BIRDS AND WIND FARMS IN IRELAND: A REVIEW OF POTENTIAL ISSUES AND IMPACT ASSESSMENT

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INTRODUCTION

The potential effects of wind farms on birds have been an issue with many recent proposals in Ireland and indeed across Europe and other parts of the world. In some cases they have even been the primary reason for a site being rejected during the planning process. It is therefore important that developers are aware of the potential impacts that may occur, and that new sites are located to avoid such problems as much as possible. With wind farm applications in Ireland set to rise considerably (Sustainable Energy Ireland 2003), this issue is likely to become more frequently encountered in the coming years.

It is in the interests of both wind farm developers and those seeking to protect bird populations that wind farms should be located away from areas in which such developments may have significant impacts. In achieving this objective it is important to make the best use of the available information on the effects of existing wind farms on birds. Hence the first part of this document aims to provide a review of the current knowledge on the effects of wind farms on birds, particularly in relation to potential issues in Ireland.

Another key component to successfully managing bird issues with wind farm developments is to have an agreed way in which the potential effects should be assessed. This should be as transparent and objective a process as possible, so that it can be clearly ascertained whether a proposal would be acceptable or not in terms of its potential ornithological impact. Therefore the second part of this document aims to provide a methodology for assessing the effects of wind farm on ornithological interests. This is based closely on the methodology developed jointly between Scottish Natural Heritage and the British Wind Energy Association, which is used widely for ornithological impact assessment in Scotland and other parts of Britain, but modified slightly to fit the Irish context.

Part I. Birds and Wind Farms

Introduction

The have been several reviews published of the effects of wind farms on birds dating back more than a decade. All provide useful information about the state of knowledge at the time that they were compiled, and all are useful sources of reference:

- Crockford (1992) – a review carried out for the Royal Society for the Protection of Birds [RSPB].
- Gill *et al.* (1996a) – carried out for Scottish Natural Heritage.
- SGS Environment (1996) – carried out for the UK Department of Trade and Industry Energy Technology Support Unit.

- Percival (2000) – a review for the British Wildlife journal.
- Erickson *et al.* (2001) – a review of the collision rates at wind farms in the United States for the US National Renewable Energy Laboratory.
- Percival (2001) – a review of offshore wind farm potential ornithological impacts, for the UK Department of Trade and Industry Energy Technology Support Unit.
- Langston and Pullan (2002) – a review compiled by RSPB and its BirdLife partners, for the Bern Convention.

The purpose of this part of the current document is to update the information currently available on the bird-wind farm issue, highlighting particularly that which is relevant in Ireland. The section concludes with an assessment of the likely bird species/groups that may pose problems with wind farm developments in Ireland.

There are two main processes by which wind farms can potentially have significant impacts on birds. Firstly they can pose a risk of collision, with birds flying into rotor blades, resulting in increased mortality rates. Secondly they can result in habitat loss, mainly through displacement of birds from an area around the wind turbines (effectively disturbing the birds from this zone).

Collision Risk

There have been a number of inappropriately located wind farms that have resulted in considerable numbers of bird collisions with the turbine rotor blades. Two particular sites where this has occurred are Altamont Pass in California and Tarifa in southern Spain. Both these sites hold a combination of high densities of species at high risk of collision (mainly raptors) and very high numbers of wind turbines. The numbers of collisions per turbine were quite low (rather less than one bird per year, see Table 1), but as there were such large numbers of turbines, this still meant that significant collisions were recorded. This included protected species such as Golden Eagle *Aquila chrysaetos* (Altamont) and Griffon Vulture *Gyps fulvus* (Tarifa). The problems resulted from a combination of sensitive species flying through the area in large numbers (as they were important migration and feeding areas), and turbine layout (very large numbers densely packed in sensitive locations where birds were very concentrated) and design (particularly many lattice towers attractive to raptors as perches).

Recent studies in Navarre in northern Spain have found similar problems with Griffon Vultures at several wind farms in that region too (Lekuona 2001).

Collisions of larger raptor species have also been reported from other regions, though not in such large numbers. For example two sea eagles have recently been reported colliding with wind turbines in northern Germany (Krone and Scharnweber 2003).

Table 1 summarises reported collision rates from a range of different wind farms, including Altamont and Tarifa. There are considerable problems in carrying out studies of bird collisions at wind farms, in particular ensuring that a high proportion of any casualties are detected (and that the detection rate is quantified) and that account is taken of possible carcase removal by scavengers. Such potential flaws should be carefully taken into account when interpreting the results of these studies.

Studies at upland sites in the UK have generally reported very low collision rates indeed, with some studies finding no collisions at all. This probably reflects the generally low bird densities present in these areas, though it should be noted that to date little work has been undertaken at upland wind farm sites that would pose a significant risk to larger raptor species such as golden eagle or hen harrier, so possible impacts on species such as these are not yet well understood in these locations.

Studies of bird collisions at coastal wind farms have generally reported rather higher numbers of collision than in upland areas, probably reflecting the higher bird densities in those areas. Studies at Blyth Harbour (Still *et al.* 1995, Painter *et al.* 1999) and at Zeebrugge Harbour (Everaert *et al.* 2002) both found collision rates in excess of a bird per turbine per year, with most casualties at both sites being gulls. Numbers of collisions estimated in the Zeebrugge study were particularly high (up to 29 birds per turbine per year), though this was at least partly a result of the very high correction factor applied there. Whereas at Blyth, where there was comprehensive monitoring of bird mortality including strand-line searches in a wide area around the wind farm, around 55% of the collision victims were found, only 10% were estimated to be found at Zeebrugge. Extrapolating up where the recovery rate is so low means that the precise numbers may not be as reliable, though it is still clear that quite a number of collisions were occurring.

Overall it is clear that birds are generally able to avoid collisions and do not simply blindly fly into wind turbines. Collision rates typically in range of only 1 in 1,000-10,000 bird flights through wind farm, even in studies such as Zeebrugge where relatively high numbers of collisions have been reported. In some cases they are considerably lower, such as at the offshore wind farm at Utgrunden, where over 500,000 eider flights through the wind farm study area have been observed without a single collision being seen (Petterson and Stalin 2003). Studies using radar tracking have helped to provide further information on birds' general ability to avoid collisions. Dirksen *et al.* (1998), for example, showed that Pochard *Aythya ferina* and Tufted Duck *Aythya fuligula* flew regularly through a wind farm in the Netherlands at night under moonlight but flew around the turbines at greater distance from them when dark and foggy.

It is also clear, however, that bird collisions with wind turbines can be a problem under some circumstances. It would seem from the evidence available from existing wind farms that there are two main types of sites that have had collision problems:

1. Sites with large raptors occurring regularly within the wind farm at the same height as the rotor blades. In Ireland the main species that would fall into this category would be golden eagle and hen harrier.

2. Sites with very high densities of other birds flying at rotor height. In Ireland these could include seabird breeding colonies and feeding concentrations, wetlands (including coastal sites) with large waterfowl concentrations and on any major migration routes.

Whilst we now have information on collision risk for a range of species, there remain a large number that have not been studied at wind farms and hence the likely risk would be less readily determined. Ways of dealing with this uncertainty in the wind farm assessment process are discussed in the second part of this document.

Table 1. Studies of collision rates of birds and wind turbines.

Site	Habitat	Species present	Size of wind farm	Collision rate per turbine per year	Species colliding	Source
Altamont, California	Ranch land	Raptors	VL	0.05	Raptors, inc. Golden Eagle	Orloff and Flannery 1992, 1996
"	"	"	"	0.06	Continuing mortality of raptors, inc. golden eagle	Thelander and Rugge 2000
US sites (review)	Various	Various	Mixed	2.2 (0.03 for raptors)	Various	Erickson *et al* 2001
Tarifa, S. Spain	Coastal hills	Raptors, storks and many other migrants	VL	0.34	Raptors, inc. Griffon Vulture	SEO/ BirdLife 1995
"	"	Raptors	"	0.03	Griffon vulture and short-toed eagle	Janss 1998
Navarre, Spain	Inland hills	Various, inc. raptors, pigeons, passerines	VL	0.34 [1]	Griffon vulture (62%), smaller nos of other spp.	Lekuona 2001
Burgar Hill, Orkney	Coastal moorland	Upland species inc. divers and raptors	S	0.15	Gulls, Peregrine (1)	Meek *et al*. 1993
Haverigg, Cumbria	Coastal grassland	Golden plover, gulls	S	0	None	SGS Environment 1994
Blyth, Northumb-erland	Coastal shoreline	Cormorant, eider, purple sandpiper, gulls, migrants	S	1.34	Mainly gulls, Eider	Still *et al*. 1995
"	"	"	"	2.52	Mainly gulls, less eider in later years	Painter *et al*. 1999
Zeebrugge, Belgium	Coastal shoreline	Mostly gulls, terns, passerine migrants.	M	11-29 [2]	>90% gulls, also few terns, raptors, passerines	Everaert *et al* 2002.
Bryn Tytli, Wales	Upland moorland	Upland species, inc. red kite and	M	0	None	Tyler 1995

		peregrine				
Cemmaes, Wales	Upland moorland	Upland species	M	0.04	Snipe (1)	Dulas 1995
Urk, Netherlands	Coastal – on dyke wall	Waterfowl, inc. geese, Bewick's swans, migrants	M	1.7	Gulls, waders, other waterfowl (no geese or Bewick's Swans), migrants	Winkelman 1989
Oosterbierum, Netherlands	Coastal – on dyke wall	Migrants, waterfowl	M	1.8	Waterfowl, kestrel, woodpigeon, passerines.	Winkelman 1992a
Kreekrak, Netherlands	Coastal – on dyke wall	Waterfowl, inc. geese	S	3.4	Gulls, waders, Brent Goose (1), other waterfowl	Musters *et al.* 1996
Ovenden Moor, south Pennines	Upland moorland	Upland species, inc. golden plover and curlew	M	0.04	Golden plover (1), curlew (1)	EAS 1997
Novar	Upland moorland	Upland species	M	0.08	Red grouse (3) and kestrel (2)	Bioscan 2001
Tjaereborg, Denmark	Coastal grassland	Waterfowl, mainly waders and gulls	S	3.0	Gulls, Mallard, Moorhen, passerines	Pedersen and Poulsen 1991
Näsudden, Gotland, Sweden	Coastal marsh and arable	Waterfowl inc. geese and breeding waders, migrants	L	0.7	Redshank (1)	Percival 1998
Utgrunden	Offshore	Eiders	S	0	None	Petterson and Stalin 2003

VL=very large (>200 turbines); L=large (50-200 turbines); M=medium (10-50 turbines); S=small (<10 turbines).

[1] – for this study the raw collision rates are given, as the reported correction factors were very high indeed (with less than 10% of collisions reportedly being found).

[2] – this study included high correction factors (detecting only 11% of collisions).

Disturbance

The second main potential impact of wind farms on birds is through displacement from an area around the wind turbines, effectively resulting in habitat loss. Numerous studies have investigated this potential problem, with a range of results. In many cases no significant disturbance effect at all has been detected, including studies at upland, coastal and offshore wind farms (see Table 2). However in some studies birds have been reported to have been displaced by as much as 800m (and up to 300m for breeding birds). Often studies have had confounding factors such as increased human disturbance, lack of habitat studies to determine birds' preferences in relation to wind farm location and lack of proper statistical testing/experimental design. It is still clear however that under some circumstances some displacement can occur (and that such displacement has the potential to be ecologically significant).

One of the more comprehensive studies of disturbance at wind farms was undertaken in Denmark by Larsen and Madsen (2001). They studied the effects of a large number of wind turbines (61) on the feeding distribution of wintering pink-footed geese. They found that these birds kept about 100m away from single/rows of turbines, and 200m from clusters of turbines, a disturbance effect of similar magnitude to the other structures in the local landscape such as hedgerows, roads and buildings. This information can be very useful in planning other wind farms in similar situations: locating turbines in areas that are already disturbed can reduce their actual impact.

As shown in Table 2 the results of bird-wind farm disturbance studies have found rather variable results. This is perhaps best highlighted by studies on the same goose population (the Russian/Swedish-breeding barnacle geese) that found very contrasting results. On spring staging grounds in Gotland these birds feed in very close proximity to wind turbines (to within 25m; Percival 1998). A study on the wintering grounds in Germany (Kowallik and Borbach-Jaene 2001), however, found almost no geese feeding within 350m of wind turbines, and reduced numbers up to 600m away. The most likely explanation for these variable results is that these birds will avoid the vicinity of wind turbines (by a few hundred metres) where there is alternative feeding habitat in the area, but will move closer to them when alternative resources are more scarce. The birds in Gotland were feeding primarily on saltmarsh habitats, which were very resitructed in their distribution. In contrast the birds in Germany were feeding on farmland habitats, which were much more widespread. Similar results have been found in studies of other sources of disturbance on wintering waterfowl (e.g. Percival 1993). In terms of the ecological consequences of potential disturbance effects, these results would therefore suggest that birds may either just move to nearby alternative food sources, if available, or be more tolerant of the presence of the wind turbines if not.

Generally there is little evidence of any major disturbance impacts in upland habitats on waders, grouse or passerines. Effects on birds of prey in this habitat have however been less studied, so the results are less clear for these species. Several (including golden eagle and hen harrier) have been shown to be tolerant of wind turbines in other habitats, e.g. Californian grasslands (Thelander and Rugge 2000), though their behaviour at European upland wind farms is less well known.

There is generally more evidence of displacement of birds around wind farms occurring in coastal habitats, though even here many studies that have shown no significant effect. Most of the examples of such disturbance relate to waterfowl, over distances of up to 800m (wintering birds) and 300m (breeding birds).

Table 2. Studies of possible disturbance effects of wind farms on bird distribution.

Site	Habitat	Species present/ studied	Number of turbines	Species significantly affected	Distance affected	Source
Tjaereborg, Denmark	Coastal grassland	Waterfowl, mainly waders and gulls	S	Lapwing, Golden Plover, gulls	Max 800m. Breeding lapwing up to 300m	Pedersen and Poulsen 1991
Urk, Netherlands	Coastal – on dyke wall	Waterfowl, inc. geese, Bewick's and whooper swans	M	Whooper Swan, Pochard, Goldeneye.	Max 300m.	Winkelman 1989
Oosterbierum, Netherlands	Coastal – on dyke wall	Waterfowl	M	Waders, gulls and Mallard	Max 500m. No effect on breeding waders	Winkelman 1992b
Vejlerne, Denmark	Farmland	Pink-footed geese	L	Pink-footed geese	1-200m	Larsen and Madsen 2001
Westermarsch, Germany	Farmland	Barnacle geese	M	Barnacle geese	Max 600m.	Kowallik and Borbach-Jaene 2001
Burgar Hill, Orkney	Coastal moorland	Upland species inc. divers and raptors	S	Red-throated Diver	Human disturbance during initial construction only	Meek *et al*. 1993; Haworth 2002
Haverigg, Cumbria	Coastal grassland	Golden plover, gulls	S	None		SGS Environment 1994
Blyth, Northumb-erland	Coastal shoreline	Cormorant, eider, purple sandpiper, gulls	S	None		Still *et al*. 1995
Bryn Tytli, Wales	Upland moorland	Upland species, inc. red kite and peregrine	M	None		Philips 1994; Green 1995.
Cemmaes, Wales	Upland moorland	Upland species	M	None		Dulas 1995
Carno, Wales	Upland moorland	Upland species	L	None		Williams and Young 1997; Young 1999
Ovenden Moor, NW England	Upland moorland	Upland moorland, inc. golden	M	None		Bullen Consultants 2002

		plover and curlew				
Windy Standard, SW Scotland	Upland moorland	Upland species	M	None		Hawker 1997
Nasudden, Gotland, Sweden	Coastal marsh and arable	Waterfowl inc. barnacle geese and breeding waders	L	None		Percival 1998; Percival and Percival 1998
Various UK sites	Upland	Upland species, inc. lapwing, curlew, skylark and meadow pipit	M	None		Thomas 1999
Tunø Knob, Denmark	Offshore	Eider, Common Scoter	M	None, other than minor flight route changes		Guillemette *et al*. 1998, 1999; Tulp *et al* 1999
Zeebrugge, Belgium	Coastal shoreline	Waterfowl	M	Mostly wildfowl and waders	Up to 300m	Everaert *et al* 2002
Novar	Upland moorland	Upland species	M	None		Bioscan 2001; Percival 2003
Utgrunden	Offshore	Long-tailed duck	S	None		Petterson and Stalin 2003

VL=very large (>200 turbines); L=large (50-200 turbines); M=medium (10-50 turbines); S=small (<10 turbines)

A further possible disturbance effect is disruption to flight lines. Several studies have shown that some bird species alter their flight routes to avoid flying through wind farms (e.g. tufted duck and pochard at Lely in the Netherlands, Dirksen *et al*. 1998, eiders at Tuno Knob in the Danish Baltic, Tulp *et al*. 1999, and eiders at Utgrunden in the Swedish Baltic, Petterson and Stalin 2003). Whilst this may have the beneficial effect of reducing collision risk, it could also result in the wind farm acting as a partial barrier to bird movements.

In Ireland disturbance problems with wind farms would therefore be most likely to occur at sites with important waterfowl populations (including seabirds). It will always be important to consider the ecological consequences of any such potential disturbance. The worst case would be where birds were disturbed from a scarce resource. There may be an indication that some species may become more tolerant where their resources are more limited, but there is currently insufficient information for most species to be able to be sure that this would be the case. As with collision risk, the major problem is the lack of information on likely key species, such as breeding hen harrier and corncrake.

Part II. Assessment Methodology

Environmental Impact Assessment [EIA] is now an important part of the application process for wind farms in Ireland (and indeed across Europe), and ornithology ornithological assessment is usually an integral part of that process. Most if not all Environmental Statements in relation to wind farms will need to include a section assessing the impact that the development is likely to have on the development site's bird populations.

In 1998 the Scottish Branch of the British Wind Energy Association [BWEA] (the wind industry trade association in the UK) and the government conservation agency in Scotland (Scottish Natural Heritage [SNH]) met to develop a common methodology that could be used by all interested parties for ornithological impact assessment [OIA]. The aim was to develop a methodology that was as transparent and as objective as possible. That collaborative work has continued to date. The initial draft of the methodlogy was published in 1999 (Percival *et al*. 1999) but this has been refined and developed further. The current version presented here is a working version of the document, and this is still very much a methodology in development. In particular, the current draft is in the process of review with regard to its application on European Union protected Special Protection Areas [SPAs]. It has been an inherent part of the methodology that it should not be fixed but should be a flexible methodology that can continue to be refined in the light of experience of its use. The methodology presented here has additionally been updated to address the Irish context.

The key aims of the methodology are to establish a process by which developers and conservation agencies can work together to:

- Ensure that wind farm development does not occur in inappropriate locations where important bird populations may be affected.
- Ensure that bird issues do not hinder development of wind farms at sites where they are not significant.
- Identify where appropriate mitigation measures should be undertaken and where developments may be able to deliver a conservation gain to the area's ornithological interest.

The methodology developed has followed existing guidance on the general EIA process as much as possible (UK Department of the Environment, Transport and the Regions 1995, Institute for Environmental Assessment 1995). The process can be summarised as follows:

- Baseline data collection – carrying out appropriate surveys/desktop studies to determine the bird populations that may be affected by the development
- Determination of the sensitivity of those populations, i.e. their conservation importance.
- Assessment of the magnitude of the effects that may occur on those populations.
- Integration of sensitivity and magnitude into an overall assessment of effects

- Use of that overall assessment to reaching conclusions on the significance and acceptability of the predicted effects.

BASELINE DATA COLLECTION

An underlying principle of the methodology is that the detail of the assessment should reflect the ornithological sensitivity of the site being assessed. More work would be expected to be required at a site of high ornithological sensitivity and vice versa. Hence it is not possible to have a fixed baseline survey requirement. Therefore it was decided in the SNH/BWEA methodology to recommend a phased approach, with the level of detail required depending on the ornithological sensitivity of the site.

Phase 1

The first work undertaken for an OIA should be a desk study to collate all of the available information on the proposal site. It may be possible in a few cases where sites have been recently surveyed for other purposes to obtain sufficient information through this desk study to establish that no significant effect is likely and that no further assessment would be required.

For all OIAs it is essential to determine the bird populations that may be at risk of impact, and in most cases this will involve at least some field survey work. The appropriate survey methodologies will vary between sites, and would be dependent on the ornithological sensitivity of the site. It should be part of the desk study to determine the details of this survey requirement, though this may need to be refined as more data are collected. Agreement on the surveys to be carried out should be sought with conservation agencies as early as possible in the assessment process.

In terms of general recommendations, the Brown and Shepherd (1993) standardised timed surveys can usually provide an appropriate method for carrying out breeding bird surveys. Though originally designed for upland habitats, they can readily be used for any open ground. For habitats such as woodland, point count methods are recommended. More detail on specific survey methodologies can be obtained from Bibby *et al.* (2000) and Gilbert *et al.* (1998). The latter publication is also a very useful source of information for more detailed species-specific survey methodologies (see Phase 2 below).

As well as the survey method, it is also important to ensure that the appropriate survey area is covered. This needs to include all of the area that could potentially be affected by the wind farm. In most cases an area of 500m from the proposed wind turbines would be appropriate to achieve this coverage, though for breeding bird surveys in less sensitive habitats such as farmland this could be reduced to 300m.

Knowledge of the availability of bird habitats is an important part of the baseline data, as well as information on the birds themselves. Most EIAs require mapping of the habitats in and around the development site as part of the ecological assessment. These habitat maps can be very useful in the ornithological assessment as well. In the UK the usual process is to map the broad scale habitats according to the Joint Nature Conservation Committee [JNCC] Phase 1 scheme (JNCC 1993) and identify the vegetation communities within each of these habitat classes according to the National Vegetation

Classification [NVC] (Rodwell *et al.* 1991-2000). Mapping to a similar degree of detail would be equally appropriate in Ireland.

Similarly in the offshore environment, EIAs include description of the marine fauna and environmental conditions that provide habitat information on these sites too.

Phase 2

Where the field surveys and/or other available data indicate that important bird species/populations may be affected, the next phase is triggered. 'Important species' are defined as:

- Species listed on Annex 1 of the EU Birds Directive as requiring special conservation measures.
- Species listed on BirdWatch Ireland's red data list (Newton *et al.* 1999).
- Regularly-occurring relevant migratory species which are either rare or vulnerable, or warrant special consideration on account of the proximity of migration routes, or breeding, moulting, wintering or staging areas in relation to the proposed wind farm. Like the Annex 1 species above, special conservation measures are required for these.
- Species occurring at the site in regionally or nationally important numbers (>1% of the resource).
- Species occurring in special concentrations or which for other reasons may be at an exceptional risk of impact.

This second phase of the OIA entails a more detailed assessment of the importance of the site and its airspace for these species, and may require more detailed site surveys and/or observations of flight behaviour (where species may be at risk of collision). Information on appropriate surveys techniques for any of these important species is best obtained from Gilbert *et al.* 1998, which provides a comprehensive review of specific bird survey methods. These would generally be required where scarcer species that would not necessarily be detected by the basic surveys may occur (e.g. divers, scarcer raptor species such as hen harrier, merlin and corncrake). In most cases it will be necessary to extend the study area for these species-specific surveys, to ensure that the context of the site is fully described. An area of at least 1km from the proposed wind turbine sites is recommended where access is possible.

This second phase includes the evaluation of potential collision risk and direct and indirect disturbance for the relevant species. In some cases this may be achievable with minimal data, using 'worst case' assumptions. In others (particularly where the outcome is less certain), more detailed field data are usually required. The key requirement in terms of both collision and disturbance risk is to quantify the bird numbers and the amount of time that they spend in the area in which they may be affected. This will include data on flight activity and height, in order to calculate the numbers that may pass through the wind farm. More detailed methodologies are described by Morrison (1998) and Band *et al.* (in press).

Phase 3

In cases where a significant potential adverse effect is predicted the third phase of the assessment is required. This includes population analysis to determine the effects of the wind farm on the population, range and distribution. During this phase options for reducing the risk of impact should be explored, by amending or relocating the development and examining options for conservation measures that might outweigh any possible adverse effects.

EVALUATING SENSITIVITY

The sensitivity of a species can be defined as its ecological importance and nature conservation interest at the site being assessed. This is determined by a number of factors, including:

- whether the species is on Annex 1 of the EC Birds Directive
- whether the species is particularly ecologically sensitive: this includes larger birds of prey and rare breeding birds (including divers, common scoter, hen harrier, golden eagle, red-necked phalarope, roseate tern and chough).
- whether the site contains species at nationally important numbers (>1% of Irish population)
- whether the site contains species at regionally important numbers (>1% of regional population, with the region usually taken as the county)
- whether the species is subject to special conservation measures, eg as red or amber species on the BirdWatch Ireland's (Newton *et al.* 1999) list of Birds of Conservation Concern.

The sensitivity is further affected by any nature conservation designations in the area. The determination of sensitivity needs to take into account whether a species contributes to the overall objectives of the designation (including whether the species is notified as a qualifying feature of the site), and specifically for internationally important Special Protection Areas (SPA), it needs to consider whether the species contributes to the overall integrity of the site. The determination of sensitivity is summarised in Table 3.

Table 3: Determination of Sensitivity

SENSITIVITY	**DETERMINING FACTOR**
VERY HIGH	Species that form the cited interest of SPAs and other statutorily protected nature conservation areas. Cited means mentioned in the citation text for the site as a species for which the site is designated.
HIGH	Species that contribute to the integrity of an SPA but which

	are not cited as species for which the site is designated. Ecologically sensitive species including the following: divers, common scoter, hen harrier, golden eagle, red-necked phalarope, roseate tern and chough. Species present in nationally important numbers (>1% Irish population)
MEDIUM	Species on Annex 1 of the EC Birds Directive Species present in regionally important numbers (>1% regional (county) population) Other species on BirdWatch Ireland's red list of Birds of Conservation Concern
LOW	Any other species of conservation interest, including species on BirdWatch Ireland's amber list of Birds of Conservation Concern not covered above.

Overall the determination of sensitivity should generally be a straightforward and objective exercise. Once the bird populations in the study area have been surveyed, it should simply be a matter of using Table 1 to identify the appropriate level of sensitivity for each species present.

DETERMINING THE MAGNITUDE OF POSSIBLE IMPACTS

Once the species/populations in the wind farm area have evaluated in terms of their sensitivity, the next step is to determine the magnitude of the possible impacts that may occur on those species/populations. The methodology addresses this issue by quantifying the effect as far as possible, and expressing the size of that effect in relation to the existing baseline conditions (see Table 4).

One issue in this process concerns the precise area or bird population against which the degree of impact should be judged. For protected SPAs this is usually quite straightforward, comprising simply the populations for which that site has been designated. It is less clear-cut where such protected sites are not involved. The methodology states *"the test of significance of an impact will be whether the wind farm impact is causing a significant change to the population, its range or distribution."* A key point in the assessment is whether the development results in a loss of potential for the site to support its current bird populations. Generally an area wider than the wind farm needs to be considered to allow a balanced view of any displacement effects. A small-scale (e.g. 0-1km) displacement to an adjacent area may have little or no ecological consequence, in which case the magnitude would be low. However if the displacement were over a wider area (e.g. >5km) then it may be more appropriate to regard the impact as medium or high. Another important consideration here is the availability of alternative habitat. Even small-scale displacement may be important if no such alternatives exist and the development results in a local population decline.

A suggested zone of 5km within the wind farm site for making this assessment is suggested in the methodology, though it should be noted that this is only a suggestion and not a definitive position. In some cases it may be more appropriate to consider a local ecological unit if its extent is of a suitable scale, e.g. an island (actual or habitat). The populations of each important species at the wind farm within this zone should be estimated using the best available data on bird densities and habitat availability. These populations then constitute the baseline against which the magnitude of any predicted effects should be judged.

Table 4: Determination of Magnitude of Effects.

MAGNITUDE	**DESCRIPTION**
VERY HIGH	Total loss or very major alteration to key elements/ features of the baseline conditions such that the post development character/ composition/ attributes will be fundamentally changed and may be lost from the site altogether. *Guide: < 20% of population / habitat remains*
HIGH	Major loss or major alteration to key elements/ features of the baseline (pre-development) conditions such that post development character/ composition/ attributes will be fundamentally changed. *Guide: 20-80% of population/ habitat lost*
MEDIUM	Loss or alteration to one or more key elements/features of the baseline conditions such that post development character/composition/attributes of baseline will be partially changed. *Guide: 5-20% of population/ habitat lost*
LOW	Minor shift away from baseline conditions. Change arising from the loss/alteration will be discernible but underlying character/composition/attributes of baseline condition will be similar to pre-development circumstances/patterns. *Guide: 1-5% of population/ habitat lost*
NEGLIGIBLE	Very slight change from baseline condition. Change barely distinguishable, approximating to the “no change” situation. *Guide: < 1% population/ habitat lost*

There are three main ways in which a wind farm development could affect bird populations: (i) direct habitat loss to the development, (ii) collision and (iii) disturbance (construction and operational phases). Each is considered in turn below.

Direct Habitat Loss

This impact comprises the loss of habitat that would result from the take by the turbine bases, access tracks, grid connection cabling and any other associated construction. Assessment of the impact in relation to ornithological interests should involve quantifying the area of each habitat that would be lost (using information from the baseline habitat survey). The magnitude of this effect can then be determined in relation to the proportion of each habitat available that will be lost, in the context of the wind farm site itself and the surrounding ranges of any key bird species present.

In some circumstances it is also possible that there may be indirect loss of habitat, and this should be considered too. An example of how this might occur would be on peatland habitats, where construction activity may affect the site's hydrology and have an impact over a much greater area. Appropriate environmental management systems/ mitigation measures should be put in place to ensure that such effects are avoided as much as possible – indeed such impacts could constitute significant ecological impacts in their own right if such practice is not followed.

Collision Risk

Birds flying at the same height as the wind turbine rotor blades within the wind farm area will be at some risk of colliding with those blades. Mechanistic models to predict the theoretical numbers of birds that would collide with wind turbines in the absence of any avoiding behaviour have been developed by Tucker (1996) and Band (2001). The Band model has developed this in a simple spreadsheet form and is available from SNH (from bill.band@snh.gov.uk), and is the method recommended here. Full details are given in Band (2001) and the model is summarised in Percival *et al.* (1999).

In terms of using the model in the assessment process, the main consideration is the required data input. This is the reason why it is necessary to collect detailed field data on the flight activity of important species in and around the wind farm site being assessed. These include:

1. Numbers of flights per year through wind farm at rotor height
2. Bird flight speed
3. Size of bird (length and wingspan)
4. Size and rotational speed of wind turbine rotor.

Data for points 2-3 should usually be available from published sources (e.g. Campbell and Lack, 1985, and Cramp 1998), though it may be necessary in some cases to quantify flight speeds at the site in relation, for example, to wind conditions, where published data are sparse. Data for point 4 would be readily available from wind turbine manufacturers.

Where a range of different specification turbines are being considered the assessment should be carried out on a worst-case basis.

The mechanistic model produces an estimate for the number of collision likely to occur in the absence of any avoiding behaviour being exhibited by the birds. In reality birds do not just fly around at random but will usually avoid structures in their flight path, so an account of this avoidance needs to be taken in the assessment. It is likely that this will have greatest level of uncertainty in whole of this collision risk assessment process, as it is difficult to quantify. Numerous collision studies have been carried out at existing wind farms, generally reporting only low levels of collision but sometimes have included important species (Percival 2000). In order to estimate avoidance rate, these collision studies ideally need also to have measured the bird flight rate through the wind farm before and after construction. The basic principle of this calculation is straightforward. The predicted number of collisions without avoidance should be calculated using the Band model, the actual number of collisions measured, and then avoidance rate is calculated as:

Avoidance rate = 1 - observed/predicted number of collisions.

It is important that account is taken in any collision studies of the collision victims that may have been missed through removal of corpses by scavengers or birds falling into habitats in which recovery of the corpses is more difficult. In many cases precise estimation of collision (and hence avoidance) rate has proved difficult simply because the frequency of collision is so low. As a result of these issues and the need for bird flight rates, there are few examples where it is possible to obtain a firm value for avoidance. There is an urgent need for studies to determine avoidance rates more precisely. New technologies to achieve this are currently being developed, including the use of infra-red video cameras to monitor collisions, but these have not yet provided more definitive estimates of collision rates.

Many collision risk assessments therefore need to be on the basis of a ‘reasonable worst case’ approach, i.e. what could possibly happen, not what would be totally unrealistic. The assessment of the magnitude of the impact needs to take into account the additional uncertainties that this approach involves. The most likely outcome should be estimated but the likely bounds of that estimate should also be presented and considered in the determination of magnitude. Simulation modelling, e.g. using Monte Carlo methods, may be useful in some circumstances. If the uncertainty in the possible avoidance rates is high, then the analyses should be presented acknowledging that uncertainty. This could be achieved by presenting graphs of the range of possible avoidance rates plotted against the predicted collision rate, so that the effect on the collision predictions of the uncertainty could be illustrated.

The general principle should be to use the worst case avoidance rate for the most closely related taxonomic group, but also to consider the effects of weather conditions and local topography (and the consequences of those effects) that could potentially also affect the avoidance rate.

The collision risk modelling approach also allows the question to be tackled from another direction, to determine the level of avoidance required in order to result in different magnitude impacts, and then assess likelihood that this may occur. This can be useful to demonstrate the degree of difference between what might actually happen and what would need to happen in order for a significant impact to occur.

This approach can be used to predict the likelihood of collision impact, but can also demonstrate the process of risk minimisation during the wind farm design, whereby different layouts can be assessed in relation to the collision risk that they pose.

Whilst the numbers of likely collisions is an important part of predicting the magnitude of any impacts, it is not the only part. The impact of such collisions at the population level can be very different between different species. Differences in life-history strategies are likely to reflect differences in vulnerability to any additional mortality that may result from collisions with wind turbines, and hence the magnitude of the impact. Many populations may be unaffected by a small level of additional mortality, but there are some where even this could result in a significant population decline (Morrison *et al.* 1998). Species with high adult survival rate and low breeding rate may be more susceptible to population impacts, as they would be less able to replace any losses. Similarly species that were unable to compensate for any losses incurred, for example by increased survival or breeding rate (i.e. populations regulated in a density-independent way) would be more susceptible. It is therefore recommended that the magnitude of the predicted collision rate should be determined in the context of the background mortality rate for that species (obtained, for example, from Cramp 1998). A ‘negligible’ magnitude impact would, for example, be predicted if the collision mortality was to represent an increase of less than 1% on the background mortality rate.

Population Viability Analysis models may be useful in exploring this further, where such models or at least the data on which to base such models exist. These could potentially identify levels of mortality at which statistically and biologically significant impacts could be detected.

In many cases it may be that the politically acceptable number of collisions is considerably lower than that at which significant biological impacts would occur on the population. For some species of particular conservation importance it may be that ‘acceptability threshold’ would be better set at a lower level - in some cases perhaps even just a single collision - and look at likelihood of that occurring.

Disturbance

The presence of wind turbines at a site could potentially deter some birds from using that site and its surrounds, effectively resulting in a disturbance impact. In addition during the construction phase of the project the human presence on the site will often be much increased on the baseline conditions, adding further to potential disturbance effects.

Such disturbance would only have a real ecological impact if it resulted in reduced resource use by the birds (i.e. it directly causes resource under-utilisation and hence a reduction in carrying capacity; see Gill *et al*. 1996b). It is also important to consider the likely ecological consequences of any disturbance effect. Displacement may occur but if there were ample alternative habitat to accommodate the displaced birds it may actually be inconsequential.

It is also important in determining the likely magnitude of any disturbance impact to decide on the size of the potential disturbance zone (or sizes, given that it is likely to be greater during construction). If important bird populations may be affected, it may be possible to mitigate this by temporal avoidance, restricting potentially disturbing activities to periods when the important bird populations are not using the site.

Reasonable worst-case potential disturbance distances would be 300m during the breeding season and 800m at other times of year, based on observations from existing wind farms (Gill *et al.* 1996a, Percival 2000, Langston and Pullan 2002). However, for species with larger home ranges, there is also the potential to affect birds breeding at considerably greater distances, for example through partial loss of their foraging range. It is important to determine the populations that could be affected by appropriate field survey and collation of existing data. These worst reasonable case distances could then be reduced where there is robust evidence that effects in similar situations affect a rather smaller area. In the offshore environment, where the scale of impact is currently less well-studied than in terrestrial habitats (Percival 2001), it may be appropriate to use larger potential disturbance distances (e.g. 1-2km), particularly where important bird populations may be affected of species that have not been studied elsewhere.

As with the assessment of collision risk, this approach can also be applied in the wind farm design process to examine different possible layouts in order to minimise the possible impacts.

DETERMINATION OF SIGNIFICANCE

The assessments of magnitude and sensitivity lastly need to be brought together in order to determine the significance of the potential impact, and hence their acceptability in a planning context. The methodology achieves this by cross-tabulating the magnitude and sensitivity, using Table 5 below, to give a prediction of the significance of each potential impact.

Table 5. Significance matrix: combining magnitude and sensitivity to assess significance.

SIGNIFICANCE		**Sensitivity**			
		Very high	**High**	**Medium**	**Low**
Magnitude	**Very high**	Very high	Very high	High	Medium
	High	Very high	Very high	Medium	Low
	Medium	Very high	High	Low	Very low
	Low	Medium	Low	Low	Very low
	Negligible	Low	Very low	Very low	Very low

This significance should then be used to determine whether a predicted impact is acceptable or not. The methodology suggests the following interpretation of the significance ratings:

> **Very low** and **low** should not normally be of concern, though normal design care should be exercised to minimise impacts.
>
> **Very high** and **high** represent a highly significant impact on bird populations and would warrant refusal of a planning proposal.
>
> **Medium** represents a potentially significant impact that requires careful individual assessment. Such an impact could warrant planning refusal, but it may be of a scale that can be resolved by revised design or appropriate mitigation.

In complex or particularly sensitive situations, it may be appropriate to look at a range of possible magnitude effects and make the final assessment on this basis, taking into account the various uncertainties in the available data.

FURTHER APPLICATIONS

Mitigation measures

In circumstances where significant impacts are predicted, or where they may be possible, it may be possible to undertake mitigation measures to offset any adverse effects. Full consideration should be given to habitat enhancement and other measures that could ensure that the development results in a local conservation gain rather than any adverse impact.

The methodology can also be very useful in the wind farm design process. Where significant impacts are predicted it may be possible to re-design the proposed wind farm to avoid the features of particular conservation importance. The methodology provides a way in which the benefits of such re-design can be assessed and demonstrate the benefits of the new layout.

Measures than deliver enhancement to the local bird populations can be a very useful way to manage the uncertainties in the assessment process. There will inevitably be a degree of uncertainty in the predictions of wind farm impacts on birds. An effective way to deal with this would be to put enhancement measures in place that would provide a benefit over and above the predicted adverse effect. This assessment methodology provides a way in which those benefits can be evaluated and the balance between possible adverse and beneficial effects determined.

Cumulative Impact Assessment

The issue of the assessment of the cumulative impact of wind farm developments on bird populations is an issue that is becoming of increasing concern as more wind farms are constructed. The SNH/BWEA methodology does not explicitly consider cumulative impacts, but its underlying principles can equally be applied to cumulative issues. The same principles of analysis can readily be applied over more than a single proposed (or existing) wind farm site. Essentially a cumulative analysis is analogous to a single development but with turbines distributed over a wider area.

Cumulative impact assessment becomes necessary where more than one wind farm (or indeed other development) may affect a local population of conservation importance. There are two cases where it may be particularly relevant:

- At the individual level, in circumstances where a bird species, such as golden eagle or hen harrier, has such an extensive range that it may include more than one development.
- Where a population range has a high level of co-incidence with large-scale existing and/or proposed wind farms (e.g. offshore wind farms and common scoter, where both have a similar preference for relatively shallow (5-15m depth) waters.

Conclusion

In conclusion, the development of the SNH/BWEA ornithological assessment methodology has brought together wind farm developers and conservation agencies in Scotland to work together to develop a solution to what had previously been a source of much disagreement. The methodology now provides a means by which the assessment process can be carried out to reach a reasonably objective conclusion, and it can be readily applied in the Irish context (with the refinements as suggested in this document). It is not a completed process but an ongoing one, and one that will continue to be refined as it is more widely used and as more knowledge of the effects of wind farms on birds is accumulated.

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