

NATIONAL PARKS AND WILDLIFE SERVICE



A SURVEY OF BREEDING WADERS
ON MACHAIR AND OTHER COASTAL
GRASSLANDS IN COUNTIES MAYO
AND GALWAY



Dave Suddaby, Irene O'Brien, Dermot
Breen & Seán Kelly



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

National Parks and Wildlife Service (NPWS) commissions a range of reports from external contractors to provide scientific evidence and advice to assist it in its duties. The Irish Wildlife Manuals series serves as a record of work carried out or commissioned by NPWS, and is one means by which it disseminates scientific information. Others include scientific publications in peer reviewed journals. The views and recommendations presented in this report are not necessarily those of NPWS and should, therefore, not be attributed to NPWS.

Front cover, small photographs from top row:

Limestone pavement, Bricklieve Mountains, Co. Sligo, Andy Bleasdale; **Meadow Saffron** *Colchicum autumnale*, Lorcan Scott; **Garden Tiger** *Arctia caja*, Brian Nelson; **Fulmar** *Fulmarus glacialis*, David Tierney; **Common Newt** *Lissotriton vulgaris*, Brian Nelson; **Scots Pine** *Pinus sylvestris*, Jenni Roche; **Raised bog pool**, Derrinea Bog, Co. Roscommon, Fernando Fernandez Valverde; **Coastal heath**, Howth Head, Co. Dublin, Maurice Eakin; **A deep water fly trap anemone** *Phelliactis* sp., Yvonne Leahy; **Violet Crystalwort** *Riccia huebeneriana*, Robert Thompson

Main photograph:

Coastal grassland, Inishkea South, Co. Mayo, Dave Suddaby



A survey of breeding waders on machair and other coastal grasslands in Counties Mayo and Galway

Dave Suddaby¹, Irene O'Brien², Dermot Breen² & Seán Kelly²

¹BirdWatch Ireland, Eachléim, Clogher, Ballina, Co. Mayo; ²National Parks and Wildlife Service

Keywords: Breeding waders, machair, coastal grassland, Mayo, Galway.

Citation: Suddaby, D., O'Brien, I., Breen, D. & Kelly, S. (2020) A survey of breeding waders on machair and other coastal grasslands in Counties Mayo and Galway. *Irish Wildlife Manuals*, No. 119. National Parks and Wildlife Service, Department of Culture, Heritage and the Gaeltacht, Ireland.

The NPWS Project Officer for this report was: Seán Kelly (Sean.Kelly@chg.gov.ie)

This IWM was edited by Brian Nelson

ISSN 1393 – 6670

© **An tSeirbhís Páirceanna Náisiúnta agus Fiadhúlra 2020**
National Parks and Wildlife Service 2020

Contents

Executive Summary	i
Acknowledgements.....	ii
1 Introduction.....	1
2 Survey Area.....	2
3 Survey Methods.....	4
3.1 Data interpretation and analysis.....	4
4 Results	6
4.1 Coverage.....	6
4.2 Breeding wader numbers.....	8
4.3 Habitat components and management	10
4.4 Survey comparisons.....	14
5 Discussion.....	17
6 References	22
Appendix 1 Recording Forms	24

Executive Summary

Thirty-four coastal grassland sites in Counties Mayo and Galway were surveyed for breeding waders by National Parks and Wildlife Service staff in 2019. Sites were visited up to three times from April to June, following the same survey methods as in previous surveys at these sites. A total of 280 pairs were recorded, comprising seven species: Oystercatcher *Haematopus ostralegus*, Ringed Plover *Charadrius hiaticula*, Lapwing *Vanellus vanellus*, Dunlin *Calidris alpina*, Snipe *Gallinago gallinago*, Redshank *Tringa totanus* and Common Sandpiper *Actitis hypoleucos*, all of which are ground-nesting species.

Twenty-four of the sites had been surveyed previously, in both 1996 and 2009. Comparisons with these surveys revealed total breeding wader population declines of 51% since 1996 and 62% since 2009. All breeding wader species have declined by 28% or more since 2009, with Dunlin showing the largest decline in numbers at 91%. Oystercatcher, Ringed Plover, Redshank and Common Sandpiper declined by 70% or more since 2009, whilst Snipe and Lapwing declined by 28% and 30% respectively since 2009.

The recorded wader population declines were most evident on the offshore islands, where the total number of breeding pairs dropped by 65% since 1996 and 81% since 2009, with each breeding wader species declining by between 69% and 91% since 2009. During the 2009 survey, the Inishkea Islands Special Protection Area held the largest numbers of breeding waders at 377 pairs; however, only 68 pairs were recorded in 2019, a total decline of 82%. These declines are alarming and have likely primarily been driven by habitat change and increased predation pressure; both of which have been cited as root causes of global breeding wader population declines.

Changes in the habitat structure were recorded at the surveyed grassland sites; for example, the coverage of tussocks, which many waders require for nesting, has decreased. This change is likely a result of increased grazing pressure in the recent decade; estimates of livestock grazing from this survey support this, with sheep densities noted to have increased markedly at numerous sites. These changes in habitat structure likely also exacerbate predation pressures, often with site-specific factors at play.

In some instances, where interventions such as predator exclusion fences and/or targeted predator control measures have been put in place, some wader species have responded positively. However, there are significant concerns for some species, such as Dunlin, which seem to have shown no response to these interventions. It is possible that, due to the small and isolated breeding populations, Dunlin are suffering from significantly reduced genetic diversity, which could increase the risk of extinction for Dunlin as a breeding species on Irish coastal grasslands.

Two conservation strategies that are commonly employed across Europe to address the decline of breeding waders are site protection and agri-environment schemes. For these coastal grassland sites, nine are within four Special Protection Areas (SPAs) that list breeding Dunlin as a Special Conservation Interest; however, breeding Dunlin were only recorded in the Inishkea Islands SPA. The main agri-environment scheme applicable to these coastal grassland sites is the Green Low-carbon Agri-Environment Scheme (GLAS). Initial findings from an assessment of a sample of farms participating in the GLAS Breeding Wader measure suggest the measure is not meeting the ecological requirements of breeding waders. Greater collaboration and cooperation among stakeholders for the design and delivery of improved breeding wader management in SPAs and the wider countryside is urgently required. The creation of a unique agri-environment scheme for breeding waders on machair and other grasslands is likely required for improved and more focused management within target areas. The majority of these coastal grasslands are commonages and this factor will likely present a significant challenge to the successful design and implementation of any management measures. Site restoration measures need to be considered at multiple sites, and additional measures at key sites to reduce the impact of predation, a key factor limiting population recovery, are almost certainly required. Furthermore, improved knowledge of the role of, and interaction between, habitat and predation is required to understand how breeding success can be improved. However, improving the fortunes of Dunlin may prove more complicated and challenging.

Acknowledgements

Thanks to the National Parks and Wildlife Service (NPWS) staff who delivered the fieldwork and surveying for this project; namely Sue Callaghan, Sam Birch, Leonard Floyd, Eoin McGreal, Penny Bartlett, Helen Carty and Elaine Keegan. Special thanks to Sue Callaghan and Cameron Clotworthy for their facilitation and assistance. Thanks to Cathal O'Brien (BirdWatch Ireland) for digitising and producing the final maps for each site. Finally, thanks to all the landowners who allowed access to their lands.

1 Introduction

Breeding wader numbers have been in decline across much of Western Europe, including in the Republic of Ireland and the United Kingdom since the 1950s (Gibbons *et al.*, 1993; Balmer *et al.*, 2013). Agricultural intensification, particularly on grasslands, and increased levels of predation have been implicated as primary drivers of these declines (e.g. BirdLife International, 2004; Hayhow *et al.*, 2019; Seymour *et al.*, 2003; Wilson *et al.*, 2005). Wader declines continue to be severe as shown through successive breeding bird atlases (Balmer *et al.*, 2013; Gibbons *et al.*, 1993; Sharrock, 1976).

In the Republic of Ireland, there have been no complete national breeding wader surveys, but between 2008 and 2018 the numbers of breeding Lapwing *Vanellus vanellus*, Dunlin *Calidris alpina*, Redshank *Tringa totanus* and Common Sandpiper *Actitis hypoleucos* have declined, whilst Ringed Plover *Charadrius hiaticula* numbers have remained stable (National Parks & Wildlife Service (NPWS), 2019a; summarised from various sources, e.g. Balmer *et al.*, 2013; Crowe, 2019; Lauder & Donaghy, 2008). These trends have been largely derived from breeding wader surveys in key habitats and/or geographic regions, such as the lowland wet grasslands of the midlands and the coastal machair grasslands of the west and north-west.

Previous breeding wader populations for the coastal machair grasslands, stretching from north Co. Donegal to south Co. Galway, have been given as 604 pairs across 51 sites in 1985 (Nairn & Sheppard, 1985), 697 pairs across 48 sites in 1996 (Madden *et al.*, 1998) and 714 pairs across 55 sites in 2009 (Suddaby *et al.*, 2009 & 2010). Across 35 comparable sites, the 2009 survey found that the breeding wader numbers had declined by over 30% since 1996 (Suddaby *et al.*, 2009). The numbers of Oystercatcher *Haematopus ostralegus*, Lapwing and Dunlin had declined whilst Ringed Plover, Snipe *Gallinago gallinago* and Redshank numbers had increased; although all but Snipe had declined when excluding offshore island sites. In 2009 these grasslands held 5% of the national population of these breeding waders, indicating the importance of these grasslands.

An important site was the offshore island, Inishkea North, which held 35% of all the breeding waders recorded in the 2009 survey. However by 2015, the populations on this island had declined dramatically, in the order of 18% for Oystercatcher, 51% for Ringed Plover, 74% for Lapwing, 76% for Dunlin, 77% for Redshank and 67% for Snipe (Suddaby, 2015). To assess whether these declines were evident on the coastal grasslands in Counties Donegal and Sligo, BirdWatch Ireland (under the Cooperating Across Borders for Biodiversity Project, supported by the European Union's INTERREG VA programme) surveyed 27 sites from the 2009 survey (McMonagle *et al.*, 2017). They found that breeding wader numbers had declined by 48% since 1996, although they had increased by 26% since 2009. McMonagle *et al.* (2017) found that the increase was attributed to the installation of predator exclusion fencing at three of the surveyed sites. Excluding these three sites, they estimated that the breeding wader numbers elsewhere had declined by 5% since 2009. To assess whether these changes were also reflected in the coastal grasslands in Counties Mayo and Galway, National Parks and Wildlife Service (NPWS) staff carried out a survey of breeding waders at 34 sites in 2019 (30 sites of which were previously surveyed in 2009). This report provides the findings of that survey.

2 Survey Area

The term 'coastal grassland' used throughout this report relates to machair, as well as, wet grasslands and other types of grasslands that do not necessarily meet the machair habitat characteristic listed in Fossit (2000), nor those sites listed in Ryle *et al.* (2009).

A total of 30 sites were selected based on those surveyed in Counties Mayo and Galway in 2009 (Suddaby *et al.*, 2010). Of these, 24 sites had also been surveyed in 1996 (Madden *et al.*, 1998). The survey area and boundaries for each of these sites remained the same, apart from an additional 27 ha being included at Dooaghtry. A further four coastal grassland sites, which had not been surveyed in either 1996 or 2009, were selected based on local NPWS knowledge of breeding waders being present in recent years. Therefore an overall total of 34 sites were selected for surveying, covering some 2,507 ha; 21 sites covering 1,744 ha in Co. Mayo and 13 sites covering 763 ha in Co. Galway (Table 1). It is noteworthy that 25 (74%) of the 34 sites were commonages (entirely or in part; NPWS, 2012). The site code for each site follows those given in the previous surveys. For new sites, codes were generated to follow numerical order apart from the additional sites on Inishmore which were affixed with a letter (A, B, C) following the island site code number 48.



Figure 1 Coastal grassland sites surveyed included a range of habitats from machair to wet grasslands to wet marsh with open water. BirdWatch Ireland's Annagh Marsh reserve, Mullet Peninsula, Co. Mayo. Photograph © Dave Suddaby.

Table 1 List of Survey Sites and their areas covered in the 2019 coastal grassland breeding wader survey in Counties Mayo and Galway.

Site name	Site code	County	Grid Ref. ID	Survey area (ha)
Garter Hill**	25	Mayo	F8141	105
Termoncarragh Lough**	26	Mayo	F6634	184
Cross Lough**	27	Mayo	F6429	92
Leam Lough**	28	Mayo	F6426	81
Agleam**	29	Mayo	F6221	29
Inishkea North**	30	Mayo	F5622	196
Inishkea South**	31	Mayo	F5521	160
Srah (North & South) **	32	Mayo	F7226	46
Doo Lough**	33	Mayo	F7322	50
Dooyork**	34	Mayo	F7320	39
Kinrovar (Doohooma)**	35	Mayo	F7115	115
Doona (Trawboy)**	36	Mayo	F7614	7
Fahy Lough**	37	Mayo	F7512	99
Corraun Point**	38	Mayo	F7509	11
Lough Doo (Doogort)**	39	Mayo	F7009	87
Keel Lough**	40	Mayo	F6404	108
Rosmurrevagh**	41	Mayo	L8595	59
Dooaghtry**	42	Mayo	L7369	120
Lough Baun*	50	Mayo	L7579	18
Roonagh Lough*	51	Mayo	L7476	75
Cross Lough (Killadoon)*	52	Mayo	L7374	63
Mannin Beg**	43	Galway	L5946	235
Aillebrack**	44	Galway	L5742	125
Dog's Bay**	45	Galway	L6938	50
Mweenish Island**	46	Galway	L7629	20
Finish Island**	47	Galway	L7928	34
Trawmore (Inishmore)**	48	Galway	L8907	33
Dog's Head, (Inishmore)	48A	Galway	L9007	39
Kilmurvey, (Inishmore)	48B	Galway	L8210	24
Oghil, (Inishmore)	48C	Galway	L8809	8
Augrusbeg*	53	Galway	L5558	89
Omey Island*	54	Galway	L5655	25
Murvey*	55	Galway	L6639	39
Inis Meain (Innis Maan)	56	Galway	L9506	42

* Sites surveyed in 2009; ** Sites surveyed in 1996 and 2009

3 Survey Methods

The methods used to assess breeding wader numbers were the same as those used in the 2009 survey (Suddaby *et al.*, 2010). Observers were asked to make three visits between 7 April and 30 June 2019 (aimed at one visit per month). Following the first visit the observer made an assessment as to whether a subsequent visit was required; this was based on whether any waders were present. If no waders were present on site during the first visit and no waders had been recorded at the site in the previous 2009 survey, then a second visit was not required. However, if waders had been recorded at the site in the previous 2009 survey then a second visit was required; but if that visit failed to locate any waders then a third visit was not necessary.

At the start of each survey visit the site name and code, observers name, survey date, survey start and finish times, survey visit number and brief weather conditions were recorded on an individual field form. Generally, the surveys were completed between dawn and midday, and sites were not visited in adverse weather conditions, such as strong wind or rain. For each visit, and if possible, observers were first asked to scan the site to look for signs of breeding waders and to record any breeding activity on the relevant field map using standard species recording and behavioural codes (Marchant, 1983). Thereafter the site was walked over, such that the observer(s) physically reached to within 100m of every point and any further breeding waders located were also recorded on the field map. Signs of breeding pairs were taken as either displaying males, paired adults, incubating adults, adults performing distraction displays or adults with chicks. To minimise disturbance, observers were not encouraged to look for nests or broods but were asked to record any fledged chicks that were seen in the course of a survey. Additionally, and where possible, specific counts for chipping or drumming Snipe were encouraged from strategic locations at dusk.

After completing a survey visit, the observer(s) estimated the numbers of pairs they thought were present for each species. If the site was surveyed by two or more observers, then field maps and notes were compared immediately after the survey to produce a single completed recording form and map for that visit. Additionally, following the survey walkover on the first visit, observers were asked to record basic parameters on the habitat condition and site management which were to reflect the surveyed site as a whole unit. The assessments were recorded on a habitat recording form and included categories on the dominant habitat type, the main management type, other land uses and assessments of the sward height, habitat features (rushes, tussocks, bare ground and surface water) and any other physical features present (ditches, walls, fences etc.). In addition, observers were asked to record the livestock type and numbers to give some indications of grazing stocking densities. All recording forms are shown in Appendix 1.

3.1 Data interpretation and analysis

All data recorded (site information, bird and habitat related data) were input into Microsoft® Excel (2018) templates. For each survey visit and for each species, the estimated numbers of pairs and the total number of individuals were produced. For each breeding wader species within a given site, the maximum number of pairs recorded on a visit (from the three visits) was taken as the estimated number of breeding pairs, and a final map for each surveyed site was produced to reflect these estimates. All surveyed site boundaries and the approximate location of any breeding waders were digitised using QGIS version 2.18 (2016) software. Assessment of changes in breeding wader numbers were made from all sites that were surveyed in both 1996 and 2009.

Grazing animal stocking density was calculated by dividing the number of animals with the surveyed area to give a measurement of the animal-to-land area relationship at the time, whilst specific coefficients for each animal type (an animal unit, expressed as livestock unit) were used to give a measurement of grazing pressure at the time (Allen *et al.*, 2011).

Sites were assessed for their relative importance for breeding waders; numbers of pairs, species diversity and species rarity (based on national population estimates) were the three attributes used to derive an index value for each site (see Table 2). The score values given to the attributes are the same as those given by Madden *et al.* (1998). However, for species rarity the evaluation initially requires estimates of the national population. Since the previous survey (Suddaby *et al.*, 2010), national population estimates for Dunlin, Redshank, Lapwing, Ringed Plover, Common Sandpiper and Oystercatcher have been revised (Balmer *et al.*, 2013; Crowe, 2019; NPWS, 2019a) and these are used in this assessment. For Snipe the estimates given by Lauder and Donaghy (2008) are used. An overall index value for each site was derived by adding the scores of the three attributes described. Although this method of indexing is rather basic and does not consider important variables such as area surveyed, habitat diversity or quality, it does provide a useful assessment of their importance.

Table 2 National population estimates for the seven target species and the score values used to assess the species rarity value score for each surveyed site.

Species	National population estimate (pairs)*	Species score	Data source
Dunlin	50	10	Crowe, 2019
Redshank	300	10	NPWS, 2019a
Lapwing	620	9	NPWS, 2019a
Ringed Plover	1,045	7	Balmer <i>et al.</i> , 2013
Common Sandpiper	1,850	6	Balmer <i>et al.</i> , 2013
Oystercatcher	3,100	3	Balmer <i>et al.</i> , 2013
Snipe	5,000	1	Lauder & Donaghy, 2008

*National population estimates used here are the maximum estimates, unless where only a single 'best' estimate was available (see NPWS, 2019a)

The following standard species codes (Marchant, 1983) are used in the report tables: OC = Oystercatcher, RP = Ringed Plover, L. = Lapwing, DN = Dunlin, SN = Snipe, RK = Redshank and CS = Common Sandpiper.

4 Results

4.1 Coverage

The fieldwork was carried out by NPWS staff coordinated by NPWS Conservation Rangers Irene O'Brien, for the Co. Mayo sites, and Dermot Breen for the Co. Galway sites. BirdWatch Ireland assisted with surveying the Annagh Marsh area (part of the Termoncarragh Lough site) (Table 3). The survey period extended from 7 April to 3 July 2019. A total of 2,507 ha was surveyed. Of the 34 sites, 33 were surveyed between 7 April and 4 May 2019; thereafter 20 of these sites were surveyed again between 4 May and 29 May 2019, and 17 of these received at least a third visit between 20 May and 30 June 2019. Overall, all sites received the required number of visits as per the outlined process of whether a return visit was required (see Survey Methods). The exceptions being Keel Lough and Murvey because of time constraints, and Inis Meain due to logistical reasons of accessing the island. This latter site was also surveyed later than all the other sites, with the first visit on 20 May 2019 and a follow up visit on 3 July 2019.

Table 3 Number of visits and the Surveyors for each site in the 2019 coastal grassland breeding wader survey in Counties Mayo and Galway.

Site name	Site code	County	Number of visits	Surveyor(s)
Garter Hill	25	Mayo	1	Irene O'Brien
Termoncarragh Lough	26	Mayo	3	Irene O'Brien & Dave Suddaby
Cross Lough	27	Mayo	1	Irene O'Brien & Sue Callaghan
Leam Lough	28	Mayo	2	Irene O'Brien
Agleam	29	Mayo	1	Irene O'Brien & Sue Callaghan
Inishkea North	30	Mayo	3	Irene O'Brien
Inishkea South	31	Mayo	3	Irene O'Brien
Srah (North & South)	32	Mayo	1	Irene O'Brien
Doo Lough	33	Mayo	3	Irene O'Brien & Sam Birch
Dooyork	34	Mayo	3	Irene O'Brien & Sam Birch
Kinrovar (Doohooma)	35	Mayo	1	Irene O'Brien & Sam Birch
Doona (Trawboy)	36	Mayo	1	Irene O'Brien
Fahy Lough	37	Mayo	3	Irene O'Brien
Corraun Point	38	Mayo	3	Irene O'Brien
Lough Doo (Doogort)	39	Mayo	3	Leonard Floyd
Keel Lough	40	Mayo	2	Leonard Floyd
Rosmurrevagh	41	Mayo	1	Leonard Floyd
Dooaghtry	42	Mayo	3	Eoin McGreal
Lough Baun	50	Mayo	3	Eoin McGreal
Roonagh Lough	51	Mayo	3	Eoin McGreal
Cross Lough (Killadoon)	52	Mayo	3	Eoin McGreal
Mannin Beg	43	Galway	3	Dermot Breen
Aillebrack	44	Galway	2	Dermot Breen
Dog's Bay	45	Galway	1	Dermot Breen
Mweenish Island	46	Galway	1	Dermot Breen
Finish Island	47	Galway	1	Dermot Breen
Trawmore (Inishmore)	48	Galway	3	Penny Bartlett & Helen Carty
Dog's Head, (Inishmore)	48A	Galway	3	Penny Bartlett
Kilmurvey, (Inishmore)	48B	Galway	3	Helen Carty
Oghil, (Inishmore)	48C	Galway	3	Penny Bartlett & Helen Carty
Augrusbeg	53	Galway	1	Dermot Breen
Omey Island	54	Galway	1	Dermot Breen
Murvey	55	Galway	1	Dermot Breen
Inis Meain (Innis Maan)	56	Galway	2	Penny Bartlett, Elaine Keegan & Helen Carty

4.2 Breeding wader numbers

Oystercatcher, Ringed Plover, Lapwing, Dunlin, Snipe, Redshank and Common Sandpiper were recorded breeding. The other breeding wader recorded was Red-necked Phalarope *Phalaropus lobatus*, with up to nine breeding males at two of the surveyed sites; however these are not included in the totals of this survey.

From the 34 surveyed sites, 20 held breeding waders, with an overall total of 280 breeding pairs (Table 4). Just over half (149 pairs; 53%) were found at just four sites: Inishkea North, Termoncarragh Lough and Roonagh Lough in Count Mayo, and Mannin Beg in Co. Galway.

Overall, Lapwing was the most numerous breeding species with a total of 143 pairs (51% of all wader pairs recorded); approximately 23% of the national population estimate. They were recorded breeding at 16 sites, and the top five sites i.e. holding 10 or more pairs were Mannin Beg (32 pairs), Termoncarragh Lough (21 pairs), Dooaghtry (16 pairs), Inishkea North (10 pairs) and Roonagh Lough (10 pairs). Ringed Plover was the next most abundant species with a total of 43 pairs spread across 11 sites, with only Roonagh Lough holding double figures of pairs (14 pairs). Oystercatcher and Snipe were next with a total of 35 pairs each, although Oystercatcher were only found at three sites (all apart from one pair were on the Inishkea islands) whereas Snipe were found at eight sites, with only Termoncarragh Lough holding double figures of pairs (15 pairs). However, interpreting the numbers of breeding Snipe requires caution as they are challenging to survey due to their secretive behaviour. The next three most abundant breeding waders, in descending order, were Common Sandpiper (nine pairs), Dunlin (eight pairs) and Redshank (seven pairs); all of which were only recorded at sites in Co. Mayo.

In Co. Mayo, 1,744 ha over 21 sites were surveyed at least once and of these, only 12 sites held one or more pairs of breeding wader. A collective total of 198 pairs were found; equating to an overall breeding density of 0.11 pairs/km² in Mayo. As indicated, the highest numbers were found on Inishkea North (44 pairs), Termoncarragh Lough (37 pairs) and Roonagh Lough (33 pairs). Two other sites held over 20 pairs (Inishkea South and Dooaghtry) and two sites over 10 pairs (Fahy Lough and Lough Baun) whilst the other five sites held between two and four pairs each. All seven wader species were found breeding within the county. Lapwing was the most numerous species with 81 pairs (41% of the county total) recorded from nine sites, the majority of which were at Termoncarragh Lough (21 pairs). This was followed by Oystercatcher (34 pairs), Snipe (31 pairs), Ringed Plover (28 pairs), Common Sandpiper (nine pairs) and Redshank (seven pairs). Breeding Dunlin were only recorded in Co. Mayo with eight pairs from three sites.

In Co. Galway, 763 ha over 13 sites was surveyed, from which 82 pairs of breeding wader were found at eight of those sites. As in Co. Mayo, the overall breeding density was 0.11 pairs/km². The highest numbers were found at Mannin Beg (35 pairs). Two other sites, Trawmore and Dog's Head (both on Inishmore) held 12 pairs whilst the other five sites held between two and nine pairs. Four of the seven wader species were recorded breeding, with Lapwing being the most numerous with 62 pairs (76% of the county total) and recorded breeding at seven of the eight sites. The other three species were Ringed Plover (15 pairs), Snipe (four pairs) and Oystercatcher (one pair).

No breeding waders were recorded at the following sites: Co. Mayo – Garter Hill, Cross Lough, Agleam, Srah (North & South), Doo Lough, Kinrovar (Doohooma), Doona (Trawboy), Corraun Point and Rosmurrevagh; Co. Galway - Dog's Bay, Mweenish Island, Finish Island, Augrusbeg and Omey Island.

Table 4 Results of the 2019 breeding wader survey showing the number of territories, expressed as breeding pairs, for each species recorded at each site surveyed in Counties Mayo and Galway.

Site name	Site code	County	OC	RP	L	DN	SN	RK	CS	Total pairs
Termoncarragh Lough	26	Mayo	0	0	21	0	15	1	0	37
Leam Lough	28	Mayo	0	0	0	0	0	2	0	2
Inishkea North	30	Mayo	20	4	10	3	4	2	1	44
Inishkea South	31	Mayo	14	5	2	1	0	0	2	24
Dooyork	34	Mayo	0	0	2	0	0	0	0	2
Fahy Lough	37	Mayo	0	0	9	0	4	1	0	14
Lough Doo (Doogort)	39	Mayo	0	1	2	0	0	0	0	3
Keel Lough	40	Mayo	0	1	0	0	2	0	0	3
Dooaghtry	42	Mayo	0	0	16	0	5	0	0	21
Lough Baun	50	Mayo	0	1	9	0	0	0	1	11
Roonagh Lough	51	Mayo	0	14	10	4	1	1	3	33
Cross Lough (Killadoon)	52	Mayo	0	2	0	0	0	0	2	4
Mannin Beg	43	Galway	0	0	32	0	3	0	0	35
Aillebrack	44	Galway	0	0	3	0	0	0	0	3
Trawmore (Inishmore)	48	Galway	0	5	6	0	1	0	0	12
Dog's Head, (Inishmore)	48A	Galway	1	7	4	0	0	0	0	12
Kilmurvey, (Inishmore)	48B	Galway	0	0	5	0	0	0	0	5
Oghil, (Inishmore)	48C	Galway	0	0	4	0	0	0	0	4
Murvey	55	Galway	0	2	0	0	0	0	0	2
Inis Meain (Innis Maan)	56	Galway	0	1	8	0	0	0	0	9
Co. Mayo Total (n = 21)			34	28	81	8	31	7	9	198
Co. Galway Total (n = 13)			1	15	62	0	4	0	0	82
Overall Total (n = 34)			35	43	143	8	35	7	9	280
Percentage of National Population*			1%	4%	23%	16%	1%	2%	0.5%	2%

*National population estimates used here are the maximum estimates, unless where only a single 'best' estimate was available (see NPWS, 2019a); thus, some of these proportions may be higher if minimum population estimate was more accurate.

Of the 34 sites, 24 were located on the mainland and at these the average surveyed area was 80.2ha. The other 10 sites were on offshore islands with an average survey area of 58.2ha. Collectively, the mainland sites recorded 61% (170 pairs) of all the breeding waders (Table 5) with Lapwing, Snipe, Redshank and Common Sandpiper being recorded most frequently at these sites. Breeding Dunlin and Ringed Plover were equally split between the mainland and the offshore islands, whilst Oystercatchers were all recorded on the offshore island sites. However the offshore island sites recorded higher densities of breeding waders at 0.19 pairs/ha as opposed to 0.09 pairs/ha for the mainland sites, with higher densities recorded on the offshore islands for Oystercatcher (0.06 pairs/ha), Ringed Plover (0.04 pairs/ha), Lapwing (0.07 pairs/ha), Dunlin (0.01 pairs/ha) and Common Sandpiper (0.01 pairs/ha).

Table 5 Frequency distribution (%) and breeding density (pairs per ha) between island and mainland surveyed sites for each breeding wader species in 2019. Breeding densities are in parentheses; n = number of surveyed sites.

Location	n	Survey area (ha)	OC	RP	L.	DN	SN	RK	CS	Total
Islands	10	582	100% (0.06)	51% (0.04)	27% (0.07)	50% (0.01)	14% (0.01)	29% (0.003)	33% (0.01)	39% (0.19)
Mainland	24	1925	0% (0.00)	49% (0.01)	73% (0.05)	50% (0.002)	86% (0.02)	71% (0.003)	67% (0.003)	61% (0.09)

4.3 Habitat components and management

The dominant habitat recorded at most of the surveyed sites was machair (76% of sites) and the main management practice was livestock grazing (at 91% of sites; Table 6). In addition, amenity (e.g. camping) or recreational (e.g. sports pitches) use was evident at 22 sites (65%) and these were particularly prevalent on the machair habitat (recorded at 18 of the 26 machair sites). Many of the sites were subdivided, mainly by fences (74%) and or walls, and half of the sites had some form of drainage, which was mainly an outflow watercourse (Table 7).

Table 6 General land management assessments affecting the dominant habitat type at the 34 surveyed sites in 2019. Frequency (%) is the percentage of total sites where said management occurred.

Dominant habitat	n	Grazed	Abandoned	Amenity / recreational	Other
Machair	26	24	2	18	1
Semi-improved	2	2	0	2	0
Wet marsh	4	3	1	1	0
Damp/dry marsh	1	1	0	1	0
Fixed dune	1	1	0	0	0
Total	34	31	3	22	1
Frequency (%)		91%	9%	65%	3%

Table 7 Number of sites showing physical features on the dominant habitat, recorded at the 34 surveyed sites in 2019. Frequency (%) is the percentage of total sites where features were present.

Dominant habitat	Ditches	Walls	Fences	Power lines
Machair	12	11	18	2
Semi-improved	1	2	2	1
Wet marsh	3	3	3	
Damp/dry marsh	1	1	1	
Fixed dune		1	1	
Total	17	18	25	3
Frequency (%)	50%	53%	74%	9%

Livestock numbers were recorded at 24 sites (Table 8). Note that, Termoncarragh Lough was divided into two sub-sites to reflect the different management regimes between the larger lough area and the BirdWatch Ireland Annagh Marsh reserve. Sheep were recorded as the main (i.e. most numerous) grazing animal at 15 sites. But with the sites comprising different farm holdings, then 11 sites recorded a mixture of sheep and cattle grazing, seven sites recorded sheep grazing only, whilst six sites recorded cattle grazing only and one site recorded horse grazing only. The grazing pressure, expressed as livestock unit per hectare (LSU/ha), for these 24 sites varied from 0.06 LSU/ha to 1.97 LSU/ha. At the six sites where they were 15 or more breeding wader pairs then the grazing pressure ranged from 0.06 LSU/ha to 0.51 LSU/ha or if expressed as the stocking density, then these ranged from 0.29 animals/ha to 1.79 animals/ha at those six sites.



Figure 2 Grazing pressure was evident at most of the surveyed coastal grasslands, with short sward heights being recorded at three-quarters of sites. Cross Lough, Mullet Peninsula, Co. Mayo. Photograph © Irene O'Brien.

Table 8 Assessment of the grazing animal stocking density expressed as both the Livestock Unit (LSU) and total animals per hectare, at 24 sites where counts of grazing animals were recorded on one visit in 2019. Livestock unit (LSU) calculated using specific coefficients for each animal type (cattle 0.90, sheep 0.20, and horse 1.0).

Site name	Site code	Dominant habitat	Month recorded	Primary stock	LSU / ha	Animals / ha	Total breeding pairs
Garter Hill	25	Machair	April	Sheep	0.06	0.29	0
Termoncarragh Lough	26	Machair	June	Sheep	0.73	2.08	4
Annagh Marsh		Wet Marsh	June	Cattle	0.51	0.80	33
Cross Lough	27	Machair	April	Cattle	1.59	2.46	0
Leam Lough	28	Wet Marsh	April	Cattle	0.89	0.99	2
Agleam	29	Machair	April	Cattle	1.97	2.16	0
Inishkea North	30	Machair	June	Sheep	0.36	1.79	44
Inishkea South	31	Machair	May	Sheep	0.34	1.59	24
Srah (North & South)	32	Semi-improved	April	Cattle	0.31	0.35	0
Doo Lough	33	Machair	June	Sheep	1.02	3.15	0
Dooyork	34	Machair	June	Cattle	1.04	1.16	2
Kinrovar (Doohooma)	35	Machair	April	Cattle	0.78	0.87	0
Fahy Lough	37	Wet Marsh	June	Sheep	0.08	0.40	14
Lough Doo (Doogort)	39	Machair	May	Sheep	0.53	2.55	3
Keel Lough	40	Machair	April	Sheep	0.22	0.95	3
Rosmurrevagh	41	Machair	April	Sheep	0.27	1.33	0
Dooaghtry	42	Machair	May	Sheep	0.19	0.90	21
Lough Baun	50	Machair	May	Sheep	1.17	3.50	11
Roonagh Lough	51	Damp Marsh	April	Sheep	0.06	0.32	33
Cross Lough (Killadoon)	52	Wet Marsh	April	Sheep	0.06	0.32	4
Mannin Beg	43	Machair	April	Sheep	0.12	0.29	35
Aillebrack	44	Machair	April	Cattle	0.09	0.10	3
Finish Island	47	Semi-improved	April	Cattle	0.79	0.88	0
Oghil, (Inishmore)	48C	Wet Marsh	April	Horse	0.12	0.12	4
Murvey	55	Machair	April	Sheep	0.13	0.64	2

The effects of the grazing are noted in the sward height assessment where short sward (criteria being where 70% of the grass sward across the site is <10cm) was recorded at 76% of sites (Table 9). Grazing also impacts on the availability of tussocks (used by breeding waders for their nest location or for concealment of their chicks) with 26% of sites recording no tussocks present and a further 35% of sites recording <5% of tussocks present (Table 10). Other features used by breeding waders, particularly during chick rearing, are the combination of surface water and bare ground however nearly 60% of sites were relatively dry, in that they had none or very little surface water and 76% of sites had very little bare ground. It is noteworthy that some sites were only visited early in the season (as they did not hold breeding waders; see Table 3) and stocking densities would likely be higher later in the season; thus, the true stocking density for some sites may be underestimated.

Table 9 Basic sward height assessment at the 34 survey sites. Frequency (%) is the percentage of total sites which recorded a given dominant sward type.

Dominant habitat	n	Short sward	Mixed sward	Long sward
Machair	26	25	1	0
Semi-improved	2	1	1	0
Wet marsh	4	0	3	1
Damp/dry marsh	1	0	1	0
Fixed dune	1	0	1	0
Total	34	26	7	1
Frequency (%)		76%	21%	3%

Short: 70% of the grass sward across the site is <10cm, **Mixed:** the grass sward is a mixture of short (<10cm) and medium (10-20cm) length, with at least 25% of area being short, and **Long:** 70% or more of the grass sward is of long length (>20cm).

Table 10 Frequency distribution (%) of the basic habitat components measured at the 34 survey sites in 2019.

Cover attribute*	Rushes	Tussocks	Bare Ground	Surface Water
None	59%	26%	32%	41%
Sparse	21%	35%	44%	18%
Occasional	21%	38%	15%	15%
Frequent	0%	0%	0%	15%
Abundant	0%	0%	9%	12%

*None is 0%, Sparse <5%, Occasional 5-15%, Frequent 15-35% and Abundant is >35%, coverage of the entire site.

**Figure 3** Restricting grazing animals to certain grazing periods can create a mixed sward structure which is more beneficial to breeding waders. Inishkea North, Co. Mayo. Photograph © Dave Suddaby.

4.4 Survey comparisons

Twenty-four of the surveyed sites in Counties Mayo and Galway were surveyed previously, in both 1996 and 2009 (Table 1). Collectively, these show an overall decline in breeding pairs of 51% since 1996 and 62% since 2009 (Table 11). Since 2009, all seven breeding wader species have declined by 28% or more, with the largest decline at 91% being found in breeding Dunlin numbers. Oystercatcher, Ringed Plover, Redshank and Common Sandpiper have all declined by 70% or more since 2009, whilst Snipe and Lapwing have declined by 28% and 30% respectively.

The declines are most evident on the offshore islands where the numbers of breeding pairs have dropped by 65% since 1996 and 81% since 2009, with each breeding wader species declining by between 69% and 91% since 2009. During the 2009 survey, the Inishkea islands (North and South) held the largest numbers of breeding waders at 377 pairs. These have now declined to 68 pairs (down 82%), and these declines have been across all seven species; Oystercatcher have declined by 69% (108 pairs to 34 pairs), Ringed Plover by 89% (81 pairs to 9 pairs), Lapwing by 87% (95 pairs to 12 pairs), Dunlin by 89% (38 pairs to 4 pairs), Snipe by 81% (21 pairs to 4 pairs), Redshank by 91% (23 pairs to 2 pairs) and Common Sandpiper by 73% (11 pairs to 3 pairs).

Table 11 Changes in the numbers of breeding pairs across 24 comparable sites in Mayo and Galway, on either offshore islands or mainland, surveyed in 1996, 2009 and 2019 (n = number of sites).

Year / Location	n	OC	RP	L.	DN	SN	RK	CS	Total
1996 Island	5	136	42	35	6	5	5	0	229
1996 Mainland	19	0	29	85	42	15	6	3	180
1996 All	24	136	71	120	48	20	11	3	409
2009 Island	5	110	103	115	38	21	23	11	421
2009 Mainland	19	2	29	33	7	26	3	2	102
2009 All	24	112	132	148	45	47	26	13	523
2019 Island	5	34	14	18	4	5	2	3	80
2019 Mainland	19	0	2	85	0	29	4	0	120
2019 All	24	34	16	103	4	34	6	3	200
Percentage change 1996 to 2019 Island		-75%	-67%	-49%	-33%	0%	-60%	+100%	-65%
Percentage change 1996 to 2019 Mainland		0%	-93%	0%	-100%	+93%	-33%	-100%	-33%
Percentage change 1996 to 2019 All		-75%	-77%	-14%	-92%	+70%	-45%	0%	-51%
Percentage change 2009 to 2019 Island		-69%	-86%	-84%	-89%	-76%	-91%	-73%	-81%
Percentage change 2009 to 2019 Mainland		-100%	-93%	+158%	-100%	+12%	+33%	-100%	+18%
Percentage change 2009 to 2019 All		-70%	-88%	-30%	-91%	-28%	-77%	-77%	-62%

In contrast to the offshore islands, the numbers of breeding pairs at the mainland sites have increased by 18% since 2009. This is largely due to the increase in breeding Lapwing numbers at three sites; Mannin Beg (five pairs to 32 pairs), Termoncarragh Lough (six pairs to 21 pairs) and Dooaghtry (seven pairs to 16 pairs). However, breeding Oystercatcher, Dunlin and Common Sandpiper have been lost from the mainland sites. Even though Dunlin were only found in small numbers (7 pairs at three sites) in 2009, there were 42 pairs recorded in the 1996 survey at seven mainland sites with the two key sites being Termoncarragh Lough (14 pairs) and Fahy Lough (12 pairs).

For some sites, these changes in breeding wader numbers is reflected in their calculated Site Index Value (SIV). As in the 2009 survey, of the 20 sites with breeding waders only three achieved the top index value (SIV I), and hence were assessed as being of high importance (Table 12). In both surveys the sites were Inishkea North, Inishkea South and Roonagh Lough. Their high index value being mainly because they each hold five or more breeding wader species, including Dunlin, Redshank and Lapwing; worryingly though these three sites have recorded declining numbers of pairs since 2009. Only two sites, Termoncarragh Lough and Lough Baun, were ranked with an index value II; previously, in both the 1996 and 2009 surveys, Termoncarragh Lough had been ranked with an index value III but with increasing numbers of breeding Lapwing and Snipe (associated with the Annagh Marsh sub-unit) the site importance has been elevated. Of the remainder, eight were ranked as index value III and seven as index value IV; mainly due to the declining numbers of breeding pairs.

Table 12 Site index values (SIV) for the 20 sites that held breeding waders in 2019, and comparisons values for 16 sites holding breeding waders in the 1996 and 2009 surveys. SIV Grades: I = score 10-12, II = score 7-9, III = score 4-6, IV = score 1-3 & V = score 0. NS = Not surveyed.

Site name	Site code	Total breeding pairs 2019	SIV 1996	SIV 2009	SIV 2019
Termoncarragh Lough	26	37	III	III	II
Leam Lough	28	2	IV	IV	IV
Inishkea North	30	44	I	I	I
Inishkea South	31	24	I	I	I
Dooyork	34	2	III	III	IV
Fahy Lough	37	14	III	II	III
Lough Doo (Doogort)	39	3	V	V	III
Keel Lough	40	3	IV	IV	IV
Dooaghtry	42	21	II	II	III
Lough Baun	50	11	NS	II	II
Roonagh Lough	51	33	NS	I	I
Cross Lough (Killadoon)	52	4	NS	V	III
Mannin Beg	43	35	III	III	III
Aillebrack	44	3	IV	III	IV
Trawmore (Inishmore)	48	12	II	II	III
Dog's Head, (Inishmore)	48A	12	NS	NS	III
Kilmurvey, (Inishmore)	48B	5	NS	NS	IV
Oghil, (Inishmore)	48C	4	NS	NS	IV
Murvey	55	2	IV	III	IV
Inis Meain (Innis Maan)	56	9	NS	NS	III

Livestock grazing remains the principal management at the surveyed sites (at 93% of sites in 2009 and at 91% of sites in this survey). However based on a single count of grazing animals at the same 23 surveyed sites, indicates that their numbers have increased by around 45%, from an estimated 0.80 animals/ha in 2009 (1,727 animals; Suddaby *et al.*, 2010) to 1.16 animals/ha in 2019 (2,498 animals). This increase in numbers being a result of more sheep grazing being recorded; 1,071 sheep in 2009 (Suddaby *et al.*, 2010) and 1,850 sheep in 2019. This increased sheep grazing, due to their grazing characteristic of nibbling the vegetation and creating a uniformly low sward height, has likely led to the decreased tussocks coverage recorded at each site. In 2009, nine out of 23 sites recorded frequent or abundant tussock coverage (>15% coverage), whereas all 23 sites recorded occasional to no tussock coverage (<15% coverage) in 2019.

Single counts of grazing animals at six key sites (i.e. a site holding more than 20 pairs of breeding waders; see Table 12) found increased animal numbers at five of them, in comparison to the 2009 numbers (Suddaby *et al.*, 2010). For example, on Inishkea North there was a notable increase in the numbers of grazing animals, with a near doubling of sheep numbers, from 0.94 animals/ha in 2009 (167 sheep and 17 cattle) to 1.79 animals/ha in 2019 (350 sheep). There were similar findings also on Inishkea South. The increase in sheep numbers at Dooaghtry has been even greater, with near triple the numbers of sheep: from 0.28 animals/ha in 2009 to 0.90 animals/ha in 2019. While the total population of breeding waders at Dooaghtry has remained relatively stable (unlike the Inishkeas), this apparent stability can be attributed to the increase in Lapwing population alone, whilst breeding Dunlin, Redshank, Common Sandpiper and Ringed Plover have all been concurrently lost from the site. The only key site to record decreasing numbers of grazing animals was Mannin Beg; at this site the numbers decreased from 0.53 animals/ha in 2009 to 0.29 animals/ha in 2019, mainly through a reduction in sheep numbers from 116 in 2009 to 46 in 2019.

5 Discussion

This survey found that breeding wader numbers have declined in the order of 51% and 62% since the 1996 and 2009 surveys respectively, with the declines being most evident on the offshore islands. Dunlin showed the greatest population decline of any species, at 91% decline since 2009. The survey also found a decrease in the extent of grass tussocks within the surveyed sites, which is most likely due to an increase in the numbers of grazing animals, particularly sheep.

To give an overarching assessment of the numbers of breeding waders on the coastal grasslands between Counties Donegal and Galway, the numbers of this survey were combined with those of the 2017 survey (McMonagle *et al.*, 2017); see Table 13. Between the three surveys (1996, 2009 and 2017-2019 combined) there are 48 sites that were surveyed in each of those years, and these show a change in the breeding numbers over the past two decades, with a total population decline of 48% since 1996 (Table 14). Since 1996, across these sites, breeding Dunlin numbers have shown the largest declines from 60 pairs to four pairs (a 93% decline). Four other species have also declined by 50% or more over the same period: Oystercatcher numbers have declined from 166 pairs to 55 pairs, Ringed Plover from 96 pairs to 34 pairs, Redshank from 21 pairs to 9 pairs and Common Sandpiper from six pairs to three pairs. Lapwing numbers have also declined from 313 pairs to 190 pairs (a 39% decline), although since 2009 their numbers have declined by only 12 pairs. Across all seven species, the changes were greatest at the 24 sites within Counties Mayo and Galway, with an overall decline of 62% (523 pairs to 200 pairs), whereas there was an overall increase of 40% (113 pairs to 158 pairs) at the 24 sites within Counties Donegal and Sligo; this being primarily attributed to the installation of predator exclusion fencing at sites in Donegal (McMonagle *et al.*, 2017).

Table 13 Coastal breeding wader populations from Counties Donegal, Sligo, Mayo and Galway using combined 2017 and 2019 data, and their proportion of the estimated national populations (n = number of surveyed sites). Data presented is for all sites surveyed.

County	n	OC	RP	L.	DN	SN	RK	CS	Total
Donegal*	29	153	70	178	6	30	26	3	465
Sligo*	5	0	0	10	0	16	0	0	26
Mayo	21	34	28	81	8	31	7	9	198
Galway	13	1	15	62	0	4	0	0	82
Total	68	188	113	331	14	81	33	12	771
Percentage of National Population		6%	11%	53%	28%	2%	11%	0.6%	6%

*Data for Counties Donegal and Sligo from 2017 surveys (McMonagle *et al.*, 2017)

Variations in the breeding numbers are, in some part, likely to reflect the differences in counting efficiency between observers and the breeding species detectability which can be influenced by the bird's behaviour, the habitat, the weather and the times of day and year (Calladine *et al.*, 2014). However, by adopting the same methods as in the previous surveys, the influence of these factors was minimised; and with most sites having a relatively flat open topography and the number of breeding pairs per site being relatively low, it is considered (as per the previous surveys) that the count error was low.

Table 14 Changes in breeding pairs since 1996 from 48 comparable coastal grassland sites from Counties Donegal, Sligo, Mayo and Galway, using combined 2017 and 2019 data for the 2019 total.

Year	OC	RP	L.	DN	SN	RK	CS	Total
1996	166	96	313	60	33	21	6	695
2009	122	144	202	45	83	27	13	636
2019	55	34	190	4	63	9	3	358
Percentage change 1996 to 2019	-67%	-65%	-39%	-93%	+91%	-57%	-50%	-48%
Percentage change 2009 to 2019	-55%	-76%	-6%	-91%	-24%	-67%	-77%	-44%

Despite the possibility of some count error occurring, it is evident that the breeding wader numbers on the coastal grasslands within Counties Mayo and Galway have declined significantly over the past decade. The declines found on the offshore islands are alarming, particularly on the Inishkea islands which held 377 pairs in 2009 (Suddaby *et al.*, 2010) but only 68 pairs in 2019. Previous studies on the Inishkea islands have indicated that a range of threats to the breeding waders occur there; broadly categorised as habitat change and increased predation pressure (Gamero *et al.*, 2008; Suddaby, 2012, 2013, 2014 & 2015). And these combined threats have been cited as one of the root causes in declining breeding waders on grasslands elsewhere (e.g. Audsen *et al.*, 2010; Colhoun, *et al.*, 2015; Laidlaw *et al.*, 2015; MacDonald & Bolton, 2008; O'Brien & Smith, 1992).

Changing agricultural practices are particularly prevalent on these coastal grasslands. For example, while the majority of the surveyed sites are commonages, some of the machair grasslands have recently been fenced, resulting in greater concentration of grazing animals in confined areas, ultimately leading to overgrazing, supplementary feeding and poaching of the land (Cooper *et al.*, 2005; Ryle *et al.*, 2009). While grazing is essential to the maintenance of suitable habitat for breeding waders, e.g. by creating a less dense and more open sward that is suitable for nesting and foraging, it requires careful consideration when determining the appropriate stocking density and timing and duration of grazing (Franks *et al.*, 2018). Although interpretation of the stocking densities for each surveyed site requires caution due to them being a snapshot of the numbers on a single visit, they do highlight some important changes. None more so than the increase in the number of grazing animals, especially sheep, which are impacting on the grassland structure. It is noteworthy that grazing pressure at some sites are likely underestimated due to only receiving early season visits (see Section 4.3). These findings are in line with more focussed habitat assessment studies of the machair grasslands which found that the criteria that failed most frequently was sward height (due to grazing), with average sward height being lower than the target of 8cm in July and August (Delaney *et al.*, 2013; Ryle *et al.*, 2009). This has led to the overall conservation status of these machair grasslands being assessed as *Inadequate* (National Parks and Wildlife Service, 2019b). Furthermore, studies have shown that high stocking densities can cause increased incidences of nest trampling (e.g. Smart *et al.*, 2006), but as sheep generally do not react to distraction displays performed by an attentive adult wader, then sheep are considered the greater threat to nesting success (Shrubbs, 2007). A large proportion of the coastal grassland sites that breeding waders utilise are managed as commonages; this factor can make the design and implementation of management measures significantly more challenging. This factor will need to be considered fully and addressed in any future management.

On the Inishkea islands, the increased grazing levels have culminated in a less than ideal vegetation height for nesting Dunlin and Redshank, leaving their nests susceptible to predation (Suddaby, 2012). On Inishkea North, the predation of wader eggs by Common Gulls *Larus canus* has been noted as an increasing phenomenon, where it has been found that up to 35% of observed Common Gull predation attempts were successful in predating wader eggs from Ringed Plover, Lapwing, Dunlin and Redshank

nests (Suddaby, 2012, 2013, 2014 & 2015). As a response to these habitat changes and increased predation levels, it could be argued that birds may have gradually redistributed to a more preferred grassland habitat. However there is no direct evidence for this and the indications from the Bird Atlas 2007-11 (Balmer *et al.*, 2013) shows contractions in the breeding ranges of these grassland breeding waders. However, there have been increases in overall breeding wader numbers on coastal grasslands in Co. Donegal (McMonagle *et al.*, 2017) and a noted increase at mainland sites in this survey, particularly for Lapwing. At sites in Co. Donegal, McMonagle *et al.* (2017) found that breeding Lapwing had responded positively, with a 128% increase overall, to the installation of predator exclusion fence, which is noted as an effective conservation management tool for improving breeding wader success (e.g. Malpas *et al.*, 2013; Smith, Pullin, Stewart & Sutherland, 2011). Similarly, BirdWatch Ireland installed a predator exclusion fence (primarily to deter Foxes *Vulpes vulpes* from entering) around their reserve and adjacent lands at Annagh Marsh (part of the Termoncarragh Lough site) in 2011. At this site, despite active habitat and predator control management between 2002 and 2011, the breeding Lapwing numbers declined as a result of nest predation by Foxes (Troake & Suddaby, 2008). After the installation of the fence, breeding Lapwing success improved with an average of 1.4 fledged chicks/year and breeding numbers have increased (Figure 4; BirdWatch Ireland, unpublished data). However, the construction, operation and maintenance of these predator exclusion fences can be costly, as such they tend to be focused on relatively small areas and are therefore rarely practical on a landscape scale (Smith *et al.*, 2011).



Figure 4 Number of breeding Lapwing pairs and their productivity at BirdWatch Ireland's Annagh Marsh reserve (sub-site of Termoncarragh Lough) between 2002 and 2019 (BirdWatch Ireland, unpublished data).

At Fahy Lough and Mannin Beg, there have been predator control measures put in place in recent years by NPWS to protect the breeding waders (NPWS, personal communication, 16 July 2019). Like Annagh Marsh, the habitat structure at Fahy Lough was assessed as having a mixed sward height with frequent surface water (similar to the assessment in 2009); this being a habitat structure which has been suggested could potentially help to reduce levels of nest predation in breeding waders (Laidlaw *et al.*, 2015). But the breeding wader numbers at Fahy Lough have decreased (from 30 pairs in 1996 to 14 pairs in this

survey, with the loss of breeding Dunlin since 2009); this could be a result of the predator control measures failing in lowering the target predator numbers to an extent that completely removes the threat of predation (Bolton *et al.*, 2007; Smith *et al.*, 2011). In contrast, the breeding wader numbers at Mannin Beg are increasing (from zero in 1996 to 17 pairs (including five Lapwing pairs) in 2009 to 35 pairs (including 32 Lapwing pairs) in this survey). This may be a result of effective predator control measures being in place as the habitat structure assessment (short sward height with sparse surface water) has remained the same, even though the numbers of grazing animals have apparently reduced. However, these complexities are rarely straightforward and can often be site-specific, therefore gaining a better understanding of the actual predators, their impacts, and the influence of the habitat and its associated management on predator activity may help to focus actions to benefit these breeding waders.



Figure 5 A mixed sward height with an open structure and wet features should benefit breeding waders but predation levels at some sites can reduce breeding numbers. Fahy Lough, Co. Mayo. Photograph © Irene O'Brien.

Previous surveys of these coastal grasslands have shown that they can support greater numbers of breeding waders, although indications suggest this will not be possible without considerable intervention. Where interventions, such as predator exclusion fences, have been put in place, then certainly some breeding wader species have responded positively. However, breeding Dunlin have not responded to these interventions and have now declined by over 90% on these coastal grasslands over the past decade. In a declining breeding Dunlin population in southern Sweden, despite improved habitat management and implementing nest protection to improve nest survival, Blomqvist *et al.* (2010) found that their declines were associated with increased pairings between related individuals creating reduced genetic diversity. This led to reduced fitness throughout their lifespan, which in turn was increasing the risk of extinction as a breeding species in that area. Given that these findings were within a declining population, down to 16 pairs in 2004 (Blomqvist *et al.*, 2010), and with the Irish population estimated at 50 pairs, all within a relatively small area (Crowe, 2019), the remaining Dunlin may be suffering from reduced genetic diversity. This could, at least partly, explain their rapidly declining numbers in Ireland.

There are two commonly employed conservation strategies in Europe to address breeding wader declines: site protection and agri-environment schemes (AES). For these coastal grassland sites, legal protection through the designation of sites as Special Protection Areas (SPAs) is afforded to nine out of the 34 surveyed sites. Those nine sites are within four SPAs, where breeding Dunlin is listed as one of the Special Conservation Interests. Breeding Dunlin were only recorded in the Inishkea Islands SPA, whereas the other three SPAs have not recorded them for at least the past decade. The only other site

where breeding Dunlin were recorded was at Roonagh Lough which is not designated as a SPA. Whilst the main AES applicable to these coastal grassland sites is the Green Low-Carbon Agri-Environment Scheme (GLAS); this is a scheme focused on Priority Environmental Assets and Actions and includes actions for breeding waders that occur in certain areas (parts of the north and west, and the Shannon Callows). In 2017, an initial evaluation of GLAS (ADAS, 2018) assessed 30 farms with lands (sites) entered into the GLAS Breeding Wader measure; from the results reported, many of the sites did not meet the range of ecological requirements of breeding waders (see ADAS, 2018). Additionally, several of the breeding wader sites were deemed to be too improved overall, or too dense in terms of thick rush cover and/or gorse, to be suitable for breeding waders (Elliot & Image, 2018). These initial findings suggest that the measure is sub-optimal and not providing the ecological conditions required by breeding waders for successful breeding and thus population maintenance or growth.

Smart *et al.* (2014), following an assessment of whether site protection (designated sites and nature reserves) and AES improves the conservation status of breeding waders within England, concluded that using limited AES money to support management for breeding waders on, around and between the existing network of protected sites will protect remaining populations while presenting opportunities for population expansion in future. For this to apply to these coastal grasslands, a greater collaboration and cooperation for the delivery of appropriate management both within the SPAs and the wider countryside is urgently required. This would likely also require a reassessment of the farming conditions for the sand dune and machair areas which are given in the GLAS specification document (DAFM, 2016), where the primary recommendation is to avoid farming practices that cause environmental damage. The findings from this report and others (e.g. Delaney *et al.*, 2013; NPWS, 2019b) suggest that the existing conditions are not optimal to maintain these habitats in favourable conservation status, or are not being adhered to.

Farmers and landowners should be encouraged to manage relevant lands for breeding waders through AES, such as GLAS; however, the creation of a specific agri-environment measure for breeding waders on machair and other coastal grasslands would likely be required to provide more focused management within targeted areas and thus improve success of the measure. It is noteworthy that a large proportion of the relevant machair and coastal grassland sites supporting breeding waders are commonages; this will likely present significant challenges for the design and implementation of management measures. Outside of AES, site restoration measures will also likely be required at some sites.

Urgent conservation intervention is required to safeguard these remaining breeding wader numbers, including measures at key sites to reduce the impact of predation, *e.g.* via the use of exclusion fences. Site restoration measures are also likely required at some sites. This will likely require an improved understanding of the key habitat components needed for achieving high breeding success, the interaction between landscape, vegetation and predators, and the predator-prey interactions at key sites. Delivering these interventions would be extremely valuable in turning around these declining populations. However, improving the fortunes of Dunlin may well be more complicated and challenging.

6 References

- ADAS. (2018) Baseline Analysis of Actions under GLAS: Full Report. *Unpublished report to the Department of Agriculture, Food and the Marine*, Dublin, Ireland.
- Allen, V.G., Batello, C., Berretta, E.J., Hodgson, J., Kothmann, M., Li, X., McIvor, J., Milne, J., Morris, C., Peeters, A. & Sanderson, M. (2011) An international terminology for grazing lands and grazing animals. *Grass and Forage Science* **66**, 2–28.
- Audsen, M., Boton, M., Butcher, N., Hoccom, D.G., Smart, J. & Williams, G. (2010) Predation of breeding waders on lowland wet grassland-is it a problem? *British Wildlife* October 2009.
- Balmer, D.E., Gillings, S., Caffrey, B.J., Swann, R.L., Downie, I.S. & Fuller, R.J. (2013) *Bird Atlas 2007–11: The breeding and wintering birds of Britain and Ireland*. BTO Books, Thetford, UK.
- BirdLife International (2004) *Birds in Europe: population estimates, trends and conservation status* (Birdlife Conservation Series No. 12). BirdLife International, Cambridge, UK.
- Blomqvist, D., Pauliny, A., Larsson, M. & Flodin, L. (2010) Trapped in the extinction vortex? Strong genetic effects in a declining vertebrate population. *BMC Evolutionary Biology* 2010, **10**, 33.
- Bolton, M., Tyler, G., Smith, K. & Bamford, R. (2007) The impact of predator control on Lapwing *Vanellus vanellus* breeding success on wet grassland nature reserves. *Journal of Applied Ecology* **44**, 534–544.
- Calladine, J., Pakeman, R.P., Humphreys, E., Huband, S. & Fuller, R.J. (2014) Changes in breeding wader assemblages, vegetation and land use within machair environments over three decades. *Bird Study* **61**, 287–300.
- Colhoun, K., Mawhinney, K. & Prach, W.J. (2015) Populations estimates and changes in abundance of breeding waders in Northern Ireland up to 2013. *Bird Study* **62**, 394–403.
- Cooper, A., McCann, T. & Ballard, E. (2005) The effects of livestock grazing and recreation on Irish machair grassland vegetation. *Plant Ecology* **181**, 255–267.
- Crowe, O. (2019) Status of rare breeding birds in the Republic of Ireland 2013 - 2018. *Unpublished report to the National Parks and Wildlife Service*, Dublin, Ireland.
- DAFM. (2016) *GLAS specification for GLAS Tranche 3*. Dublin, Ireland.
- Delaney, A., Devaney, F.M., Martin, J.M. & Barron, S.J. (2013) Monitoring survey of Annex I sand dune habitats in Ireland. *Irish Wildlife Manuals*, No. 75. National Parks and Wildlife Service, Department of Arts, Heritage and the Gaeltacht, Dublin, Ireland.
- Elliott, J. & Image, M. (2018) Design of Agri-Environmental Schemes: evidence from the monitoring and evaluation GLAS in Ireland. Paper prepared for presentation for the 166th EAAE Seminar: *Sustainability in the Agri-Food Sector*.
- Fossit, J.A. (2000) *A guide to habitats in Ireland*. The Heritage Council of Ireland Series, Heritage Council, Kilkenny, Ireland.
- Franks, S.E., Roodbergen, M., Teunissen, W., Cotton, A.C. & Pearce-Higgins, J.W. (2018) Evaluating the effectiveness of conservation measures for European grassland-breeding waders. *Ecology and Evolution*. **8**, 10555–10568.
- Gamero, A., McNaghten, L., & Suddaby, D. (2008) Research of breeding Dunlin ecology associated with machair and upland NATURA 2000 sites in N.W. Mayo. *Unpublished report to the National Parks and Wildlife Service*, Dublin, Ireland.
- Gibbons, D.W., Reid, J.B. & Chapman, R.A. (1993) *The New Atlas of Breeding Birds in Britain and Ireland 1988–1991*. T. & A.D. Poyser, London.
- Hayhow, D.B., Eaton, M.A., Stanbury, A.J., Burns, F., Kirby, W.B., Bailey, N., Beckmann, B., Bedford, J., Boersch-Supan, P.H., Coomber, F., Dennis, E.B., Dolman, S.J., Dunn, E., Hall, J., Harrower, C., Hatfield, J.H., Hawley, J., Haysom, K., Hughes, J., Johns, D.G., Mathews, F., McQuatters-Gollop, A., Noble, D.G., Outhwaite, C.L., Pearce-Higgins, J.W., Pescott, O.L., Powney, G.D. & Symes, N. (2019) *The State of Nature 2019*. The State of Nature partnership, UK.
- Laidlaw, R.A., Smart, J., Smart, M.A. & Gill, J.A. (2015) Influence of landscape features on nest predation rates of grassland-breeding waders. *International Journal of Avian Science* **157**, 700–712.
- Lauder, C. & Donaghy, A. (2008) Breeding Waders in Ireland 2008: A Review and Recommendations for Future Action. *Unpublished report to the National Parks and Wildlife Service*, Dublin, Ireland.
- Macdonald, M. & Bolton, M. (2008) Predation of Lapwing *Vanellus vanellus* nests on lowland wet grassland in England and Wales: effects of nest density, habitat and predator abundance. *Ornithologen-Gesellschaft* **149**, 555–563.
- Madden, B., Cooney, T., O'Donoghue, A., Norris, D.W. & Merne, O.J. (1998) Breeding waders of machair systems in Ireland in 1996. *Irish Birds* **6**, 177–190.
- Malpas, L.R., Kennerley, R.J., Hiron, G.J.M., Sheldon, R.D., Ausden, M., Gilbert, J.C. & Smart, J. (2013) The use of predator-exclusion fencing as a management tool improves the breeding success of waders on lowland wet grassland. *Journal for Nature Conservation* **21**, 37–47.
- Marchant, J. (1983) *BTO Common Birds Census Instructions*. British Trust for Ornithology, Tring, UK.
- McMonagle, C., Bell, M. & Donaghy, A. (2017) Survey of Breeding Wader Populations at Machair & Offshore Islands in North-West Ireland, 2017.

- Unpublished report to the Cooperating Across Borders for Biodiversity Project, an INTERREG V Project under the European Regional Development Fund.*
- National Parks and Wildlife Service (2012) Commonage areas dataset. Available: <https://www.npws.ie/maps-and-data/habitat-and-species-data>.
- National Parks and Wildlife Service (2019a) Annex B – Bird species' status and trends report format (Article 12) for the period 2013 – 2018. Available on EIONET Central Data Repository - see: <https://bit.ly/34jqBx2>
- National Parks and Wildlife Service (2019b) The Status of EU Protected Habitats and Species in Ireland. Volume 1: Summary Overview. *Unpublished report to the National Parks and Wildlife Service*, Dublin, Ireland.
- Nairn, R.G.W. & Sheppard, J.R. (1985) Breeding waders of sand dune machair in north-west Ireland. *Irish Birds* **3**, 53-70.
- O'Brien, M. & Smith, K.W. (1992) Changes in the status of waders breeding on wet lowland grassland in England and Wales between 1982 & 1989. *Bird Study* **39**, 165-176.
- QGIS Development Team (2016) QGIS Geographic Information System. Open Source Geospatial Foundation Project. <http://qgis.osgeo.org>.
- Ryle, T., Murray, A., Connolly, K. & Swann, M. (2009) Coastal Monitoring Project 2004-2006. *Unpublished report to the National Parks and Wildlife Service*, Dublin, Ireland.
- Seymour, A.S., Harris, S., Ralston, C. & White, P.C. (2003) Factors influencing the nesting success of Lapwings *Vanellus vanellus* and behaviour of red fox *Vulpes vulpes* in Lapwing nesting sites. *Bird Study* **50**: 39-46.
- Sharrock, J.T.R. (1976) *The Atlas of Breeding Birds in Britain and Ireland*. British Trust for Ornithology, Tring, UK.
- Shrubb, M. (2007) *The Lapwing*. T & A.D. Poyser, London, UK.
- Smart, J., Gill, J. A., Sutherland, W. J. & Watkinson, A. R. (2006) Grassland-breeding waders: identifying key habitat requirements for management. *Journal of Applied Ecology* **45**, 454-463.
- Smart, J., Wotton, S.R., Dillon, I.A., Cooke, A.I., Diack, I., Drewitt, A.L., Grice, P.V. & Gregory, R.D. (2014) Synergies between site protection and agri-environment schemes for the conservation of waders on lowland wet grasslands *Ibis* **156**, 576-590.
- Smith, R.K., Pullin, A.S., Stewart, G.B., & Sutherland, W.J. (2011) Is nest predator exclusion an effective strategy for enhancing bird populations? *Biological Conservation* **144**, 1-10.
- Suddaby, D., Nelson, T. & Veldman, J. (2009) Resurvey and comparative changes of breeding wader populations of Irish machair and associated wet grasslands in 2009. *Irish Birds* **8**, 533-542.
- Suddaby, D., Nelson, T. & Veldman, J. (2010) Resurvey of breeding wader populations of machair and associated wet grasslands in north-west Ireland. *Irish Wildlife Manuals*, No. **44**. National Parks and Wildlife Service, Department of the Environment, Heritage and Local Government, Dublin, Ireland.
- Suddaby, D. (2012) Ornithological Research and Scientific Monitoring on breeding waders and terns on the Inishkea Islands, Co. Mayo in 2012. *Unpublished report to the National Parks and Wildlife Service*, Dublin, Ireland.
- Suddaby, D. (2013) Ornithological Research and Scientific Monitoring on breeding waders and terns on the Inishkea Islands, Co. Mayo in 2013. *Unpublished report to the National Parks and Wildlife Service*, Dublin, Ireland.
- Suddaby, D. (2014) Ornithological Research and Scientific Monitoring on breeding waders and terns on the Inishkea Islands, Co. Mayo in 2014. *Unpublished report to the National Parks and Wildlife Service*, Dublin, Ireland.
- Suddaby, D. (2015) Ornithological Research and Scientific Monitoring on breeding waders and terns on the Inishkea Islands, Co. Mayo in 2015. *Unpublished report to the National Parks and Wildlife Service*, Dublin, Ireland.
- Troake, P. & Suddaby, D. (2008) Monitoring and measuring breeding parameters of Lapwing and other waders at selected NATURA 2000 sites in N.W. Mayo, 2008. *Unpublished report to the National Parks and Wildlife Service*, Dublin, Ireland.
- Wilson, A.M., Vickery, J.A., Brown, A., Langston, R.H.W., Smallshire, D., Wotton, S. & Vanhinsbergh, D. (2005) Changes in the numbers of breeding waders in lowland wet grasslands in England and Wales between 1982 and 2002. *Bird Study* **52**, 55-69.

Appendix 1 Recording Forms

These forms were completed after a survey visit. The field recording form was completed after each survey visit and summarises the total number of waders present at the whole-site level; this includes the estimated number of apparently occupied territories (e.g. displaying males, and paired adults) and number of confirmed breeding pairs (e.g. incubating adults, adults performing distraction displays, or adults with chicks). The Habitat recording form was completed after the first survey visit.

Field recording form

Site name and code:				County:		
Date:				Observer(s):		
Visit number:	1 st	2 nd	3 rd	Start time:		
Weather:				Finish time:		
Species:	Single birds:			No. of AOTs**	No. of confirmed breeding pairs [†]	No. of fledglings
	Male*	Female*	Total			
Oystercatcher (OC)						
Ringed Plover (RP)						
Lapwing (L.)						
Dunlin (DN)						
Snipe (SN)						
Redshank (RK)						
Common Sandpiper (CS)						
Golden Plover (GP)						
<i>Other species of note: (e.g. Skylark, Meadow Pipit, any raptors, Curlew or other waders with evidence of breeding; note corvids can be recorded in text box below)</i>						

*Only use in instances when can confidently determine sex of individuals.

**Apparently occupied territories (AOTs): displaying/singing males and paired adults. Enter as relevant.

[†]Confirmed breeding pairs: incubating adults, adults performing distraction displays, or adults with chicks (e.g. one adult performing distraction display = one confirmed breeding pair). Enter as relevant.

General comments (e.g. main nesting area(s), pressures/threats, disturbance, etc):

Livestock type and number present (per visit):

Species and number of avian and mammalian predators present (per visit): (e.g. *min. 25 Hooded Crows*)

Habitat recording form 2019

Site name and code:		County:	
Date:		Observer(s):	

In each of the following tables, please circle or tick the appropriate category or categories based on your best estimate after the site has been walked in full (as per the bird survey methodology). This assessment should be completed for the site as a whole (even if there are many divisions within the site). This assessment will provide a rough overview of the condition of each site. Each site is to be assessed only once using this form. Other issues can be recorded via the bird field recording form.

Dominant habitat type across the site as a whole (circle single most appropriate category):	
Machair	Semi-improved grassland
Wet marsh	Rank grassland
Damp/dry marsh	Fixed dunes

Management type that best describes the site (circle single most appropriate category):	
Grazed	Meadow
Tillage	Abandoned

Other land uses (circle all as relevant):	
Developed (e.g. housing)	Amenity (camping, etc)
Recreational (e.g. sports pitches)	Other: specify -

Sward height of grass (only)	Tick most appropriate
Short: 70% of the grass sward across the site is <10cm	
Mixed: the grass sward is a mixture of short (<10cm) and medium (10-20cm) length, with at least 25% of area being short.	
Long: 70% or more of the grass sward is of long length (>20cm)	

Habitat features (tick a single most appropriate estimate percentage cover for each feature):

Habitat feature:	Estimated % coverage of feature across whole site:				
	None (0%)	Rare/Sparse (<5%)	Occasional (5-15%)	Frequent (15-35%)	Abundant (>35%)
Rushes					
Tussocks					
Bare ground					
Surface water (or waterlogged areas)					

NOTE: Tussock = any patch of herbage at least 5cm taller than surrounding sward.

Other features present on site (circle all present on site):		
Ditches	Walls	Fence lines
Power lines	Hedges/treelines	Other (specify):

