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BTO Research Report No. 502

**Association of
British breeding birds
with freshwater wetland habitats**

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1. Introduction

Wild bird indicators composed of the trends of species associated with key British landscapes (such as farmland and woodland) are reported annually by the UK government and have raised public awareness about the conservation problems which many of these species face. A major objective of this project - the Wetland Bird Indicators Project - is to develop parallel indicators for breeding birds associated with different types of freshwater wetlands and waterways.

The association of species of British birds with certain habitat types at defined periods of the year is central to various routine censuses. For example, the Waterways Bird Survey (WBS) assesses populations of a defined subset of wetland-associated species found by linear waterways during the spring breeding period from late March through to July (Marchant *et al.*, 2006). By contrast, the Wetland Birds Survey (WeBS) scheme produces indices for a number of waterfowl and waders at selected sites during the winter months (Banks *et al.*, 2006). A number of other bird surveys are founded on habitat associations including, for example, the Garden Bird Feeding Survey, the Winter Farmland Bird Survey, the Scarce Woodland Bird Survey 2005-2006 and the Upland Breeding Bird Survey. Conversely, the Breeding Bird Survey (BBS) records numbers of a wide range of bird species in randomly-stratified quadrats across the UK (Raven and Noble, 2006) and surveys such as the Nest Record Scheme cover all habitats. The Common Birds Census (CBC) survey (Marchant *et al.*, 1990), the predecessor of BBS, also recorded a wide range of bird species at survey sites, though these were not selected on a random-stratified basis.

The association of British bird species with habitat types is also central to various applications of these data. Habitat preferences defined in the Breeding Bird Atlas of Britain and Ireland (Gibbons *et al.*, 1993) were used to classify species to habitat in the development of landscape-specific indicators, such as assessment of farmland bird populations (Gregory *et al.*, 2004) and indicators for wetland, farmland and woodland birds within the UK government's suite of *Sustainable Development Strategy* indicators (DETR, 1999; Defra, 2007) as well as the England Biodiversity Group's indicators of water and wetland birds, farmland birds, coastal and marine birds, urban birds and woodland birds (England Biodiversity Group, 2006). In recent work on developing bird indicators for Scotland (Noble *et al.*, 2006), habitat information recorded on BBS sites was used to firstly classify species as habitat generalists or specialists and, secondly, to derive habitat-specific trends for species found in more than one major habitat (e.g. farmland and woodland).

Since 2002, an indicator for Water and Wetland birds has been produced to represent one of the five landscape themes of the England Biodiversity Strategy. Composed of the population trends of a suite of wetland birds, composite trends are derived mainly from the BTO's Waterways Bird Survey (WBS) with 1975 serving as the base year of the indicator. Since its inception, this indicator has been disaggregated into three component lines; one for birds of fast-moving waters (3 species), one for birds of standing and slow-moving waters (14 species) and one for birds of wet grasslands and marshes (4 species). As for other bird indicators, most species were classified according to their habitat categorisations in the Atlas of Breeding Birds in Britain and Ireland (Gibbons *et al.*, 1993). These were birds of 'lowland wetlands' and some species classified as 'upland' but known to have strong associations with waterways (e.g. dipper). For three species (lapwing, pied wagtail and reed bunting) also monitored in other habitats (e.g. farmland), we used the WBS trend to represent trends in the waterways component of these populations. The latest Water and Wetland bird indicator provided to Defra in November 2007 was assembled using these categorisations, with a note to the effect that ongoing developments in waterbird indicators funded by the Environment Agency are likely to result in recommendations for a modified indicator, and a suite of sub-indicators representing a set of key wetland habitats. In the meantime, it has also been decided by UK Treasury that a new Public Service Agreement (PSA) for bird populations will be produced by aggregating the three current separate indicators for Water and Wetland birds, Woodland birds and Farmland birds (the latter already a PSA). The trend line for Water and Wetland birds will be shown alongside those for Farmland and Woodland birds to communicate information on the status of biodiversity in each sector.

The main aim of this report is to provide the background and present evidence for the categorisation of species in a revised indicator of Water and Wetland birds, including their categorisations into key wetland habitats such as fast-flowing waters and reedbeds. We also consider the representativeness and availability of key datasets for generating population trends for each of the proposed species.

This paper considers four strands of evidence leading to an overall recommendation for inclusion of bird species into a suite of indicators of five freshwater wetland types of primary interest and two of secondary interest, based upon the freshwater habitat over which environmental regulators of the UK have some degree of control. These freshwater wetland habitats include five primary types: (1) fast-flowing rivers; (2) slow-flowing rivers; (3) standing fresh waters; (4) reedbed habitat; and (5) riparian wet grassland and wetland. The distinction between 'fast-flowing' and 'slow-flowing' rivers is essentially that used in the Waterways Bird Survey (WBS), though with some subjective judgement based largely on altitude differences at either end of the survey reach of linear waterway (Marchant and Hyde, 1979 and 1980). Owing to the unique relationship in the British Isles between altitude and river slope, these 'fast-flowing river' birds more or less coincide with water-associated birds categorised as 'upland' by Gibbons; *et al.* (1993). Secondary habitat types of potential interest include: (6) wet woodland and (7) wet moorland. Saltmarsh and brackish habitats are excluded from this analysis which focuses primarily upon the freshwater environment.

The 'long list' of birds subjected to this analysis started with all 24 within the restricted list of bird species routinely indexed by WBS (Baillie *et al.*, 2007). Other bird species were included where routine survey data (WBBS, BBS) were available and where the species were highlighted for attention by the combination of expert input from a Project Board or the literature review.

The first of the four analyses informing the choice of birds to support indicators for different wetland types in the British Isles is a 'review of reviews' of breeding bird associations with selected British wetland habitats. As habitat use by various bird species is known to vary across their European and wider global ranges, confounding consensus on habitat use and consistent international indicators (Gregory *et al.*, 2005), this review is based predominantly upon British sources except in certain clearly-described instances where the literature addresses wider habitat use. For this reason, reviews addressing birds in habitats across Europe (for example Tucker and Evans, 1997) are expressly omitted from this literature search. Since there is also no consistent method of habitat classification throughout the literature, there is a degree of subjectivity and lack of transparency in determining habitat use by birds during the breeding season. Therefore, the second supporting strand of work entails analyses comparing mean bird counts in recorded habitat types in the BBS dataset as a basis for justifying the association of bird species according to their relative abundance in certain wetland types. The third evidence base is taken from an analysis of associations of bird species from the WBBS dataset with habitat features from associated stretches of river using the River Habitat Survey (RHS) methodology (Vaughan *et al.*, 2007). Lastly, we consider the quantity or coverage of data available in order to make a confident determination of bird population trends. Habitat associations are deduced from these four evidence bases for each of a series of wetland birds of interest for indicator development. An allocation is suggested of bird species into groups potentially indicative of different wetland types, justified on the basis of their ecology and statistical association and compared to the allocation of birds to habitat classes within the England Biodiversity Group's (EBG's) *WI: Populations of Water and Wetland Birds in England* indicator (England Biodiversity Group, 2006). The process by which observed trends in population of these birds are combined into a habitat indicator, together with the statistical handling including weighting of bird species between habitat indicators and their alliance to either one or multiple habitats, will be the subject of further publications.

It should be noted that this assessment excludes analyses of species unlikely to be included in the indicator because of their rarity (e.g. black-throated diver) or the lack of reliable monitoring data (e.g. water Rail) even though these species may show very strong associations with particular habitats. The best example is bittern, a species found only in reedbeds of particular size and quality, but occurring in such low numbers and on such a restricted range of sites that it would be difficult to use it for assessing changes in biodiversity more broadly.

2. Methods and results

The first analytical strand, the ‘review of reviews’ of breeding birds’ associations with selected British wetland habitats, primarily entailed three reviews (Gibbons *et al.*, 1993; Fuller, 1982; Brown and Grice, 2005). Contributory authors providing some of the overviews and trend assessment in Gibbons *et al.* (1993) are not separately acknowledged in this publication. All three sets of authors also make secondary references throughout their books, and these are not separately acknowledged either. Additional literature sources are used where necessary, for example, to determine habitat alliance for birds becoming less scarce since the above works were published (i.e. little egret) or to clarify other aspects of habitat use.

The second strand of evidence took the form of an analysis of counts of each species within various wetland and waterway habitat types as recorded in the BBS dataset for the year 2006. The results of this analysis are described in detail in the next section of this report. BBS surveyors have, from inception of the survey in 1994 through to 2006, recorded both primary habitat and a secondary habitat type. For the 2007 BBS survey only, additional habitat data were gathered, including up to four different levels of habitat. Henceforth, capture of wetland habitat data should be improved.

The third strand of evidence is the analysis of associations of bird species from the WBBS dataset with RHS habitat features from associated stretches of river conducted by Vaughan *et al.* (2007). This study modelled the relationships between WBBS bird species’ distributions and hydromorphology recorded by RHS, building regression models for 20 bird species associated with attributes of the river channel and neighbouring floodplains. Upland, fast-water species and reedbed specialists showed the closest links with RHS, followed by lowland, slow water species, where correlations to RHS varied widely in magnitude. The distributions of floodplain wading birds were poorly modelled by RHS, suggesting that floodplain land uses as quantified by RHS were poor predictors of distributions. Specific features were also important, including hydraulics, bank/channel vegetation, depositional features and anthropogenic structures. The relative strength of bird and river habitat data may be in part due to the selective recording of habitat data by RHS, which focuses predominantly upon channel hydromorphology and vegetation but less so on the wider riverine landscape including floodplain variables and proximity to other water bodies.

The fourth and final consideration for the use of birds as indicators of freshwater wetland habitats entailed judgement about the limitations to the quantity or coverage of data available in order to make a confident determination of bird population trends. This analysis was based upon the number of survey sites at which bird species were present in survey units reported for the 2005 and 2006 BBS (Raven and Noble, 2006; Raven *et al.*, 2007) and 2004 WBBS (Marchant *et al.*, 2006). Minimum sample sizes for constructing BBS population indices were established by Joys *et al.* (2003).

2.1 Habitat associations of waterways species

As the second strand of evidence for this review, habitat and bird data from the 2006 Breeding Bird Survey were used to examine the habitat associations of 27 species of waterways birds. Contributors to the BBS record birds along two 1km transects on two visits (‘early’ and ‘late’) and in three distance bands (0-25m, 25-100m and >100m) as well as a ‘flying over’ category. Habitat data is also recorded with each 200m transect section being assigned to broad habitat types. In this report, to obtain a single count value for each transect section, we sum the birds counted in the two nearest distance bands, with the exception of sand martin data, where ‘flying over’ counts are included. The greater of the resulting ‘early’ and ‘late’ totals was used in the analysis.

ANOVAs were used to compare the mean count per transect section of each of the five habitat types (fast-flowing water, slow-flowing water, standing water, wet meadow and reedbed) for each of the 27 species. Post hoc comparisons between the five habitat types were performed using least significant difference (LSD) pairwise t-tests. The results of these analyses can be seen in Table 1. Table 2 shows

a summary of the first set of analyses, showing the species most associated with each habitat type (^{2nd} indicates a species that shows a secondary association to a habitat type). Grey heron, kingfisher and sand martin showed no clear preference between the five habitat types. Goosander, common sandpiper, dipper and grey wagtail had a preference for fast-flowing water. No species showed a primary preference for slow-flowing water, whilst standing water was the habitat of preference for little grebe, great crested grebe, mallard, tufted duck, moorhen, coot, and pied wagtail. Wet meadows and marshes were preferred by mute swan, teal, curlew, lapwing, snipe, redshank, grasshopper warbler, yellow wagtail and little egret. Cetti's, sedge and reed warblers all preferred reedbed, as did reed bunting.

Table 1. Mean count per transect section of each habitat type for each of the 27 species.

Species	LSD tests	Anova p value	Mean count per transect section				
			1. Fast (322)	2. Slow (1232)	3. Standing (673)	4. Water meadow & marsh (303)	5. Reedbed (82)
Mute swan	4 v 1/2/3/5	0.0385	0.0932	0.1577	0.1692	0.3003	0.0732
Teal	4 v 1/2/3/5	0.0005	0.0124	0.0065	0.0374	0.1023	0.0000
Mallard	3 v 1/2/4/5	<0.0001	0.6739	1.0082	1.9746	0.9571	0.5244
Tufted duck	3 v 1/2/4/5	<0.0001	0.0062	0.0858	0.8174	0.0990	0.0000
Goosander	1 v 2/3/4/5	0.0005	0.0590	0.0033	0.0000	0.0033	0.0000
Little grebe	3 v. 1/2/4/5	<0.0001	0.0000	0.0057	0.0853	0.0363	0.0122
Great crested grebe	3 v 1/2/4/5	<0.0001	0.0062	0.0286	0.1602	0.0429	0.0244
Little egret	4 v 1/2/3/5	0.0018	0.0000	0.0041	0.0015	0.0264	0.0000
Grey heron	-	0.2320	0.0373	0.0645	0.0943	0.0825	0.0122
Moorhen	3 v 1/2/4/5 1 v 2/3	<0.0001	0.0807	0.2565	0.4775	0.2409	0.1341
Coot	3 v 1/2/4/5	<0.0001	0.0497	0.2108	0.9371	0.2739	0.0976
Lapwing	2 v 3/4	0.0012	0.1615	0.0907	0.2260	0.2541	0.0610
Snipe	4 v 1/2/3/5 1 v 2	<0.0001	0.0373	0.0106	0.0120	0.1056	0.0366
Curlew	4 v 2/3/5	0.0004	0.0652	0.0278	0.0299	0.1089	0.0244
Redshank	4 v 2/3/5 2 v 1/3	0.0001	0.0683	0.0114	0.0614	0.1254	0.0122
Common sandpiper	1 v 2/3/4/5/	0.0006	0.0652	0.0180	0.0225	0.0000	0.0000
Kingfisher	-	0.6295	0.0062	0.0082	0.0030	0.0033	0.0000
Sand martin	-	0.3142	0.5186	0.2687	0.5349	0.2541	0.2317
Yellow wagtail	(4 v 1/3)	0.1452	0.0000	0.0278	0.0135	0.0693	0.0122
Grey wagtail	1 v 2/3/4/5 2 v 3/4	<0.0001	0.1087	0.0547	0.0120	0.0066	0.0122
Pied wagtail	3 v 1/2/4	0.0045	0.0994	0.0964	0.1632	0.0594	0.1098
Dipper	1 v 2/3/4/5 2 v 3	0.0011	0.0373	0.0139	0.0000	0.0066	0.0000
Cetti's warbler	4 v 1/2/3 5 v 1/2/3	<0.0001	0.0000	0.0025	0.0045	0.0396	0.0488
Grasshopper warbler	4 v 1/2/3 5 v 1/2/3	<0.0001	0.0031	0.0016	0.0030	0.0330	0.0244
Sedge warbler	1 v 3/4/5 4 v 2/3 5 v 2/3	<0.0001	0.0466	0.1234	0.1407	0.4653	0.4756
Reed warbler	1 v 2/3/4/5 5 v 1/2/3/4 2 v 4	<0.0001	0.0062	0.1062	0.1572	0.2343	0.4634
Reed bunting	All but 2 v 3	<0.0001	0.0621	0.1855	0.1766	0.4620	0.8048

Table 2. Summary of the first comparisons of BBS counts, listing the species most associated with each habitat type (* indicates the strongest habitat association for species that shows associations to more than one habitat, *^{2nd} is the secondary habitat association, parentheses indicate an overall non-significant difference among habitats).

No preference	Fast flowing water	Slow flowing water	Standing water	Wet meadow	Reedbed
Grey heron	Goosander	Dipper* ^{2nd}	Mallard	Mute swan	Cetti's warbler*
Kingfisher	Common sandpiper	Grey wagtail* ^{2nd}	Tufted duck	Teal	Grasshopper warbler*
Sand martin	Grey wagtail*	Moorhen* ^{2nd}	Little grebe	Little egret	Sedge warbler*
	Dipper*		Great crested grebe	Lapwing*	Reed warbler*
	Snipe* ^{2nd}		Moorhen*	Snipe	Reed bunting*
			Coot	Curlew	
			Lapwing*	Redshank	
			Pied wagtail	(Yellow wagtail)	
				Cetti's warbler*	
				Grasshopper warbler*	
				Sedge warbler*	
				Reed warbler* ^{2nd}	
				Reed bunting* ^{2nd}	

In order to further explore some of the associations identified, we repeated the analyses comparing BBS counts in transect sections, but with standing waters and slow-moving water amalgamated into a single category because of the apparently poor distinction between these two habitat types. We also split the wet meadows and open marsh category into two categories to further explore habitat preferences of species showing a preference for this category. The results of the second set of analyses are shown in Table 3 (conventions as in Table 2).

Table 3. Summary of the second comparisons of BBS counts, listing the species most associated with each habitat type. (* indicates the strongest habitat association(s) for species that shows associations to more than one habitat, ^{2nd} indicates the secondary habitat for such species, parentheses indicate an overall non-significant difference among habitats).

No preference	Fast flowing water	Standing & slow-moving water combined	Water meadow & grazing marsh	Other open marshes	Reedbed
Grey heron	Goosander	Mallard	Mute swan	Teal*	Cetti's warbler*
Kingfisher	Common sandpiper	Tufted duck	Teal* ^{2nd}	Little egret*	Grasshopper warbler* ^{2nd}
Pied wagtail	Grey wagtail*	(Great crested grebe)	Little egret* ^{2nd}	Curlew	Sedge warbler*
	Dipper	Moorhen*	(Lapwing)	Redshank	Reed warbler*
	Curlew* ^{2nd}	Coot	Snipe*	(Sand martin)	Reed bunting*
	Snipe* ^{2nd}	Grey wagtail* ^{2nd}	Redshank	Yellow wagtail	
		(Little grebe)	Cetti's warbler*	Grasshopper warbler*	
			Grasshopper warbler* ^{2nd}	Sedge warbler *	
			Sedge warbler*		
			Reed warbler* ^{2nd}		
			Reed bunting* ^{2nd}		

2.2 Species by species assessment of associations with freshwater wetland habitats

This section collates, for a series of wetland birds of potential value for inclusion into freshwater wetland indicators, the results of the four strands of evidence noted above with comments on their use in other relevant indicators. Where Vaughan *et al.* (2007) do not refer to the bird species, no reference is made to their paper. Bird species most strongly associated with the five freshwater wetland types of primary interest – (1) fast-flowing rivers; (2) slow-flowing rivers; (3) standing fresh waters; (4) reedbed habitat; and (5) riparian wet grassland and wetland – are considered first. Following these is another evaluation for birds potentially associated with habitat of secondary interest – (6) wet woodland and (7) wet moorland. Following this final category are details for birds excluded by this evaluation from inclusion in indicators of freshwater wetland habitats.

Mute swan

The mute swan (*Cygnus olor*) is a common temperate Eurasian species found across much of lowland Britain.

Habitat usage. Distribution maps in Gibbons *et al.* (1993) show the mute swan to be a widespread but predominantly lowland species in Britain, rarely occurring above 300m, though a preference for eutrophic waters is surmised to restrict its breeding extent. Gibbons *et al.* (1993) also record that over-zealous marginal habitat management on waters can seriously damage the nesting potential for mute swans and other water birds, though this loss may be offset by creation of standing waters through gravel workings. Mute swans can also exploit coastal brackish lagoons. Brown and Grice (2005) note that, “*Mute Swans inhabit a wide variety of still and slow-running freshwater wetlands (including those in urban areas) throughout the year, provided they contain adequate supplies of food in the form or such submerged vegetation as pondweeds, milfoil and stoneworts*”. Vaughan *et al.* (in press) note that mute swan distribution was significantly related to RHS-derived indices describing slow-moving water, and was also significantly correlated with channel vegetation. The initial BBS analyses suggested an association with ‘wet grasslands’, but when this habitat was split into marshes and wet meadows, mute swans were found in significantly higher numbers in the latter. This may reflect feeding areas rather than nest sites but most swans counted at this time should be breeders. Numbers along slow-moving waters were next highest but not significantly so.

Allocation to habitat group. The above suggests that the mute swan should be allocated to the ‘wet meadows and marsh’ category and secondarily to the ‘slow-flowing river’ and ‘standing fresh water’ habitat, perhaps by splitting the data. (Mute swans are in the ‘slow/still water’ group in the EBG indicator.)

Notes on data holdings. Mute swans are widespread across Britain and well-represented in data holdings. Mute swans were recorded at 318 sites across the UK in the 2006 BBS survey (Raven *et al.*, 2007). However, a question remains as to whether ‘bachelor territories’ might skew conclusions about trends.

Further note: Mute swan bachelor territories can contain large number of individuals which, as BBS and WBBS record only swan numbers and not just breeding pairs, can conceivably add ‘noise’ to the data. However, unless more or fewer bachelor territories occur over time, the presence of these territories should not skew the overall picture. The same principle applies to congregations of non-breeding birds of any species (i.e. herons, waterfowl in general, mallards, etc.) Under BBS, records of more than ten lapwings per survey section are excluded from trend analyses by BTO (Field and Gregory, 1999) as these birds (at least not all of them) will not be breeding.

Teal

The teal (*Anas crecca*) is Britain's smallest dabbling duck. The drake can be recognised at a distance by its narrow white shoulder stripes and yellow patch below the tail. Non-breeding visitors vastly outweigh the British breeding population.

Habitat usage. Gibbons *et al.* (1993) note that teal favour generally oligotrophic waters including upland moors, bogs and mires, though the species will adapt to lowland Britain where it may nest in various well-vegetated wetland environments. Consequently, they are susceptible to insensitive habitat modification. Gibbons *et al.* (1993) also note that the species is sparsely-represented on CBC and WBS surveys. Brown and Grice (2005) note that, "*In England, Teal breed in a range of freshwater and brackish wetlands, including upland bogs, mosses and moorland pools*". The initial analyses of BBS data revealed a preference for wet grassland habitats (and when this habitat was split into open marshes, and water meadows /grazing marshes, teal were found to prefer the former). Del Hoyo *et al.* (1992) record that teal inhabit, "...*small freshwater lakes and shallow marshes with abundant vegetation*", though the recording of teal in WBBS sites (see below) also suggests an association with linear waterways.

Allocation to habitat group. Based on the BBS analyses and literature, teal are allocated to 'wet meadows and marsh' habitat type, and there is also an association with 'wet moorland'.

Notes on data holdings. Though relatively sparse, data holdings for teal are adequate for population trend assessment. Teal were recorded at only 30 and 38 sites respectively across the UK in the 2005 and 2006 BBS surveys (Raven and Noble, 2006; Raven *et al.*, 2007), but also on 14 WBBS sites in 2004 (Marchant *et al.*, 2006).

Mallard

The mallard (*Anas platyrhynchos*) is Britain's largest dabbling duck. It is widespread on both the moving and still fresh waters of Britain.

Habitat usage. Gibbons *et al.* (1993) note that few waters are too insignificant to provide a nesting site for mallards, the few 10km recording squares from which it is absent comprising high moorland and mountain. Brown and Grice (2005) note that, "*It is highly adaptable and opportunistic, thriving in virtually all types of wetland, from the smallest farm pond to the largest of reservoirs*". These wordings, though potentially construed as referring to moving and standing waters, relate primarily to static and slow-moving water and wetland areas. Vaughan *et al.* (2007) note that mallard show an aversion to rocky channels and no clear relationships to the other RHS variables in their models, suggesting that they do not favour fast-flowing rivers. Perhaps surprisingly, Vaughan *et al.* (in press) found that mallards were not significantly correlated with river channel vegetation. The first analyses of BBS data suggested a preference for standing waters; and this preference was retained when slow-moving and standing waters were combined.

Allocation to habitat group. These habitat preferences suggest that the mallard be allocated to the 'standing waters' category although the species was also found to be relatively abundant in both 'slow-moving waters' and 'wet meadows and marshes'. (Mallard are in the equivalent EBG 'slow/still water' indicator). However, a potential problem with including Mallard is that their numbers may be influenced by widespread releases of reared mallards for shooting purposes. Some sources suggest that up to 400,000 individuals are released annually in the UK. Although a large proportion of these individuals will be shot, some of them are likely to survive and contribute to the breeding population.

Notes on data holdings. Data holdings are adequate for population trend assessment for this widespread duck. Mallard were recorded at 1631 sites across the UK in the 2006 BBS survey (Raven *et al.*, 2007).

Tufted duck

The tufted duck (*Aythya fuligula*) is the commonest diving duck found throughout Great Britain, its numbers increasing dramatically since it was first recorded breeding in 1849 (Gibbons *et al.*, 1993).

Habitat usage. Gibbons *et al.* (1993) note that the tufted duck is widespread though predominantly a lowland species, with some implication that duck distribution is limited to availability of standing waters larger than 1 hectare and rivers of equivalent size. The first set of analyses of BBS data confirmed the species' preference for standing water, and further analyses showed the preference for standing and slow-moving waters combined. Tufted ducks were not recorded in marshes or reedbeds.

Allocation to habitat group. These preferences for lowland areas and larger lakes and reservoirs suggest that tufted duck be allocated to the 'standing water' category. (Tufted duck are in the equivalent EBG 'slow/still water' indicator.)

Notes on data holdings. Data holdings are adequate for population trend assessment for this widespread duck. Tufted duck were recorded at 185 sites across the UK in the 2006 BBS survey (Raven *et al.*, 2007).

Goosander

The goosander (*Mergus merganser*), also known as the common merganser, is a saw-billed duck feeding mainly on small fish in faster rivers.

Habitat usage. Gibbons *et al.* (1993) note that, "Although typically a breeding bird of upland rivers, goosanders may also be found nesting in a variety of other habitats ranging from meandering lowland reaches to moorland tarns." Data presented in Gibbons *et al.* (1993) demonstrates that breeding is largely restricted to Scotland, northern England and west Wales. They further note that goosanders are a relatively recent addition to the British and Irish avifauna, having been first recorded nesting in 1871. Considerable range expansion has subsequently occurred in England and Wales. Brown and Grice (2005) and note that the goosander "... is a scarce breeding bird in England but is widespread and locally numerous in winter", agreeing with Gibbons *et al.* (1993) in terms of their regions of greatest breeding success. Vaughan *et al.* (in press) found that goosanders showed a preferential association with intermediate levels of tree cover and rocky channel respectively, indicating an association with fast-moving rivers. Both sets of analyses of BBS data confirmed the species' preference for fast-moving waters.

Allocation to habitat group. These habitat requirements place the goosander in the 'fast-flowing river' habitat grouping. Although we lack good evidence, there may be a secondary association with wet moorland. Goosander do not feature in the EBG indicator.

Notes on data holdings. The inclusion of this saw-billed duck into indicators is marginal, recorded at only 30, 34 and 39 WBBS sites in the UK respectively in 2002, 2003 and 2004 (Marchant *et al.*, 2006). However, goosander were recorded at an additional 53 sites across the UK in the 2006 BBS survey (Raven *et al.*, 2007).

Little grebe

The little grebe (*Tachybaptus ruficollis*) is widespread on both slow-moving and still fresh waters of Britain, and has a wide global distribution throughout the Old World.

Habitat usage. According to Gibbons *et al.* (1993), this secretive bird "...frequents still or slow-moving waters, and for a breeding site needs submerged and emergent vegetation." Gibbons *et al.*

(1993) also report it as absent from East Anglia's fenland due to an absence of suitable bank-side cover. Dobinson and Richards (1964) showed that little grebes are very susceptible to prolonged frosts, with Moss and Moss (1993) showing pronounced cold weather losses. Brown and Grice (2005) note that the little grebe "...is a widespread and numerous resident throughout much of lowland England" which "...show a marked preference for eutrophic waters with a muddy substrate: small ponds, ditches, canals, lakes, reservoirs, streams and rivers...". Birds may leave their breeding territories to occupy a wider range of wetland types in winter. The analyses based on BBS habitat classifications showed that little grebes have a marked preference for standing waters. When standing and slow waters were combined, this preference was non-significant, and counts were similar to those in wet meadows. However, the absence of little grebes in fast-moving water was confirmed.

Allocation to habitat group. Based on the analyses of BBS data and references in the literature to eutrophic waters, little grebes are assigned to the 'standing waters' category. Counts in wet meadows were second highest, although not significantly so, and when slow-moving and standing waters are combined, no preference is apparent. Little grebe is therefore placed in the 'slow/still water' group in the EBG indicator.

Notes on data holdings. There are relatively few data for this species in waterways surveys across the UK, comprising <15 WBBS and <20 WBS sites. However, little grebes were recorded at 96 sites across the UK in the 2006 BBS survey (Raven *et al.*, 2007). This may be in large measure due to under-recording rather than scarcity for the bird is very secretive and tends to hide in dense vegetation at the water's edge.

Great crested grebe

The great crested grebe (*Podiceps cristatus*) has recovered from near extinction in the Victorian era, due largely to hunting for its prized plumage used in the millinery industry, to a point where the bird is again widespread on both larger rivers and still fresh waters in Britain.

Habitat usage. According to Gibbons *et al.* (1993), "*Great Crested Grebes breed on large, shallow waters with some fringing vegetation in which the nest is sited, usually concealed in emergent vegetation, or protected from predators by its inaccessibility (Simmons, 1974). Still waters – lakes, reservoirs and gravel pits – are favoured, but they can use reedy fringes of slow-flowing rivers.*" Brown and Grice (2005) note that, "*The favoured breeding haunts of Great Crested Grebes in England include natural and man-made freshwater lakes, pools, gravel pits and reservoirs, with fallen trees, islands or emergent vegetation capable of supporting a nesting platform and shallow open water in which the birds fish. ...they also breed locally in coastal pools and lagoons and, in recent decades, have increasingly taken to nesting in the slow-moving, lower reaches of rivers...*" However, analyses of BBS data showed that great crested grebes had a preference for standing waters. When slow-moving and standing waters are combined, the preference for these habitats over fast-moving water was almost, but not quite, significant, and counts in wet meadows and reedbeds were comparable.

Allocation to habitat group. The great crested grebe is allocated to both the 'slow-flowing river' and 'standing fresh water' habitat types. (Great crested grebes are associated in the 'slow/still water' group in the EBG indicator.)

Notes on data holdings. Data are sparse in the WBBS data set (less than 20 sites) but great crested grebes were recorded at 79 sites across the UK in the 2006 BBS survey (Raven *et al.*, 2007).

Little egret

The little egret (*Egretta garzetta*) is an increasingly common sight by fresh and brackish waters across lowland Britain, and indeed through Eurasia, Africa and through to Australasia.

Habitat usage. Gibbons *et al.* (1993) do not discuss the little egret as few records were found in 1988-91. However, the species has spread rapidly across lower reaches of rivers and coastal plains across southern Britain and Ireland. Brown and Grice (2005) note that, “*The Little Egret has undergone one of the most dramatic changes in status of any bird in England*” though it remains a scarce breeding bird. Addressing the general behaviour of this species across its European range, Voisin (1991) notes that, “*Little Egrets forage in lagoons, salt pans, estuaries, freshwater marches, rice fields and along streams and rivers. They fish in areas with low vegetation or no vegetation*”. Although the little egret then seems to thrive in a diversity of low-gradient wet and riparian habitats, the analyses of BBS data reveal a significant preference for open marshes, and secondarily wet meadows (together wet grassland) in the UK.

Allocation to habitat group. Despite its use of a diversity of habitats, the little egret is provisionally assigned to the ‘wet meadows’ habitat grouping. (The species does not feature in the EBG water and wetland bird habitat indicators.)

Notes on data holdings. The recent spread of this bird may make a long run of data difficult to assess, but its rise in numbers has been well documented. Formerly, little egret were scarce in the UK but numbers are increasing strongly, recorded at 44 and 43 sites across the UK in the 2005 and 2006 BBS surveys (Raven and Noble, 2006; Raven *et al.*, 2007). Additional data are held by WeBS, RBBP and the Heronries Census.

Grey heron

The grey heron (*Ardea cinerea*) is a common waterside sight throughout Britain except in the most mountainous regions, and also has a wide global distribution.

Habitat usage. Gibbons *et al.* (1993) note that grey heron populations appear to be related strongly to the availability of fish, with populations densest in lowland rivers and coastal waters and sparser in upland areas, the smaller streams of which support lower populations of fish. Brown and Grice (2005) note that the grey heron “... *may be seen hunting in almost any wetland habitat from coast to mountain*”. Vaughan *et al.* (in press) note that grey heron showed an aversion to rocky channels and no clear relationships to the other RHS variables in their models, suggesting that this bird does not favour fast rivers. In both sets of analyses based on BBS habitats, grey heron densities were lowest in reedbeds and near fast-flowing rivers but there were no significant associations with any habitat.

Allocation to habitat group. Grey herons are not allocated to any category as none of the evidence suggests preferences for any particular wetland habitats, other than the note that upland/fast-flowing water populations can be expected to be smaller than lowland populations. The EBG indicator has the grey heron in the ‘slow/still water’ category.

Notes on data holdings. The widespread heron is well represented in breeding bird survey data holdings, and there is also an annual heronry census. Grey heron were recorded at 868 sites across the UK in the 2006 BBS survey (Raven *et al.*, 2007).

Moorhen

The moorhen (*Galinula chloropus*) is widespread and common throughout lowland Britain and also has a wide global distribution.

Habitat usage. Gibbons *et al.* (1993) note that, “*The adaptable Moorhen breeds on any lowland freshwater body, from the smallest farm pond to the fringes of the largest lake, wherever there is sufficient bankside or emergent vegetation.*” Consequently, it is widespread in the lowlands but absent from the higher ground of England, Wales, Scotland and Ireland. Brown and Grice (2005) note that, “*The Moorhen has an almost cosmopolitan breeding range and is a widespread and numerous resident in England, where it is probably the most numerous waterbird of lowland watercourses, being found in virtually any vegetated lowland freshwater habitat*”. Assessing habitat use by the (common) moorhen across its wide global range, Taylor and van Perlo (1998) note that, “*It exploits a wide range of natural and manmade eutrophic freshwater wetlands with fringing (often emergent) vegetation, occurring on both still and moving water; the species of plants available may not be as important as having a robust growth of emergents*”. In further discussion of habitat requirements for the moorhen, Taylor and van Perlo (1998) continue to distinguish the habitat needs of coots and moorhens noting that, “*It occurs alongside the Common Coot at wetland margins but is less prone to venture far out into open water*” being more a bird of the emergent vegetation than the open waters. In addressing the requirements of the coot, Taylor and van Perlo (1998) further emphasise that the coot “*...usually avoids closely overgrown, narrowly confined or very shallow waters... In contrast, the Common Moorhen prefers smaller waterbodies with more cover*”. Vaughan *et al.* (in press) note that moorhen distribution was significantly related to RHS-derived indices describing slow-moving water, and were also significantly correlated with channel vegetation. The analyses of BBS data showed that moorhens were at highest densities in standing water (similar to coots) and, when standing and slow-moving waters were combined, this pattern was retained. Wet meadow was the habitat showing second highest counts but not significantly more than in reedbeds or marshes

Allocation to habitat group. This distribution and breeding habit leads to allocation of the moorhen to the ‘standing waters’ category with secondary preferences for wet meadows, marshes and areas of reedbed. (The moorhen is allocated to the ‘slow/still water’ group in the EBG indicators.)

Notes on data holdings. The widespread moorhen is well represented in bird census data. Moorhen were recorded at 831 sites across the UK in the 2006 BBS survey (Raven *et al.*, 2007).

Coot

The coot (*Fulica atra*) is a common and familiar breeding water bird of the standing and slow-moving waters of Great Britain, also widely distributed across the Palaearctic, the Indian subcontinent, Indonesia and in Australasia.

Habitat usage. Gibbons *et al.* (1993) note that coots are commonest and most widespread in lowland areas, particularly on larger, more fertile standing and moving waters with abundant bottom vegetation for food and some emergent plants for nest anchorage and concealment. Upland waterways are, for this reason, generally unsuitable for coots; WBS data show that most riparian territories are on waters below an altitude of 50 metres. Brown and Grice (2005) note that, “*Favoured breeding areas are large, shallow, eutrophic freshwaters, rich in submerged vegetation providing food, and emergent vegetation providing suitable nest sites*”. Assessing habitat use by the (common) coot across its wide global range, Taylor and van Perlo (1998) note that, “*It inhabits mainly large, still of slow-moving waters, occurring on eutrophic and mesotrophic lakes, pools, ponds, dams, reservoirs, barrages, gravel pits, canals, drainage channels, dykes, rivers and river deltas, creeks, oxbows, open marshes, freshwater meadows, floodlands and lagoons; also lakes and pools in towns, sewage ponds,, and saltpans and claypans. It exploits temporary pools and seasonal marshes and seasonal marshes for breeding , and also in the winter quarters*”. However, Taylor and van Perlo also record that, “*It usually avoids closely overgrown, narrowly confined or very shallow waters... In contrast, the Common Moorhen prefers smaller waterbodies with more cover*”. Vaughan *et al.* (in press) note that coot distribution was significantly correlated with channel vegetation. The first set of analyses of BBS

data showed that coots were at highest densities in standing water (similar to moorhens). When standing and slow-moving waters were combined, counts of coots were still highest compared to other habitats.

Allocation to habitat group. This distribution and breeding habit leads to allocation of the coot to 'standing waters'. (Coot are allocated to the parallel 'slow/still water' group in the EBG indicators). Although, coots do use reedbeds, they generally use reed habitat marginal to larger shallow open waters for the purposes of cover and breeding, whereas moorhens tend to exploit reedbeds throughout life. Indeed, Taylor and van Perlo (1998) make this distinction and also state that the coot "...sometimes occurs on fast rivers where suitable vegetation flourishes.

Notes on data holdings. Coots are widespread and well represented in bird census data. Coot were recorded at 351 sites across the UK in the 2006 BBS survey (Raven *et al.*, 2007).

Lapwing

The lapwing (*Vanellus vanellus*), also known as the peewit or green plover, is a migratory wader that can form dense flocks. Our most numerous breeding wader, the lapwing feeds on invertebrates in damp soil.

Habitat usage. Gibbons *et al.* (1993) record that over 90% of pairs in England and Wales breed on agricultural land (Shrubb and Lack, 1991), and that changing agricultural patterns are having significant effects on lapwing populations. For breeding success, they require mixed farming landscapes offering both bare land, the optimal habitat for breeding, with adjacent grassland for feeding by adults and the precocial chicks. Population trends match the decline of mixed farming in Britain since the 1960s (Gibbons *et al.*, 1993). Brown and Grice (2005) note that, "*Lapwings nest on bare ground or short turf: on ploughed land, amongst crops, on grazed grassland pastures, on close-cropped or burnt heathlands and on saltmarsh*". In common with oystercatcher and curlew, Vaughan *et al.* (in press) found no clear associations between lapwing presence and RHS data, perhaps related at least in part to the relatively sparse recording of catchment habitat adjacent to the river channel in the RHS technique. The analyses of BBS data for lapwing showed only that the species favoured standing water and wet grassland over slow-moving rivers, probably reflecting associations with surrounding farmland as much as the water body itself. The second set of analyses provided some evidence that that lapwings prefer wet meadows over other habitats (slow/standing waters and reedbeds) but overall differences were not significant.

Allocation to habitat group. The lapwing is allocated to the 'wet meadow' habitat grouping (the same as in the EBG indicator) and showed a secondary preference for 'standing waters'.

Notes on data holdings. Though overall numbers are declining, lapwing data are adequate to inform population trends. Lapwing were recorded at 844 sites across the UK in the 2006 BBS survey (Raven *et al.*, 2007).

Snipe

The snipe (*Gallinago gallinago*), also known as the common snipe, is a migratory wader breeding and feeding on wet meadows.

Habitat usage. Gibbons *et al.* (1993) note that snipe become conspicuous in the breeding season as they display in the air over bogs and marshy pastures. Distribution maps reveal greatest densities of snipe in upland areas with only patchy distribution in the lowlands where they breed on fens, wet pastures in river valleys and coastal grazing marsh (Gibbons *et al.*, 1993). Brown and Grice (2005) note that snipe are, "*Birds of damp lowland meadows, grazing marshes and washlands, and of wet*

moorlands, bogs and lightly-grazed tussocky or rushy pastures along the upland fringe, breeding Snipe are distributed throughout England wherever soils are moist enough for a sufficient period to allow them to probe for earthworms and soil-dwelling insects". The analyses of BBS data confirm the preference for wet grassland. When these habitats were split, the preference appeared to be for wet meadows rather than marsh. A secondary preference for fast-flowing waterways was also revealed, probably related to the species' association with upland areas.

Allocation to habitat group. The snipe is allocated to the 'wet meadow' habitat grouping (the same as used for the EBG indicator). Snipe are also associated with upland wet moorland, but this association is not seen as strong enough to warrant the use of data in a 'wet moorland' indicator.

Notes on data holdings. Data holdings permit assessment of national population trends. Snipe were recorded at 166 sites across the UK in the 2006 BBS survey (Raven *et al.*, 2007).

Curlew

The curlew (*Numenius arquata*) is a wader that is a partial migrant, feeding on invertebrates in damp soil.

Habitat usage. The curlew frequently nests at altitudes of up to 600m with damp upland and northern moorlands its traditional haunts during the breeding season, although it has colonised lowland agricultural habitats such as pastures and cereals (Gibbons *et al.*, 1993). Largely absent from the south east of England, it is nonetheless a widespread breeding species elsewhere in Great Britain. Unimproved habitats such as rough pasture are strongly favoured for breeding. The analyses of BBS data showed that curlews occurred at highest numbers in open marshes, and at lowest densities along standing and slow-moving waters. Numbers in wet meadows were intermediate. A secondary habitat associated with fast-flowing waterways was also revealed, probably reflecting the species' association with uplands. Brown and Grice (2005) note that, "*Curlews nest on poorly-drained upland heather and grass moorlands up to 600m above sea-level as well as on upland marginal farmland, meadows and unimproved pastures, lowland heaths, damp river flood plains, bogs and, in some areas, on lowland arable and pasture land*".

Allocation to habitat group. Based on these requirements, the curlew is allocated to the 'wet meadows and marsh' habitat grouping. The curlew also has association with upland wet moorland, but this association is not seen as strong enough to warrant the use of curlew data in a 'wet moorland' indicator. In common with oystercatcher and lapwing, Vaughan *et al.* (in press) found no clear associations between curlew presence and RHS data, perhaps related at least in part to the relative sparse recording of catchment habitat adjacent to the river channel in the RHS technique.

Notes on data holdings. Data density is adequate to make assessments of population trends. Curlew were recorded at 520 sites across the UK in the 2006 BBS survey (Raven *et al.*, 2007).

Redshank

The redshank (*Tringa totanus*) is a partially migrating wader that breeds and feeds on damp meadows.

Habitat usage. Gibbons *et al.* (1993) record that, "*Breeding Redshanks are found on wet grasslands inland and on coastal saltmarshes...*" The analyses of BBS data confirms the species' preference for wet grassland. Brown and Grice (2005) note that the redshank, though familiar, has been in long-term decline and, "*...it is now a scarce and local breeder on coastal and inland grazing marshes and in the uplands*".

Allocation to habitat group. The redshank is allocated to the ‘wet meadow’ habitat grouping (the same as used for the EBG indicator).

Notes on data holdings. There are only relatively low densities of sites at which redshank are recorded. There are less than 20 WBBS sites, less than 220 [Can David check this number please] WBS sites, though adequate BBS sites with redshank recorded at 97 sites across the UK in the 2006 BBS survey (Raven *et al.*, 2007).

Common sandpiper

The common sandpiper (*Actitis hypoleucos*) is a ground-nesting wader found near water.

Habitat usage. Although on migrations and outside of the breeding season the range of this bird encompasses a far broader range of wetland habitats, Gibbons *et al.* (1993) note that, “*Skimming low over the water on stiff wings, the Common Sandpiper is a characteristic sight on hill streams, reservoirs and lochs, but only for its short, three-month breeding period...*” Gibbons *et al.* (1993) go on to note that the habitat requirement of the chick is exacting, with stony shorelines providing them with both food (small flies and beetles) and cover. The margins of both upland rivers and still waters with variable water levels meet these requirements for marginal stony habitat, with birds consequently scarce in the breeding season in lowland Britain. Brown and Grice (2005) note that, “*England’s breeding birds are closely associated with upland streams, rivers, reservoirs and lakes with stony or shingle banks and shores...*”. Fuller (1982) also notes an association with oligotrophic lakes and also upland rivers, omitting any reference to them when discussing lowland rivers. They are strongly associated with gravel banks scoured of vegetation. Vaughan *et al.* (in press) found that common sandpiper had, as could be reasonably expected from known bird ecology, a close association with un-vegetated gravel bars and aversion to tree cover on rivers. Both sets of analyses of BBS data revealed a strong preference for fast-flowing rivers as expected, and no preference for standing waters.

Allocation to habitat group. Due to these habitat requirements, common sandpipers are allocated to the ‘fast-flowing water’ indicator (they also feature in this habitat type in the EBG indicator).

Notes on data holdings. Data density is adequate for population trend assessment. Common sandpiper were recorded at 74 sites across the UK in the 2006 BBS survey (Raven *et al.*, 2007).

Kingfisher

The kingfisher (*Alcedo atthis*) is a well-known bird with a wide distribution beside the fresh waters of Britain, and indeed throughout Eurasia.

Habitat usage. Gibbons *et al.* (1993) note that, “*Many lowland rivers, streams, and waters hold resident birds throughout the year – but some only after a series of mild winters.*” Kingfishers require shallow and slow-moving fresh water holding a good density of the small fish upon which they feed, as well as the proximity of vertical banks of fairly soft material in which they excavate their nesting burrows. Water pollution can compromise food fish availability, as can drought which dries up pools and streams. Brown and Grice (2005) note that, “*Kingfishers breed beside still or slow-moving freshwaters throughout England, wherever they are rich in small fish and have vertical banks that can be excavated to provide nest tunnels*”. With reference to breeding preference for different artificial stillwater types, Fuller (1982) notes that, “*...Kingfishers and Sand Martins strongly prefer gravel pits*”. They are also frequently observed using fast-flowing streams as habitat in the breeding season. Neither set of analyses of BBS data revealed any preference for any of the habitats considered.

Allocation to habitat group. Due to these needs and their opportunistic use of freshwater (and indeed brackish) habitat for feeding purposes, the kingfisher is not allocated to any of the separate wetland

habitat indicators. Kingfishers are allocated to the 'slow/still water' group in the EBG water and wetland bird indicators.

Notes on data holdings. Data holdings are sufficient for population trend analysis. Kingfishers were recorded at 88 sites across the UK in the 2006 BBS survey (Raven *et al.*, 2007).

Sand martin

The sand martin (*Riparia riparia*), is a summer visitor to the British Isles, nesting in a self-excavated burrow generally beside water. Breeding population trends are known to be significantly influenced by conditions in wetlands bordering the Sahel region of Africa.

Habitat usage. Gibbons *et al.* (1993) note that sand martins are largely dependent upon sandy banks by rivers or gravel pits for breeding, and that breeding success is further influenced significantly by weather during the breeding season with up to two broods produced in favourable years. Brown and Grice (2005) note that breeding colonies are, "...mainly found below 400m and in association with water, though feeding areas may be several kilometres distant". With reference to breeding preference for different artificial stillwater types, Fuller (1982) notes that, "...Kingfishers and Sand Martins strongly prefer gravel pits" and also that notes sand martins as a typical species of eutrophic lakes. As might be reasonably anticipated, Vaughan *et al.* (in press) found a significant relationship between the presence of sand martins and eroding cliffs. The first analyses of BBS data revealed no preference for any of the wetland/riparian habitats; the second analyses revealed significantly higher counts in areas of open marsh, but no significant overall differences among habitats. These may be foraging birds and it should be noted that foraging birds recorded during BBS counts may be some distance from the breeding colony.

Allocation to habitat group. On the basis of the evidence above, sand martins are not allocated to any of the habitats. Sand martins are in the equivalent 'slow/still water' group in the EBG *W1: Water and wetland bird* indicators.

Notes on data holdings. Data holdings are adequately dense to make an assessment of bird populations. Sand martins were recorded at 166 sites across the UK in the 2006 BBS survey (Raven *et al.*, 2007).

Yellow wagtail

The yellow wagtail (*Motacilla flava*) is an increasingly scarce, brightly-coloured migrant wintering in West Africa. Yellow wagtail numbers in the UK are diminishing on wet habitats and skewed now more to arable areas, where they are also declining.

Habitat usage. Yellow wagtails breed on lowland damp pastures preferring "...broad valleys in the lower reaches of rivers, usually nesting in water meadows, damp cattle-grazed pastures and marshes, or at the edges of lakes and on sewage farms" (Gibbons *et al.*, 1993). Some also breed in cereal crops (Gibbons *et al.* 1993). Yellow wagtails have a wide but patchy distribution in England, with some presence in south and eastern Wales. Brown and Grice (2005) note that the yellow wagtail is a common summer visitor to British shores breeding in virtually all counties of England, "...beside reservoirs, flooded gravel pits and water treatment works and quite commonly within arable crops and upland hay meadows..." with highest breeding densities encountered in "...cattle-grazed, wet lowland grasslands, both in coastal areas and within inland river floodplains". BBS analyses revealed an association with open marsh habitats but not grazing marshes or reedbeds.

Allocation to habitat group. This habitat requirement places the yellow wagtail in the 'riparian wet grassland and wetland' habitat grouping. (The species is not used in the EBG indicator set.)

Notes on data holdings. As numbers decline, there may become too few sites to justify inclusion of yellow wagtails in the wet grassland indicator. Yellow wagtails were recorded at 178 sites across the UK in the 2006 BBS survey (Raven *et al.*, 2007).

Grey wagtail

The grey wagtail (*Motacilla cinerea*) is a partial migrant always found near water, with its characteristically aerobatic flight a common sight as it hunts insects by upland streams.

Habitat usage. Gibbons *et al.* (1993) note that grey wagtails have “...a preference for feeding by fast-flowing watercourses, bordered by broadleaved trees, where there are rocks, riffles and areas of shingle” which accounts for its success in upland areas though “...where there are suitable watercourses it breeds down to sea-level.” Breeding success can be attributed to the abundance of food, which includes predominantly adult flies but also spiders and caterpillars. Brown and Grice (2005) note that they are, “Principally birds of fast-flowing streams and rivers, especially where bordered by native broadleaved trees, Grey Wagtails are also found along lowland watercourses wherever riffles, weirs, mill races, canal locks, inflows or outflows speed the water”. Vaughan *et al.* (in press) found that grey wagtails showed a preferential association with intermediate levels of tree cover and rocky channel respectively, indicating that their association with fast-moving rivers is not quite so close as for dippers. The analyses of BBS data showed that this species favours fast-flowing rivers but a secondary preference for slow-moving rivers was also significant. Further analyses showed that this pattern persisted when slow-moving and standing waters are combined.

Allocation to habitat group. The breeding habitat preferences of the grey wagtail are primarily ‘fast-flowing water’ (to which it is allied in the EBG indicator); and secondarily ‘slow-flowing water’.

Notes on data holdings. Data densities support assessment of population trends. Grey wagtails were recorded at 257 sites across the UK in the 2006 BBS survey (Raven *et al.*, 2007).

Pied wagtail

The pied wagtail (*Motacilla alba*), also known as the white wagtail, is a common and widespread passerine bird feeding on insects and often found near water.

Habitat usage. The pied wagtail occurs in a wide range of urban and rural habitats, their adaptability of habitat and nest sites readily explaining their wide distribution throughout the British Isles. Reductions in mixed farming are thought to account for some declines in population, affecting populations of dipterans which account for the overwhelming bulk of the diet of the pied wagtail (Gibbons *et al.*, 1993). Brown and Grice (2005) record that this species has “...an exceptionally wide breeding distribution... ..able to exploit an extremely wide range of rural and urban habitats”. Vaughan *et al.* (in press) found that pied wagtail distribution was related to urban areas and simpler vegetation types such as crops or recreational grassland. Analyses of BBS data revealed a preference (only just significant) for standing waters, but all other habitats were also occupied. When standing and slow-moving waters were combined, no particular habitats were preferred.

Allocation to habitat group. On the basis of the above reviews, the pied wagtail is not allocated to any habitat grouping. It is certainly a common sight on wet grassland though, despite an alternative common name of ‘water wagtail’, the bird is an opportunist rather than a specialist as much at home in the built environment, sports fields, dry pasture and a range of other habitats. (The pied wagtail is allied to the ‘wet grass’ EBG indicator.)

Notes on data holdings. Data densities support assessment of population trends for the pied wagtail. Pied wagtails were recorded at 1543 sites across the UK in the 2006 BBS survey (Raven *et al.*, 2007).

Dipper

The dipper (*Cinclus cinclus*) is a truly aquatic bird, widespread in fast-flowing waters in upland Britain.

Habitat usage. Gibbons *et al.* (1993) records that the dipper is “*Traditionally associated with rocks and waterfalls in mountain streams, it breeds also on some lowland rivers in association with weirs and bridges.*” Brown and Grice (2005) record that dippers are “*...a characteristic bird of clear, fast-flowing and well-oxygenated streams and rivers...*” nesting near water “*...under rock ledges or overhanging banks, in crevices, amongst tree roots or beneath man-made structures such as bridges and culverts*”. Dippers feed largely on small fish and aquatic insect larvae. For dippers, Vaughan *et al.* (in press) found an expected positive relationship between the presence of the bird and both rocky channels and riffles. Both sets of analyses of BBS data confirmed a strong association with fast-flowing rivers, and a secondary habitat association with slow moving waterways.

Allocation to habitat group. This affinity for fast waters sets the dipper in the ‘fast-flowing water’ habitat grouping, in agreement with its inclusion in the equivalent category in the EBG indicator.

Notes on data holdings. Data density for dippers is adequate to support indicator development. Dipper were recorded at 68 sites across the UK in the 2006 BBS survey (Raven *et al.*, 2007).

Cetti’s warbler

Cetti’s warbler (*Cettia cetti*) is a resident warbler breeding in waterside vegetation, singing throughout the year. The first records of Cetti’s warbler in Britain and Ireland came in the 1960s, and the population has been spreading since that time.

Habitat usage. Cetti’s warblers are sedentary with male birds occupying territories and singing from autumn onwards. Cetti’s warbler inhabits scrub in damp places, nesting in thick vegetation and feeding on damp, bare ground often in places adjoining reedbeds though the reeds are not much occupied (Gibbons *et al.*, 1993). Gibbons *et al.* further note that, “*Although suitable breeding habitat occurs along stream and canal sides, most of the population is on sites with major reedbeds.*” Brown and Grice (2005) note that, “*Although they do not require the presence of reedbeds or standing water, there is a strong association with fens and reedbeds, a particularly favoured habitat being where willow or bramble scrub is invading the edge of extensive reedbeds*”. The initial analyses of BBS data revealed a preference for reedbeds and wet grassland (the latter slightly but not significantly preferred). The second set of analyses confirmed this pattern with wet meadows, marshes and reedbeds preferred over standing/slow-moving waters and especially over fast-moving water.

Allocation to habitat group. These habitat preferences place the Cetti’s warbler in the ‘reedbed habitat’ indicator group but suggest that wet meadows are also occupied. (Cetti’s warbler is in the ‘slow/still water’ group in the EBG indicators.) The divergence between our recommendation and that of the EBG indicators most likely reflects the lack of a ‘reedbeds’ category in the EBG set. In the majority, this warbler will be using reeds, scrub and rank grassland adjacent to standing fresh waters and slow-flowing rivers.

Notes on data holdings. Cetti’s warbler were recorded at only 28 sites across the UK in the 2006 BBS survey (Raven *et al.*, 2007), which is low for calculating population trends. It is possible to include Cetti’s warbler in the indicator if CES (Constant Effort Sites survey) data are used.

Grasshopper warbler

The grasshopper warbler (*Locustella naevia*) is a small, secretive migratory summer visitor found in reeds and scrub near water as well as in crops.

Habitat usage. Gibbons *et al.* (1993) record that, “*The Grasshopper Warbler requires three basic components within its breeding territory: firstly thick ground cover (normally provided by coarse grasses, bramble, sedges or rushes), secondly several suitable song posts (usually stocks of dead herbage, short bushes or sapling trees), thirdly a rich source of invertebrate foods, preferably within 50m, but sometimes up to 200m from the nest site.*” This can encompass both ‘wet’ and ‘dry’ habitats, leading to a fragmented distribution across the British Isles. Brown and Grice (2005) note that grasshopper warblers “...*breed in a wide diversity of habitats including scrub, thick hedgerows, open woodland, young conifer plantations, heathlands, wetland margins, sand dunes, uncultivated fields and disused industrial sites*”. The analyses of BBS data showed that of the wetland habitats considered, this species favoured open marshes, with reedbeds and wet meadows / grazing marshes of secondary importance.

Allocation to habitat group. Although grasshopper warblers are frequently encountered using reedbed habitat in the breeding season, the literature review above demonstrates how plastic this bird is in its use of coarse ground cover in wet, dry, arable and any other appropriate habitats. It is therefore excluded from any wetland habitat indicator group as the bird is opportunist rather than specialist in its needs.

Notes on data holdings. There are insufficient records in the WBBS database to permit confident trend assessment, though grasshopper warblers were recorded at 79 sites across the UK in the 2006 BBS survey (Raven *et al.*, 2007).

Sedge warbler

The sedge warbler (*Acrocephalus schoenobaenus*) is a migratory summer visitor usually arriving in April and nesting in marsh, sedge and scrub near water.

Habitat usage. Gibbons *et al.* (1993) note that the sedge warbler is, “*Characteristic of lowland marsh and waterside habitats, this close relative of the Reed Warbler breeds also in a variety of dry scrub vegetation, including bramble and hawthorn thickets and occasionally young conifers and crops like oil-seed rape.*” Sedge warblers build nests close to the ground and appear to prefer patches of dense vegetation with a complex structure. The drainage of wetlands coupled with intensification of agricultural methods are suggested by Gibbons *et al.* as contributory to an increasingly patchy distribution. Brown and Grice (2005) note that sedge warblers “...*breed in all manner of lowland wetlands, although dry habitats such as inland and coastal scrub, hedgerows, young plantations and even some arable crops are also occupied*”. The pattern for sedge warbler is exactly the same as for Cetti’s according to the analyses of BBS data, which demonstrate that this species shows roughly equivalent preferences for marshes, reedbeds and wet meadows.

Allocation to habitat group. These habitat preferences place the sedge warbler in the ‘reedbed’ indicator group, but also in an ‘open marsh’/‘grazing meadow’ category. (Sedge warbler is allied to the ‘slow/still water’ group in the EBG indicators.) This divergence between our analytical recommendation and that of the EBG indicators most likely reflects the lack of a ‘reedbeds’ category in the EBG set. The majority of individuals will be using reeds, scrub and rank grassland adjacent to standing fresh waters and slow-flowing rivers.

Notes on data holdings. Sedge warblers were recorded at 344 sites across the UK in the 2006 BBS survey (Raven *et al.*, 2007).

Reed warbler

The reed warbler (*Acrocephalus scirpaceus*) is a migratory summer visitor commonly nesting in reedbeds close to or over water, where its song is a conspicuous feature during the summer. The reed warbler, along with the dunnock (*Prunella modularis*) and meadow pipit (*Anthus pratensis*), is one of the three most important host species for the cuckoo in Britain (Brooke and Davies, 1987).

Habitat usage. Gibbons *et al.* (1993) note that, “*Reed warblers are closely associated with Phragmites and can be found not only in extensive reedbeds, but also where reeds form a fringing vegetation to riverbanks and gravel pits.*” However, this association is not exclusive, as willowherb, some arable crops and other vegetation may be used as breeding habitat from time to time. Reed warblers occur mainly in lowland Britain (Gibbons *et al.*, 1993). Brown and Grice (2005) note that reed warblers breed “...*especially in those wetlands which support large stands of common reed and low-lying farmland with an abundance of reed-fringed wet ditches, the remnants of once more extensive wetlands*”. The analyses of BBS confirmed this species’ preference for reedbeds, although grazing marshes were a secondary habitat.

Allocation to habitat group. These habitat preferences place the reed warbler in the ‘reedbed’ indicator group. (Reed warbler is allied to the ‘slow/still water’ group in the EBG indicators.) This divergence between our recommendation and that of the EBG indicators most likely reflects the lack of a ‘reedbeds’ category in the EBG set. By majority, this warbler will be using reeds, scrub and rank grassland adjacent to standing fresh waters and slow-flowing rivers.

Notes on data holdings. Reed warblers were recorded at 170 sites across the UK in the 2006 BBS survey (Raven *et al.*, 2007).

Reed bunting

The reed bunting (*Emberiza schoeniclus*) is widespread around both moving and still fresh waters of Britain, and indeed has a wide global distribution

Habitat usage. Gibbons *et al.* (1993) note that, “*Although typically associated with marshland, gravel pits and riversides, male Reed Buntings can be found voicing their repetitive song alongside Yellowhammers in young forestry plantations, and in company with Corn Buntings in rape fields. The proportionate use made of such less preferred habitats clearly varies with population size, however, and increases when numbers are high.*” Riparian habitats are therefore favoured, but not exclusively.

Allocation to habitat group. On the basis of the above habitat usage, the reed bunting is allocated to two habitat groupings: ‘reedbed’; and ‘wet meadows and marshes’. Brown and Grice (2005) note that, “*The traditional breeding stronghold of Reed Buntings in England is the marginal vegetation of freshwater wetlands. Even quite small ponds, ditches and areas of boggy ground can support one or two breeding pairs. Large numbers also now nest in cultivated fields, especially in oilseed rape, cereal crops and set-aside*”. The analyses of BBS data revealed markedly higher counts of this species in reedbeds, and secondarily in wet meadows, in particular water meadows and grazing marshes. We have provisionally allocated this species to the reedbed indicator.

Notes on data holdings. Data holdings do not appear to limit the assessment of population trends. Reed buntings were recorded at 649 sites across the UK in the 2006 BBS survey (Raven *et al.*, 2007).

2.3 Other species assessed as potential indicators of wet woodland

In order to assess the potential for a sub-indicator of wet woodland habitats, we also reviewed selected bird species thought to be associated with this habitat. For most species, there were insufficient BBS data to formally test habitat associations.

Woodcock

The woodcock (*Scolopax rusticola*) is widespread throughout the UK, where it breeds largely in damp woodlands. It is sometimes found on heathlands.

Habitat usage. Breeding woodcocks are found predominantly in moist woods, with lower densities in waterlogged or dry woodland (Gibbons *et al.*, 1993). They use both deciduous and coniferous woodland, but the structure is important with dense cover avoided (Gibbons *et al.* 1993).

Allocation to habitat group. The literature review suggests that there is insufficient evidence to associate woodcock with 'wet woodland' habitat type. Moreover, there may be insufficient data to include it any indicator.

Notes on data holdings. Although woodcock were originally monitored by the Common Birds Census, their dwindling numbers made it impossible to generate an index in the latter years of that survey. The species is not well monitored using BBS because of their nocturnal habits, but there has been at least one national survey and the Game & Wildlife Conservation Trust maintains records of woodcock in game bags.

Nightingale

The nightingale (*Luscinia megarhynchos*) is a summer migrant of the thrush family, famed for the nocturnal spring song of the male during the breeding season.

Habitat usage. Gibbons *et al.* (1993) note that the nightingale has a restricted distribution in the south east of England, showing a preference for the increasingly scarce habitat of coppice woodland. Brown and Grice (2005) note that the nightingale is a summer visitor restricted as a breeding bird to southern and eastern counties where they "...inhabit a variety of scrubby and wooded habitats which possess a dense understorey and areas of bare or sparsely vegetated ground".

Allocation to habitat group. There appears to be little evidence, in Britain, for an association with wet woodlands and hence nightingales are provisionally excluded from this indicator.

Notes on data holdings. Data holdings are sparse but permit calculation of annual population trends. Nightingales were recorded at 35 sites across the UK in the 2006 BBS survey (Raven *et al.*, 2007).

Marsh tit

The marsh tit (*Poecile palustris*) is a small resident tit with an omnivorous diet, found in a range of woodland and scrub habitats, sometimes close to water or wetland habitats.

Habitat usage. Gibbons *et al.* (1993) note that, "Despite their name, Marsh Tits in Britain are typically found in open deciduous woodland, parkland, mature gardens or partly wooded farmland." Brown and Grice (2005) note their widespread yet patchy distribution across England, also recording that, "Despite its name, the Marsh Tit tends to prefer drier habitats than the closely related Willow Tit...".

Allocation to habitat group. The literature reviews does not support the inclusion of the marsh tit in the ‘wet woodland’.

Notes on data holdings. Data are wholly adequate for trend assessment, marsh tits being recorded at 182 sites across the UK in the 2006 BBS survey (Raven *et al.*, 2007).

Willow tit

The willow tit (*Poecile montana*) is a scarce woodland tit with a patchy English distribution.

Habitat usage. Gibbons *et al.* (1993) note that, “*Their typical habitats are generally damper than those used by Marsh Tits. Alder carr, streamside wood and scrub, the wooded surroundings of gravel pits and reservoirs, as well as lowland coniferous woodland, are all used.* Gibbons *et al.* also add that “*...high densities of Willow Tit may be encountered in waterlogged woods and carrs*”. Brown and Grice (2005) note that this is the only English tit to excavate a new nest hole each breeding season, positioned less than a metre above the ground in a rotten stump, typically a birch which “*...may account for the birds’ association with damp conditions as suitable dead wood is more likely to be available here*”.

Allocation to habitat group. Willow tit are provisionally allocated to the ‘wet woodland’ habitat type.

Notes on data holdings. Data are sparse, with willow tits recorded at only 51 and 60 sites respectively across the UK in the 2005 and 2006 BBS surveys. Moreover, the population appears to be in steep decline which, if this trend continues, may compromise its suitability for inclusion in an indicator (Raven and Noble, 2006; Raven *et al.*, 2007).

2.4 Species assessed as potential indicators of wet moorland

Another sub-habitat that would, ideally, be included in the suite of indicators considered is ‘wet moorland’. However, most upland species found in this habitat are either too scarce to be monitored (e.g. greenshank, whimbrel, dunlin) or are found in a broad range of upland habitats with no particular association with wet moorland (e.g. hen harrier, peregrine falcon, golden plover). Moreover, some of these species are found only in Scotland and hence not suitable for an indicator for the wider UK. Potential species for this sub-indicator are considered below.

- The common scoter (*Melanitta nigra*) is a black or brownish duck, most commonly observed as a line of dumpy ducks flying low over winter seas. However, the British breeding population is restricted to just a few sites which compromises its usefulness for the purpose of this indicator. With a national population size of c¹⁰⁰ pairs (almost all in Scotland), common scoter were recorded at only 5 sites across the UK in the 2005 BBS survey (Raven and Noble, 2006) and are not listed in the report of the 2006 BBS survey (Raven *et al.*, 2007). Common scoters were surveyed nationally in 1995 and in 2007 as part of the SCARABBS programme.
- Hen harrier (*Circus cyaneus*), the only breeding site for which in England is on blanket bog in the upland Forest of Bowland, were recorded at 19 sites across the UK in the 2006 BBS survey (Raven *et al.*, 2007). Hen harriers are monitored every 10-12 years under the SCARABBS programme. Fuller (1982) notes that hen harriers are largely confined to uplands during the breeding season.
- Peregrine (*Falco peregrinus*) were recorded at 51 sites across the UK in the 2006 BBS survey (Raven *et al.*, 2007) and are surveyed every 10-12 years under SCARABBS. Fuller (1982) notes

of the peregrine that it “...is perhaps the raptor most restricted by nest site, but even so it uses small crags in some of the less precipitous uplands”. It too has a strong association with uplands, but not particularly with wet moorland.

- Golden plover (*Pluvialis apricaria*) were recorded at 111 sites across the UK in the 2006 BBS survey (Raven *et al.*, 2007), but these include many outside the breeding range. Fuller (1982) notes of the presence of breeding golden plover and red grouse that they “... reflect more closely than any other bird species the distribution of bog, moors and rough grazing in the north and west”, although also recognising that this guide is not infallible as golden plovers are absent from Exmoor and several parts of Wales and the Lake District. Fuller (1982) notes that, “Dunlins and Golden Plovers in particular show an attachment to blanket bogs throughout their ranges”.
- Dunlin (*Calidris alpina*) were recorded at 23 sites across the UK in the 2006 BBS survey (Raven *et al.*, 2007). Whilst dunlin may be a familiar sight feeding in estuaries and saltmarshes during the winter, Fuller (1982) notes that, “Dunlins and Golden Plovers in particular show an attachment to blanket bogs throughout their ranges”. A few more occupied sites were found on the Upland Breeding Bird Survey.
- Whimbrel (*Numenius phaeopus*) were recorded at 31 sites across the UK in the 2006 BBS survey (Raven *et al.*, 2007) but the number of records has fluctuated considerably from year to year and may include passage birds. Fuller (1982) noticed that migrant whimbrel feed on machair and neutral grassland, but the species is largely confined to Scottish uplands during the breeding season, favouring serpentine moors on Shetland.
- Greenshank (*Tringa nebularia*), found only in Scotland, were recorded at just 9 sites across the UK in the 2006 BBS survey (Raven *et al.*, 2007) and have never been fully censused in the UK. Fuller (1982) records greenshank as a species breeding on damp peat surrounding dystrophic upland lakes and also the exposed peaty hinterland of dunes, and particularly in upland blanket bog where they are largely confined in the breeding season.
- Ring ouzel (*Turdus torquatus*) were recorded at 28 sites across the UK in the 2006 BBS survey (Raven *et al.*, 2007) and are surveyed every 10-12 years as part of SCARABBS (the last full survey was in 1999). Fuller notes that, “Ring Ousels nest in a variety of situations from steep cliffs to fairly open moorland, but some broken ground, crags, screes or boulders are often a feature of their territories”. There is an association with uplands, but not with wet moorland.

2.5 Excluded Species

The following bird species, although likely to qualify for allocation to one of the target wetland habitats on the basis of their habitat preferences, are provisionally excluded from the indicators because they are either too scarce (or inconspicuous) to be monitored annually by any survey or else their populations in the UK are so small that trends represent changes at a very small number of sites rather than the wider countryside. In the following section, they are grouped according to preferred habitats. For some species, the population is largely or wholly confined to Scotland, and hence unsuitable for an indicator of wetlands and waterways in England and Wales, or at UK scale.

Reedbeds:

- Although the bittern (*Botaurus stellaris*) is strongly associated with reedbed edge habitat, it is an extremely scarce bird. Bitterns were recorded at only 3 sites across the UK in the 2006 BBS survey (Raven *et al.*, 2007) but numbers of booming males are reported annually by RSPB.
- The marsh harrier (*Circus aeruginosus*) is a raptor associated with reedbeds, but it may also breed in arable crops. At the time of publication of the 1993 Breeding Bird Atlas of Britain and Ireland,

marsh harriers were restricted to East Anglia where around half of them nested in large reedbeds, around 40% in small reedbeds and around 10% in arable crops (Gibbons *et al.*, 1993). This suggests that marsh harrier would be a good indicator for reedbed habitats, however there may not be enough data to justify its inclusion. Currently, a trend based on about 15 BBS sites (all in England) falls below the minimum threshold for reporting, and the species was detected on only 5 WBBS sites in 2006.

- The water rail (*Rallus aquaticus*) is a small, retiring waterside bird most commonly encountered in Britain when over-wintering in bank-side vegetation. Water rails feature in none of the common bird surveys of the UK. Gibbons *et al.* (1993) note that the species is among the ‘top ten’ of elusive birds, more often heard than seen during the breeding season, and that “...*Water Rail breeding territories usually embrace a mosaic of static or slow moving freshwater, usually with open mud, and always expanses of tall emergent vegetation*”. Brown and Grice (2005) note that, “*The favoured breeding habitat of Water Rails in England usually consists of wetlands with a mosaic of still or slow moving freshwater, with muddy margins and such tall emergent vegetation as sedges, rushes, reed mace and reeds*”. Water rails were recorded at 10 and 7 sites respectively across the UK in the 2005 and 2006 BBS survey (Raven and Noble, 2006; Raven *et al.*, 2007).
- The bearded tit (*Panurus biarmicus*), also known as a reedling, “...*lives almost exclusively in or near reeds...*” (Gibbons *et al.*, 1993) with nests “...*usually placed in the drier parts of the reedbeds and supported in piles of old reed stems and other herbage over shallow water or damp mud...*” (Brown and Grice, 2005). It would therefore, in theory, be a useful addition to a reedbed indicator. However, since bearded tit were recorded at only 3 sites across the UK in both the 2005 and 2006 BBS surveys (Raven and Noble, 2006; Raven *et al.*, 2007), population numbers are too low to support confident assessment of trends.

Shallow lakes and marshes:

- The wigeon (*Anas penelope*), also known as the European widgeon, is a largely migratory dabbling duck wintering commonly in the British Isles but scarce as a breeding bird (numbering between 300 and 500 pairs in the UK). Inhabiting lakes, marshes and open moorland, wigeon were recorded at only 6 and 8 sites across the UK in the 2005 and 2006 BBS surveys (Raven and Noble, 2006; Raven *et al.*, 2007).
- The gadwall (*Anas strepera*) is a brown or grey duck recognisable all year by white specula, bordered anteriorly with chestnut feathers. Gibbons *et al.* (1993) record that gadwall have become more securely established as a breeding species over recent years, although at densities too low during the breeding season for confident assessment of population trends. Found on lakes and marshes, gadwall were recorded at 41 and 44 sites respectively across the UK in the 2005 and 2006 BBS survey (Raven and Noble, 2006; Raven *et al.*, 2007), and at between 10 and 15 WBBS sites. This species used to be recorded by the Rare Breeding Bird Panel, but its increasing population (c⁷⁹⁰ pairs) suggests that it might soon be possible to monitor gadwall annually on BBS. A provisional UK trend with a mean sample of 28 BBS sites is available, and the species was detected on 23 WBBS sites in 2006. These may not all represent breeding birds.
- The shoveler (*Anas clypeata*) is a duck distinguished by its long, wide bill found in shallow lakes, marshes, reedbeds and wet meadows. Though common in winter, breeding birds are relatively scarce (c¹³⁰⁰ pairs) and can go unnoticed as they nest in the close cover of marshland or rough pasture adjacent to standing eutrophic water in lowland areas (Gibbons *et al.*, 1993). Shovelers were recorded at only 19 sites across the UK in both the 2005 and 2006 BBS surveys (Raven and Noble, 2006; Raven *et al.*, 2007) and on 9 WBBS sites in 2006.

Lakes and rivers:

- The pochard (*Aythya ferina*) is a robustly-built, migratory diving duck found mainly on lakes and slow-moving rivers. It became established as a breeding species in Britain early in the eighteenth century, but has not expanded rapidly in range (Gibbons *et al.*, 1993) though it is numerous and

widespread in winter (Brown and Grice, 2005). With a national breeding population of c450 pairs, pochard were recorded at 25 and 19 sites respectively across the UK in the 2005 and 2006 BBS surveys (Raven and Noble, 2006; Raven *et al.*, 2007) and on 4 WBBS sites in 2006.

- The goldeneye (*Bucephala clangula*), also known as the common goldeneye, is a migratory diving duck found on lakes and rivers. Gibbons *et al.* (1993) note that the goldeneye is a typical breeding bird of boreal forests, and though a common winter visitor to the UK does not commonly breed here (Brown and Grice, 2005). It is often classed as a sea duck. With a national population size of c200 pairs, goldeneye were recorded at only 5 and 7 sites across the UK in the 2005 and 2006 BBS surveys (Raven and Noble, 2006; Raven *et al.*, 2007).
- The red-breasted merganser (*Mergus serrator*) is a saw-billed duck that feeds primarily upon small fish and aquatic invertebrates in a variety of freshwater and marine habitats. Gibbons *et al.* (1993) note that the species is widely dispersed during the breeding season, and has a predominantly northern and western maritime distribution. Brown and Grice (2005) record it as a scarce breeding bird in England but a locally numerous winter visitor. Red-breasted mergansers were recorded at only 11 and 16 sites respectively across the UK (mainly in England) in the 2005 and 2006 BBS surveys (Raven and Noble, 2006; Raven *et al.*, 2007) and on 5 WBBS sites in 2006.
- The little ringed plover (*Charadrius dubius*) is a small wader nesting on sand or gravel banks beside water (usually lakes or reservoirs), spreading rapidly since the first breeding pair was recorded at Tring in 1938 to a population of c1000 pairs (Gibbons *et al.*, 1993; Brown and Grice, 2005). Little ringed plover were recorded at only 15 and 11 sites respectively across the UK in the 2005 and 2006 BBS survey (Raven and Noble, 2006; Raven *et al.*, 2007).

2.5.1 Introduced species:

The (breeding) introduced waterfowl have generally not been included in other BTO wild bird indicators, mainly because an increase in numbers would not be regarded as positive. In the case of Canada geese, their rapid increase would skew the overall assessment. Moreover, trends for some species may be influenced by releases and control measures. Nevertheless, these species are now a significant component of the avifauna of Britain's waterways and may have effects (often negative) on other species. An indicator comprised of the trends of the more common introduced wetland and waterways species would help to make this point. Information on trends and the population status of key species follow.

- The greylag goose (*Anser anser*) is a large grey goose comprising two distinct British populations, the Scottish (Hebridean) population which is native and wild and a re-introduced southern population that has expanded rapidly since the indigenous population was eliminated by wetland drainage by the mid-1800s (Gibbons *et al.*, 1993). Greylag geese were recorded at 249 sites across the UK in the 2006 BBS survey (Raven *et al.*, 2007) and trends are reported annually.
- The Canada goose (*Branta canadensis*) is the most abundant and familiar alien waterfowl in Britain, now often perceived as a nuisance or a pest. Breeding sites are by water but with a catholic taste of standing or flowing, rural or urban locations (Gibbons *et al.*, 1993). Vaughan *et al.* (in press) note that Canada geese showed an aversion to rocky channels and no clear relationship to the other RHS variables, indicating that they do not favour fast-flowing rivers. Canada geese were recorded at 635 sites across the UK in the 2006 BBS survey (Raven *et al.*, 2007) and trends are reported annually.
- The Egyptian goose (*Alopochen aegyptiaca*) is an exotic bird whose distribution is tied to the history of releases from captivity. Egyptian geese were recorded at only 19 sites across the UK in the 2006 BBS survey (Raven *et al.*, 2007), and hence are too scarce for calculation of a confident population trend.

- The mandarin (*Aix galericulata*) is a spectacular duck in breeding plumage, native of the Far East and first imported before 1745 (Gibbons *et al.*, 1993). Mandarins frequent standing or flowing fresh waters with a dense growth of marginal trees and shrubs. Mandarins were recorded at only 39 sites across the UK in the 2006 BBS survey (Raven *et al.*, 2007), so are too scarce for calculation of a confident population trend.
- The ruddy duck (*Oxyura jamaicensis*), native to North America, became established in Britain in the 1960s following the escape and deliberate releases of the duck since 1953 (Brown and Grice, 2005). The duck has since bred and spread extensively, threatening the native European species of *Oxyura*, but is now retreating as control measures take effect. Ruddy duck were recorded at only 13 sites across the UK in the 2006 BBS survey (Raven *et al.*, 2007), which also makes them too scarce for confident calculation of population trend.

2.5.2 Birds also using other habitats

The following birds, though often associated with freshwater habitats, also occupy other habitat types. Trends would therefore need to be restricted to data from the freshwater environment in order to represent changes in those habitats.

- Shelduck (*Tadorna tadorna*) is a colourful estuarine duck familiar on muddy and sandy shores around Great Britain, breeding wherever there is an adequate supply of aquatic invertebrate food in proximity to their nest sites in rabbit burrows, tree cavities or similar holes. Shelduck were recorded at 191 sites across the UK in the 2006 BBS survey (Raven *et al.*, 2007) but almost entirely on coastal sites.
- The cormorant (*Phalacrocorax carbo*) is a large and conspicuous sea bird with a primarily coastal breeding distribution, though it has invaded inland waters over recent years. Brown and Grice (2005) note that, “*Cormorants are moderately widespread seabirds in England, traditionally associated with the coast, but with an increasing proportion of both the breeding and non-breeding populations now occurring at inland wetlands, especially in southern England*”. Vaughan *et al.* (2007) note that cormorants showed an aversion to rocky channels and no clear relationships to the other RHS variables in their models, suggesting that they do not favour fast rivers. Cormorants were recorded at 332 sites across the UK in the 2006 BBS survey, and it would be possible to generate habitat-specific trends (Raven *et al.*, 2007). There are already sufficient WBBS data to generate trends for linear waterways and we suggest it could be included in the still/slow-moving river indicator. However, it is likely that fresh-water trends of cormorants in Britain would be influenced by changes to marine populations, and also by control measures.
- The oystercatcher (*Haematopus ostralegus*) is a strongly territorial wader familiar along much of the coastline and lower reaches of rivers especially in northern Britain. Although it may breed inland and is adaptable in its requirements, it is considered primarily a coastal bird and not one of fresh waters (Gibbons *et al.*, 1993; Brown and Grice, 2005). In common with curlew and lapwing, Vaughan *et al.* (2007) found no clear associations between oystercatcher presence and RHS data, perhaps related at least in part to the relative sparse recording of catchment habitat adjacent to the river channel in the RHS technique. Oystercatcher were recorded at 379 sites across the UK in the 2006 BBS survey (Raven *et al.*, 2007). This species is found on enough WBBS sites to calculate an index for the population associated with linear waterways.
- With a growing national population of c900 pairs, avocets (*Recurvirostra avosetta*) were recorded at 8 sites across the UK in the 2006 BBS survey (Raven *et al.*, 2007). Strongly associated with coastal habitats particularly “...*coastal lagoons on the east coast in summer and the Exe estuary in winter*”, this species is not considered suitable for a freshwater wetland indicator.
- Cuckoos (*Cuculus canorus*) are obligate brood parasites, in the UK exploiting mainly reed warbler, meadow pipit, sedge warbler, pied wagtail and dunnoek. Some of these hosts are

wetland species, and the cuckoos parasitizing them could also be categorised as having an association with the same habitat. Indeed, Fuller (1982) records cuckoos as being characteristic of intertidal marshes, large woods, lowland heath and also that they are one of four non-passerine species (along with mallards, curlew and snipe) which “...can be regarded as typical of open raised mires throughout England”. Cuckoos were recorded at 801 sites across the UK in the 2006 BBS survey (Raven *et al.*, 2007). This is a large sample but it would be difficult to generate trends for populations solely in wet habitats.

- The tree sparrow (*Passer montanus*) is a partial migrant that nests in trees, shrubs and gardens. It is included in this assessment because it is known to benefit from the provision of wet areas by its breeding areas. Gibbons *et al.* (1993) note that the tree sparrow, “...tends to be associated with trees, but only where these occur in hedgerows or open woodland, not in large or dense forests” with Brown and Grice (2005) further noting that tree sparrow “...mainly inhabit lowland farmland in England...” Gibbons *et al.* further state that the tree sparrow is mainly a bird of the lowlands, common on farmland and the edges of built up areas. Numbers are known to fluctuate significantly between years, and the British population has declined more steeply over the last 30 years than any other English bird (Brown and Grice, 2005), though the reasons for this are not well understood. Population data are adequate for trend assessment. Tree sparrow were recorded at 210 sites across the UK in the 2006 BBS survey (Raven *et al.*, 2007). However, given the lack of evidence for any wetland association, tree sparrows will not be used to support a ‘wet woodland’ or any other freshwater habitat type indicator.

3. Discussion and conclusions

The four strands of evidence reviewed in this report inform the use of population data for different bird species to support indicators for selected freshwater habitat types. The strength of association of bird species varied across habitat types, with some significant lack of discrimination in some habitats and a paucity of data to support representative indicator development for others.

The association of a subset of birds with fast-flowing rivers, and data quantity for those species at least at national level, was entirely adequate to support development of a 'fast-flowing river' indicator. These bird species are noted in Table 4, together with a note of species included in the England Biodiversity Strategy's 'Water and Wetland Bird' indicator for 'fast water'. There is reasonable agreement between the two sets of bird species although this analysis also brings in goosander (for which sufficient data are available from 1998).

The association of species in this analysis for 'slow-flowing rivers' overlapped significantly with that for 'standing fresh waters', the latter apparently marginally preferred. These bird species are again noted in Table 4, together with a list of species included in the England Biodiversity Strategy's 'Water and Wetland Bird' indicator for 'slow/still water'. Of the species for which an association was recorded, a number were common to both water types (little grebe, great crested grebe, mallard, tufted duck, moorhen, coot). A few species (e.g. grey wagtail) were secondarily associated with slow-moving rivers, and primarily with fast-moving rivers due to a dependence upon riverine insects. The England Biodiversity Strategy's 'Water and Wetland Bird' indicators do not segregate between slow and still water habitats, instead opting for a single 'slow/still water'. This rationalisation of habitat types was based on the opinion of the steering group devising the indicator that habitat associated with these water types was similar as far as its exploitation by birds was concerned. The analyses in this paper endorse that opinion.

Our explanation for this lack of segregation between slow-flowing from standing water is that wetland birds are mainly associated with the surrounding vegetation (e.g. fringing reedbed, wet grassland, wet woodland) rather than the water body, and that this vegetation does not differ greatly on the basis of whether it is slow-moving or standing water. A probable exception would be differences in fish-eating birds preying on fish populations in small land-locked waters as opposed to those in linear waterways usually connected to larger water bodies.

A further issue confounding derivation of meaningful 'standing fresh water' indicator is that 'standing fresh waters' are a far from homogenous group of habitats. This heterogeneity confounds any simple classification. For example, the diverse group of habitats falling under the heading of 'standing fresh water' may be:

- man-made or natural;
- subject to drawn-down or not;
- very large or else tiny and largely overlooked and under-surveyed;
- isolated or interconnected with other wetlands, including rivers;
- permanent or temporary water bodies;
- concrete-lined or naturally (or artificially) earth-banked;
- urban or rural;
- with or without fringing habitat such as reed/woodland/grassland;
- deep water bodies with different mixing regimes or shallow pools; and
- likely to respond in radically different ways to the same environmental pressures.

Whilst an indicator based upon breeding bird exploitation of fast-flowing water, reedbeds or wet grassland has some objective meaning, it is arguably more difficult to conceive what a breeding bird indicator for such as heterogenous groups of 'standing fresh waters' might mean or achieve.

Furthermore, the use of small still waters by birds is a largely under-researched topic. Owing to their small individual size, smaller standing water bodies are generally inadequately surveyed by most monitoring techniques (Fuller *et al.*, 2000). Yet bird species such as mallards and moorhens are known to thrive on small water bodies such as ditches or farmland ponds (Fuller, 1982; Gibbons *et al.*, 1993; Brown and Grice, 2005). These small, dispersed still water habitats, which are known to be of great conservation importance for a range of taxa be they permanent or temporary (Collinson *et al.*, 1995; Pond Action, 1993), may also be cumulatively important at landscape scale despite the knowledge gap.

In the Wetland Bird Survey (WeBS), we already have a well-tested scheme for monitoring non-breeding over-wintering birds (Banks *et al.*, 2006). The British Isles are arguably of the greatest ornithological significance for providing winter habitat for migratory birds when assessed in a global context. Extensive and ongoing work at the BTO on digitisation of habitats is bringing WeBS close to correcting for habitat area coverage, addressing some its acknowledged shortfalls and particularly better discrimination of bird populations in smaller standing water bodies (Mark Rehfish, BTO, *personal communication*). Whilst WeBS has historically been excellent for covering larger estuaries and lakes, its coverage of smaller wetlands including ponds has been acknowledged as poor. The digitisation exercise should help correct habitat bias by normalisation to area, improving WeBS reporting on, for example, under-recorded birds such as moorhens and water rails. Therefore, WeBS may soon improve its discrimination of data for these species of smaller water bodies. Nevertheless, shortfalls are acknowledged in addressing small fresh water bodies and in providing estimates of water birds dispersed across the wider countryside (Jackson *et al.*, 2006), with systematic biases in which data confound population estimates for individual species due to surveyor-selection of sites, incomplete coverage of less accessible sites and the distribution patterns of individual species (Pollitt *et al.*, 2003; Kershaw and Cranswick, 2003). Surveyor disturbance may also be a greater factor where water bodies are small and particularly where they lack fringing habitat.

The British Trust Ornithology (BTO) co-ordinated a Dispersed Waterbirds Survey (DWS) to seek to overcome some of these biases, with observers recording habitat type and water bird numbers within a stratified random sample of 1-kilometre grid squares across Great Britain during the winter of 2002/03. Revised population estimates, extrapolated nationally by boot-strapping these survey data, increased WeBS-based population estimates for little grebe, teal, mallard, golden plover, lapwing, snipe, back-headed gull and herring gull, providing a useful source of supplementary information for species known to have a dispersed distribution (Jackson *et al.*, 2006). The DWS method is available to augment WeBS accounts if required.

This is, of course, outside the breeding season, which is the focus of data used for the other suite of freshwater habitats being considered for indicator development using bird population trends. However, this cuts to the purpose of the indicator. One could insist upon consistency of method between habitat types, or alternatively to seek indication of the aspect of wetland functioning of primary importance for each habitat. This question of the purpose of indicator being developed, and of the selection of appropriate birds data to inform the indicator, lies outside the scope of this report which seeks simply to provide a evidence-base for selection of bird species during indicator development.

There is a divergence of species associated with 'slow-moving rivers' and the EBG 'slow/still water' category. A significant explanatory factor for this is that the EBG classification does not include a 'reedbed' habitat type, and the three warbler species included in the EBG 'slow/still water' category (Cetti's, sedge and reed warblers) associated most strongly with our 'reedbed' category. It is assumed that the relationship between these birds and slow/still waters in the EBG schema pertains largely to their use of riparian scrub and reeds. The association with reedbeds of four species for which there is

adequate data (Cetti's warbler, sedge warbler, reed warbler and reed bunting) provides a good basis for development of a discrete 'reed' habitat indicator, although it does exclude the scarcer reedbed specialists.

The ‘wet meadow and marsh’ habitat type potentially has many species associated in our analyses (little egret, mute swan, teal, curlew, lapwing, snipe, redshank, yellow wagtail, Cetti’s warbler, sedge warbler and reed bunting). These are noted in Table 4, together with species included within the equivalent EBS ‘wet meadows’ group. Three of these species (lapwing, snipe and redshank) overlap with the equivalent EBG indicator.

The proposed ‘wet woodland’ indicator is more problematic, with our review suggesting only a single species (willow tit) fitting the criteria, although woodcock and nightingales readily utilise moist wooded areas. There is no parallel EBG indicator group. The paucity of data for these species, and of this habitat as defined by BBS and WBBS habitat categories, means that the calculation of a representative ‘wet woodland’ indicator’ is not feasible.

The proposed ‘wet moorland’ indicator is equally problematic as, although there are potential associations for a number of species (including teal, greenshank, whimbrel, dunlin, golden plover and ring ouzel), there are only adequate data from core BBS for one of those species (golden plover). Moreover, there is no parallel EBG indicator group for this habitat. (See Table 3.) It is unlikely that these data will enable confident calculation of a ‘wet moorland’ indicator’ until the new upland bird surveys in England become more established.

Table 4. Provisional allocation of species to target freshwater habitat types as a result of this review, this list comprising the more common species for which sufficient data on populations are collected regularly. The allocation of species to the England Biodiversity Strategy indicator for breeding birds of wetlands and waterways (as last reported) is also included and denoted ‘EBG’. Note that ‘EBG’ in the slow-moving water column means that the species was allocated to the slow-moving / standing waters category.

Provisional list of species considered for inclusion in bird indicator for freshwater habitats (X indicates main habitat associations)	Fast-flowing river	Slow-flowing river	Standing water (lakes, reservoirs and ponds)	Reedbed habitat	Wet meadows and marshes	Wet woodland	Wet moorland
Mute swan		EBG			X		
Teal					X		
Mallard		EBG	X				
Tufted duck		EBG	X				
Goosander	X						
Little grebe		EBG	X				
Great crested grebe		EBG	X				
Little egret					X		
Grey heron		EBG					
Moorhen		EBG	X				
Coot		EBG	X				
Oystercatcher							
Lapwing					X EBG		
Snipe					X EBG		
Curlew					X		
Redshank					X EBG		
Common sandpiper	X EBG						
Kingfisher		EBG					

Table 4 (continued)

Provisional list of species considered for inclusion in bird indicator for freshwater habitats (X indicates main habitat associations)	Fast-flowing river	Slow-flowing river	Standing water (lakes, reservoirs and ponds)	Reedbed habitat	Wet meadows and marshes	Wet woodland	Wet moorland
Sand martin		EBG					
Yellow wagtail					X		
Grey wagtail	X EBG						
Pied wagtail					EBG		
Dipper	X EBG						
Cetti's warbler		EBG		X	X		
Grasshopper warbler							
Sedge warbler		EBG		X	X		
Reed warbler		EBG		X			
Reed bunting		EBG		X	X		
Woodcock							
Nightingale							
Marsh tit							
Willow tit						X	
Peregrine							
Golden plover							X
Dunlin							X
Whimbrel							X
Greenshank							X
Ring ouzel							

Various alien and invasive bird species have been explicitly omitted from the analyses supporting this paper due to the capacity of their increasing numbers to skew the indicator trajectory. Moreover, further increases in these species would not be considered a positive outcome in conservation terms. Notes are nevertheless provided for Canada goose, greylag goose, ruddy duck, Egyptian goose and mandarin duck, although data are currently adequate for confident trend analysis only for Canada goose and greylag geese. There may be some justification for the development at some future point of an 'introduced and invasive species' indicator, as rising numbers may form part of the forces driving the decline of other native bird species.

It is important to be aware that the associations identified in this review are coarse-grained, as most species will use a range of different habitats as long as they contain key features for breeding or nesting. Species detected on the waterways surveys (WBBS and WBS), for instance, may actually be more dependent on the surrounding habitat (arable crops, woodland, rough grassland) than the waterway itself. For example, although there is a strong association for both dippers and grey wagtails with fast-moving water, the two bird species are differentially sensitive to water pollution as dippers feed exclusively in the river whilst grey wagtails exploit significant food sources from the riparian zone (Ormerod and Tyler, 1993). Foraging or roosting birds may use habitats different to those where they nest, and some of the habitat associations in the literature review and in the BBS dataset may refer to nonbreeding or passage birds rather than confirmed breeders.

Additional statistical issues entailed in indicator development are not the subject of this paper. Some indicators, for example, assign one species of organism to one habitat type only, whilst others might allocate a species to two or even more habitats that it is known to use and weightings may be applied. Such issues will be the subject of separate studies underpinning recommendations for optimal

indicator development. This paper seeks only to provide a solid evidence base for association of bird species with different freshwater habitat types.

This evidence identified in this report is sufficient to recommend species suitable for indicators of 'fast-flowing river', 'slow/still water', 'reedbed' and a 'wet meadow' indicator, the latter including wet grassland and marshes.

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