An tSeirbhís Páirceanna Náisiúnta
agus Fiadhúlra
National Parks and Wildlife Service

I-WeBS Trends Report Methodology

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April 2022

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Introduction

Monitoring of non-breeding waterbirds has been undertaken by the Irish Wetland Bird Survey (I-WeBS) in the Republic of Ireland since winter 1994/95. For such long-term count data, there is clearly a need to assess long-term trends in a consistent and objective manner (Atkinson *et al.* 2006). Analysis of the nationwide dataset allows for the calculation of estimates and trends of the Irish population as a whole (Burke *et al.* 2018), which can be put in the context of flyway-level changes. Analysis of species trends at a smaller spatial scales can provide a more detailed picture of regional trends and changes in habitat quality at site level. This is particularly important for sites designated as Special Protection Areas (SPAs) for wintering waterbirds where trends of the listed species can be used to assess the current conservation status (condition) of the species listed as being of special conservation interest (SCIs).

The species trends of wintering waterbirds at I-WeBS site-level have most recently been analysed over the period 1994/95 to 2019/20. This document outlines the methodology employed for this analysis.

The methodology used by I-WeBS has been inspired by the Wetland Bird Survey (WeBS) Site Alerts methodology developed by the British Trust for Ornithology (BTO) (Austin *et al.* 2019). BirdWatch Ireland are grateful to the BTO WeBS team for providing insights into the methodology that they have developed and indeed continue to refine.

Please direct any questions about this analysis to the I-WeBS project manager via email at ljlewis@birdwatchireland.ie.

The national and site-level trends are available online at the following location:

https://birdwatchireland.ie/app/uploads/2022/04/iwebs_trends_report.html

Methodology

Overview

The national and site-level trends produced in this analysis are derived from count data gathered by the I-WeBS survey. Missing or poor-quality monthly counts are imputed using the Underhill process. Seasonal summaries are then calculated and indexed. The indexed values are smoothed using a Generalised Additive Model. Short-Term, Medium-Term and Long-Term Trends are then calculated, and a Long-Term Trend classification is assigned.

Species

A total of 35 wintering waterbird species monitored by I-WeBS are included in this site trend analysis (Table 1). Gulls, Terns and species with low detectability (e.g. Moorhen and Water Rail) are excluded from the analysis, as are species that are more accurately monitored through regular targeted censusing (i.e. migratory swans and geese).

For wildfowl and wildfowl allies, counts from all seven I-WeBS core count months (September through March inclusive) are included for analysis and indexing (see below). For wading bird species, only counts from the four-month mid-winter period (November through February inclusive) are used. This minimises the inclusion of passage populations of waders passing through sites in autumn and spring, as this can result in significant fluctuations in numbers.

Table 1: Wintering waterbird species included in the I-WeBS trends analysis

Wildfowl & Allies **(7 monthly counts per season)**	**Waders** **(4 monthly counts per season)**
Light-bellied Brent Goose	Oystercatcher
Mute Swan	Lapwing
Shelduck	Golden Plover
Shoveler	Grey Plover
Gadwall	Ringed Plover
Wigeon	Curlew
Mallard	Bar-tailed Godwit
Pintail	Black-tailed Godwit
Teal	Turnstone
Pochard	Knot
Tufted Duck	Sanderling
Scaup	Dunlin
Goldeneye	Purple Sandpiper
Red-breasted Merganser	Redshank
Coot	Greenshank
Little Grebe	
Great Crested Grebe	
Cormorant	
Grey Heron	
Little Egret	

Source Data

For consistency, site trends are derived from I-WeBS core count records alone. Neither I-WeBS supplementary count records, special censuses, nor counts from Non-Estuarine Waterbird Surveys (NEWS) are employed in this analysis.

Only sites that achieve good count coverage on at least 50% of potential count months are included. Good count coverage in general amounts to complete count coverage of a site in a given month, where counts of all subsites are deemed accurate by the counter (i.e. neither partially counted nor negatively affected by disturbance or poor visibility). In a small number of cases, core count coverage at certain sites was deemed 'good' even though some minor subsites were not fully counted, e.g. if the missed subsite generally holds few birds, or only species whose trends aren't analysed using this process (e.g. Whooper Swan).

Given that there are 26 seasons from 1994/95 through to 2019/20, for wildfowl and allies a site must have at least 91 good quality counts to be included in the analysis (50% of 26 seasons multiplied by 7 months). For waders a site must have at least 52 good quality counts, across the months from November to February inclusive, to be included (50% of 26 seasons multiplied by 4 months).

Imputation of Missing or Poor-Quality Monthly Count Data

The first stage in the analytical process involves the use of the 'Underhill process' (Underhill & Prŷs-Jones 1994) to model the raw monthly counts using a Generalised Linear Model (GLM) and impute count values for the months where count data are missing or of poor quality. This process accounts for changes in numbers at the site and the timing of the count (month, year) while also taking into account completed counts and trends at other sites. When counts at a site are flagged as poor quality (e.g. due to poor visibility) or where there are missing values in a given month because a site wasn't counted, then the imputed values are used unless a supplied (poor quality) count is higher. Imputed counts are rounded to the nearest whole number. This imputation process is used widely to replace missing data points (e.g. Houlahan *et al.* 2000; Atkinson *et al.* 2006; Leech *et al.* 2002; Gregory *et al.* 2005). The resulting dataset is therefore complete for all months and seasons and comprises a combination of actual count data and imputed count data. For sites with less than 50% good quality actual count coverage, the reliability of imputed counts is likely to be relatively low because the model has insufficient actual count data on which to base imputed counts. For this reason, sites with good count data in less than 50% of count months over the period examined are excluded from the analysis (Underhill & Prŷs-Jones 1994, Leech *et al.* 2002).

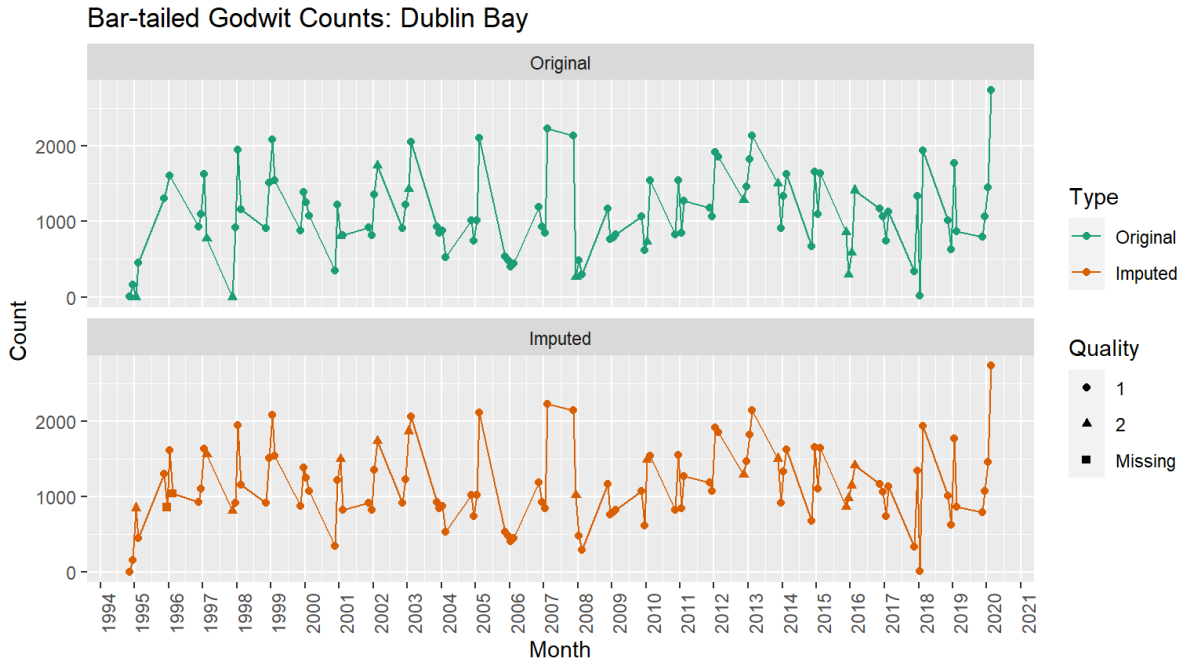

Figure 1: Monthly Counts for Bar-tailed Godwit in Dublin Bay showing both original counts and counts after imputation. Counts are imputed where the original count is missing or of poor quality (Quality of 2).

Indexing of the Seasonal Counts

Annual indices are calculated for each species at a national level, based on data from all of those sites with sufficient count coverage, and also individually for each site. For each winter season included in the analysis, a total is obtained by summing the number of birds recorded in the relevant winter months (the seven months September through March for wildfowl and allies, the four months November through February for waders) (Figure 2).

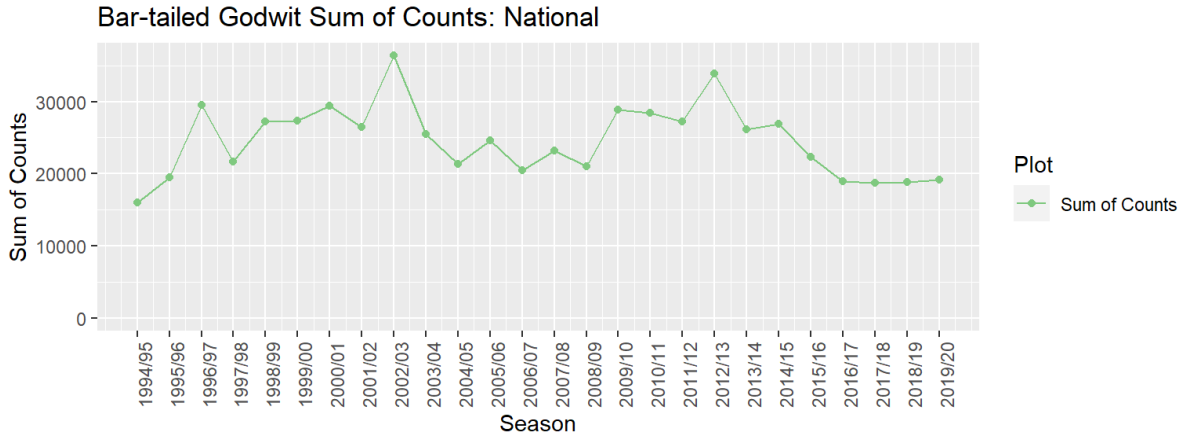

Figure 2: National, seasonal, sum of count data for Bar-tailed Godwit

This data are then indexed such that the final season is assigned the index value of 100.

An index number can be defined as a measure of population size in one year expressed in relation to the size of the population in another selected year (Leech *et al.* 2002). Changes in the index numbers can therefore explain the pattern of population change over time (Underhill & Prŷs-Jones 1994).

By selecting 100 as the index value for the final season, the percentage differences in population size between any season and the final season can be easily observed. By indexing all species and all sites analysed, both cross-species and cross-site comparisons can be readily made.

Smoothing of the Index

The index values over time are then smoothed using a Generalised Additive Model (GAM). GAMs are non-parametric and flexible extensions of the generalised linear model (GLM) where the linear predictor of the GLM is replaced by a general additive predictor which allows mean abundance to vary as a smooth function of time. Indexed data are assumed to follow independent Poisson distribution with 0.3T degrees of freedom (e.g. after Atkinson *et al.* 2006). The application of GAMs to analyse population trends was applied to UK farmland birds by Fewster *et al*. (2000) and has since been adopted for modelling waterbird trends elsewhere, including in the UK WeBS Alert system (Leech *et al.* 2002).

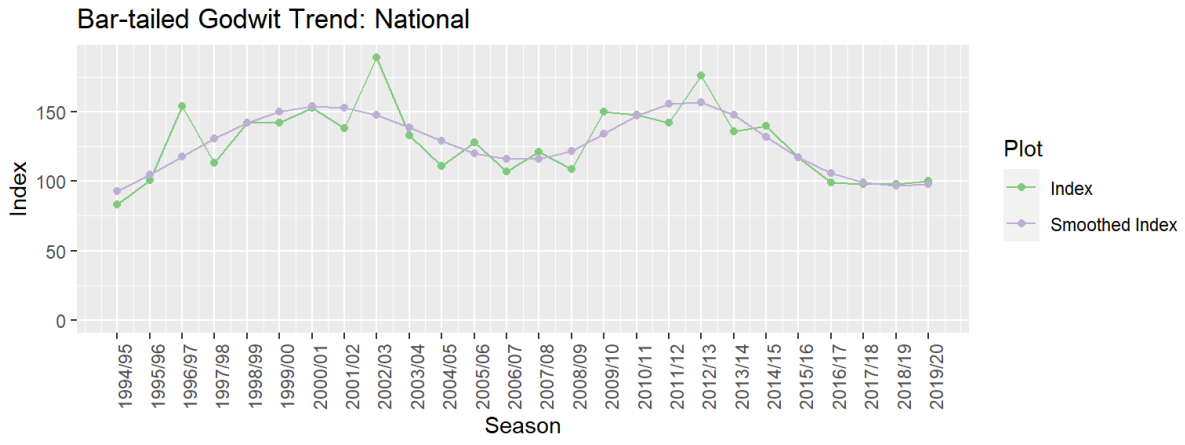

Figure 3: National Trend for Bar-tailed Godwit. The data illustrated in Figure 2 have been indexed such that the final year scales to 100. The Smoothed Index is also displayed.

Trend Calculations

The smoothed index calculated via GAM allows the proportional change in population size between one season and another to be determined. The smoothed indices are used to calculate short-term, medium-term and long-term trends for each species, which here relate to changes from 5 years ago, 12 years ago and 23 years ago respectively. The change values given represent the percentage change in index (population) values across the specified time period, calculated by subtracting the smoothed index value at the start of the time-frame from the smoothed index value in the reference season.

$$\text{Change} = ((I_{ref} - I_x) / I_x) \times 100$$

where I_{ref} is the index from the reference season and I_x is the index value at the start of the selected time period (Table 2).

Table 2: Short-term, medium-term and long-term trends for Bar-tailed Godwit at national level (as illustrated in Figures 2 and 3)

Trend Range (years)	Trend (%)	Time Window
5	-32.6	2013/14 – 2018/19
12	-13.9	2006/07 – 2018/19
23	-5.1	1995/96 – 2018/19

The reference season is the penultimate season in the time series (i.e. 2018/19) because, when smoothing, the GAM takes into account values from both the preceding and following season. The most recent value in the smoothed dataset is therefore likely to be the least robust because it has no count data for the following season. Similarly, the long-term trend compares counts back to 1995/96, because there are no count data for the season preceding 1994/95 and so the imputed values for 1994/95 would similarly be less robust.

The final result is therefore the percentage change in population size across a specified time period. Larger values indicate larger proportional changes in population size; positive values indicating relative increases while negative values indicate relative decreases over the specified time period.

Note that where there is a zero count in the reference season (2018/19) for a species at a site, the site trend cannot be calculated for that species as a divide-by-zero condition arises. Additionally, if a species does not occur in at least 50% of the seasons between the first and last season it is observed on a site, the trends for that species on that site are not calculated. This avoids producing trends for species on sites on which they occur only occasionally.

Trend Classification

A classification scheme has been adopted to assist in describing long-term trends. The classification is illustrated in Table 3.

Table 3: Long-term Trend Classifications

Trend Range (%)	Classification
Lower than -50%	Large Decline
Between -50% and -25%	Moderate Decline
Between -25% and -1%	Intermediate Decline
Greater than -1%	Stable or Increasing

Further Information

Further information on population indexing and trend analysis can be found in the references listed at the end of this document. For information related to waterbirds in particular please see Leech *et al*. (2002) and Atkinson *et al.* (2006). For information on the UK WeBS Alerts system, see Thaxter *et al.* (2010).

Glossary

Annual Index	An index number can be defined as a measure of population size in one year expressed in relation to the size of the population in another selected year. We select 100 as the index value for the final season.
Degrees of Freedom	Broadly defined as the number of "observations" (pieces of information) in the data that are free to vary when estimating statistical parameters.
GAM	Generalised Additive Model. A statistical technique to model the behaviour of a system using a generalised linear model in which the linear response variable depends linearly on unknown smooth functions of some predictor variables.
GLM	Generalised Linear Model. A statistical technique to model the behaviour of a system using ordinary linear regression.
I-WeBS	Irish Wetland Bird Survey. The National Parks and Wildlife Service survey of non-breeding waterbirds in Ireland, coordinated by BirdWatch Ireland.
NEWS	Non-Estuarine Waterbird Survey. The survey of non-estuarine sites not monitored by I-WeBS on an annual basis, carried out every 9 years (most recently in winter 2015/16).
Reference Season	The penultimate season in the time series of data (i.e. 2018/19)
SCIs	Special Conservation Interest. Those species for which a site has been designated a Special Protection Area.
SPAs	Special Protection Areas. Sites that are designated areas of protection under the EU Birds Directive (Directive 2009/147/EC (Birds Directive) on the conservation of wild birds (the codified version of Council Directive 79/409/EEC as amended)).
Underhill process	A technique to impute the count of birds on a site in a month where the count is unknown or of low quality. See Underhill & Prŷs-Jones (1994)
Wader	A wading bird of the order *Charadriiformes*, including all sandpipers and plovers.
Waterbirds	A bird that frequents water, especially one that habitually wades or swims in fresh water.
WeBS	Wetland Bird Survey. A long-running survey of wetland birds in the United Kingdom. WeBS is a partnership jointly funded by the British Trust for Ornithology, the Royal Society for the Protection of Birds and the Joint Nature Conservation Committee, in association with the Wildfowl and Wetlands Trust.
Wildfowl	Birds such as ducks, geese and swans (Order: *Anseriformes*).

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Citations

Please cite this work as follows:

Kennedy, J., Burke, B., Fitzgerald, N., Kelly, S.B.A., Walsh, A.J. & Lewis, L.J. 2022. Irish Wetland Bird Survey: I-WeBS National and Site Trends Report 1994/95 – 2019/20. BirdWatch Ireland Waterbird Report to the National Parks and Wildlife Service. BirdWatch Ireland, Wicklow. (https://birdwatchireland.ie/app/uploads/2022/04/iwebs_trends_report.html)