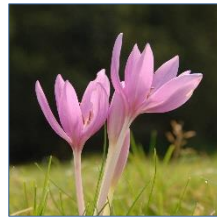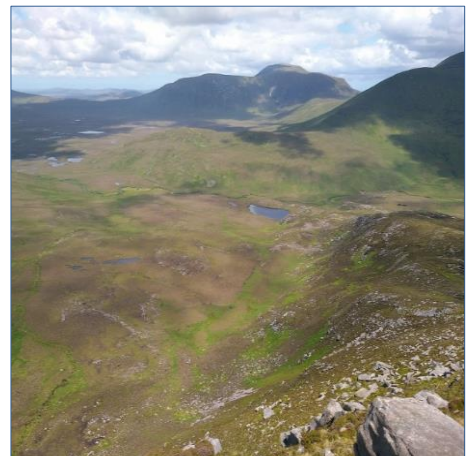# NATIONAL PARKS AND WILDLIFE SERVICE

A SURVEY OF BREEDING GOLDEN PLOVER WITHIN THE OWENDUFF/NEPHIN COMPLEX SPA, COUNTY MAYO

Dave Suddaby & Cathal O'Brien

An Roinn Cultúir,
Oidhreachta agus Gaeltachta
Department of Culture,
Heritage and the Gaeltacht

IRISH WILDLIFE MANUALS 120

A survey of breeding Golden Plover within the Owenduff/Nephin Complex SPA, County Mayo

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Contents

Executive Summary

The Irish breeding population of Golden Plover *Pluvialis apricaria*, a species listed on Annex I of the Birds Directive, was estimated at 134 to 156 pairs following surveys between 2002 and 2004. From those surveys, the Owenduff/Nephin Complex Special Protection Area (SPA) (site code 4098) in County Mayo was identified and designated as an important breeding area for Golden Plover. Further surveys within this SPA in 2005 and 2006 estimated a breeding population of 60 to 67 pairs. These estimates were based on an extrapolation from single survey visits to up to 26 one-kilometre grid squares in both 2005 and 2006. There has been no systematic survey or population estimate for Golden Plover within SPA since these surveys. Robust data on population size, range and habitat use are essential to the development and implementation of effective conservation programmes.

This report provides the results of a survey for breeding Golden Plover in the Owenduff/Nephin Complex SPA, based on the most cost-effective approach to providing a population estimate. The survey was completed during the 2019 breeding season using the same 27 one-kilometre grid squares identified and surveyed between 2005 and 2006. This survey followed the same transect routes within each one-kilometre square that were set during those previous surveys. In consideration that any changes in Golden Plover population may be habitat mediated, a repeat of the habitat assessments completed in 2005 and 2006 was also undertaken, using pre-determined 1 m^2 quadrats along the established transect routes. Additionally, territorial Skylark *Alauda arvensis* and Meadow Pipit *Anthus pratensis* were recorded.

This survey found five Golden Plover breeding territories within the 27 one-kilometre grid squares surveyed. All were recorded between 19 April and 16 May, and despite surveying through until 21 June 2019, no further territorial birds were detected. These findings indicate a breeding density of 0.25 Apparently Occupied Territories (AOTs) per kilometre-squared (0.25 AOT/km^2) across the total surveyed area of the SPA (19.92 km^2). Surveys in 2005 and 2006 estimated the density of Golden Plover at 0.37 AOT/km^2 and 0.44 AOT/km^2, respectively. These density estimates are considerably lower than those from a 2013-2015 survey in the Connemara Bog Complex SPA (1.35 AOT/km^2).

The results from this survey suggest that the total population of breeding Golden Plover within the repeated surveyed sites has declined by 37.5% (from a maximum eight AOTs in 2006 to five in 2019), and that the density of AOTs has declined by 43% (from a maximum of 0.44 AOT/km^2 in 2006 to 0.25 AOT/km^2 in 2019). However, these trends should be interpreted with caution as the survey methods differed between periods: two survey visits were completed to each one-kilometre grid square in 2019, while each square received only a single visit in both 2005 and 2006. Due to a lack of high quality data on habitat availability within the SPA, it was not possible to produce a robust estimate of the total breeding Golden Plover population within the SPA.

Compared to the habitat assessments completed in 2005 and 2006, this survey found increased cover of shrub/heather in survey squares. As breeding Golden Plover do not utilise extensive or old stands of dense tall heather, the increased heather cover found may have impacted negatively upon the breeding population. This could perhaps, in part, explain the observed decline in the density of breeding Golden Plover pairs, and, if so, may continue to affect populations without changes in land management. While one may have expected an increase in shrub/heather cover to result in decreased Skylark abundance and increased Meadow Pipit abundance, this survey broadly indicated that Skylark increased while Meadow Pipit were stable.

There is significant scope for further analysis of the detailed habitat data collected in this survey (and from previous surveys); for example, to investigate changes in habitat condition and how habitat management practices can be optimised for Golden Plover and other biodiversity priorities within the Owenduff/Nephin SPA and other protected areas.

Given the reported low densities of breeding Golden Plover, as well as the lack of information on key local breeding parameters, it is recommended that future Golden Plover surveys employ a minimum of four survey visits between April and June. This will allow for more robust estimates of population size. It is also recommended to use high quality digital aerial imagery and/or other available data sources to quantify the availability of suitable breeding habitat for breeding Golden Plover within the whole of the Owenduff/Nephin Complex SPA. This would allow a robust estimate of the breeding Golden Plover population within the SPA to be calculated. It is also recommended to encourage research to attain a better understanding of the grazing levels within the SPA and their impacts on the vegetation composition and structure within the SPA. This is required for the future design, target and implementation of effective conservation measures for Golden Plover and other species within the Owenduff/Nephin Complex SPA and other protected areas.

Acknowledgements

Areas of mire/quaking bog and bog pools within the Owenduff/Nephin Complex SPA.
Photograph © Dave Suddaby.

1 Introduction

Breeding waders in Ireland have experienced significant population declines and range contractions in recent decades (*e.g.* Lauder & Donaghy, 2008; Balmer *et al.*, 2013) and many are now considered of high conservation concern (Colhoun & Cummins, 2013). Two wader species that are listed on Annex I of the Birds Directive breed within the upland habitats in Ireland, which include blanket bogs, heather dominated areas and marginal grasslands; these being Golden Plover *Pluvialis apricaria* and Dunlin *Calidris alpina schinzii*. Lauder & Donaghy (2008) estimated the national populations to be 150 pairs each, with declines noted in the order of 73% for Golden Plover since 1993. The Bird Atlas 2007-11 (Balmer *et al.*, 2013) also noted accelerated breeding range losses for Golden Plover, with a 40% loss since the New Atlas 1988-91 (Gibbons *et al.*, 1993), and a *c.* 65% loss since the first Atlas 1968-72 (Sharrock, 1976) for Dunlin.

From an upland bird survey over three breeding seasons (2002 - 2004), Cummins *et al.* (2004) identified a discrete area in County Mayo, now designated as the Owenduff/Nephin Complex Special Protection Area (SPA) (site code 4098), as an important breeding area for Golden Plover. Based on that, Golden Plover, along with Merlin *Falco columbarius*, Peregrine *Falco peregrinus* and wintering Greenland White-fronted Goose *Anser albifrons flavirostris,* was listed as Special Conservation Interests for the SPA in 2005 with a given (minimum) population of 14 pairs in 2004 (National Parks and Wildlife Service (NPWS), 2006). Further surveys in 2005 and 2006 by Clotworthy (2009), aimed to provide a more robust population estimate for breeding Golden Plover within the SPA, based on surveying up to 26 randomly selected one-kilometre squares with suitable breeding habitat within the SPA. From these, based on an estimate of the total available area of suitable breeding habitat, Clotworthy (2009) extrapolated and estimated the Golden Plover population for the SPA at 60.48 pairs in 2005 and 66.96 pairs in 2006. There have been no further estimates since.

Robust data on population size, range and habitat use are essential to the development and implementation of effective conservation programmes. To this end the National Parks and Wildlife Service of the Department of Culture, Heritage and Gaeltacht commissioned a re-survey during the 2019 breeding season of the Owenduff/Nephin Complex SPA, focused on pre-selected sites. The aim was to assess any changes in the numbers of breeding Golden Plover within the SPA based on the same one-kilometre squares surveyed by Clotworthy (2009). In consideration that any population changes may be habitat related, re-assessments of habitat condition were undertaken within each survey site following the methods of Clotworthy (2009). Furthermore, as per the work of Clotworthy (2009), Skylark *Alauda arvensis* and Meadow Pipit *Anthus pratensis*, two widely distributed and abundant species within the uplands (Cummins *et al.*, 2004), were also recorded. Observations of other species of conservation concern, such as Merlin and Red Grouse *Lagopus lagopus* were also recorded. This report provides the findings of that survey.

The objectives of the survey were

1. To provide a population density estimate for breeding Golden Plover within the Owenduff/Nephin Complex SPA and an assessment of trends relative to previous surveys

2. To provide population density estimates for breeding Skylark and Meadow Pipit within the Owenduff/Nephin Complex SPA and an assessment of trends relative to previous surveys

3. To provide an assessment of the habitat condition for breeding Golden Plover within the Owenduff/Nephin Complex SPA, and

4. To provide records of other key species, notably Merlin and Red Grouse in the Owenduff/Nephin Complex SPA.

2   Survey Area

2.1   Site Description

The Owenduff/Nephin Complex SPA extends to around 25,707 ha (NPWS, 2006) and lies within the Nephin Beg Mountain range in north-west County Mayo, situated north-east of Clew Bay and south of Bangor Erris and Bellacorrick (Figure 1). The centre, south and east of the site is dominated by mountainous terrain, which includes the highest peak, Slieve Carr at 721 m above sea level. The area is also designated as a Special Area of Conservation (the Owenduff/Nephin Complex SAC, site code 000534) due to the presence of one of the largest and best national examples of active blanket bog (a priority habitat as listed in Annex I of the Habitats Directive), as well as eight other Annex I habitats. These comprise two heath habitats, Juniper scrub, two different lake habitats, a river habitat, and mire/quaking bog habitat (NPWS, 2017). However, coniferous plantations are a feature along the eastern fringes and some valleys near the southern margins, while the northern and western margins consist of pockets of improved / semi-improved agricultural land and cut-over peat along roadsides and tracks (Clotworthy, 2009; NPWS, 2017).
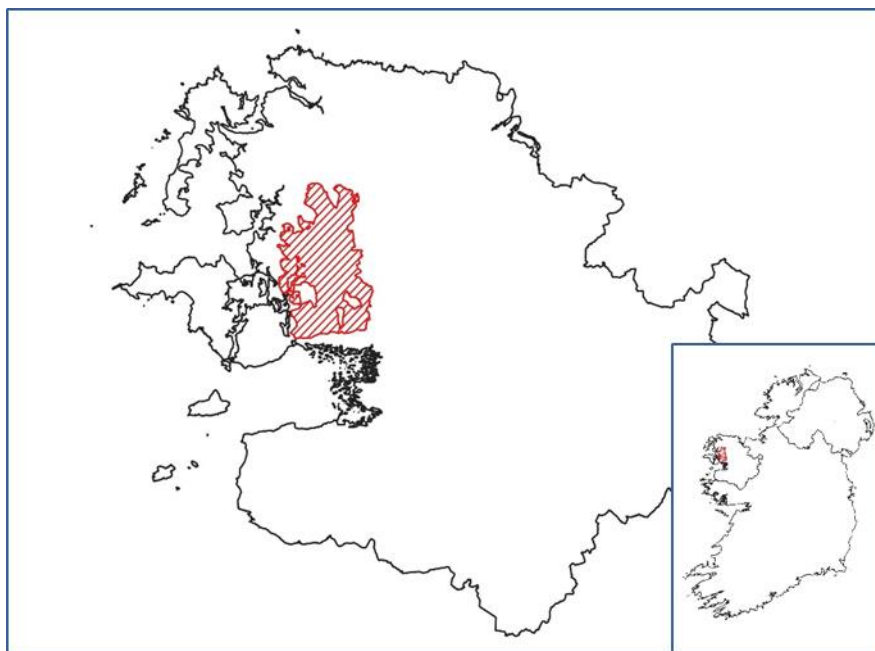
Figure 1   Location of the Owenduff/Nephin Complex SPA (red hatched area), County Mayo.

Lands within the SPA are both state- and privately-owned. State owned lands predominantly lie within the Ballycroy National Park, which was established in 1998 and covered around 11,000 ha. The park was then further expanded through the inclusion of Coillte owned lands (around 4,000 ha) in 2017, and became known as the 'Wild Nephin Ballycroy National Park'. Commonage lands, shared with the NPWS, also form part of the area primarily on the southern, northern and western edges of the SPA. A further small area is privately owned.

There has been considerable sheep grazing pressure within these uplands over the years. To address this, an off-wintering grazing scheme was established and implemented between 2006 and 2011. The impacts of this scheme, on the commonage areas and the National Park were assessed through the Commonage Framework Planning Project (a joint initiative between the National Parks and Wildlife Service and the Department of Agriculture, Food and the Marine (DAFM)) which found an

improvement to the extent that, in 2010, of the 76 habitat stations surveyed, 68 (90%) showed positive recovery (Murray *et al.*, 2013). However, there was a slower rate of recovery in the commonages in the south of the SPA, so the off-wintering scheme continued on these commonages through until 2013. Following the end of the off-wintering grazing scheme, Commonage Framework Plans were drawn up and these still apply to the commonages. They are monitored through DAFM and were last surveyed in summer 2015 (S. Callaghan, personal communication, 26 September 2019).
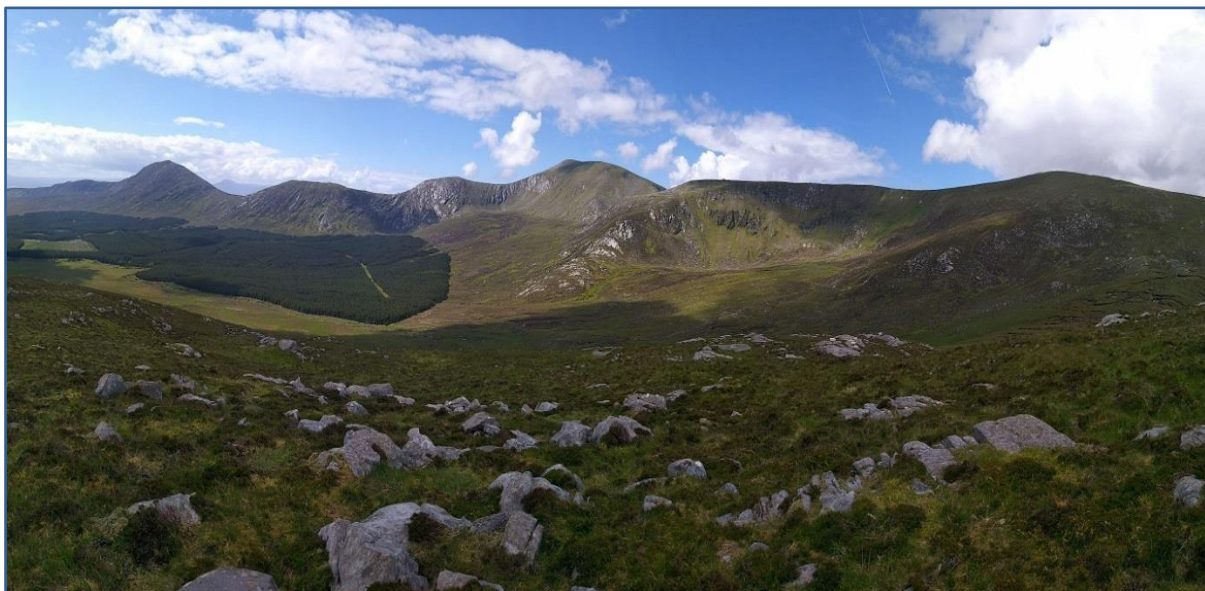
Figure 2 Wild Nephin Ballycroy National Park; looking south-west from survey square 22. Photograph © Dave Suddaby.

2.2 Site Selection

Clotworthy (2009) identified a total of 257 one-kilometre grid squares within the SPA boundaries and assessed each square for their suitability for breeding Golden Plover. A squares was excluded if it contained <20% of suitable breeding habitat (as defined in previous research, *e.g.* Byrkjedal, 1987, 1989; Edwards, 1982; Parr, 1980) or contained steep/sloping habitats or cliffs. This resulted in 216 one-kilometre grid squares (equates to 21,600 ha) being deemed as potentially suitable for breeding Golden Plover. From these, a random sample of survey squares was obtained. In order to draw effective comparisons between this survey and the surveys of Clotworthy (2009), this survey covered the same 27 one-kilometre squares as proposed by Clotworthy (Figure 3). As per Clotworthy (2009), within the 27 one-kilometre squares, surveys were only undertaken on land that was within the SPA and deemed to be suitable habitat for breeding Golden Plover. Within the 27 squares, a total of 23.72 km^2 was within the SPA and, of that, a total of 3.79 km^2 was not surveyed as it was deemed to be unsuitable breeding habitat for Golden Plover by Clotworthy. The total area of land within the SPA that was surveyed in 2019 was 19.92 km^2 (Table 1). In 2005 and 2006, the area surveyed within the SPA was 18.92 km^2 (from 25 of the 27 one-kilometre squares) and 18.25 km^2 (from 26 of the 27 one-kilometre squares) respectively (Clotworthy, 2009).
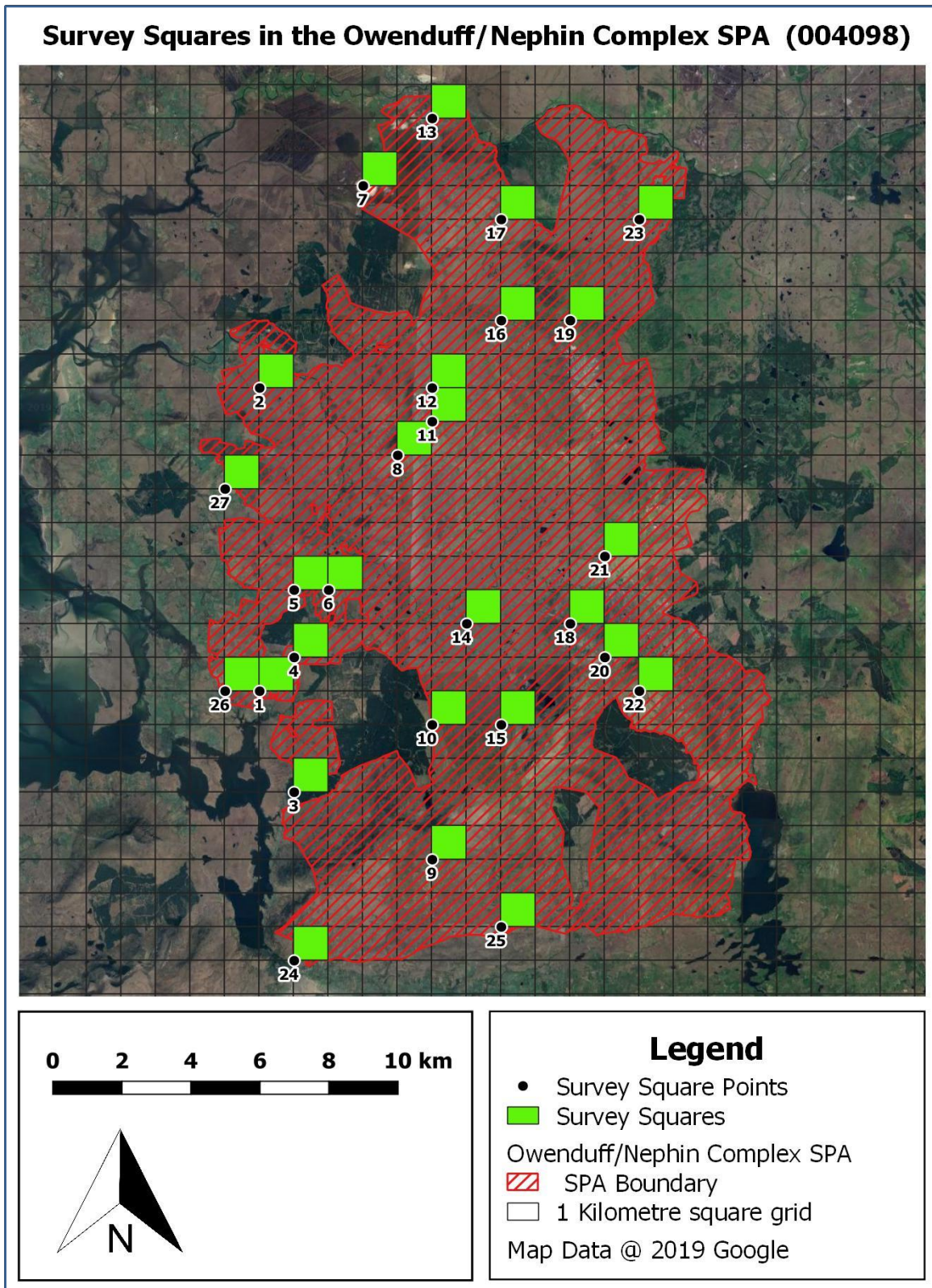
Figure 3 Map showing locations of each of the 27 one-kilometre squares surveyed in 2019 within the Owenduff/ Nephin Complex SPA and their respective square codes.

Table 1   Area of the Owenduff/Nephin Complex SPA, and the land area surveyed, within each pre-determined 1km square.

Survey square	Area in SPA (km²)	Surveyed area in SPA (km²)	Survey Transect Length (km)	Number of habitat quadrats (1m²)
1	0.58	0.35	2.0	8
2	0.92	0.81	3.4	15
3	0.32	0.32	2.0	8
4	0.72	0.72	3.2	14
5	0.83	0.83	5.0	18
6	0.98	0.98	5.0	20
7	0.67	0.67	3.0	14
8	1.00	0.57	2.5	10
9	1.00	0.39	1.8	8
10	1.00	1.00	5.0	17
11	1.00	1.00	5.0	20
12	1.00	1.00	5.0	20
13	0.56	0.56	3.3	11
14	1.00	1.00	5.0	20
15	1.00	0.54	2.0	8
16	1.00	0.73	3.0	13
17	0.61	0.61	2.9	13
18	1.00	1.00	4.6	19
19	1.00	0.89	4.1	17
20	1.00	1.00	2.0	19
21	1.00	0.39	2.0	7
22	1.00	0.77	5.0	7
23	0.70	0.70	2.8	12
24	0.88	0.88	5.0	20
25	1.00	1.00	5.0	20
26	1.00	1.00	5.0	15
27	0.95	0.20	0.9	6
Totals	**23.72**	**19.92**	**95.5**	**379**

3   Methods

3.1   Breeding Birds

The field surveys adopted were based on methods for censusing upland breeding wader populations over two visits between early April and late June (Brown & Shepherd, 1993), with adjustments in relation to the time spent surveying within an area. To maximise compatibility with Clotworthy (2009), the survey was conducted following the same transect routes as covered by Clotworthy. These transect routes were established to ensure that all the suitable breeding habitat for Golden Plover, within a given square, was approached to within 100 m; thus, aiming to maximise the detection of any breeding Golden Plover present (Yalden & Yalden, 1989). This meant that the survey time, depending on the topography, was between 50 and 250 minutes per one-kilometre square as opposed to 20-25 minutes per 500 m² quadrat as in Brown & Shepherd (1993).

Field maps of each square were created in QGIS version 2.18 (2016) using aerial imagery (Google Maps, 2019) of each one-kilometre square to record breeding bird activity; these also displayed the pre-determined transect survey lines and habitat quadrat points (see Section 3.2 Habitat Assessments). Co-ordinates for the transect lines and quadrat points were also pre-installed into a handheld Global Positioning System (GPS) unit (in this case a Garmin® GPSMAP® 64s) and used for navigating to, within and back from the survey square.

For each survey visit, the (i) survey square grid reference number, (ii) surveyors name(s), (iii) survey date, (iv) survey start and finish time, (v) survey visit number and (vi) basic weather conditions (cloud cover (0-33%, 33-66% or 66-100%), rainfall (none, showers or drizzle), wind (calm, light or breezy) and visibility (good, moderate or poor)) were recorded on an individual field form.

Following Brown & Shepherd (1993) surveys were conducted between 08.30 BST and 18.00 BST, thereby avoiding the main periods of rapidly changing bird activity (Reed *et al.*, 1985). Surveys were also conducted in good weather conditions with wind less than Beaufort force 4 (World Meteorological Organization, 1970) and visibility greater than 2 km. As adopted from Clotworthy (2009), the surveyor walked at a steady pace (around 1-2 km/hr.) along the same transect routes (each up to 1 km in length and spaced 200 m apart within a given square), observing the surrounding area using the 'look-see' technique (Bibby *et al.*, 2000). The number of transect routes in each survey square ranged from two to five depending on habitat suitability for breeding Golden Plover, and they were orientated either east-west or north-south depending on topography and terrain (see Figure 6 for example). All observations of Golden Plover, Skylark and Meadow Pipit (see below) and other species of conservation concern, such as Merlin and Red Grouse, were recorded on field maps, using British Trust for Ornithology (BTO) standard species recording and behavioural codes (Marchant, 1983). If seen closely enough, the sex of any suspected breeding Golden Plover was determined by the degree of ventral blackness (Cramp & Simmons, 1983). Territorial birds (expressed as Apparently Occupied Territories (AOTs)) were recorded showing their approximate locations and were linked with an arrow to denote the same bird(s) if they were seen to be flying, and were considered as breeding if they satisfied at least one of the following criteria

- Observed displaying or singing

- A nest or young were located

- Observed calling or repeatedly alarm-calling, indicating nearby nest or young

- Observed performing distinct distraction displays. or

- Observed in territorial disputes.

In instances where two Golden Plover, exhibiting such breeding behaviour, were seen on the same visit, but it was unsure whether they were a single pair (*e.g.* difficult to confirm sex of the birds), then if the birds were within 500 m of each other they were recorded as being a single pair; if the distances were greater than 500 m then they were recorded as two pairs (as in Brown & Shepherd, 1993). All other Golden Plover sightings, including those considered as breeding but outside of the survey square, were recorded but these were not considered in any analysis.

For Skylark and Meadow Pipit, all individuals seen were recorded on field maps and the approximate location of any singing males were differentiated to give an estimation of the number of AOTs. If two or more singing males were encountered within 200 m of each other, then they were recorded as a single AOT unless it was clear that they were separate territories *i.e.* two singing males seen at the same time in close proximity; otherwise at greater distances apart (*i.e.* >200 m) they were recorded as different breeding territories (Browne, 1997; Thompson & Brown, 1996). For other species of note, such as Merlin, Red Grouse or other birds of conservation concern then their behavioural activity and direction of movement were marked on the field maps.

3.2   Habitat Assessments

Clotworthy (2009) indicated that breeding Golden Plover territories, within the Owenduff/Nephin Complex SPA, may be linked with shorter vegetation heights (from maximum and average graminoid heights) and that they showed a preference for either undamaged or moderately grazed Ling Heather *Calluna vulgaris*. These findings were based on measuring 14 variables within 1 m² quadrat points set at 200 m distant along each of the bird survey transect lines (see Section 3.1 above). To ensure compatibility with Clotworthy (2009), the habitat assessment methodologies employed, and the information gathered in this survey were identical to those of Clotworthy.

The aim of these habitat assessments was to assess habitat condition and grazing impact within the SPA. Habitat assessments were undertaken once for each survey square (completed on the first bird survey visit where possible). Within each square, the number of 1 m² quadrat points ranged from six to 20 (this was dependent on the total area of suitable breeding habitat for Golden Plover that was within the SPA boundary, see Table 1). Within each quadrat, 14 habitat and grazing-related variables were recorded, as per Clotworthy (2009). All the data were recorded on a specific field recording form. The 14 measured variables within each of these quadrats followed those provided by Dúchas and the Department of Agriculture and Food (1999) in assessing grazing impacts in upland and peatland habitats, with adjustments by Clotworthy (2009) in relation to grouping shrub, graminoid and bryophyte species rather than measuring them individually. The measured variables per quadrat were

1.   The total percentage of vegetation cover

2.   The total percentage of bare ground

3.   The percentage cover of shrub plant species (*e.g.* Heather *Erica* species, Gorse *Ulex* species)

4.   The percentage cover of graminoid (herbaceous plant / grass / sedge) species

5.   The percentage cover of bryophyte (mosses / liverworts) species

6.   The percentage cover of litter (dead or decaying) vegetation

7.   The percentage cover of surface water

8.   The maximum vegetation height (cm)

9.   The average shrub height (cm) (average height taken from five measurements)

10.   The average graminoid height (cm) (average height taken from five measurements)

11.   The percentage cover of Ling Heather within the shrub cover

12.   The average Ling Heather height (cm) (average height taken from five measurements)

13. The growth condition of Ling Heather (either carpet, topiary or drumstick form), and

14. The overall damage assessment of the quadrat (either undamaged, moderately damaged or severely damaged).

Twelve of these variables were measured either by estimating the percentage cover within the 1 m² quadrat or by measuring the heights (to the nearest centimetre) of the vegetation using a ruler, with the average height being calculated from five measurements. The other two variables (growth form of Ling Heather and overall damage) were assessed through criteria provided to assess grazing impacts in upland and peatland habitats; these are summarised below (see Dúchas & DAF (1999) for full descriptions).

The growth condition of Ling Heather was categories into three distinct, grazing-related growth forms as follows (see Figure 4 for illustration):

1. Carpet form: young growing shoots destroyed by grazing (or severe weather) leading to lateral branches rooting and, if recurrent, a dense carpet-like growth form develops

2. Topiary form: maturing plants develop a rounded form but with intense grazing the number of growing points increases, which in turn leads to a changing structure including a dense, compact canopy down to ground level, or

3. Drumstick form: lower branches in older plants become shaded and die and, through grazing, new shoots are unable to form and growth is constrained, reducing the plant to intertwined and contorted shoots at the ends of scattered long, bare stems.

Figure 4 Examples of different Ling Heather forms found within the quadrats; (left to right) carpet, topiary and drumstick. Photographs © Cathal O'Brien.

Assessment of the overall damage within a quadrat was based on whether the area within the quadrat met one of the following descriptions (see Figure 5 for illustration)

1. Undamaged: there is complete vegetation cover with little evidence of damage by treading of grazing. There is little or no bare ground

2. Moderately damaged: the vegetation is visibly damaged by trampling and grazing, and there may be some bare ground or early signs of erosion starting, or

3. Severely damaged: there is conspicuously damaged vegetation structure and cover with abundant signs of severe grazing to most plants and bare ground (>5%) is obvious. In severe cases, peat erosion is a visible feature.

Figure 5 Examples of vegetation cover within the quadrats; (left to right) undamaged, moderately damaged and severely damaged. Photographs © Dave Suddaby.

3.3 Data Interpretation and Analysis

All bird and habitat data recorded were input to Microsoft Excel® (2018) templates. For each survey visit and for each species, the estimated numbers of pairs (expressed as Apparently Occupied Territories (AOTs)) and the total number of individuals were produced. Bird data including the peak number of AOTs for key species were also digitised for each survey square using QGIS version 2.18 (2016) software.

For each of Golden Plover, Skylark and Meadow Pipit, within a given survey square, the maximum number of AOTs recorded within a survey single visit was taken as the final estimated number of AOTs per square; and a final map for each square was produced to reflect these estimates (see Figure 6 for example map). These estimates were then used to calculate the density of AOTs for each species per square across the total surveyed SPA area.

An average value for each of the 14 habitat variables was produced per square, based on values from the quadrats completed within the given square. To assign a heather condition and damage assessment per square the relative percentage of each category across all quadrats within the square was determined, and subsequently used to make an assessment for each square. These figures were then used to provide an assessment of the habitat across the total surveyed SPA area and used to assess the habitat condition of the squares where breeding Golden Plover were found.
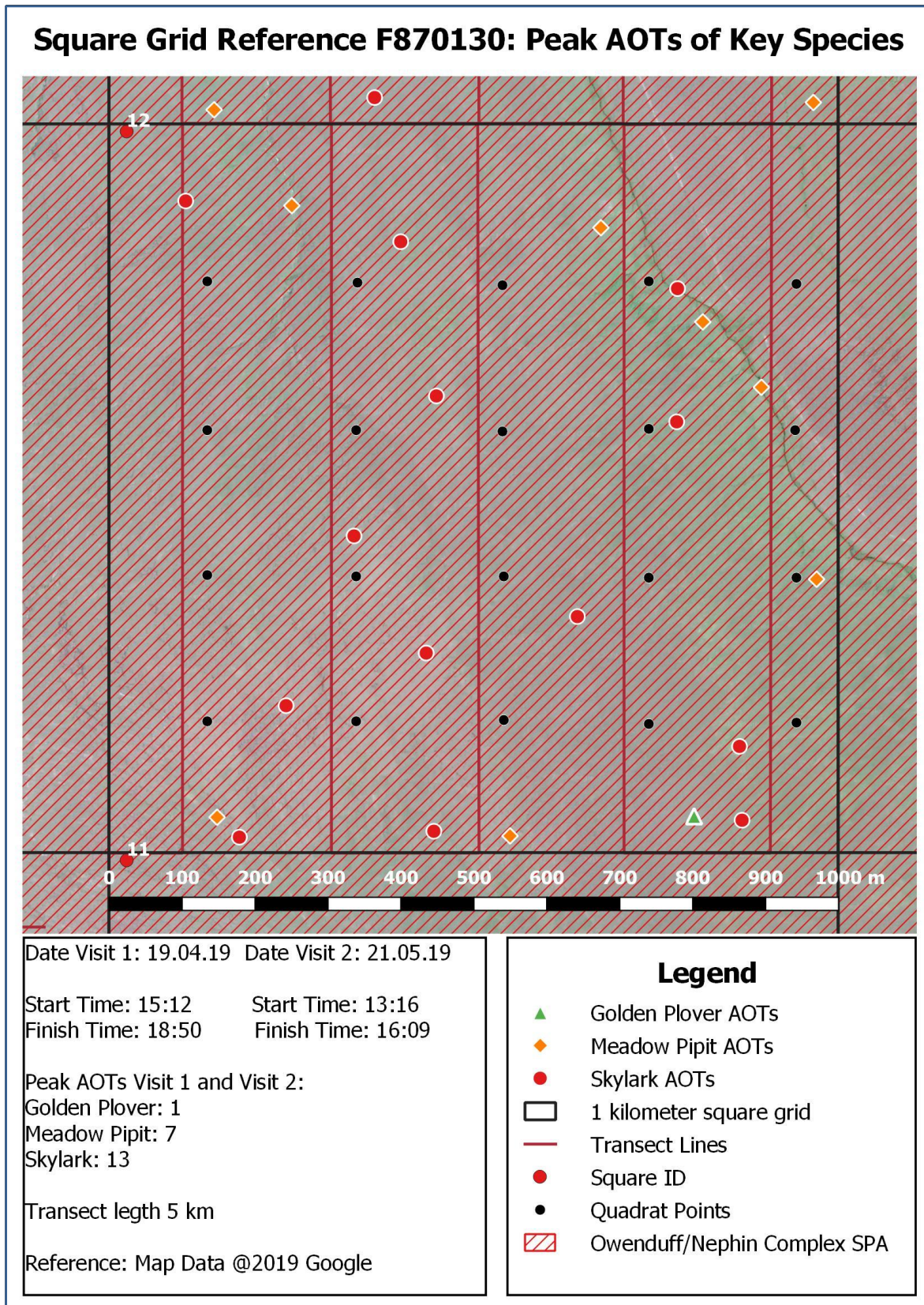
Figure 6 Example of a final survey map produced following an assessment of numbers from both surveys conducted in 2019. The Owenduff/Nephin Complex SPA is shown in red hatching.

4　Results

4.1　Coverage

All 27 one-kilometre squares were surveyed twice for Golden Plover and other bird species, with a total of 19.92 km² of suitable breeding Golden Plover habitat within the SPA surveyed. The survey period extended from 16 April 2019 to 21 June 2019, with first visits to all 27 one-kilometre squares being completed by 15 May 2019. The average time to complete a survey square for the first visit (that included completing the habitat assessment quadrats) was 205 minutes (range 105 - 307 minutes) and 166 minutes (range 48 - 240 minutes) for the second visit. The average transect length within a square was 3.58 km which was walked at an average pace of around 1.3 km/hour.

Generally the weather throughout the survey period was suitable and did not cause any delays with completing the two survey visits within the specified visit periods. The April period was notably warm, over one degree Celsius above the long-term mean, whilst the other months were around average (Table 2). The month of May was notably dry and allowed for the completion of nearly half (26; 48%) of all the survey visits. By the end of May, 42 (78%) of the survey visits were completed.

Table 2　Monthly Weather Data from the Belmullet Synoptic Weather Station, Co. Mayo for the 2019 breeding wader survey season compared with the 29-year Mean values (1981-2010). Data downloaded from www.met.ie.

Month	Mean temp. (°C)	29-year mean temp. (°C)	Total precipitation (mm)	29-year mean total precipitation (mm)
April	10.2	8.9	84.7	72.0
May	11.1	11.1	57.5	70.4
June	12.7	13.1	86.6	72.1
July	15.5	14.8	101.0	79.0

4.2　Breeding Birds

Within the 27 one-kilometre squares surveyed, Golden Plover, Skylark, Meadow Pipit and Red Grouse were recorded on breeding territories. Merlin or Dunlin were not recorded. Other species of conservation concern that were recorded showing breeding behaviour, included Snipe *Gallinago gallinago* (1 AOT), Common Sandpiper *Actitis hypoleucos* (5 AOTs), Teal *Anas crecca* (2 AOTs), Stonechat *Saxicola rubicola* (13 AOTs), Wheatear *Oenanthe oenanthe* (4 AOTs) and Grey Wagtail *Motacilla cinerea* (1 AOT).

4.2.1　Golden Plover

From the 27 surveyed one-kilometre squares, a total of five squares were occupied by Golden Plover showing breeding behaviour, with a total of five AOTs; these were in survey squares 2, 5, 8, 11 and 23 (see Figure 7 and Table 3). Of these, all held a single bird on territory except for square No. 11 which held a breeding pair. Using these figures it is estimated that the breeding density across the total surveyed area (of 19.92 km²) is 0.25 AOT/km².
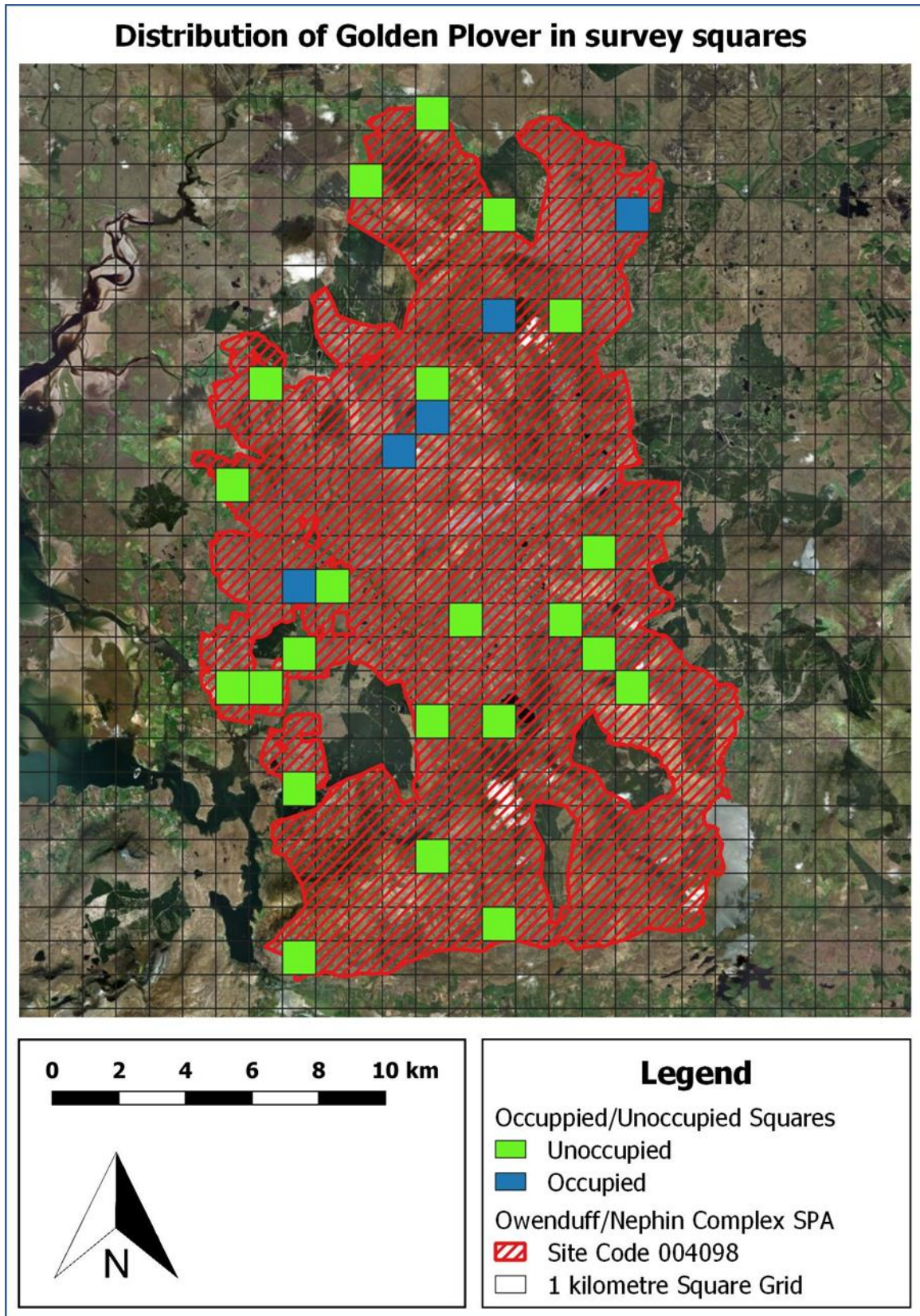
Figure 7 Distribution of Golden Plover breeding territories within the surveyed squares in 2019.

Figure 8 A calling adult Golden Plover in breeding plumage. Photograph © Dermot Breen, NPWS.

Table 3 Numbers and densities of Golden Plover AOTs recorded in the surveyed squares within the Owenduff/Nephin Complex SPA.

Survey square	Evidence Visit 1	Evidence Visit 2	Golden Plover AOTs
2	Calling adult	-	1
5	Calling adult	-	1
8	-	Calling Female	1
11	Pair	-	1
23	-	Calling Male	1
Total			**5**

Two additional breeding territories were recorded outside of the survey squares that included a pair and an individual flushed from heather exhibiting 'distraction display'. On 21 May, 12 Golden Plover were observed foraging on an improved agricultural field adjacent to the Owenduff River within survey square 2; they were considered not to be territorial birds given the observed flocking nature and, given the date, were considered to be staging ahead of migration to more northern breeding grounds.

4.2.2   Skylark and Meadow Pipit

The most abundant breeding species recorded were Skylark and Meadow Pipit; they were recorded in all 27 one-kilometre squares surveyed, ranging from two to 28 AOTs per square for Skylark and five to 23 AOTs per square for Meadow Pipit (Table 4). These AOTs were based on the number of singing males and using these figures it is estimated that the breeding density across the total surveyed SPA area is 19.37 AOT/km² for Skylark and 15.01 AOT/km² for Meadow Pipit.

Table 4 Numbers and densities of singing male Skylark and Meadow Pipit AOTs recorded in the surveyed squares within the Owenduff/Nephin Complex SPA. Density is calculated based on the total surveyed area within each survey square (see Table 1).

Survey square	Skylark AOTs	Skylark Density (AOT/km²)	Meadow Pipit AOTs	Meadow Pipit Density (AOT/km²)
1	11	31.30	7	19.92
2	14	17.19	6	7.37
3	9	28.27	7	21.98
4	16	22.09	9	12.43
5	20	24.22	8	9.69
6	28	28.52	19	19.35
7	14	20.87	6	8.94
8	17	29.58	7	12.18
9	12	30.86	7	18.00
10	21	21.00	23	23.00
11	13	13.00	7	7.00
12	23	23.00	14	14.00
13	13	23.31	5	8.97
14	25	25.00	14	14.00
15	5	9.19	9	16.55
16	11	15.12	16	22.00
17	9	14.75	10	16.39
18	8	8.00	19	19.00
19	6	6.71	23	25.72
20	2	2.00	10	10.00
21	11	28.21	8	20.51
22	9	11.69	5	6.49
23	15	21.54	13	18.67
24	17	19.23	11	12.44
25	25	25.00	22	22.00
26	25	25.00	7	7.00
27	7	34.90	7	34.90
Total	**386**	**19.37**	**299**	**15.01**

4.2.3 Red Grouse

Although this survey was not specifically targeted at Red Grouse, all observations of the species were recorded. From the 27 one-kilometre squares, Red Grouse was recorded in 12 squares (Table 5). Of these, seven were of males observed in suitable habitat and two were of a pair in suitable habitat. In addition, evidence in the form of fresh droppings was found in a further four squares; following Murray *et al.* (2013) this, indicates a minimum of four more breeding territories. These records equate to an estimated minimum of 13 pairs recorded within the 27 survey squares.

Table 5 Numbers of Red Grouse AOTs recorded in the surveyed squares within the Owenduff/Nephin Complex SPA.

Survey square	Evidence	Red Grouse AOTs
1	Droppings	1
2	Male sighting	1
4	Droppings	1
5	Male sighting	1
6	Male sighting	2
7	Male sighting	1
10	Droppings	1
12	Pair sighting	1
17	Droppings	1
20	Pair sighting	1
22	Male sighting	1
27	Male sighting	1
Total		**13**

4.3 Habitat Assessment

From the 19.92 km^2 of surveyed area within the 27 one-kilometre squares, habitat data were collected from a total of 379 1 m^2 quadrats. All quadrats were surveyed once between 16 April 2019 and 18 May 2019.

The average percentage vegetation cover per square was estimated at 87% (range 66% - 99%), with an average of 13% bare ground (comprised of 11.5% exposed peat soils and 1.5% bare rock). Within vegetation cover, the survey squares on average contained 21% shrub cover (range 0% - 40%), 28% graminoid cover (range 16% - 57%), 23% bryophyte cover (range 11% - 37%), 26% ground litter cover (range 2% - 41%) and 1% surface water (range 0% - 8%). Whilst the average maximum vegetation height within the surveyed squares was 23 cm (range 12 cm – 31 cm), the average shrub height was 11 cm (range 3 cm – 17 cm) and the average graminoid height was 12 cm (range 3 cm – 18 cm).

Ling Heather was present in 26 of the 27 surveyed squares; it was not recorded in survey square 25. It was recorded in 325 (86%) of the quadrats and made up 27% of all the shrub cover recorded. In general, it was short with an average height of 10 cm (range 3 cm - 20 cm); 61% of measurements being equal to or less than 12 cm, and only 2% being greater than 30 cm tall with a maximum recorded average height of 43 cm. This was also reflected in its growth forms, with most (64%) being classified as 'topiary'; generally being isolated bushes which were dense and had a compact canopy at ground levels

(indicative of grazing). A further 31% was classified as 'drumstick' heather, which is an indication of prolonged damage, *e.g.* through grazing or severe weathering.

Of the 379 quadrats, 80% were assessed as being moderately damaged *i.e.* showing visible damage by treading and grazing. A further 17% of quadrats were assessed as severely damaged *i.e.* showing abundant signs of severe grazing with the extent of bare ground being obvious, whilst 3% of quadrats were assessed as undamaged, *i.e.* complete vegetation cover with little evidence of grazing. Overall the surveyed area within the 27 one-kilometre squares was assessed as moderately damaged, with only survey square 24 assessed as severely damaged. The results of the habitat assessments are further detailed in the Appendix.

4.4 Habitat condition and the occurrence of breeding Golden Plover

Of the 27 surveyed one-kilometre squares, a combined total of 14 squares have been occupied by breeding Golden Plover in either the 2005, 2006 or 2019 surveys (see Table 6). In 2005, breeding Golden Plover were recorded from seven squares, and from eight squares in 2006. Of the five occupied squares in 2019, three had previously recorded breeding Golden Plover; these were survey squares 8, 11 and 23.

Table 6 Numbers of Golden Plover AOTs recorded in the surveyed squares within the Owenduff/Nephin Complex SPA in 2005, 2006 and 2019.

Survey square	2005	2006	2019
2	0	0	1
5	0	0	1
6	1	0	0
8	0	1	1
9	1	0	0
10	0	1	0
11	0	1	1
12	0	1	0
14	0	1	0
18	1	1	0
19	1	1	0
20	1	0	0
21	1	0	0
23	1	1	1
Total	**7**	**8**	**5**

With only five surveyed squares recording breeding Golden Plover in 2019, there were insufficient data and statistical power to undertake any meaningful statistical analysis of the difference in habitat variables between squares that did and did not hold Golden Plover. Basic, direct comparisons of the measured habitat variables suggest that, in 2019, breeding Golden Plover were recorded in areas where the graminoid and heather cover was less than in those squares where they were absent in this survey but had been recorded in previous surveys (see Table 7). However, it is not possible to ascertain robust conclusions from these data.

Table 7 Comparison of habitat variable averages between squares where breeding Golden Plover were recorded as present in 2019 ('Present') versus where they were absent in 2019 but had been present in the square in either 2005 or 2006 ('Absent'). Data from 14 squares in total; n = number of surveyed quadrats.

Habitat Variable	Present (n = 75)	Absent (n = 147)
Vegetation Cover ($\bar{x}$ %)	85	87
Bare Ground ($\bar{x}$ %)	15	13
Shrub Cover ($\bar{x}$ %)	24	21
Graminoid Cover ($\bar{x}$ %)	24	30
Bryophyte Cover ($\bar{x}$ %)	24	19
Ground Litter ($\bar{x}$ %)	28	28
Surface Water ($\bar{x}$ %)	1	3
Vegetation height ($\bar{x}$ max. cm)	21	23
Shrub height ($\bar{x}$ cm)	11	12
Graminoid height ($\bar{x}$ cm)	11	13
Ling Heather Cover ($\bar{x}$ Shrub %)	23	27
Ling Heather Height ($\bar{x}$ cm)	11	11
Dominant heather form	Topiary	Topiary
Dominant damage category	Moderate	Moderate

From all the surveyed squares in 2019, measured habitat variables indicate that the overall amount of vegetation cover is increasing, with the amount of bare ground decreasing correspondingly (Table 8). The maximum vegetation height, average graminoid height and graminoid cover were found to have decreased but bryophyte, ground litter and shrub cover has increased in extent, with heather cover being an increasing component of the shrub cover.

Figure 9 Owenduff/Nephin Complex SPA. Photograph © Dave Suddaby.

Table 8 Summary of the measured habitat variables from all the quadrats within the squares surveyed in 2005, 2006 and 2019 (n = quadrats). Standard deviation from the mean is shown in parenthesis for each variable (±). Data for 2005 and 2006 was supplied by C. Clotworthy (personal communication, 26 June 2019).

Habitat Variable	2005 (n = 355)	2006 (n = 355)	2019 (n = 379)
Vegetation Cover ($\bar{x}$ %)	77 (± 28)	81 (± 28)	87 (± 20)
Bare Ground ($\bar{x}$ %)	22 (± 28)	19 (± 28)	13 (± 20)
Shrub Cover ($\bar{x}$ %)	16 (± 16)	16 (± 17)	21 (± 16)
Graminoid Cover ($\bar{x}$ %)	38 (± 21)	43 (± 21)	28 (± 17)
Bryophyte Cover ($\bar{x}$ %)	17 (± 17)	19 (± 16)	23 (± 15)
Ground Litter ($\bar{x}$ %)	3 (± 5)	2 (± 4)	26 (± 15)
Surface Water ($\bar{x}$ %)	3 (± 11)	2 (± 11)	1 (± 8)
Vegetation height ($\bar{x}$ max. cm)	28 (± 16)	36 (± 17)	23 (± 10)
Shrub height ($\bar{x}$ cm)	8 (± 8)	10 (± 8)	11 (± 7)
Graminoid height ($\bar{x}$ cm)	20 (± 13)	19 (± 11)	12 (± 6)
Ling Heather Cover ($\bar{x}$ Shrub %)	16 (± 16)	16 (± 17)	23 (± 23)
Ling Heather Height ($\bar{x}$ cm)	7 (± 6)	9 (± 7)	10 (± 7)
Dominant heather form	Drumstick	Drumstick	Topiary
Dominant damage category	Moderate	Undamaged	Moderate
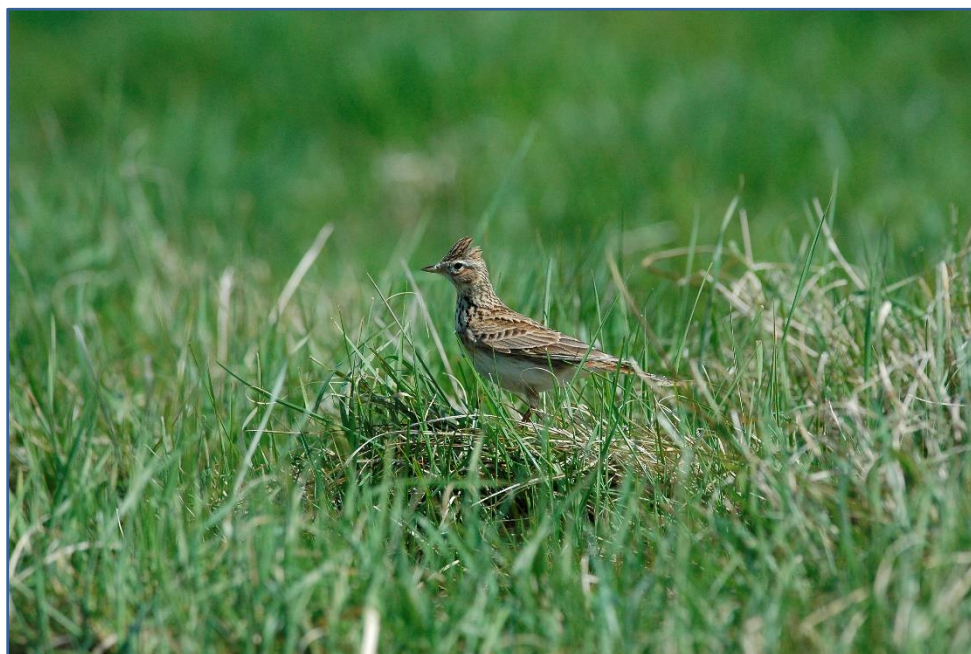
Figure 10 Skylark. Photograph © Alyn Walsh, NPWS.

5   Discussion

Accurate population estimates for breeding Golden Plover are difficult to determine as they have a cryptic plumage, occur in low densities and their territories and foraging areas may be larger and/or extend outside one-kilometre survey squares; and thus may be missed between site visits (Brown & Shepherd, 1993; Ratcliffe, 1976; Whittingham *et al.*, 2000). Adopting the Brown & Shepherd (1993) methodology in carrying out two survey visits (once from early April to mid-May and again from mid-May to the end of June) and covering the suitable habitat to within a minimum of 100 m, was thought to be the most cost-effective approach to providing a population estimate. Using that methodology, this survey located a total of five Golden Plover AOTs within the surveyed area and estimated that the Golden Plover breeding density within the Owenduff/Nephin Complex SPA to be 0.25 AOT/km². This density figure is based on the total surveyed area within the SPA. Clotworthy (2009) surveyed 18.92 km² of suitable habitat within the SPA in 2005 and recorded seven AOTs; which corresponds to a Golden Plover density estimate of 0.37 AOT/km². In 2006, Clotworthy (2009) covered 18.25 km² of suitable habitat within the SPA and recorded eight AOTs; corresponding to a Golden Plover density estimate of 0.44 AOT/km².

The results from this survey suggest that the total population of breeding Golden Plover within the repeated SPA survey sites has declined by 37.5% (from a maximum eight AOTs in 2006 to five in 2019), and that the density of AOTs has declined by 43% (from a maximum of 0.44 AOT/km² in 2006 to 0.25 AOT/km² in 2019). However, while indicative, these trends should be interpreted with caution as the survey methods differed between periods: two survey visits were completed to each one-kilometre square in 2019, while each square received only a single visit in both 2005 and 2006.

In addition to the results from this survey and Clotworthy (2009), a previous survey of Golden Plover in parts of Galway and Mayo estimated the density of breeding pairs was similarly low, at 0.42 to 0.49 pairs/km² (see Cummins *et al.*, 2004). In contrast, provisional analyses from a survey of three discrete areas within the Connemara Bog Complex SPA in 2013, 2014 and 2015 (with 12 one-kilometre squares surveyed in each area), estimated the density of breeding Golden Plover at 1.35 pairs/km² (C. Clotworthy & D. Breen, personal communication, April 2020). Ireland has been noted to support lower densities of breeding Golden Plover compared to neighbouring Britain (except for the west Highlands in Scotland, which support similar densities to Ireland) (Gibbons *et al.*, 1993). Parts of Britain have supported densities multiple times those reported in this survey; for example, from 1.02 pairs/km² in the Southern Pennines and 1.38 pairs/km² in the Grampians, to 2.15 pairs/km² in the North Pennines (see Brown, 1993). The reasons for observed differences in density within and between Ireland and Britain likely relate to site-specific factors, including topography, habitat suitability and food availability (for adults and chicks), climate, and levels of predation.

Territorial Golden Plover were only recorded between 17 April and 16 May (first survey period). Similarly, Clotworthy (2009) only detected territorial birds during the first survey period in 2005 (actual dates: 13 April to 15 May); furthermore, five of the eight territories recorded by Clotworthy in 2006 were also recorded in the first survey period (actual dates: 20 April to 30 May). According to Yalden & Yalden (1990), the mid-April to mid-May period is the period of low detectability for breeding Golden Plover (around 20% during incubation) and one would expect higher detection rates thereafter. This goes against the findings from this and previous Golden Plover surveys in the Owenduff/Nephin Complex SPA, suggesting: Golden Plover within the SPA may be failing early in the breeding season (thus not being present during the second survey visit); that Golden Plover detectability is significantly lower where they occur in lower densities (such as those recorded here); and/or that variation in factors such as climate and topography affect the breeding biology (including breeding phenology) of Golden Plover.

Calladine *et al.* (2009) found that population estimates for Golden Plover, derived from two survey visits are likely to miss up to 44% of their territories compared to results derived from four survey visits spread between early April and late June. They also found that three or fewer survey visits risk biases

through uneven sampling in periods of differing detectability and that applying some correction factor to the findings to give a more accurate estimate would be unreliable. This indicates that the breeding density estimates provided for the Owenduff/Nephin Complex SPA likely contain inaccuracies. To ascertain a more robust breeding density estimate, in the absence of local breeding parameters being known (such as peak times of the display, incubation and chick rearing periods) and to ensure maximum detectability, we recommend that a minimum of four survey visits (one in April and May and two in June), using the same field survey methodology as employed here, are carried out in future. This recommendation follows those given by Calladine *et al*. (2009) and is particularly relevant given the comparatively low density of breeding pairs in Ireland.

Similarly, the territory abundance estimates for Skylarks and Meadow Pipits were derived from either one or two survey visits when they should ideally be derived from at least four survey visits (Calladine *et al*., 2009). Even so, compared to the findings of Clotworthy (2009), the general indications are that the Skylark populations have increased (from 13 AOT/km^2 in 2005/2006 to 19 AOT/km^2 in 2019), whilst Meadow Pipit populations remained stable at 15 AOT/km^2 within the Owneduff/Nephin Complex SPA. Clotworthy's estimates were based on records of singing males during the 2005 and 2006 surveys with a correction factor applied to account for the total area not surveyed (C. Clotworthy, personal communication, 17 July 2019). Murray *et al.* (2013) estimated Skylark densities within the Owenduff/Nephin Complex SPA at 7 AOT/km^2 in 2002 and 17 AOT/km^2 in 2012. Furthermore, Murray *et al.* (2013) estimated Meadow Pipit densities within the SPA at 20 AOT/km^2 in 2002 and 15 AOT/km^2 in 2012. While broadly indicative, comparisons of Skylark and Meadow Pipit densities between this survey and those of Clotworthy (2009) and Murray *et al.* (2013) likely suffer some inaccuracies due to differences in data interpretation; *i.e.*, this survey employed a hard '200 m rule' to avoid double-counting singing male Skylark and Meadow Pipits (see Section 3.1), while the latter surveys employed more subjective processes to eliminate double-counting.

Clotworthy (2009) provided Golden Plover population estimates for the whole of the Owenduff/Nephin Complex SPA in each year (2005 and 2006) based on the calculated breeding density for a year and the estimated 21,600 ha of suitable Golden Plover habitat within the SPA. Given the lack of high-quality data to assess the availability of suitable breeding habitat for Golden Plover within the entire SPA, and the noted issued with survey methodology (see above), this report does not provide a Golden Plover population estimate for the SPA. Population estimates for the SPA will be possible in the future via a combination of more intensive Golden Plover survey methodologies and a quantified assessment of the available suitable breeding habitat. The latter could be generated, for example, using high quality digital aerial imagery and information on known Golden Plover breeding requirements, for example with respect to topography, nest-site selection, and chick-rearing habitats (as given in Whittingham *et al.*, 2000, 2001 and 2002, for example). This would likely provide a more robust population estimate for the SPA.

Golden Plover breed on open upland habitats (which includes blanket bogs, heather dominated areas and marginal grasslands), where they are known to favour areas of short vegetation (<10 cm), particularly dominated by heather mixed with grasses (Parr, 1980; Whittingham *et al.*, 2001). Clotworthy (2009) found the same pattern within the Owenduff/Nephin Complex SPA. Similarly, in this survey where breeding Golden Plover were recorded, we found that the shrub, heather and graminoid heights were on average 11 cm, and that they showed a preference for areas where there was less heather cover. However, overall, within the surveyed SPA area, the area of shrub/heather cover has increased: from 16% in 2005 and 2006 to 23% in this survey. This presumably reflects changes in the grazing livestock levels in this period (2005 to 2019). An increase in heather cover was also noted by Murray *et al.* (2013) who recorded an increase from 18% in 2002 to 28% in 2012 within their surveyed areas in the Owenduff/Nephin Complex SPA. Although this change facilitated an increase in the numbers of Red Grouse within the SPA (Murray *et al.*, 2013), further changes could have impacts on the breeding Golden Plover population, as it is known that breeding Golden Plover avoid both extensive and old stands of dense tall heather (Whittingham *et al.*, 2000, 2001, 2002).

Similarly, some studies have found that the abundance of Skylark declined with increasing heather cover (Brown & Stillman 1993; Chamberlain & Gregory, 1999; Smith *et al.*, 2001) while, conversely, Meadow Pipit increased (Vanhinsbergh & Chamberlain, 2001). Given this, within this survey we may have expected Skylark density to have decreased (whereas an increase was observed) and Meadow Pipit density to have increased (whereas their density was observed to be stable). There are likely many additional regional and site-specific factors varying between the study sites of this survey and of those referenced that may explain the observed differences, at least in part.

Extensive and detailed habitat data were collected during this survey and those of Clotworthy (2009). There is significant scope for further exploration and analysis of these data, for example, with regard to changes in habitat condition and management within the SPA, and interactions between habitat and bird populations. These analyses would be useful to inform the management of the Owenduff/Nephin Complex SPA and similar SPAs and protected areas, as well as to provide a greater understanding of the habitat condition and management preferences of Golden Plover and other bird species. Additional data on grazing levels and other management practices may also be available under DAFM's Commonage Framework Plans and associated monitoring.

The objectives of this survey were to resurvey selected sites within the Owenduff/Nephin Complex SPA for breeding Golden Plover, Skylark and Meadow Pipit, and to reassess the habitat condition of these sites. The findings of this work give an indication of their population trends within the Owenduff/Nephin Complex SPA; broadly summarised as a declining breeding Golden Plover population, an increasing Skylark population and a stable Meadow Pipit population. The area of shrub/heather cover has increased within the SPA, likely reflecting changes in grazing livestock levels. This change in habitat structure could have further impacts on these bird populations. To ascertain more robust population estimates for these species, following recommendations of Calladine *et al.* (2009), a minimum of four survey visits would be required between early April and late June. It is therefore recommended to survey the 27 one-kilometre squares for the key species over four visits. It is also recommended to use high quality digital aerial imagery and/or other available data sources to undertake a quantified assessment of the suitable habitat available for breeding Golden Plover across the whole of the SPA. In combination, these would allow robust population estimates for the SPA to be calculated. Additional research, incorporating data from this survey and others, is also recommended to attain a better understanding of the grazing levels and their impacts on the vegetation composition and structure within the SPA; this would enable effective conservation measures to be drawn up for these key breeding bird species within the Owenduff/Nephin Complex SPA and other protected areas.

6   Bibliography & Relevant Literature

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Appendix   Habitat Assessment Summaries

The tables below provide a further summary of the habitat assessment results, as per Section 4.3.

Table I   Summary of the percentage cover of the total vegetation cover and bare ground, as well as percentage cover of each vegetation type, within each surveyed square (n = the number of quadrats in each square).

Square No.	n	Total Vegetation Cover (%)	Bare Ground (%)	Shrub Cover (%)	Graminoid Cover (%)	Bryophyte Cover (%)	Ground Litter (%)	Surface Water (%)
1	8	95	5	18	21	33	29	0
2	15	94	6	25	19	24	32	0
3	8	99	1	23	18	32	26	1
4	14	88	12	15	25	27	31	1
5	18	88	12	20	29	21	29	2
6	20	90	10	16	34	22	26	3
7	14	96	4	26	23	26	25	0
8	10	67	34	37	21	19	24	0
9	8	76	24	19	37	17	26	0
10	17	96	4	19	22	20	40	0
11	20	82	18	23	23	21	35	0
12	20	88	12	24	24	12	41	0
13	11	92	8	25	16	33	26	0
14	20	96	4	16	24	21	40	0
15	8	76	24	19	38	17	26	0
16	13	96	4	27	20	19	34	0
17	13	99	1	32	25	20	22	0
18	19	83	17	16	27	25	28	3
19	17	87	13	40	16	21	17	6
20	19	66	34	18	57	11	7	8
21	7	98	2	22	28	32	15	3
22	7	84	16	7	37	37	2	0
23	12	90	10	20	27	37	16	0
24	20	71	29	14	44	22	21	0
25	20	86	14	0	47	30	24	0
26	15	94	6	25	21	29	24	0
27	6	96	4	32	28	27	13	0

Table II Summary of the average values per vegetation height categories within each surveyed square (n = the number of quadrats in each square).

Survey square	n	Maximum Vegetation height (cm)	Shrub height (cm)	Graminoid height (cm)
1	8	25	13	13
2	15	21	10	11
3	8	23	11	12
4	14	24	10	12
5	18	28	12	14
6	20	25	9	13
7	14	28	17	18
8	10	13	7	6
9	8	27	11	11
10	17	23	12	14
11	20	21	13	10
12	20	25	13	13
13	11	18	16	9
14	20	25	11	15
15	8	27	11	11
16	13	30	17	18
17	13	21	10	3
18	19	27	14	14
19	17	25	16	12
20	19	14	8	8
21	7	15	9	9
22	7	12	3	5
23	12	19	9	11
24	20	17	7	10
25	20	29	0	16
26	15	21	10	14
27	6	26	11	16

Table III Summary of the condition of Ling Heather within each surveyed square (n = the number of quadrats in each square).

Survey square	n	Cover (Shrub %)	Height ($\bar{x}$ cm)	Dominant heather form
1	8	15	12	Topiary
2	15	22	10	Topiary
3	8	18	9	Topiary
4	14	16	9	Topiary
5	18	19	12	Topiary
6	20	14	8	Topiary
7	14	25	16	Topiary
8	10	37	7	Topiary
9	8	19	11	Drumstick
10	17	19	12	Topiary / Drumstick
11	20	22	12	Topiary
12	20	17	12	Topiary
13	11	24	14	Topiary
14	20	15	10	Drumstick
15	8	19	11	Drumstick
16	13	26	20	Topiary
17	13	35	14	Carpet / Drumstick
18	19	14	12	Topiary
19	17	40	16	Topiary
20	19	74	8	Drumstick
21	7	22	9	Topiary / Drumstick
22	7	43	3	Drumstick
23	12	21	9	Topiary
24	20	13	6	Drumstick
25	20	0	0	-
26	15	23	10	Topiary
27	6	32	11	Topiary

Table IV Frequency distribution (%) of the damage categorise within each surveyed square and the overall damage assessment (n = the number of quadrats in each square).

Survey square	n	Undamaged	Moderately damaged	Severely damaged	Overall damage assessment
1	8	0	88	12	Moderately
2	15	13	87	0	Moderately
3	8	12	88	0	Moderately
4	14	0	67	33	Moderately
5	18	0	89	11	Moderately
6	20	0	90	10	Moderately
7	14	0	86	14	Moderately
8	10	0	70	30	Moderately
9	8	0	100	0	Moderately
10	17	6	94	0	Moderately
11	20	15	50	35	Moderately
12	20	5	80	15	Moderately
13	11	0	100	0	Moderately
14	20	5	95	0	Moderately
15	8	0	63	37	Moderately
16	13	8	84	8	Moderately
17	13	0	100	0	Moderately
18	19	0	74	26	Moderately
19	17	18	76	6	Moderately
20	19	0	63	37	Moderately
21	7	0	86	14	Moderately
22	7	0	86	14	Moderately
23	12	0	83	17	Moderately
24	20	0	40	60	Severely
25	20	0	75	25	Moderately
26	15	7	86	7	Moderately
27	6	0	100	0	Moderately