

An assessment and evaluation of herbivore impacts on blanket bog in part of Caithness and Sutherland peatlands Special Area of Conservation



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**An assessment and evaluation of
herbivore impacts on blanket bog in part
of Caithness and Sutherland peatlands
Special Area of Conservation**

(ROAME No. F02AC202/2)

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blanket bog in part of Caithness and Sutherland peatlands
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Commissioned Report No. 164 (ROAME No. F02AC202/2)

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Background

This survey was commissioned to assess the current levels and patterns of herbivore grazing and trampling in the areas of blanket bog within part of the Caithness and Sutherland Peatlands SAC. This survey was commissioned in response to concerns about the impacts of deer on plantation woodlands within the area and related concerns about potential deer impacts on the adjacent peatlands. The survey followed a systematic sampling methodology focusing on areas close to forestry plantations, combined with observations along transects joining the systematic points. A lack of access permissions resulted in not all the intended areas being surveyed.

Main findings

The assessment of grazing and trampling impacts was carried out by assessing the small-scale field indicators following MacDonald *et al.* (1998) at 90 pre-determined systematic sample points located at the intersection of Ordnance Survey 1km grid lines using geographical positioning system (GPS) receivers. Assessments included a range of indicators, such as the amount of current and past browsing on heather and the amount of trampling of bog mosses, within 2m x 2m fixed quadrats. Trampling impacts were assessed more extensively by assessing the same indicators along transect lines taken between these systematic sample points. Where significant impacts were encountered the impact levels were assessed using the same method.

- Of the 90 systematic sample points, 38 were assessed as having a light trampling and grazing impact, 43 as Moderate and nine as High.
- A total of 511 target notes of trampling events were taken along approximately 112km of blanket bog habitat.
- There were on average three tracks per kilometre of blanket bog traversed and they were typically between 20–30cm wide.
- At six locations there were wide tracks and at six other locations there were numerous parallel tracks. At a further 10 locations the trampling impacts were assessed to be High. These locations were mostly within 2km of the margins of the habitat.

- The trend indicators in most instances did not give consistent results, hence few conclusions can be drawn about whether impact levels are increasing, stable or decreasing.
- There was no difference in the level of browsing/grazing impact between those areas of blanket bog close to forestry plantations and those more than 2km from the nearest plantations.

In summary, current levels of grazing are unlikely to lead to a significant loss of vegetation structure or loss of blanket bog habitat, although there is some evidence that the structure and the proportion of dwarf shrubs in the vegetation cover may have been affected by either current or historic browsing levels. Current levels of trampling do not generally appear to be leading to a significant loss of blanket bog vegetation. However, the number of systematic samples with High impacts suggests that localised areas may be subject to deterioration of the habitats through a progressive loss of *Sphagnum* mats and hummocks with the potential for peat erosion. These impacts appear to be more prevalent in the areas surveyed south of the railway. In addition, the incidence of Moderate impacts over the survey area more widely, may give cause for concern, with Moderate impacts potentially giving rise to more localised negative consequences for the bog communities over a longer timescale.

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CDs containing the original data and photographs referred to in the text have not been reproduced in this copy of the report, but are available on request by contacting Jenny Bryce, (jenny.bryce@snh.gov.uk)

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1 BACKGROUND

Under the Deer (Scotland) Act of 1996, the Deer Commission for Scotland (DCS) is empowered to take action where deer are causing damage to the natural heritage. Scottish Natural Heritage (SNH), as the statutory body responsible for conservation of the natural heritage, advises the DCS on the significance of impacts. The statutory agencies' approach to this issue is set out in the document "Deer (Scotland) Act & Damage by Wild Deer to Woodland and the Natural Heritage". In this document, damage to the natural heritage is defined (on p.8) as occurring:

"...when natural and semi-natural habitats are prevented from regenerating to sustain their ground cover and the diversity of plant species; or where; local populations of important species (animal or plant) are in decline; or where important earth science features are being eroded by deer."

This assessment of grazing and trampling impacts on the blanket bog features within the Caithness and Sutherland Peatlands Special Area of Conservation (SAC) was prompted following concern that deer are damaging trees in forestry blocks within the area and may be increasingly likely to impact on the neighbouring peatlands as forest fences reach the end of their expected lifespan. On this basis, the entire area between the A879 and the A9 was accepted by DCS as a Site for Assessment. This project aims to gather information in relation to the nature and distribution of herbivore, and in particular, deer impacts on the designated interests, but does not pre-judge that current impacts are at damaging levels.

2 OBJECTIVES

The objective of the proposed work within part of the Caithness and Sutherland Peatlands SAC was to:

- i) assess current grazing and trampling impacts from deer (of any species) or other herbivores on the notified features and the direction of any apparent trends in impact levels;
- ii) determine whether current levels of impact can at present be considered damaging to any of the designated natural heritage features and/or whether trend indicators suggest that such impacts, if continued, are likely to become damaging in the future;
- iii) capture images of the blanket bog sample plots using fixed point digital photography with a view to assessing their potential use for detecting changes in trampling impacts.

3 THE SITE

The parts of the Caithness and Sutherland Peatlands SAC that were originally targeted for survey were the following Sites of Special Scientific Interest (SSSI) (Map 1):

- East Halladale
- Strathmore Peatlands
- Sletill Peatlands
- Knockfin Heights
- Dunbeath Peatlands
- Loch Caluim Flows
- Blar nam Faoileag
- Rumsdale Peatlands
- Coire na Beinne Mires
- Morven and Scaraben

Map 1 SSSI boundaries



All of these SSSIs, with the exception of Morven and Scaraben SSSI, are part of the Caithness and Sutherland Peatlands SAC which is designated under the EU Habitats Directive for the habitat of blanket bog (H7710). Morven and Scaraben SSSI meanwhile, is designated for the upland features Alpine heath and Subalpine dry heath. Blanket bog was also to be assessed within the Morven and Scaraben SSSI as deer traverse areas of blanket bog in order to reach the notified upland communities.

4 METHODS

4.1 Sampling strategy

Two factors determined the sampling strategy employed in this survey. The first was the basis for the DCS Site for Assessment, which related to deer impacts on plantation woodlands and hence the related concern that deer may be having an increasing impact on the adjacent areas of designated peatland. Therefore the areas of blanket bog within 2km of conifer plantations (zone 1) were sampled more intensively than those areas more distant from plantations (zone 2). Sample points were selected on the basis of a regular grid at 1km intervals wherever blanket bog habitat has been recorded in previous surveys (see Figure 1 for all generated points from which sample points were derived).

The second factor was the anticipated nature of trampling impacts by deer on blanket bog. Blanket bog does not provide herbivores with very attractive grazing, hence the more significant impacts on this habitat tend to be as a result of tracking and trampling of the sensitive wet communities when travelling between feeding grounds. Trampling impacts tend to be very localised or linear in character and are therefore unlikely to be detected using random or systematic points, even at moderately high frequency. While the systematic points are likely to provide an indication of the frequency of trampling impacts across the survey area as whole, they are unlikely to provide much detail of the pattern and range of trampling impacts. Therefore additional sampling of impacts was undertaken on an *ad hoc* basis along transect lines between the systematic sample points. This data is presented as “target notes”, and is interpreted as additional data rather than as the basis for assessing impact levels.

Map 2 Management units



A set of sample points at intersections of the Ordnance Survey (OS) 1km grid lines within 2km of plantations are shown as red circles in Figure 1, whilst the more distant sample points are shown in blue. It was originally envisaged that a total of 162 systematic sample points at the 1km intervals would be sampled with an average of 9km travel between these systematic sample points travelled per day (Figure 2). However it was not possible to sample the whole of the SAC as some estates preferred not to allow access at the proposed time of survey. Therefore this report only includes the results from the following management units: Ackron, Bighouse, Dorrery Forest, Forsinard, Forsinard Croft No. 1, Fountain Forestry, Golval 218, Limekiln and Whitewell, Sandside Estate, Shurrery, Sinclair Estates and Strathmore Estate (Map 2, Figure 3).

4.2 Field assessment of grazing and trampling impacts

Methods for assessing the grazing and trampling impacts of herbivores have been standardised by MacDonald *et al.* (1998). The appropriate small-scale field indicators were used to assess the current impacts and look for possible trends in grazing and/or trampling at each of the systematic sample points. This involved marking out a 2m x 2m quadrat with four wooden dowels joined together with four 2m lengths of string. The south-west corner of the quadrat was marked using an approximately 0.8m length of 22mm x 22mm wooden post which was pushed into the peat so that the top of the wooden post was at approximately the same height as the top of the vegetation. The post was located at the intersection of the OS 1km grid lines taken from a global positioning satellite (GPS). A metal disc with an embossed number (between 001 and 099) was nailed to the top of each wooden post.

If there was no suitable blanket bog vegetation at the anticipated sample point, a new location was taken where the appropriate vegetation was found within 20m of the allocated grid reference. A photograph of the quadrat was taken with a digital camera from the south. Due to the inherent variation in topography of the blanket bog, the photographs do vary in their relative height and distance with respect to the quadrat. However most were taken between 1.5–2m above the plots in a northerly direction with the south-west corner of the quadrat nearest to the photographer on his/her left.

Within each quadrat most of the pertinent small-scale indicators of current grazing and trampling by herbivores were assessed using the method of MacDonald *et al.* (1998) and these are given in Table 1. Browsing of *Betula nana* is suggested as an indicator, but this species was not encountered during the survey. Access was not arranged for the southern part of the proposed survey area, ie Latheronwheel, Dunbeath & Glutt and Welbeck Estates and therefore the Alpine heath and dry heath (as well as the blanket bog) habitats on Morven and Scaraben SSSI could not be assessed.

4.3 Data analysis

The combined assessment of impact levels of grazing and trampling was derived by calculating a mean-weighted score for the various indicators. An assessment of Low impact for each indicator was given a score of 1, Moderate impacts a score of 2, High impacts 3 and Moderate–Low and High–Moderate 1.5 and 2.5, respectively. To derive the combined assessment, each score was multiplied by a weighting for each indicator. The weightings for the various indicators are given in Table 2. The sum of the weighted scores was then divided by the total of the weights used to provide a weighted average score which could be compared with the original scale of High = 3, Moderate = 2 or Low = 1, ie some indicators (generally the most reliable) had a greater influence on the combined assessment of impact class than others. The values

were then reclassified according to the original High, Moderate and Low classes ie Low = 1–1.5, Moderate = 1.5–2.5 and High = 2.5–3.00.

In order to come to a conclusion as to the trend in grazing and trampling impacts at each point, the three trend indicator values were examined in the following way. If all three indicators gave different results then it was concluded that there was no clear trend. If two of the trend indicators, ie height of dwarf shrubs relative to graminoids and changes in dwarf-shrub form, both indicated a decreasing trend then a decreasing trend in grazing and trampling was assigned. If the changes in dwarf-shrub form were not applicable and their height relative to graminoids was assessed as chronic High and the abundance of *Carex panicea* (carnation sedge) indicated chronic Low a trend of 'stable' grazing and trampling was assigned. The term 'stable' was used rather than 'chronic' as this word has negative connotations. When both the *Carex panicea* and the height of dwarf shrubs relative to graminoids indicators were placed in the chronic High category and the changes in dwarf-shrub form indicated increasing grazing and trampling pressure, the point was assigned to the 'increasing' class.

5 RESULTS

5.1 Systematic sample points

The fieldwork took a total of 18.5 man-days to assess the indicators of grazing and trampling at a total of 90 systematic sample points and over 137km of terrain within the East Halladale SSSI, Strathmore Peatlands SSSI, Sletill Peatlands SSSI, Knockfin Heights SSSI, Loch Caluim Flows SSSI and Rumsdale Peatlands SSSI. Of these, 64 were within zone 1, ie close to areas of plantation, whilst 16 were in zone 2 (Figure 3). Because suitable blanket bog vegetation was not present within 20m of the assigned location for 25 points, grazing and trampling was assessed at an additional 10 locations where blanket bog vegetation was found to be present along routes between other systematic sample points. Six of these were within zone 1 and four in zone 2.

Tables 3 and 4 summarise the number of systematic points and "target note" samples recording different individual grazing/browsing or trampling impact indicators. The number of systematic and "target note" samples recording individual trend indicators are given in Table 5. Other tables refer to combined grazing and trampling impact classes as detailed in 4.3.

Using the weightings and scoring system devised by MacDonald (*pers. comm.* 2005) combined impact scores encountered varied over the whole range from Low–High. 48% (n = 43) of systematic sample points had Moderate combined impact scores, 42% (n = 38) had Low combined impact scores and 10% had High (n = 9) impact scores (Table 6). All but two of the nine systematic sample points with High combined grazing and trampling impact scores are located south of the railway line (Figure 4).

The East Halladale and Sletill Peatlands SSSIs have the largest proportion of systematic points with Low combined grazing and trampling impact scores, whilst Loch Caluim Flows SSSI has the largest proportion of systematic points with Moderate combined grazing and trampling scores (Table 6). East Halladale and Loch Caluim Flows are the only SSSIs which do not have at least one systematic sample point in the High class. Eighty-five out of the 90 samples were assessed as having conspicuous browsing of heather. However, only nine sample points were assessed as having combined High trampling and grazing impacts, all of which had recorded high levels of trampling of *Sphagnum* or hoof prints in bare peat. As the number of sample points within each of the SSSIs is relatively low in number, the comparisons of the percentage of points in the different impact classes between SSSIs are not statistically valid.

There is no difference in the proportion of High, Moderate and Low combined grazing and trampling impact scores between those systematic sample points in zone 1 (ie within 2km of forestry plantations) and those in zone 2 (Table 7). Also the browsing/grazing trend indicator scores do not differ between the two zones (Table 7).

Because trampling tends to be highly localised, the indicators for trampling at the systematic sample points tended to be Low or Moderate. Consequently the systematic sample points may not provide a complete picture of the pattern of trampling pressure.

5.2 “Target note” samples

Signs of significant trampling and/or grazing were assessed whilst walking over 137km between the systematic sample points within the SSSIs that were being assessed (Figure 3). Although it was not possible to note every time field workers came off blanket bog habitat, usually on to wet heath and then started crossing the target habitat again, it is estimated that approximately 112km of blanket bog habitat was crossed in the survey.

The surveys of the transect lines between the systematic sample points inevitably picked up more differences in trampling impacts than in grazing/browsing, as the latter is on the whole much more uniform across blanket bog habitat. Few, if any locations, showed any particularly significant areas of localised heavy grazing. When carrying out the survey any detectable tracks were assessed. Of the 511 “target note” samples taken along the transects within the SAC where the grazing and trampling impacts were assessed, 43% were of High impact and 50% of Moderate impact (Table 8).

The number of definable tracks that run across the blanket bog vegetation, provides more detail as to the pattern of trampling and tracking on the habitat. Of the 112 transect lines taken between points there were on average three tracks per kilometre (Table 8), but it varied from none to 17 in the most heavily used areas. Four one kilometre stretches of transect lines had more than 10 tracks per kilometre. The place with the highest track density was close to Shurrery Lodge where sheep in adjacent pastures probably had access to the blanket bog habitat (Figure 4). One other transect line had 14 tracks per kilometre with a High average trampling impact close to the River Thurso south-west of Loch More (Figure 4). A significant number of deer were seen in this area at the time of the survey and it is clearly an area favoured by red deer for grazing as well as a major through route to other areas of pasturage. Two other areas with 11 or 12 tracks per kilometre are on the east side of the study just either side of the railway line close to Loch Meadhoin and Loch a Chairn, respectively (Figure 4).

The majority of the tracks (inter-quartile range) were between 20 and 30cm across with the average width being 37cm (Table 8). Of the 280 tracks that were measured, eight were one metre or more wide. It is suggested that the proportion of bare peat on the tracks and the number of parallel tracks per kilometre of ground are probably the best indicators of the frequency of deer passing through an area of blanket bog habitat. However, wherever there is a high concentration of deer passing through a small area, the width of bare peat provides an indication of the intensity of trampling pressure in these localised areas. In the parts of the SAC covered in this survey, there are 12 locations where trampling has resulted in wide and/or numerous parallel tracks and consequently having an obvious ecological effect on the blanket bog (Figures 4 and 12). The most immediate effect of large amounts of trampling is the loss of cover of *Sphagnum* which is important in contributing to the build up of peat and retaining moisture within the surface layers of the bog.

The impact of deer or other large herbivores on tracks not only depends on the absolute numbers that pass through, but more importantly how frequently the track is used and how widely the animals spread across the terrain. At certain types of location the blanket bog habitat can be particularly sensitive to trampling, eg where there is a peat bank where large herbivores tend to be forced through by the nature of the topography, in areas which are used as a through route between one grazing area and another, or ‘bridges’ of more solid ground between *Sphagnum* pools. Here the impacts can be particularly severe, even for a modest number of animals.

5.3 Trends in browsing and trampling

For much of the SAC the grazing and trampling pressure was found either to be stable or to have no clear trend (Tables 9 and 10). This did not differ greatly between the systematic points or the “target note” samples. At 12 of the systematic points and 28 of the “target note” samples, the trend indicators suggest that grazing and trampling pressure was decreasing (Tables 9 and 10). There is no obvious spatial distribution of the systematic sample points or “target note” samples with an indication of decreasing grazing and trampling (Tables 9, 10, 13 and 14, Figure 5).

At none of the systematic sample points was grazing and trampling pressure indicated to be increasing (Table 9). At only one “target note” sample taken at the northern end of the East Halladale SSSI did the trend indicators suggest that grazing and trampling was increasing (Table 10 and Figure 5).

Drumstick or carpet growth forms of *Calluna* are clear indicators of heavy and increasing browsing pressure, but none of these growth forms was observed by the field workers during the survey. *Carex panicea* was generally very rare within the part of the Caithness & Sutherland SAC surveyed and the lack of variations in micro-topography of the peatland which this sedge evidently exploits under heavy grazing pressure in more westerly peatlands, was not applicable in this site. These factors combined with the absence of a clear pattern in the various trend indicators recorded, makes it difficult to reach firm conclusions about recent changes in grazing and trampling pressure within the blanket bog habitat.

5.4 East Halladale SSSI

The systematic sample points had Low (n=15) and Moderate (n=12) combined grazing and trampling impact scores within this SSSI (Table 6, Figure 6).

The “target note” samples in the High combined grazing and trampling impact class (n=35, Table 8) are at the northern end of the SSSI within the Sandside and Bighouse estates (Figure 6). It is notable that the transects with the highest number of tracks and with the greatest impact run east-west, which reflects the fact that, in this part of the SAC at least, most of the deer movement appears to be in a north-south direction. It was notable that in many parts of this SSSI there were few definable tracks and consequently this SSSI has one of the lowest densities of tracks per km traversed compared to other SSSIs in the survey (Table 8).

Only one systematic sample point suggests that grazing and trampling pressures on the blanket bog habitat was decreasing and this was in the south-west corner of the SSSI (Figure 5). The only “target note” sample with indicators suggesting increasing browsing and trampling pressure for the whole SAC was observed within this SSSI at the northern end (Figure 5).

5.5 Loch Caluim Flows SSSI

Most of the assessments were concentrated in the eastern half of this SSSI, with the central area of the SSSI having been recorded as wet heath rather than blanket bog in the base survey (Figure 7). The combined grazing and trampling impact scores were all in the Low (4) to Moderate (10) range for the systematic sample points (Table 6).

Of the “target note” samples taken along the transects within this SSSI, 37% have a High combined grazing and trampling impact score (Table 8). This appears mainly to be due to one particular kilometre stretch of ground on the edge of the blanket bog close to pastures with sheep (Figure 7). The keeper for this estate indicated to the surveyor (Anna Griffith *pers. comm.*) that deer move down off the adjacent hills through this area to feed in the fields adjacent to the road.

For much of the remainder of the SSSI, the combined impact scores were Moderate (61%) (Figure 7). There were a lot of tracks (11 per km) in one small area close to the railway line and were of Moderate impact (Figure 7). Much of the central eastern part of the blanket bog in the northern part of the Dorrery Forest estate and the adjoining southern part of the Shurrery estate, is composed of the National Vegetation Classification (NVC) vegetation types M20, M25 and M15, rather than blanket bog NVC types M17, M18 and M19 (www.jncc.gov.uk/csm/guidance/upland.htm). The community composition is not necessarily due to current grazing pressures, instead is more likely to be a reflection of the topography of the mire, past land-use and drainage practices.

For most of this SSSI there appears to be either no clear trend or stable levels of grazing and trampling (Table 9, Figure 5). There were two systematic sample points where the grazing pressure appeared to be decreasing and these are located towards the eastern edge of the SSSI (Figure 5).

5.6 Sletill Peatlands SSSI

The combined grazing and trampling impact scores at nine of the 16 systematic sample points within this SSSI were low, five were Moderate and two points were in the High category (Table 6). The two points with high trampling impacts as well as conspicuous heather browsing were in the Forsinard Holding No. 1 management unit on the western side of the SSSI (Figure 8).

The impact scores along the transects were highest towards the west of this SSSI, especially around Weddon Hill where sheep from the lower slopes around Forsinard may be contributing to the observed impacts (Figure 8). Grazing and trampling impacts in the eastern part of the SSSI were particularly low (Figure 8).

Where the trend indicators are consistent, they suggest that there are stable levels of grazing and trampling within this SSSI (Tables 9 and 10, Figure 5), but there are no indications that it is decreasing or increasing.

5.7 Strathmore Peatlands SSSI

Three of the 13 systematic sample points assessed within this SSSI had High combined grazing and trampling impact scores (Table 6). All of these High class points were between the River Thurso and Backlass to the east (Figure 9). In this area there were also High impact scores recorded as “target notes”. In one kilometre stretch, there were 12 tracks (Figure 9). In contrast, in the northern part of the SSSI the grazing and trampling impact scores for the systematic sample points and the transect data were largely in the Low (4) or Moderate classes (6) (Figure 9).

The number of tracks per km traversed within this SSSI was the highest at nearly five per km and these tracks were on average the second widest at 44cm (Table 8). Whether this represents a higher level of trampling in absolute terms is difficult to determine.

At five of the 13 systematic sample points within this SSSI the trend indicators suggest that levels of grazing and trampling are decreasing (Table 9, Figure 5). Most of these points are in the northern part of the SSSI, especially those close to the railway line (Figure 5). However, whether this pattern is of significance is unclear on this evidence alone.

5.8 Rumsdale Peatlands SSSI

This SSSI is similar to the Strathmore Peatlands SSSI in having three systematic sample points in the High combined grazing and trampling class (Table 6). These were located in the northern part of the SSSI where the survey was carried out close to the railway line and plantations (Figure 10). This SSSI was the only one, other than Strathmore Peatlands SSSI, to have systematic sample points with inconspicuous heather browsing. Like the Strathmore Peatlands SSSI, trampling impacts made the greatest contribution to the three sample points that were assessed as having combined High impacts.

The average combined grazing and trampling impact scores recorded on the transect lines were Moderate or High and this SSSI had the highest proportion (61%) of "target note" samples in the High impact class (Table 8). However, the number of tracks per km traversed and the width of the tracks were below the average for the whole survey (Table 8).

Four out of the 18 systematic sample points within this SSSI have trend indicators suggesting that grazing and trampling pressure is decreasing (Figure 5). These are spread across the northern part of the SSSI (Figure 5).

A significant proportion of this SSSI had wet heath vegetation on areas where one might have expected blanket bog habitat. This is partly due to the shallow nature of the peat, but there are also a number of drainage ditches across the area surveyed on the hills just to the south of the railway line.

5.9 Knockfin Heights SSSI

Only a very small proportion of the northern part of this SSSI was covered in this survey (Figure 11) and consequently few if any conclusions can be drawn about the grazing and trampling impacts within this part of the SAC. Only two systematic points were assessed and five target note samples taken (Tables 6 and 8). There are no clear trends in grazing or trampling pressure within the northern part of the SSSI that was surveyed (Figure 5).

It was notable that this SSSI had the most extensive areas of peat erosion observed in this survey and in the immediately adjacent part of Rumsdale Peatlands SSSI on the hill top as illustrated in the photograph in Figure 13. Because of the erosion and consequent drainage of lochans the hoof prints across these areas were much more evident than in areas of blanket bog with intact vegetation and undrained bog pools. Consequently the conspicuousness of hoof prints may exaggerate the trampling impacts in this part of the blanket bog habitat.

The presence of shoots of *Eriophorum angustifolium* and *E. vaginatum* (cotton-grasses) within the trampled area suggests that the bare peat is being re-vegetated (Figure 13).

5.10 Management units SSSI

The grazing and trampling impacts within individual management units largely reflects the patterns observed in the individual SSSIs. Consequently, the analysis of the information obtained shows that the management units to the south of the railway line (Sinclair Estates, Strathmore, part of Forsinard and Hope & Bhealiach) have a significantly higher proportion of high impacts for most attributes assessed than the average for the whole survey (Tables 11 & 12). There are only two systematic points (Forsinard) to the north of the railway with High impacts, but Moderate impacts are widespread at both systematic points and as target notes.

Sinclair Estates had a higher proportion of High impacts for trampling around bog pools and water tracks, *Sphagnum* (bogmoss) hummocks and lawns, hoof prints in bare peat and dung of deer. The Forsinard Holding No. 1 estate showed significantly higher than average levels of trampling on *Sphagnum* hummocks and lawns, whilst the quantities of dung within the Dorrery Forest were significantly more than the average for the survey. The height of dwarf-shrubs relative to graminoids within the Dorrery Forest estate was disproportionately less than the average for the survey indicating above average levels of grazing.

As there were relatively few points for several of the management units or estates, little meaningful information can be gleaned from examining the distribution of impacts in the different management units beyond that already described above for the different SSSIs.

6 DISCUSSION

The impact classes detailed in the tables and figures combine assessments of grazing and trampling impacts. However, the relative contribution of each type of impact is discussed below, together with an interpretation of the trend indicators, where possible. The significance of these impacts is then discussed together with an assessment of the likely contribution of different herbivores.

6.1 Current grazing impacts

Because trampling is highly localised, the systematic points may be expected to provide a better representation of the browsing impacts across the majority of the blanket bog habitat than for trampling.

The vast majority (94%) of systematic sample points were observed to have conspicuous browsing of *Calluna vulgaris* (heather) or *Vaccinium myrtillus* (blaeberry). The conspicuousness of browsing on *Calluna* and/or *Vaccinium* was given a weighting of 75 in the overall assessment of impacts as compared with 150 for trampling of mosses and pool edges (Table 2). Consequently the scoring of the browsing impact was given less prominence in the overall assessment than trampling. A justification for the weightings used is given in Appendix 1, but generally trampling impacts on lichens and mosses are regarded as more significant in bog communities. The combined indices of browsing and trampling tended to be weighted towards the trampling indicators, however, the Moderate combined grazing and trampling impact classes are mostly due to the grazing indicators being assessed to be Moderate or High.

The growth form of the bushes of *Calluna* in the area surveyed is particularly stunted and consequently the browsing of the shrubs is far more evident than on peatlands where the growth of *Calluna* is much more vigorous. Also the low availability of alternative winter forage makes heather browsing more likely to be conspicuous, particularly where sparse in cover.

The poor growth of *Calluna* over the area surveyed may in part be due to the highly waterlogged conditions of the peat and poor drainage due to the low slopes. Low summer temperatures (Goudie & Brunsden 1994) and low rates of deposition of atmospheric nitrogen (NEG-TAP 2001) are other factors which will also contribute to low rates of growth. However, in nearby sites where grazing has been excluded, vigorous growth of heather has been observed (A. Coupar *pers. comm*). Nevertheless there was very little indication of browsing on the less palatable dwarf shrubs, in particular *Erica tetralix* and/or *Empetrum nigrum* (Table 3).

The absence of any *Betula nana* in the samples and the highly localised distribution of *Myrica gale* meant that these species were of limited use for assessing grazing impacts.

Overall it is considered that the grazing in the area surveyed is moderate with only a very few localised areas of heavy grazing. This is particularly noticeable in flushes (Figure 14). There is heavier grazing on the margins of the SAC where sheep have access to the peatland and within some of the river valleys, eg River Thurso, where there is better grazing for the red deer (Figure 12). However, browsing has not given rise to a very obvious difference in the structure and composition of the vegetation.

6.2 Current trampling impacts

The proportion of the systematic sample points in the High class was 10% (Table 6). The High combined grazing and trampling impacts are largely due to the trampling indicators being assessed as High (Table 4). The choice of systematic sample points was biased towards existing areas of forestry plantation or the margins of the SAC where grazing and trampling may be expected to be more intense. However, there appeared to be no difference in the levels of impacts recorded between the samples in zones 1 (within 2km of plantations) and those in zone 2 (Table 7).

The assessment of trampling impacts on the peatland is more straightforward than it is for grazing impacts and there are one or two areas (described below) where the trampling impacts are of probable ecological significance.

In the case of the areas near Shurrery Lodge and close to Forsinard village, these areas of High impact are likely to be more due to sheep than red deer. Close to Shurrery Lodge there are six locations very close to each other where there is a very high density of tracks (Figure 12). One area where significant impacts of deer grazing and trampling were evident that might cause concern is the small area by the River Thurso between grid references NC0542 and NC0642 (Figure 12). The densities of tracks across much of the SAC are relatively low and appear to be having minimal impact on the vegetation or the integrity of the peat mass. There are however, localised areas with a high frequency of tracks or wide tracks. The interpretation of ecological consequences based on the frequency of tracks is not straightforward. Well used tracks tend to have very localised high impacts, but little impact on the surrounding vegetation, whereas more dispersed trampling may have more widespread impacts which are individually of lower intensity.

The prognosis (MacDonald *et al.* 1998) for areas of blanket bog subject to heavy trampling is for a decline in vegetation height and moss depth, a loss of structural diversity, low dwarf-shrub and declining *Sphagnum* cover, with damage to pool systems and a risk of erosion of peat. Under Moderate levels, the impacts are predicted to be similar, but likely to be more patchy and over a longer timescale.

The only area of significant peat erosion is associated with the higher level peatland on Knockfin Heights where the erosion gullies and drained lochans appear to be long standing and do not appear to be being actively enlarged by current levels of deer movement in the small area of the blanket bog that was surveyed.

6.3 Trends in grazing and trampling

The survey failed to provide unequivocal assessments of impact trends. The use of changes in growth form of *Calluna* bushes depends on the plant growing in a reasonably healthy condition and on much of the particularly wet areas of blanket bog the heather is stunted due to the waterlogged conditions. Consequently the evaluation of the growth form of the bushes as evidence of "increasing" browsing pressure was not supported by other trend indicators. For example, a tight growth form was often associated with *Calluna* bushes exceeding the height of adjacent graminoids which indicates "decreasing" browsing pressure. Meanwhile, the absence of the sedge *Carex panicea* over much of the site suggests that grazing and trampling pressure over much of the site is "chronic Low". However, the abundance of *Carex panicea* on the "drier ridge" elements was of limited value due to the lack of these microsites on the peatland and the generally very low frequency of the species across the mire surface (Table 5).

The changes in growth form of the *Calluna* bushes were not used much in the interpretation of browsing trends and therefore the height of the *Calluna*, and sometimes *Erica tetralix* and *Myrica*, were used. The term 'chronic' was not used for patches of vegetation where the indicators suggest that current browsing/grazing impacts are low. Thus 'stable' was used where browsing impacts appear to indicate that it is neither increasing nor decreasing.

The interpretation of the data suggests that grazing pressures are stable at 28% of the 90 systematic sample points (Table 9) and 44% of the 511 "target note" samples (Table 10). Grazing and trampling pressure appeared to be decreasing at 13% of the systematic points and 5% of the "target note" samples. At less than 0.2% of the "target note" samples the indicators suggested that grazing and trampling is increasing (Table 10).

6.4 Overall assessment

Overall the grazing and trampling impacts are split between light and Moderate over much of the area surveyed, with 10% of points in the High category. Because of the sampling strategy (zones) and areas not surveyed, it was not possible to accurately predict what proportion of the survey area may be affected by High impacts, but including the Moderate impacts as being of potential concern, we can conclude that a considerable proportion of the survey area is at risk of experiencing negative changes to blanket bog community structure and composition. Six locations were identified where trampling by deer is giving rise to wide tracks with consequent erosion of the peat, whilst there were six locations with high track densities of potential concern (Figure 12).

Trampling by deer tended to be concentrated at the margins of the blanket bog either on ridges or along stream valleys, where the ground is generally firmer, but did not appear to be coincident with forestry blocks. The higher impacts appeared to be more prevalent in the areas surveyed south of the railway.

Where there were areas with high levels of grazing they were clearly evident and were concentrated in flushes and some of the better drained parts of the mire expanse where there is a predominance of graminoids (Figure 14). Given the above comments, it is considered more appropriate to describe the current levels of grazing encountered in this survey as Moderate. Grazing impacts were generally not regarded as having an adverse effect on the nature conservation value of the blanket bog. Grazing pressure appears to be stable and in some areas may be declining, but firm conclusions cannot be reached with respect to trends because of the ambiguity of the trend indicators.

The main conclusions of the survey are as follows:

- on balance the current levels of grazing are not leading to a significant loss of vegetation structure or loss of blanket bog habitat;
- current levels of trampling are sufficient to produce an assessment of Moderate or High impacts in over 50% of systematic samples. These levels of impacts may lead to negative consequences for the blanket bog communities and may be giving rise to some localised areas of erosion, mainly at the margins of the blanket bog habitat;
- there are no significant differences in the levels of browsing/grazing or trampling between zones 1 and 2, ie between those areas of blanket bog close to forestry plantations and those further away;
- higher impacts appeared to be more prevalent in the areas surveyed south of the railway.

6.5 Types of grazing animal

Most of the grazing on the blanket bog can be attributed to red deer. Areas of localised heavy grazing were found in the vicinity of apparent wallows used by stags. Grazing by sheep is evident on the margins of the site, particularly near Shurrery Lodge, Forsinard village and on the western margin of East Halladale SSSI close to Dalhalvaig.

Less than a handful of small groups of red grouse were disturbed during the whole survey, but this probably does not reflect the true densities of red grouse on the SAC as the birds are not readily put to flight. A number of the *Calluna* bushes on the wetter parts of the bog appeared to be grazed by red grouse rather than by red deer. This is supported by the fact that hoof prints were difficult to find, even in the waterlogged ground, yet the browsing on the *Calluna* bushes was conspicuous. Therefore there is the potential that browsing and grazing impacts on the *Calluna* bushes by large herbivores could be overestimated, and this is one of the reasons why the grazing impacts are considered not to be particularly high.

Heather beetle were probably the least important grazer within the SAC surveyed as there were only a few areas where damage to *Calluna* from heather beetle was found and it was highly localised to the better drained ground.

The suggested order of importance of the grazers/browsers on the blanket bog vegetation within this part of the Caithness & Sutherland Peatlands SAC is: red deer>sheep>red grouse>heather beetle.

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Table 1 The small scale field indicators of trampling and grazing on blanket bog habitat used in this survey of the Caithness & Sutherland Peatlands SAC (after MacDonald *et al.* 1998).

Blanket bog (M1, M2, M3, M4, M6, M17, M18, M19, M20, M21, H21, H22)

a) Current trampling and grazing impacts

Small-scale indicators	High	Moderate	Low
Pool systems and water tracks (T)	Edges of pools broken down, wet hollows obviously trampled, hoof prints abundant, <i>Sphagnum</i> cover much disturbed or absent.	Intermediate.	No evidence of trampling or grazing around pools, particularly those containing <i>Menyanthes</i> , and water tracks. Wet hollows with intact <i>Sphagnum cuspidatum</i> cover.
<i>Sphagnum</i> hummocks and lawns (T)	Most of surface broken by hoof prints, loose and bleached moss fragments frequent.	Minority of moss surfaces broken by hoof prints, loose and bleached moss portions very local.	Most of moss surface intact, hoof prints only found after extensive searching, loose and bleached moss parts absent or rare.
Hoof prints in bare peat (T)	Conspicuous and extensively present. Unmarked bare peat hard to find.	Patchily present. Unmarked bare peat can be found after limited searching.	Absent or very inconspicuous, extensive searching required to find hoof prints.
Signs of browsing of less palatable dwarf-shrubs (<i>Auu</i> , <i>En</i> , <i>Et</i> , <i>Vvi</i>) (B)	Some.	None.	
Growth form and signs of browsing of <i>Myrica</i> (B)	Browsed shoots conspicuous and easy to find. Dense branching.	Browsed shoots easy to find. Variably dense branching.	Browsed shoots difficult to find or absent. Even, regular branching with most branches/shoots growing without change in direction for >5cm.
Conspicuousness of browsing of <i>Calluna</i> and/or <i>Vaccinium myrtillus</i> (B)	Clearly browsed in general appearance though may be patchy. Browsed shoots easy to find.		Not obviously browsed. Browsed shoots difficult to find without both intensive and extensive searching.
Dung	Easy to find, though may not be immediately conspicuous.		Rare and very difficult to find, or absent.

T = trampling indicator, B = browsing indicator, *Auu* = *Arctostaphylos uva-ursi*, *En* = *Empetrum nigrum*, *Et* = *Erica tetralix*, *Vvi* = *Vaccinium vitis-idaea*.

Table 1 (continued)

b) Trends in trampling and grazing impacts

Trend	Increasing	Decreasing
Changes in growth-form of dwarf-shrubs (B)	Upper surfaces of canopy largely stripped of upright green shoots – giving it a tattered or worn appearance – but the bush structure is open, regular branching and relatively upright. It should be easy to see into the centre and lower parts of bushes without parting branches.	Lower, older parts of stems more contorted and/or densely branched than more recent parts. A relict browse line of old clipped shoot tips within the bush may be observable.
Height and cover of dwarf-shrubs versus graminoids (B)	Decreasing	Chronic High
	Dwarf-shrubs moderately tall (>10cm) with height and cover comparable to, or greater than graminoids.	Dwarf-shrubs short (<10cm) and overtopped by leaves of graminoids which also have greater ground cover.
Abundance of <i>Carex panicea</i> on drier “ridge” elements of bog patterning (T)	Chronic High	Chronic Low
	Extensive, imparting a blue-green/whitish-green colour to ridges.	Sparse or absent, not giving a blue-green/whitish-green colour to ridges.

Table 2 The classification of small-scale field indicators as grazing or trampling indicators and the weightings assigned to each of these when used for calculating combined weighted impact scores (after MacDonald *pers. comm.* 2005, Appendix 1).

Indicator	Weighting
Trampling and grazing of pool systems and water tracks	150
Trampling of <i>Sphagnum</i> moss hummock and lawns	150
Abundance of hoof prints in bare peat over the assessment unit	75
Signs of browsing on <i>Arctostaphylos uva-ursi</i> , <i>Empetrum nigrum</i> , <i>Erica tetralix</i> and <i>Vaccinium vitis-idaea</i>	3
Growth-form and evidence of browsed shoots on <i>Myrica gale</i> bushes	2
Conspicuousness of browsing on <i>Calluna vulgaris</i> or <i>Vaccinium myrtillus</i>	75
Amount of herbivore dung present	1

Table 3 The total number of locations (sum of the systematic sample points and “target note” samples) at which individual grazing/browsing related indicators were assessed to be either Low, Low–Moderate, Moderate, Moderate–High or High in this survey. NA = not applicable.

Grazing Indicators	Not Applicable	Low	Low–Moderate	Moderate	Moderate–High	High
Browsing of <i>Erica tetralix</i> , <i>Empetrum</i> or <i>Vaccinium vitis-idaea</i>	11	NA	585	NA	NA	5
Growth form and browsing of <i>Myrica gale</i> bushes	543	9	NA	24	NA	25
Conspicuousness of browsing on <i>Calluna</i> or <i>Vaccinium myrtillus</i>	23	5	NA	NA	573	NA

Table 4 The total number of locations (sum of the systematic sample points and “target note” samples) at which individual trampling related indicators were assessed to be either: Low, Moderate, Moderate–High or High in this survey. NA = not applicable.

Trampling Indicators	Not Applicable	Low	Moderate	Moderate–High	High
Pool systems & water tracks – trampled & grazed	401	75	78	NA	47
<i>Sphagnum</i> hummocks & lawns – trampling	49	127	213	NA	212
Hoof prints in bare peat	125	60	118	NA	298
Amount of herbivore dung	0	535	1	65	NA

Table 5 The total number of locations (sum of the systematic sample points and “target note” samples) at which the trend indicators were assessed to be either chronic low, decreasing, increasing or chronic high in this survey. NA = not applicable.

Trend Indicators	Not Applicable	Chronic Low	Decreasing	Increasing	Chronic High
Changes in dwarf-shrub growth form	255	NA	41	305	NA
Height & cover of dwarf-shrubs relative to graminoids	20	NA	150	NA	431
Abundance of <i>Carex panicea</i> on drier “ridge” elements of bog	2	594	NA	NA	5

Table 6 The number of systematic sample points with different combined grazing and trampling impact classes for each SSSI.

Site of Special Scientific Interest	No. of points	Low	Moderate	High
East Halladale	27	15	12	0
Knockfin Heights	2	1	0	1
Loch Caluim Flows	14	4	10	0
Rumsdale Peatlands	18	5	10	3
Sletill Peatlands	16	9	5	2
Strathmore Peatlands	13	4	6	3
Whole survey area	90	38 (42%)	43 (48%)	9 (10%)

Table 7 The number of systematic sample points with different combined grazing and trampling impact classes and grazing and browsing trend indicators for zones 1 and 2 of the assessment. Percentages are in parentheses. Chi-square test between zones 1 and 2 for combined grazing and trampling impact classes = 0.696, d.f. = 2 and p = 0.706.

	Class	Zone 1	Zone 2
Combined grazing and trampling impact classes	Low	28 (40)	10 (50)
	Moderate	35 (50)	8 (40)
	High	7 (10)	2 (10)
Grazing and browsing trend indicator classes	Stable	19 (27)	6 (30)
	Decreasing	9 (13)	3 (15)
	No clear trend	42 (60)	11 (55)

Table 8 The density of tracks (per km traversed), mean track width (one standard error in parentheses) and the number of “target note” samples in different combined grazing and trampling impact classes (percentages are in parentheses) for each SSSI.

Site of Special Scientific Interest	Number of points	Distance traversed (km)	Tracks per km	Mean track width (cm)	Grazing and Trampling Impact Class		
					Low	Moderate	High
East Halladale	110	34.1	2.2 (0.4)	46 (12)	15 (14)	60 (55)	35 (32)
Knockfin Heights	5	5.0	1.5 (0.5)	30	0	3	2
Loch Caluim Flows	122	22.0	3.3 (0.9)	25 (4)	3 (2)	74 (61)	45 (37)
Rumsdale Peatlands	74	19.6	2.5 (0.3)	28 (4)	1 (1)	28 (38)	45 (61)
Sletill Peatlands	68	18.1	3.1 (0.7)	25 (2)	10 (15)	31 (46)	27 (40)
Strathmore Peatlands	132	20.8	4.9 (0.7)	44 (17)	6 (5)	58 (44)	68 (52)
Whole survey area	511	119.6	3.0 (0.3)	37 (6)	35 (7)	254 (50)	222 (43)

Table 9 The number of systematic sample points at which the trend indicators were assessed to be either decreasing, increasing, stable or unclear for each SSSI (percentages are in parentheses).

SSSI	Number of points	Decreasing	Stable	No Clear Trend	Increasing
East Halladale	27	1	12	14	0
Knockfin Heights	2	0	0	2	0
Loch Caluim Flows	14	2	7	5	0
Rumsdale Peatlands	18	4	1	13	0
Sletill Peatlands	16	0	2	14	0
Strathmore Peatlands	13	5	3	5	0
Whole survey area	90	12 (13)	25 (28)	53 (59)	0

Table 10 The number of “target note” samples at which the trend indicators were assessed to be decreasing, increasing, stable or unclear for each SSSI (percentages are in parentheses).

SSSI	Number of points	Decreasing	Stable	No Clear Trend	Increasing
East Halladale	110	0	50 (45)	59 (54)	1 (0.9)
Knockfin Heights	5	0	0	5 (100)	0
Loch Caluim Flows	122	1 (0.8)	90 (74)	31 (25)	0
Rumsdale Peatlands	74	11 (15)	1 (1)	62 (84)	0
Sletill Peatlands	68	0	26 (38)	42 (62)	0
Strathmore Peatlands	132	16 (12)	56 (42)	60 (45)	0
Whole survey area	511	28 (5)	223 (44)	259 (51)	1 (0.2)

Table 11 The number of systematic sample points with different combined grazing and trampling impact classes for each estate/management unit.

Estate/Management Unit	Number of points	Low	Moderate	High
Ackron	1	1	0	0
Achentoul	1	0	0	1
Badnaheen	2	2	0	0
Bighouse	10	4	6	0
Dorrery Forest	7	3	4	0
Forsinard	11	4	7	0
Forsinard Holding No. 1	5	3	0	2
Golval 218	0	0	0	0
Hope & Bhealach	1	0	1	0
Limekiln and Whitewell	1	0	1	0
Maol Donn	2	1	1	0
Sandside	10	7	3	0
Shurrery	12	4	8	0
Sinclair Estates	26	8	12	6
Strathmore	1	1	0	0

Table 12 The number of “target note” samples with different combined grazing and trampling impact classes for each estate/management unit. Percentages for sample sizes >29 are in parentheses.

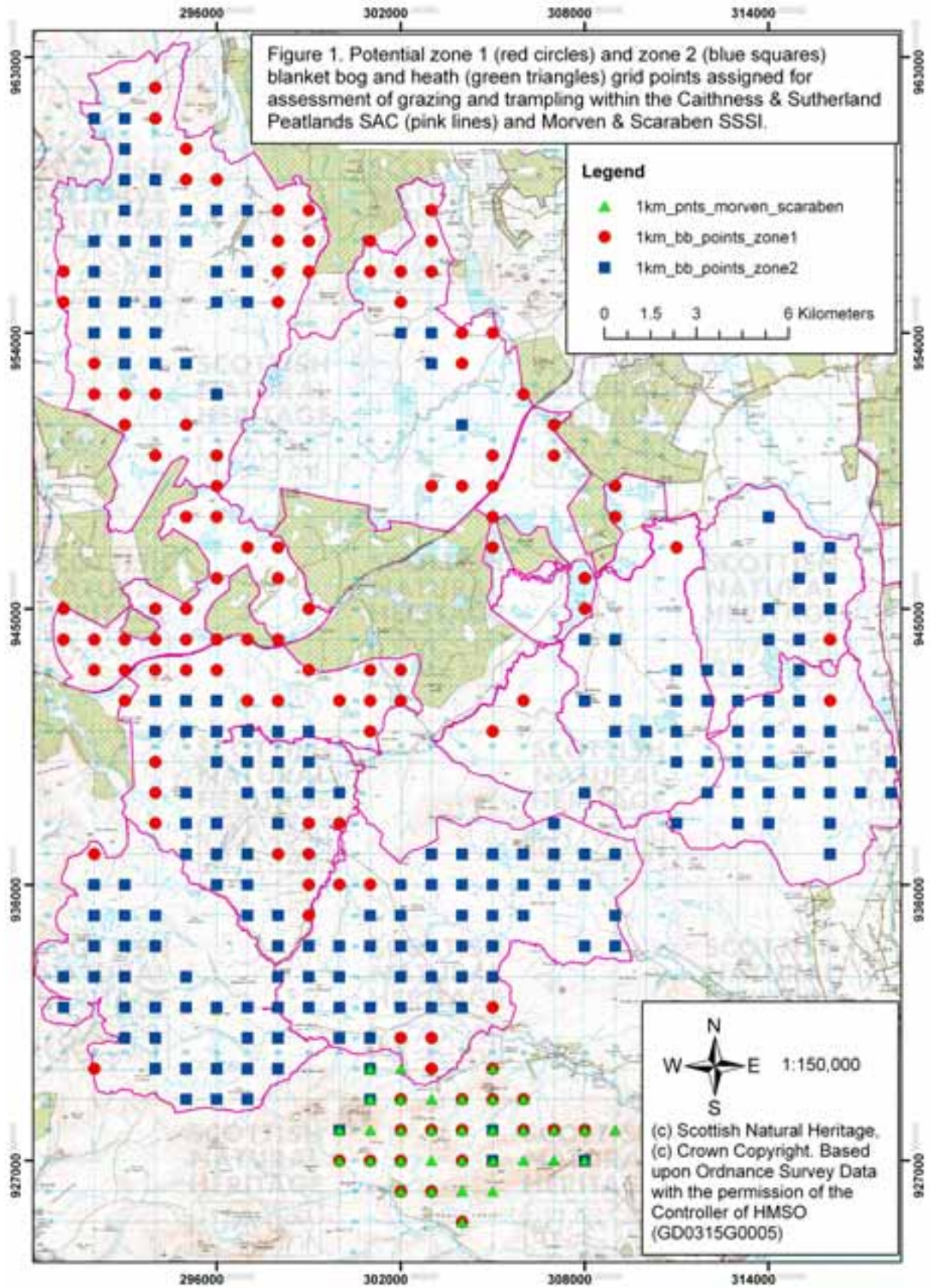
Estate/Management Unit	Number of points	Low	Moderate	High
Ackron	5	0	4	1
Achentoul	0	0	0	0
Badnaheen	5	0	2	3
Bighouse	48	7 (15)	21 (44)	20 (42)
Dorrery Forest	77	2 (3)	65 (84)	10 (13)
Forsinard	52	5 (10)	34 (65)	13 (25)
Forsinard Holding No. 1	28	0	11	17
Golval 218	4	0	1	3
Hope & Bhealach	5	0	4	1
Limekiln and Whitewell	2	1	1	0
Maol Donn	9	6	2	1
Sandside	33	3 (9)	20 (61)	10 (30)
Shurrery	60	4 (7)	21 (35)	35 (58)
Sinclair Estates	175	6 (3)	62 (35)	107 (61)
Strathmore	8	1	6	1

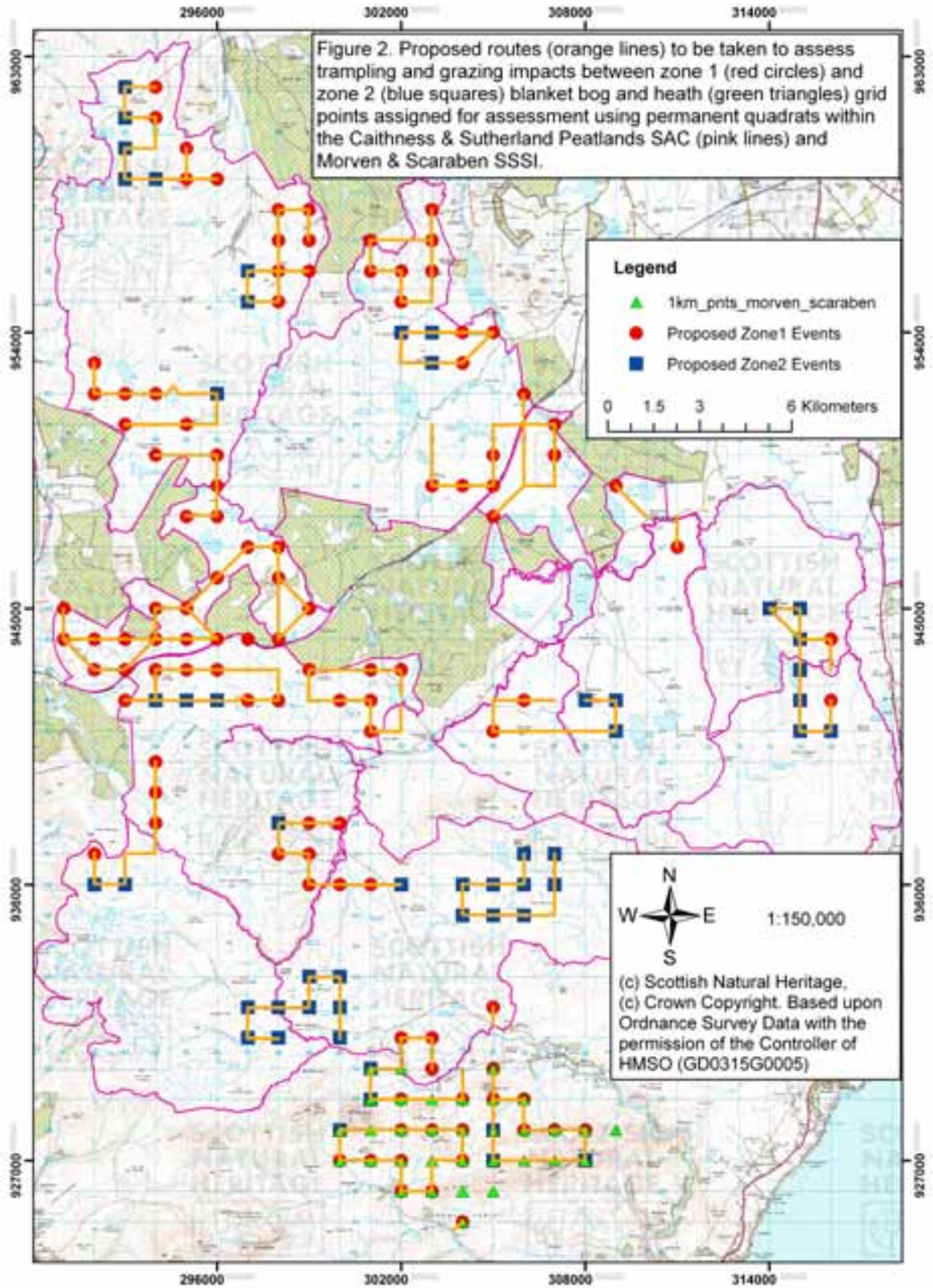
Table 13 The number of systematic sample points at which the trend indicators were assessed to be either decreasing, increasing, stable or unclear for each estate/management unit.

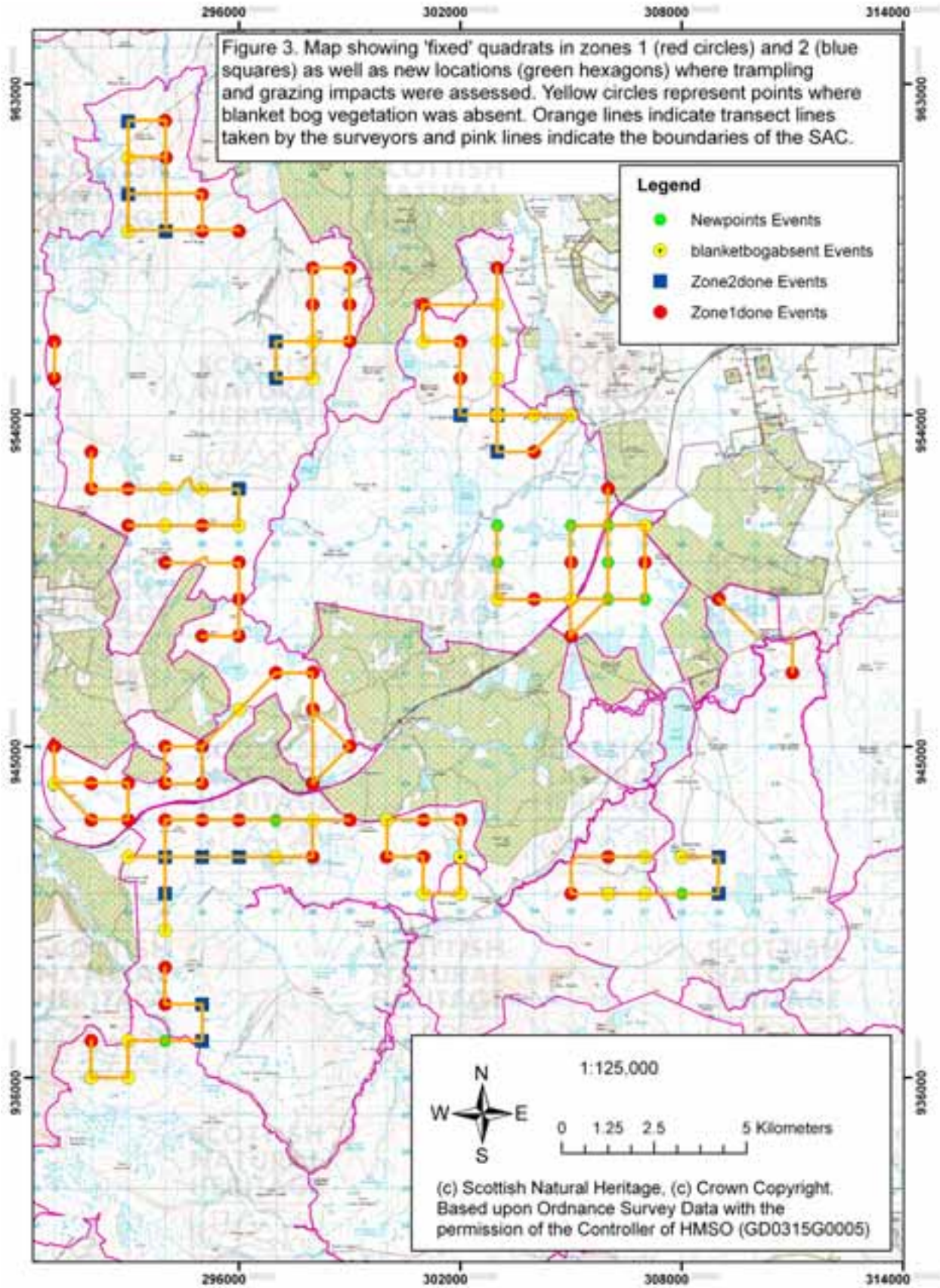
Estate/Management Unit	Number of points	Decreasing	Stable	No Clear Trend
Ackron	1	0	0	1
Achentoul	1	0	0	1
Badnaheen	2	0	0	2
Bighouse	10	1	3	6
Dorrery Forest	7	2	5	0
Forsinard	11	0	2	9
Forsinard Holding No. 1	5	0	0	5
Golval 218	0	0	0	0
Hope & Bhealaich	1	0	0	1
Limekiln and Whitewell	1	0	1	0
Maol Donn	2	0	1	1
Sandside	10	0	5	5
Shurrery	12	0	5	7
Sinclair Estates	26	8	3	15
Strathmore	1	1	0	0

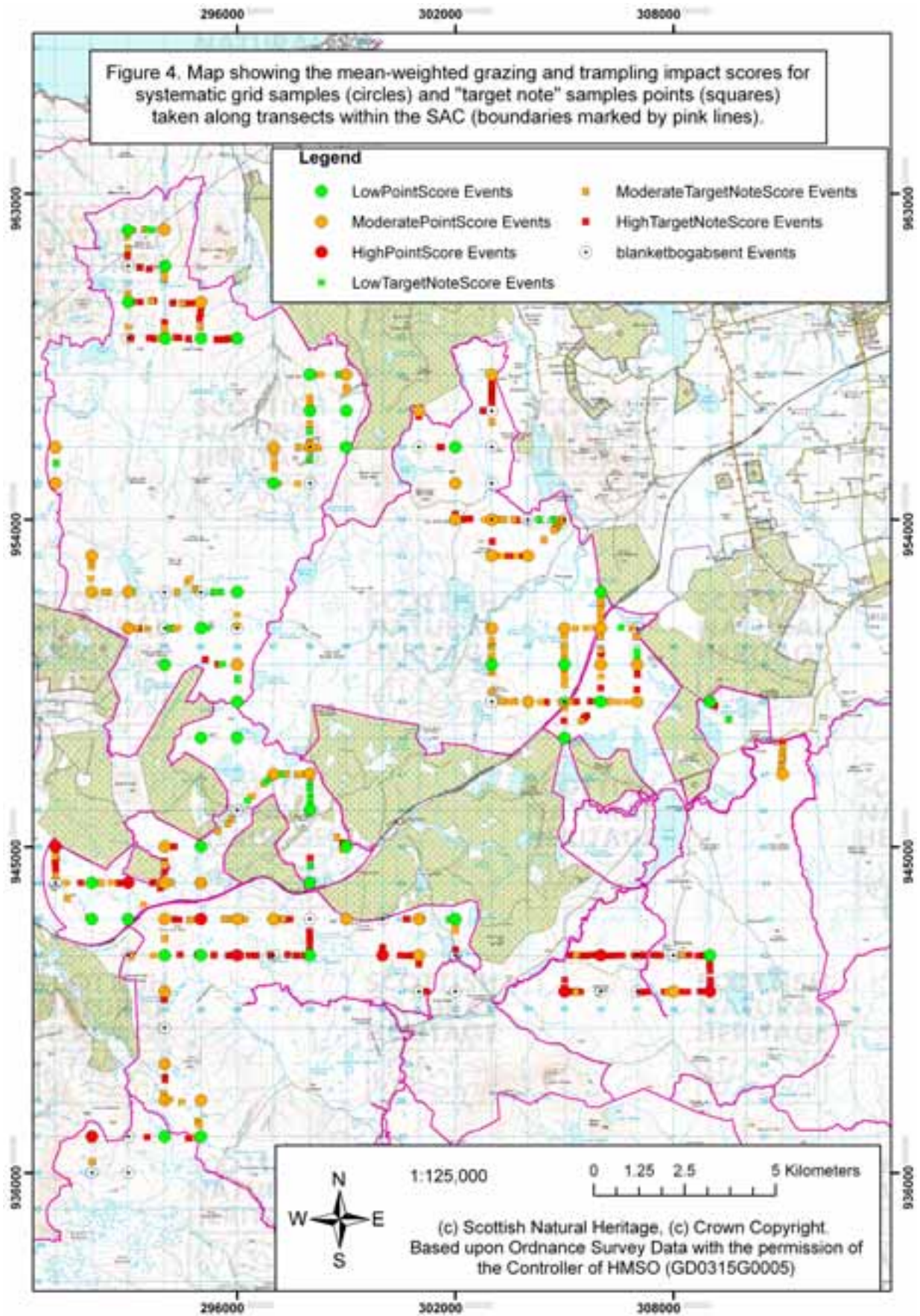
Table 14 The number of “target note” samples at which the trend indicators were assessed to be either decreasing, increasing, stable or unclear for each estate/management unit. Percentages for sample sizes >29 are in parentheses.

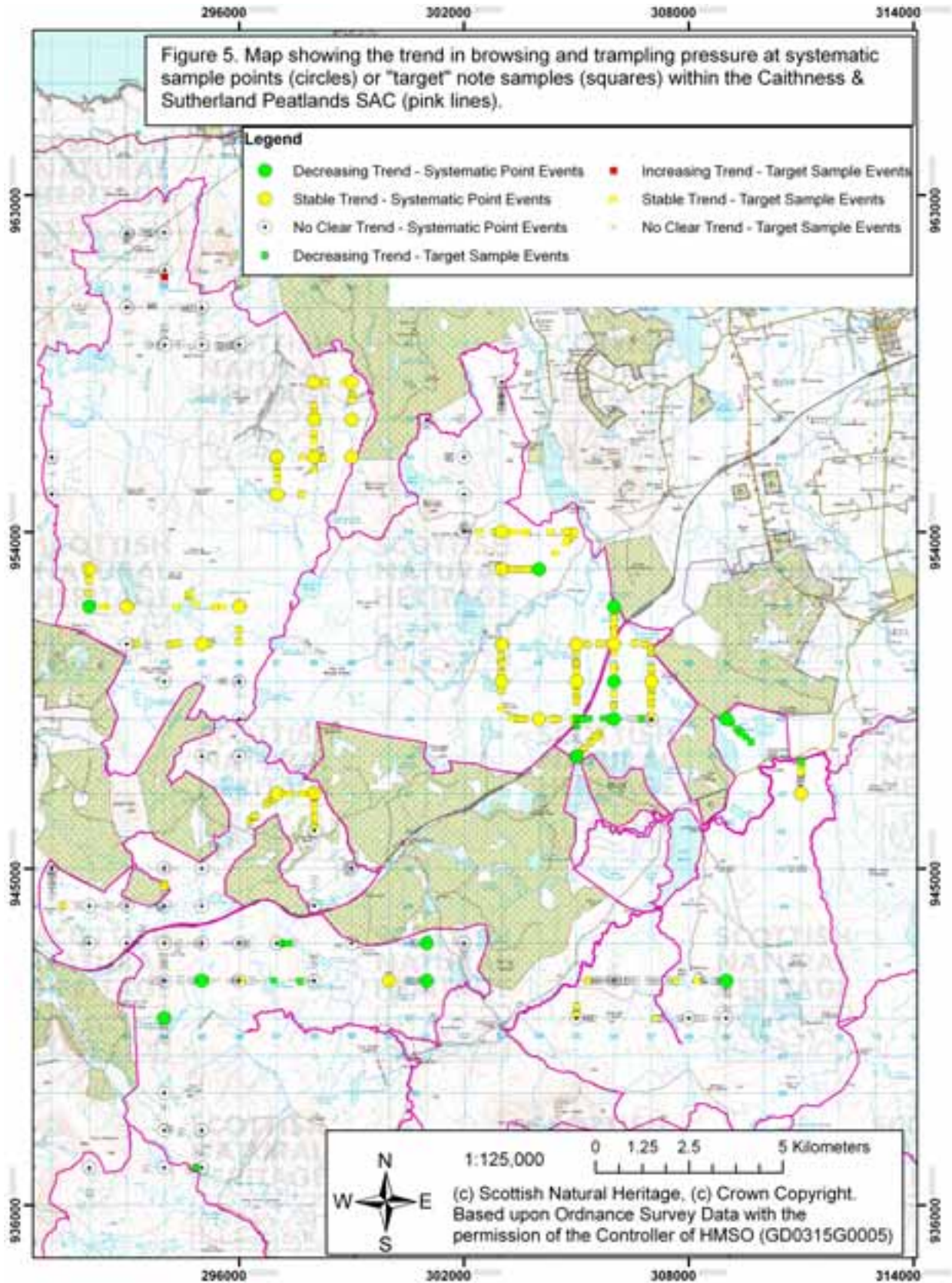
Estate/Management Unit	Number of points	Decreasing	Stable	Increasing	No Clear Trend
Ackron	5	0	0	0	5
Achentoul	0	0	0	0	0
Badnaheen	5	0	0	0	5
Bighouse	48	0	19 (40)	0	29 (60)
Dorrery Forest	77	1 (1)	76 (99)	0	0
Forsinard	52	2 (4)	21 (40)	0	29 (56)
Forsinard Holding No. 1	28	0	1	0	27
Golval 218	4	0	0	0	4
Hope & Bhealaich	5	0	0	0	5
Limekiln and Whitewell	2	0	2	0	0
Maol Donn	9	0	7	0	2
Sandside	33	0	16 (48)	1 (4)	16 (48)
Shurrery	60	0	27 (45)	0	33 (55)
Sinclair Estates	175	17 (10)	54 (30)	0	104 (60)
Strathmore	8	8 (100)	0	0	0

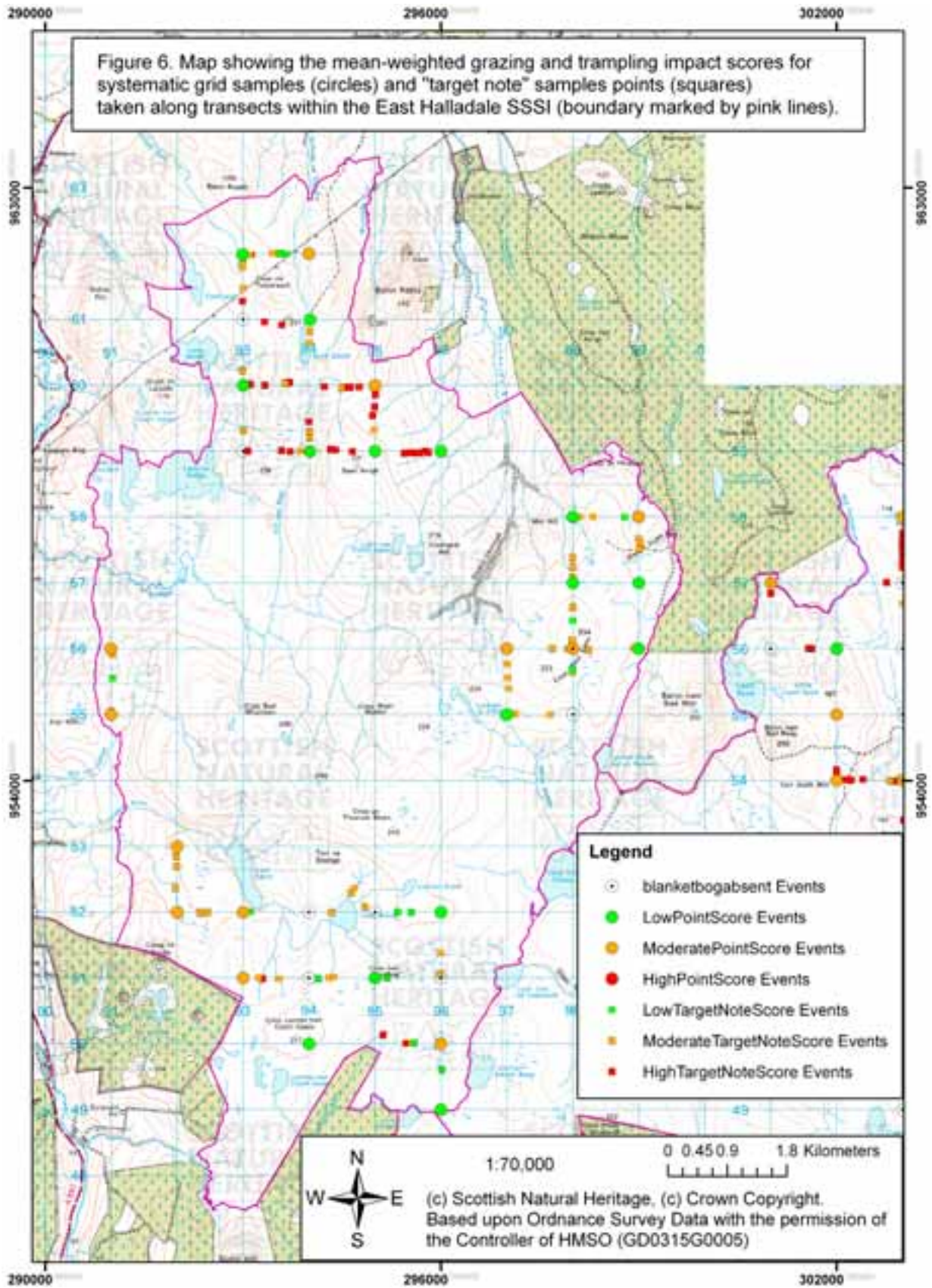


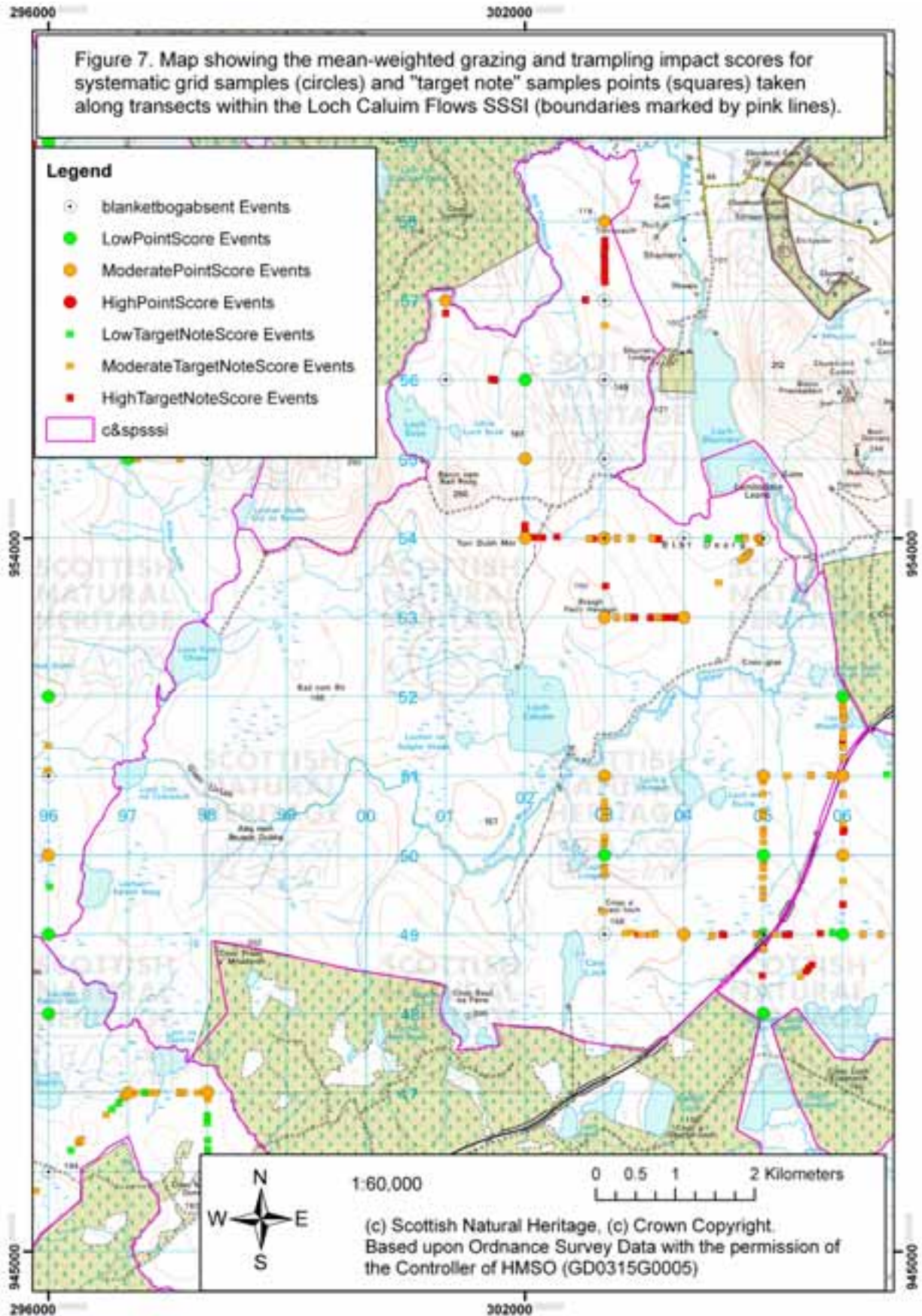


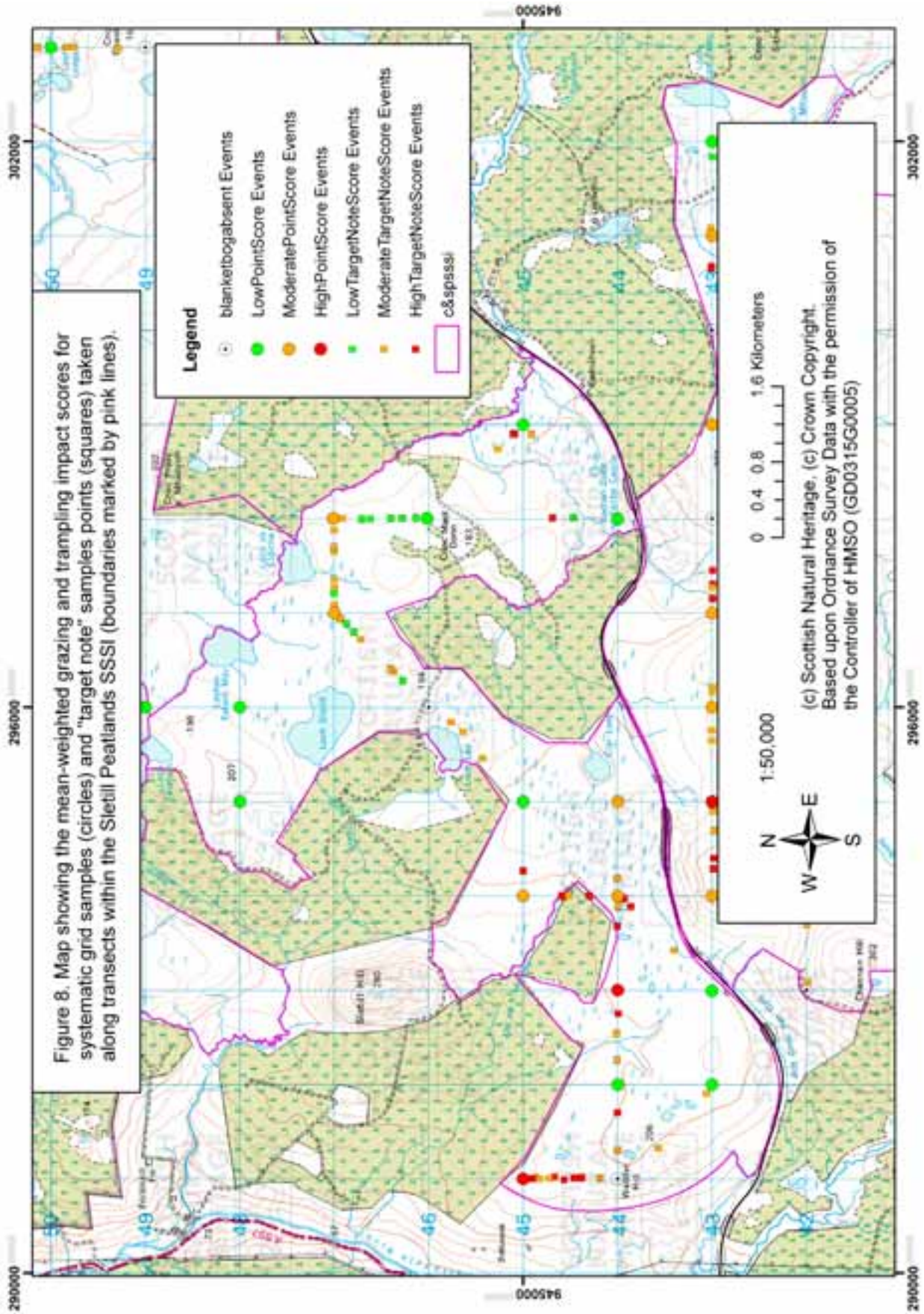


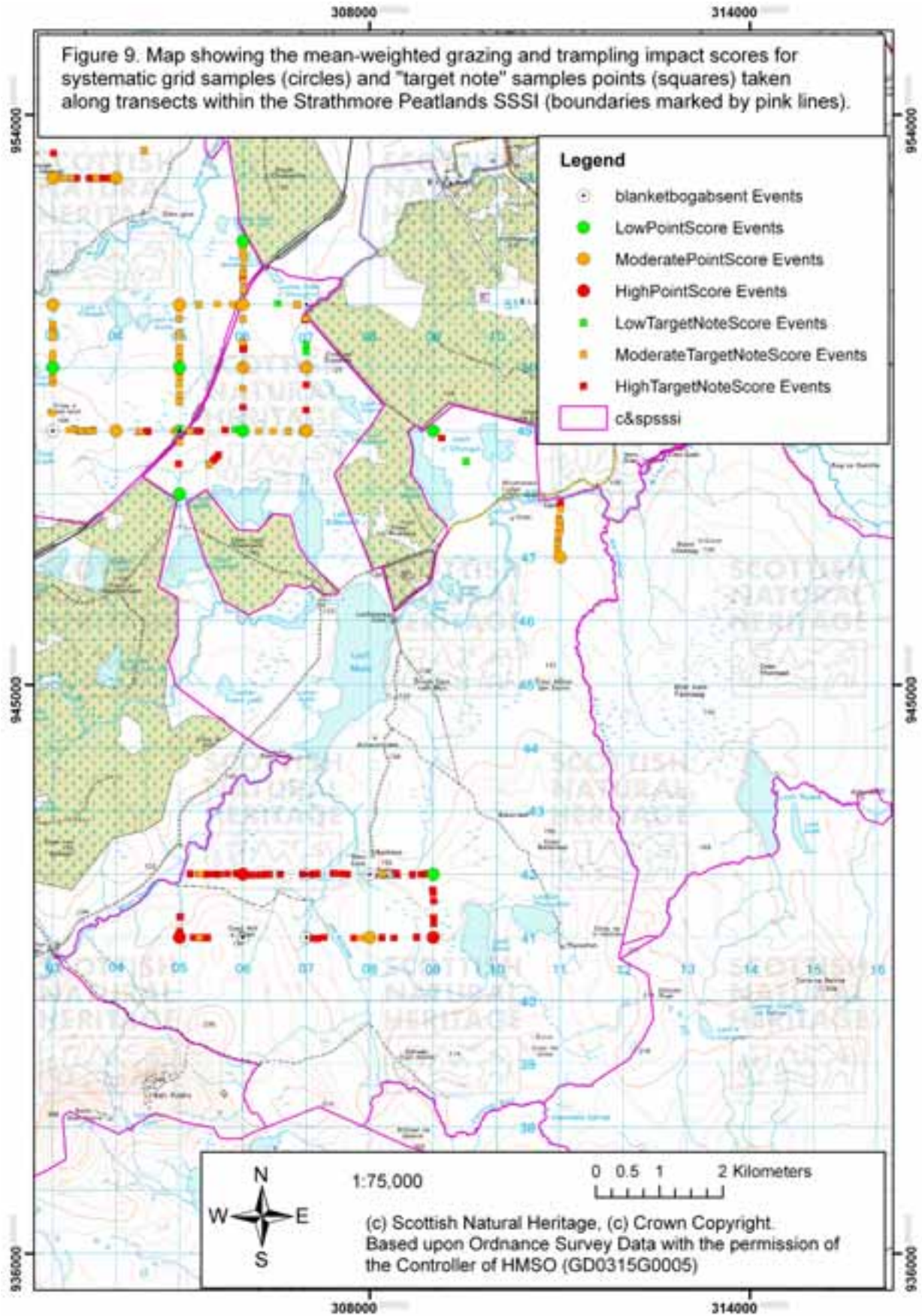


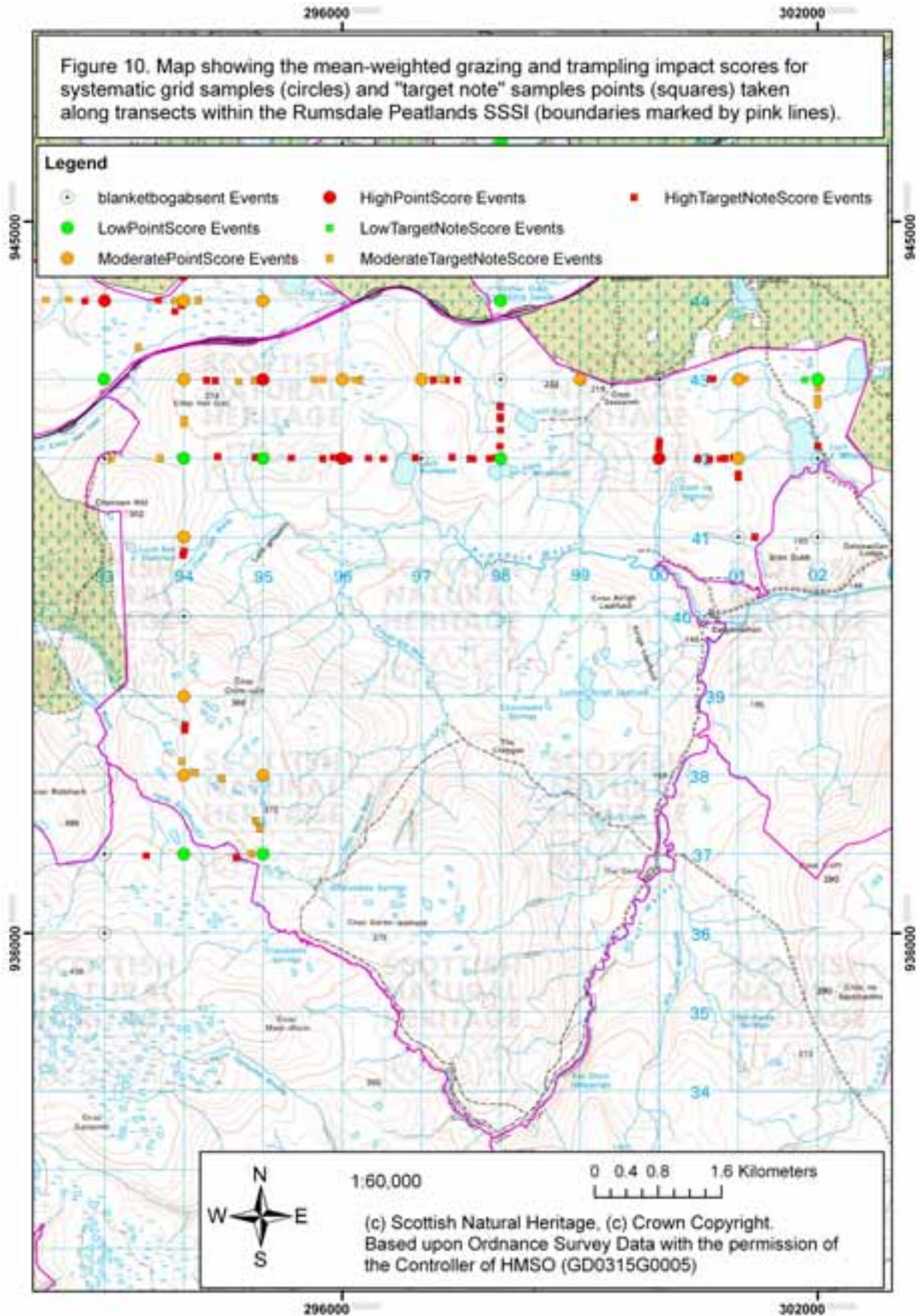












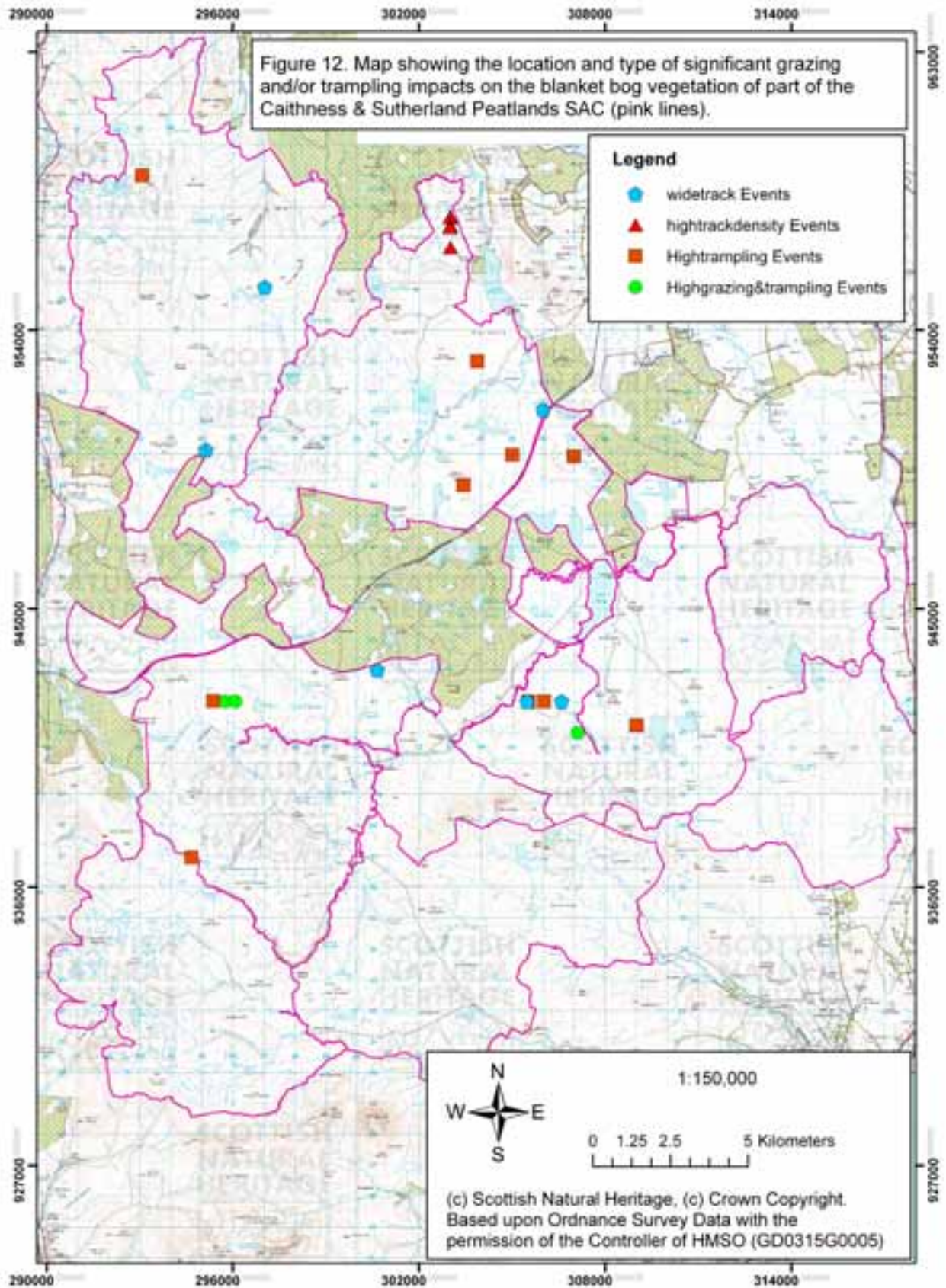




Figure 13 Example of trampling by red deer around gully.

SSSI: Knockfin Heights
Grid reference: NC 94663695
Date: 04/08/2005
Photographer: A Headley
Camera: Nikon Coolpix E4500



Figure 14 An example of heavy grazing and trampling in a *Carex echinata* – *Sphagnum recurvum* flush within the blanket bog habitat of the Strathmore Peatlands SSSI.

Grid reference: ND0710640987.
Date: 04/08/2005
Photographer: A Headley
Camera: Nikon Coolpix E4500



Figure 15 An example of a Low impact deer track.

Rumsdale Peatlands SSSI.

Grid reference: Not known

Date: 06/08/2005

Photographer: A Headley

Camera: Nikon Coolpix E4500



Figure 16 Example of Low density trampling by red deer around margins of bog pools.

Sletill Peatlands SSSI.

Grid reference: NC 98741,45268

Date: 02/08/2005

Photographer: A Headley

Camera: Nikon Coolpix E4500



Figure 17 One of only a few examples of significant trampling of fruticose lichens (*Cladina portentosa*) by red deer.

Strathmore Peatlands SSSI.
Grid reference: ND0941848612
Date: 03/08/2005
Photographer: A Headley
Camera: Nikon Coolpix E4500



Figure 18 An example of a systematic sample point (UID = 4500) with a High grazing and trampling impact score. This is due to the high density of hoof prints in bare peat, trampling of *Sphagnum* and bog pool margins.

Sletill Peatlands SSSI.
Grid reference: NC9300044000
Date: 03/08/2005
Photographer: A Griffith
Camera: Nikon Coolpix E4500



Figure 19 An example of a systematic sample point (UID = 5200) with a Low grazing and trampling impact score. This is due in part to the intact cushions of *Sphagnum* and water tracks.

Sletill Peatlands SSSI.

Grid reference: ND0500048000

Date: 03/08/2005

Photographer: A Headley

Camera: Nikon Coolpix E4500

Appendix 1 Impact assessment for trampling and grazing of blanket bog

Recommended weighting of small-scale field indicators

Angus MacDonald
Uplands & Peatlands Group
18/8/05

In deriving an overall impact assessment at a location the following procedure should be followed.

First, each indicator should be assessed as H, M or L. These should then be converted to numerical scores H=3, M=2, and L=1. For those indicators where the levels are amalgamated as ML or HM, the numerical scores should be 1.5 and 2.5 respectively. To form an overall average, multiply each of these scores by the relevant weight for all the indicators that are applicable and then total all these weighted scores. Next, divide this sum by the total of the weights used. This will provide a weighted average score which can be compared to 3=H, 2=M and 1=L.

Indicator	Weighting in overall assessment of impact
Trampling and grazing of pool systems and water tracks.	150
Trampling of <i>Sphagnum</i> moss hummock and lawns.	150
Extent of ground cover by bryophytes and/or lichens among and between dwarf-shrub, sedge and grass plants.	25
Abundance of hoof prints in bare peat over the assessment unit.	75
Firmness of ground underfoot.	1
Browsing of <i>Betula nana</i> .	2
Signs of browsing on <i>Arctostaphylos uva-ursi</i> , <i>Empetrum nigrum</i> , <i>Erica tetralix</i> and <i>Vaccinium vitis-idaea</i> .	3
Amount of flower and fruit on <i>Rubus chamaemorus</i> .	1
Amount of flowering of <i>Eriophorum</i> spp.	3
Growth-form and evidence of browsed shoots on <i>Myrica gale</i> bushes.	2
Conspicuousness of browsing on <i>Calluna vulgaris</i> or <i>Vaccinium myrtillus</i> .	75
Amount of herbivore dung present.	1
Sum of weights for all indicators	488

This weighting will ensure that current trampling is the determining factor in the overall assessment of impact. I think this is desirable because all the other indicators are often of patchy and somewhat unpredictable occurrence in time or space or are also affected by factors other than herbivore impacts.

I think browsing and grazing should not be completely overwhelmed by the weight given to trampling, although it seems unlikely that if there is heavy browsing and grazing there will not also be evidence of at least moderate trampling. For this reason, I have given a moderately high weight to the indicator for browsing of *Calluna* and *Vaccinium myrtillus*. I have given more weight to this indicator not because it is necessarily the most important aspect of browsing and grazing on bogs, but because it is likely to be more

widely relevant and less ambiguous than the other browsing and grazing indicators. For example, the flowering of *Eriophorum* spp. is an important aspect of the bog habitat but this is also affected by factors such as reduced *Eriophorum* cover after drainage, increased flowering after burning, or year to year variation in the weather.

Some indicators, such as browsing on *Myrica* or *Betula nana*, may show high impacts, especially when these species are of low abundance on an area of bog, even when all other indicators suggest low herbivore impacts. In this circumstance, it seems unreasonable to attribute high impact to the whole bog. The indicators for browsing on these species have, therefore, been given a low weight. Also, the browsing of *Betula nana* is only likely to be sporadically relevant. *Myrica* and *Betula nana* are most indicative the plants are conspicuous (and not hidden among the heather) and are also *not* browsed. This is a good indicator that few or no herbivores are using the immediate area. However, *Betula nana* and *Myrica* (to a lesser extent) are very frequently browsed *wherever* they occur outside exclosures.

I have also tended to downweight indicators according to two additional criteria. First, I have downweighted those indicators that seem less precisely specified, and that might therefore give more observer variation. Second, I have given less weight to those indicators that may also indicate historical carry-over effects, making them less good as indicators of current impact. Firmness of ground underfoot might be used as an example of both these considerations.

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