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1. INTRODUCTION

The Eurasian Curlew *Numenius arquata* (hereafter, Curlew) is a large, predominantly greyish-brown wader with long, dark legs and a distinctively long, decurved bill. The species' breeding range extends from Britain and Ireland, across north-western Europe and Scandinavia, into Russia and Siberia (Van Gils and Wiersma, 1996). Across their range, Curlew typically breed in wet or marshy habitats including bogs, fens, moors and damp grasslands; in Britain and Ireland, they are often associated with semi-improved pastures; outside the breeding season they are primarily found in muddy, coastal habitats.

The global population of Curlew has been classified as 'near threatened' by the International Union for the Conservation of Nature (IUCN) due to sustained and rapid population declines (BirdLife International, 2012). It is estimated that global populations declined by 20-30% from 1997-2012 (BirdLife International, 2012). Within Europe, where more than 75% of the global population breeds (BirdLife International, 2004), the threat level is thought to be higher. As a result, the species is currently recognised as 'vulnerable' on the European Red List of Birds (BirdLife International, 2015). Habitat loss and degradation (as a result of agricultural intensification, land drainage and afforestation), predation, and human disturbance were identified as the primary threats to breeding populations in Europe (European Commission, 2007).

Curlew is now Red-listed as Birds of Conservation Concern in Ireland, and represents one of the highest conservation priorities in both the Republic of Ireland and Northern Ireland (Colhoun and Cummins, 2013). In Ireland, breeding Curlew have experienced an estimated 86% decline in population size (Colhoun and Cummins, 2013) and a range contraction of 78% (Balmer *et al.*, 2013). Furthermore, Balmer *et al.*, (2013) concluded that this range contraction occurred primarily during the previous 20 years. A recent study by Colhoun *et al.*, (2015) estimated that breeding Curlew populations in Northern Ireland declined by 82% from 1987 to 2013, with populations becoming increasingly fragmented. Colhoun *et al.*, (2015) estimated that just over 500 pairs of breeding Curlew remained in Northern Ireland in 2013.

Ireland's 2014 Article 12 report from the National Parks and Wildlife Service (NPWS) of the Department of the Arts, Heritage and Gaeltacht (DAHG) to the European Commission under the Habitats Directive estimated that Curlew breeding populations in the Republic of Ireland had declined by 98% and contracted in range by 86% (NPWS, 2014). However, the data used to generate these figures were incomplete. Extrapolation from a survey of breeding Curlew in counties Donegal, Leitrim, Cavan and Monaghan as part of the Halting Environmental Loss Project (HELP, funded by INTERREG IVA) produced an informal estimate of less than 200 pairs of breeding Curlew remaining in the Republic of Ireland in 2014 (Donaghy, 2014), a possible decline of over 96% since 1993. In 2014, BirdWatch Ireland and NPWS collated all known recent records from a range of sources, including the 2007-11 Bird Atlas and records from NPWS rangers and BirdWatch Ireland members. A total of 73 records of breeding pairs were collated. However, more accurate information on the population size, location and breeding habitats, as well as threats to breeding success, are essential for effective conservation measures in the Republic of Ireland.

Initiated in 2015, Bord na Móna funded a joint conservation programme with BirdWatch Ireland for breeding Curlew on their landholdings (Copland, 2015). During the breeding season, and using standardised methodologies, this project will identify Bord na Móna sites that currently have breeding Curlew. In addition, habitats at these sites will be evaluated to determine potential management options to maintain or enhance their value for breeding Curlew. Also, using expert opinion and the habitat assessments, key determinants at each site (habitats, size, hydrology and other physical characteristics) that are critical for breeding Curlew will be identified, to allow other sites within Bord na Móna's land holding to be considered in terms of suitability for this species. This project continued in 2016 (Copland, 2016)

Ballydangan South was one site surveyed in 2015 as part of the Bord na Móna – BirdWatch Ireland Curlew Conservation Programme. In 2015, it was estimated that Ballydangan South held three pairs of Curlew, with a fourth pair on Bord na Móna's nearby Cranberry Bog. The survey was repeated on Ballydangan South in 2016 to help feed in to the development of a new management plan for Ballydangan South. In addition, Knock Bog was surveyed as part of the Bord na Móna – BirdWatch Ireland Curlew Conservation Programme in 2016. Data from the 2016 surveys indicated that this bog complex may be important for breeding Curlew, with c.7 pairs recorded. In 2017, additional fieldwork was conducted at Ballydangan and Knock Bog to look at later season aspects of Curlew on the site; specifically in relation to breeding success and fledgling, for further refinement of management planning. Data from the 2016 survey of Ballydangan South is presented here, along with the results from later season fieldwork in 2017, and discussions that include results from the Ballydangan South survey in 2015, and the survey at Knock Bog in 2016.

2. METHODS

2.1 Curlew Survey Methods

Standard Curlew survey methodologies (Brown & Shepherd, 1993) were used in order to accurately estimate the number of breeding pairs. In brief, two visits were made to areas of suitable habitat before the end of June. Separate visits to the same site are at least seven days apart. Even if no Curlew are recorded during the first visit to a site, a second visit is still carried out if suitable habitat was present. Survey visits are divided into the following periods:

- **Visit 1:** 15th April – 31st May
- **Visit 2:** 1st – 30th June

Brown & Shepherd recommend a third visit to survey sites in July to detect breeding productivity.

Visits to Ballydangan South and Knock Bog are summarised in Table 1. To estimate breeding pairs, surveys were undertaken on 26th May and 27th June 2016, on 12th June in 2017 and to Knock Bog on 15th June 2017. Additional visits in 2017 were undertaken to the eastern side of Ballydangan on 20th June 2017, to the western side on 30th June 2017 and the central area on 4th July to look for evidence of breeding. An additional visit on 18th July sought to follow-up on records from these visits.

Table 1: Summary of Curlew survey visits to Ballydangan and Knock Bog, 2015-2017

Ballydangan South	Knock Bog	Notes
26 th May 2015		<i>Bord na Móna survey</i>
29 th June 2015		<i>Bord na Móna survey</i>
	23 rd May 2016	<i>Bord na Móna survey</i>
26 th May 2016		Breeding census; three probably pairs
	23 rd June 2016	<i>Bord na Móna survey</i>
27 th June 2016		Breeding census; no records
22 nd April 2017		Three calling/displaying birds recorded
12 th June 2017		Breeding census; two Curlew feeding
	15 th June 2017	Breeding census; flock of 5 Curlew in distance
20 th June 2017		Productivity survey on eastern side; two Curlew recorded
30 th June 2017		Productivity survey at western end of site; no Curlew
4 th July 2017		Productivity survey in centre of site; no Curlew
18 th July 2017		Follow-up productivity Survey in south-eastern end of site; possible Curlew footprints in suitable foraging area

The survey itself requires walking to within 200m of all points on the site. In practice, parallel transects with a maximum spacing of 300m were used at Ballydangan South (i.e. the site was surveyed to a distance of 150m), which in the majority of cases followed drainage lines. This spacing of transect lines, which is closer than the methodology requires, is to ensure that if any deviation from the transect is required due to inaccessible habitat features (such as quaking mire or pool systems), that the requirement to get to within 200m of the whole site can be met.

All observations of Curlew were marked on site maps (using the Bord na Móna habitat maps), and annotated with the observation time and a description of numbers, behaviour, etc.

2.2 Additional Bird Recording

In addition to recording breeding waders, information on additional bird species was also collected in 2016. For each visit to Ballydangan South, a complete list of all bird species heard or seen during the survey period was made. For certain scarce or unusual species, additional data on numbers, behaviour and breeding status were also noted in both 2016 and 2017.

3. RESULTS

The results are presented in three sections. In the first section, the main habitats and physical characteristics present are described, followed by the occurrence of Curlew. The second section looks at management associated with the Ballydangan South site, included potential impacts, threats and opportunities for Curlew. The final section looks at the complete community of birds as recorded at each site.

3.1 Habitat and Curlew Occurrence

Ballydangan South and Knock Bog (as well as Cranberry Bog) comprise a large area of largely restored raised bog (see Figure 1). Ballydangan South and Knock Bog are separate by a railway line. Substantial re-wetting has occurred at both sites with many former drains blocked using peat dams. Ballydangan South is currently managed as part of the Ballydangan Bog Red Grouse Project, with associated habitat and predator management (which is also likely to benefit birds on Knock Bog). Knock Bog (and Cranberry Bog) are in the process of being restored by Bord na Móna.

2016 breeding survey

On the first visit to Ballydangan, two territorial pairs of Curlew were observed in the northern part of the site (see Figure 2). One of these pairs (the central pair) were observed for approximately 30 minutes, and the behaviour of the birds suggested that the female was incubating. A second confirmed pair (towards the eastern side of the site) was seen calling and displaying over a large area, although behaviour suggested a probable nest along the northern boundary of Ballydangan South. Birds were heard calling from a third territory towards the western side of the site. Although no birds were observed, the vocalisations were not from the other two pairs observed, indicating a third territory was present.

No Curlew were observed on the second visit to the site. However, this visit was in late June, by which time successful nesting birds may have fledged and vacated the site. This is confirmed by vocalisations of birds heard to the south of the site during fieldwork, and reported observations of six birds seen in fields (again to the south of the site) during the morning. Six birds might suggest adults and fledged young from two pairs, although this cannot be confirmed.

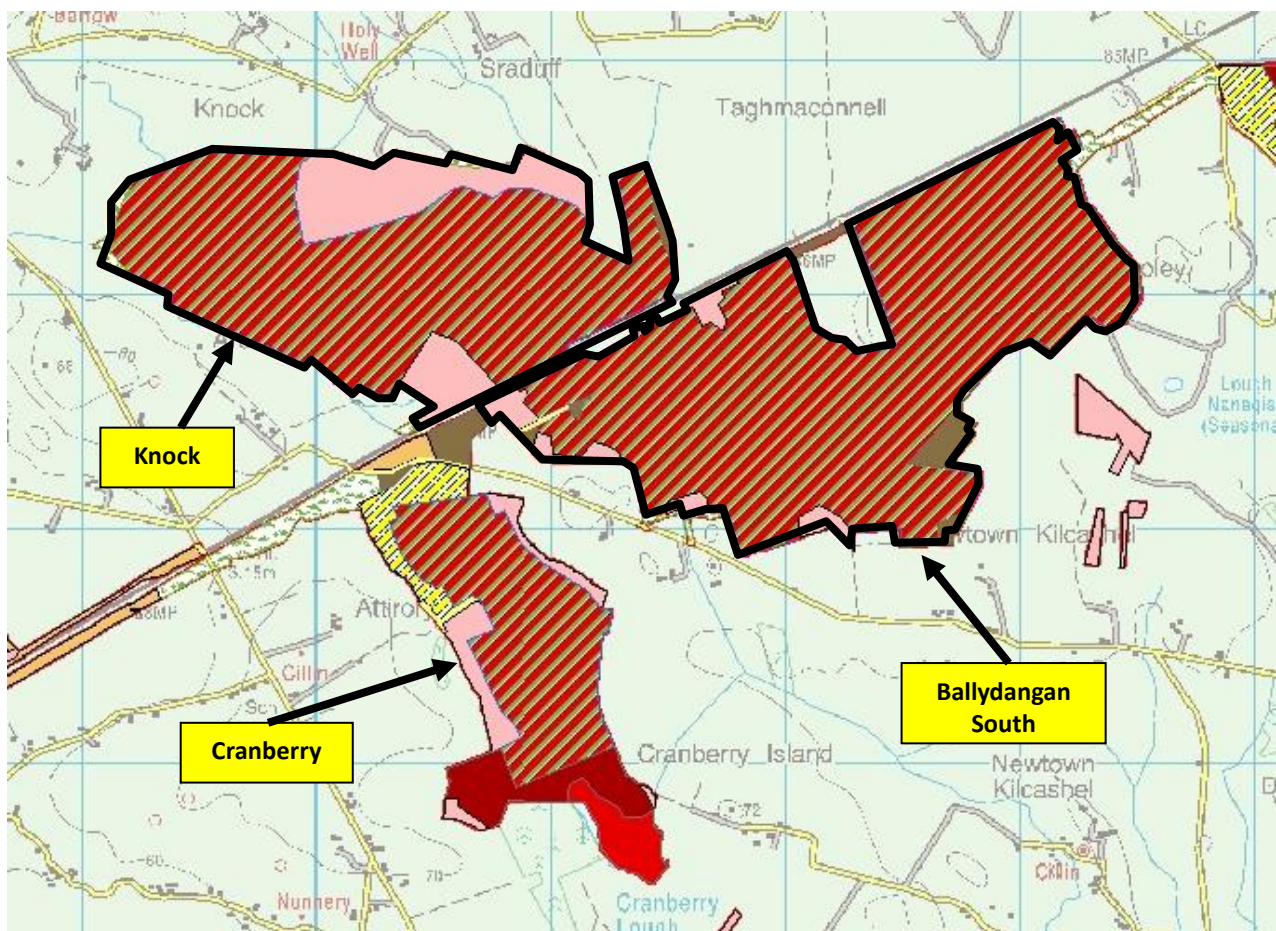


Figure 1: Map of larger Ballydangan Bog complex, with Curlew survey areas outlined in black (Ballydangan South surveyed in 2015 and 2016; Knock Bog surveyed in 2016)

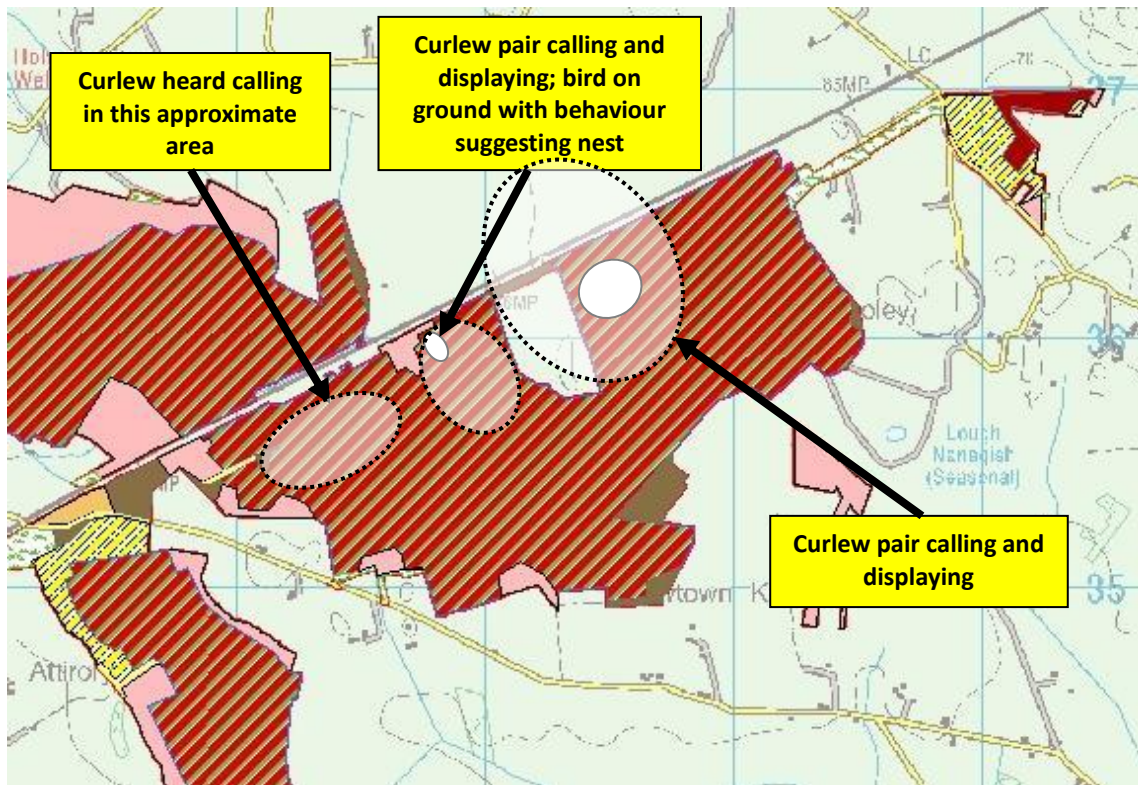


Figure 2: Ballydangan survey summary (first visit; 26-May-17); solid white circles represent likely nest locations (where known); larger shaded areas indicate likely territory

2017 breeding survey

An early visit to Ballydangan South on 22nd April suggested two pairs in the south-west part of Ballydangan (see Figure 3), when three separate calling Curlew were observed. Two birds (likely one pair) were recorded foraging just south of the site on 12th June, and a probable third pair is likely to have been present in the eastern side of the site (see Figure 3), following observation of birds there during the visit on 20th June.

The data from 2016 and 2017 compare favourably to results from the breeding survey in 2015 at Ballydangan South (Copland, 2015), when three pairs were thought to be present (see Figure 3).

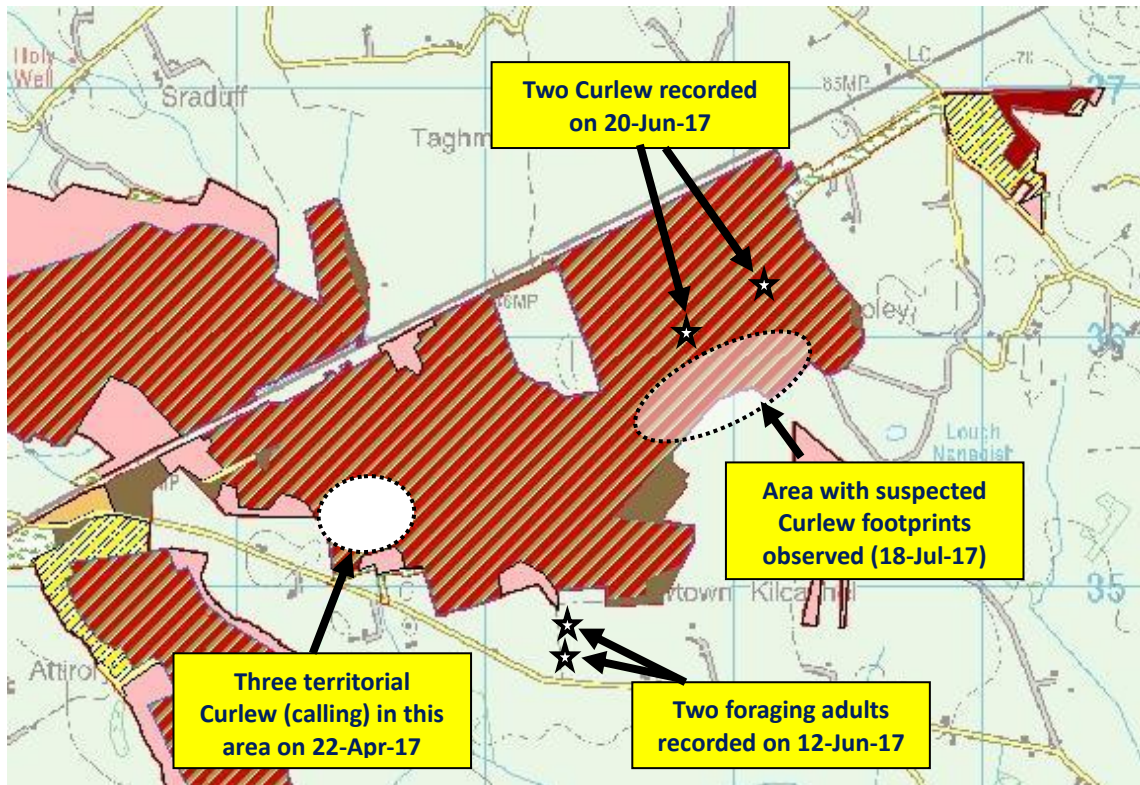


Figure 2: Ballydangan survey summary (2017); Stars indicate individual sightings of birds; circles indicate approximate area of identified activities.

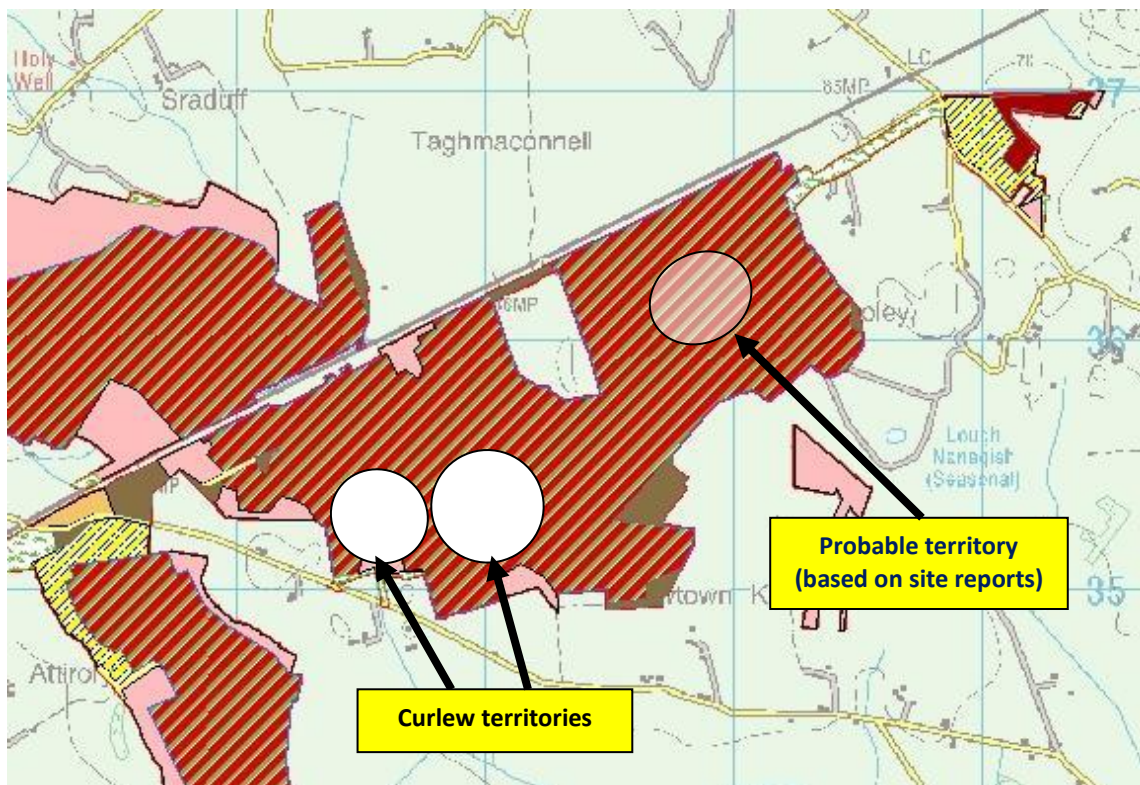


Figure 3: Ballydangan South Curlew survey results, 2015; solid white circles represent confirmed territories; shaded circle represents a likely territory based on reported observations.

3.2 Site Management Analysis

This section looks at the various issues relating to current and future management at Ballydangan South in relation to Curlew. In order to understand appropriate management strategies for Curlew, it is necessary to understand their habitat requirements. Although there is no clear definition of suitable habitat for Curlew in Ireland, a review by Denniston (2013) indicated that the most frequently recorded breeding habitats in the UK (including Northern Ireland) are semi-improved or unimproved rough grassland, particularly rushy pastures, wetlands, moorland, heath and bog, particularly raised bogs. Results of previous surveys (Denniston 2013; Donaghy 2014) indicate that Curlew are most likely to be found in Ireland on peatland habitats, unimproved or semi-improved grassland (particularly rushy pastures) wetlands and other open habitats with a heterogeneous vegetation cover comprising some short and some tall ($\leq 0.5\text{m}$) vegetation. They may also be found in damp meadows, such as on the Shannon Callows. Curlew avoid forests and woodland, built-up areas, improved grassland with a uniform sward and areas with active peat extraction. In Ireland, they are not known to nest in arable areas.

In addition to understanding habitat requirements, it is also essential to recognise and mitigate against the various threats and pressures that impact on Curlew during the nesting season. These include those affecting the suitability of nesting habitats, as well as direct impacts on breeding birds through depredation or disturbance.

A variety of threats and pressures to Curlew breeding habitats have been well documented. On peatlands, the most common threats to breeding Curlew are from hand and mechanical cutting of peat, predation by birds and uncontrolled burning. Peat removal and uncontrolled burning not only disturb breeding adults and potentially destroy their nests, but also significantly alter the habitat, making it less suitable for breeding pairs. Studies in the UK have shown that afforested areas are associated with decreased population size and breeding success in Curlew (Amar *et al.*, 2011; Douglas *et al.*, 2014). The construction and presence of wind farms also poses a threat to breeding Curlew, for example through barrier effects and disturbance displacement (see McGuinness *et al.*, 2015). Thus, Curlew face the continued loss of their breeding habitats as well as number of threats to successful breeding within the remaining areas of suitable habitat.

At two study sites in Northern Ireland, Grant *et al.* (1999) determined that predation of nests and chicks by avian and mammalian predators was the greatest proximate threat to successful Curlew breeding. The threat of predation by avian predators, such as Hooded Crows, was one of the most common and widespread threats recorded in this survey. At one study site of Grant *et al.* (1999), avian predation (by both gulls and corvids) accounted for 84% of recorded nest predation. While there were no reported observations of birds predating eggs or chicks - indicating that harassment of Curlew by corvids does not necessarily lead to egg/chick loss - Hooded Crow populations in Ireland have increased significantly in recent decades (see Balmer *et al.*, 2013) and may represent a significant threat to successful breeding among the remaining Curlew population. Studies indicate that most predation of wader chicks (on lowland wet grassland sites) is avian, whilst most predation of nests is by mammals (Ausden *et al.*, 2009). The presence of avian predators, such as Hooded Crow, is noted in Section 3.3. A Fox was recorded at Ballydangan South during fieldwork in 2015. However, as most mammal predators are nocturnal they would therefore not be recorded during post-dawn bird surveys. Mammalian predation of nests has been widely reported as a significant threat to breeding waders (Grant *et al.*, 1999, MacDonald & Bolton, 2008, Schekkerman *et al.*, 2009, Rickenbach *et al.*, 2011).

In a recent report from Natural England, Pearce-Higgins *et al.* (2015) determined, with a high level of confidence, that breeding Curlew populations in the UK are at high risk to the future impacts of projected climate change. Additionally, under these projected climate change scenarios, Curlew will have few opportunities to expand their range. Thus, it seems likely that breeding Curlew in Ireland will not only be affected by changes in land use and high levels of predation, but also the impacts of climate change. A summary of potential pressures and threats identified at Ballydangan is shown in Table 2.

Table 2 Summary of identified pressures and likely threat level on likely Curlew nesting at Ballydangan South

Site	Burning	Turf Cutting	Peat Extraction	Scrub/tree encroachment (internal)	Scrub/tree encroachment (external)	Other
Ballydangan South	Low	Low	None	Low	Moderate	Predator Management; Recreation?

With the ongoing management associated with Red Grouse at Ballydangan (including predator control), coupled with specific consideration towards Curlew in any habitat management activities, the current status of Curlew at this site appears secure. There are minor pressures from turf-cutting in the south-eastern corner of the site, and some light scrub encroachment in the extreme western end of the site, as well as along parts of the railway line to the north, where some *Rhododendron ponticum* is becoming established (see Figure 4). Towards the centre and eastern end of the site some Willows are present.

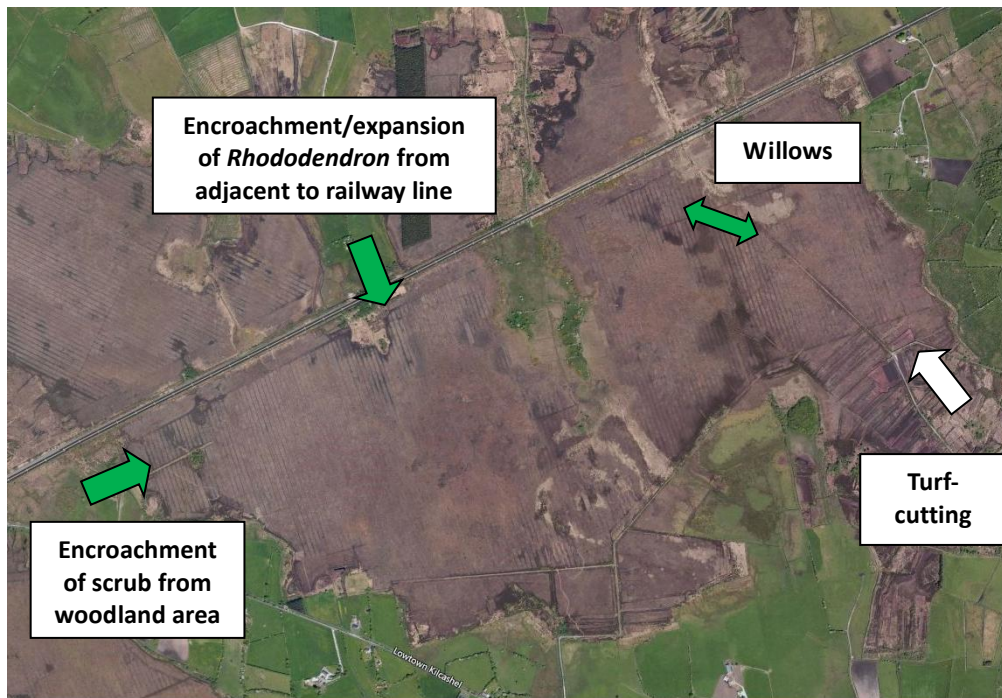


Figure 4: Aerial photograph of Ballydangan South, showing land management pressures

3.2.1 Predators

However, and despite the ongoing predator management at Ballydangan South, it would appear that productivity at these sites is very low, with few late-season records of Curlew at any site. From the three pairs observed on Ballydangan South in 2015, it seems likely that only one pair fledged chicks on the site. In both 2016 and 2017, no late-season birds were observed on the site. At Knock in 2016, despite four pairs recorded in May, none remained on the site in June, and no birds were observed breeding on the site in 2017.

During fieldwork in 2015, a fox was recorded walking across the eastern side of Ballydangan South. In 2017, two foxes were observed in Knock Bog. Although not a quantitative survey of the local fox population, three sightings of this normally elusive, nocturnal mammal during daylight surveys is suggestive of a substantial population in the area. This could be impacting upon the breeding success and productivity of Curlew at this site, and may in some way explain the low productivity levels observed.

The main avian predator of Curlew is likely to be Hooded Crow, although both Magpie and Raven may also depredate nests and chicks. These species are widespread throughout the sites surveyed, although the absence of Magpie in 2016 at Ballydangan and Knock may reflect the ongoing predator management work being undertaken. Additionally, both Sparrowhawk and Kestrel were observed during fieldwork, and Curlew were seen to mob and drive off a foraging Kestrel in 2017. It seems unlikely that these two raptors would cause concern for Curlew, unless they had very small chicks.

3.3 Other species

A full list of all species recorded during fieldwork visits to Ballydangan South in 2015 and 2016, and on Knock Bog in 2016, is presented in Annex 1. Additional data for certain species was also collected during 2017. These data are not necessarily collected systematically (the larger sites that took longer to survey will have more records than the smaller sites that could be surveyed more quickly), and also do not comment on the relative abundance or scarcity of species at each site, nor on whether birds were breeding or simply passing through. Nevertheless, these data do illustrate some of the bird communities present, and offer an indication to the value of habitats that may be present.

3.3.1 Specialist raised bog (and upland) species

Table 3 shows the occurrence of BoCCI Red and Amber-listed species associated with active raised (and blanket) bog habitats that were recorded during fieldwork. These species are identified from those listed in the BirdWatch Ireland Species Action Plans for Raised Bog and Upland Birds (BirdWatch Ireland 2010; BirdWatch Ireland 2011), with the addition of Meadow Pipit. Meadow Pipit has recently been added to the BoCCI Red List due to population declines in Ireland subsequent to the completion and publication of the group species action plans.

It is important to note the value of these sites for all these species of conservation concern. It seems likely that all of these species were breeding on the sites where they were recorded, with a pair of Lapwing recorded in 2017 when a Snipe nest was also found (confirming suspected breeding for this species in 2015 and 2016 when displaying birds were present at Ballydangan South and Knock. Two Meadow Pipit nests were also recorded at Ballydangan South in 2016.

Table 3: Occurrence of Raised Bog and Upland Birds at Ballydangan South and Knock Bog

Species	Site	Ballydangan 2015	Ballydangan 2016	Ballydangan 2017	Knock 2016
Lapwing				X	X
Snipe		X	X	X	X
Curlew		X	X	X	X
Skylark		X	X	X	X
Grasshopper Warbler			X		X
Meadow Pipit		X	X	X	X

Note: Colour denotes status in the Birds of Conservation Concern in Ireland (BoCCI) lists (**Red** or **Amber**)

3.3.2 Other species

A possible (but unconfirmed) Short-eared Owl was seen quartering the north-east corner of Ballydangan South in 2016. This species only breeds very rarely in Ireland and this sighting (in late May) would likely refer to a non-breeding bird passing through. The only other raptor recorded was Kestrel, which was observed hunting for prey at Ballydangan South (probably for juvenile Meadow Pipits).

Although peatlands have extensive pool systems, few true wetland species use the small open water habitats in these areas. Mallard are likely to be breeding at Ballydangan South, but Grey Heron are likely foraging in the pool and drain systems, whilst breeding off-site (they nest in trees); the Lesser Black-backed Gull was observed on passage.

Cuckoo (and Grasshopper Warbler (see Table 3)) favours open, scrubby habitats for nesting (in the case of Grasshopper Warbler) or for seeking out suitable host species (in the case of Cuckoo). In Ireland, Meadow Pipit are likely to be one of the main nesting species parasitized by Cuckoo, and high densities of Meadow Pipits in the peatland areas are likely the reason for the occurrence of this species.

Sedge Warbler and Reed Bunting are species of rough vegetation, particularly reeds and tall grasses found at the edge of wetlands and drains. Again, these two species may be able to indicate wetness at the sites, although more usually along ditches or at the edge of ponds rather than in bog-pool systems that Curlew would typically favour.

4. DISCUSSION

The occurrence of at least seven pairs of breeding Curlew in the wider Ballydangan Bog area (comprising Ballydangan South, Knock and Cranberry) is very significant at a national level. With the Irish population estimated at around 150 breeding pairs (Kelly & Donaghy, 2015), these sites hold almost 5% of the national population. Given that ownership, and therefore management, of these sites ultimately lies with the state (all these sites are owned by Bord na Móna) this area may be crucial to the conservation of this species in Ireland. Therefore, and despite certain knowledge gaps, due to the extreme vulnerability of breeding Curlew in Ireland and globally, action to conserve the remaining breeding population at Ballydangan, as well as on Bord na Móna's wider land holdings, is an urgent priority.

In considering this Curlew population, this discussion and subsequent recommendations reflect requirements for both the Ballydangan South site, as well as the wider hinterland, including (but not limited to) Knock and Cranberry Bogs, and adjacent farmland. The collection of these data as part of the re-drafting of the Ballydangan management plan is very timely. Although the focus of management at Ballydangan South is for Red Grouse, opportunities to undertake explicit management actions that target Curlew are recommended. In addition, it is recognised that the continuation of works to benefit Red Grouse will also have positive impacts on Curlew; indeed it is likely that the Curlew population at these sites may be a direct result of such actions already in place, such as drain-blocking and re-wetting of peatlands, and predator management.

4.1 Management of Curlew sites

Threats and pressures to Curlew breeding on Bord na Móna sites can be viewed as internal – those pressures arising from Bord na Móna's actions on their own sites, and external – threats arising on lands adjacent to Bord na Móna's properties.

4.1.1 Internal threats and pressures

There are likely to be two main pressures linked to nesting Curlew from Bord na Móna activities; this is the active production of peat and habitat change on the raised bog remnant areas where Curlew still occur.

Peat harvesting operations may threatened nesting Curlew though actual development of nesting habitats, but in the majority of cases the areas where nesting Curlew are likely to occur are not currently being exploited for peat harvesting. More of an issue is likely to arise in areas where peat production is happening very close to a breeding Curlew site and nesting birds could be disturbed. With a conservation management plan in place at Ballydangan South, and extensive drain-blocking and re-wetting at Knock, peat harvesting would no longer appear to be a threat to Curlew at these sites.

The other main threat arising within Bord na Móna landholding is changes to the raised bog habitat itself, either due to drainage works resulting in the peatlands drying out or, and linked to, the encroachment of scrub (either from within the Bord na Móna site or from external areas). However, even if the source of tree or scrub encroachment is from land outside of Bord na Móna property, its management within the site should be considered as part of the holistic management of the site. This issue is partly addressed in section 4.2 below, but it is important that some the conservation plan can address these specific threats at Ballydangan.

4.1.2 External threats and pressures

The main direct pressure to Curlew nesting on Bord na Móna sites originating from off the actual property is private turf cutting. Although there is some turf-cutting immediately adjacent to Ballydangan South (and Knock Bog) it may be that the turf cutting does not get close enough to the actual Curlew territory to cause damage. However, disturbance from these activities may be a risk. Opportunities to engage with neighbouring landowners could be considered to advise them of the presence of nesting Curlew, and seek to limit the disturbance during the breeding season through voluntary commitments if possible. To reduce disturbance impacts, activities during the nesting season should be limited or (ideally) postponed until the nesting season is completed (usually the period March – July). In instances where this is not practicable, then reducing the extent of operations to as small a time as possible would be preferable e.g. activity is reduced to less than one hour per day, and any one activity should not continue for more than 30 minutes at any time, with at least one hour between such activities. There are no hard and fast rules for what might be deemed acceptable, but simply minimising such disturbance should be targeted.

The other external threat is, as outlined above, from woodland and forest planting adjacent to the breeding site. Again, landowners of these areas could be consulted to see if buffer zones could be employed to reduce the direct impacts of the trees on the Ballydangan sites.

4.2 Curlew habitat conservation

The key habitat determinants for breeding Curlew have been widely accepted. These are typically open landscapes with an absence of trees and scrub (which Curlews avoid due to perceived predation risk), a cover of vegetation between 5cm and 50cm tall, and wet areas for foraging. The context of landscape for Curlew to choose nesting habitat is also likely to be a factor, although this is poorly understood – Curlew often nests on raised bog areas with adults foraging on nearby wet grassland fields.

In the first instance, it is important to develop and implement management plans to enhance breeding habitats to increase productivity (e.g. block drains in degraded peatlands to create better habitat for insect prey and remediate bare/eroding peat, etc.). This is already underway at Ballydangan and Knock, and should be continued/expanded if possible. During fieldwork some areas at Ballydangan were still quite dry on the surface, suggesting that further drain-blocking may be required or investigated. Ideally, a full LIDAR assessment for all bog areas and hinterland should be conducted and/or evaluated to block drains where possible. This would include management on surrounding, privately-owned farmland. To facilitate this, a conservation scheme (such as is available in GLAS already for Curlew) for farmers should be explored, and opportunities to undertake this type of detailed work may be available in the current Rural Development Programme (RDP). Joining up sites, and linking these to surrounding farmland areas where possible, could create landscapes of greater value for breeding waders and other fauna while offering additional benefits of improving carbon storage and flood prevention. Such options, and funding mechanisms for such work, should be explored as part of any future management of these sites.

4.3 Predator Management

As noted in Section 3.2.1, depredation may be a key limiting factor for the breeding productivity of Curlew, particularly if other habitat requirements are being met. A full evaluation of the current predator control work being undertaken at Ballydangan, both to highlight the achievements to date and also identify any potential gaps should therefore be conducted as part of the management planning process. Such a review should look at other forms of predator control and management not currently part of the work programme at Ballydangan. This could include wider habitat management actions to reduce predator habitats in adjacent areas, as well as on-site actions such as installing predator-proof fences.

4.4 Research and Monitoring

As Curlew is one of Ireland's highest conservation priorities, it is essential that they continue to be monitored, especially at key breeding sites such as Ballydangan. This would be particularly valuable in the context of a management plan, where impacts from management actions can be identified or, where impacts are not being seen, the actions can be reviewed and fine-tuned to improve their delivery. Typically in such situations, baseline data are collected (for which the 2016 data presented here could be considered), along with some form of ongoing, longitudinal or mid-term evaluation, coupled with a final assessment at the end of the plan.

In addition to Curlew, it may be of value to monitor other species at Ballydangan, particularly those identified as being of conservation concern, or specialists on peatland habitats. Although of value in their own right, the occurrence of other species, which are more common and widespread than Curlew, may provide a useful indicator of habitat quality. For example, Snipe will use wet areas throughout the nesting season, whereas Curlew will more usually rely on these wet features for chick rearing, as the adults can often fly substantial distances to forage (usually on nearby areas of grassland). Skylarks are also useful indicators of the “openness” of habitats, as they avoid areas with trees, much the same as Curlew. It may be that the presence of these two species, during the nesting season, collectively provides a valuable indicator of the suitability of habitat for Curlew. Moreover, as they are commoner than Curlew, they may provide a more sensitive the presence of wet habitats that are important to both these species for foraging.

Despite the substantial amount of surveying undertaken for breeding waders on peatlands, their ecology on these habitats is poorly understood. Therefore, in addition to monitoring, detailed studies of Curlew breeding ecology are required to determine levels of breeding productivity and assess the proximate threats to breeding success (e.g. predation, habitat condition, food availability). These studies could include, but are not limited to, tracking of adults and chicks via geo-locators or satellite tags in order to determine their ranging behaviour and habitat use around breeding sites (of which there is a global data gap). Part of this research could be to develop and promote a targeted colour-ringing scheme for Curlew. This will not only be useful for monitoring population trends and breeding productivity but also the movement ecology and survival of Curlew.

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ANNEX I: FULL LISTING OF BIRD SPECIES RECORDED AT EACH SITE

Species	Site	Ballydangan 2015	Ballydangan 2016	Knock 2016
Mallard		X	X	
Pheasant		X	X	X
Grey Heron		X	X	
Kestrel		X	X	X
Lapwing				X
Snipe		X	X	X
Curlew		X	X	X
Lesser Black-backed Gull				X
Woodpigeon		X	X	X
Cuckoo		X	X	X
Magpie		X		
Jackdaw		X		
Rook		X	X	X
Hooded Crow		X	X	X
Raven		X		
Goldcrest			X	X
Great Tit				X
Skylark		X	X	X
Sand Martin				X
Swallow		X	X	X
House Martin				X
Long-tailed Tit			X	
Willow Warbler		X	X	X
Blackcap		X	X	
Whitethroat		X	X	X
Grasshopper Warbler			X	X
Sedge Warbler		X	X	X
Wren		X	X	X
Blackbird		X	X	X
Song Thrush		X	X	X
Mistle Thrush			X	
Robin		X	X	
Stonechat		X	X	X
Duncock		X	X	X
Pied Wagtail				X
Meadow Pipit		X	X	X
Chaffinch		X	X	X
Linnet		X	X	
Lesser Redpoll		X	X	X
Reed Bunting		X	X	X
No. species		30	31	30