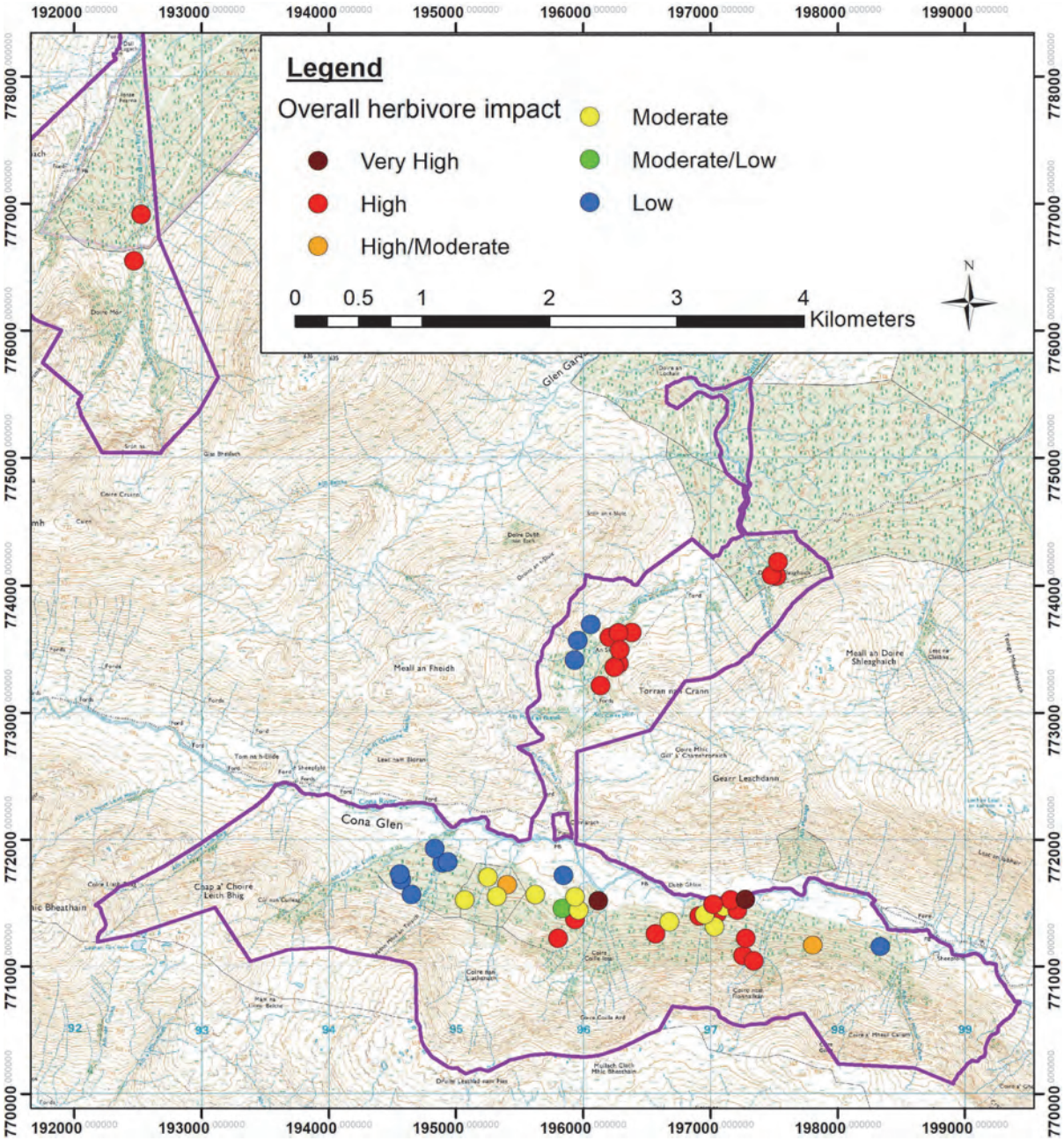


Figure 22. The overall current herbivore impacts on seedlings, saplings, trees and the sward in the 49 sample plots surveyed across the Ardgour Pinewoods SSSI. © Crown copyright and database right 2018. Ordnance Survey 100017908.

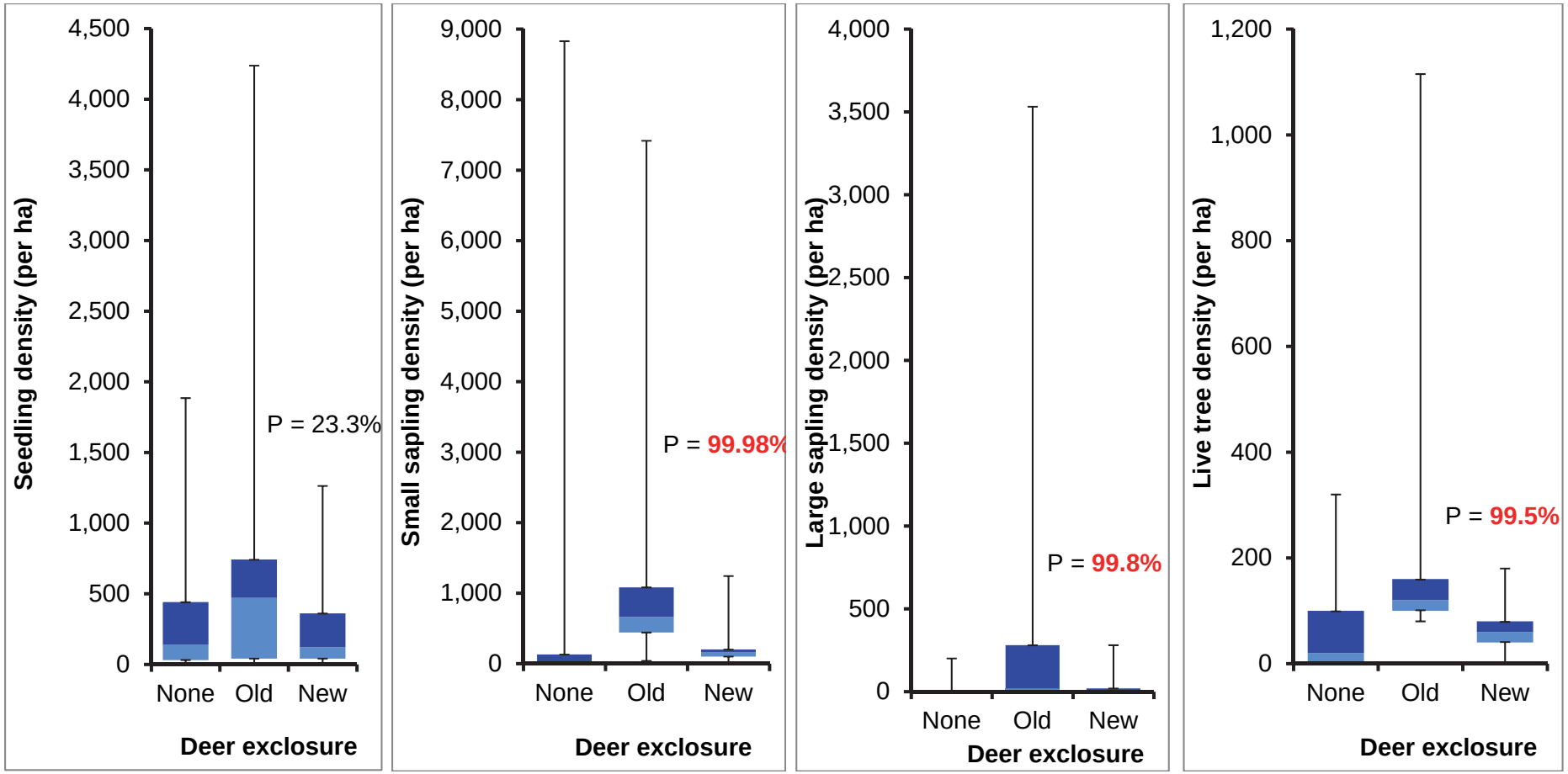


Figure 23. The range in the density of seedlings, small saplings, large saplings and all live trees for more than 5 cm in diameter within (old or new) and outside (none) deer exclosures.

The range from the 25th percentile to median is shown by the lower pale blue bar and the range of values from the median to the 75th percentile is shown by the dark blue bar. The lower whisker shows the minimum value and the upper whisker shows the maximum value. The probability of the differences between the values being inside (old and new) or outside the deer exclosures (none) are shown by the P value within the charts. These values were obtained by carrying out an analysis of variance (ANOVA) using logarithmically transformed data. P values greater than 95% (in red and bold) are considered to be statistically significant, i.e. the probability of occurring by chance is less than 5% of the time.

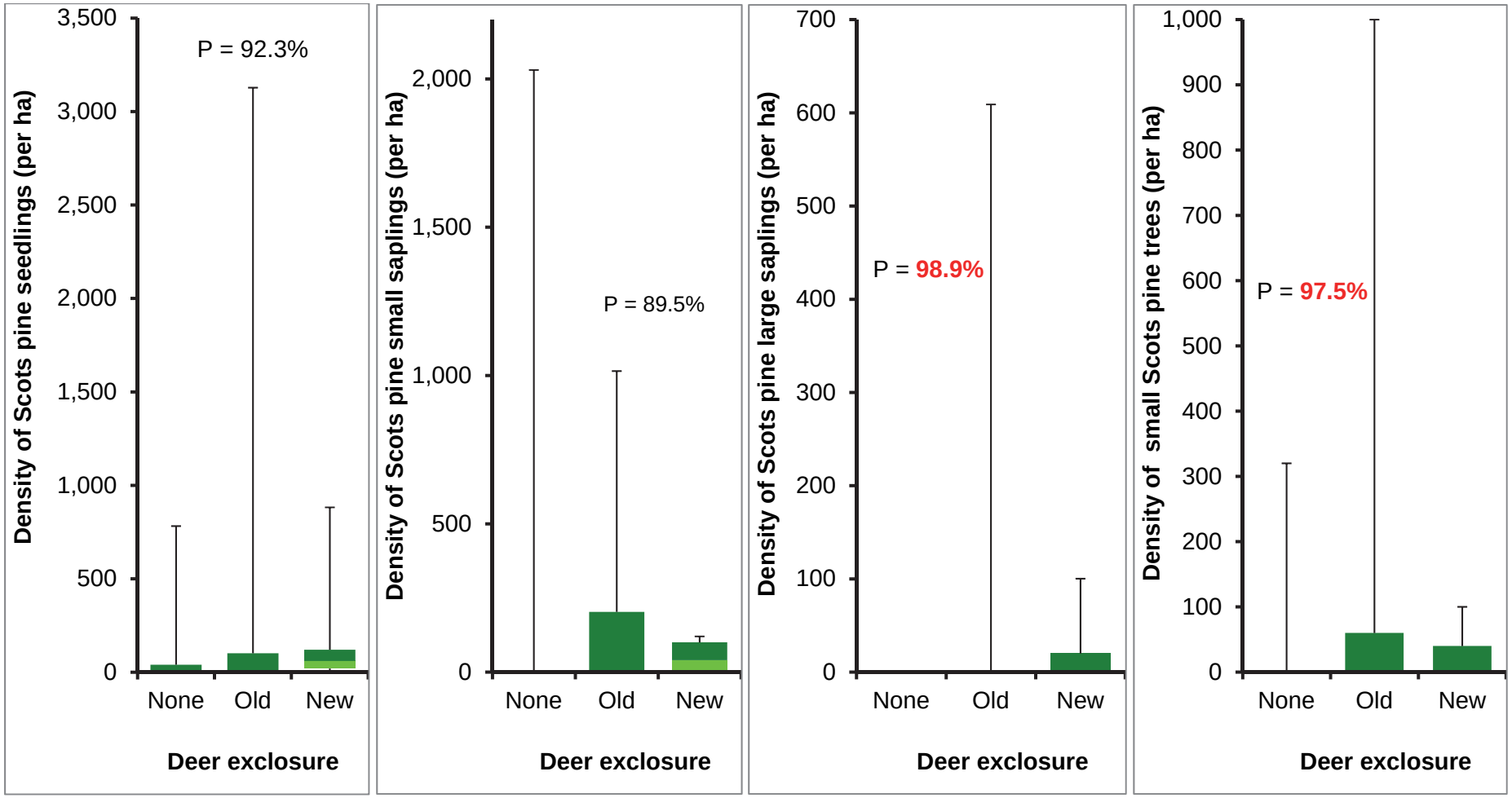


Figure 24. The range in the density of Scots pine seedlings, small saplings, large saplings and all live trees more than 5 cm in diameter within (old or new) and outside (none) deer exclosures.

The range from the 25th percentile to median is shown by the lower pale green bar and the range of values from the median to the 75th percentile is shown by the upper dark green bar. The lower whisker shows the minimum value and the upper whisker shows the maximum value. See Figure 23 for an explanation of the probability (P) values.

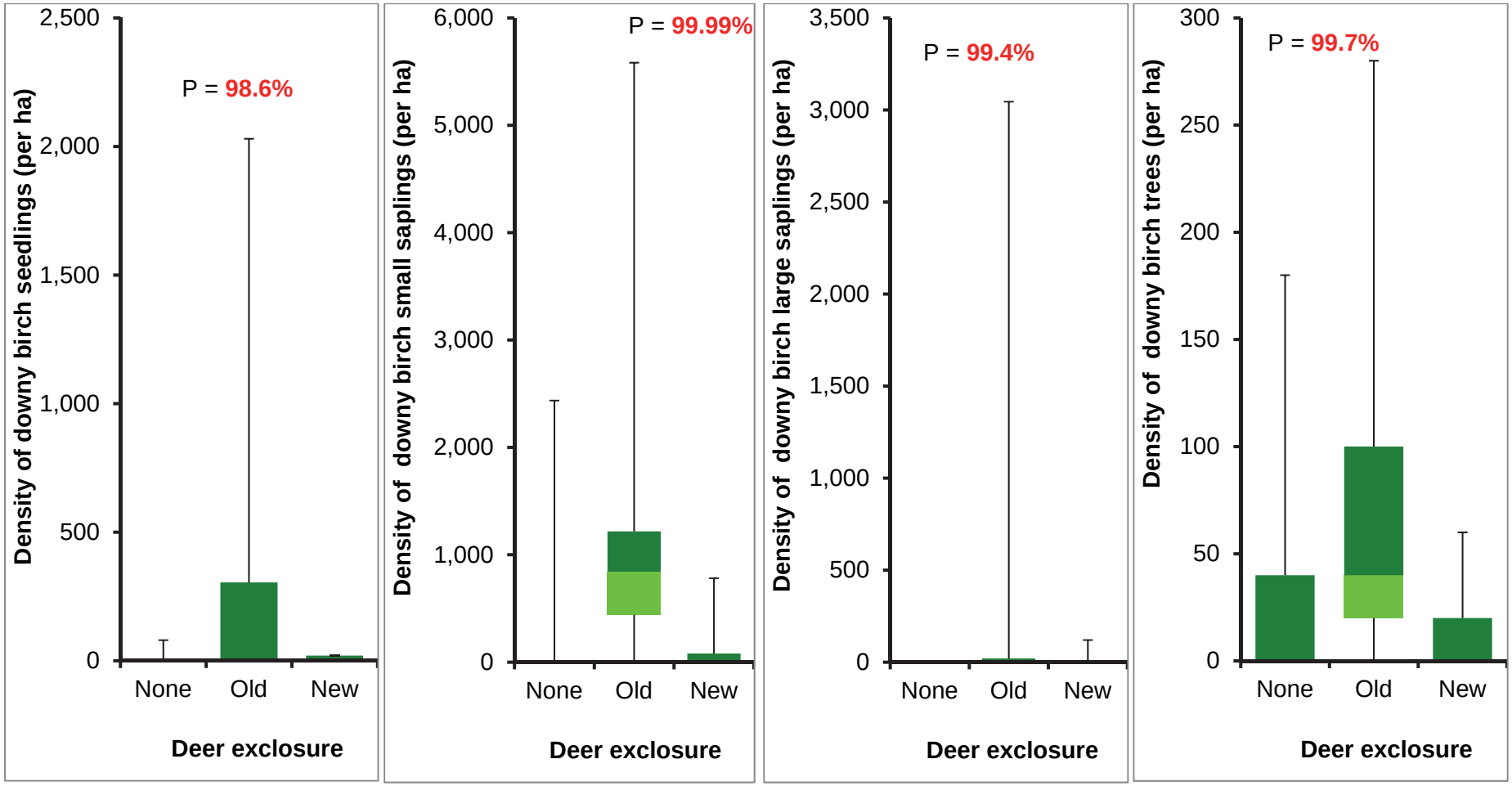


Figure 25. The range in the density of downy birch seedlings, small saplings, large saplings and all live trees for more than 5 cm in diameter within (old or new) and outside (none) deer exclosures.

The range from the 25th percentile to median is shown by the lower pale green bar and the range of values from the median to the 75th percentile is shown by the upper dark green bar. The lower whisker shows the minimum value and the upper whisker shows the maximum value. See Figure 23 for an explanation of the probability (P) values.

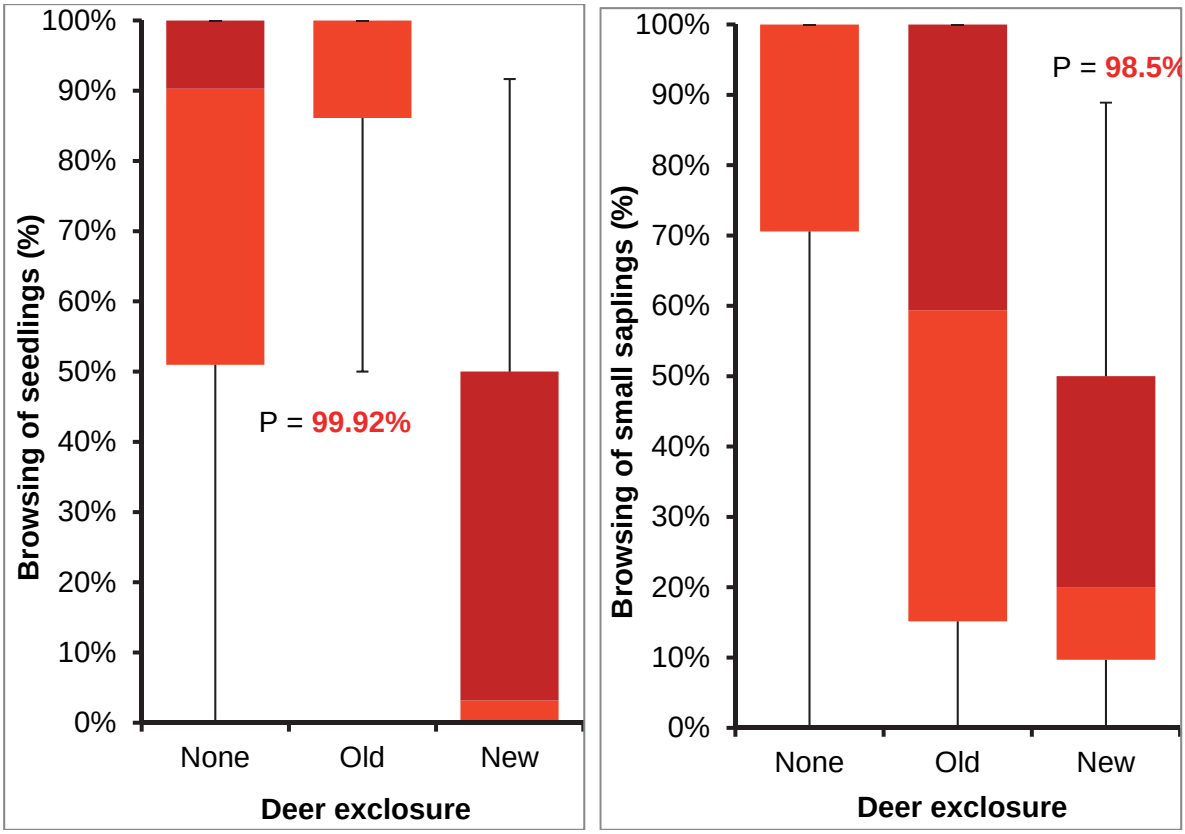


Figure 26. The range in browsing levels on all seedlings and saplings inside (old and new) and outside (none) deer exclosures.

The range from the 25th percentile to median is shown by the lower bright red bar and the range of values from the median to the 75th percentile is shown by the upper dark red bar. The lower whisker shows the minimum value and the upper whisker shows the maximum value. See Figure 23 for an explanation of the probability (P) values.

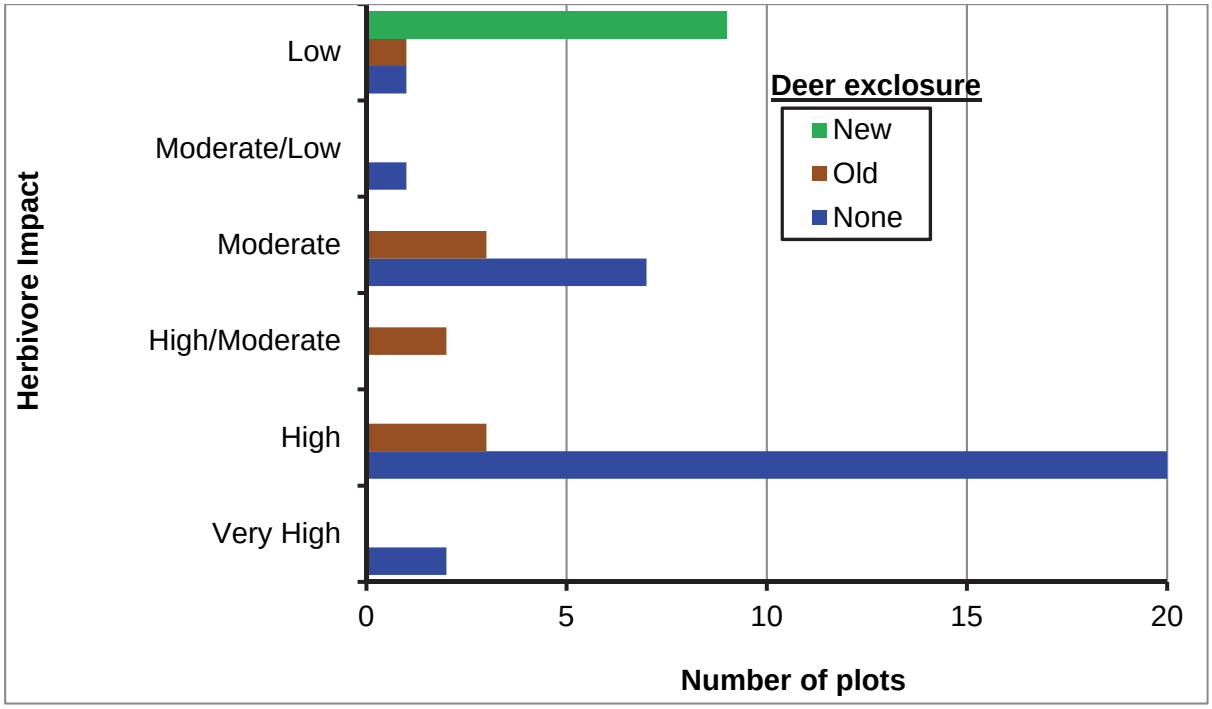


Figure 27. The number of plots with different overall herbivore impacts inside (old and new) and outside (none) deer exclosures.

Chi-square = 42.13, differences due to deer exclosures >99.99%

ANNEX 3: METHODS USED FOR ASSIGNING LIFE STAGE CLASSES AND LEVELS OF BROWSING BLES

Table 8. Life Stage Classes for Broad-leaved trees (Birch, Alder, Rowan) (After Clifford, 2004).

Tree Life Stage:	Tree sub-class:	Descriptor:	Stand type/conditions:	Biodiversity characteristics:	Stand process:
1. Seedling	1.1 Small seedling	All seedlings **at or below the predominant field layer vegetation height,** Includes newly germinated seedlings of the year & **"oscars**" which have repeatedly been browsed back to field layer height or below	Fragmented canopy, usually with large gaps, & woodland stand edges	Generally high biodiversity in sheltered canopy gaps with increased woodland edge habitat, particularly birds and lepidoptera. Biodiversity generally reduced on exposed woodland edges.	**Stand initiation/regeneration**
	1.2 Large seedling	Seedlings above field layer vegn height, **up to 1m tall**;	Fragmented canopy, gaps & woodland stand edges		
2. Juvenile non-reproductive	2.1 Small sapling	Young trees **1m - 3m height;** usually not yet seed producing	Both dense drifts & scattered individuals in canopy gaps & at stand edges		
3. Young reproductive	3.1 Large sapling	Young trees **3m - 5m in height** usually seed producing DBH usually < 5 cm	Either in dense patches but with branches of established trees not yet fully interlocking, or as small patches or scattered individuals		
	3.2 Pole stage	Seed producing young trees **usually over 5m in height**, where canopy has closed DBH range usually **5 – 20 cm**	Dense stands & patches with fully interlocking branches [thicket]	1. Low light levels, declining biodiversity; 2.some deadwood formation through self-thinning	**Stem exclusion**
	3.3 Young reproductive [non-thicket]	Seed producing young trees **usually over 5m in height** DBH range usually **5 – 20 cm**	Lone trees & small scattered groups in canopy gaps & at stand edges		
4. Mature reproductive	4.1 Mature	Seed-producing trees where growth has begun to significantly slow down. **Usually over 5m height & 20 cm DBH[1]**,not falling into the preceding or following classes; **crown usually spreading and at its maximum development** May be **canopy die-back up to 10%** due to competition for light or wind damage	1. Usually scattered open-crowned individuals [often poor form] but 2. Occasionally closer grown stands of better form	1.Some deadwood habitat provided on standing tree and forest floor from wind thrown branches; 2.Canopy provides nesting & feeding sites for birds & invertebrates; 3.Sap-runs developing; 4. Bryophytes, fungi & lichens on bole/bark	**Dynamic Equilibrium**

5. Over-mature	5.1 Early canopy decline	Trees **usually over 5m** height, with spreading canopy; **Canopy 10-20% dead** with reduced seed production [Any reduction likely to be proportional to crown size]	Usually more open conditions, where wind has begun to de-limb trees Characteristic of conditions with low stocking & little/no recruitment of earlier life stages; wood beginning to look Moribund	1. Increase in standing and fallen deadwood; 2. Torn branches & broken limbs; 3.rot-holes developing on tree & saprophytic fungi fruiting 4. Crown dieback → increased light to bole → more opportunities for epiphytes!	**Canopy breakup**
	5.2 Mid-canopy decline	Trees **usually over 5m** height, with spreading canopy; **Canopy 20-50% dead** with consequent much reduced seed production			
6. Senescent post-reproductive	6.1 Heavy canopy decline	Trees **usually over 5m** height, with spreading canopy much ravaged by wind & pathogens; **Canopy 50-99% dead** with markedly reduced seed production proportional to loss of canopy	Often [but not always] very open stand with large canopy gaps, with or without recent regeneration	As above sub-class with significant increase in standing & fallen deadwood habitat on/around trees	
7. "Phoenix" trees	7.1 Main bole dead [usually stump]	**Main bole of tree dead** & usually decaying; **new growth [usually vigorous] from base**			**Canopy rejuvenation**
	7.2 main bole procumbent	**Usually wind thrown** tree with main bole lying along forest floor & **vigorous branches growing more or less vertically**		Displaced root plate often provides additional niches, including "safe sites" for seedling trees	
8. Dead	8.1 Standing dead	Three classes as broad indicators of time elapsed since death: 1.Most bark still on tree [recent dead], bole still hard 2. <80% & >20% bark still on tree, surface of bole hard or becoming softer with decay 3. <20% bark still on tree, surface of bole usually soft [long dead]	Often degrading fragmented stands of large old trees with significant wind throw: but: includes smaller specimens resulting from competitive exclusion in dense stands and: Steep scree slopes with a mobile substrate where trees have been uprooted	Bio-diversity likely to be high for recently dead trees [bark still on tree] with larger stem diameters, which are more typical of fragmented open stands.	**Death, decay & nutrient cycling**
	8.2 Fallen dead	Three classes as broad indicators of time elapsed since death: 1.Most bark still on tree [recent dead] 2. <80% & >20% bark still on tree, surface of bole hard or just softening 3. <20% bark still on tree, surface of bole mostly soft [long dead]			

	8.3 Stumps with no fallen trunk/bole evident	Two classes as broad indicators of past history/management: 1.Stumps from past logging operations [clean cut surface] but in varying stages of decay depending on when cut 2.Torn stumps resulting from wind ”snap”, where trunk has either been removed for firewood or completely decayed	Various but typical of open stands of old wide-crowned trees. Where straightest large specimens have been removed for timber		

N.B. Maturity is defined as the point at which growth starts to slow down significantly.

Table 9. Life Stage Classes for Scots Pine (After Clifford, 2004).

Scots Pine Life Stage:	**Tree sub-class:**	**Descriptor:**	**Stand type/conditions:**	**Biodiversity characteristics:**	**Stand process:**
1. Seedling	1.1 Small seedling	All seedlings **at or below the predominant field layer vegn height,** Includes newly germinated seedlings of the year	Fragmented canopy, gaps & woodland stand edges	Generally high biodiversity in sheltered canopy gaps with increased woodland edge habitat, particularly birds and Lepidoptera. Biodiversity generally reduced on exposed woodland edges.	**Stand initiation/regeneration**
	1.2 Large seedling	Seedlings above field layer vegn height, **up to 1m tall**; **usually conical form**	Fragmented canopy, gaps & woodland stand edges		
2. Juvenile non-reproductive	2.1 Small sapling	Young trees **1m - 3m height;** not yet producing **significant** quantities of seed, (**usually conical form**	Both dense drifts & scattered individuals in canopy gaps & at stand edges		
3. Young reproductive	3.1 Large sapling	Young trees **3m - 5m in height** usually coning/seed producing **usually conical form** **DBH usually < 7cm**	Either in dense patches but with branches of established trees not yet fully interlocking, or as small patches or scattered individuals		
	3.2 Pole stage	Seed/cone producing young trees **usually over 5m in height** where canopy has closed; **usually conical canopy form** **DBH range usually 7– 30 cm**	Often dense stands & patches with fully interlocking branches [thicket], but also lone trees & small groups in canopy gaps & at stand edges	1. Low light levels, declining biodiversity; 2.some deadwood formation through self thinning	**Stem exclusion**
4. Mature reproductive	4.1 Mature	Seed/cone-producing trees **usually over 5m height & 30cm DBH**[1] not falling into the preceding or following classes; **crown usually spreading rather than conical and at its maximum development** May be **canopy die-back up to 10%** due to competition for light	1. Scattered open-crowned individuals [often poor form] or 2. closer grown stands of first progeny [better form] around "pioneer trees"	1.Some deadwood habitat provided on standing tree and forest floor from wind thrown branches; 2.Canopy provides nesting & feeding sites for birds & invertebrates; 3.Sap-runs developing; 4. Mosses, lichens on bark (but greater development of bryophytes on over-mature trees	**Dynamic Equilibrium**
5. Over-mature	5.1 Early canopy decline	Trees **usually over 5m** height, with spreading canopy; **Canopy 10-20% dead** with reduced coning/seed production [Any reduction likely to be proportional to crown size]	Usually more open conditions, where wind has begun to de-limb trees	1. Increase in standing and fallen deadwood; 2. Torn branches & broken limbs; 3.rot-holes developing on tree & saprophytic fungi fruiting	**Canopy breakup**

	5.2 Mid-canopy decline	Trees **usually over 5m** height, with spreading canopy; **Canopy 20-50% dead** with consequent further reduction in coning/seed production		4. Crown dieback → increased light to bole → more opportunities for epiphytes!	
6. Senescent post-reproductive	6.1 Heavy canopy decline	Trees **usually over 5m** height, with spreading canopy much ravaged by wind & pathogens; **Canopy 50-99% dead** with markedly reduced coning/seed production proportional to loss of canopy	Often [but not always] very open stand with large canopy gaps, with or without recent regeneration	As above sub-class with significant increase in standing deadwood habitat on each tree	**Canopy breakup**
7. Dead	7.1 Standing dead	Three classes as broad indicators of time elapsed since death: 1.Some needles & all bark still on tree [recent dead] 2. >20% bark still on tree, surface of bole hard 3. <20% bark still on tree, surface of bole soft [long dead]	Often degrading fragmented stands of large old trees with significant windthrow; but: includes smaller specimens resulting from competitive exclusion in dense stands and: Steep scree slopes with a mobile substrate where trees have been uprooted	Bio-diversity likely to be high for recently dead trees [bark still on tree] with larger stem diameters, which are more typical of fragmented open stands. Epixylic lichens an important feature of pinewood biodiversity, restricted to decorticate trees. Overall lichen diversity appears to be much higher for dead pines than live ones!	**Death, decay and nutrient cycling**
	7.2 Fallen dead	Three classes as broad indicators of time elapsed since death: 1.Some needles & most [>80%] bark still on tree [recent dead] 2. <80% & >20% bark still on tree, surface of bole hard, even though heartwood may be soft and rotting. 3. <20% bark still on tree, surface of bole usually soft [long dead]			
	7.3 Stumps with no fallen trunk/bole evident	Two classes as broad indicators of past woodland history and management: 1. Stumps from past logging operations [clean cut surface] but in varying stages of decay depending on when cut 2. Torn stumps resulting from wind "snap" where trunk has either been removed for firewood or completely decayed	Various but typical of open stands of old wide-crowned trees. Where straightest large specimens have been removed for timber		

NOTES: 1. Maturity is defined as the point at which growth starts to slow down significantly. FC Yield class models can provide an approximate guide to minimum DBH at the age of Maximum mean annual volume increment [MAI], the point at which growth begins to slow down. However, these cannot be reliably applied to trees in conditions of environmental stress such as exposure and poor drainage, where maturity may be reached at much smaller size [DBH].

Table 10. Guidance table for determining species of grazing animal present (after Thomson, 2006).

Animal (plus code)	Signs	Dung (droppings)	Tracks and Pathways	Min ht of grazed sward	Browsing characteristics (a)	Bark stripping characteristics (b)	Max ht of (a) and (b)	Comments
Sheep (S)	White wool snagged on fences/ shrubs.	Roundish but angular and irregular shape. Smooth surface, shiny when fresh.	Slots rounded at tips. Broader and more rectangular than for deer.	3cm	Ragged ends to bitten-off shoots which are always eaten.	Occasionally. Young to pole stage trees. Can be severe in seriously over-grazed woods. Diagonal incisor marks.	1.5m	Avoids less palatable species in spring (eg rushes). Impact can be uniformly spread over large areas in most regions.
Goats (G)	Black and white wool snagged on fences.	As for sheep.	As for sheep.	6cm	As for sheep.	Can be severe with small/ medium sized trees/shrubs killed. Diagonal incisor marks.	1.5m	Confined to very few areas. Rocky outcrops/ledges are required for shelter and foraging. Can negotiate most fencing with ease.
Cattle (C)	Trampled tall vegetation. Rubbed trees. Poaching.	Large round pats.	Widely splayed deep slots. Pathways 0.3m wide.	6cm	Roughly torn and pulled up vegetation. Trampled standing areas for ruminating.	Rubbed trees only	2.0m	Are often sheltered in woodlands in winter where poaching of soil surface around supplementary feeding stations can occur.
Ponies/ horses (P)	Trampled vegetation. Rubbed trees. Barked stripped trees.	Coarse fibrous heaps.	Rounded hoof marks. Pathways 0.3m wide.	2cm	Nipped favoured vegetation close to ground. Less woody growth.	Individual trees of any age can be stripped in patches.	2.0m	Rarely found or sheltered in close-canopied woodland.
Roe deer (RO)	Frayed young trees. Hair in barbed wire fencing.	Short blackish cylindrical and pointed at one end. Smooth surface, shiny when fresh.	Well used narrow pathways. Slots pointed and together at tips.	4cm	As for sheep. New bramble and birch shoots favoured.	Rarely strips but frayed stems (ie young bendy trees with bark rubbed off by antlers) frequent on edges.	1.1m	Most likely deer species in the uplands. Impacts may be acceptable where other herbivores absent, due to social spacing.

Animal (plus code)	Signs	Dung (droppings)	Tracks and Pathways	Min ht of grazed sward	Browsing characteristics (a)	Bark stripping characteristics (b)	Max ht of (a) and (b)	Comments
Fallow deer (F)	As for roe, and chewed/ thrashed plastic tree shelters.	As for roe, but larger with striations and less uniform shape for older males.	As for roe, but pointed tips more splayed (seen at wet muddy crossings).	4cm	As for sheep. Bramble leaves in winter, shoots in spring. Ash also favoured.	Young pole sized trees or stools of favoured species. Bark eaten. Vertical incisor marks. Some frayed young trees.	1.8m	Less likely than red or roe in the uplands. Impact may be heavy but variable due to social spacing, use of favoured traditional areas and degree of disturbance.
Red deer (RE)	As for roe and wallows in wet hollows.	As for fallow, but larger and more fibrous and brownish.	As for fallow but more poached pathways in places.	4cm	As for sheep/roe.	As for fallow.	1.8m	Common in some upland regions. Impacts may be uniformly heavy over large areas. Favours wet, boggy woodlands.
Rabbits (R) and hares (H)	Holes, dunging tumps. Very short vegetation in patches.	Roundish and fibrous. Deposited in favoured areas.	Narrow vegetated pathways. Pad marks evident in snow/frost.	1cm	Sharp angled, knife-like cut ends to bitten shoots which can be left uneaten (NB always left uneaten in hares).	Areas of young/medium aged smooth barked trees and shrubs. 3-4mm wide diagonal incisor marks in pairs. Bark patches removed often not eaten.	0.5m	Locally at very high densities on dry, calcareous free draining slopes mostly on the east side of the Pennines.

Table 11. Current Herbivore Impacts (current /recent = since the start of the last growing season). Taken from Armstrong et al. (2014).

Indicator	Very High	High	Medium	Low	No impact
Basal shoots Includes all accessible shoots sprouting from tree bases.	**All species** very heavily browsed. NB. Where large herbivores have been rare or absent in previous years there may be basal shoots that are now too large to browse.	**Palatable species** very heavily browsed. **Unpalatable species** heavily browsed.	**Palatable species** heavily browsed. **Unpalatable species** lightly to moderately browsed.	**Palatable species** lightly to moderately browsed. **Unpalatable species** generally unbrowsed, some lightly browsed.	**All species** unbrowsed.
Epicormic & lower shoots Includes all shoots on tree trunks (epicormic), lower branches or fallen trees that are within reach of herbivores.	A very obvious and well maintained browse-line on all trees, with plenty of evidence of recent browsing to shoot tips. Shoots below the browse-line difficult to find on palatable tree species because they are browsed close to the trunk. Even woody shoots of less palatable species are moderately to heavily browsed.	An obvious browse-line on all trees that have live lower branches with most or all shoot tips browsed. All but the most unpalatable shoots below the browse-line (e.g. old woody birch shoots) moderately to heavily browsed.	A browse-line starting to develop (i.e. evidence of some recent browsing to shoot tips) on most or all tree species. The presence of some unbrowsed lower branches may interrupt the horizontal browse-line. Most shoots below the browse-line lightly browsed with a few browsed moderately to heavily.	Shoot tips within the reach of large herbivores unbrowsed on all but the most palatable tree species.	No sign of *recent* browsing on any live shoots within reach of large herbivores.
Bark stripping & stem breakage dbh = diameter at breast height (1.3 m above ground)	>50% of live stems, and recently fallen branches, showing recent bark stripping that may be severe. One tree species (e.g. rowan) can have all accessible live stems stripped by deer. >50% of live stems of saplings <5 cm dbh may be snapped by cattle and /or red deer.	20-50% of live stems, and recently fallen branches, showing recent bark stripping. One tree species (e.g. rowan) can have all accessible live stems stripped by deer. 20-50% of live stems of saplings <5cm dbh may be snapped by cattle and /or red deer	<20% of live stems, and recently fallen branches, showing signs of recent bark stripping. Sometimes one individual tree is badly bark stripped. <20% live stems of saplings <5 cm dbh may be snapped by cattle and /or red deer. One tree species (e.g. rowan) may be heavily targeted.	Recent bark stripping generally hard to find. There may be one stripped or frayed tree. Occasional stem snapping by cattle and /or red deer.	No recent bark stripping or stems snapped by large herbivores.
Seedlings & saplings Seedlings = <50 cm tall. Saplings = 50-200 cm tall. "Old seedlings" = trees < 50 cm tall that may be many years old but	**"Old seedlings**" very heavily browsed into a topiaried form. Other seedlings, of all species, will only be present if in their first growing season.	**Seedlings** of unpalatable species and all "old seedlings" moderately or heavily browsed. Seedlings of palatable and browse-sensitive	**Seedlings** of unpalatable species unbrowsed or lightly browsed. Those of palatable species moderately or heavily browsed	**Seedlings** of unpalatable species generally unbrowsed but some may be lightly browsed. Seedlings of palatable species generally lightly	Numerous seedlings present provided that there is an adequate seed source, suitable ground conditions, and an absence of very dense

Indicator	Very High	High	Medium	Low	No impact
adverse conditions, usually browsing pressure, prevent them from growing upwards	All will be browsed the following winter. **Saplings** battered by very heavy browsing, with many woody side shoots browsed back or snapped. Leaders of saplings undamaged only if they cannot be reached by herbivores.	species are likely to be absent (apart from possibly first year seedlings in the growing season). If they are present, they will be very heavily browsed. **Saplings** of all species heavily browsed. Leaders of saplings undamaged only if they cannot be reached by herbivores.	**Saplings** of unpalatable species lightly to moderately browsed. Those of palatable species moderately to heavily browsed. Groups of birch, alder and willow saplings may have some unbrowsed leaders. Otherwise, leaders undamaged only if they cannot be reached by herbivores.	browsed but some may be moderately browsed. Most **saplings** of palatable species lightly browsed. Most saplings of unpalatable species unbrowsed.	shading. These will be unbrowsed by large herbivores. **Saplings** of all species (if present) un-browsed.
Preferentially browsed or grazed plants Vegetation other than trees; primarily species listed as "very palatable" in Table 4. Score as "Not applicable" if there are no accessible preferentially browsed or grazed plants can be identified.	All accessible shoots heavily to very heavily browsed /grazed. No unbrowsed accessible runners of palatable species e.g. honeysuckle, bramble. There may be some growth of the current year's shoots in the growing season.	Accessible shoots generally heavily browsed /grazed but some of the most preferred species may be very heavily browsed /grazed. No unbrowsed accessible runners of palatable species e.g. honeysuckle, bramble.	Accessible shoots moderately to heavily browsed /grazed. Some, more preferred, species may be heavily browsed while others are unbrowsed e.g. bramble browsed but blaeberry unbrowsed. No unbrowsed accessible runners of palatable species e.g. honeysuckle, bramble.	Accessible shoots generally lightly browsed /grazed but there may be some shoots or individual species moderately browsed /grazed or unbrowsed /ungrazed. There may be some unbrowsed runners of palatable species e.g. honeysuckle, bramble.	No browsing /grazing on accessible shoots. Depending on the time since large herbivores have been present, there may be long unbrowsed runners /climbers or a dense tangled field layer obscuring views through the wood.
Sward Ground cover vegetation. This may include preferentially grazed species Rank = tall, dense vegetation, sometimes with a well-developed understorey of mosses or herbs. Score as 'Not applicable' if the ground cover is < 5%.	Unpalatable species such as rushes and tussock-forming grasses (e.g. tufted hair-grass, purple moor-grass) heavily grazed. If grazing limited to autumn/winter, unpalatable species may be only lightly grazed. Palatable species very heavily grazed. Flowering herbs of palatable species hug the ground, flower stalks difficult to find. N.B. In the growing season, spring flowering	Unpalatable species moderately grazed. If grazing limited to autumn/winter, unpalatable species may be only lightly grazed. Palatable species heavily grazed. Flowering herbs of palatable species hug the ground, flower stalks difficult to find. In the growing season, spring flowering herbs may be ungrazed even	If palatable species are abundant, unpalatable species will be ungrazed. If palatable species are rare or absent, unpalatable species will be lightly grazed, except where livestock have been put into the wood at the start of the spring, At this time many unpalatable species are relatively palatable and they may be heavily grazed.	Unpalatable species ungrazed. They may form a rank field layer more than 10 cm tall that shades the ground layer vegetation beneath. Palatable species rarely or lightly grazed.	All sward species ungrazed. There may be a rank and tussocky sward with abundant leaf litter, and /or a high proportion of woody herbs (e.g. bramble) or heathy species in the sward, depending on site characteristics such as soil, exposure and light availability.

Indicator	Very High	High	Medium	Low	No impact
	herbs may be ungrazed even where winter impacts were very high.	where winter impacts were high.	Palatable species moderately grazed.		
Ground disturbance Animal disturbance = trampling, pathways or wallows. Score as "Not applicable" if the ground is composed of boulders or scree. N.B. plant litter is very quickly mineralised in moist, very rich woodlands and soil may be bare in spring. The lack of vegetation in these cases is not due to animal disturbance.	**Wet ground** >75% devoid of vegetation due to animal disturbance. **Dry ground**: > 50% devoid of vegetation due to animal disturbance. Where deer are the main herbivore, disturbance may take the form of frequent wide, heavily used pathways and /or, on wet, open ground, there may be kicked out clods of turf and *Sphagnum* and well-defined deer wallows.	**Wet ground**: >50% devoid of vegetation due to animal disturbance **Dry ground**: 20-50% devoid of vegetation due to animal disturbance. There may be heavier disturbance around feeding areas and pig shelters. . Where deer are the main herbivore, disturbance may take the form of frequent pathways that are partially or wholly unvegetated.	**Wet ground:** 10-50% devoid of vegetation due to animal disturbance.. **Dry ground**: 10-20% devoid of vegetation due to animal disturbance. There may be heavier disturbance around feeding areas and pig shelters. Where deer are the main herbivore, disturbance may take the form of occasional pathways.	Occasional areas of ground devoid of vegetation due to animal disturbance. There may be heavier disturbance around feeding areas and pig shelters. Where deer are the main herbivore, disturbance may take the form of occasional pathways.	No areas of ground devoid of vegetation due to animal disturbance.

Score as *"Not applicable"* if there are none of the attributes available for assessment, i.e. no basal shoots or epicormic shoots or no stems suitable for bark fraying, etc.

Table 12. Guide to Browsing Rates

Variable	Very Heavy	Heavy	Moderate	Light
Browsing on tree basal shoots Estimate % of current shoot growth removed based on the ratio of shoot diameter to length.	> 90% of the current year's growth removed. Short stubby stems, difficult to see on some species. Most older woody shoots browsed.	50% -90% of the current year's growth removed. Some older, woody shoots browsed.	10% -50% of the current year's growth removed. No older, woody shoots browsed.	<10% of the current year's growth (only shoot tips) removed.
Browsing on other tree shoots i.e. seedlings/saplings, epicormics, lower branches.	All outer shoots removed (including many old, woody shoots) and remaining growth old and woody with short internodes.	>80% of the current year's growth removed. Older, woody growth removed from some shoots	30-80% of the current year's growth removed. Older, woody growth removed from some shoots	<30% of the current year's growth removed
Browsing /grazing on preferred plants and sward	All of leading shoots browsed or leaves grazed.	>75% of leading shoots browsed or leaves grazed	25-75% of leading shoots browsed or leaves grazed	<25% of leading shoots browsed or leaves grazed.

Table 13. Relative palatability of non-tree plants (herbaceous perennials and small woody perennials)

Season	Very palatable	Moderately palatable	Unpalatable
All year	bramble, honeysuckle, ivy, blaeberry, **greater woodrush,** common bent, red fescue, Yorkshire fog	*hard fern, b*og myrtle, heather (Ling), bell heather, sheep's fescue	hard fern, greater woodrush, purple moor-grass, mat grass, tufted hair-grass, soft and sharp-flowered rush, cross-leaved heath
Spring - Summer	As above. In addition: valerian, meadowsweet, angelica, dog's mercury, raspberry, *buckler ferns*	devil's-bit scabious, **purple moor-grass, soft and sharp-flowered rush,** *lemon-scented fern, lady fern*	buckler ferns, lemon-scented fern, lady fern, primrose

***bold = cattle only**, *italics* = *deer only*, Normal font = all other large herbivore species. More detailed information can be found at: http://scotland.forestry.gov.uk/woodland-grazing-toolbox/habitat-condition/assessing-habitat-condition/palatability

Table 14. Palatability of key field layer species.

Taken from http://scotland.forestry.gov.uk/woodland-grazing-toolbox/habitat-condition/assessing-habitat-condition/palatability

Palatability of key field layer species - Ground layer and small field layer herbs			
Species	**Latin name**	**Palatability**	**Comments**
Dog's mercury	*Mercurialis*	High	Particularly attractive to sheep. May remain untouched by deer
Devil's-bit scabious	*Succisa pratensis*	Medium	
Heath bedstraw	*Galium saxatile*	Low	A species of low palatability, heath bedstraw is often the first species to assert itself through abundant flowering following the fencing out of large herbivores
Tormentil	*Potentilla erecta*	Low	
Primrose	*Primula vulgaris*	Low	
Bluebell	*Hycainthoides non-scripta*	Low	High for muntjac deer
Wood sorrel	*Oxalis acetosella*	Low	

Palatability of key field layer species - Ferns			
Species	**Latin name**	**Palatability**	**Comments**
Buckler ferns	*Dryopteris sp*	Medium	High for deer in the spring
Lady fern	*Athyrium felix-femina*	Medium	
Lemon scented fern	*Oreopteris limbosperma*	Medium	
Hard fern	*Blechnum spicant*	Low	Moderately palatable for deer. May be relatively more palatable on nutrient-poor soils
Bracken	*Pteridium aquilinum*	Low	Bracken is toxic, especially to cattle, but young fronds may be browsed in late spring

All species of moss and lichen are of very low palatability.

www.nature.scot

ISBN: 978-1-78391-824-9

Great Glen House, Leachkin Road, Inverness, IV3 8NW
T: 01463 725000

You can download a copy of this publication from the SNH website.

recycle

Scottish Natural Heritage
Dualchas Nàdair na h-Alba
nature.scot