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The effect of management measures on breeding wader populations in the Shannon Callows

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The Shannon Callows is an area of approximately 4,500ha of seasonally flooded grassland flanking the middle reaches of the Shannon and Little Brosna Rivers. Designated as both a Special Area of Conservation (SAC) and a Special Protection Area (SPA), the site, which contains both wetland and grassland habitats, is internationally important for its wintering wildfowl populations. It also holds important populations of breeding Lapwing *Vanellus vanellus,* Redshank *Tringa totanus,* Curlew *Numenius arquata* and Snipe *Gallinago gallinago,* with over 1,500 pairs recorded in 1987. By 2002, this had declined to just over 300 pairs. A research project carried out in 2007/08 recorded high levels of nest predation, mostly by mammalian predators. The National Parks and Wildlife Service (NPWS) have funded a range of management measures since 2006 aimed at protecting and enhancing the wader populations. Measures include the Breeding Wader Grant Scheme (BWGS) offered to farmers with breeding waders on their land, *inter alia* to restrict grazing and field operations during the breeding season. A gamekeeper is deployed to control Fox *Vulpes vulpes* and Hooded Crow *Corvus cornix* populations at sites important for breeding waders, and a predator exclusion fence was erected in 2009 on Inishee Island. Monitoring of wader populations and habitat condition indicate that stocking levels and vegetation height are consistently within recommended limits on fields in the BWGS, compared with similar fields not in the scheme. Wader populations showed an initial recovery, against a backdrop of further declines in the wider Callows, but in 2011, populations crashed, probably as a result of the severe winter of 2010/11. However, since 2011 there has been a steady overall recovery in the total number of pairs. On BWGS land, wader populations on Inishee are recovering more quickly than elsewhere, almost certainly as a result of the predator exclusion fence. On BWGS land outwith Inishee, Redshank and Snipe populations have shown an upward trend since the crash in 2011; Lapwing continued to decline until 2012, but in 2013 showed some recovery.

Introduction

The Shannon Callows are the largest single area of seasonally flooded grassland in Ireland and Britain, covering approximately 4,500ha, stretching from Athlone (NO442) to Portumna (M8704), and covering parts of counties Westmeath, Roscommon, Offaly, Galway and North Tipperary. Seasonal flooding has meant that the area is still extensively farmed, and unlike much of Ireland and Europe it escaped the full rigour of agricultural intensification which took place during the last century (Ausden & Hirons 2002, Wilson *et al.* 2005,

Plate 1. Lapwing chick (Colum Clarke).

Bolton *et al.* 2007, Eglington *et al.* 2008, Lauder & Donaghy 2008). The timing of farming operations varies from year to year, depending on weather conditions; stock are usually turned out to pasture in April–May and remain on the land until November or when winter flooding occurs, whilst hay is usually cut in July or August. The Callows are particularly important for their wintering wildfowl populations, and previously for their breeding populations of some waders and for Corncrake *Crex crex*. The area is made up of two separate Special Protection Areas (SPA) designated under the Birds Directive (79/409/EEC). These are (i) the Middle Shannon Callows SPA (site code 4096) and (ii) the River Little Brosna SPA (site code 4086). The area is also a Special Area of Conservation (SAC) designated under the Habitats Directive (92/43/EEC), and a proposed Natural Heritage Area, under Irish legislation. Four wader species breed regularly on the Callows, mostly on the grazed pastures; Lapwing *Vanellus vanellus,* Redshank *Tringa totanus,* Curlew *Numenius arquata* and Snipe *Gallinago gallinago.* All are Species of European Conservation Concern (SPEC), listed either as SPEC 1, 2 or 3, due to their unfavourable conservation status in Europe. All are on the Red List in Birds of Conservation Concern in Ireland, with the exception of Snipe, which is on the Amber List (Colhoun & Cummins 2013). In 2009, Curlew was added to the IUCN Red List of Threatened Species (BirdLife International 2012), it being one of only two globally threatened bird species nesting in Ireland, along with Corncrake.

In 1987, the Callows held one of the three largest concentrations of breeding waders of lowland wet grassland sites in Ireland and Britain (Nairn *et al.* 1988), but between 1987 and 2002 numbers of all four species declined by between 68% and 83% (Tierney *et al.* 2002). Monitoring at other selected sites important for breeding waders indicates this trend is mirrored elsewhere, and *Bird Atlas 2007–2011* results show severe declines throughout Ireland (Lauder & Donaghy 2008, Suddaby *et al.* 2010, Fernández–Bellon & Donaghy 2011, Balmer *et al*. 2013). Similar declines have also been recorded across Europe (Beintema & Muskens 1987, Stanbury *et al.* 2000, Donald & Greenwood 2001, Wilson *et al.* 2005, Thorup 2006).

It is generally accepted that intensification of agricultural practices has been the main factor in breeding wader declines (Baines 1989, Chamberlain & Fuller 2000, Wilson *et al.* 2001). Habitat measures aimed at creating ideal conditions for nesting have been included in agri-environment schemes in Britain (Ausden & Hirons 2002), but have not always resulted in population recovery, even though suitable conditions have been created (Ausden *et al.* 2009). High rates of nest predation, particularly by nocturnal mammalian predators, mostly Fox *Vulpes vulpes,* are also recorded as having significant impacts on breeding wader populations (Grant *et al.* 1999, MacDonald & Bolton 2008, Schekkerman *et al.* 2009, Rickenbach *et al.* 2011). There have also been a number of studies which have recorded the impact of predator control measures on breeding success. These have included the use of conventional game keeping, with the results being quite variable (Cote & Sutherland 1997, Bolton *et al.* 2007, Fletcher *et al.* 2010), and more recently, the use of anti-predator fences which appear to be largely successful in increasing breeding success (Ausden *et al.* 2009).

The Shannon Callows Breeding Wader Project was introduced in response to the declines recorded by Tierney *et al.* (2002). In 2005, a small-scale pilot grant scheme was introduced with funding from National Parks and Wildlife Service (NPWS), to trial a habitat prescription on the Callows. The pilot scheme was extended in subsequent years and a Breeding Wader Grant Scheme (BWGS) now operates at key sites, with farmers being paid to adhere to a grazing management plan and restrict tractor operations during the breeding season. A project officer provides specialist advice and training, and monitors habitat condition and populations. In addition, selected capital works for tree and scrub removal have been carried out at some sites; these measures provide a more open aspect favoured by incubating birds as it allows for better detection of approaching predators, as well as removing cover for Foxes and nesting and perching areas for corvids, particularly Hooded Crows *Corvus cornix*. Direct control of the impact of predators has also been implemented, mostly through conventional game keeping, coordinated by NPWS. However, in 2007, an anti-predator fence to exclude mammalian predators was erected at Inishee Island, the most important site on the Callows. This paper reports on trends in wader numbers and habitat condition observed on the Shannon Callows within and outwith areas where the BWGS operates, together with an assessment of the effects of the anti predator fence on the wader populations at Inishee.

The Breeding Wader Grant Scheme (BWGS)

The BWGS is an annual voluntary agreement offered to selected farmers in target areas, made up of two tiers. The Breeding Tier is designed to reduce the impacts of agricultural practices on breeding birds, in addition to ensuring the habitat remains suitable for breeding and chick rearing throughout the season. To this end, stocking levels are restricted to <1LU/ha from 10 March to 30 June, and no tractor operations are permitted between 10 March and 15 July (LU = Livestock Unit, coefficients follow Bensted *et al.* 1999). The Late Tier is designed to ensure that there is suitable breeding habitat the following spring. Stocking operations are carefully managed at the end of the year to produce a suitable sward structure. Approximately 210ha is entered into the scheme each year.

Sites known to be of greatest importance for breeding waders were included in the scheme, based on the 1987 and 2002 surveys (Nairn *et al.* 1988, Tierney *et al.* 2002) and subsequent census and breeding observations in 2005, 2006 and 2007 (BirdWatch Ireland, unpublished data). Each site is a discrete area of callow important for breeding waders and consists of a number of usually adjacent sub-sites. Nomenclature follows that of Nairn *et al.* (1988). Management Blocks (MBs) are defined areas, comprising some, all, or partial areas of sites or sub-sites entered into the BWGS, which were regularly monitored to assess habitat condition and populations. Some fields adjacent to BWGS fields, but not in the scheme, were included in some MBs to act as a control; these areas were in close proximity to allow for ease of access during monitoring and were similar habitat, mostly grazed grassland. The list of MBs and their location are shown in Table 1 and Figure 1.

Table 1. Breeding Wader Grant Scheme (BWGS) areas, site and sub-site and corresponding Management Block (MB), Shannon Callows (MB 7 has been omitted since 2010).

Management Block (MB)	Site (see Nairn *et al.* 1988)
MB 1	Site 6, sub-site 4
MB 2 & site 9 sub-site 2 (part of)	Site 9, sub-site 1 & 2 (part of)
MB 3	Site 11, sub-site 8
MB 4 & MB 5	Site 12, sub-site 2, 3 & 5 (parts of)
MB 6	Site 11, sub-site 3 & 4 (parts of)
MB 8	Site 20, sub-site 8
MB 9	Site 23, sub-site 1 & 2
MB 10 & MB 11	Site 24, sub-site 1 (part of)
n/a (Esker Island)	Site 11, sub-site 8 (part of)
n/a	Site 23, sub-site 5 & 6 (parts of)
n/a	Site 19, sub-site 2 (part of); Site 19, sub-site 8 & Site 20, sub-site 7 (parts of)

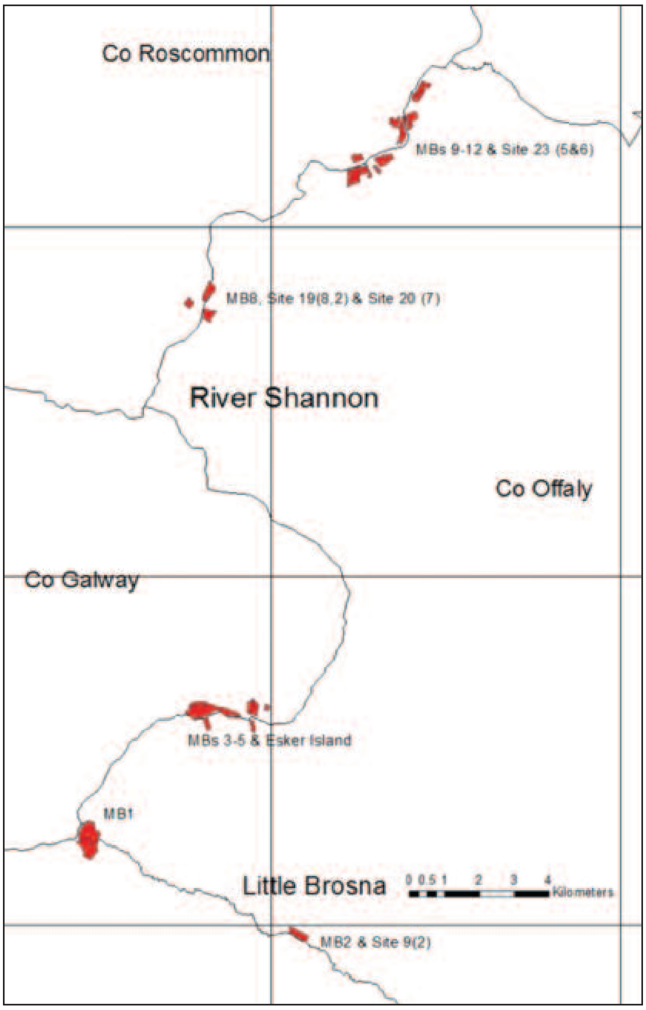

Figure 1. Location of Breeding Wader Grant Scheme (BWGS) areas at the Shannon Callows.

In 2007, additional habitat improvement works were carried out at three sites, Inishee Island, Esker Island and Devenish Island. On Inishee, scrub and trees were removed, ditches were re-profiled and a new scrape created; a sluice and water pump were also installed to allow for management of water levels. On Esker, scrub was removed from about 40% of the island and a new scrape created, and on Devenish, scrub and heavy grass tussocks were removed.

Installation of Predator Proof Fence

Following evidence of high levels of nest predation at several sites from research carried out in 2007 and 2008 (Prosser *et al.* 2008), a predator fence designed to exclude Foxes, Mink *Neovison vison* and other potential mammalian predators was erected in 2009. The basic design of standard permanent fox-proof fences (Kennerley 2008) was amended to include an overlay of chicken wire, which extended approximately 30cm along the ground perpendicular to the base of the fence, pegged down securely to prevent mammals from burrowing under the fence. The fence is 3.7km long, enclosing the whole island (29.6ha) and was operational from the start of the 2009 breeding season.

Methods

Habitat monitoring of MBs was carried out on six visits at three week intervals between 24 March and 27 July between 2008 and 2012. A range of habitat features important for breeding waders were recorded on a field by field basis, including the timing and intensity of stocking and sward height. Since 2008 the mean stocking density (LU/ha) per field has been calculated for visits 3 and 4 (9 May–19 June), as these closely coincide with peak nesting and hatching dates. Sward height was recorded as short (most vegetation was not above ankle height), long (most vegetation was above ankle height) or mixed, i.e. vegetation comprised of roughly equal proportions of short and long. Mean sward height was calculated on visits 1–4, 24 March–19 June, to ensure that most vegetation was short or mixed.

Breeding waders were surveyed on all MBs at the same time as the habitat monitoring. A sub-set of areas were visited weekly during the breeding season to improve population and productivity estimates. Where possible, fields were initially scanned from a distance using a telescope prior to observers walking through the area, following standard methodology. All observations of aerial or ground displays and breeding calls were recorded and used to estimate the number of breeding pairs of each species (O'Brien & Smith 1992). As the season progressed, pairs were judged as having hatched or fledged successfully if adults exhibited the typical behaviour and/or fledglings were seen. In cases where brood calling continued up until the estimated fledging date, but fledglings were not seen, these pairs were regarded as having successfully fledged young and attributed a value of one fledgling per pair. Pairs were judged to have failed if adults were no longer observed before hatching or fledgling was expected. Other outcomes were classified as unknown.

Population trends on Inishee Island may differ from trends on other BWGS land due to additional protection afforded by the predator fence. As this may influence overall trends on BWGS areas, trends on Inishee and other BWGS areas were examined separately. In 2013, the number of visits for census and productivity monitoring was reduced, so results between 2013 and other years are not directly comparable. In 2010, a total of 17 sites not under breeding wader management but for which breeding wader numbers and productivity were known in 1987 and 2002, were surveyed as outlined above. The trends in population and productivity of these sites since 1987 were compared to managed sites. The unmanaged sites received at least one visit during the breeding season, between 26 April and 28 May.

Results

Uptake and compliance with the BWGS has been high each year, with approximately 79% of all target land entered each year and compliance rates of greater than 95%. The number of BWGS fields which have grazing livestock present on visits 3 and 4 is consistently greater than non BWGS fields across all years (Table 2). Grazing levels on BWGS land are also consistently within the recommended limit of <1LU/ha for the scheme on visits 3 and 4, compared to non-grant scheme fields, where grazing levels on visit 4 in particular are consistently above that level (Figure 2). Since 2008, the percentage of the total area entered into the BWGS recording short vegetation on visit 1 has been high and has increased in most years. In comparison, the percentage on non-BWGS land is variable between years (Figure 3). On visit 3 the percentage of the total BWGS area recording a short sward has increased each year since 2008, in spite of annual variations in grass growth. On visit 4, BWGS land is more likely to have a short sward than land outwith the scheme.

Table 2. Percentage of total number of fields in each category (Breeding Wader Grant Scheme and non Breeding Wader Grant Scheme) which had grazing livestock present on visits 3 and 4 (9 May–19 June), Shannon Callows, 2008–2011.

		2008	2009	2010	2011
Visit 3	BWGS	64	52	48	71
	Non BWGS	57	0	0	33
Visit 4	BWGS	100	64	92	83
	Non BWGS	57	43	50	67

In 2012 no values were recorded for visit 4 due to summer flooding

The trend in the number of pairs of breeding waders on BWGS land since the full scheme was introduced is shown in Figure 4, alongside numbers for the same areas in 1987. Populations showed a marked decline in these areas between 1987 and 2009, although with some recovery in 2010. However, this was short lived and numbers declined again in 2011, most likely as a result of the extremely harsh winter of 2010/2011. In 2012 and 2013 Lapwing and Redshank populations have shown some recovery, though Snipe and Curlew have changed little. The total number of pairs of waders at sites surveyed in 2010 is shown in Table 3, alongside numbers from the 1987 and 2002 surveys. The general long term trend on unmanaged sites outside BWGS areas has been one of continued decline, with some variability between some sites in some years. The percentage change between 2002 and 2010 on managed sites in the BWGS shows less severe

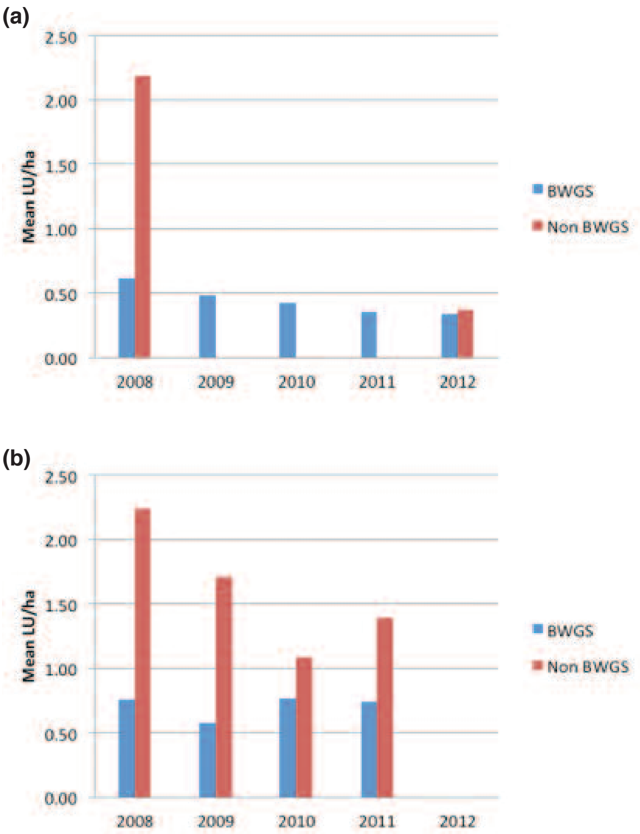

Figure 2. Mean stocking density (LU/ha) on (a) visit 3 (9–31 May) and (b) visit 4 (1–19 June) on fields entered and not entered into the Breeding Wader Grant Scheme (BWGS), Shannon Callows, 2008–2012 (a = in 2009–2011, stocking density on Non BWGS fields was 0) (b = in 2012 no values were recorded for stocking levels on visit 4 due to summer flooding).

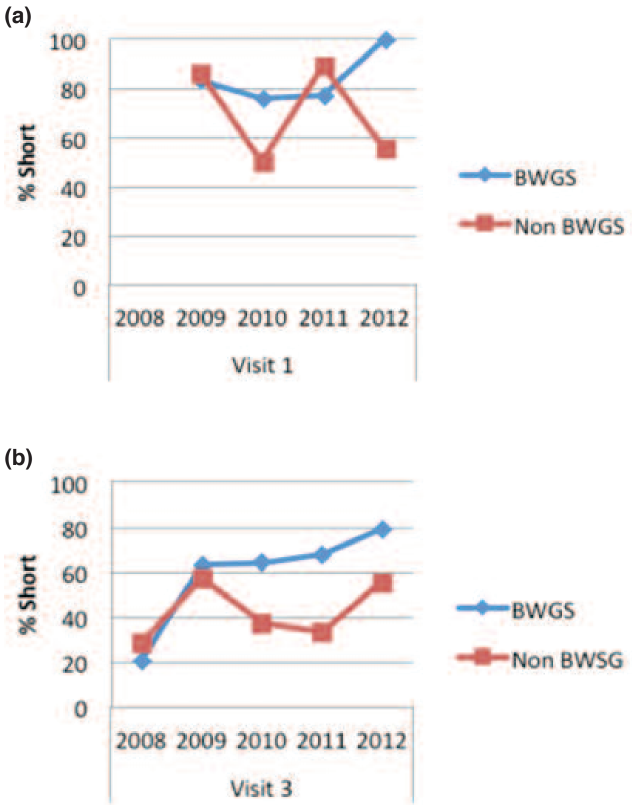

Figure 3. The percentage of fields in each category (Breeding Wader Grant Scheme and non Breeding Wader Grant Scheme) with short vegetation on (a) visit 1 (24 March–15 April) and (b) visit 3 (9–31 May), Shannon Callows, 2008–2012 (a = there was no visit 1 in 2008).

Plate 2. Curlew and chick (Derek Belsey & Cliff Reddick).

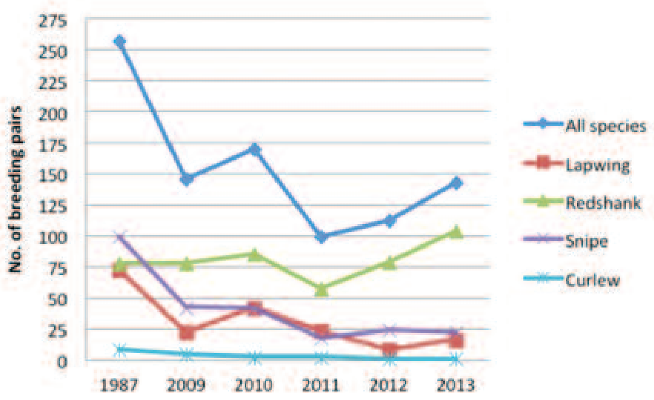

Figure 4. Population trends on Breeding Wader Grant Scheme land, Shannon Callows, 1987, 2009–2013.

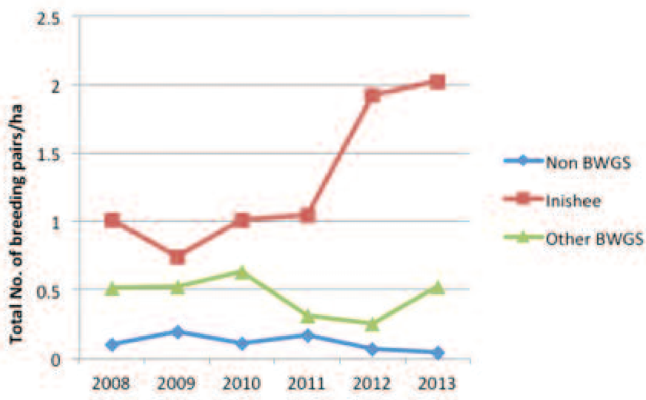

Figure 5. Density (total number of breeding pairs/ha) of breeding waders (Lapwing, Redshank, Snipe, Curlew) on Breeding Wader Grant Scheme land (Inishee and other BWGS land) and land monitored outwith the scheme (Non BWGS), Shannon Callows, 2008–2013.

declines for all species and a considerable increase in Redshank, sufficient to turn the overall trend to a 14% increase (Table 3). Numbers of pairs in 1987 and 2002 correspond to whole site surveys, while numbers from 2010 correspond only to data collected on BWGS or MB land within the site, the amount of which varies, and are generally based on a single visit. Therefore some pairs on these sites may have been missed.

Due to differences in the total area of BWGS and non BWGS land within management blocks, the changes in density (i.e. total number of pairs per ha) of all breeding wader species for BWGS and non BWGS is shown in Figure 5. The non BWGS area varied from 30ha to 93ha between 2008 and 2013, compared with the BWGS area of between 159ha and 219ha. The trend for Inishee Island is shown separately (Figure 5). Population figures for each species on BWGS/MB areas on both Inishee Island and areas outwith Inishee, are shown in Figure 6.

Outwith Inishee Island, populations of Lapwing, Redshank and Snipe appear to be showing some level of recovery since the sharp decline in 2011, with the total number of pairs increasing from a low of 68 pairs in 2011 to 82 pairs in 2013. On Inishee, Lapwing and Redshank populations are recovering well since the installation of the predator fence in 2009; the total number of pairs of breeding waders increased from 22 in 2009 to 61 in 2013, a 177% increase. Snipe numbers on the island are variable, though the apparent decline in 2013 may be due to reduced monitoring. On Devenish Island, where habitat work was carried out in 2009, numbers have not recovered, falling from a total of 13 pairs in 2009 to four pairs in 2013. However, on Esker Island the number of breeding pairs of waders increased from zero in 2009 to three in 2010–2013.

Productivity monitoring of Lapwing on BWGS land appears to indicate that in most years, fledging success is generally below 0.83 to 0.97 chicks per pair. This is the figure considered necessary for a self-sustaining population (Peach

Table 3. Difference in the number of pairs of Lapwing, Redshank, Snipe and Curlew between sites with no active management and sites with active management, Shannon Callows, 1987–2010.

	Unmanaged sites				Managed sites			
	1987	2002	2010	% change 2002–2010	1987	2002	2010	% change 2002–2010
Lapwing	180	23	8	-65	141	43	42	-2
Redshank	235	69	39	-43	148	53	85	+60
Snipe	229	88	10	-88	127	50	41	-18
Curlew	25	4	1	-75	18	3	2	-33
Total	669	184	58	-68	434	149	170	+14

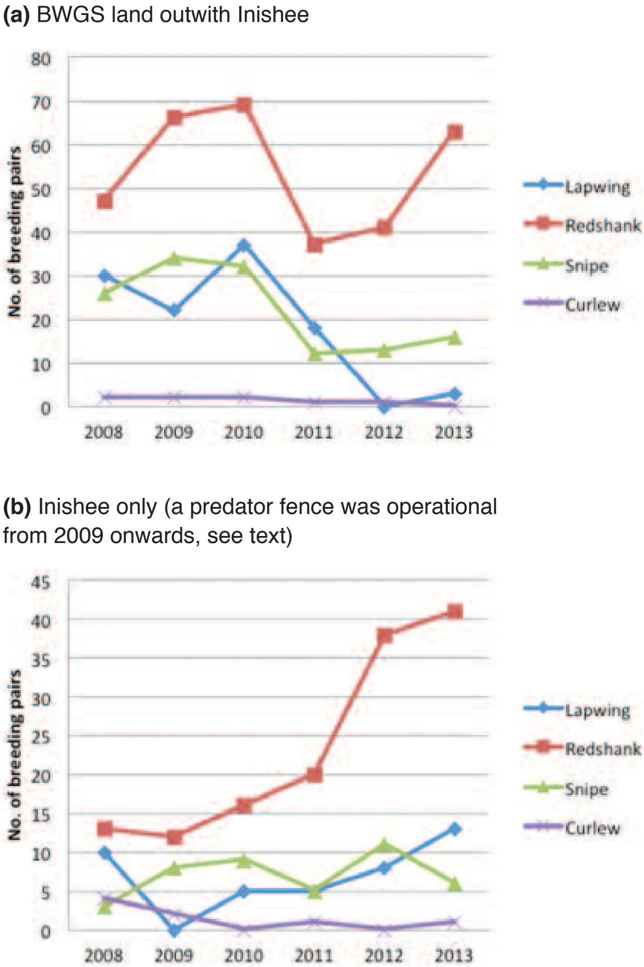

Figure 6. Number of pairs of breeding waders on (a) BWGS land outwith Inishee and (b) on Inishee Island alone, Shannon Callows, 2009–2013.

et al. 1994) (Table 4). While this figure is based on data from Britain, it is unlikely to be significantly different in Ireland, though no published estimates are available. The exception is Inishee Island, where productivity has approached, or exceeded, this figure in most years since 2009. However, the overall percentage of pairs which are successfully hatching and fledging young is increasing, both on Inishee and on the BWGS land outwith Inishee (Figure 7).

Plate 3. Redshank (Eddie Dunne).

Table 4. Lapwing breeding success on Breeding Wader Grant Scheme (BWGS) and Management Block (MB) sites, Shannon Callows, 2009–2013 (where pairs were known to successfully fledge young, one fledgling per pair was assumed unless otherwise observed).

	Year	Total no. of pairs	No. of pairs hatching	Fledging > 1 chick	No. of fledglings seen	No. of pairs failed	Productivity
Inishee	2008	10	3	0	0	8	0.00
	2009	0	0	0	0	0	0.00
	2010	5	5	5	3	0	1.00
	2011	5	5	1	1	3	0.20
	2012	8	8	8	14	0	1.75
	2013	13	7	4	10	0	0.77
Other BWGS areas	2008	30	5	1	0	21	0.03
	2009	22	3	3	5	0	0.23
	2010	37	15	3	6	13	0.16
	2011	18	8	2	3	15	0.17
	2012	0	0	0	0	0	0.00
	2013	3	1	1	2	0	0.67

(a) BWGS land outwith Inishee

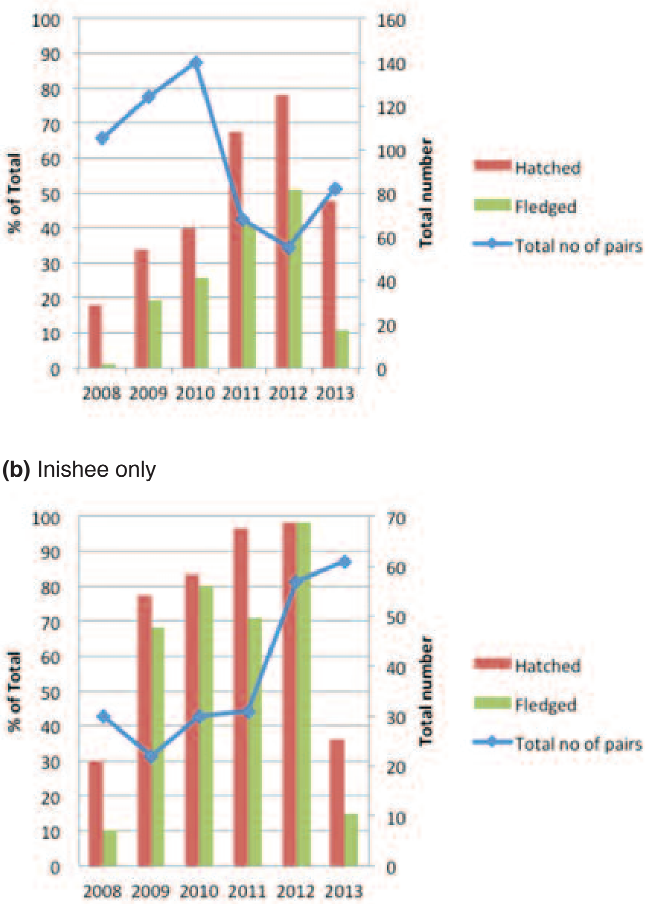

Figure 7. Hatching and fledging success and total number of pairs of all species of breeding waders (Lapwing, Redshank, Snipe, Curlew) on (a) BWGS land outwith Inishee and (b) Inishee only, Shannon Callows, 2009–2013.

Discussion

Results of habitat monitoring indicate that BWGS land is consistently stocked in May and June to within the scheme's recommended level of <1 LU/ha. This contrasts with non BWGS land, which is more likely to be either too heavily stocked (>1 LU/ha) or not stocked at all. Grazing, especially by cattle, produces a heterogeneous sward, suitable for nesting waders, particularly Redshank, Snipe and Curlew. Overstocking can cause trampling of nests, but at densities of <0.7LU/ha, nest losses of Redshank are just 7% (Smart *et al.* 2006), although losses rise to 35–70% at densities of >2.5 LU/ha (Green 1986).

The percentage of short vegetation, which is particularly suitable for Lapwing, has also increased overall on BWGS land on visits 1 and 3, compared with non BWGS land. In 2012, all fields in the BWGS recorded short vegetation, compared with less than 60% in non BWGS fields. This is achieved despite the fact that stocking restrictions apply. In order to achieve this, participating farmers are advised to stock their land earlier in the season than they otherwise would, and this practice has resulted in improvements to habitat suitability throughout the breeding season.

The results of the 2010 scoping survey, which compared the breeding wader population trends on BWGS land and other sites on the Callows where there is no active management or regular monitoring, shows a continued decline on these sites between 1987, 2002 and 2010, compared with BWGS land, where there has been some overall recovery since 2002. Density of breeding waders on land which is regularly monitored since 2008, but which is outwith the BWGS, also shows a continued decline, compared with density on land managed under the BWGS, which shows an overall increase.

Within BWGS land, the population trend every year has been an increase on the previous year, with the exception of a sharp decline in all species between 2010 and 2011, probably as a result of the severely cold weather that winter. December 2010 was one of the coldest months on record in Ireland and there was a prolonged number of days with ground frost recorded (between 52 and 67), almost twice the normal number (www.met.ie). Mean winter soil temperature is one of the most important factors influencing winter survival of Lapwing (Peach *et al.* 1994), and it seems likely that the decline in populations observed in 2011 may be largely attributable to poor winter survival. Since 2011, numbers of Redshank and Snipe have begun to recover, though an overall upturn in Lapwing numbers was not recorded until 2013.

The population trends on Inishee Island have been stable or increasing for Lapwing and Redshank since the installation of the predator fence in 2009. Snipe show more variation, though the declines observed in 2011 and 2013 may be due to poor winter survival in 2010 and a lower level of monitoring in 2013. There are many sources of bias that need to be considered when counting Snipe populations and accurate estimates are difficult to obtain (Hoodless *et al.* 2006). Redshank populations on BWGS land outwith Inishee also showed upward trends on the previous year every year, except 2011. This may indicate that management measures alone are having a positive impact on breeding success, though the influence of ongoing predator control effort is also likely to be a contributory factor. Wilson *et al.* (2005) have shown that Redshank benefit from entry level agri-environmental measures, similar to those contained in the BWGS.

The failure of the Lapwing population to respond better to management measures alone may be due to several factors. Lapwing nests are usually more exposed than those of the other species, and predation of Lapwing nests and/or young outwith Inishee may be occurring at levels which are preventing recovery. The existing game keeping effort may therefore need to be at least sustained over the longer term, if not increased. In addition, Lapwing and Snipe populations have been shown by Wilson *et al.* (2005) to benefit from higher level schemes, with more interventionist management, similar to the habitat restoration measures carried out on Inishee, Esker and Devenish Islands. More habitat intervention measures could therefore also improve Lapwing nest and chick survival by, *inter alia,* providing chicks with better feeding and more cover from predators. Peach *et al.* (1994) observed that poor breeding success up to or just after fledging was the most likely contributory factor in declines observed in the British Lapwing population, and the fact that Lapwing populations continued to recover on Inishee indicates that basic management prescriptions, habitat measures and reducing the impact of predators are all likely to be required to increase breeding success and achieve a recovery in Lapwing populations outwith Inishee.

On Inishee, Lapwing productivity has been close to, or above, the required level to sustain the population in three out of the four years since the predator fence was installed, though it remains low on BWGS land outwith Inishee. However, total hatching and fledging success is increasing on BWGS land outwith Inishee, and encouragingly, 2013 saw an overall increase in the total number of wader pairs for the first time since 2010, though this is largely influenced by increases in the Redshank population. As indicated by other studies (Aebischer *et al*. 2000, Peach *et al.* 2001), central to the success of the BWGS has been the provision of ongoing specialist advice and training to participants. Managing land for wildlife is challenging and requires skill and knowledge of wildlife needs, agricultural operations and the site-specific circumstances. Ausden and Hirons (2002) observed that increased farmer buy-in to a scheme, its successful implementation and increased cost effectiveness, can be achieved by working closely with participants. This has also been found to be the case with the BWGS.

In non-management areas of the Shannon Callows, as in areas important for breeding waders in the wider countryside, population declines are still occurring and it is likely that without implementation of similar management measures, these declines will continue, with inevitably, further site extinctions occurring.

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Barnacle Geese *Branta leucopsis* in Ireland: a report on the 2013 census, and long-term trends

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A complete aerial and ground census of Barnacle Geese *Branta leucopsis* was carried out in Ireland in spring 2013. The census was part of periodic monitoring of the entire Greenland-breeding population which overwinters almost exclusively in Scotland and Ireland, with a very small flock in Wales. A total of 144 island and mainland sites was surveyed along the west and northwest coasts of Ireland. Most sites were surveyed from the air, although several ground-based counts were undertaken. The aerial census was carried out on two days, 26 and 27 March. All sites in a south to north direction from the Blasket Islands, Co. Kerry to Inishtrahull, Co. Donegal were surveyed. A total of 31 sites held 17,500 geese, representing 22% of the flyway population, and an increase of 43% compared with the most recent census in 2008. The combined Scottish, Welsh and Irish total of 80,670 Barnacle Geese is the highest ever recorded. A portion of the range, namely that north of Galway Bay to Inishtrahull was surveyed by aerial census in 2011, 2012 and 2014 in an attempt to monitor annual changes in numbers wintering in Ireland. Totals varied widely and it is suspected this variation was caused by the different times of season in which the surveys were undertaken. Further study of intra-seasonal movements of birds at key sites is necessary.

Introduction

The Greenland-breeding population of Barnacle Geese *Branta leucopsis* winters in Ireland and in western and northern Scotland, with a small outlying flock in Wales (Ogilvie *et al.* 1999). Censusing of this population on the wintering grounds commenced in 1959/60 and has since been undertaken at approximately five-year intervals. Over this period, the population has increased, from 8,277 to 70,501 geese in 2008 (Mitchell *et al.* 2009). Numbers in Ireland increased from 2,771 to 12,232 over the same period. Here they occur predominantly on islands off the west and northwest coasts between Counties Donegal and Galway, with more isolated flocks occurring at fewer scattered locations south to the Magharee Islands in Co. Kerry.

Plate 4. Barnacle Goose (Clive Timmons).

Plate 5. Barnacle Geese and other waterfowl (Carl Morrow, carlmorrowphotography.com).

Thorough surveys that cover the entire wintering range in Ireland are relatively labour intensive, requiring two days of flying in combination with a co-ordinated network of counters monitoring mainland sites on the designated survey days. In the intervening years, only a small proportion of the population is surveyed annually at mainland sites, thereby limiting an assessment of how the population is faring from year to year. Therefore, since 2011, in the years between full censuses, i.e. 2011, 2012 and 2014, an attempt has been made to sample the population during a one-day aerial census in each season.

This paper presents the results of the most recent full census in 2013. It also describes patterns of change at a selection of sites that were regularly covered between 2011 and 2014 and presents an overview of how Barnacle Geese have fared in Ireland since 1959.

Methods

2013 census

A full census of known haunts used by Barnacle Geese was undertaken over three days, between 25 and 27 March 2013, by aerial census and through land-based counts. All sites where geese have been recorded over the last forty years or so, together with a small number of additional sites which looked suitable for Barnacle Geese were included in the census. The aerial census in 2013 was carried out on 26 and 27 March using an Irish Air Corps Rheims Rocket Cessna (model 172). This is the same method that has been used for all aerial censuses to date where a standardised transect taking in all key sites between the Blasket Islands (Great Blasket and Beginish) in County Kerry and Inishtrahull in County Donegal is undertaken. Observers placed at both sides of the aircraft make counts of flocks flushed from the islands. This method was used to census the remote and inaccessible areas, largely the offshore islands. The full methodology is described by Walsh and Merne (1988) and Merne and Walsh (2003).

The census commenced at the Blasket Islands on 26 March at approximately 11.00 hours. From there the flight route was northwards along the Kerry, Clare and Galway coastline and islands as far as Slyne Head, and from Mannin Bay northwards along the Galway and Mayo coast checking islands from Turbot Island to Stags of Broad Haven, and the north Mayo coastline, completing the first days census at 15.00 hours. The survey recommenced the following day at 09.06 hours in Sligo at Inishmurray, and proceeded north along the Sligo and Donegal coast and islands to Inishtrahull and Malin Head, where the census was completed at 11.05 hours.

Ground coverage was achieved at several sites, including Termoncarragh, Annagh Head, Cross Lough, Carriglahan and Fallmore (Co. Mayo), Ballintemple, Kilmacannon and Streedagh (Co. Sligo) and Dunfanaghy (Co. Donegal), all on 25 March.

Annual censuses (2011, 2012, 2014)

In 2011, 2012 and 2014 the northern part of the wintering range of the Barnacle Goose between Inner Galway Bay and Inishtrahull and Malin Head in Co. Donegal was surveyed in accordance with the methodology described above (a combination of aerial and ground-based counts). Counts were undertaken largely by aerial census, with a selection of mainland sites surveyed from ground-based vantage points.

These censuses took place on:

- 24 March 2011 (10.50–15.19)
- 14 February 2012 (9.08–10.53). This census was curtailed approximately half-way through due to poor weather and the remainder of the stretch was completed on 19 February (11.14–12.55)
- 4 March 2014 (10.35–15.48)

Results

2013 census

A total of 144 sites was visited during the 2013 census, and the full list is presented in Appendix 1. Some 31 sites supported flocks of Barnacle Geese (Figure 1, Table 1). The total number of geese recorded was 17,500, and largest numbers were recorded in Counties Donegal, Mayo and Sligo. A relatively large proportion of geese (76%) was recorded in, or associated with, 17 Special Protection Areas (SPAs) designated under the European Birds Directive (Table 1).

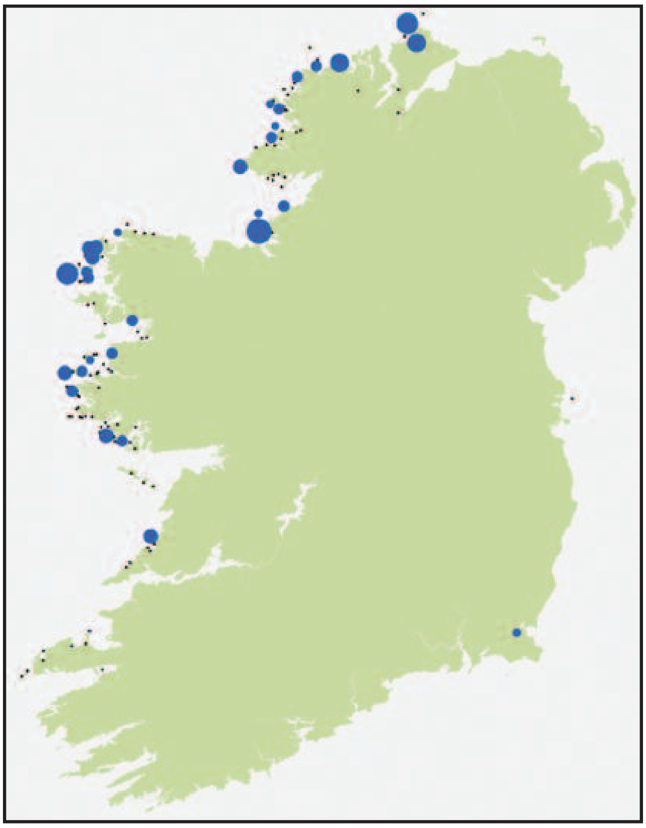

Figure 1. Distribution and abundance of Barnacle Geese during the 2013 census (blue dots), with surveyed sites where no birds were seen (small black dots).

Table 1. Total number of Barnacle Geese (individuals and flocks) recorded in 2013 in each county, and overall, also indicating totals and proportions occurring in Special Protection Areas (SPAs).

	Total number	Total flocks	Total in SPAs	Total SPAs	% in SPAs
Clare	450	1	450	1	100.0
Galway	1,724	5	1,724	3	100.0
Mayo	5,025	10	3,510	3	69.9
Sligo	4,608	4	4,157	2	90.2
Donegal	5,681	10	3,506	7	61.7
Wexford	12	1	12	1	100.0
Overall	17,500	31	13,359	17	76.3

A total of five sites held internationally important numbers of geese and a further 18 sites held nationally important numbers using an updated flyway threshold of 890 geese (Mitchell & Hall 2013), and a national threshold of 175 geese. The largest flocks were recorded at Ballintemple, Inishkea Islands, Malin Head, Dunfanaghy New Lake and Trawbreaga Bay. The full list of sites visited, together with totals recorded is presented in Appendix 1.

Annual censuses (2011, 2012, 2014)

A total of 132 sites was visited in all seasons between 2011 and 2014 inclusive along a standard aerial transect between the northern shoreline of Galway Bay and Inishtrahull, Co. Donegal. The total number of geese recorded varied widely between seasons (5,350 in 2012 to 17,038 in 2013) (Figure 2). County-level counts were highly variable, largely because of a lack of counts in February and March for several key sites, especially Ballintemple and Lisadell in Co. Sligo and Termoncarragh Lake in Co. Mayo (2011 and 2012) and Dunfanaghy New Lake in Co. Donegal (2011). Counts of geese varied considerably at almost all sites between 2011 and 2014. Of the sites that were identified as internationally and nationally important based on the 2013 census (Table 2), the standard deviations were greater than 10% of the mean at all sites with the exception of the Inishkea Islands (8%) and Annagh Head (7%).

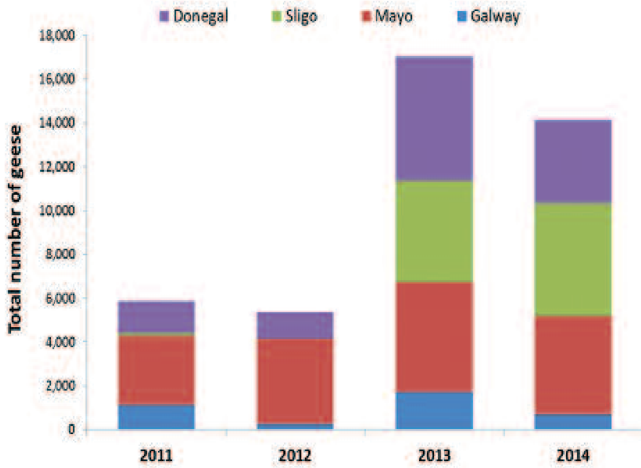

Figure 2. Total number of Barnacle Geese recorded at county level between 2011 and 2014, inclusive.

Table 2. Sites where totals of Barnacle Geese exceeded internationally and nationally important thresholds in 2013. In each case the Special Protection Area (SPA) status is given for sites that have been so designated.

Site	County	Grid	SPA	Total count	% change since 2008
Sites exceeding the international threshold*					
Ballintemple	Sligo	G570440	Ballintemple and Ballygilgan SPA	4,140	5.3
Inishkea Islands	Mayo	F5020	Inishkea Islands SPA	2,250	-10.9
Malin Head	Donegal	C399599		1,800	311.9
Dunfanaghy New Lake	Donegal	C020380	Horn Head to Fanad Head SPA	1,215	279.7
Trawbreaga Bay	Donegal	C4549	Trawbreaga Bay SPA	890	na
Sites exceeding the national threshold*					
St Macdara's Island	Galway	L721299		680	na
Termoncarragh Lake	Mayo	F663350	Termoncarragh Lake and Annagh Machair SPA	640	-24.7
Cross Lough (Mullet)	Mayo	F645295	Blacksod Bay/Broadhaven SPA	620	na
Rathlin O'Birne	Donegal	G467800	Rathlin O'Birne Island SPA	560	51.4
Annagh Head (Mullet)	Mayo	F626345		490	na
Inishshark	Galway	L490650	High Island, Inishark and Davillaun SPA	454	2.3
Mutton Island	Clare	Q9774	Mid-Clare Coast SPA	450	275.0
Inishbarnog	Donegal	G640963		340	6700.0
Moynishmore Is.	Mayo	L865943		320	14.3
Inishsirrer	Donegal	B785302	West Donegal Islands SPA	318	62.2
Birmore Island	Galway	L800262		280	131.4
Streedagh Estuary	Sligo	G710580		246	na
Inishbofin, Inishdooey, Inishbeg	Donegal	B890360	Inishbofin, Inishdooey and Inishbeg SPA	232	na
Carriglahan (Mullet)	Mayo	F610215		225	na
Fallmore (Mullet)	Mayo	F620180		205	na
Kilmacannon (Drumcliff)	Sligo	G590440		205	na
Roonagh Lough	Mayo	L752760		200	284.6
Inishkeeragh	Donegal	B682123	Illancrone and inishkeeragh SPA	191	16.5

* = internationally important sites based on Mitchell & Hall (2013), and nationally important sites based on the estimate given here (17,500)

na = indicates that no geese were present in 2008

The extent of variation between years at site level is illustrated in Figure 3. It shows the means and standard deviations across years at sites that were identified as internationally important based on the 2013 census. It shows that with the exception of the two key sites, Lissadell and Ballintemple, and the Inishkea Islands, which together support a substantial proportion of the national total (37%), there is extensive variation between years at sites supporting lower numbers.

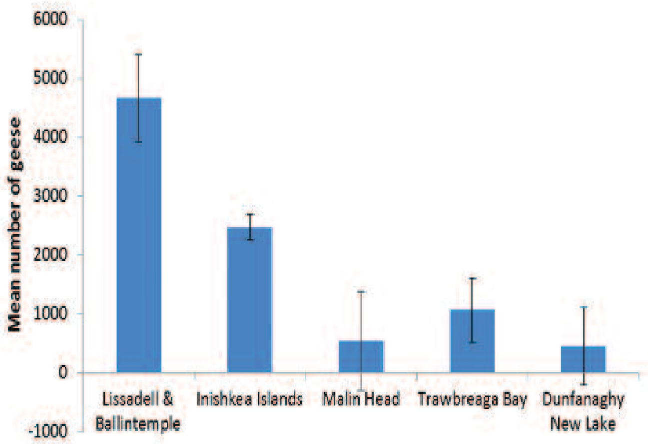

Figure 3. Mean number of Barnacle Geese recorded at internationally important sites between 2011 and 2014, inclusive.

Patterns of change in Barnacle Geese in Ireland between 1959 and 2013

The total number of Barnacle Geese in Ireland have increased from 2,771 in 1959 (Ogilvie 1999) to a peak of 17,500 in 2013 (Figure 4). The rate of increase was relatively consistent up to 2003, but has become substantial since then; there was a 35% increase in numbers between 2003 and 2008 and a further increase of 43% between 2008 and 2013. These rates of increase are notably higher than the changes taking place at flyway level (25% and 14% respectively).

Throughout the period between 1959 and 2013, Ireland has supported on average 23% of the flyway population (Figure 4). The percentage composition has fluctuated widely, and was highest during the earlier years peaking at 34% in 1965 and dropping to a low of 13% in 1982. Since 1998, the percentage composition of the total flyway has shown a sustained increase from 16% to a current level of 22%. There has been an increase in numbers across most counties, with numbers in Donegal showing the greatest increase of 143% between 2008 and 2013. In contrast, no birds have been

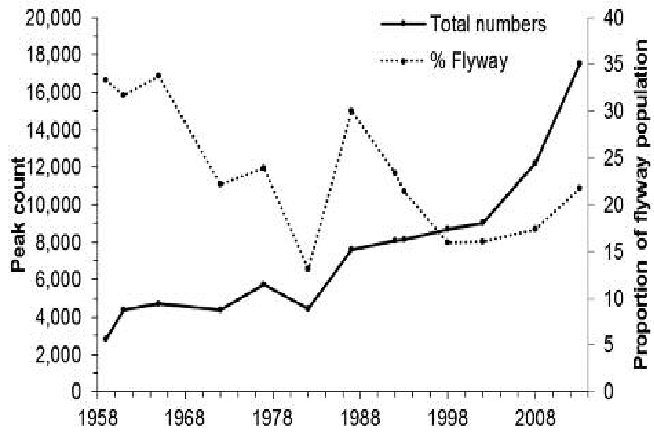

Figure 4. Patterns of change in total numbers of Barnacle Geese in Ireland between 1959 and 2013, with the percentage composition of the flyway population.

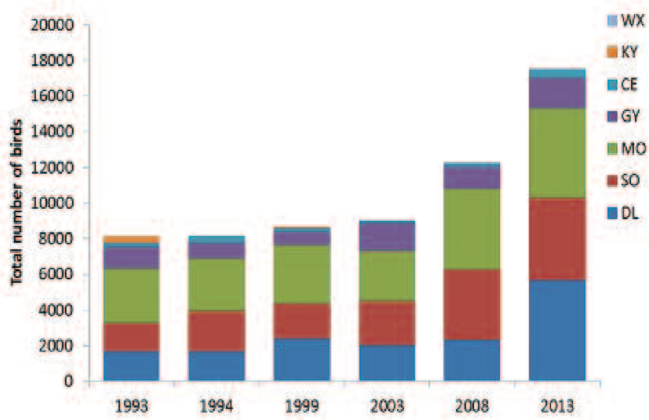

Figure 5. Changes in numbers of Barnacle Geese at county level between 1993 and 2013 (Wexford, Kerry, Clare, Galway, Mayo, Sligo, Donegal).

recorded in Kerry (Magharees Peninsula & Blasket Islands) during full censuses since 1999. However, I-WeBS records (I-WeBS unpublished data) indicate that the site continues to be used, although numbers have declined from 210 in 2003. They were last recorded there during the winter of 2011/12, when 24 birds were reported.

Discussion

Population status

The 2013 census of Barnacle Geese in Ireland, Scotland and Wales was the 14th thorough survey since 1959/60 (Ogilvie *et al.* 1999). Weather conditions during the survey were good, as was the extent of coverage, with all key sites visited. The total of 17,500 geese counted in 2013 represents the maximum total ever recorded in Ireland, and 22% of the overall flyway population. Furthermore, it represents a 43% increase in the total Irish population when compared with the last full census in 2008. There was also an increase in numbers in Scotland, and thus at an overall population level (Mitchell & Hall 2013). The total of 80,670 geese recorded in Scotland, Ireland and Wales (Mitchell & Hall 2013) represents a 14% increase in the population when compared with 2008.

Numbers in Ireland have shown a continued increase during all censuses since 1959/60, with the exception of declines shown in just two intervals, namely between censuses in 1965/66 and 1972/73 and between 1977/78 and 1982/83. Based on a detailed long-term demographic study of birds on Islay since the 1960s, a site which alone supports 56% of this flyway in winter, Trinder (2014) indicated that the demographic rates have, on balance, driven the increase in the overall population, but the specific causes of population increase remain unclear. The study showed that the mean brood size has fluctuated throughout the period between 1.2 and 2.5 young per family. Survival has also fluctuated between 0.7 and 1.3. The proportion of breeding adults has also varied (between 0.04 and 0.33), but there seems to have been a pattern of decline with the five-year mean declining from 0.29 during the late 1960s to a current level of 0.11. There has also been a decline in the proportion of juveniles during the period. However, both of these parameters have shown recovery when examined in the recent shorter (20-year) term (Trinder 2014). That study concluded that the combinations of survival and reproduction have been sufficient for gains to exceed losses and thereby result in population increase.

With the long-term population increase, Mitchell and Hall (2013) have indicated that Islay and some other key sites may be reaching carrying capacity, and this is possibly why the rates of increase here in Ireland were higher than in Britain overall during the 2013 census. But the proportionate increase in Britain was strongly driven by the change at Islay, and in fact the increase in Ireland was comparable with the increase at Scottish sites combined, excluding Islay. It is also possible the recorded increases in Ireland and elsewhere in Scotland may have been influenced by goose management activities on Islay (Trinder 2014). Ultimately, a combination of these factors (McKenzie 2014) may have caused some birds to abandon Islay in favour of alternative wintering areas here in Ireland and elsewhere in Scotland. This may explain some of the especially large counts at sites on the north coast, especially Malin Head and Trawbreaga Bay, which together held 2,690 geese in 2013 compared to just 400 in 2008.

The strong increase in numbers of geese overwintering in Ireland will lead to conservation challenges. As geese utilise both island and mainland sites the greater numbers grazing on agricultural fields is likely to result in increased conflicts between geese and the farming community due to loss of forage. Although the majority of birds were recorded within, or closely associated with, the SPA network, it is acknowledged that a proportion of the geese also use grassland sites that lie outside of designated areas. Suitable agri-environmental schemes to promote goose tolerance targeted at both relevant SPAs and also important non-designated areas could form an integral part of how this species in managed in the coming years.

Distributional range

The total number of flocks wintering in Ireland has also increased over time, in line with the increase in numbers, although the number of flocks (31) recorded in 2013 represents a slight decline when compared with 2008 when 33 flocks were reported. The distribution of Barnacle Geese in Ireland is highly concentrated in the northwest, north of the Aran Islands in Galway. Formerly, flocks were known to occur in several areas in Kerry and Clare, and during each census some 14 locations are surveyed in these counties. However, since 1993 (inclusive), flocks have been recorded only at three locations, namely the Magharee Islands (Kerry) and at Illaunonearaun and Mutton Island (Clare).

Future monitoring

The five-yearly international censuses of Greenland Barnacle Geese provide robust population estimates of the flyway population. However such censuses only provide a snapshot of the distribution of geese during the overwinter period. In an attempt at providing a better indication of annual variation in population levels and site use, aerial censuses were undertaken once per season between 2011 and 2014, and focussed on surveying a sample of sites that hold a significant proportion of the population. These surveys included sites located between Galway and Donegal, excluding only those sites in Clare and Kerry that are known to support a relatively small proportion of the population (<5%). The results showed large-scale variation in the numbers recorded between years, both at site level and overall.

There is some variation with time of season, and these annual censuses were undertaken between mid February and late March, a period when there may have been some northward movement of birds prior to migration. This may explain the lack of birds on the Magharees and Blasket Islands in Kerry during the 5-yearly spring surveys since 1999, possibly reflecting movement of birds away from their mid-winter haunts by this relatively late stage in the season. On this basis, it is possible that when the 5-yearly international censuses are undertaken in the spring, there has already been some

Plate 6. Barnacle Goose (Michael Finn).

movement of birds away from their regular wintering areas. Drawing meaningful conclusions on patterns of change from this variable dataset was not possible. To do so it would require an increase in the overall frequency of the aerial surveys, a greater spread of survey effort throughout the winter period, and a greater input of ground counts to supplement the aerial data.

As the Greenland Barnacle Goose population continues to increase, an increasing proportion of the flyway population are using Irish sites. A better understanding of how Barnacle Geese use both island and mainland sites throughout the season warrants further attention. Increasing overwinter survey effort on a subsample of flocks would provide a better understanding of both arrival and departure dates, as well as intra-seasonal patterns of site use.

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Appendix 1

Sites visited during the Barnacle Goose survey in 2013, arranged south to north from Kerry to Donegal (* indicates Special Protection Area (SPA) with count given where geese present).

Great Blasket Island (V250960)*
Beginish Island (V282988)
Young's Island (V284993)
Smerwick Harbour (Q370050)
Dunacapple Island (Q372102)
Brandon Bay (Q530130)
Lough Gill (Q608141)*
Magharees (Q628212)*
Illaunonearaun (Q834570)*
Bishop's Island (Q855595)
Killard (Q954678)
Carrownore Point (Q988698)
Mattle Island (Q972722)*
Mutton Island (Q9774)* 450
Aran Islands (Inisheer) (L980020)
Aran Islands (Inishmaan) (L930040)
Aran Islands (Inishmore) (L860090)*
Gorumna Island (L880230)
Inishbarra Island (L855265)
Birmore Island (L800262)* 280
Finish Island (L790288)
Inishmuskerry (L783266)*
Duck Island (L769270)*
Mweenish Island (L765295)
Mason Island (L743293)
St. Macdara's Island (L721299)* 680
Illauneeragh Island (L885348)
Croaghnakeela Island (L683320)*
Illaunacroagh (L693348)*
Freaghillaun Island (L732352)
Inishlackan Island (L717375)
Inishdowros Island (L643407)
Fox Islands (L606411)
Illaunurra Island (L588403)
Horse Island (Slyne Head Islands) (L575408)
Chapel Island (Slyne Head Islands) (L530410)
Illaunamid Island (Slyne Head Islands) (L515410)
Inishkeeragh Island (L555448)
Inishdugga Island (L565458)
Turbot Island (L570520)
Eeshal Island (L560530)
Cruagh Island (L530550)* 150
Omey Island (L560550)
High Island (L502575)*
Friar Island (L525575)
Killary (L750660)
Inishshark (L490650)* 454
Inishgort Island (L502632)
Inishskinny Island (L513640)
Inishbofin (Galway) (L535660)*
Inishlyon Island (L565645)
Davillaun (L585660)* 160
Lecky Rocks (L597651)
Inishbroon Island (L632640)
Freaghillaun North Island (L667648)
Crump Island (L677655)
Inishdegil More Island (L735671)
Frehill Island (L708698)
Inishdalla (L630722) 45
Caher Island (L665757)
Ballybeg Island (L650754)
Inishturk (L600740)
Roonagh Lough (L752760) 200
Clare Island (L680850)*
Inisheeny (L920844)
Pigeon Point, Clew Bay (L948849)
Rosturk, Clew Bay (L866957)
Moynishmore Island (L865943) 320
Rosmurrevagh (L859954)
Achillbeg Island (L715925)
Inishgalloon (F621030)
Achill Island (F650040)
Duvillaun Islands (F580160)*
Duvillaun More (F574160)*
Duvillaun Beg (F595165)*
Leamareha Island (F605178)*
Gaghta Island (F601175)
Inishkea Islands (F5020)* 2,250
Carrickmoylenacurhoga Island (F570257)
Inishkeeragh (F605303)*
Inishglora (F610313)*
Mullet peninsula (F700300)*
Fallmore (Mullet) (F620180) 205
Carriglahan (Mullet) (F610215) 225
Cross Lough (Mullet) (F645295)* 620
Termoncarragh Lake (F663350)* 640
Annagh Head (Mullet) (F626345) 490
Erris Head (F722386)
Kid Island (F785435) 30
Stags of Broadhaven (F840480)*
Pig Island (F882440)
Illaunmaster Island (F935432)*
Horse Island (F983425)
Lissadell (G645435)*
Kilmacannon (Drumcliff) (G590440) 205
Ballintemple (G570440)* 4,140
Ardboline (G5544)*
Streedagh Estuary (G650710) 246
Inishmurray (G570540)* 17
St John's Point (G700690)
Rotten Island (G716742)
Fintragh Bay (G680760)
Inishduff (G648724)*
Shalwy Point (G653753)
Muckross Head (G620735)
Rathlin O'Birne (G467800)* 560
Tormore Island (G555909)*
Gull Island (G612925)
Loughros Beg Bay (G660920)*
Sheskinmore Lough (G695956)*
Inishbarnog (G640963) 340
Roaninish (B662027)* 100
Inishkeel (B705000)*
Gweebarra Bay (G780994)
Lettermacaward (B805005)
Termon (B712105)
Inishal Island (B727115)
Inishfree Upper Island (B715120)
Rutland Island (B710140)
Illauncrone Island (B692107)
Inishkeeragh (B682123)* 191
Illanaran (B633150) 35
Aran Island (B650170)
Inishinny Island (B710180)
Cruit Island (B730200)
Owey Island (B712232)
Inishfree Lower Island (B758240)
Gola Island (B770270)*
Umfin Island (B766285)*
Inishmeane (B785287)*
Inishsirrer (B785302)* 318
Tory Island (B855465)*
Inishbofin, Inishdooey, Inishbeg (B890360)* 232
Inishbofin (Donegal) (B890360)*
Inishdooey (B895382)*
Inishbeg (B898398)*
Dunfanaghy New Lake (C020380)* 1,215
Inch Lough (C350230)*
Glashedy Island (C382527)*
Trawbreaga Bay (C4549)* 890
Malin Head (C399599) 1,800
Garvan Islands (C440600)
Inishtrahull (C485653)*
Wexford Harbour & Slobs (T006203)* 12

Nest movement by Little Terns *Sternula albifrons* and Ringed Plovers *Charadrius hiaticula* in response to inundation by high tides

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Keywords: *Charadrius hiaticula*, Little Tern, nest movement, Ringed Plover, *Sternula albifrons*, tidal inundation

Little Terns *Sternula albifrons* are particularly vulnerable to nest inundation by high tides, due to their habit of nesting on shingle beaches. At the Kilcoole Little Tern colony (County Wicklow), a high tide on 19 June 2014 caused considerable damage. While 12 nests were completely washed away, another 13 pairs whose nests had been washed out managed to gather their eggs into new nest scrapes, nine pairs managing to gather all of their eggs and another four gathering all but one of their eggs. This is a behaviour never previously recorded for a member of the family Sternidae. These nests were monitored closely to ascertain the viability of the eggs re-gathered after inundation. The proportion of eggs which were embryonically dead was significantly higher in tide affected nests when compared to non-tide affected nests. A higher proportion of the chicks that did hatch from these tide affected nests died at an early age, than those from non-tide affected nests, though this was not a statistically significant relationship (possibly due to the small sample size of tide affected chicks). The lower hatchability and chick survival in tide affected nests was likely to be due to the mechanical damage caused to the eggs when they were washed out, as well as potential negative developmental affects from the chill caused by the tide. However, of the 13 nests inundated by the high tide, ten are thought to have produced 20 fledglings, a remarkable success considering the circumstances. A pair of Ringed Plovers *Charadrius hiaticula* also had their nest washed away at Kilcoole during a storm on 23 May 2014. They re-gathered all of their four eggs in a new scrape, although none hatched and incubation was abandoned after 30+ days.

Introduction

Since 1985 BirdWatch Ireland and the National Parks and Wildlife Service have carried out a colony protection and management project for the Little Tern *Sternula albifrons* colony at Kilcoole, County Wicklow (O'Briain & Farrelly 1990). Little Terns typically lay two or three eggs in a scrape on a shingle beach near to a source of brackish water, such as at Kilcoole (Patten 1899, Gochfeld & Burger 1996). The Kilcoole

Plate 7. Little Tern (John Fox).

Little Tern project involves having wardens on site throughout the breeding season to monitor breeding attempts and ward off predators. This project has led to a dramatic increase in Little Tern numbers at Kilcoole (O'Connell *et al.* 2014), but the colony remains vulnerable to the effects of high tides, which can have both a severe, direct, impact on productivity and an indirect impact by temporarily breaching the predator-proof fences (Keogh *et al.* 2012). During the 2014 breeding season high tides once again posed a threat to Little Tern nests, however several of the Little Terns responded to this threat with a behaviour previously unrecorded for this species.

Methods

As part of the Kilcoole Little Tern protection scheme, the colony is monitored by wardens 24 hours a day. This allows all Little Tern breeding activity to be closely monitored. The beach was scanned daily to check that terns in known nests were still incubating (indicating that the nest was still active) and to find new nests. When new nests were located their exact position was noted and the nest was given a unique code written on a pebble ca 1m from the nest so that the nest could be easily re-found. The nest was visited again near the end of the incubation period, to check for chicks hatching. This close monitoring gave an excellent picture of the outcome of each breeding attempt.

A binomial regression was used to compare the proportion of eggs which were embryonically dead (i.e. failed to hatch due to inherent infertility, or environmental influences such as excessive cold or mechanical damage causing embryonic death) between tide affected nests and nests which were unaffected by the tide. The same method was used to compare the proportion of chicks which died of natural mortality (i.e. no evidence of predation) between tide affected nests and nests which were unaffected by the tide. Nests which were depredated or abandoned before the end of the incubation period were not considered in this analysis, as there is no way of knowing whether the eggs in these nests would have been embryonically dead.

Results

On 19 June 2014 a high tide at 03:38 (GMT) washed into a gully low down on the beach at Kilcoole, where a large number of Little Tern nests were situated. When the warden on duty inspected the foreshore to assess the damage, it was found that the nests of 12 pairs had been completely washed away. However, another 13 pairs whose nests had been washed out managed to gather their eggs into new scrapes, nine pairs managing to gather all of their eggs and another four gathering all but one of their eggs. The new scrapes were generally ca 0.5–1.0m further inland than the old scrapes. These nests were observed and it was ascertained that the adult birds were incubating the eggs in these new scrapes. In the case of two of the nests where the pair had re-gathered part of their clutch, the final egg from their clutch was found in the seaweed near to the new scrape about six hours after the high tide. In both cases the warden placed the final egg into the new scrape formed by these pairs. Both pairs accepted their eggs back and went on to successfully hatch them.

Out of the 32 eggs in these tide affected nests, six (18.8%) were embryonically dead, and of the 24 chicks hatched, four (16.7%) died of natural mortality generally within the first two days after hatching. In comparison, in the nests which were not tide affected (n = 102), only 7.7% of eggs were embryonically dead, and 6.1% of chicks died of natural mortality (Figure 1). A significantly higher proportion of eggs from tide affected nests were embryonically dead than in nests which were not tide affected (Binomial regression; n = 115, P = <0.05). The proportion of chicks which died of natural mortality was not found to be significantly different between tide affected nests and nests which were not tide affected (Binomial regression; n = 109, P = 0.07), however this may be due to the small sample size.

There was no clear relationship between the incubation stage the eggs had reached and the severity of the impact from the high tide, it is likely that factors such as the length of time spent in the water and the level of mechanical damage suffered by the eggs were more important. However more observations would be needed to ascertain whether certain stages of development within the egg are more vulnerable to damage from inundation by high tides.

There were two further examples of the adaptability of adult Little Terns and the ability of their eggs to tolerate cold

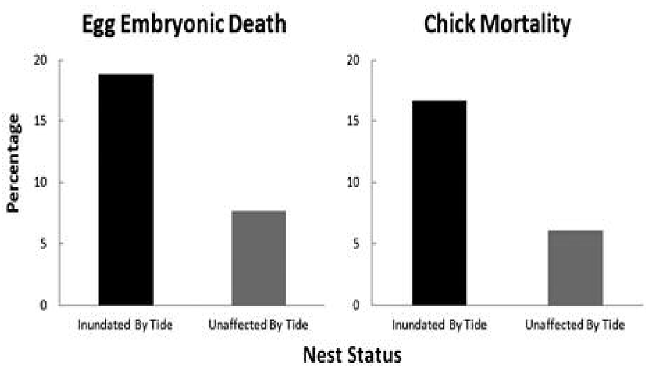

Figure 1. Percentage of eggs of Little Terns which failed to hatch due to egg embryonic death, and of chicks which died of natural mortality, in nests which were inundated by the tide (black) and which were unaffected by the tide (grey).

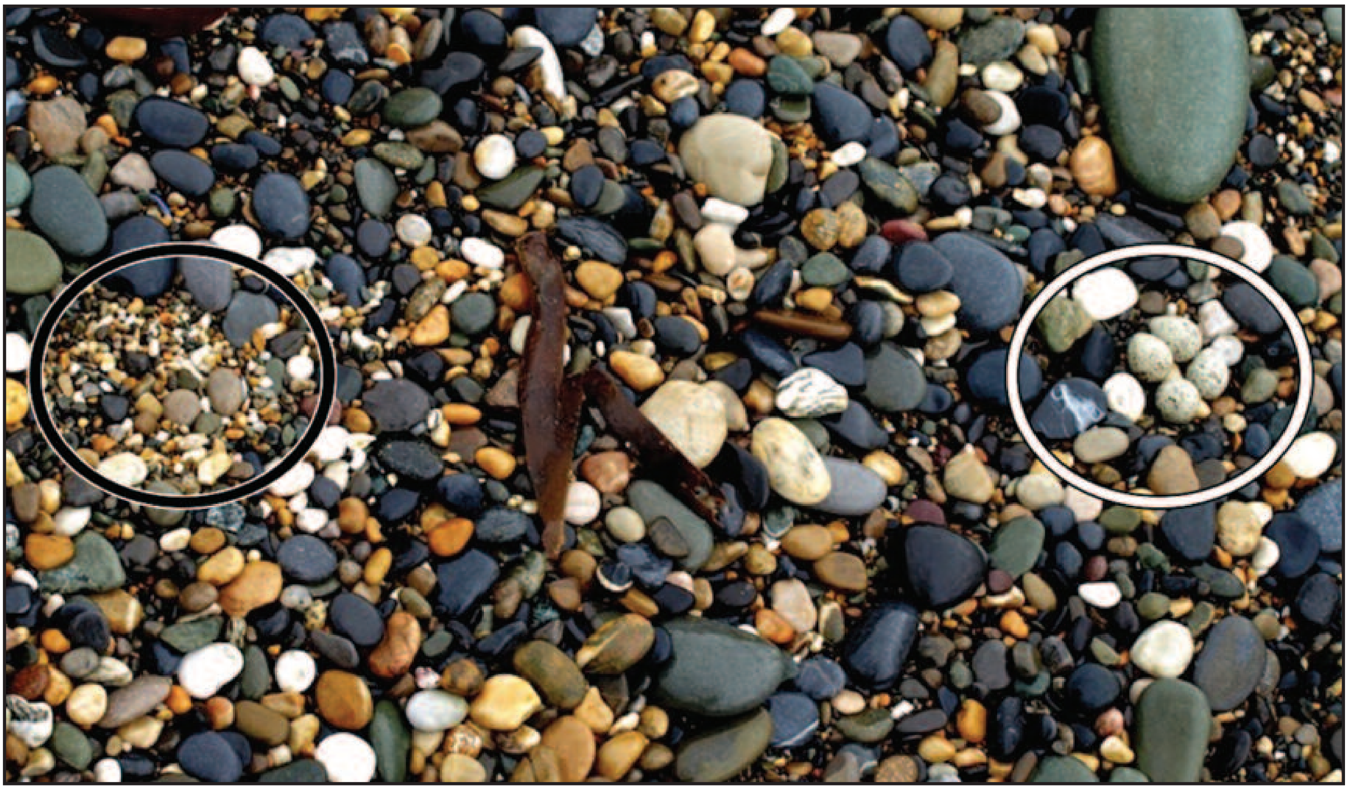

Plate 8. Nest move by Ringed Plover pair after the storm on 23 May 2014. The original nest site is in the black circle, while the new nest (containing four eggs) is in the white circle.

temperatures and long periods without incubation during 2014. During the high tide on 19 June one Little Tern nest was washed over and covered with a layer of seaweed. The eggs were not moved from their original position but the layer of seaweed prevented the adults from returning to incubate. The nest was uncovered by the warden assessing the tide damage about six hours later. The eggs were left in place and the parents returned to incubate and hatched two chicks, one of which died in the scrape, but the other chick is thought to have fledged. A high tide on 15 July washed out one Little Tern nest. The parents made no attempt to reform a new scrape, but both eggs were found nearby in the seaweed line. One was obviously damaged but the second egg appeared undamaged so the two eggs were placed back in the position of the original scrape about four hours after the high tide. The parents returned to incubate and one chick successfully hatched and is thought to have fledged. The damaged egg was considered embryonically dead.

A pair of Ringed Plovers *Charadrius hiaticula* also engaged in similar behaviour at Kilcoole, a storm on 23 May 2014 having washed out a single nest. They re-gathered all of their four eggs in a new scrape ca 1m further inland. However, all of the eggs were visibly damaged and failed to hatch. The nest was abandoned after 30+ days of incubation. This behaviour has previously been observed in the closely related Piping Plover *Charadrius melodus*; see discussion (Wiltermuth *et al.* 2009).

Discussion

The damage caused by the high tide on 19 June shows the vulnerability of the Little Tern to inclement weather and sea conditions. Equally, it demonstrated the robustness of the eggs and adaptability of the adult birds in re-gathering their eggs. The movement of eggs into new nests has been observed in waders and waterfowl, both as a pre-emptive attempt to avoid inundation, to re-gather eggs after inundation and due to anthropogenic influences. Waterfowl have been reported moving nests due to changing water levels near the nest (Avitabile 1969, Fleskes 1991), and as a response to being trapped on the nest by researchers (Oring 1964, Johnson & Kirsch 1977, Blohm 1981, Hill 1985). American Oystercatchers *Haematopus palliates* have been observed rolling their eggs using their bill to new nest sites to avoid encroaching high-tides (Kenyon 1949). Wiltermuth *et al.* (2009) looked closely at this behaviour in Piping Plovers and found that they moved eggs as a pre-emptive attempt to avoid inundation and to re-gather eggs into a new nest after inundation. One individual was also seen to move its nest when disturbed by cattle. Richardson (1967) showed that Black Terns *Chlidonias niger* re-gathered eggs which had been experimentally removed from the nest back into the original nest scrape, by pulling the egg against their breast with the throat and the underside of the bill, but only if the eggs were moved just outside the nest scrape. Moving the eggs any further caused the Black Terns to abandon the original nest and form a new nest where the eggs had been placed. Nests are regularly moved short distances in this way by wardens at tern colonies, and this technique is used at Kilcoole to move nests, vulnerable to high tides, further up the beach (O'Connell *et al.* 2014). However, to the knowledge of the authors, this is the first time that a member of the family Sternidae has been noted to re-gather their eggs in a new nest in response to nest inundation, without any anthropogenic interference. It is also the first time this has been noted in the Ringed Plover, though as only one such instance was observed, a consideration of the success of this strategy for the Ringed Plover will have to await further observations.

The damage caused to eggs by nest inundation by the tide is clear from the higher proportion of eggs which failed to hatch in tide affected nests. Though chick mortality was not found to be significantly higher in tide affected nests, this is likely due to the small sample size of tide affected chicks. The result was near significant and would likely become a clear trend with a larger sample size. As well as the mechanical damage caused by being washed out of the nest scrape, it is possible that the chill of the sea water negatively affected development within the egg, contributing to the lower egg hatchability and chick survival in tide affected nests. Lourens *et al.* (2005) found that chicken eggs which suffered lower temperatures during incubation had lower hatchability and the chicks which did hatch from these eggs had a slower growth rate.

For a bird which nests in an environment where nest inundation is a major hazard, such as the Little Tern, being able to re-gather their eggs post inundation and move them to a new location is a key strategy. While the potential developmental impacts on the eggs have been noted above, this strategy allowed several of the Little Terns whose nests were inundated to successfully breed and maintain at least part of their overall reproductive output. Of the 13 nests inundated by the high tide, ten are thought to have produced 20 fledglings, a remarkable success considering the circumstances.

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Estimates and trends of common breeding birds in the Republic of Ireland

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Knowledge of bird numbers and their trends is critical to underpinning conservation policy to ensure that we are tracking birds and their populations. The Countryside Bird Survey (CBS) has been in operation since 1998 with the primary aim of monitoring breeding bird populations in the Republic of Ireland. It is based on a stratified and random sample of 10km squares, and within each, the most south-westerly 1km square is surveyed twice during each breeding season. Bird numbers are counted along two roughly parallel 1km transects in each square. Recent analyses have shown that the data gathered as part of this survey can be used to generate relatively robust regional densities. The recently completed *Bird Atlas 2007–11* provides detail on the current distribution of birds across Ireland and Britain. Thus, population estimates can be generated when the densities obtained using the CBS dataset are applied in accordance with the distribution patterns from the bird atlas. This paper presents the trends and estimates for 53 species for the 16-year period between 1998 and 2013. Overall, 20 species showed increasing trends, 16 species declined, while the remaining 17 species remained relatively stable. Greatest increases occurred in Blackcap *Sylvia atricapilla* and Goldfinch *Carduelis carduelis,* while greatest declines occurred in Grey Wagtail *Motacilla cinerea,* Stonechat *Saxicola rubicola*, Meadow Pipit *Anthus pratensis* and Greenfinch *Chloris chloris.* The trend patterns illustrated that there were very severe declines in many species between 2009 and 2012 which coincided with two especially cold winters (2009/10 and 2010/11). Numbers of most species appear to have recovered since then. The CBS trends for Skylark *Alauda arvensis,* Meadow Pipit, Grey Wagtail and Stonechat showed that the relative abundances of all of these species were lowest in 2011, but increased in 2012 and 2013. More than 52 million individuals of 49 common breeding species were estimated. Wren *Troglodytes troglodytes*, with an estimate of 5.4 million individuals, contributed more than 10% of the total number of birds recorded. Swallow *Hirundo rustica,* Robin *Erithacus rubecula* and Blackbird *Turdus merula* were the next most numerous, at more than 4 million individuals each. In total, 15 species were estimated at more than 1 million individuals each. Incorporation of the bird atlas data permits vastly improved estimates by providing better informed distribution ranges across which the regional densities were extrapolated. However, estimation of densities and population sizes based on data from annual monitoring surveys alone are limited to species with widespread distributions because of the relatively low coverage and the limited detection rate of scarce species using this methodology.

Introduction

The status of Ireland's terrestrial breeding bird populations prior to 1998 was poorly known, although two breeding bird atlases, undertaken between 1968–72 (Sharrock 1976) and 1988–91 (Gibbons *et al.* 1993), showed that some alarming range contractions had taken place over the twenty-year period. This had implications for changes in population levels. The declines in distribution range of several farmland bird species coincided with a period of increased agricultural intensification. Similar declines occurred throughout Europe over the same period, and were attributed to agricultural intensification, which was brought about by increased demand for agricultural productivity following the Second World War (Krebs *et al.* 1999, Donald *et al.* 2001).

Agriculture continues to occupy the largest proportion (almost two-thirds) of Ireland's land surface area (Department of Agriculture & Food 2008), with the remaining land area consisting mostly of peatland (14%, Connolly *et al.* 2007) and woodland (9%, Anon 2007). It is perhaps as a consequence of a long history of a continuously changing environment that the majority of Ireland's countryside birds are habitat generalists. They have adapted and occur in a variety of habitats and many are very widely distributed, therefore it is difficult to detect subtle changes in status. Nonetheless, the recently published *Bird Atlas 2007–11* (Balmer *et al.* 2013) (hereafter referred to as "the bird atlas"), has shown that the ongoing declines in many farmland birds have persisted to the present day. Notable species suffering declines have been Yellowhammer (hereafter, scientific names are given in Table 1) and Skylark.

In 1998, the Countryside Bird Survey (CBS) was initiated with the primary objective of monitoring the trends of these common and widespread breeding bird species in the Republic of Ireland. It is an annual survey that employs the efforts of around 200 observers each year. Trend analyses are undertaken on a regular basis on more than 50 common and widespread breeding birds. Recent analyses (Crowe *et al.* 2014) have shown the scope of this survey extends beyond annual trends, and that CBS data in conjunction with data from the bird atlas can be used to inform on total numbers present. Population estimates are important for setting conservation priorities (Heath & Evans 2000, IUCN 2004, Keller & Bollmann 2004, Perez-Arteaga *et al.* 2005) and national estimates are compiled at a wider scale to generate European and/or global population estimates (BirdLife International 2004, Wetlands International 2006). National estimates thereby allow an assessment of the conservation status of a site at national level and/or the importance of a country in a wider geographical context.

This paper presents details on the annual trends of Ireland's common birds between 1998 and 2013 inclusively. It also presents the estimates for common and widespread breeding birds in the Republic of Ireland using data from the CBS, together with distribution data from the bird atlas.

Plate 9. Robin (Michael Finn).

Methods

Data sources

The Countryside Bird Survey (CBS) is based on a random stratified approach. The Republic of Ireland was divided into eight regions, and 10km squares (based on the Irish National Grid) were randomly selected within each, and allocated in sequence. For each 10km square selected, the 1km square at the extreme southwest corner is surveyed. Those with less than 50% land, e.g. coastal areas or lake shores, have been excluded, leaving some 700 possible survey squares. The survey aims to achieve coverage of the same 1km squares each year, ideally by the same observer, although there is likely to be some change of survey participants.

The CBS uses a line-transect method. Two bird-recording visits to each survey square per year are undertaken. These visits are timed so that the first is in the early part of the breeding season (early April to mid-May) and the second at least four weeks later (mid-May to late June). This reflects the abundance of residents and early migrants, which tend to be more easily detected in the first visit, and later migrants, which are more abundant in the second visit. Observers are asked to begin their counts between 06.00 and 07.00 hours to coincide with maximum bird activity, but to avoid concentrated song activity at dawn. Observers are also encouraged to record only adult birds seen or heard as they walk along their transect routes. Bird counts in heavy rain, poor visibility, or strong winds are discouraged. Survey work has been undertaken during all seasons since 1998, but was prevented in 2001 by

Plate 10. Wren at the nest (Michael Finn).

foot-and-mouth disease restrictions. Population trends were produced for the Republic of Ireland and were also produced for each of the eight sampling regions (Figure 1). Full details on the survey design and production of species indices are presented in Crowe *et al.* (2010).

The CBS is largely targeted at monitoring species with widespread distributions across the island. Accordingly, many of the colonial-nesting species, such as seabirds, whose breeding distributions are largely confined to coastal wetlands or to inland lakes, and/or dispersed and shy or skulking species with sparse distributions such as Curlew *Numenius arquata* and Snipe *Gallinago gallinago* are not adequately monitored using CBS methodology. Trends for these species are not presented here.

The bird atlas for Ireland and Britain began in November 2007, and unlike the CBS, it aimed to achieve coverage of all 10km squares on both islands during winter and summer. In Ireland, the Irish National Grid formed the basis for identifying the sampling units. Two survey methods were used. The simpler 'Roving Records' aimed to gather details on presence or absence of a species in each 10km square. The second 'Timed Tetrad Visit' (TTV) method was used to provide an indication of relative abundance. The TTV survey method is considerably more labour intensive as it required the observer to devote time to surveying a minimum of eight tetrads (2x2km squares) within their allocated 10km square. They were required to spend at least two hours in each tetrad and to focus their survey effort within the major habitats present in that tetrad. It was deemed from the outset that the coverage of all 10km squares in Ireland for TTVs would be unachievable. Therefore, a chequerboard approach was applied, where efforts were focused instead on ensuring TTV coverage of every alternate 10km square. Full details of the survey methods and coverage are presented in Balmer *et al.* (2013).

Trend analyses

For generating trends based on CBS data, the total number of adult birds of each species detected in each 1km square was calculated for each year. Full details are presented in Crowe *et al.* (2010) and are summarized below. The maximum of the two counts (from early and late visits) was used as the annual measure of relative abundance for each species. Annual population indices were calculated using TRIM (Trends and Indices for Monitoring Data), a program used for the analysis of time series of counts with missing observations (Pannekoek & van Strien 1996). Counts were modelled as a function of square (site) and year effects, with interpolated estimates for site-year combinations with missing data. The stratified sampling design results in unequal representation of regions across Ireland, so annual counts were weighted by the inverse of the proportion of the area of each region that was surveyed that year. Population trends for species occurring in a mean of 30 or more squares over the duration of the survey were estimated by examining the overall rate of annual change, as caution is urged because of low precision associated with sample sizes smaller than 30 (Joys *et al.* 2003). Population change is usually displayed in the form of indices, where the results from one season are set to some arbitrary figure, usually 1 or 100, and index values are calculated for all other seasons according to how each relates to the base season (1998). The mean annual change was estimated by fitting a regression line through the data. Trends were calculated across all habitats.

Population estimates

Specific details on how the estimates were produced are presented in Crowe *et al.* (2014). Densities were first produced using CBS data for all common and widespread species using distance sampling analyses, while data gathered during the bird atlas were used to describe the patterns of distribution of each species. Specifically, this latter dataset was used to (1) quantify the distribution of each species (10km squares), and (2) generate an indication of proportion occurrence of each species within each square.

CBS data were first used to generate densities. Bird totals were calculated for each 200m section, square and distance band, and were pooled across five years between 2006 and 2010 inclusive. Although birds are recorded in three bands, only two defined bands are available through CBS methods, given that the third, outermost, distance band is unbounded, and counts in an unbounded category are difficult to interpret (Buckland *et al.* 2001). For resident species, analyses were restricted to the early visit only given earlier occupation of nest sites and breeding relative to the migrants (www.bto.org/about-birds/birdtrends/2013). This reduces the risk of recording juveniles and post-breeding flocks of species such as Woodpigeon and Rook normally recorded during late visits. For migrant species data from both visits were included and treated as independent visits.

Data from these distance bands were modelled and density estimates produced using Distance sampling software developed by Buckland *et al.* (2001) (Version 6.0, Thomas *et al.* 2010). Count data were fitted with a half-normal detection function, one of two detection functions available, and the model that is recommended by Thomas *et al.* (2010) for binomial data of this kind.

The total number of breeding birds of each species was estimated for each 10km square by multiplying the mean regional density generated by the CBS by the proportion of occupancy generated by bird atlas data, and by the total area of the 10km square (coastal squares and those divided by region boundaries typically had lower areas). Regional estimates were then calculated by totaling the estimates of squares within each region, and a population estimate by summing the regional estimates. Confidence intervals generated for the densities estimated for each species in each region were treated similarly to generate upper and lower limits. The estimates presented are of individuals detected.

Results

CBS coverage and annual trends

In total, 401 1km squares have been surveyed as part of CBS between 1998 and 2013 (Figure 1), all of which have been surveyed in two or more years. The number of squares covered in any one season ranged from 259 in 1998 to 325 in 2000. Overall, 20% of squares were covered in all 15 years, and 72% of squares in 10 years or more. Highest coverage has been in the southwest and western regions and lowest in the northeast and midlands regions. However, in relative terms, coverage continues to be highest in the eastern regions, with an average 76% and 83% of available squares covered in the east and southeast respectively.

A total of 158 species was recorded between 1998 and 2013. Of this total, 53 species were recorded in 30 or more squares and were included in the trend analyses (Table 1). The list of monitored species includes three that are Red-listed as Birds of Conservation Concern in Ireland (Colhoun & Cummins 2013), Meadow Pipit, Grey Wagtail and Yellowhammer, and a further 17 that are Amber-listed. Overall, a total of 16 species declined between 1998 and 2013, while 20 species increased and 17 species remained stable (Table 1). Declining trends were shown for Grey Heron, Kestrel, Stock Dove, Swift, Skylark, Meadow Pipit, Grey Wagtail, Robin, Stonechat, Song Thrush, Mistle Thrush, Goldcrest, Rook, Raven, Starling and Greenfinch. The patterns of change of a selection of these species are presented in Figure 2. The decline in Grey Wagtail was considered especially severe, with a mean annual decline of 9.0% per annum. It was one of a suite of species, which includes several others listed as declining above, which showed especially dramatic declines between 2009 and 2011, coinciding with two severe and prolonged cold winters. However, most of these species appear to be in recovery since 2011 (Figure 3).

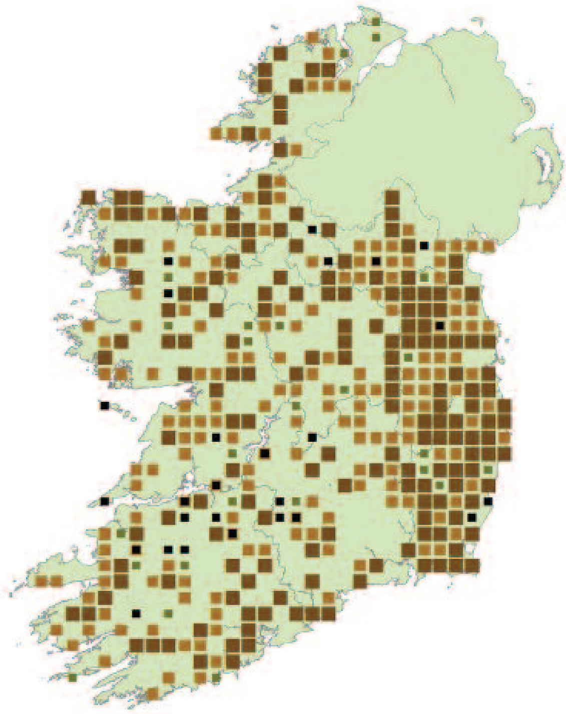

Figure 1. Map showing coverage during the CBS between 1998 and 2013, illustrating the eight sampling regions, also showing the extent of coverage within each ranging from best coverage (largest squares, 12–15 years) through to poor coverage (smallest squares, 2–6 years). Small black squares indicate those that have been consistently poorly covered.

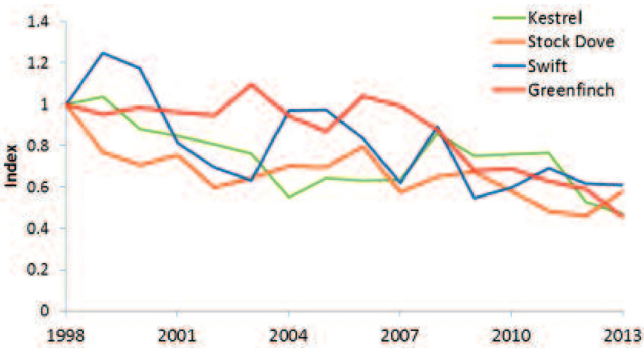

Figure 2.Trends in a selection of declining species.

Table 1. Species recorded in 30 squares or more during the CBS between 1998 and 2013, indicating the mean number and proportion of squares in which each species was recorded, the mean annual change (trend) and the estimates of individuals. Red- and amber-listed species of Birds of Conservation Concern in Ireland (BoCCI) are also indicated (R & A). Significant trends are represented by asterisks (** indicates a highly significant trend (P = <0.01), and * a moderately significant trend (P = <0.05). Population estimates are given with upper and lower 95% confidence intervals.

Species		BoCCI[1]	Number of squares	Proportion squares	Mean annual change[2]	Estimate of individuals
Mallard	*Anas platyrhynchos*		85	28	0.04	[3]
Pheasant	*Phasianus colchicus*		238	79	2.09**	281,320 (221,020–350,140)
Grey Heron	*Ardea cinerea*		61	20	-3.16**	[3]
Sparrowhawk	*Accipiter nisus*	A	30	10	-1.91	12,340 (9,100–14,830)
Kestrel	*Falco tinnunculus*	A	39	13	-3.2**	16,470 (12,100–21,220)
Moorhen	*Gallinula chloropus*		37	12	-0.87	[3]
Feral Pigeon	*Columba livia*		35	12	0.36	[3]
Stock Dove	*Columba oenas*	A	32	11	-3.04**	36,830 (20,010–57,670)
Woodpigeon	*Columba palumbus*		268	89	2.48**	2,315,360 (1,857,130–2,809,470)
Collared Dove	*Streptopelia decaocto*		62	21	3.97**	199,800 (119,750–294,750)
Cuckoo	*Cuculus canorus*		73	24	-0.88	11,150 (6,750–16,830)
Swift	*Apus apus*	A	39	13	-3.85**	68,920 (25,520–130,540)
Magpie	*Pica pica*		252	84	0.01	601,110 (478,190–741,140)
Jackdaw	*Corvus monedula*		223	74	1.51**	2,308,180 (1,628,220–3,068,910)
Rook	*Corvus frugilegus*		244	81	-1.51**	3,392,520 (2,220,050–4,719,510)
Hooded Crow	*Corvus cornix*		238	79	1.64**	465,490 (354,460–586,520)
Raven	*Corvus corax*		68	23	-2.26**	58,460 (38,030–79,940)
Goldcrest	*Regulus regulus*	A	150	50	-1.26**	611,280 (443,590–818,300)
Blue Tit	*Cyanistes caeruleus*		239	80	0.8**	1,865,350 (1,503,720–2,273,990)
Great Tit	*Parus major*		216	72	3.32**	1,086,300 (870,340–1,335,580)
Coal Tit	*Periparus ater*		178	59	2.58**	765,850 (560,550–996,620)

Table 1 (continued).

Species		BoCCI[1]	Number of squares	Proportion squares	Mean annual change[2]	Estimate of individuals
Skylark	*Alauda arvensis*	A	125	42	-3.04**	322,900 (218,410–430,880)
Sand Martin	*Riparia riparia*	A	33	11	-1.53	517,310 (144,100–1,113,380)
Swallow	*Hirundo rustica*	A	268	89	0.01	4,960,250 (4,076,190–5,932,420)
House Martin	*Delichon urbicum*	A	92	30	2.41**	537,200 (309,400–838,300)
Long-tailed Tit	*Aegithalos caudatus*		52	17	1.45	102,570 (61,920–153,600)
Chiffchaff	*Phylloscopus collybita*		132	44	4.04**	269,970 (198,200–352,230)
Willow Warbler	*Phylloscopus trochilus*		217	72	4.18**	1,377,910 (1,064,110–1,729,670)
Blackcap	*Sylvia atricapilla*		99	33	18.23**	222,750 (140,060–327,170)
Whitethroat	*Sylvia communis*		65	22	3.24**	86,170 (58,000–116,680)
Grasshopper Warbler	*Locustella naevia*		38	13	2.34*	21,160 (12,990–31,540)
Sedge Warbler	*Acrocephalus schoenobaenus*		67	22	0.66	111,380 (74,630–152,670)
Wren	*Troglodytes troglodytes*		289	96	0.06	5,356,710 (4,545,510–6,186,180)
Starling	*Sturnus vulgaris*	A	214	71	-1.19**	2,118,580 (1,473,510–2,873,120)
Blackbird	*Turdus merula*		281	93	0.7**	4,362,070 (3,743,890–5,026,340)
Song Thrush	*Turdus philomelos*		255	85	-1.2**	874,140 (704,710–1,053,350)
Mistle Thrush	*Turdus viscivorus*	A	133	44	-3.04**	197,070 (144,500–254,510)
Robin	*Erithacus rubecula*	A	281	93	-2.32**	4,769,540 (4,121,450–5,488,570)
Stonechat	*Saxicola rubicola*	A	63	21	-5.62**	109,770 (72,130–161,180)
Wheatear	*Oenanthe oenanthe*	A	31	10	-0.72	43,530 (18,560–75,290)
Dunnock	*Prunella modularis*		224	75	0.40	1,509,650 (1,198,330–1,821,150)
House Sparrow	*Passer domesticus*	A	145	48	3.3**	1,855,720 (1,302,040–2,501,830)
Grey Wagtail	*Motacilla cinerea*	R	39	13	-8.97**	73,920 (53,800–96,150)

Table 1 (continued).

Species		BoCCI[1]	Number of squares	Proportion squares	Mean annual change[2]	Estimate of individuals
Pied Wagtail	*Motacilla alba*		149	50	0.46	442,920 (328,840–567,330)
Meadow Pipit	*Anthus pratensis*	R	177	59	-4.38**	1,463,310 (1,090,350–1,869,060)
Chaffinch	*Fringilla coelebs*		275	92	1.61**	3,298,320 (2,767,400–3,871,930)
Greenfinch	*Chloris chloris*	A	168	56	-4.19**	693,890 (520,480–879,350)
Goldfinch	*Carduelis carduelis*		140	47	7.72**	755,970 (551,890–989,620)
Linnet	*Carduelis cannabina*	A	124	41	0.67	451,430 (306,500–619,180)
Redpoll	*Carduelis cabaret*		58	19	6.17**	265,890 (149,140–394,970)
Bullfinch	*Pyrrhula pyrrhula*		135	45	3.96**	446,570 (343,580–570,320)
Yellowhammer	*Emberiza citrinella*	R	76	25	-0.46	214,150 (143,020–290,390)
Reed Bunting	*Emberiza schoeniclus*		87	29	0.10	180,370 (128,240–240,870)

1 From Birds of Conservation Concern in Ireland (Colhoun & Cummins 2013)

2 Mean annual change per year

3 No estimate was generated for these species on the basis that this methodology is not considered appropriate

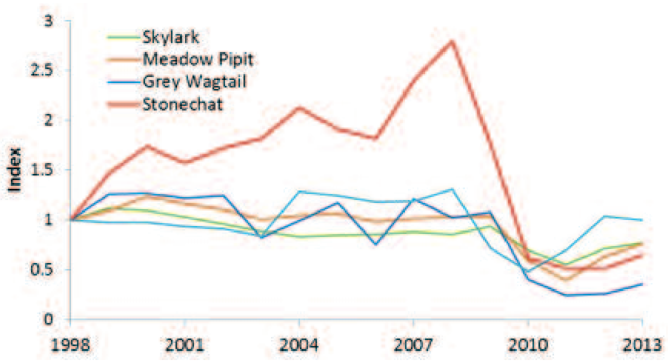

Figure 3. Trends in species previously reported affected by the cold winters of 2009/10 and 2010/11, showing apparent recovery between 2011 and 2013.

Increasing trends during the period were shown in Pheasant, Woodpigeon, Collared Dove, House Martin, Blackbird, Grasshopper Warbler, Blackcap, Whitethroat, Chiffchaff, Willow Warbler, Blue Tit, Great Tit, Coal Tit, Jackdaw, Hooded Crow, House Sparrow, Chaffinch, Goldfinch, Redpoll and Bullfinch (Table 1). Most noteworthy were the increases in Blackcap and Goldfinch which were especially strong. Both species have shown increases in almost all years throughout the CBS, but with a notable 20% decline in both species between 2012 and 2013.

Patterns of change across species with similar habitat requirements have been relatively consistent over time. Some examples are illustrated in Figure 4, which shows change in Robin, Song Thrush and Mistle Thrush (Figure 4a), and in the three tit species (Figure 4b). Similarities over time in trend patterns for Skylark and Meadow Pipit are shown in Figure 3.

Population estimates

Altogether, more than 52 million individuals of 49 species were estimated in the Republic of Ireland (Table 1). Wren was the commonest of the species analysed, with an estimate of more than 5.4 million individuals, contributing more than 10% of the total number of birds recorded. Swallow, Robin and Blackbird were the next most numerous, at more than 4 million individuals each, while 15 species were estimated at more than 1 million individuals each.

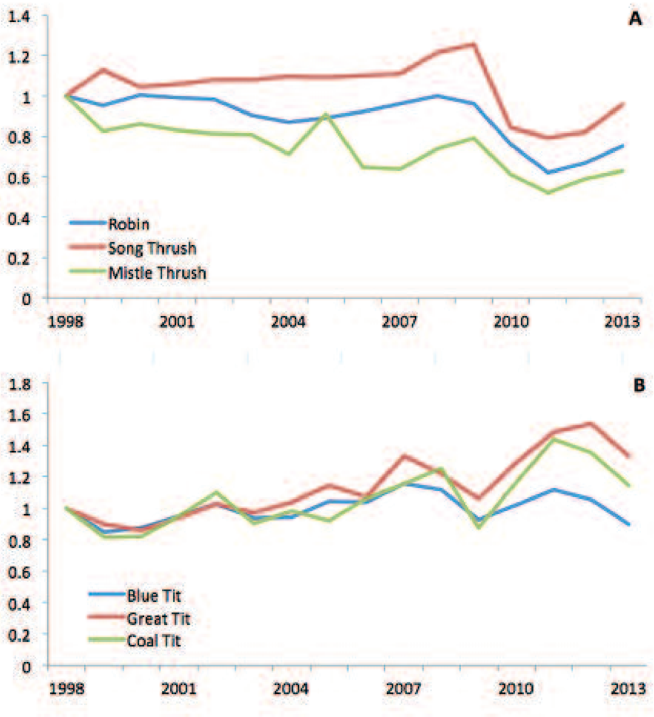

Figure 4. Trends in a selection of species grouped according to habitat requirements, illustrating the similarities in patterns of change in (a) three songbirds Robin, Song Thrush and Mistle Thrush (declining trends) and (b) Blue Tit, Great Tit and Coal Tit (increasing trends).

Plate 11. Blackcap (John Fox).

Discussion

The CBS continues to inform on significant changes taking place in many of our common and widespread birds. The present analyses indicate that the trends of most species are stable or increasing. The striking patterns of increase in Blackcap and Goldfinch throughout the period have been especially noteworthy. However some caution is urged when interpreting these trends in the status of Ireland's countryside birds for two main reasons. Firstly, the CBS has been in operation for a relatively short period of time, 16 years. It therefore does not include the period during the 1970s and 1980s when considerable changes in bird populations were taking place in Ireland and Britain, as documented by the bird atlases (Balmer *et al.* 2013). Secondly, the CBS is targeted at common and widespread species and largely excludes those that have confined distributions and that are not recorded in a sufficient number of squares during surveys for trend analyses. This certainly means that some of the species that have been affected by the changes mentioned above are excluded from CBS analysis. Thus, most of the species included in these analyses are likely to be those which have been able to adapt to change. Worryingly, the CBS has shown that declines identified by the atlases in Stock Dove, Swift and Skylark have continued to the present. In contrast, the range and/or relative abundance declines shown by the bird atlas for species such as Cuckoo and Yellowhammer are not reflected by the CBS which has indicated that the trends of these species are stable. This may indicate that the large-scale declines in these species that have been evident since the early 1970s may be coming to an end.

The CBS has so far been quite successful in detecting short-term changes that have taken place, such as those driven by cold winters in 2009/10 and 2010/11, or those caused by other recent factors such as 'Trichomoniasis' which is thought to be the cause of the decline shown by Greenfinch. It is encouraging to see that numbers of the species that were most impacted upon by the cold winters, especially Stonechat, Skylark, Meadow Pipit, Grey Wagtail and Goldcrest, appear to be in recovery. The annual indices for these species as well as a suite of other small-bodied residents showed that there were increases in 2012 and 2013 relative to 2011, when relative abundance was at its lowest.

It has been especially interesting to compare the trends within species groups, and/or in species with similar habitat requirements. In particular, the pattern of change that has taken place in Meadow Pipit has closely tracked that shown by Skylark, perhaps illustrating that they are both sensitive to similar factors potentially driving their trends in the uplands. Similarly, there has been considerable consistency in patterns of change among the three tit species (Great Tit, Coal Tit, Blue Tit), so perhaps the factors driving the trends of all three species are similar, and related to the conditions within their preferred habitats, especially plantation forests, woodland margins, hedgerows, and possibly even the availability of provisioned food supplies in gardens.

Plate 12. Stonechat (John Fox).

In describing the status of a suite of Ireland's birds, the CBS provides evidence for updates on Birds of Conservation Concern in Ireland (BoCCI), and was an integral part of Ireland's recent report for Article 12 of the EU Birds Directive for the period 2008–2012. A recent update of BoCCI (Colhoun & Cummins 2013) includes a number of new species identified on the basis of combined trends across Northern Ireland (from the Northern Ireland Breeding Bird Survey, BBS) and the Republic of Ireland (CBS). CBS data are also used in combination with bird monitoring schemes across Europe to report on the status of bird populations at a wider scale (www.ebcc.info/pecbm.html).

The recent bird atlas (Balmer *et al.* 2013) has on balance served to identify and support some of the striking patterns of change that have been shown by CBS for several species. There were several notable consistencies, especially relating to increasing trends. The bird atlas and the CBS have both shown the remarkable increase in the breeding range and abundance of Blackcap. The CBS has continually highlighted its dramatic increase, and the current levels show that there has been a staggering 736% increase in numbers since 1998. Similarly, the bird atlas has shown an increase in range and abundance of Goldfinch in Ireland, and CBS has shown an increase of 200% between 1998 and 2013. The bird atlas has shown that relative abundance of House Sparrow has increased across most of Ireland. This is consistent with increases in numbers shown by the CBS, but contradicts the serious declines reported in England and across much of northwest Europe in recent decades. The BBS showed significant declines in England (12%) between 1995 and 2011 (Risely *et al.* 2013). The bird atlas has shown a substantial increase in range of some species that are not yet sufficiently widespread for meaningful trend analysis, particularly in Buzzard and Tree Sparrow. Buzzard, in particular, has been showing increased prevalence in CBS squares since the survey began, and it is likely that this species will soon be sufficiently widespread for inclusion in trend analyses.

Common bird monitoring schemes are generally not designed for producing robust population estimates. Rather they are focused on measuring change over time by generating annual totals from a representative selection of survey sites (Voríšek & Marchant 2003). However, monitoring schemes such as these are now increasingly being used, either solely or in combination with other datasets, to generate national population estimates (Newson *et al.* 2005, Herrando *et al.* 2008). These analyses have applied distance sampling techniques to model the decline in detection with distance from the observer (Buckland *et al.* 2001), and improved distance sampling software (Thomas *et al.* 2010) has greatly facilitated this modelling process and the production of densities from count data.

Some limitations in the current derivations of the estimates are discussed in Crowe *et al.* (2014). They include the impacts of estimating density based on counts from just two distance bands (Buckland *et al.* 2001). Further limitations arise on the basis of relatively low coverage. Less than 0.5% of the land area is sampled during CBS. This means that there is a much reduced chance of detecting a scarce species in a given survey square, especially one which may be local to a specific region or habitat type. The same argument applies to species that are territorial with relatively large home ranges, and/or those which occur at low densities, such as Kestrel, which may go undetected in a survey square. Indeed, many regions registered zero density for some scarce species where we know from the bird atlas that they are present.

Perhaps the greatest limitation is the impact of autoecological traits of species. It is acknowledged that the estimates do not accurately reflect the total number of breeding individuals present. Firstly, there is currently no way to distinguish between breeding and non-breeding birds, or even juvenile birds for most species, and examples of this include Rook, Starling and Woodpigeon which are highly sociable and are often seen in large flocks of more than 100 individuals. Secondly, for most species it is impossible to detect every individual present along the transect routes. The detections for many species are reliant on calling or singing individuals (usually males), thus the densities reflect singing males, and thereby more accurately reflect territories as opposed to individuals. For example, for a vocal species, such as Wren, where most individuals are detected by song, it is likely that most detections are males and therefore that the maximum number of individuals recorded is at most close to 50%. This means that the majority of individuals of many species detected are males, and that a substantial proportion of female birds are probably missed, which would ultimately lead to an underestimate in density and population size of total breeding birds. The estimates presented here are based on individuals and no attempts are made to apply additional factors, such as to convert individuals to breeding pairs or to account for differences in detection rates between sexes.

The estimates generated here for 49 species are based on best available information and analyses to date, combining relatively robust density estimates with the best available and relatively current distributional data from the bird atlas. Incorporating the bird atlas data permits vastly improved estimates by providing better informed distribution ranges across which the regional densities were extrapolated. Without these distributional data it is impossible to refine the area across which the density estimates could be extrapolated.

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Temporal changes in the diet of Tufted Ducks *Aythya fuligula* overwintering at Lough Neagh

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Plate 13. Tufted Duck (Michael Finn).

Numbers of Tufted Ducks *Aythya fuligula* wintering at Lough Neagh declined dramatically following the winter of 2000/01. The abundance and biomass of benthic macroinvertebrates, their main food source, declined significantly between the winters of 1997/98 and 2010. Therefore, information on recent diet was required to determine if there had been any significant changes before and after the observed declines in numbers of both macroinvertebrates and birds. Here, we used oesophageal content analysis to characterise the contemporary diet of Tufted Ducks at Lough Neagh during 2010–2012. Out of 75 shot ducks, only three individuals had prey items in their oesophagi while all four ducks that accidentally drowned in gill nets contained prey items. Oesophageal contents were then compared with data collected during a study conducted in the late 1990s. Contemporary diet of Tufted Ducks was dominated by *Asellus aquaticus* (48%), but molluscs (14%), grain (13%) and chironomid larvae (11%) were also consumed. Between 1998–1999 and 2010–2012, the contribution of *Asellus aquaticus* to the diet significantly decreased while the proportions of chironomid larvae, grain, *Gammarus* spp. and *Mysis* spp. increased. Alternative methods of dietary analysis, for example stable isotope analysis, are recommended in future studies of diving duck diet at Lough Neagh.

Introduction

Dietary analysis provides information on foraging behaviour, habitat use and general ecology. Temporal variation in diet may contribute to our understanding of population dynamics, particularly in species exhibiting declining populations. For some species, such as diving ducks, diet cannot be inferred from direct observations of foraging, and alternative methods of dietary analysis must be employed; typically stomach content analysis. Analysing stomach contents is simple and straightforward, providing a precise snapshot of recent ingestion (Hynes 1950). However, stomach content analysis tends to be biased towards food items that are hard-bodied and take longer to digest, while softer-bodied prey items which are more easily digested may be under-recorded (Hyslop 1980). This can be overcome to some extent by examining oesophagus contents rather than gizzard contents (Swanson & Bartonek 1970, Guillemette *et al.* 1994). In ducks, prey items pass through the oesophagus undigested, before they enter the proventriculus and gizzard. Ducks swallow and store large amounts of grit in their gizzards (Tománková *et al*. 2013a) to grind up food and aid digestion, causing prey items to breakdown rapidly. Swanson and Bartonek (1970) found that within ten minutes of ingestion, 100% of amphipods, 82% of molluscs and 24% of diptera larvae in the gizzard were digested beyond recognition.

The diet of diving ducks overwintering at Lough Neagh, Northern Ireland was described in a series of detailed studies during the late 20th century (e.g. Winfield & Winfield 1994, Bigsby 2000, Evans 2000). At that time, the diet of Pochard *Aythya ferina,* Scaup *Aythya marila* and Goldeneye *Bucephala clangula* was typically dominated by chironomid (Chironomidae) larvae (Winfield & Winfield 1994, Evans 2000) while the diet of Tufted Duck *Aythya fuligula* also contained substantial quantities of molluscs (Winfield & Winfield 1994). Bigsby (2000) suggested that the predominant prey items in the diet of Pochard and Scaup were larval and pupal chironomids, while Tufted Duck fed primarily on *Asellus aquaticus*. Goldeneye took both chironomid larvae and *Asellus aquaticus* in approximately equal proportions (Bigsby 2000).

Lough Neagh is a stronghold for overwintering diving ducks in Northern Ireland (Holt *et al.* 2012) and was formerly the most important overwintering site in the United Kingdom for Pochard, Tufted Duck, Scaup and Goldeneye (Pollitt *et al.* 2000). Numbers of migratory diving ducks overwintering at Lough Neagh have declined dramatically since the winter of 2000/01. Declines occurred over a period of two winters, after which populations appeared to stabilise at relatively low abundances, suggesting the change was rapid (Tománková *et al.* 2013b). Between the winters of 1994/95–1998/99 and 2006/07–2010/11, the winter five-year mean declined from 24,525 to 7,599 individuals in Pochard, from 22,566 to 6,938 individuals in Tufted Duck and from 7,557 to 3,501 individuals in Goldeneye (Pollitt *et al.* 2000, Holt *et al.* 2012). The density and biomass of macroinvertebrates in Lough Neagh declined by 65–70% between the winters of 1997/98 (prior to observed declines in diving duck numbers) and 2010 (after the decline) Tománková *et al.* 2014). These declines may have reduced the quantity and quality of food resources available to overwintering ducks.

This study examined the diet of Tufted Ducks overwintering at Lough Neagh using oesophageal contents analysis. The results were compared with similar data gathered during earlier periods of 1988–1990 (Winfield & Winfield 1994), 1998-1999 (Evans 2000) and 1998–2000 (Bigsby 2000). This comparison was required to determine if there has been any significant temporal change in the composition of the diet of diving ducks.

Methods

Diving ducks (Pochard, Tufted Duck, Scaup and Goldeneye) were obtained from wildfowlers and fishermen operating on Lough Neagh during the winters 2008/09 to 2011/12. Ducks were aged and sexed based on plumage characteristics (Boyd *et al.* 1975, Baker 1993). A total of 79 individuals was collected, of which 75 (95%) had been shot and four (5%) accidentally caught in legally set gill nets. Only seven (9%) ducks examined had prey in their oesophagi. They included all four ducks that had been recovered drowned from gill nets, and only three (4%) that had been shot. All seven individuals were male Tufted Duck; three were first-winter birds and four were adults.

The oesophagus of each duck was dissected and all prey items recovered. These were stored in 80% ethanol and subsequently identified. Chironomid larvae head capsules were mounted with either Euparal or Hydromatrix solutions to allow identification (Wiederholm 1983, Brooks *et al.* 2007). Results were compared with those from an earlier study on the diet of diving ducks on Lough Neagh investigated in 1998–1999 (Bigsby 2000).

Chironomid larvae dissected from the oesophagi of ducks were measured and length frequencies compared with those of chironomids found in oesophagi of Tufted Ducks collected in 1988–1990 (Winfield & Winfield 1994), 1998–1999 (Evans 2000) and 1998–2000 (Bigsby 2000). Data from these three studies were extracted from graphs using Plot Digitizer (version 2.5.1) software. Chironomid larvae were pooled irrespective of species or genus.

To examine changes in the proportional composition of macroinvertebrates in the diet of Tufted Ducks between 1998–1999 and 2010–2012, 2x2 χ^2 contingency tests were used within each prey category. To determine whether there was any difference in the size of chironomids consumed, their length frequencies were compared between 1988–1990, 1998–1999, 1998–2000 and 2010–2012 using a Generalized Linear Mixed Model (GLMM) with a fitted gamma distribution and logarithmic link function where chironomid size was fitted as the dependent variable, study as a fixed factor and size category as a random factor to account for the multiple observations per size category, thus avoiding pseudo-replication.

Results

The diet of Tufted Ducks (Figure 1) was predominantly composed of the freshwater crustacean *Asellus aquaticus* (48%), molluscs (14%) and grain (13%). Of the chironomid larvae, the most commonly consumed genera were *Glyptotendipes* spp. (5%) and *Microtendipes* spp. (4%). Molluscs taken were (in descending order of abundance): *Potamopyrgus antipodarum, Lymnaea peregra, Valvata* spp., *Planorbis carinatus, Physa* spp., *Planorbis corneus* and *Bithynia* spp. Trichoptera larvae belonged to families Leptoceridae, Molannidae, Phryganeidae and Polycentropidae while Hemiptera were of the family Corixidae.

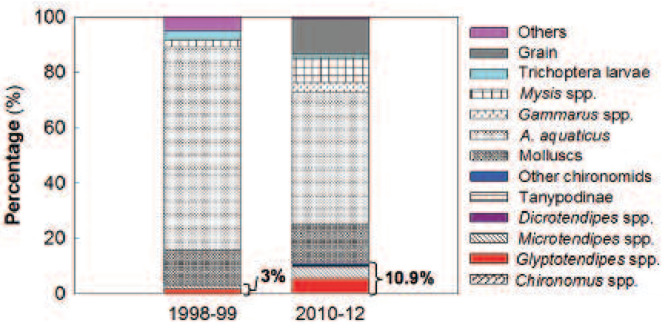

Figure 1. Comparison of Tufted Duck diet between 1998–1999 (Bigsby 2000) and 2010–2012. The percentages indicate the combined contribution of chironomid larvae.

Acknowledging that the sample size was low, the oesophageal contents of Tufted Ducks in 2010–2012 differed significantly from 1998–1999. Specifically, the greatest change was the appearance of grain in the diet (13%) during 2010–2012, which mostly comprised wheat *Triticum* spp., and which was entirely absent in 1998–1999 (χ^2_1 = 13.9, P = <0.001). The proportion of chironomid larvae (all genera pooled) increased from 3% to 11% in 2010–2012 (χ^2_1 = 4.92, P = 0.027), *Mysis* spp. increased from 2% to 9% (χ^2_1 = 4.71, P = 0.030) and *Gammarus* spp. increased from 0% to 4% (χ^2_1 = 4.08, P = 0.043) (Figure 1). Conversely, the proportion of *Asellus aquaticus* decreased from 73% during 1998–1999 to 48% during 2010–2012 (χ^2_1 = 13.1, P = <0.001) (Figure 1). The proportion of molluscs in the diet did not differ significantly with 13% during 1998–1999 and 14% during 2010–2012 (χ^2_1 = 0.043, P = 0.836), nor did the remaining dietary items at 8% in 1998–1999 and 2% in 2010–2012 (χ^2_1 = 3.79, P = 0.052) (Figure 1). There was a strong trend for the size frequency distribution of chironomid prey to vary between studies conducted during 1988–1990, 1998–1999, 1998–2000 and 2010–2012 ($F_{3,47}$ = 2.314, P = 0.088). Specifically, the median length of chironomid larvae in 1998–1999 and 2010–2012 was smaller, and exhibited a normal distribution, than those during 1988–1990 and 1998–2000, which exhibited a bimodal distribution (Figure 2).

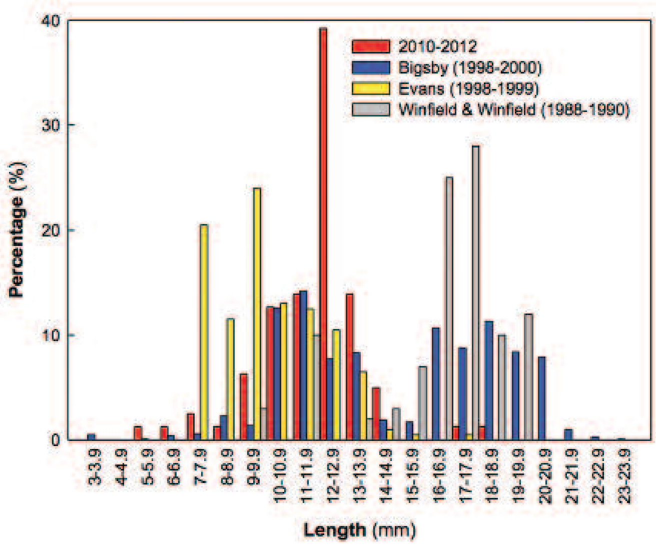

Figure 2. Comparison of length frequencies of chironomid larvae from Tufted Duck diet during 1988–1990, 1998–1999, 1998–2000 (Winfield & Winfield 1994, Evans 2000, Bigsby 2000) and 2010–2012.

Discussion

In the current study, all ducks that had been drowned contained prey in their oesophagi compared to only 4% that had been shot. Diving ducks at Lough Neagh, with the exception of Goldeneye, are primarily nocturnal feeders (Evans & Day 2001), so most birds would have finished feeding several hours before being shot by wildfowlers during daylight hours. Consequently, oesophageal contents analysis of shot ducks cannot be recommended in dietary studies. Ducks accidentally captured in gill nets while feeding would be the best source of material for oesophageal analysis (Tománková *et al.* 2013a); though they are more difficult and less reliable to obtain. Such bias in sampling methods has been reported previously by Winfield and Winfield (1994) and Bigsby (2000).

Analysis of the oesophageal contents of male Tufted Ducks suggested they fed primarily on *Asellus aquaticus* and to a lesser extent on molluscs. Whilst this analysis was based on a small sample size (n = 7), Bigsby (2000) reported a similar diet utilizing a larger, but still limited, sample (n = 18). Evans (2000) and Winfield and Winfield (1994) found that, although not the dominant prey item, *Asellus aquaticus* appeared more important in the diet of Tufted Duck than in other diving duck species overwintering at Lough Neagh. Differences between the studies may be accounted for by changes in food availability which can influence consumer prey choice (Vickery *et al.* 1995). Grain was found in the oesophagi of shot Tufted Ducks in 2010–2012 while none was recorded in 1998–1999 (Bigsby 2000). It is possible that Tufted Ducks now rely more on supplementary feeding provided by wildfowlers than in the past due to the decline of their macroinvertebrate prey (Tománková *et al.* 2014).

The trend for difference in size frequency distribution of chironomid larvae between studies may reflect the timing, or location, of sampling. The majority of ducks sampled in previous studies (Winfield & Winfield 1994, Bigsby 2000, Evans 2000) had been drowned accidentally in gill nets whilst three out of seven ducks (43%) in the current study had been shot. The differences in the size frequencies of chironomids might be due to the varying depth at which the gill nets were set (which was unknown in most cases) when the birds were caught. Depth may influence the dynamics and thus size structure of chironomid populations (Winfield & Winfield 1994). Chironomid larvae were also pooled irrespective of their taxonomic classification, and it is possible that compositional differences at the species level may account for differences in the size classes recorded.

Alternative methods of dietary analysis are recommended for future studies of diving duck diet at Lough Neagh, as oesophageal content analysis of a large number of individuals resulted in a limited sample size. Of those, stable isotope analysis (Inger & Bearhop 2008), which allows for the inclusion of all 79 diving duck individuals irrespective of their oesophageal content, is currently being employed to study the diet of ducks in greater detail.

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Factors affecting breeding success of waders at the Shannon Callows in 2007 and 2008

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The Shannon Callows held one of the three largest populations of lowland breeding Lapwing *Vanellus vanellus,* Redshank *Tringa totanus,* Curlew *Numenius arquata* and Snipe *Gallinago gallinago* in Ireland and Britain in the late 1980s at just over 1,500 pairs. However, numbers there had declined to 326 pairs by 2002. In 2007/08, the National Parks and Wildlife Service (NPWS) funded a research program to investigate reasons for the decline. Nest survival was monitored primarily through the use of temperature loggers and a small number of nest cameras. Nest outcomes were recorded, and where predation was the cause of failure, an assessment was made of which predator was responsible. Where temperature profiles from data loggers showed that predation happened at night, mammals, in particular Fox *Vulpes vulpes,* was assumed to be the main predator, and where during the day, avian predators were assumed, mainly Hooded Crow *Corvus cornix.* Predation accounted for over 85% of all nest failures, and mammals accounted for over 85% of all predation events. Five broods were monitored through radio-tracking one or more of the chicks. Only one brood survived to fledging; the other broods survived for between one and nine days before being predated; indications were that American Mink *Neovison vison* was the most likely predator. The high rates of nest and chick losses to predation on the Callows are likely to lead to further significant declines. Urgent intervention measures to enhance habitat and control the impact of predators are required if the breeding wader population on the Callows is to survive.

Introduction

Populations of breeding wader species (Lapwing *Vanellus vanellus,* Redshank *Tringa totanus*, Curlew *Numenius arquata,* Snipe *Gallinago gallinago*) were first monitored at the Shannon Callows in the Irish midlands in 1988. At that time these Callows held one of the three most important concentrations of breeding waders in Ireland and Britain at just over 1,500 pairs (Nairn *et al.* 1988). A re-survey in 2002 recorded declines of 85% for Lapwing, 67% for Redshank, 81% for Curlew and 56% for Snipe, with a total of 326 pairs recorded across all four species (Tierney *et al.* 2002). Similar trends have been observed in England and Scotland (Wilson & Browne 1999, Wilson *et al.* 2005), and Europe (Beintema & Muskens 1987, Thorup 2006). All four species are on the red

Plate 14. Snipe nest (Paul Troake).

or amber lists of Birds of Conservation Concern in Ireland (Colhoun & Cummins 2013), while the decline in Curlew is of concern globally, and it was added to the International Union for the Conservation of Nature (IUCN) global Red List in 2008 (BirdLife International 2012).

Land use change and intensification of agriculture are regarded as the main causes of breeding wader declines in Western Europe (Galbraith 1988, Baines 1990, Berg *et al.* 1992, Chamberlain *et al.* 2000, Wilson *et al.* 2001) which has resulted in habitat degradation and loss, and reduction in food availability (Beintema & Muskens 1987, Galbraith 1988, Chamberlain *et al.* 2000). Habitat measures aimed at creating ideal conditions for nesting waders have been included in agri-environment schemes in Britain (Ausden & Hirons 2002), but have not always led to population recovery, even though suitable conditions have been created (Ausden *et al.* 2009). High rates of nest predation, particularly by nocturnal mammalian predators, mostly Foxes *Vulpes vulpes,* are also recorded as having significant impacts on breeding wader populations (Grant *et al.* 1999, MacDonald & Bolton 2008, Schekkerman *et al.* 2009, Rickenbach *et al.* 2011), and this factor may become increasingly significant as suitable nesting habitat becomes more fragmented. Several studies have shown that predation, in particular by mammals, can now be the primary cause of nest failure in some cases (Baines 1990, Herbert 1997, Ferreras & MacDonald 1999, Grant *et al.* 1999, O'Brien *et al.* 2002, Eglington *et al.* 2009).

In this study, the causes of wader nest and chick losses were assessed, and where predation was a factor, an assessment of the predator species involved was made. This information can be used to plan for effective management measures to protect and restore populations.

Study sites and methods

The flood plains, or Callows, of the middle Shannon and Little Brosna Rivers in central Ireland occupy an area of approximately 45km^2 between Lough Ree and Lough Derg. Flooding of lands bordering the river occurs regularly during the winter and spring due to the shallow gradient. Summer flooding also occurs in some years (Heery 1995). There are approximately 5,000ha of wet grassland bordering the rivers, which are primarily used for pasture and hay. The middle Shannon is designated as a Special Area of Conservation (SAC) under the EU Habitats Directive (92/43/EEC); it is also a Special Protection Area (SPA) under the EU Birds Directive (79/409/EEC), along with the Little Brosna Callows, both on account of their wintering waterbird populations. In the 1980s, the Shannon Callows were nationally important for breeding Redshank.

Four study sites with important populations of breeding Lapwing and Redshank were selected from a total of 27 sites surveyed in 1987 and 2002 (Nairn *et al.* 1988, Tierney *et al.* 2002); the selection of sites was influenced by the total number of pairs present and also by ease of access and landowner permissions. The sites selected are shown in Table 1. Inishee and Inchinalee are islands in the River Shannon. Inch Callow and Glaster are on the Little Brosna River, a tributary of the River Shannon; the former is commonage with unimproved pasture and the latter is a farm with, during the period of research, a mix of improved grazing and tillage subject to tractor operations.

A combination of two methods was used to discover nests. Most Lapwing nests were found by direct observation of sitting birds from a concealed location. Redshank nests were found by walking transects or were detected when birds were flushed whilst walking across the sites during nest checks. A small number of Curlew nests were also found in this way. Nest locations were identified with a GPS, and the number of eggs and their length, breadth and weight was recorded to determine expected hatching dates. Where a clutch was incomplete, i.e. less than four eggs, and assuming one egg was laid per day (Cramp & Simmons 1983), the nest was visited again within a few days to determine if a full clutch of four eggs had been laid. Otherwise, to minimize disturbance, nests were not visited again until close to the expected hatch date.

Tinytag® data loggers were inserted into all nests discovered in order to monitor disturbance and nest outcome. The thermal sensor was placed between the eggs and the

Table 1. Sites selected for research into breeding wader declines at the Shannon Callows in 2007 and 2008.

Site	O/S Ref	County	Area (ha)	Habitat
Inishee*	M980160	Galway	33.0	Island, unimproved pasture
Inchinalee	N038328	Roscommon	8.6	Island, unimproved pasture
Glaster	N017094	Offaly	9.3	Farm, improved grazing, tillage
Inch Callow+	N005095	Offaly	50.5	Commonage, unimproved pasture

* Includes Esker Island at 3.5ha.

+2007 only.

Plate 15. Curlew chick (Anita Donaghy).

logger was buried 30cm from the nest cup. Each logger was programmed to take a reading every 20 minutes over a period of 29 days. Tags were retrieved after the eggs had hatched or after the nest had failed. An infra-red, motion-detecting nest camera was deployed to determine which predators were approaching nests at night. The lens was placed within 50cm of the nest, with the lead, recording equipment and battery buried out of sight 4m away.

A successful outcome was recorded if small fragments of shell were found in the nest, if chicks were observed or adult behavior indicated the presence of a brood. An unsuccessful outcome was recorded if the eggs were missing, predated or abandoned, or if adults were absent on two consecutive visits at least one week apart. In the case of nest failure, the nest temperature profile as recorded by the data logger was examined to determine the timing of nest failure. The nest was judged to have failed when the temperature fell substantially below normal with no subsequent recovery. If normal incubation ceased during the hours of darkness, the nest was assumed to have been predated by a mammal. Conversely, if cessation was during the day, the predator was assumed to be avian (Bolton *et al.* 2007b). Additional information from egg shell fragments in the nest vicinity was collected where available; a single large hole in the side of the egg shell was taken as a sign of predation by Hooded Crow *Corvus cornix*, while two small puncture marks were indicative of small mammal predation, such as by American Mink *Neovison vison* (Green *et al.* 1987).

Once a clutch had hatched, the number of chicks was recorded and measurements of wing and weight taken. If large enough, they were fitted with a British Trust for Ornithology (BTO) ring and were also fitted with colour-rings. The heaviest chick in each clutch was identified and fitted with a type Pip3 radio tag, weighing 0.45g, supplied by Biotrack®. The tag was attached to the down on the chick's back, just over the synsacrum, with latex-based glue. Each chick was radio-tracked from a distance until the tag was shed or stopped working, or the death of the chick occurred, when an attempt was made to recover the tag. Outside the main study sites, an additional Lapwing brood was located at Bunthulla (M023315) and two of these chicks were tagged, while a Curlew brood located at Tower Callow (N003164) had two chicks tagged.

Mayfield estimates of daily nest survival were calculated for each site using the following formula:– Nest Success (S) = 1 – (number of nests lost per site/Exposure days) (Mayfield 1961). Exposure days were the total number of days each nest survived until it hatched, or was predated. Lapwing hatch dates were calculated using the formula: 301731.3*(weight/(length* (width*width)))-129 (M. Bolton, pers comm.). Redshank and Snipe hatch dates were calculated using nomograms (Green 1984) and Curlew hatch dates were calculated after Grant (1996). Clutch initiation dates were calculated from hatch dates, or estimated hatch dates, by back-dating as follows: Redshank 24 days; Snipe 19 days; Lapwing 28 days (Green 1984) and Curlew 33 days (Grant *et al.* 2000). The Kruskal Wallis test was used to detect differences in rates of nest predation for different time periods.

Results

A total of 100 nests was located in 2007 and 63 in 2008. In both years, Inishee was the most important breeding site, accounting for about half of the overall total number of nests located, although nest density was slightly higher on Inchinalee (Table 2). A total of 96 nests was monitored in 2007 and 62 nests in 2008. A summary of nest outcomes is shown in Table 3; nests being classified as abandoned, predated, hatched, or where it was impossible to ascertain a definite outcome, unknown. Predation accounted for the majority of nest failures at all sites in both years (64% in 2007 and 68% in 2008), with very few nests being lost through other causes such as trampling or abandonment. The highest levels of predation occurred at Glaster in both years, followed by Inishee. On Inchinalee, predation was high in 2008 at 68%, but was only 12% in 2007, indicating predation may vary between years and sites.

Daily nest survival rates for each site and year are shown in Table 4. Rates for each species were variable across sites and years; they were highest for both species at Inchinalee in 2007, but were amongst the lowest at the same site in 2008. Daily nest survival rates for both species were low for Inishee in both years. The timing of nest predation was estimated for 31 predation events, 28 from data loggers and three from infra red cameras. Of these, two thirds took place at night, between 23.00 and 03.00 hours, indicating the predators were likely to have been mammalian (Figure 1). Predation during this time period was significantly higher than during any other four-hour time period of the day (Kruskal Wallis test, $N = 31$, $H = 21.90$, $df = 5$, $P < 0.001$). The Fox was the main predator of wader nests in 2008 (Table 5 & Figure 1), being responsible for over 80% of all nest predation in both years. Nests were also subject to predation by American Mink, Pine Marten *Martes martes* and Hooded Crow, each species taking at least one nest during the 2008 season.

Daily survival rates for each brood or partial brood are shown in Table 6. Of the four Lapwing broods monitored, only four chicks from one brood were known to fledge successfully. The remaining 11 chicks survived for between one and nine days and were all predated or suspected to have been predated. Mink are thought to have taken two of these broods, while the other two were lost to unknown predators. All broods radio-tracked moved no further than 100m from the nest to the nearest water feature in their first movement after hatching. Subsequently, much longer movements were undertaken by the brood (Table 7).

Table 2. Comparison of number of nests found and density of breeding waders at research sites at the Shannon Callows in 2007 and 2008 (n = total number of nests; L = Lapwing, RK = Redshank, SN = Snipe, CU = Curlew).

Site Name	Area (ha)	Species	n		Density (Nests/ha)	
			2007	2008	2007	2008
Inishee	**33**	L	38	11	1.15	0.33
		RK	24	13	0.73	0.39
		SN	3	3	0.09	0.09
		CU	2	4	0.06	0.12
		Total	**67**	**31**	**2.03**	**0.94**
Inchinalee	8.6	L	10	12	1.16	1.4
		RK	9	10	1.05	1.16
		SN	2	0	0.23	0
		CU	0	0	0	0
		Total	**21**	**22**	**2.44**	**2.56**
Glaster	9.3	L	10	10	0.93	1.08
		RK	1	0	0.1	0
		SN	1	0	0.1	0
		CU	0	0	0	0
		Total	**12**	**10**	**1.29**	**1.08**
Overall total			**100**	**63**		

Table 3. Summary of outcomes of nests monitored at the Shannon Callows in 2007 and 2008 (n = total number of nests, A = number abandoned, P = number predated, H = number hatched, U = number with unknown outcome. L = Lapwing, RK = Redshank, SN = Snipe, CU = Curlew).

	2007						2008					
	n	**A**	**P**	**H**	**U**	**% predated**	**n**	**A**	**P**	**H**	**U**	**% predated**
Inishee												
L	34	3	26	5	0	76	10	1	6	3	0	60
RK	24	0	16	8	0	67	13	1	9	3	0	69
SN	2	0	2	0	0	100	3	0	1	2	0	33
CU	2	0	2	0	0	100	4	0	2	0	2	50
Total	62	3	46	13	0	74	30	2	18	8	2	60
Inchinalee												
L	10	0	2	8	0	20	12	3	7	2	0	58
RK	7	0	0	7	0	0	10	0	8	0	2	80
Total	17	0	2	15	0	12	22	3	15	2	2	68
Glaster												
L	10	0	8	2	0	80	10	0	9	1	0	90
RK	1	0	1	0	0	100	0	-	-	-	-	-
SN	1	0	1	0	0	100	0	-	-	-	-	-
Total	12	0	10	2	0	83	10	0	9	1	0	90
Inch												
L	3	0	1	2	0	33	0	-	-	-	-	-
RK	2	0	2	0	0	100	0	-	-	-	-	-
Total	5	0	3	2	0	60	0	-	-	-	-	-
Overall total	**96**	**3**	**61**	**32**	**0**	**64**	**62**	**5**	**42**	**11**	**4**	**68**

Table 4. Lapwing and Redshank nest survival rates and percentage of successful nests at the Shannon Callows in 2007 and 2008.

	2007		2008	
Site	**Daily nest survival**	**Probability of nest surviving to hatching**	**Daily nest survival**	**Probability of nest surviving to hatching**
Inishee				
Lapwing	0.959	0.31	0.946	0.21
Redshank	0.936	0.20	0.95	0.29
Inchinalee				
Lapwing	0.993	0.82	0.903	0.06
Redshank	1.00	1.00	0.857	0.02
Glaster				
Lapwing	0.972	0.45	0.904	0.06
Redshank	0	0	-	-
Inch				
Lapwing	0.988	0.71	-	-
Redshank	0	0	-	-
Overall	**0.955**	**0.33**	**0.927**	**0.16**

Table 5. Comparison of predators on study sites at the Shannon Callows in 2007 and 2008.

	Inishee		Inchinalee		Glaster		Inch*	Total	
	2007	2008	2007	2008	2007	2008	2007	2007	2008
Total number of nests with known outcome	67	28	17	20	12	10	15	111	58
Avian predator	8	1	0	0	0	0	0	8	1
Mammalian predator	38	13	2	13	8	9	3	51	35
Unknown predator	0	4	0	1	0	0	0	0	5
Abandoned	3	2	0	4	0	0	0	3	6
Livestock	0	0	0	0	2	0	0	2	0
Total number of failed nests	49	20	2	18	10	9	3	64	47
Total predated	46	18	2	14	8	9	3	59	41
% of failed nests predated	94	90	100	78	80	100	100	92	87
% failed nests predated by mammal, mostly Fox	83	72	100	93	100	100	100	86	85

* No data collected at Inch in 2008.

Table 6. Survival of radio-tagged wader broods monitored at the Shannon Callows in 2008 (L = Lapwing, CU = Curlew).

Species	Site	No. of chicks in brood	No. radio tagged	No. of days surviving	Daily Survival Rate	Outcome
L	Inishee	3	1	9	0.889	Tagged chick predated by Mink, others not found, suspected predated.
L	Glaster	4	1	3	0.667	All suspected predated. No signal from transmitter and no adults in area.
L	Inchinalee	4	1	1	0	Four chicks predated by Mink.
L	Bunthulla	4	2	≥ 35	1	Four chicks fledged successfully.
CU	Tower Callow	4	2	4	0.75	Two chicks predated. Others suspected predated.

Table 7. Distance travelled by radio-tracked chicks between each location at the Shannon Callows in 2008. All chicks were Lapwing, except for Curlew at Tower.

Site	Inishee	Inchinalee	Glaster	Bunthulla	Tower
No. fixes	9	2	2	40	4
No. chicks tagged in brood	1	1	1	2	2
Minimum distance (m)	11	49	97	14	0
Maximum distance (m)	1076	-	-	130	282
Mean distance (m)	526	-	-	64	141

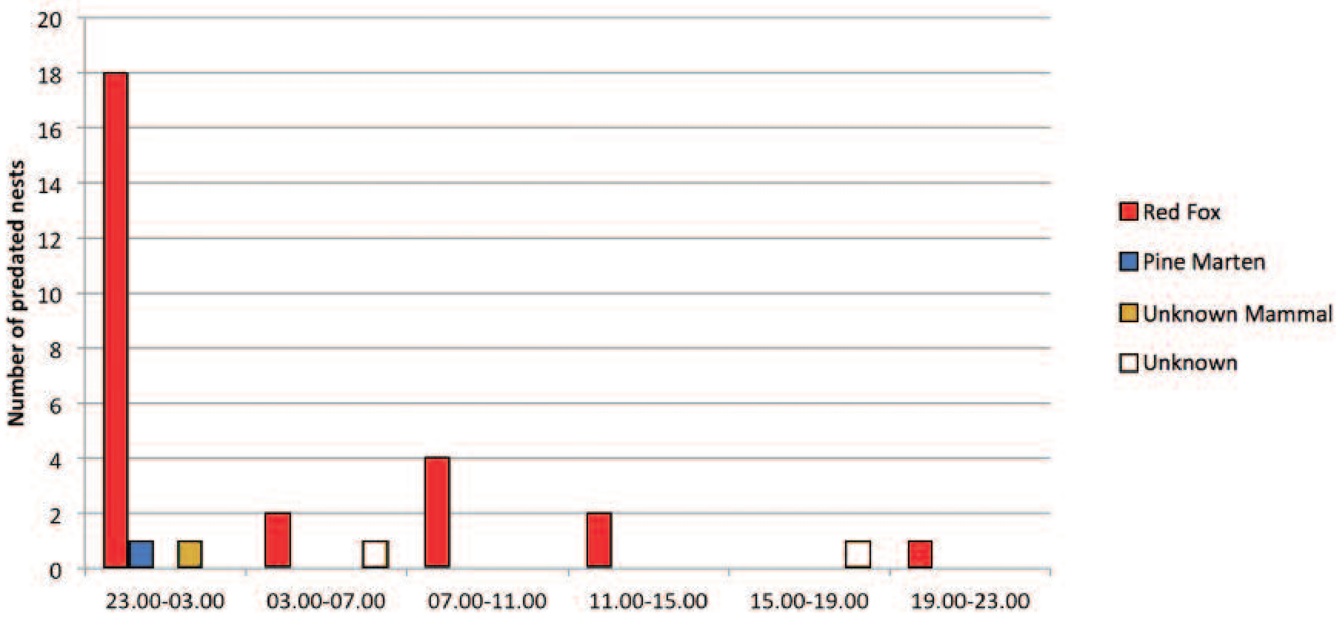

Figure 1. Comparison of number of predation events at different time periods and the main predators responsible at the Shannon Callows in 2007 and 2008 (total number of nests = 31).

Of all broods surviving more than two days, Lapwing chicks at Inishee travelled the furthest between locations, being located almost 0.5km apart between several fixes. They utilized damp areas with some cover, such as iris patches with muddy edges and ditches or shallow pools. Only the chicks at Bunthulla survived to fledging. Despite the wet areas surrounding the nest, the chicks moved to the river's edge where they remained most of the time, only occasionally being located at a shallow ditch with muddy edges approximately 12m away. The (presumably entire) brood at Inchinalee moved 48.76m, from their nest to the nearest water feature (tussocky, muddy riverbank) before being predated within 24 hours of being tagged. Likewise, the brood on Glaster lasted one radio-tracking day. Once hatched, they moved to a reedy pool, before being predated.

Discussion

The downward trend in breeding wader populations on the Shannon Callows observed by Tierney *et al.* (2002) appears to be continuing. Between 2007 and 2008, the most obvious decline in number of nests located was of Lapwing at Inishee, with just ten nests located in 2008, compared to 37 in 2007. This compares to 30 pairs in 1987 (Nairn *et al.* 1988) and a provisional 17 pairs in 2002 (Tierney *et al.* 2002). Breeding numbers of Lapwing at Inishee are therefore subject to some annual variation; Lapwings are relatively site faithful, particularly adults, most returning to within 5km of where they were hatched (Thompson *et al.* 1994). However, whilst habitat conditions on Inishee appeared very favourable in late March and early April, some relocation to other sites in the vicinity cannot be ruled out. Lapwing are known to disperse to other more favorable areas when they experience low reproductive success in an area formerly used (Groen 1993).

Loss of nests was high across all three study sites in 2008 and at two sites in 2007. High rates of nest loss to predation is frequently encountered in wader studies (Baines 1990, MacIvor *et al.* 1990, Grant *et al.* 1999, Chamberlain & Crick 2003, Seymour *et al.* 2003, Bolton *et al.* 2007b). With only two years data on the Shannon Callows and small sample sizes, the results cannot be compared directly, but mean predation rates in 2007 and 2008 of 78.6% for Lapwing and 73% for Redshank exceeded those reported by MacDonald and Bolton (2008) in their comprehensive review of over 500 studies where predation accounted for a significant proportion of nest failures. Most nest losses occurred at night, consistent with other findings (Grant *et al.* 1999, Bolton *et al.* 2007b). The losses were largely attributed to Fox, although results from the nest cameras showed just one incidence each of Fox and Pine Marten predating nests at night. However, data from other studies supports the fact that most night time predation of wader nests is a result of Fox activity (Ausden *et al.* 2009).

Agricultural intensification has led to the loss and fragmentation of wet grasslands and may also have facilitated the increase in generalist predator populations through, *inter alia,* increases in sheep numbers and permanent pasture (Grant *et al.* 1999). Other factors, such as the abolition of the bounty scheme, may also have led to increases in Fox

Plate 16. Nesting Lapwing (Anthony McGeehan).

numbers, though there are no studies to confirm this. There was some concern that predators could be picking up the scent of humans as indicated by Whelan *et al.* (1994), and this may be contributing to the predation problem. In this study, incidences of data loggers and camera batteries being dug up by (presumably) Foxes were recorded.

There is little evidence to suggest that nest cameras influence parent bird behaviour or, that cameras and temperature loggers alter predation risk (Leimgruber *et al.* 1994, King *et al.* 2001, Bolton *et al.* 2007a, MacDonald & Bolton 2008). Nest cameras give an unbiased identification of nest predators (King *et al.* 2001), and for this reason their use prior to predator management is encouraged (MacDonald & Bolton (2008).

In 2008, the radio-tracked chicks revealed that their broods at Glaster and Inchinalee only survived a couple of days after hatching; both broods having moved to areas of soft mud not far from the nest. The loss of the signal at Glaster after two days of radio-tracking has been attributed to predation of the brood, as no adults were in the vicinity during a search. At Buntulla and Inishee, where the broods survived longer, chick movement was variable and probably related to the availability of suitable habitat. At Buntulla, habitat within the vicinity of the nest was very suitable, i.e. a high water table was available with a shallow gradient to the edge of the water. The chicks appeared to spend nearly all of their time there, despite an abundance of avian predators being observed more regularly there than at Inishee. Here, the chicks moved greater distances, utilizing different areas of suitable habitat. Distances of up to 600m may be covered by wader chicks the day after hatching, and may increase with age, or may be associated with reduced food availability (Sonerud 1985).

DNA testing of the rings of one of the chicks at Inchinalee confirmed the presence of American Mink DNA. It is unlikely that the scent of fieldworkers could have led predators to the chicks. The chick at Inishee survived seven days after ringing, and no physical contact was made with the brood, except in one instance, at Inishee, to ring the radio-tagged chick.

MacDonald and Bolton (2008) modelled Lapwing productivity and showed that a site with 25% chick survival and less than 50% loss of nests should maintain a sustainable population. Chick survival in this study across all sites and in both years was 16%. This level of survival means that nest success should be considerably higher than 50% to maintain a viable population. Without intervention, the Lapwing population is likely to continue to decline. Grant *et al.* (1999) calculated that in order to have a sustainable Curlew population, between 0.48 and 0.52 fledglings per breeding pair is required with a 50–65% fledgling survival rate in the first year. Two of the four Curlew nests were predated at Inishee and the brood at Tower Callow was also predated a short time after hatching. Therefore, breeding Curlew numbers on the Callows may also be suffering unsustainable losses. Although no Redshank broods were tagged, the rate of nest loss alone would indicate that populations are also likely to experience further declines without intervention.

Urgent attempts to increase productivity by reducing predation, at least in the short term, is likely to be necessary if breeding wader populations on the River Shannon Callows are to persist. Measures such as direct control of mammalian and avian predators, and anti-predator fencing (Malpas *et al.* 2013), are all recommended.

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Habitat and diet of re-colonising Common Buzzards *Buteo buteo* in County Cork

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Plate 17. Buzzard territorial dispute, Co. Cork (Ciarán Cronin).

A survey of distribution of Common Buzzards *Buteo buteo* based on territorial display was carried out in County Cork during March and April of 2011 and 2012. Habitat and diet were investigated by analysis of prey remains and pellets. The population has increased from approximately four pairs in 2001 to a minimum of 78 pairs in 2011–12 (+1,950%). A total of 209 Common Buzzards was seen during the survey in 2011 and 2012. The population has begun to spread out from three core areas within North, East and South Cork. Common Buzzards show a strong affinity to mixed farmland with a high arable content. Rabbit *Oryctolagus cuniculus*, Brown Rat *Rattus norvegicus*, Woodpigeon *Columba palumbus* and corvids *Corvus* species were the main prey. Common Buzzards may continue to increase in County Cork for some time into the future.

Introduction

The history of the Common Buzzard *Buteo buteo* (hereafter Buzzard) in County Cork is one of decline leading to eventual extinction. Smith (1750) referred to its occurrence, but did not comment on its status, perhaps an indication it was then widespread. Harvey (1845) said it was "not common", while Thompson (1849), quoting Robert Ball, referred to Buzzards as "not uncommon" in the vicinity of Youghal. Only two occurrences of vagrants were known for Cork between 1850 and 1900, and it became extinct as a breeding species in Ireland during the 1880s (Ussher & Warren 1900).

Re-colonisation began in Northern Ireland (County Antrim) in the 1950s (Hutchinson 1989). Expansion to several counties outside Northern Ireland, especially to Donegal, had taken place by 1990, and it had reached Wicklow on the east coast (Norriss 1991). However, it was not until the mid-1990s that it began to appear in Cork. Breeding was suspected at several sites in the county from 2001, but was not proved until 2004 when two nests were found, the first near Cloyne (East Cork) and the second near Belgooly (South Cork) (Nagle

2006). During the next three years it became apparent to Irish Raptor Study Group (IRSG) members monitoring Buzzards that three distinct populations were developing in the county. The largest population was located in East Cork between Great Island and Ballymacoda, and south of a line from Lisgoold to Youghal. This population was estimated at 12 territorial pairs in 2008 (IRSG 2008). A second population was centred about Belgooly and Minane Bridge in South Cork, and was estimated at four territorial pairs in 2008 (IRSG 2008). A third population, of uncertain size, existed between Castlemagner and Doneraile in North Cork in 2009.

No detailed survey of Buzzards had been conducted in Cork prior to the present study, although population estimates made in previous years provided a useful baseline from which to measure the rate of increase. The total Cork population was estimated at 25 pairs in 2008 (IRSG 2008) and at 45 pairs in 2010 following experimental soaring surveys in two 10km squares where greater numbers than anticipated were recorded (IRSG 2010). This paper describes the results of a survey of the three core population areas (described above), as well as frontier (edge) 10km squares adjacent to these core areas. In addition to obtaining an estimate of the Buzzard population of Cork, a study of the habitats occupied and an examination of diet and productivity were also undertaken in order to gain further insights into Buzzard ecology.

Study area and methods

Distribution survey

This survey aimed to record the distribution and abundance of Buzzards in five regions in County Cork (North, South, East, West & Mid). Surveying was conducted in 34 10km squares which comprised the then known range (11 squares) and the potential range (23 adjacent edge squares). Most surveying was conducted in March and April 2011. Additional survey work was undertaken in March and April 2012 at edge squares that were either not surveyed in 2011, or where additional survey time was required to achieve a minimum three hours of coverage in each. Surveying in March allowed identification of territorial pairs as display was then regularly recorded. The methods employed followed those of Taylor *et al.* (1988) and Sim *et al.* (2000). A minimum of three one-hour observation periods was carried out at vantage points in each 10km square, and the number and behaviour of Buzzards was noted. Three tetrads ($2km^2$) with suitable potential breeding habitats for Buzzards (i.e. woodland or copse) were chosen in all squares by referring to the relevant Ordnance Survey of Ireland Discovery Series 1: 50,000 maps. Areas of deciduous or mixed woodland were prioritised for survey, but mature coniferous plantations and hedgerows were also surveyed. Surveyors were asked to note the absence of Buzzards in their tetrad if none was seen. In addition to the 34 surveyed squares, information from a further six edge squares was included for habitat and productivity analysis (therefore, data were obtained from 40 10km squares, Table 1). In these, single Buzzards were seen in two squares by surveyors working in adjoining squares, while observers not directly involved in the survey provided information from four 10km squares. Two of these squares (R51 & R61) are located in the north of the county and two in the southwest (W33 & W44).

Surveyors were asked to note their vantage point (6-figure grid reference) on maps, the location of sightings, the duration of observation, whether sightings referred to individuals or pairs, and behaviour (i.e. 'display', 'flying', 'calling', 'soaring', 'perched on ground', 'mobbing', 'stick carrying', or 'other'). Buzzard positions and flight lines were noted in order to determine the location of pairs. Pairs were distinguished from non-breeding birds by use of the following pair flight criteria: 'display', 'soaring', 'stick carrying' (i.e. carrying nest material), or 'perching in a suspected nesting area'. Care was taken to avoid duplication of records and surveyors noted the times of their sightings and indicated on maps if they thought a bird or birds were from adjoining territories. All of the core squares received adequate (over three hours) coverage in 2011, but six of the edge squares that received no coverage in 2011 were surveyed in 2012. Nine edge squares did not receive adequate coverage in 2011, so additional time was spent in different tetrads in each of these squares in 2012 to ensure that all (except two) received a minimum of three hours coverage. Statistical analysis using Spearman's rank correlation coefficient in the statistical package SPSS was used to determine whether or not the time spent surveying in 10km squares was likely to bias the survey results.

Habitat analysis

Identification of Buzzard habitat occupancy was an important part of the study. Surveyors were asked to categorise habitat and land use in the vicinity of their survey areas by noting the following habitat types: Woodland as 'mature broadleaf', 'mature conifer', or 'pre-thicket' (i.e. pre-canopy closure); Farmland as 'tillage', 'rough grazing', 'improved grazing' (i.e. improved for agricultural purposes), or 'other'. Habitat notes were also made during subsequent visits to known nest sites. Land use patterns were assessed using Lafferty *et al.* (1999) and Corine land cover data (EEA 2006). Squares (10km) were classified as 'High', 'Medium' and 'Low' in terms of land area devoted to tillage based on Lafferty *et al.* (1999), where 'High' denotes >22% of land used for tillage; 'Medium' 7–22% and 'Low' <7%.

Table 1. Number of Buzzards seen in 10km squares in different regions in County Cork in 2011–12, with number of hours spent surveying and proportion of tillage in each square.

10km Square	Region	Square Status	Tillage Area	Coverage (hours)	No. of Buzzards
R40	North	Core	Medium	3	13
R50	North	Core	Medium	5	7
R51	North	Edge	Medium	N/A	3
R60	North	Core	High	9	20
R61	North	Edge	Medium	N/A	2
R70	North	Edge	Medium	3	4
R80	North	Edge	Low	N/A	1
W49	North	Edge	Low	3	1
W59	North	Edge	Low	3	2
W69	North	Edge	Low	7	5
W79	North	Edge	Medium	9	4
W89	North	Edge	Medium	4	1
W99	North	Edge	Low	3	0
W77	East	Edge	Low	5	12
W78	East	Edge	Low	N/A	0
W86	East	Core	High	13	31
W87	East	Core	High	4	15
W88	East	Edge	Medium	5	2
W96	East	Core	High	7	7
W97	East	Core	High	5	18
W98	East	Edge	Low	3	0
X07	East	Core	High	5	7
X08	East	Edge	Medium	N/A	1
W36	Mid	Edge	Low	14	0
W37	Mid	Edge	Low	N/A	0
W46	Mid	Edge	Low	8	0
W56	Mid	Edge	Low	3	1
W57	Mid	Edge	Medium	10	3
W58	Mid	Edge	Low	4	0
W67	Mid	Edge	Low	3	2
W68	Mid	Edge	Low	6	0
W65	South	Core	High	4	18
W66	South	Edge	Medium	3	5
W75	South	Core	High	3	6
W76	South	Edge	High	3	7
W33	West	Edge	Low	N/A	2
W44	West	Edge	Low	N/A	3
W45	West	Edge	Low	3	0
W54	West	Core	Low	4	3
W55	West	Edge	High	3	3

N/A refers to squares where data was received from observers not participating in the soaring survey (six) or squares (two) that did not receive the required three hours of survey time.

Prey analysis

Pellets were collected, and uneaten or partially eaten prey remains either noted or collected at 18 nest sites in 2011. Ten of these nests were revisited post-fledging to recover further samples. Prey remains were identified to species level where possible. Mammal prey was identified from uneaten or partially eaten remains, and from bone fragments, skulls and teeth. Samples of lagomorph fur examined in five pellets all proved to be Rabbit *Oryctolagus cuniculus* (Teerink 1991), and in common with Rooney and Montgomery (2013), we assigned Rabbit a mean weight of 500g. We assigned unidentified mammals (all from pellets) a mean weight of 50g (we acknowledge that this is probably an underestimate if many refer to Rabbit), and unidentified birds (which were small) a mean weight of 20g. Bird prey was identified from various body parts and feathers. Pellets containing only mammal fur and bird feathers were ascribed to 'unidentified mammal' and 'unidentified bird', respectively, as time did not allow a more detailed analysis. The presence of bird feathers at the nest often enabled identification of species and age class (adult or fledgling) (Svensson 1992). The average weight of prey species was obtained from various sources (e.g. Cramp & Simmons 1980, Cramp 1985, 1988, Cramp & Perrins 1994, Hayden & Harrington 2000, Rooney & Montgomery 2013). The numbers of individual prey were then multiplied by their average weights to give an estimate of total weight (biomass).

Results

Distribution survey and productivity

The County Cork Buzzard population was estimated at 25 pairs in 2008 and at 45 pairs in 2010 (Figure 1). In 2011–12, a total of 174 hours of survey work was undertaken in 34 squares (62 hours in the 11 core squares and 112 hours in 23 edge squares). The minimum coverage time of three hours was not achieved in two edge squares. A total of 209 Buzzards was seen, 145 in the core squares and 64 in the edge squares (Table 1). No Buzzards were seen in seven of the edge squares where timed counts took place. More than ten Buzzards were seen in several squares in East, North and South Cork (Table 1). Numbers seen ranged from a maximum of 31 birds in W86 to single birds recorded in five separate squares. In the established strongholds, six or more Buzzards were seen in all but one core square, and several edge squares held five or more Buzzards (Figure 2). A summary of the findings of the distribution survey is shown in Table 2, which outlines the population concentrations. A minimum of 78 pairs was identified from the 209 birds seen during the survey (Figure 3). Fifty-eight of these (74.36%) were found in the eleven core squares, with the remainder in nineteen of the edge squares, while unpaired individual Buzzards were more evenly divided between core (29 birds) and edge squares (24 birds) (Table 1). Brood size was recorded at ten nests (mean brood size of 2.61 young per successful nest). Brood size varied from one to four young per nest.

Variation in the time spent surveying in different squares did not bias the results as some squares had less suitable habitat than others, and consequently required less time to survey adequately. Within the range of survey times considered, there was no significant relationship between the number of Buzzards recorded in each square and total observation time ($r_S = 0.213$, df = 30, P = 0.241). The mean

Table 2. Summary of total number of Buzzards recorded in different regions in County Cork in 2011–12.

Region	Core squares	Edge squares	All squares
North Cork	40	23	63
East Cork	78	15	93
Mid Cork	0	6	6
South Cork	24	12	36
West Cork	3	8	11
Total	145	64	209

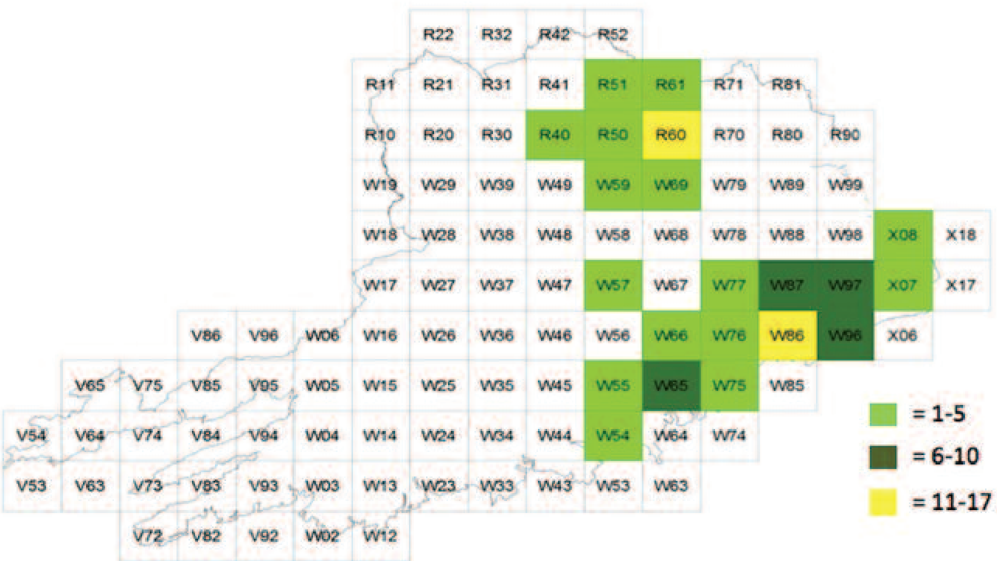

Figure 1. Distribution and density of Buzzards in County Cork in 2010 per 10km square (numbers based on individual Buzzards).

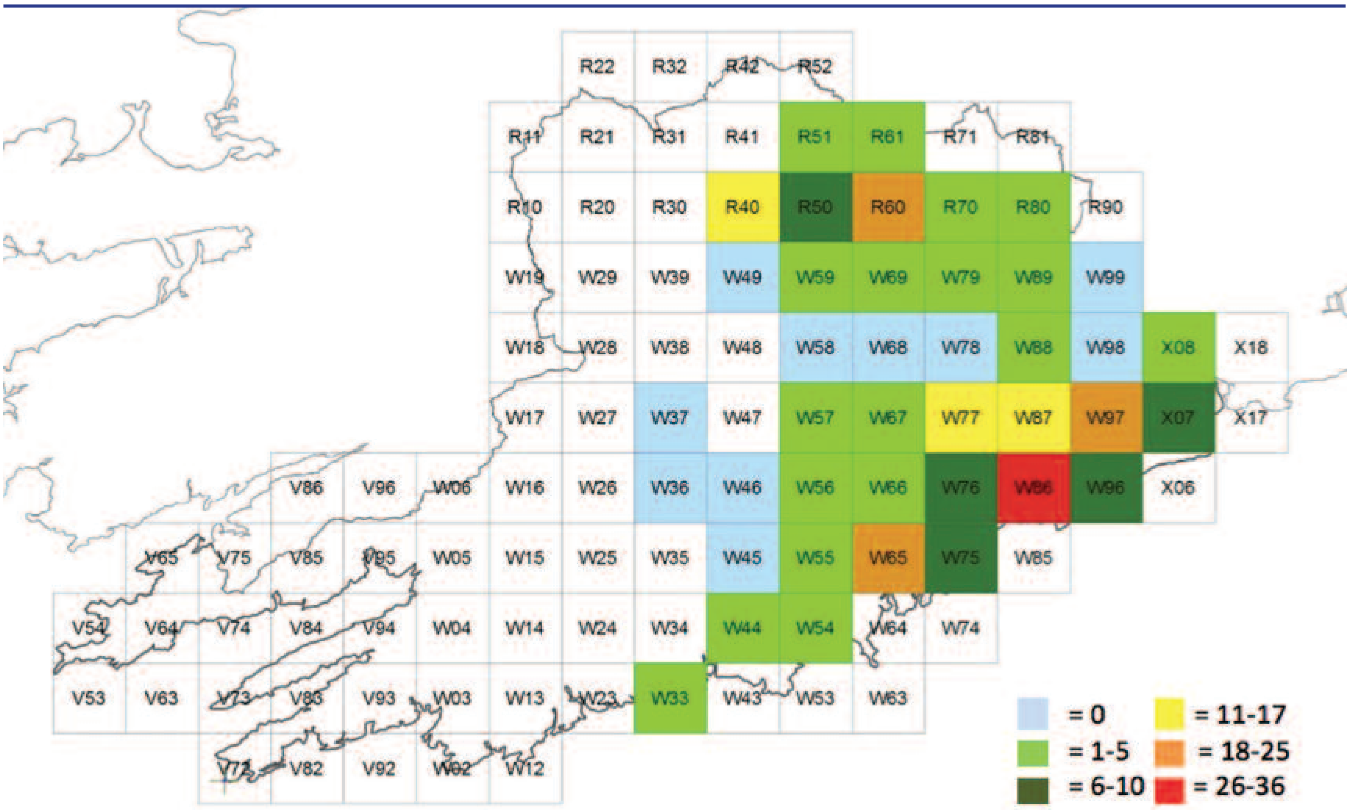

Figure 2. Distribution and density of Buzzards in County Cork in 2011–12 per 10km square (numbers based on individual Buzzards).

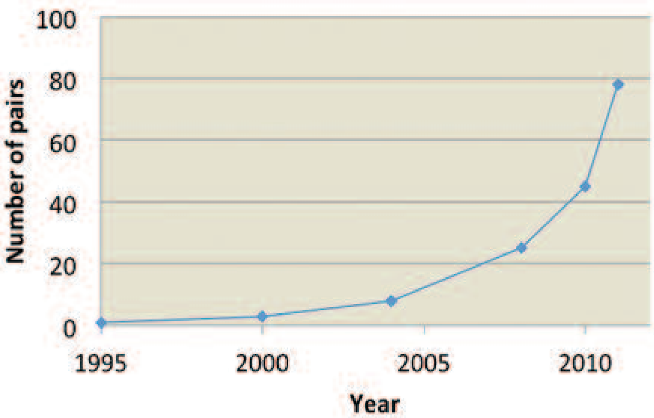

Figure 3. Population growth of Buzzards in County Cork during 1995 to 2011–12 (based on Irish Raptor Study Group data and results of the present survey).

survey time spent in each square was 313 minutes (range 180-840 minutes). Squares with the most suitable breeding habitat (mature broadleaf or mixed woodland) received more coverage. The square with the most coverage (W36) was the first square to be surveyed and this was chosen to familiarise the ten surveyors with the techniques involved in the survey. The best habitats in many squares were surveyed adequately in three hours.

Habitat analysis and nest sites

Buzzard distribution was linked to areas with a relatively high proportion of tillage (>22%) (Figure 4). There was a strong positive relationship between the number of Buzzards recorded in each square and the area of tillage ($r_S = 0.763$, df = 30, P <0.0001). Large parts of Cork, especially the north-west, west, south-west and north-east of the county, where the dominant agricultural practice is pasture, have remained largely devoid of Buzzards. The ten squares with over 22% of land use devoted to tillage accounted for 132 (63.16%) of the 209 Buzzards recorded, whereas the 11 squares with 7-22% of land use devoted to tillage accounted for only 45 (21.53%). In contrast, the 19 squares where tillage formed less than 7% of land use accounted for just 32 (15.31%) of the total number of Buzzards recorded.

Eighteen nests were located, and the tree species in which they were built was recorded (Figure 5); 72% were on deciduous (28% on oak *Quercus* species) and 28% on coniferous trees. Six of the nests were in deciduous woodland, five were in mixed woodland, four were in coniferous woodland and three were located in hedgerows.

Buzzards were recorded at altitudes from 23–205m above sea level. Only one of the 18 nests was located at an altitude greater than 200m (205m in R80) and all other nests were at sites below 120m.

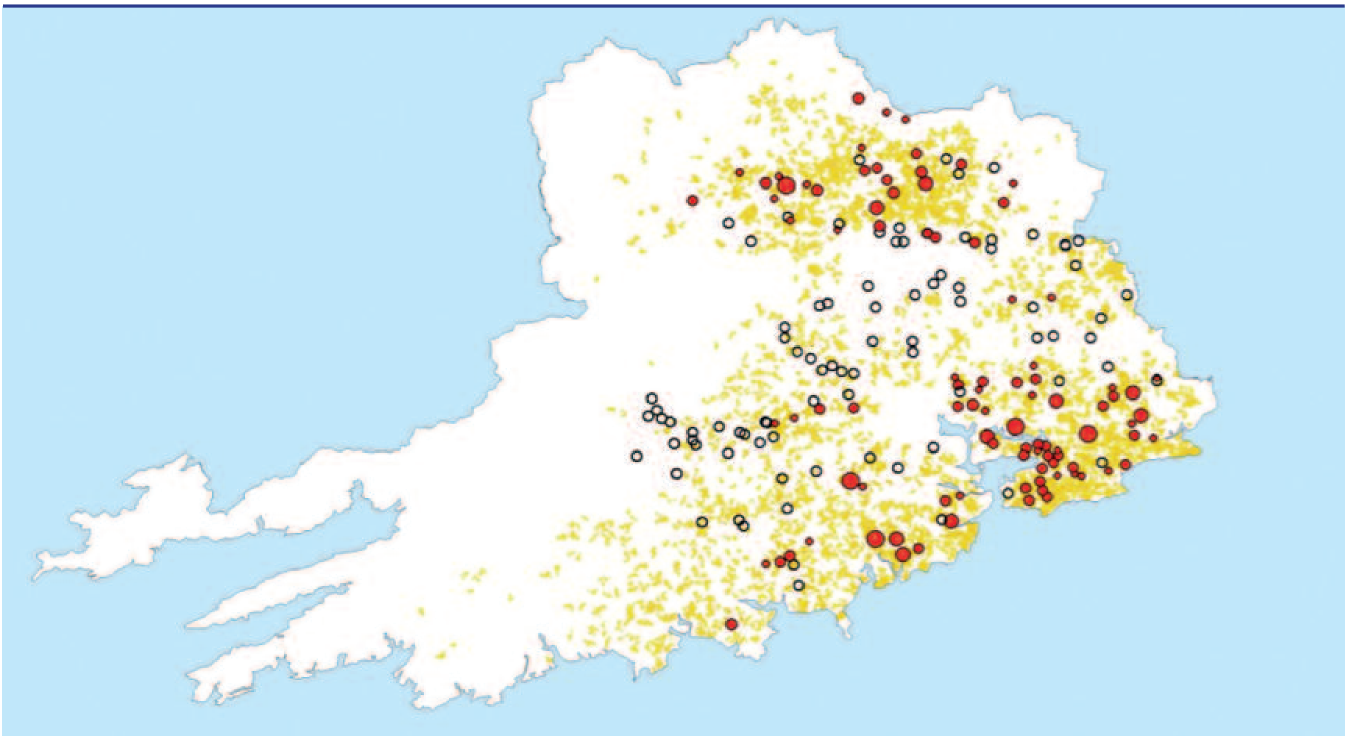

Figure 4. Distribution and density of Buzzards in County Cork in 2011–12 in relation to area of tillage. Open circles indicate no Buzzards, red circles indicate where Buzzards were present, with size denoting number (small = 1 bird, large = 5–10 birds). Areas dominated by tillage are shaded.

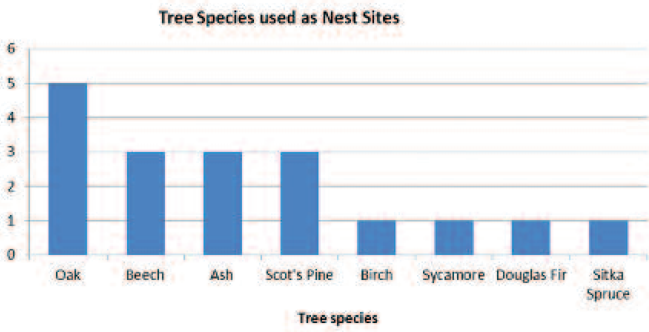

Figure 5. Tree species used by Buzzards in County Cork in 2011-12.

Prey analysis

A total of 238 prey items (85 from prey remains and 153 from pellets) were collected at the 18 nest sites visited (Table 3). Rabbit was the dominant prey at almost 40% (all percentages refer to biomass). Brown Rat *Rattus norvegicus* was the next most important mammal species at nearly 11%, although unidentified mammals formed about 9%. Bank Vole *Myodes glareolus* contributed quite a low percentage to prey weight, and a single Pygmy Shrew *Sorex minutus* was found in a pellet (Table 3). No Field Mouse *Apodemus sylvaticus* or House Mouse *Mus domesticus* was found in the prey analysis.

Birds formed 40% of prey, most being corvids *Corvus* species (almost 22%) of at least three species (Magpie *Pica pica,* Rook *Corvus frugilegus* and Jackdaw *Corvus monedula*). Woodpigeon *Columba palumbus* was also important at nearly 12%. Thrushes (Blackbird *Turdus merula* and Song Thrush *Turdus philomelos*) also occurred, but Pheasant *Phasianus colchicus* was recorded only twice. The remains of an adult Long-eared Owl *Asio otus* was found at one nest (Table 3). Most of the identifiable birds were adult, and 13 were identified as juvenile.

Discussion

Distribution survey and productivity

The number of Buzzards (209 individuals) found in County Cork during the 2011–12 survey was considerably higher than previous estimates, including the most recent of a minimum of 45 pairs in 2010 (IRSG 2010). Buzzards were only known from a small number of locations a decade earlier, and the scale of colonisation has been remarkable. From an estimate of four pairs breeding in three 10km squares in 2001, the population has grown to at least 78 territorial pairs occupying 31 10km squares (Table 1). This represents an increase in population size and range of 1,950% and 1,033% respectively, in eleven years. It should be noted however, that earlier estimates were probably too low, based on how little was

Table 3. Number of prey items (as prey remains and in pellets), frequency (%), biomass of prey and prey weight (%) collected at Buzzard nests (n = 18) in County Cork in 2011.

Prey species	Prey remains (n = 85)	Pellets (n = 104)	Prey items (%)	Prey weight (g)	Biomass (g)	Prey weight (%)
Rabbit	20	13	13.9	500	16,500	39.7
Bank Vole	1	9	4.2	18	180	0.4
Brown Rat	7	6	5.5	350	4,550	10.9
Pygmy Shrew	0	1	<1.0	4	4	<0.1
Unid. mammal	0	74	31.1	50	3,700	8.9
Pheasant	2	0	<1.0	500	1,000	2.4
Woodpigeon	11	0	4.6	450	4,950	11.9
Long-eared Owl	1	0	<1.0	250	250	0.6
Blackbird	3	0	1.3	105	315	0.8
Song Thrush	3	0	1.3	84	252	0.6
Magpie	5	0	2.1	200	1,000	2.4
Rook	4	0	1.7	480	1,920	4.6
Jackdaw	2	0	<1.0	245	490	1.2
Unid. Corvid	13	1	5.9	400	5,600	13.5
Unid. bird	13	30	18.1	20	860	2.1
Beetle	0	19	8.0	1	19	<0.1
Total	**85**	**153**	**100.0**	**-**	**41,590**	**100.0**

known about the North Cork population. Rooney (2013) estimated the all-Ireland Buzzard population at 3,312 pairs, almost half of which were in the Republic of Ireland.

Some authors (e.g. Taylor *et al.* 1988) have suggested that estimating the size of a Buzzard population from soaring surveys was difficult, because it was not possible to relate soaring numbers with numbers of pairs or territories. Birds seen soaring are mainly territorial, but may include a proportion of non-territorial individuals, especially on warm and sunny days (Sim *et al.* 2000). However, some surveys of soaring Buzzards can provide good estimates of the number of individuals (or pairs) in a study area. Sim *et al.* (2000) found significant correlations between soaring and nesting numbers, and between soaring and egg-laying numbers in the West Midlands of England, although they did caution that their sample was small. Nevertheless, they suggested that if anything, soaring surveys underestimate the breeding population, the reverse of that predicted by Taylor *et al.* (1988). The majority of the Cork survey took place in March, and because both males and females were regularly involved in courtship behaviour during that month, the findings are likely to provide a reasonably reliable estimate of the number of pairs present. An ongoing study in England (Prytherch 2009) has shown that breeding adults in a stable population comprise the majority (perhaps up to 85% in the spring), and this figure may be exceeded in dynamic, colonising populations. Therefore, the figure of 78 pairs is likely to be a conservative estimate, although some of the single birds seen in edge squares may have been lone pioneers.

The 10km square with the highest number of Buzzards recorded during the present survey was W86 (the square in which breeding was first proven in the county in 2004 (Nagle 2006)) (Table 1). This square has 13 territorial pairs, although approximately 30% of the area is marine habitat. This figure is within the typical range of 10–22 pairs per 100km^2 found in Britain (see references in Sim *et al.* 2001), but is still far below the maximum density of 81 territorial pairs in a single 10km square on the border between England and Wales, the highest density recorded in Europe to that time (Sim *et al.* 2001), while Rooney (2013) found a density of 39.4 pairs per 100km^2 in Northern Ireland. This indicates that there is likely to be space for additional territories in many Cork squares. Buzzard re-colonisation can be very rapid, as witnessed in the Lothian and Borders area of Scotland, where the population increased from 18 pairs in 1984 to over 1,000 pairs in 1999 (Holling 2003).

Buzzard expansion in East Cork has been relatively localised to date as new pairs occupy available territories in close proximity to already occupied territories. The utilisation of suitable habitats in that area has resulted in the build-up of relatively high densities, but has also contributed to a relatively slow outward spread to adjoining areas. This tendency has been noticed in Britain and it has been put forward as a contributory factor in the relatively slow spread from the

Plate 18. Buzzard chick, Co. Cork (Tony Nagle).

strongholds in the west of Britain to eastern Scotland and England (Sim *et al.* 2001). In Cork, local population build-up led to situations where large numbers of Buzzards could be seen soaring over some areas (e.g. 20 in the vicinity of the East Cork town of Midleton) while Buzzards were absent from suitable habitat only a few kilometres away. Expansion from East Cork appears to be mainly in a westerly direction and there seems to be a reluctance to spread northwards into the pastoral farmland south of the River Bride.

A small Mid Cork population, perhaps involving no more than four to six pairs, has recently become established in the Ovens area and there is much suitable habitat available for westward expansion along the Lee valley.

The South Cork population is still very much concentrated in two core squares where there are now twelve pairs and an additional three pairs in adjacent squares. This population has not grown as rapidly as the other two core populations and one possible explanation is a shortage of woodland or mature trees over much of the area. There is considerable potential for cliff nesting in coastal squares but this has yet to be recorded in the county. At least three pairs have recently established territories in W76 forming a direct link to the East Cork population.

The five to seven pairs in West Cork have, for several years, been concentrated in and around a single 10km square (W54). Recent expansion northwards from this square should facilitate colonisation of the wooded Bandon valley. Single pairs have also been seen in two squares to the west. The spread into West Cork appears to be almost following the coastline, which could be related to the concentration of arable land in areas close to the coast.

In North Cork, the population is still heavily concentrated in the three core squares, but colonisation of the Blackwater valley now seems to be underway and will probably lead to significant spread in the future. Buzzards have already reached the southern side of the Ballyhoura Mountains and it will be interesting to see how soon colonisation of nearby largely pastoral areas takes place.

Colonisation of the western half of Ireland has so far been very limited, as illustrated by the recently published *Bird Atlas* (Balmer *et al.* 2013). A similar pattern appears to apply in County Cork. There are probably several factors involved, including topography, climate and land use (see below). Buzzards have so far largely avoided upland areas (over 300m) in the county, although they have recently (since 2010) begun to colonise the southern side of the Ballyhoura Mountains (Barry O'Mahony, pers. comm.) but most of the sightings were in areas well below the 300m contour line. Several Buzzards were seen on the northern foothills of the Nagles Mountains but all sightings were in or adjacent to mixed farmland in the Blackwater valley. A newly colonising species, especially a top predator such as the Buzzard, can take advantage of the best habitats available, avoiding habitats that are sub-optimal in the early phases of colonisation. This is what appears to be

Plate 19. Buzzard chicks, Co. Cork (Tony Nagle).

happening in Cork, as the most fertile (and therefore prey-rich) parts of the county are being colonised ahead of the wetter, higher and less fertile western half of the county.

Higher rainfall in the west may well be a contributory factor in limiting the rate of colonisation. Continental studies have shown that rainfall in May can be an important determinant of breeding success (Kostrzewa & Kostrzewa 1994, Kruger 2004). Buzzards are now widely distributed (albeit thinly in many areas) east of a line from square R51 in the north to square W54 in the south and this roughly corresponds with a change in the mean annual rainfall contours from 1,000–1,200mm to 1,200–1,400mm (Met Eireann 2012). Buzzards are common in most of western Britain so they are likely to colonise the western parts of Ireland in the future, but with much habitat currently available in the drier and more fertile east, this colonisation may take some time.

Buzzards appear to be thriving in the study area. Productivity in Cork (mean brood size of 2.61 young per successful nest, n = 10) is comparable to elsewhere in Ireland and Britain, although the sample size is very small. Studies elsewhere, all with considerably larger sample sizes, identified the mean number of young fledging at 1.4 to 2.6 young per successful pair (Austin & Houston 1997). In Northern Ireland, Rooney and Montgomery (2013) recorded a mean of 1.95 young fledging per successful pair. Buzzards require a recruitment rate of about 1.15 young per productive pair to maintain a stable population (Newton 1979). Buzzards are long-lived birds and pairs have been known to remain up to 20 years together (Prytherch 2009). Longevity and comparatively high productivity should ensure that the Cork population continues to increase and spread, although the extent of illegal persecution is unknown, but is thought to be low (Pat Smiddy, pers. obs.). Immigration to Cork from other parts of Ireland, and possibly also from Britain is likely to continue, and would add to the rate of increase. Modelling of the expanding Irish population has shown that movements from Britain to southern Ireland are extremely likely (Rooney 2013).

Habitat analysis and nest sites

The areas of greatest density in Cork are located in mixed pasture and arable farmland (Figure 4). However, the core areas which contain substantial (>20%) acreages of tillage are not exclusively arable, and sizeable areas of pasture are interspersed with crop fields. Buzzards, by and large, have not yet colonised areas that are predominantly pastoral. Buzzards reach their greatest densities in areas of diverse agricultural habitat (Austin *et al.* 1996). A wide range of habitats is likely to contain a diverse range of prey, suitable hunting areas and uneven terrain which is ideal for soaring flight (Picozzi & Weir 1974). Diverse habitat is also more likely to produce a wide range of nesting sites. The greatest density of Buzzards recorded in Britain was in an area of mixed pasture and arable farmland containing woodland and forestry plantations (Sim *et al.* 2001).

Availability of nest sites, ideally woodland or large mature trees, is limited in some 10km squares in Cork. The core areas were notable in that they all contained significant proportions of arable land and most also contained substantial areas of mature woodland. The North Cork core squares, R40, R50 and R60 are unusual in that many hedgerows contain mature deciduous trees, predominantly Oak *Quercus robur* and Beech *Fagus sylvatica,* and these trees provide ideal nesting sites for Buzzard. There is some indication that deciduous trees were preferred as nest sites (Figure 5), but this may be due to local availability and a larger sample would be required to test this suggestion. It may also relate to the size of trees; in conifer plantations felling regimes result in the removal of trees long before they reach ecological maturity, and Buzzards favour mature forest for nesting, where available (Selas 1997). A large Ash *Fraxinus excelsior* tree growing in a coniferous wood at one site was used in preference to the more plentiful Sitka Spruce *Picea sitchensis* trees.

The wooded valleys of the three large rivers in the county, the Blackwater, Lee and Bandon have yet to be fully exploited by the expanding Buzzard population. There is no shortage of coniferous woodland in most of the western squares and small stands of Sitka Spruce have been planted on many farms and may be used as nest sites if allowed to mature.

Prey analysis

The analysis of prey remains and pellets is fraught with difficulties for many birds of prey. In a study of Buzzard diet in Scotland, Graham *et al.* (1995) assumed that once a species was recorded in a pellet it was represented by not more than a single individual. They also assumed, by inference, that each individual prey item is only recorded in a single pellet. This creates difficulties when interpreting the role of larger prey items, such as Rabbit, because the remains (hair and bone fragments) are likely to be found in more than one pellet as there may be three or more chicks feeding from one carcase (see Rooney & Montgomery 2013). The analysis of diet (prey remains and pellets) (Table 3) revealed the importance of lagomorphs (Rabbit), corvids (mostly Rook), Woodpigeon and Brown Rat. These results, in terms of biomass, are very similar for the main prey species to that reported for a study in Northern Ireland (Rooney & Montgomery 2013). Only two gamebirds (Galliformes) (both Pheasant) were recorded in the Cork study (2.4% biomass). In Northern Ireland the figure for gamebirds was 9.1% biomass (Rooney & Montgomery 2013). Buzzards are opportunists and scavengers and numerous species have been recorded as prey throughout their range. The most unusual prey item recorded in this study was an adult Long-eared Owl. Adult Long-eared Owls have been recorded in Buzzard diet on two occasions in Northern Ireland (Eimear Rooney, pers. comm.). Tawny Owl *Strix aluco* fledglings are occasionally taken by Buzzards in Britain (Tubbs 1974, Swann & Etheridge 1995).

Many studies have shown the importance of the Rabbit to Buzzard breeding productivity (Sim *et al.* 2000, 2001, Swann & Etheridge 1995, Rooney & Montgomery 2013). It appears from the relatively small sample of prey items in this study that Buzzards are mainly taking larger prey species, and this may contribute significantly to higher productivity. Only one Pygmy Shrew was found (Table 3), and no specimen of the recently discovered Greater White-toothed Shrew *Crocidura russula* appeared during the present study. However, a single specimen of the Greater White-toothed Shrew was found in a Buzzard nest near Kilworth in 2013.

Ten Bank Voles were found, but they represented a rather insignificant contribution to prey biomass (Table 3). Buzzards are highly efficient at digesting bone (Barton & Houston 1993), and it is likely that small mammal prey, particularly Bank Vole, was underestimated in the pellet analysis. Bank Vole may well be a significant prey item given that voles of various species feature prominently in Buzzard diet in Britain and continental Europe (Swann & Etheridge 1995, Selas *et al.* 2007). Surprisingly, no mice were detected in the Cork study, but a single Field Mouse was found in a Buzzard nest in W97 in 2013. The Field Mouse comprised 8% (frequency) of combined prey remains in Northern Ireland, and occurred at 62% of nests, although it contributed less than 1% in biomass (Rooney & Montgomery 2013). A sample of 60 pellets from Wicklow contained 16 Field Mice (Damian Clarke, pers. comm.). Mice may well have been overlooked in this study due to incompleteness of the hair analysis.

The pellet sample suggests a heavier dependence on mammal prey than can be inferred from prey remains (Table 3). Mammal species accounted for 103 (67.3%) of the 153 prey items identified from pellets, but only 28 (32.9%) of the 85 prey items identified from prey remains. Therefore, it is important to combine prey remains and pellets in dietary studies of the Buzzard in order to obtain a broad view of diet (see Rooney & Montgomery 2013). The only invertebrates recovered from pellets were 19 beetles. Many of the pellets contained earth consistent with earthworm presence, but no attempt was made to calculate earthworm content. Beetles and earthworms are regularly taken by Buzzards, but their small size means that they are of limited overall importance to prey biomass (Tubbs 1974), although invertebrate prey may well be significant to immature birds.

Arable farmland areas of Cork support high densities of a variety of potential avian prey species (Copland & Lusby 2012). Balmer *et al.* (2013) have shown that Rooks are particularly abundant in the core areas. Rooks prefer "farmland with a

Plate 20. Juvenile Common Buzzard, Co. Cork (Harry Hussey).

mixture of field types" but they depend on grassland in the breeding season (Gibbons *et al.* 1993). Rooks are known to reach higher densities in Ireland than Britain (Hutchinson 1989), so it is not surprising that Buzzards are availing of this very common prey resource.

Very little data exists on Rabbit abundance and habitat preferences in Ireland. Rabbits were regularly reported as 'pests' by local farmers during this survey, and this is not surprising as they can achieve densities of up to 40 per hectare (Hayden & Harrington 2000). Sim *et al.* (2001) found that Rabbits were numerous in unimproved pasture but scarce in arable farmland. Unimproved pasture is scarce in the core areas, but mature hedgerows and improved grassland appear to support good numbers of Rabbits, though perhaps at lower densities than recorded by Sim *et al.* (2001).

Conclusion

The re-colonisation of the Buzzard is revealing (at least initially) a distinct preference for the more fertile mixed farmland of the north, east and south of County Cork. Their choice of these more productive habitats is related to the higher proportions of arable land in these parts of the county. Mixed farmland supports higher densities of many prey species.

The arrival of a "new" apex predator presents an opportunity to take a fresh look at the state of the environment and of predator-prey dynamics. The Buzzard is a top-level predator and given the right circumstances of prey availability and the existence of suitable nesting habitat, can achieve comparatively high densities. No avian predator in Ireland is likely to achieve the densities that Buzzards are capable of reaching (with the possible exception of Sparrowhawk *Accipiter nisus*), and this may have significant implications for prey species at lower trophic levels. It is reasonable to assume that one of the reasons Ireland has unusually high densities of species such as Rook, Magpie and Woodpigeon is related to the fact that most of our large avian predators have been extirpated over the past 200 years. Buzzard re-colonisation may also have implications for other avian predators. There is some evidence to suggest that the Buzzard has displaced the Hen Harrier *Circus cyaneus* from nesting areas in Antrim (Scott & McHaffie 2003). Buzzards have apparently also displaced the Peregrine Falcon *Falco peregrinus* from a number of coastal sites in Antrim (Marc Ruddock, pers. comm.), although the Red Kite *Milvus milvus* has apparently displaced Buzzards themselves at several sites in Northern Ireland (Eimear Rooney, pers. comm.). The recent decline of the Kestrel *Falco tinnunculus* in parts of Britain has been linked to increases in the Buzzard population and other raptors, resulting in increased competition and intra-guild predation (Balmer *et al.* 2013). However, it is probably too early in the re-colonisation process of the Buzzard, and in the re-establishment (following re-introduction) of the Red Kite, White-tailed Eagle *Haliaeetus albicilla* and Golden Eagle *Aquila chrysaetos,* to make definitive statements regarding the likely long-term effects of these top predators.

The sudden arrival of a relatively large bird of prey (the Buzzard) is likely to inspire a variety of responses in the future from interest groups (farming, sporting and conservation). Hopefully, the present study will inform some of these responses, and perhaps it will encourage further study of this intriguing raptor.

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Alexander Williams: a forgotten Dublin ornithologist

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Plate 21. Alexander Williams, Dublin ornithologist (photo courtesy of Gordon Ledbetter).

Alexander Williams (1846–1930) was a Dublin ornithologist, whose significant contribution to the early development of bird study in Ireland seems to have been virtually forgotten. Together with his brothers Edward and William, he became one of the leading taxidermists of his time, but he was also an accomplished field ornithologist. Because he was mainly known and respected as a landscape painter, a comprehensive biography of Alexander Williams has recently been published (Ledbetter 2010), but his contribution to natural history has been somewhat overlooked elsewhere. Praeger (1949) fails to mention him in his encyclopaedic book *Some Irish Naturalists,* although there are entries for his father, William, and his brother Edward. There is no reference to him in the historical review in Clive Hutchinson's *The Birds of Dublin and Wicklow* (1975), nor in his landmark book *Birds in Ireland* (1989). Williams is not included in a historical account of bird study in Ireland (Hutchinson 1997), nor in a review of the essential texts in Irish natural history (Cabot 1997). Similarly, Cabot (1999) did not mention Williams in his chapter on Irish naturalists and their works.

Alexander Williams was originally from Drogheda, but moved to Dublin as a youth. His family were hat manufacturers, but, following a disastrous fire in 1866 at their shop at Westmoreland Street, he and his brother began a taxidermy business, first in Bachelor's Walk and then Dame Street, where they sold mostly bird specimens. Starting with a single taxidermy specimen set among the hats, the brothers' business quickly progressed to the point that, while one window in their new shop in Dame Street was devoted to hats, the other was given over to birds. Thus began what the ornithologist R.M. Barrington described in the *Irish Naturalist* as 'the battle of the hats and birds' (Ledbetter 2010). Many of the specimens mounted by the Williams brothers are still on display in the Natural History Museum in Dublin and the Ulster Museum in Belfast and the backgrounds of these display cases were probably painted by Alexander Williams himself as he was an accomplished artist and, later, a member of the Royal Hibernian Academy. He was also a fine musician and he sang professionally in the choirs of St. Patrick's and Christchurch Cathedrals in addition to the Chapel Royal in Dublin Castle.

From the start, the brothers called themselves naturalists rather than taxidermists as this was a more prestigious term in the Victorian era. In fact, Williams was a dedicated naturalist and birdwatcher who spent every free day outdoors. His unpublished ornithological diaries from the period 1909–1911, are now housed in the Ulster Museum and have been transcribed by Gordon Ledbetter who provided the author with a copy. These give a fascinating day-to-day account of the bird species that he encountered in Dublin Bay and further afield. Typically, he would walk or catch a tram from the family home in Clontarf (later in Hatch Street) to a favourite spot such as Sandymount Strand, North Bull Island, Baldoyle or Malahide. He wrote many articles for the journal the *Irish Naturalist.* Among his more substantial writings was a paper entitled 'Bird Life in Dublin Bay' (Williams 1908a).

In one of his most interesting observations from South Dublin Bay, Williams records that: "a colony of the Lesser Tern [now known as the Little Tern *Sternula albifrons*] has existed for many years in varying numbers, nesting under many difficulties. Unfortunately, in recent years bicyclists in increasing numbers and youngsters have found their way to the bank, chiefly on Sundays, often accompanied by dogs, and the nests have frequently been raided". Williams then gives a brief account of what must be the earliest tern conservation project in Dublin Bay: "Owing to the success attending the protection of the terns at Malahide Island by the Irish Society of the Protection of Birds [ISPB], arrangements have been made to place a watcher on the Shelly Bank [on Sandymount Strand], and it is hoped that the birds may now have a better chance of their numbers increasing, especially since the flattening down and spreading out of the sand-banks have broadened the zone selected by them".

Despite his requirement to shoot interesting bird specimens for his taxidermy business, Williams was also interested in their conservation. Early developments in wild bird protection in County Dublin were reviewed by Williams (1908b) shortly after the passing of the first legislation for the preservation of Irish birds. He wrote: "It is not so very many years since the poulterer's shops in the City of Dublin often contained in the last week of April numbers of Golden Plover [*Pluvialis apricaria*] in the handsome black, white and yellow full summer plumage, together with specimens of the fine White-fronted Goose [*Anser albifrons*], a sight that often grieved humane bird lovers".

Williams was very impressed by the direct effects of protection of a colony of Common *Sterna hirundo* and Arctic Terns *Sterna paradisaea* nesting on the north County Dublin mainland beach, still known today as Malahide Island. He recounts how the ISPB appointed a watcher, "whose duty it was to see that visitors do not molest the birds or take their eggs". On 7 July 1907, Williams and his brother visited the site where "some egg-collecting boys, provided with pill boxes, had just come over for a raid on the nests and the watcher had been doing his duty, greatly to the disappointment of the young naturalists. As we approached the colony, the birds collected in a great white flock and we found it impossible to calculate their numbers". The two ornithologists later counted 211 tern nests with 338 eggs and 31 young. Assuming that these were recently hatched chicks, this gives an average clutch size of 1.75 eggs per nest which is lower than average for Common Tern clutches and more typical of Arctic or Roseate Terns *Sterna dougallii* (Cabot & Nisbet 2013). Williams mentions that "Thirty-one of the nests contained three eggs each, and four nests had four eggs in each", which confirms that at least some of the colony also contained Common Terns. By 1922, this colony was estimated at 3,000–4,000 birds, of which 90% were considered to be Common Terns (Kennedy 1961, Cabot & Nisbet 2013), but by 1955 the colony was deserted (Rochford 1975).

Williams welcomed the success of the tern protection scheme at Malahide and expressed the hope that "this may be imitated in other parts of the country, and that it may be the means of inducing the Roseate Tern, which formerly bred abundantly at Rockabill, and which yearly breeds on the Welsh coast, to become once more a summer resident". Cabot and Nisbet (2013) record that the Roseate Tern colony at Rockabill was destroyed by egg-collecting and shooting, and in 1850 had decreased to "at least seventy or eighty" birds (Thompson 1851). By 1900 it had been completely deserted (Ussher & Warren 1900), but by 1949 there were at least 200 pairs of Roseate and 250 pairs of Common Terns nesting on Rockabill (Rochford 1975). Williams' hopes were fulfilled in later years as Rockabill has become the largest single colony of Roseate Terns in Europe with 1,243 pairs in 2014 (data from BirdWatch Ireland).

Williams was also especially knowledgeable about the birds that used a now vanished island on the north side of Dublin Bay. This feature was close to the North Lotts (now beneath Dublin Port) and was described by Williams (1908a) as originally measuring about 400 yards long, and about 40 yards wide (about 1.3 hectares): "On Clontarf Island and in its vicinity my late brother Edward and myself for years had many opportunities of becoming acquainted with the appearance and habits of nearly every species of bird that frequented the shores of Dublin Bay. The early frosty mornings of September used to find us wading along the sandy margins of the streams that skirted the island, searching closely among the flocks of Dunlins [*Calidris alpina*] for the Little Stint [*Calidris minuta*] or the Curlew Sandpiper [*Calidris ferruginea*], and sometimes late into moonlight nights lying among the long grass and listening to the confused cries of the multitudes of sea-fowl spread all over the island to the water's edge. The rising of the tide away down at Sutton and Dollymount, and the covering up of the mud-flats and feeding-grounds, both by day and night, brought great flocks of birds up the bay, and gradually as the tide approached high water they crowded on Clontarf Island. On a day in winter it used to be a great delight to watch through a field-glass the movements of this great collection of wild-fowl. Afloat at some distance might be seen

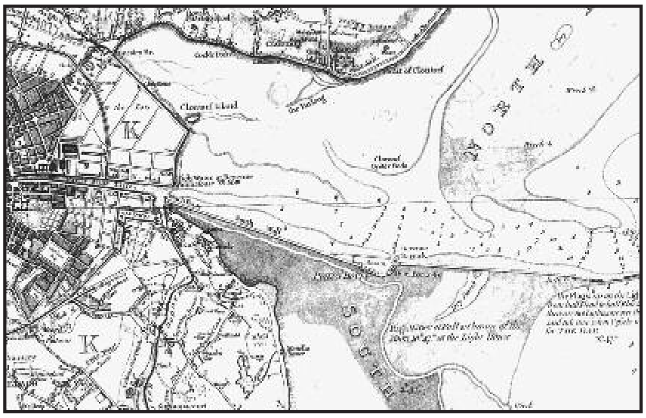

Plate 22. Map of part of Dublin Bay, showing the location of Clontarf Island in 1816 (Taylor).

big quantities of wild ducks in distinct flocks, Wigeon [*Anas penelope*] forming the largest portion. Shelducks [*Tadorna tadorna*], Golden-eyes [*Bucephala clangula*], active little Tufted Ducks [*Aythya fuligula*] and Pochards [*Aythya ferina*], strong-looking Scaups [*Aythya marila*], Red-breasted Mergansers [*Mergus serrator*], occasionally the Buff-breasted Goosander [*Mergus merganser*], Common Mallards [*Anas platyrhynchos*] and Teal [*Anas crecca*], and the Great Northern [*Gavia immer*] and Red-throated Divers [*Gavia stellata*]. More prominent and darker was a fairly big flock of Brent Geese [*Branta bernicla*] that every winter came to the bay and stayed till spring-time. Standing just at the water's edge a row of Great Cormorants [*Phalacrocorax carbo*] were always a feature, and higher on the shore a few Herons [*Ardea cinerea*] rested motionless, whilst flocks of Curlew [*Numenius arquata*] and Oyster-catchers [*Haematopus ostralegus*] stood preening their feathers. Of the smaller waders Golden Plover, Godwits [*Limosa lapponica*], Knots [*Calidris canutus*], Redshanks [*Tringa totanus*], Ringed Plovers [*Charadrius hiaticula*] and Dunlin in flocks of various sizes rested along the gravelly shore. In the company of this living mass of ducks and waders the great family of the gulls were always well represented, a couple of pairs of adult Great Black-backed Gulls [*Larus marinus*] usually resting with the others, and Herring Gulls [*Larus argentatus*], Common Gulls [*Larus canus*], and Black headed Gulls [*Chroicocephalus ridibundus*], the most numerous and noisy of all, made up the flock." His ornithological diary entry for 28 November 1909 records a high tide visit to the North Bull, Dollymount in Dublin Bay where he saw Godwit and Grey Plover [*Pluvialis squatarola*] and he describes the lagoons as "black with masses of uncountable Curlew, Oystercatcher and duck including Wigeon, Red-breasted Merganser and Shelduck on the edge of the saltmarsh". This description of the roost at the North Bull Island lagoons is remarkably similar to the situation a century later (Crowe 2005).

The appearance of a bird of prey at the high tide roost was eloquently described by Williams: "This scene of repose and enjoyment would sometimes suddenly change, the birds at the same instant becoming violently agitated, and springing into the air in masses, wheeling and curving as the different flocks swept away from the island, their loud call-notes and alarm cries making a babel of musical sounds. The startled onlooker might gaze in surprise, thinking a boat had suddenly appeared to cause so great a disturbance, but the quick eyes of the birds had discerned their natural enemy, the Peregrine Falcon [*Falco peregrinus*], high overhead, coming from his eyrie over the rugged slopes of Ireland's Eye, where the Falcons have bred for years, and in a few seconds he might be seen in a long swooping flight in search of his prey, alarming and putting up every flock of birds from Howth to Clontarf".

This was a time when shooting birds was an acceptable method of describing the plumage and obtaining specimens for taxidermy. Williams writes: "Owing to the want of cover for shooters few of the rarer birds have been obtained on the island. A friend once on a moonlit night obtained a Little Stint by firing at random at a flock of Dunlin. My brother secured some Curlew Sandpipers more than once from a boat at the tail of the Bank, and one misty morning in September I had the pleasure of getting quite close in my boat to a Grey Phalarope [*Phalaropus fulicarius*] swimming in a bend of the stream off the island. It was just like a miniature Little Gull [*Hydrocoloeus minutus*], floating so buoyantly, and pecking at something minute on the surface of the water".

Williams' work in taxidermy led to his assisting more eminent scientists with their fieldwork. One of these was C.J. Patten who studied anatomy at Trinity College Dublin and later became Emeritus Professor of Anatomy at the University of Sheffield. Patten was an enthusiastic ornithologist who wrote *The Aquatic Birds of Great Britain and Ireland* (Patten 1906). He asked Williams to collect some specimens of Sanderling *Calidria alba* so that he could examine the variations in the plumage and anatomy of this species. In pursuit of these specimens, Williams ranged over various estuaries from Dublin to Drogheda. His paper, 'Observations on the Sanderling of Dublin Bay' (Williams 1910), contains a table giving counts of these tiny waders in the month of July over five years 1906–1910. This must be one of the first systematic counts of water birds published in Ireland. While his main interest was in describing the different seasonal plumages, he was fascinated by the early arrival of these birds back in Ireland while other individuals of the species were still breeding in the high Arctic. He writes: "I think it may be taken for granted that all of the birds noticed during the month of July were non-breeders, either old or barren. Then the question would be, did they remain behind in the bay and on the Drogheda coast, when the main body was speeding to their far northern breeding haunts in May or early June? Or were they, as non-breeders, the early outposts of the main flocks on their return later, old and young, from the north?" This speculation shows that he was already aware that some waders do not migrate each season but remain in the 'winter' habitats throughout the year.

Williams' ornithological diaries from the period 1909 to 1911 have been preserved in the Ulster Museum in Belfast, possibly because they were acquired by the naturalist Robert Patterson (1863–1931) who served as President of the Belfast Naturalists' Field Club. Patterson made an early collection of zoological exhibits which was opened to the public and ultimately transferred to the Ulster Museum (Praeger 1949). These unpublished diaries give a wonderful portrait of a man who loved the outdoors and was most at home walking the coastline of Dublin and meticulously recording the birds that he saw. The diaries also contain some valuable counts of birds that make interesting comparison with modern population estimates for the same species. For example, on 15 January 1911, he records a large flock of 1,500 Bar-tailed Godwit between the Bull Wall and the end of Dollymount Strand in north Dublin Bay. Similar numbers are still recorded a century later as part of the Irish Wetland Bird Survey with an average peak of 1,732 Bar-tailed Godwit in Dublin Bay in the period 2004/05–2008/09 (Boland & Crowe 2012).

Williams' writings are quite factual but they also capture the excitement that he experienced in seeing common bird species in large numbers as well as painting a verbal picture of the surrounding landscape. On 1 January 1911 he writes: "We now walked across to the [Bull Island] sand dunes on the sea side and were rewarded by a peep through the long marram grass [*Ammophila arenaria*] of a large flock of Curlew and Oystercatchers along the tidal fringe, quite close in. They soon saw us and flew off away to where the sea line extended at the far edge of the sandy shore. Beyond was the misty hill of Howth with the sea between and spread out all at rest were hundreds of small waders where the sand ridge of the shore was highest and the other side of a long lagoon of water. Ringed Plover extended, most of them resting. To the right, half a mile away, 23 Sanderling, their white breasts and foreheads very conspicuous, were the only birds actively feeding. 8 Grey Plover at rest stood near and out in the shallow water about 50 Knots were also standing. It was a delightful sight for a naturalist for the morning sun was slanting its bright beams on the white parts of the plumages of the birds in sight and cast long shadows on the dry yellow sands. Gulls were flying back and forward and a single Great Cormorant was winging its way towards the bar at Sutton. We noticed a very large flock of Green Plover [Lapwing *Vanellus vanellus*] flying about the trees near Raheny but none of that species were to be seen at the Bull. We remarked the entire absence of Wigeon, not having observed a single specimen from the Railway at Fairview to Sutton, an unusual circumstance." Such detailed observations were rare a century ago and give a valuable historic record of important bird areas.

Williams' paintings contain a wealth of detail of the landscapes and human activities of his time, especially coastal and maritime subjects. He was largely self-taught, attending only the RDS night school for some lessons in drawing. He was good at marketing his wares and found shops along the Dublin quays prepared to take some of his boating pictures. He had 'Hard Times' a winter scene with birds painted from nature accepted for the Royal Hibernian Academy (RHA) annual exhibition of 1870, and had his first sales at the RHA the following year. He continued to exhibit at the academy every year, without missing a single year, until his death, an unbroken record of 61 years in all. Williams continued to paint and observe the natural environment around him until he died in 1930, aged 84. Through most of his long life he was an astute observer and recorder of Ireland's bird life and he deserves his place among Ireland's ornithological pioneers.

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