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A Guide to Waterbird Alerts

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EXECUTIVE SUMMARY

1. The Alerts System provides a standardised technique with which to monitor changes in the population sizes of wintering waterbirds in the UK over a range of spatial scales and time periods using data collected as part of the Wetland Bird Survey (WeBS).

2. The total numbers of 37 species of wader and wildfowl observed during synchronised monthly counts are recorded at approximately 2000 wetland sites in the UK. Using these data, annual indices are calculated for each species.

3. During the Alerts process, the influence of short-term fluctuations and sampling errors on annual population indices is reduced using a smoothing process (Generalised Additive Model). This reduces the probability of categorising populations as declining in the long-term when observed decreases are in fact temporary, caused by factors such as harsh winters or disturbance.

4. Proportional population changes over a series of time periods (5-, 10- and 25-year and full data set periods) are calculated from the smoothed indices at a range of spatial scales. Population declines of between 25% and 50% are flagged as Medium Alerts and changes of greater than 50% as High Alerts. Equivalent increases in population size can also be flagged.

5. Alerts are intended as advisory measures triggering further investigation and should be interpreted with reference to the population dynamics and abundance of the species involved.

6. Population monitoring at the level of the individual site is vital if the "Favourable Conservation Status" of individual Special Protection Areas (SPAs) is to be maintained. Alerts at individual sites should be interpreted in light of population trends at larger spatial scales. Of particular concern are those SPAs where species are declining at a rate of greater than 25% over a specified time period when the larger-scale regional or national trends indicate stable or increasing population sizes.

7. All sites falling into this category will be short-listed for Level 1 Interpretation, which involves rapid assessment of all factors with the potential to negatively influence waterbird population sizes, with the exception of those pertaining to operations and permissions. If the factors responsible remain unidentified, sites will be retained for Level 2 Interpretation, which involves systematic investigation of site-based issues via analyses of existing data sets and discussions with local experts. Finally, if the reason for the observed decline is still not apparent, population trends will be examined in relation to Environment Agency water quality data.

1. INTRODUCTION

The UK holds internationally important populations of wintering waterbirds, and there is a statutory duty on government to protect these populations. Monitoring is essential if populations are to be managed and conserved efficiently as both time and resources available with which to do so are finite. To effectively monitor changes in the size of populations it is necessary to collect and analyse data at a range of spatial scales in order to examine changes at the level of the individual country, region or site. Numbers of wintering waterbirds have been recorded in Britain as part of the Wetland Birds Survey (WeBS) since 1966/67, providing a large, detailed, long-running data set for analysis. The Alerts System (Atkinson & Rehfisch 2000, Underhill 2000) was developed to provide a standardised method of identifying the direction and magnitude of changes in population size at a variety of spatial and temporal scales for a range of waterbird species for which WeBS data are available. Species that have undergone major changes in population size can then be flagged by issuing an Alert. Alerts are intended to be advisory and, subject to interpretation, should be used as a basis on which to direct research and subsequent conservation efforts if required.

This report summarises the concept of Alerts, details the data and methods used in their calculation and discusses their application. Particular mention is made of the caveats surrounding the use and interpretation of Alerts.

2. DATA COLLECTION – THE WETLAND BIRDS SURVEY (WeBS)

Waterbird data used in the calculation of Alerts are collected by a network of counters as part of the Wetland Bird Survey (WeBS) monitoring scheme, which is jointly organised by the British Trust for Ornithology (BTO), the Wildfowl and Wetlands Trust (WWT), The Royal Society for the Protection of Birds (RSPB) and the Joint Nature Conservation Committee (JNCC – on behalf of the Countryside Council for Wales, English Nature, the Environment and Heritage Service in Northern Ireland and Scottish Natural Heritage). The WeBS scheme is an amalgamation of two previous long-term monitoring schemes, the Birds of Estuaries Enquiry (BoEE) and the National Waterfowl Count (NWC), and aims to identify important sites and monitor changes in numbers and distribution of divers, grebes, cormorants, herons, wildfowl, rails, waders, gulls, terns and kingfishers in the UK.

WeBS data are collected under two main counting schemes – Core Counts, originally developed to generate population estimates of waterbirds and therefore to assess the relative importance of different sites in the UK, and Low Tide Counts – although numbers of some birds, including several geese and sea duck species, are recorded during separate, species-specific counts. Data from Core Counts only are currently used when calculating Alerts. Core Counts are made at approximately 2000 wetland sites in both coastal and inland locations around the UK. Whilst a wide variety of wetland habitats are included in the Core Count scheme, a large proportion of the total area covered consists of estuaries, of which over 90% are covered nationally, and large still waters. Many of the sites included in the scheme are, or have been proposed as, Special Protection Areas (SPAs) or Sites of Special Scientific Interest (SSSIs). The areas surveyed during Core Counts are matched as accurately as possible to SPA and SSSI boundaries at these sites. Where WeBS count sectors and SPA and SSSI boundaries do not coincide, the optimum match is in the process of being assessed on a site-specific basis. In many cases there may be practical reasons for any discrepancy. For example, most WeBS counts of estuaries are made at high tide when the birds are easier to count at roost, whereas some statutory site boundaries largely encompass the intertidal habitat.

The WeBS Alerts scheme is concerned solely with highlighting changes in the abundance of waterbirds in Britain and Ireland during the winter months. Whilst several of the wildfowl and wader species recorded under the scheme do breed in the UK and Ireland, with the possible exception of the redshank it is the size of the wintering populations that is of conservation interest at a European or global scale. In addition, the type of habitat in which some of these species, for example golden plover and curlew, breed is not covered under the WeBS surveys. WeBS data are generally not suitable for determining changes in the size of waterbird breeding populations.

Core Counts are conducted monthly, preferably on synchronised 'priority dates' to avoid double-counting or birds being overlooked, and are usually carried out during the high tide period. Counts are made using "look-see" methodology (Bibby *et al.* 2000), whereby an observer familiar with the species involved surveys the whole of a predefined area. Only birds seen or heard by the observer are included, with no allowance made for the ease with which a species may be observed. Ease of observation may, however, be taken into account when interpreting data collected. Wildfowl data have been collected from the majority of English, Scottish and Welsh sites since the winter of 1966/67, with wader data available from 1969/70. The survey was extended to include Coot and Great-crested Grebe from 1983/84, Little Grebe from 1985/86 and Cormorant from 1986/87. Wader numbers have been recorded from sites in Northern Ireland since 1970/71, with numbers of other waterbirds recorded since 1986/87.

3. POPULATION INDEXING

Table 3.1 Species to which the waterbirds Alerts System has been applied and the months used in calculating indices in Great Britain and Northern Ireland (indicated using the first letters of the months September to March).

Species	Great Britain	Northern Ireland
Little Grebe (*Tachybaptus ruficollis*)	SO	SON
Great Crested Grebe (*Podiceps cristatus*)	SON	SONDJFM
Cormorant (*Phalacrocorax carbo*)	SONDJFM	SOND
Mute Swan (*Cygnus olor*)	SONDJFM	SONDJ
Bewick`s Swan (*Cygnus columbianus*)	JF	NDJF
Whooper Swan (*Cygnus cygnus*)	ND	ONDJFM
European White-fronted Goose (*Anser albifrons albifrons*)	JF	
Feral Greylag Goose (*Anser anser*)	S	
Canada Goose (*Branta canadensis*)	S	
Dark-bellied Brent Goose (*Branta bernicla bernicla*)	DJF	
Light-bellied Brent Goose (*Branta bernicla hrota*)		SONDJFM
Shelduck (*Tadorna tadorna*)	JF	DJFM
Wigeon (*Anas penelope*)	J	SONDJFM
Gadwall (*Anas strepera*)	SONDJFM	SONDJ
Teal (*Anas crecca*)	DJF	DJ
Mallard (*Anas platyrhynchos*)	DJF	SO
Pintail (*Anas acuta*)	ONDJ	ONDJFM
Shoveler (*Anas clypeata*)	SO	SONDJFM
Pochard (*Aythya ferina*)	NDJ	NDJF
Tufted Duck (*Aythya fuligula*)	NDJF	ONDJFM
Goldeneye (*Bucephala clangula*)	F	DJFM
Red-breasted Merganser (*Mergus serrator*)	ONDJFM	SONDJFM
Goosander (*Mergus merganser*)	DJF	
Ruddy Duck (*Oxyura jamaicensis*)	SONDJFM	
Coot (*Fulica atra*)	SONDJ	SONDJFM
Oystercatcher (*Haematopus ostralegus*)	DJF	DJF
Avocet (*Recurvirostra avosetta*)	DJF	DJF
Ringed Plover (*Charadrius hiaticula*)	DJF	DJF
Grey Plover (*Pluvialis squatarola*)	DJF	DJF
Knot (*Calidris canutus*)	DJF	DJF
Sanderling (*Calidris alba*)	DJF	DJF
Dunlin (*Calidris alpina*)	DJF	DJF
Black-tailed Godwit (*Limosa limosa*)	DJF	DJF
Bar-tailed Godwit (*Limosa lapponica*)	DJF	DJF
Curlew (*Numenius arquata*)	DJF	DJF
Redshank (*Tringa totanus*)	DJF	DJF
Turnstone (*Arenaria interpres)*	DJF	DJF

3.1 Calculating Indices

An index number can be defined as a measure of population size at a specific spatial scale in one year expressed in relation to the size of the population at the same spatial scale in an arbitrarily selected base year. Index values therefore increase as the number of individuals observed relative to the number sighted in the base year increases. Trends in population size over time can be identified by comparing index values in successive years. Of the species recorded during WeBS Core Counts, 37

(Table 3.1) – 12 waders and 25 wildfowl – are suitable for inclusion in the Alerts System. The remaining species recorded are either not sufficiently abundant to index or are distributed such that the majority of the population is located on sites not surveyed under the WeBS scheme, as is the case for Lapwing (*Vanellus vanellus*), Golden Plover (*Pluvialis apricaria*) and Purple Sandpiper (*Calidris maritima*). In the latter case, variation in the numbers of individuals recorded may not accurately reflect changes in the size of the population as a whole. These species are therefore currently excluded from the Alerts System. It is hoped that further coverage of appropriate sites will enable these species to be incorporated into the Alerts System in the future. In future years it may also be possible to include those species for which numbers are recorded using species-specific counts rather than Core Counts, e.g. Barnacle Geese (*Branta leucopsis*), Pink-footed Geese (*Anser brachyrhynchus*), Icelandic Greylag Geese (*Anser anser anser*) and Greenland White-fronted Geese (*Anser albifrons flavirostris*).

Indices are calculated using data collected between September and March. The subset of these months used to calculate the index value varies with species, representing the period during which the size of the population is at its most stable (Table 3.1). The length of this period for individual species may vary between countries. For all 12 wader species, data are collected monthly on standardised dates during December, January and February in both Great Britain (GB) and Northern Ireland (NI). The window of data collection for wildfowl is variable, ranging from the period between September and March for species such as Gadwall (GB) and Shoveler (NI), to counts during a single month for species including Wigeon (GB) and Goldeneye (GB). To calculate the index value for individual species at a particular site, the number of birds recorded during each month of the respective data collection period is totalled by year (Table 3.2).

Table 3.2 Calculating index values at individual sites. Coot are traditionally indexed over 7 months – September to March. The table shows the number of individuals recorded during each monthly Core Count over this period at a fictitious site between 1998 and 2001. The total count from the last year for which data is available (2001) has been scaled so that it is equal to 100. Total counts collected in previous years are scaled using the same formula ((Total count for year "x" / Total count for 2001) × 100), *i.e.* the index for 2000 is (1130 / 1244) × 100) = 91, for 1999 is (1415 / 1244) × 100 = 114, etc. Indices therefore indicate the size of the population relative to its size in the final year.

Year	Sep	Oct	Nov	Dec	Feb	Mar	April	Total	Index
1998	153	446	318	156	54	32	15	1174	94
1999	214	512	453	102	66	45	23	1415	114
2000	190	400	328	150	40	12	10	1130	91
2001	180	495	345	125	55	34	10	1244	100

This figure is then scaled so that the index value for the most recent year of data collection is equal to 100. If the data for 2001 in the above example are the most recent available, the annual site total for each preceding year (x) would then be scaled using the formula (x / 1244) × 100. The same principle applies for calculation of indices over larger spatial scales. Totals obtained for all individual sites in the relevant area are summed and the resultant values scaled so that the value in the current year is equal to 100. In this way, regional, country and national indices can be calculated.

3.2 Imputing Values

One of the major problems with data sets collected over long periods of time by large numbers of observers is that of missing values. As index values are obtained by totalling monthly counts at individual sites, sites from which count data are missing are likely to produce lower totals. Counts based on different sampling periods are therefore not equivalent and cannot be compared directly. In order to overcome this problem, missing values are estimated using the Underhill method (for full details see Underhill & Prŷs-Jones 1994), a standard technique for replacing missing data points (Goss-Custard *et al*., 1998; Austin *et al*., 2000; Gill *et al*., 2001). Using known values from existing

Core Counts, the Underhill method utilises a Generalised Linear Model (GLM) to calculate the influence of both the site surveyed and the timing of the count, in terms of the month and year of data collection, on the number of birds recorded. For a simplified example, let us say that the waterbird counts for December 1995 are missing at site A. The imputing method allows for differences in counts made in December to those made in all other months (the month effect). For example, for a particular species there may be 10% more individuals in December than in November, and therefore any December missing count will be, all things being equal, 10% higher than a missing count for November. In a similar manner, the imputing method also allows for differences in counts made in 1995 to those made in all other years (the year effect) and it allows for differences in counts made at Site A to those made in all other sites (the site effect). Using the month, year and site effects to help predict the missing value allows an accurate estimate to be generated of the number of birds that would have been recorded at a specific location on a specific date had a Core Count taken place (Underhill & Prŷs-Jones 1994). This process is known as imputing. Missing values in the data set are therefore replaced by imputed values, which are treated identically to actual counts when calculating indices.

The accuracy of individual Core Counts may vary according to factors such as visibility or movement of birds due to disturbance during the survey. Count quality, in terms of estimated accuracy, is therefore recorded by the observer in the field on a scale of 1-4, with 1 representing the highest quality count and 4 the lowest. Low quality counts (3-4) are considered likely to represent underestimates of the number of birds present in the field. These values are therefore treated as missing values and replacement values are imputed by the Underhill method as above. If the imputed value exceeds the value recorded in the field, the imputed value is used in calculating the index for the species. If, however, the observed value is greater, then the data collected in the field are used when calculating the index.

Although location and date are likely to be the main factors influencing the number of birds recorded during individual Core Counts, other factors that it may not be possible to measure, for example the degree of disturbance at a site prior to the count, could also have some effect on abundance. Imputed values are therefore unlikely to be 100% accurate and may disagree slightly with the actual number of birds that would have been recorded by an observer had a Core Count taken place. This level of accuracy is likely to decrease as the size of the data set on which the imputation is based decreases, because fewer estimates of the effect of location and date are available. Data from sites at which many values are imputed may therefore produce less reliable indices of population sizes. For this reason, sites at which 50% or more of the monthly count values used in calculating the indices were obtained by imputation were excluded from the Alerts System (Underhill & Prŷs-Jones 1994).

3.3 Consistency Intervals

Species indices at national, country and regional scales are calculated by summing the individual counts from the sites contained within their respective boundaries and scaling the values obtained (Section 3.1). National, country and regional indices therefore summarise the population indices at the individual sites that were used in their calculation. The national index value calculated for a particular species in the UK, for example, will summarise the index values for that species calculated at all UK sites. In order to assess the degree of variation in index values across these sites, a bootstrapping process is used.

Bootstrapping involves repeated recalculation of the index value using randomly selected subsets of this data. Let us say that a national index value is calculated using count data from the 100 sites included in that nation. Site counts would be selected at random from the 100 available. Each could be included on multiple occasions in each individual recalculation, but the total number of counts used must be equal to the number used in the original calculation, *i.e.* 100. The number of sites contained in each subset is therefore determined randomly, according to the number of counts that have been included on multiple occasions, and the number of times which each of these counts has been used. This process is then repeated 999 times using a different randomly selected subset of sites on each occasion, giving a range of values for the national index. Whilst it is theoretically possible that an individual calculation could be based on values from a small number of sites repeated

many times, the probability of this occurring is extremely low, and the probability of this occurring repeatedly during the 999 separate calculations of the value is even more remote.

The range of values over which 95% of the national index values calculated in this way fall is known as the 95% consistency interval (Underhill & Prŷs-Jones 1994). If individuals are distributed evenly across all sites, the consistency intervals will be small, as the summed counts from different subsets of sites will contain similar numbers of birds. However, for patchily distributed species consistency intervals are likely to be large as subsets of sites used during the bootstrapping process are likely to yield very different results depending on the identity of the specific sites included.

It is important to note that consistency intervals provide a measure of variance in the number of birds counted at individual sites. If national indices were calculated from an incomplete sample of UK sites, consistency intervals could be used to determine the accuracy with which the value obtained reflected the true index value of the whole population, and would therefore be termed confidence intervals. Large confidence intervals infer that index values are potentially poor estimates, as very different values might have been obtained should a different set of sites have been used in the calculation. However, for the majority of species included in the Wetland Birds Survey, notably wader species that are confined to estuarine sites (sites of which more than 90% are surveyed nationally), a large proportion of the total population is counted during WeBS Core Counts. Indices calculated are therefore close to absolute, accurately reflecting the actual number of individuals that were present as the majority were counted, and not estimates based on a limited sample of sites. No measure of accuracy can therefore be placed on these values.

For some species included in WeBS Core Counts, such as Turnstone, Ringed Plover and Curlew, a relatively large proportion of the population occurs at stretches of non-estuarine coast, habitat that is not extensively covered by the Wetland Birds Survey. Factors influencing species abundance in this habitat are likely to differ from those affecting the population sizes of waterbirds in estuarine habitat. For example, the decline in organic inputs resulting from the UWWT and Water Framework Directives may have a greater effect within estuaries than off non-estuarine coasts, as the waters of the former are more enclosed (Burton *et al*. 2001). It is suggested, therefore, that consistency intervals generated for these species should not be treated as confidence intervals even though the species may only have been partially surveyed, as population trends in the subset of birds inhabiting WeBS sites may not be representative of those population trends observed on non-WeBS sites. Population indices for these species should therefore be thought of as reflecting the size of the sub-population of the species inhabiting WeBS sites, and the consistency intervals surrounding them should be considered measures of variation in population size between these sites.

4. CALCULATING ALERTS

4.1 Alert categories

The function of the Alerts System (Atkinson & Rehfisch 2000; Underhill 2000) is to provide a framework within which the direction and magnitude of long-term changes in population size can be identified and evaluated. By raising Alerts, attention can be drawn to those populations that are increasing or, in particular, decreasing in size at the proportionately highest rates. Alerts are raised if the size of a population decreases by more than 25% over a specified period of time. If this decline is between 25% and 50%, a Medium Alert is raised (Table 4.1). If the decline exceeds 50% over the specified time period, a High Alert is raised (Table 4.1).

Whilst these threshold levels do not possess a specific ecological significance, they have not been chosen arbitrarily. Small decreases in abundance experienced by a given population are more likely to be reversible, and are therefore less likely to influence the conservation status of the species in the long-term. Threshold levels should therefore be sufficiently large to draw attention only to those decreases that may be of significance ecologically. However, decreases in population size should also be identified whilst a reversal in the direction of the trend is still theoretically possible. For this reason, the Alerts thresholds should not be set at too high a level.

These set limits are also in line with those used previously when monitoring the conservation status of bird species. A 50% population decline over a 25-year period was previously used as one of the criteria when identifying 'Red Data Birds' (Batten *et al.* 1990), species of high conservation priority in the UK. A recent modification of this criterion (Avery *et al.* 1995) recommended the additional identification of species that had decreased by 25%- 49% over the same period as species of medium conservation priority. These criteria for rapid and moderate declines have since been adopted by the statutory and voluntary conservation agencies (Anon 1995, Gibbons *et al.* 1996, JNCC 1996).

The Alerts System can also be used to flag positive changes in population size (Table 4.1) and a term other than Alert should be developed to describe notification of increases in population size. Populations that are declining by less than 25%, exhibiting no change in population size, or increasing by less than 25% over a specified time period are classified as 'stable'.

Table 4.1 Alert definitions.

Alert type:	50% Negative	25% Negative	25% Positive	50% Positive
When flagged:	Decline greater than 50%	25–50% decline	25–50% increase	Increase greater than 50%
Description:	Large decline or **High Alert**	Moderate decline or **Medium Alert**	Moderate increase	Large increase

The specified time period over which Alerts are calculated is flexible, but 5-year, 10-year, 25-year and full data set Alerts are recommended. Alerts calculated over longer time-periods are less likely to represent temporary, short-term declines in population size due to factors such as weather conditions (Section 4.2), but instead are more likely to be the result of long-term trends in population size. However, if a species has undergone a long-term increase in abundance and numbers have subsequently fallen rapidly to a level approaching the initial population size, longer-term measures of change in population size could fail to identify this decline even though it may be ecologically significant. Shorter-term measures of change might therefore be more appropriate in this situation, and could help to identify decreases in population sizes, such as those occurring at individual SPAs due to changes in management practices, more rapidly relative to the beginning of the decline.

The ecology of a species, in particular its life-span and reproductive rate, may influence the speed at which population size changes, the average rate being higher for shorter-lived more rapidly reproducing species. Species ecology should therefore also be considered when interpreting Alerts generated over different time periods (Section 5.1).

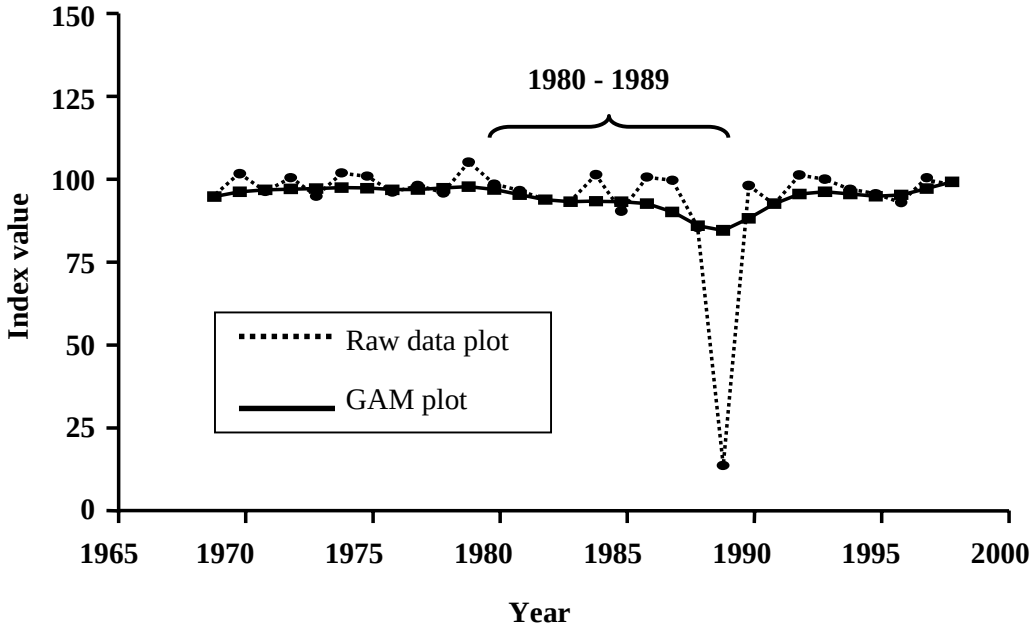
It is therefore imperative to measure proportional changes in population size over a variety of time periods and to interpret each case individually according to the ecology of the species and the dynamics of the population.

4.2 Smoothing Data

Natural short-term fluctuations in population size, for example those caused by variation in the severity of conditions over the winter period, can differ in size and/or direction from longer-term population trends, hindering their interpretation. Extreme values may trigger false Alerts due to misinterpretation of temporary, short-term declines as longer-term population trends. Alternatively, long-term trends that may have led to Alerts being flagged could be obscured by short-term fluctuations.

In order to avoid such misinterpretations and misidentifications when calculating Alerts, the Alerts System uses Generalised Additive Models (GAMs) to fit a smoothed curve to the annual population indices. Figure 4.1 presents a plot of the annual population size indices for a fictitious species using data collected between 1969 and 1998. The raw data show that the index value dropped severely during 1989, but had recovered to its previous level by 1990. If the ten-year period between 1980 and 1989 is considered, the raw data suggest that the population experienced a severe decline over the decade from an index value of 95 in 1980 to around 15 in 1989. However, if any other ten-year period, for example 1979 – 1988 or 1981 - 1990, is used to calculate the change in population size over the same approximate time period, the change is then close to zero, a result which is more representative of the overall long-term population trend. For raw data, the change in index numbers observed is therefore highly dependent on the specific period of time used in the calculation. If the change in index values for the 1980 - 1989 period is taken from the GAM plot, however, the drop in index value measures 5 - 10 units compared with a figure of approximately zero for the 1979 – 1988 and 1981 - 1990 periods. The change in index numbers observed is therefore much less dependent on the specific time period used in the calculation.

Figure 4.1 Use of Generalised Additive Models (GAMs) to investigate medium- and long-term trends in population sizes.



Changes in population size calculated using smoothed values produced by GAMs are therefore less likely to be due to the effects of short-term fluctuations in population size or to errors when sampling than results produced using raw data plots.

4.3 Assigning Alerts

Proportional changes in the index value of a population over a specified time period are calculated by subtracting the index value at the start of this period from the index value in the current year. This value is expressed as a percentage of the index at the start of the period (Table 4.2). Larger values therefore indicate larger proportional changes in population size, with positive values equating to relative increases in the population size and negative values equating to relative decreases over the specified time period. These values are then categorised according to their magnitude and direction, as indicated in Section 4.1. A Medium Alert is flagged if a negative value of between 25% and 50% is obtained from the above calculation. Example a) in Table 4.2 would therefore be described as a 5-year Medium Alert. A High Alert is flagged if the proportional decline in population size exceeds 50%. Example b) in Table 4.2 would therefore be termed a 10-year High Alert. The method outlined in Table 4.2 can also be used to flag Alerts on the basis of proportional changes in the geographical range of species over specified time periods.

The spatial scale over which Alerts can be calculated is flexible and is dependent on the index value used in the calculation. It is therefore possible to calculate Alerts at national (UK) and country (England, Scotland, Wales and Northern Ireland) scales using national and country indices respectively. Alerts can also be calculated by region or at the scale of the individual site, for example specified SPAs or SSSIs, to identify more localised trends in population size, but care should be taken when interpreting the results (Section 5.3). As there are a large number of SPAs and SSSIs designated to protect waterbird populations, it has been agreed with the Joint Nature Conservation Council (JNCC) that Alerts should be calculated annually for a proportion of the total number of these sites, one third of SPAs and one sixth of SSSIs, in rotation.

When smoothing the index value for individual years, the GAM takes index values from both preceding and subsequent years into account. The smoothed value for a particular year may therefore change as values from subsequent years are added to the data set. The degree to which this value is prone to variation with the addition of further data is termed the robustness of the value. The last point in the smoothed data set is likely to be the least robust as there are no data from subsequent years available with which to smooth it. The addition of the following year's data therefore has the potential to change the smoothed value considerably, with the size of this change decreasing as each subsequent year's data is added thereafter. Late submission of data, and the resultant recalculation of indices, may also cause values to change slightly in subsequent years. Changes in population size should therefore ideally be calculated one year retrospectively using penultimate index values, as these values are likely to be more robust and therefore less susceptible to variation as the data set is continued. However, a balance must be reached between the robustness of the values generated by the Generalised Additive Model and the need to identify population trends as rapidly as possible if successful conservation measures are to be taken. The most recent index value available is therefore often used in calculating Alerts even though this may not be ideal from a statistical standpoint.

Table 4.2 Worked example of Alerts calculations.

Alert type	Year	Index	Index value
Full data set	**1970**	**590**	**590**
	1971	511	
25 year	**1972**	**423**	**423**
	1973	354	
	1974	322	
	1975	333	
	1976	357	
	1977	370	
	1978	349	
	1979	348	
	1980	351	
	1981	348	
	1982	326	
	1983	300	
	1984	282	
	1985	283	
	1986	302	
10 year	**1987**	**327**	**327**
	1988	342	
	1989	322	
	1990	262	
	1991	199	
5 year	**1992**	**153**	**153**
	1993	127	
	1994	113	
	1995	105	
	1996	101	
	1997	**100**	**100**

Calculation of Alerts

"x" Year Alert: $((I_y - I_x) / I_x) \times 100$ where I_y is the index value for the current year and I_x is the index value "x" years previously

Examples:
a) 5-year Alert: $((100 - 153) / 153) \times 100 =$ **35% decrease**
b) 10-year Alert: $((100 - 327) / 327) \times 100 =$ **69% decrease**
c) 25-year Alert: $((100 - 423) / 423) \times 100 =$ **76% decrease**
d) Full data set Alert: $((100 - 590 / 590) \times 100 =$ **83% decrease**

As discussed in Section 3.3, consistency intervals around the index numbers for individual years at the national, country and regional scales can be determined by repeatedly calculating the annual indices using data from different subsets of randomly selected sites. The 95% consistency interval is defined as the range of values over which 95% of the index numbers calculated in this way are likely to fall. It is also possible to calculate consistency intervals around the proportional population change value at national, country and regional scales using a bootstrapping technique. Index values for the current year and the year at the beginning of the period over which the population change is being determined (I_y and I_x respectively in Table 4.2) can be calculated repeatedly using randomly selected sets of sites,

as described in Section 3.3. Using these values, the proportional change in population size over this time period can then be calculated repeatedly using the method in Table 4.2. The 95% consistency interval around the proportional population change value is again defined as the range over which 95% of these values are likely to fall.

The caveats mentioned in Section 3.3 also apply to the interpretation of consistency intervals around proportional population change values. Consistency intervals, unlike confidence intervals, should not be used to infer the statistical significance of changes in population size. As a large proportion of the total population is likely to have been counted for the majority of WeBS species, changes in population size calculated are close to absolute, and not estimated from smaller samples of the population. Larger consistency intervals therefore do not indicate that estimates of population trends are potentially less accurate, but rather that the nature of changes in population size varies greatly between individual sites, possibly suggesting a relatively large influence of local factors on population size. Small consistency intervals indicate that population trends are similar across individual sites, possibly suggesting that observed changes in population size are due to factors acting at larger spatial scales. Changes in population size of those species that also occur on non-WeBS sites should again be considered as representative only of the sub-population that frequent WeBS sites.

Consistency intervals cannot be calculated for site-based population trends, as only a single index value is available for each site in each year, thus rendering bootstrapping impossible.

5. INTERPRETING ALERTS FOR THE ENVIRONMENT AGENCY

Qualifying species are defined as those that are responsible for the designation of an individual SPA. An individual SPA may have several qualifying species (Stroud *et al*. 2001). Changes in population sizes of the respective qualifying species of waterbird at each SPA throughout England and Wales will be calculated for the Environment Agency during 2002. Observed population trends at individual SPAs will be interpreted in relation to both regional and national population trends (Section 5.2). This analysis will help to determine whether the "Favourable Conservation Status" of these sites is being maintained. Possible causes of those population declines that are restricted to the site in question will then be investigated under Level 1 Interpretation. If this fails to identify the factors responsible for the observed decrease in population size, sites will be retained for more intensive investigation under Level 2 Interpretation (Section 5.2).

It is important that Alerts raised during this process should be seen as advisory and not absolute, acting as triggers for closer scrutiny of results and potential further investigation. Characteristics of the species involved may affect the reliability of Alerts and therefore should be taken into consideration during their interpretation, as discussed below (Section 5.1).

5.1 Influence of Species Ecology and Abundance on Alert Interpretation

The population dynamics of a species may influence the degree to which the size of the population fluctuates annually, and therefore the probability of false Alerts being flagged. The potential for short-term fluctuations in population size is greater for short-lived species with high rates of reproduction, such as Wrens (*Troglodytes troglodytes*) and other small passerines, than it is for longer-lived species that reproduce at slower rates, such as raptors and many waterbird species. Species ecology is not allowed for directly when calculating Alerts and therefore must be taken into account during interpretation of 5, 10, 25-year and full data set Alerts.

Mean species abundance may also influence the probability of Alerts being flagged. For small populations, smaller absolute changes in numbers are necessary to elicit equivalent proportional changes in population size. A 50% Negative Alert for a population of 1000 birds involves the loss of 500 individuals, whereas a 50% Negative Alert for a population of 100 birds involves the loss of only 50. Larger changes in absolute numbers are less likely to be due to short-term fluctuations in population size and may therefore be more ecologically significant than smaller absolute changes in the numbers of rare species. Absolute population size should therefore also be taken into consideration when interpreting Alerts.

The Alerts system is unsuitable for monitoring species that are present in large numbers in some years but are very scarce in others, such as Bewick's and Whooper Swans wintering on the Wash. If an influx year were compared to a non-influx year, a large change in proportional population size would be observed. A comparison between influx years or between non-influx years, however, is likely to indicate a much smaller change in population size. Both the magnitude and the direction of observed changes in population size are therefore highly dependent on the specific time period used in their calculation. The probability of observed trends representing long-term population trends is therefore greatly reduced, even after smoothing of the data.

5.2 Interpretation of Site-Based Alerts

All site-based Alerts, such as those calculated for England and Wales' SPAs for the Environment Agency, will be assessed in relation to national and regional population trends separately. Qualifying species at each site can therefore be categorised according to the nature of the relationship between the population change identified at the site level and that identified at both the regional and the national levels, producing two separate tables, one for the regional comparison and one for the national comparison, as illustrated in Table 5.1.

Group A incorporates those species for which population sizes are stable or increasing at both the level of the site and at the national or regional scale. These species will therefore have a "Favourable

Conservation Status" both on the SPA and in the UK as a whole. Group B includes those species that are maintaining a stable population or increasing in number on the SPA in question, but experiencing a decline in numbers nationally or regionally. By comparing these sites to those where populations of the same species are decreasing, in line with the national or regional trend, it may be possible to gain an insight into the factors causing the national or regional decline. It is unlikely that local site management issues are exerting a negative influence on population size for species included in category A or category B.

Categories C and D include all species that are exhibiting a decline in numbers at the level of the SPA. Species of particular interest are those in category C, which are declining in number on the site in question, but are maintaining stable populations or increasing in number at national or regional scales. This discrepancy in the direction of population trends suggests that local site management issues, such as the amount of water being abstracted, pollution events, or the amount of organic matter in the water (Rehfisch and Austin, *in press*), may be responsible for triggering the observed decline in the local population. Species included in category D are those that are declining in number both at the SPA in question and at a national or regional level. In these cases factors such as climate change (Austin et al., 2001; Austin and Rehfisch, *submitted*), which may affect populations over a much larger spatial scale, are more likely to be responsible for the observed decrease in numbers at the SPA in question, as similar decreases in population sizes are occurring at other locations. However, it is possible that localised changes in site management, such as wastewater treatment processes, which are implemented simultaneously at regional or even national scales, could be responsible for observed changes in population sizes at these larger spatial scales. Local management issues at other sites should therefore be considered when investigating the factors responsible for site-based Alerts.

Table 5.1 The possible classification of Alerts triggered for species at the level of individual SPAs relative to Alerts generated regionally or nationally for the same species. Species included in Category A represent those that are increasing or stable (decreasing by less than 25%) both on the relevant SPA and nationally (or regionally). Category D represents those species that are decreasing by greater than 25%, both on the relevant SPA and nationally (or regionally). Species in Category B are those that are increasing or stable on the SPA but decreasing nationally (or Regionally), whilst those in Category C are decreasing on the SPA but are stable or increasing nationally (or regionally).

		National/Regional Alerts	
		Population increasing or stable (decreasing by less than 25%)	Population decreasing by 25% or more
SPA Alerts	Population increasing or stable (decreasing by less than 25%)	A	B
	Population decreasing by 25% or more	**C**	D

It is important to compare local population trends to both regional and national trends. National indices may not reveal regional changes in population sizes if increases in some regions are balanced by decreases in other regions, for example if population distributions are changing within a country. In a recent study of waders wintering in Britain, Austin *et al.* (2000) identified a decrease in numbers of several wader species in the southwest of England. Further analysis revealed that population sizes

were increasing on the east coast of England, and thus the national population size was approximately stable. A site on the southwest coast at which the population of one of the aforementioned wader species was decreasing would therefore be classified as category C in relation to the national population change, but category D in relation to the regional population trend. The results of subsequent studies (Austin et al., 2001; Austin and Rehfisch, *submitted*) suggested that changing settlement patterns of juvenile waders, at least in part due to the reduced severity of winter temperatures on the east coast over the last 30 years, are likely to have been responsible, although water quality may also have affected settlement patterns (Rehfisch and Austin, *in press*). Changes in population sizes are therefore likely to have been due to large-scale factors as well as more localised factors, as suggested by the comparison between site-based and regional population trends.

5.2.1 Level 1 Interpretation

Under Level 1 Interpretation, sites included in category C, at which local populations are declining whilst regional and/or national populations are stable or increasing, will be short-listed. Sites of particular interest are those at which a large number of waterbird species are included in category C. Rapid assessments of the observed population changes are then carried out to determine if factors not pertaining to water issues are responsible for the observed declines. Sites at which declines remain unexplained are retained for Level 2 Interpretation. We estimate that approximately 20% of short-listed sites will be retained in this way.

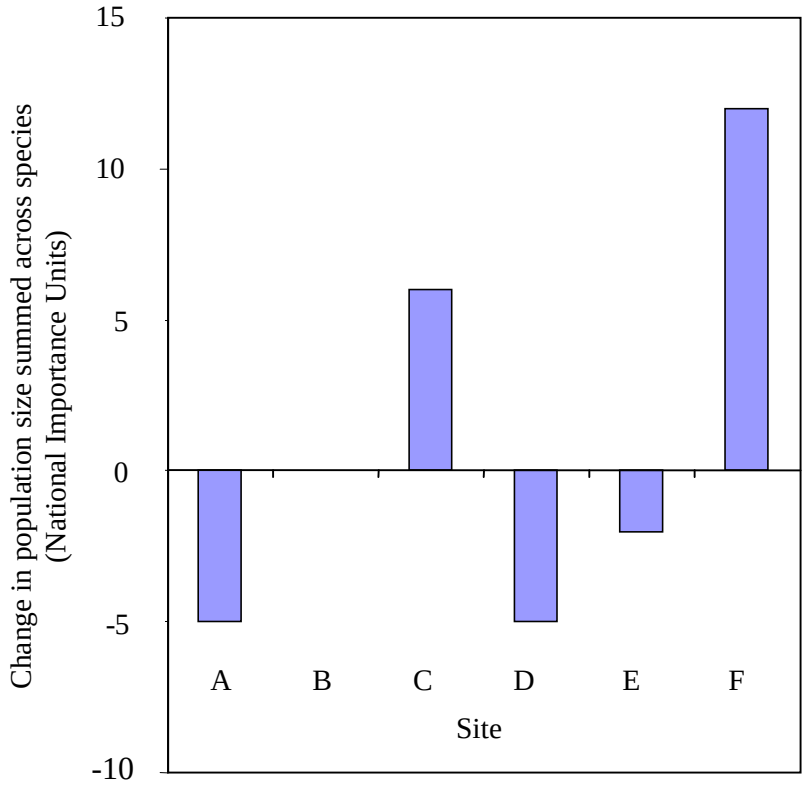


Figure 5.1 Overall trends in SPA conservation status.

Summarising population changes for groups of species may aid in the assessment of population declines. Scores, given in National Importance Units (NIU), can be allocated to the different types of Alert, ranging from –2 for a 50% Negative Alert, through 0 for proportional population size changes which are smaller than 25% but larger than –25%, to +2 for a 50% Positive Alert. These values can then be summed across the relevant spatial scale. A positive result indicates that the overall trend across the species in the group is for an increase in population size (Figure 5.1, Sites C and F), a negative result that overall trend is for decreasing population sizes (Sites A, D and E), and result of

zero either that population sizes are stable for all species, or that the number of species increasing is approximately equal to the number decreasing (Site B). Summarising data in this way is useful in interpreting the causes underlying changes in population sizes as it helps to distinguish between causal factors such as disease, which may reduce the population size of individual species, and factors such as habitat change or pollution which are likely to influence population size in a range of species. Areas in which the majority of species recorded are in decline may be identified as priority sites for Level 2 Interpretation. However, significant declines in population size at the level of the individual species should be investigated regardless of NIU totals for the site.

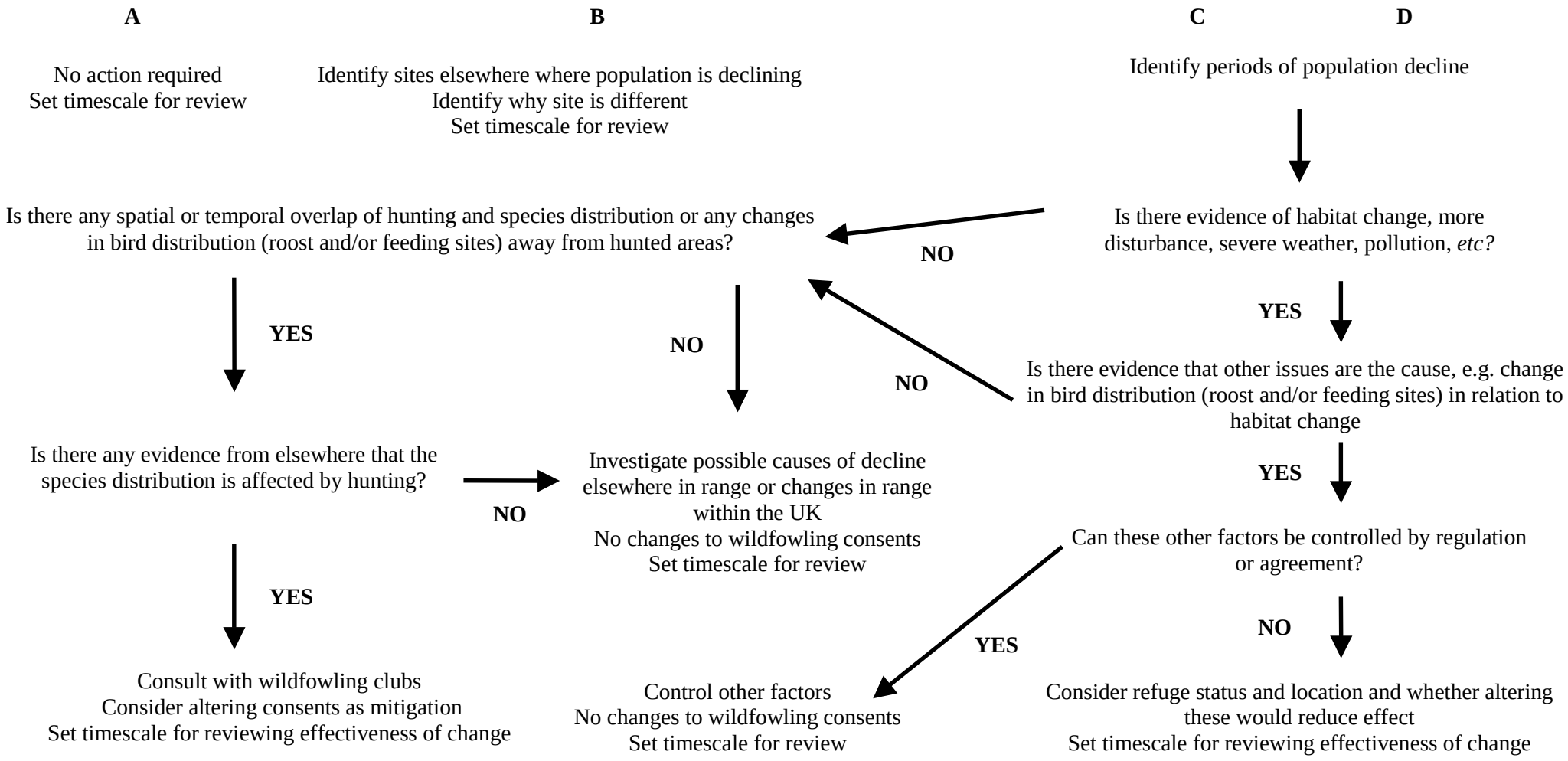
5.2.2 Level 2 Interpretation

The second level of interpretation will involve the investigation of site-specific management issues that may be responsible for the observed waterbird declines by systematically following a decision tree, an example of which is given in Figure 5.2. In this way, factors that may have triggered Alerts, such as habitat change at sites within or adjacent to the SPA, recreational disturbance, including wildfowling, and pollution may be identified.

Analysis of existing data sets and discussions with local site experts, such as EA, Water Company, Country Agencies (the Countryside Council for Wales, English Nature, the Environment and Heritage Service in Northern Ireland and Scottish Natural Heritage), local authority, Wildlife Trust, RSPB and BASC staff, may help to identify local factors, or combinations of factors, that could be responsible for triggering the observed Alerts, such as variation in the quantity of freshwater flowing over estuarine mudflats, changes in the levels of human recreational disturbance, wildfowling, , sewage inputs or gross pollution incidents. Such analyses are dependent on the availability of suitable data.

If the poor conservation status of the site remains unexplained, the timing of the observed changes in waterbird numbers would be related to data concerning EA operations and permissions. This would provide a preliminary, if crude, assessment as to whether there is any evidence that such changes could potentially have caused the observed changes in waterbird numbers. If there were any such evidence, future detailed work involving partners such as HR Wallingford would be suggested, as the level of expertise required is likely to be outside of that available within the WeBS partnership. At the end of Level 2 Interpretation, it is expected that the major factors driving waterbird declines would remain unidentified on only a few SPAs.

Figure 5.2 Example of a decision tree used in Level 2 Interpretation of site-based Alerts.



6. CONCLUSION

- In conjunction with data collected during the Wetland Birds Survey (WeBS), the Alerts System provides a standardised technique for monitoring the direction and the size of changes in the size of UK waterbird populations. Such population monitoring is essential if the "Favourable Conservation Status" of Special Protection Areas (SPAs) used by wintering waterbird populations is to be maintained.

- The Alerts System is a flexible monitoring system that is able to assess population changes over a range of spatial scales (site, regional, country and national) and time periods (5-, 10-, 25-year and full data set recommended).

- Alerts are triggered when proportional population size changes calculated from smoothed population indices over these specified time periods exceed set limits - between 25% and 50% for a Medium Alert, greater than 50% for a High Alert.

- Alerts should be considered as advisory, not absolute, and should be interpreted both in relation to the individual species and study areas involved.

- Site-based Alerts, such as those generated for qualifying species at individual SPAs, will be interpreted in light of both regional and national population trends. Sites will be short-listed if populations of any qualifying species are decreasing, resulting in Alerts being raised, whilst regional and/or national populations of the same species are stable or increasing in size.

- All short-listed sites will be subject to Level 1 Interpretation. The influence of all factors, with the exception of those pertaining to water quality, that have the potential to trigger a decrease in waterbird numbers will then be assessed. If the population decline is still unexplained, sites are retained for Level 2 Interpretation.

- Level 2 Interpretation involves the systematic investigation of site-based issues that may be responsible for the observed population decline(s) using a decision tree approach. Existing data sets will be analysed and local site experts consulted. If the factors responsible for the population decline remain unidentified, population trends will be examined in relation to data concerning EA operations and permissions. If there is any evidence that factors pertaining to water quality are involved in influencing changes in population size, future detailed investigation, almost certainly involving partners outside those involved in WeBS, will be suggested.

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Appendix 1 Glossary.

Alerts System	A standardised technique whereby annual population indices are used to calculate the direction and magnitude of changes in population size over a range of spatial and temporal scales. Medium Alerts are flagged when declines in population size over a specified time period exceed 25%, and High Alerts when these declines exceed 50%.
Bootstrapping	A method of generating confidence and consistency intervals by repeatedly sampling subsets of the whole data set.
Confidence Intervals	An estimation of the degree to which observed measurements, taken from a subset of the total population, reflect the measurements that would be obtained from sampling the population as a whole. Small confidence intervals indicate accurate estimates.
Consistency Intervals	Similar to confidence intervals, but obtained when the majority of the population has been sampled. Consistency intervals indicate variability between samples in terms of numbers of birds or trends in population sizes, with small intervals indicating low variability.
Core Counts	Monthly "look-see" counts of waterbird numbers at wetland sites performed by volunteers as part of the Wetland Birds Survey.
False Alerts	Flagged Alerts which are due to short-term fluctuations in population sizes due to factors such as severe winters, and are therefore of reduced conservation significance relative to long-term population declines.
Generalised Additive Model (GAM)	A statistical technique used to fit a smoothed curve to the annual index data, thus reducing variation due to short-term fluctuations, decreasing the probability of flagging false Alerts.
Generalised Liner Model (GLM)	A statistical technique that calculates the influence of survey site and date (month and year) on the number of birds observed. Used in imputing missing values.
Imputing	A technique used to replace missing values by estimating the probable number of birds that would have been recorded at a specific site on a specific date had a Core Count taken place.
Index Number	A measure of population size in a specific region in one year expressed in relation to the size of the population in the same region in an arbitrarily selected base year.
Qualifying Species	Species on which designation of individual Special Protection Areas is based. Wetland areas are designated as SPAs if they hold more than 1% of the British population of a rare or vulnerable species listed in Annex 1(Article 4.1) of the European Council Directive on the Conservation of Wild Birds (79/409/EEC), more than 1% of the biogeographical population of a regularly occurring migratory species or more than 20,000 wintering waterbirds.
Wetland Birds Survey (WeBS)	A long-running monitoring scheme that surveys wintering waterbird populations at approximately 2000 wetland sites in the UK using a combination of Core Counts, Low Tide Counts and species-specific counts. Jointly organised by the BTO, RSPB, WWT and JNCC.