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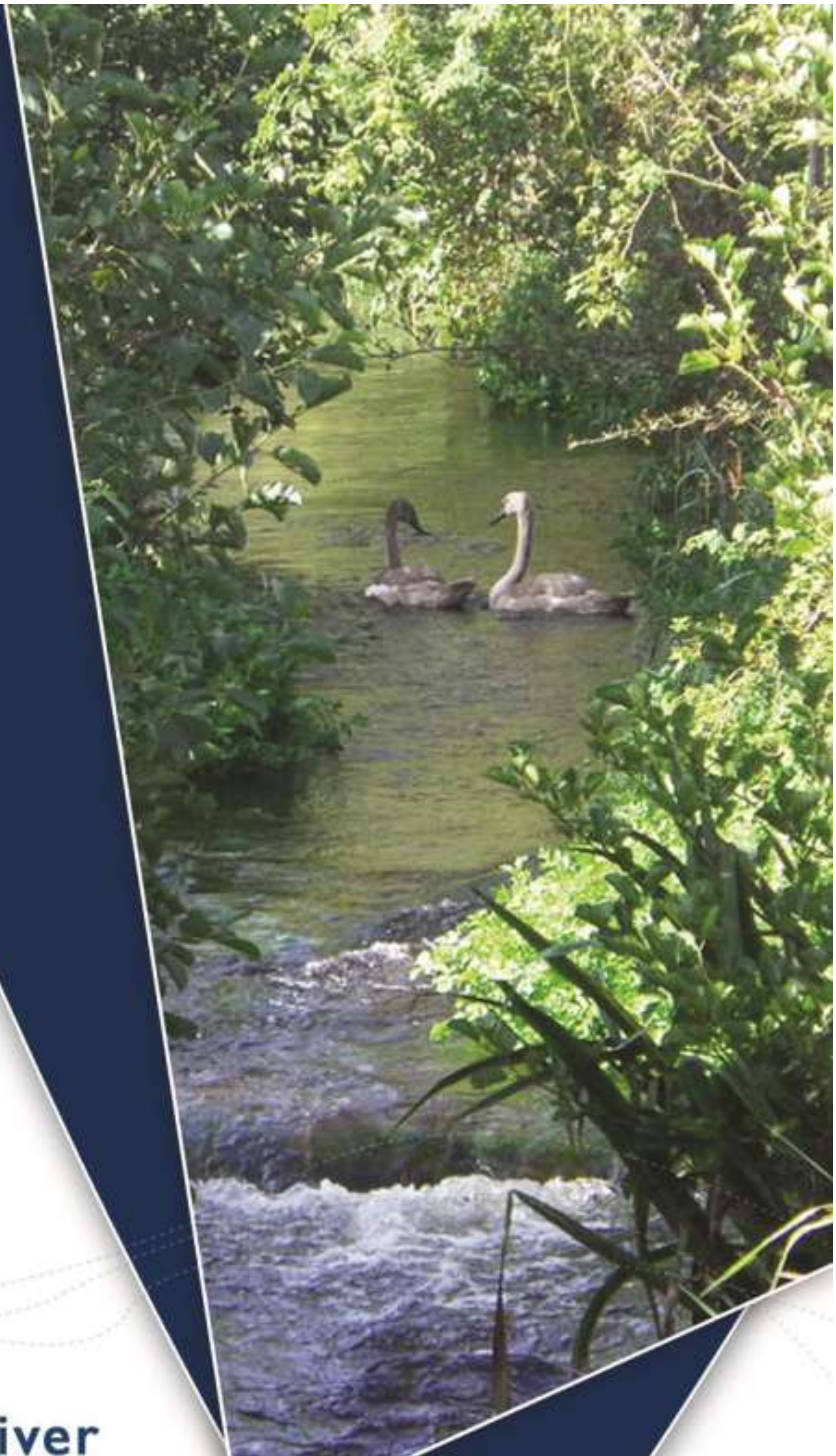

Environmental River Enhancement Programme River Corridor Bird Monitoring

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IASCACH INTÍRE ÉIREANN
INLAND FISHERIES IRELAND

River Corridor Bird Monitoring

Inland Fisheries Ireland & the Office of Public Works

Environmental River Enhancement Programme

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1 Introduction

In Ireland, river corridors support a diverse avian community (Nairn and O'Halloran 2012). Such communities include waterfowl, species with special habitat requirements and others characteristic of the riverine environment. In addition, a variety of other species use adjacent scrub and trees for nesting, cover and feeding. Specialised species such as sedge warblers (*Acrocephalus schoenobaenus* L.) and reed buntings (*Emberiza schoeniclus L*.) require tall marginal vegetation (Nairn & O'Halloran 2012), whereas exposed vertical soft river bank is a prerequisite for kingfishers (*Alcedo atthis* L.) and sand martins (*Riparia riparia* L.) for nesting purposes (Purseglove 1995; Sharrock 2010). Common waterfowl species include mute swans (*Cygnus olor* Gmelin.), moorhens (*Gallinula chloropus* L.) and mallards (*Anas platyrhynchos*) (Gibbons *et al*. 1993). Other typical species frequently encountered along river corridors are swallows (*Hirundo rustica L.*), grey herons (*Ardea cinerea L*.) and wagtails (*Motacilla* sp) (Bailey 1982; Dempsey and O'Clery 2010; Smiddy and O'Halloran 1998). Furthermore, species typically associated with broadleaf woodland including blackbird (*Turdus merula* L.), European robin (*Erithacus rubecula* L.), wren (*Troglodytes troglodytes* L.) and chaffinch (*Fringilla coelebs* L.) and others readily utilise scrub and trees that grow on the river bank (Nairn & O'Halloran 2012; Sweeney *et al*. 2010).

'Arterial drainage' is a more appropriate description of the channelisation approach implemented in Ireland, where it was undertaken in a systematic manner at the catchment level to improve land for agriculture. Between 1948 and 1995 the Office of Public Works (OPW) completed 34 catchment wide arterial drainage schemes and 5 estuarine embankment schemes in the Republic of Ireland, amounting to some 11,505km of river channel and 730km of embankments (OPW 2007b) (Map 1, see section 2). These schemes had the potential to improve drainage in > 260,000 hectares of land. Moreover, following the implementation of these drainage schemes, land owners in the affected catchments were encouraged to install land drains to maximise the impact of increased outfall to rivers and streams. Arterial drainage results in major modifications to channel morphology through engineering works, which produce a structurally simplified and hydraulically efficient channel.

The environmental impacts of river channel works associated with land drainage improvement have been recognised for many years and have been widely documented (Brookes 1989; Keller 1978a; Raven 1986; Shannon International River Basin Project (SIBRP) 2008; Swales 1982; Tockner et al. 1998). Key ecological impacts are a reduction in habitat diversity, increased sediment loads, changes in flow regime and loss of floodplain connectivity. In summary, "channel alterations caused by drainage have a serious impact on the entire instream ecology" (O'Grady and King 1992) which can result in formerly dynamic rivers becoming simplified, single thread channels, removed from their floodplains (Ward 1998).

Non-drained and undisturbed rivers gradually adapt their course and flow patterns as they progress from source to sea in a comparatively stable manner. These rivers are in equilibrium with the surrounding environment and are characterised by a variety of morphological features, the range and type of which are determined by biological and fluvial processes (Gordon *et al*. 2004). Biota with specific habitat requirements reflect the natural diversity of these river environments. Following drainage, natural hydrological processes resume and attempt to recreate lost physical (Keller *et al*. 1993; Keller 1978b) and biological characteristics (O'Grady 1991). However, the implementation of a drainage scheme usually involves subsequent channel management, including renewed dredging, management of aquatic and riparian vegetation and other instream obstructions to improve water conveyance. In Ireland, there are statutory obligations on the OPW to maintain drained channels (OPW 2007a). Drainage maintenance operations are clearly an important factor in considering the impacts of drainage on the ecological recovery of avian bird communities found in river corridors at present.

With regard to avian species, river channelisation can result in a substantial decrease in bird numbers, particularly in the case of more specialised species (Tyler 2010). Studies pre and post drainage in 1984 and 1987, respectively, on the Blackwater river in the North of Ireland found that all species declined following drainage, with the exception of dippers (*Cinclus cinclus* L.) (Watson 1984; Williams *et al*. 1984). Furthermore, on-going drainage maintenance operations can exacerbate the impact on these avian communities through continued habitat loss and disturbance during the breeding season. Past investigations cite habitat loss, principally vegetation clearance and reprofiling/revetment of river banks, as a primary factor in bird decreases (Campbell 1988; Garrison *et al*. 1987; Humphrey and Garrison 1987; Moffatt et al. 2005; Raven 1986; Smith 1975; Williamson 1971). The potential impacts of drainage and maintenance operations on the avian community in the river corridor include the loss of nesting sites, cover and feeding areas (Smith 1975). The loss of wetland/wet grassland following drainage (Baldock 1984) is undoubtedly responsible for the greatest decline in bird species (Williams, Newson, & Browne 1984; Wilson *et al.* 2005; Wilson et al. 2004). However, these habitats were outside the scope of this study.

Published studies are scarce despite the fact that rivers represent an important part of the bird habitats of Ireland (Nairn & O'Halloran 2012). Two previous Irish studies by Bird Watch Ireland (BWI) conducted on behalf of OPW assessed the impacts of river maintenance operations on bird habitat along lowland rivers during the breeding season from 2006-2009 (OPW 2007a; OPW 2010). Although drainage maintenance operations could degrade existing bird habitat in the short term, they concluded, that where sympathetic channel maintenance (as outlined in OPW Environmental Management Protocols and SOPs, (OPW 2009)) was implemented, it did not have any long term deleterious effect on the local avian community because the habitat recovered quickly. The Bird Watch Ireland / OPW studies were concerned with the short to medium impacts (3 years approx.) of river maintenance operations on the local avian community and habitat in drained rivers. This present study investigated if local avian communities inhabiting arterially drained and non-drained riverine habitats differed significantly in terms of species richness or diversity.

2 Material and Methods

In 2009, the avian communities occurring along 15 arterially drained rivers were recorded by the present authors to establish a baseline record of species richness and bird abundance. The sample sites were geographically dispersed within drained catchments to reflect any regional differences that might arise. Environmental variables that could affect the composition of avian communities were also recorded and analysed. These included channel width, depth, flow type, vegetation cover (instream, tall emergent and bankside), drainage maintenance history, adjacent land cover and habitat type. Three discrete habitat types were identified as key in determining avian community composition: treelined (broadleaf), tall emergent vegetation and open (channels with very little instream, tall emergent or bankside vegetation).

A further 45 surveys were completed from 2010-2011, of which 22 were conducted on river channels that had not been subjected to drainage (Figure 1) for the purpose of comparing the local avian communities of drained and non-drained rivers. The 2010-2011 data is presented in this paper. The 2009 data were not used in the analysis in this paper because non-drained river channels were not surveyed in those years.

2.1 Site Selection

Sites selection was based on the following criteria and habitat types:

- Located in lowland channels
- 500m of channel dominated by one habitat type
- In the case of drained sites, no channel maintenance had taken place in recent years
- Sites were geographically dispersed to account for regional differences

The habitat types are described in detail below:

1. Treelined: channel reaches with over 50% broadleaf tree and/or scrub cover. The most common tree species recorded at these sites included ash (*Fraxinus excelsior* L.), alder (*Alnus glutinosa* L.) and tall willows (*Salix alba* L. and *Salix fragilis* L.). Scrub species were generally represented by whitethorn (*Crataegus monogyna* Jacq.), blackthorn (*Prunus spinosa* L.), willow bushes (*Salix* spp.)

and gorse (*Ulex* spp.) (Webb, 1996). Other species such as sycamore (*Acer pseuodoplatanus* L.) were also present though at a lesser extent. Tree cover typically exceeded 75% in almost all sites.

2. Tall emergent: channels where stands of tall emergent macrophytes were the dominant marginal vegetation i.e. tall emergent macrophytes occupied 75%+ of the channel margins and tree cover is absent (< 5%). Stands typically comprised a mix of reed canary grass (*Phalaris arundinacea* L.), club rush (*Scirpus lacustris* L.) and burr reed (*Sparganium erectum* L.). Other species such as reed grasses (*Glyceria* spp) and yellow iris (*Iris pseudocarous*) are also present to a lesser extent.

3 Open: channels with little or no tall emergent vegetation and low growing or cropped bankside vegetation i.e. tall herb vegetation and trees are absent.

In practice, finding a sufficient number of sample sites containing discrete habitat types proved difficult. Catchments throughout 'middle' Ireland were subject to comprehensive drainage schemes in the past (Drainage Act 1842, 1863, 1925) and arterial drainage from 1940-1980 (Baldock 1984), making it difficult to find comparable non-drained sites in the same general geographic location. As a result, non-drained sites had a greater southern distribution whereas drained sites were clustered in the midlands. The potential effect of any regional bias is referred to later.

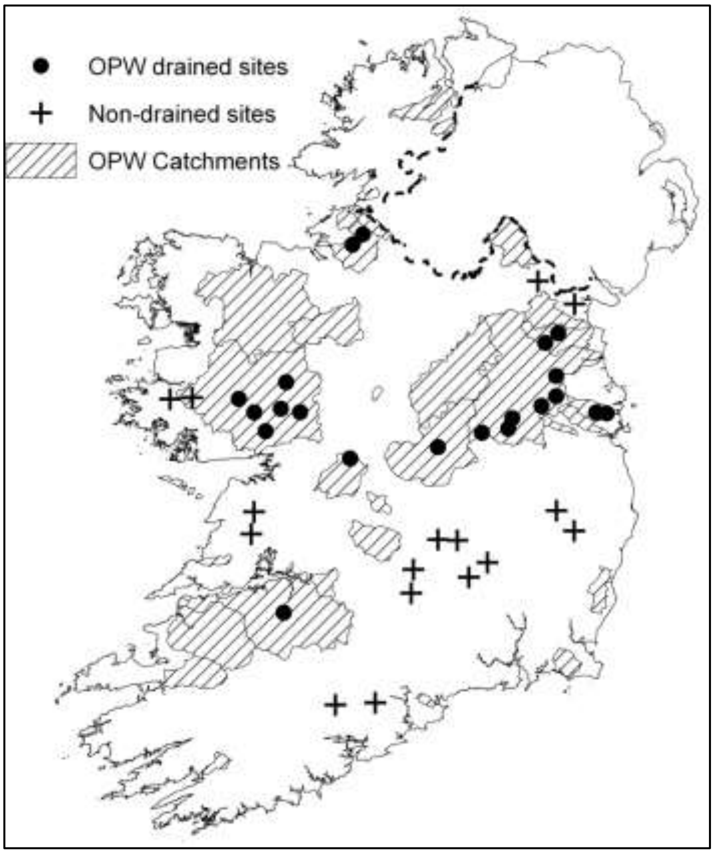

Figure 1. Approximate locations of 2010-2011 sample sites.

2.2 Field methods

The sampling methodology used by BWI (2006-2009) was also employed here (OPW 2007a; OPW 2010). The methodology is based on the Waterways Breeding Bird Survey (WBBS) started in 1998 in the UK by the British Trust for Ornithology (BTO) (Marchant *et al.* 2002). In the present study, a recorder was present on each river bank as opposed to a solitary recorder, which is the norm in WBBS surveys. This ensured more precise recording, particularly in treelined channels were stands of trees can act as sound and visual barriers. In order to accurately reflect both the migratory and resident avian community, a two stage sampling programme was undertaken. Each site was surveyed twice in the same year, April to mid-May and mid-May to mid-June). The first survey recorded the abundance of resident and early migrant birds observed in Irish rivers. The second survey recorded the later migrant birds. For each site, a minimum period of four weeks was left between the two surveys. Spring and summer results were combined to give total species and bird numbers. Surveys were conducted between dawn and 10am, so as to coincide with the period of greatest bird activity. Additionally, in order to facilitate accurate gathering of data, surveys were conducted only on days with relatively dry and calm weather conditions.

A line transect method was used. Two recorders standing on opposite banks, surveyed 500m of channel in a methodical and synchronised manner. Recorders never walked towards the sun for the purpose of visual clarity. This dictated whether they started upstream or downstream. All adult birds seen or heard within and 15m either side of the channel were recorded. Recorders were equipped with binoculars to facilitate identification. Every effort was made to ensure that each bird was recorded only once. Birds not conclusively identified were omitted.

Data collected were pooled into one survey sheet. Birds in flight were recorded separately and not used in the analysis. However, birds that are usually observed in flight such as house martins *(Delichon urbica* L.*),* sand martins (*Riparia riparia* L.) and swallows (*Hirundo rustica* L.) (Dempsey & O'Clery 2010), and specifically use the river corridor habitat, were used in the data analysis.

2.3 Analysis

Principal component analysis (PCA) was performed to establish if there was any relationship between the avian community, habitat type and drainage history. PCA showed a positive relationship between habitat type and avian composition. Consequently, a hierarchal approach was used in further data analysis. Non-parametric, permutational multivariate analysis of variance (PERMANOVA) (Anderson 2001) based on Bray-Curtis similarity values of species abundances was used to compare:

a. Avian community composition in arterially drained and non-drained rivers
b. Avian community composition within and between the three habitat types.

Firstly drained river sites were compared against each other, within and between habitat types. Then, drained sites were compared against other non-drained river sites, within and between habitat types and thirdly, sites were compared against each other, within and between habitat types regardless of their history i.e. no distinction was made between drained and non-drained sites.

Species abundance was calculated as the mean number of occurrences for each species recorded within a particular habitat type. Since mean abundance values for any individual species in this study were small (< 30), the data were not transformed to reduce the influence of abundant species.

Similarly, total bird abundance was calculated as the mean bird abundance recorded within a particular habitat type. Since the scale of total bird abundance values in any sample site were small (< 138), the data were not transformed to reduce the influence of abundant species.

The data were not distributed normally and variance was unequal. Given this, a non-parametric 2-tailed Mann-Whitney U test was used to test for differences in mean species abundance and mean individual bird abundance between:

1. Arterially drained and non-drained sites by habitat type
2. Habitat type irrespective of drainage history i.e. whether they had been recently maintained or not

The Shannon index was used to measure species diversity between habitat types.

Community Analysis Package software (version 4) was used to perform the principle component analysis. PAST software (version 3.04) was used to generate the Mann-Whitney U results and Shannon index scores.

3 Results

3.1 Preliminary results

60 bird species were recorded in total, 53 in drained and 55 in non-drained channels. Treelined sites were the richest in terms of mean number of species and birds recorded, with open sites being the poorest (Figure 3). A number of species of conservation concern were recorded (Table 1) and are referred to in the discussion were relevant.

Table 1: species of conservation recorded during surveys (Lynas *et al*. 2007).

Common name	Latin name	Conservation status
Cormorant	*Phalacrocorax carbo* L.	amber
Grasshopper Warbler	*Locustella luscinioides* Kaup	amber
House Martin	*Delichon urbicum*	amber
kingfisher	*Alcedo atthis*	amber
Lapwing	*Vanellus vanellus* L.	red
Little Grebe	*Tachybaptus ruficollis* Pallas	amber
Sand Martin	*Riparia riparia*	amber
Skylark	*Alauda arvensis* L.	amber
Swallow	Hirundo rustica L.	amber
Swift	*Apus apus* L.	amber
Teal	*Anas crecca* L.	amber
Wheatear	*Oenanthe oenanthe* L.	amber
Yellowhammer	*Emberiza citronella* L.	red

3.2 Avian communities in drained and non-drained channels

Principle Component Analysis (PCA) results did not show any relationship between drainage history and avian community composition. Furthermore, PCA did not reveal a difference in avian community composition between years. In contrast, PCA did show a positive relationship between habitat type and avian community composition (Figure 2). There is a clear distinction between those sites with extensive treelines and tall emergent vegetation. Open sites with very little vegetation cover are tightly clustered (Figure 2), suggesting they have the least varied avian communities.

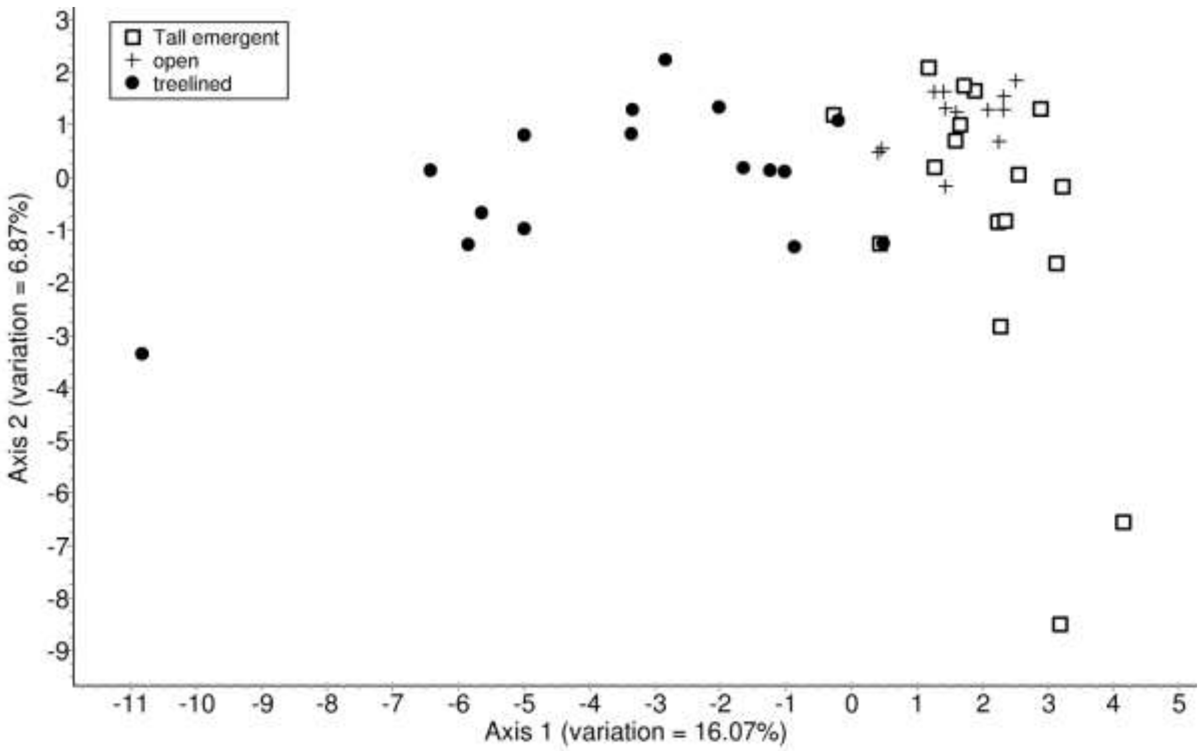

Figure 2: PCA of sampled bird sites grouped according to habitat type, irrespective of drainage history.

The low F-value and high p-value (p>0.05) indicated no significant difference between avian community composition in drained and non-drained river sites (Table 2). Moreover, results suggest that available habitat type, rather than geographic location has a stronger influence on community type in drained and non-drained sample sites.

Sites were then grouped by habitat type, irrespective of drainage history. High F values and low p-values (p<0.01) showed a significant difference in avian community composition between habitat types regardless of drainage history

Table 2: PERMANOVA results comparing bird communities sampled in different habitat types

Treatment	N (drained)	N (non-drained)	p-value	F
Open	5	7	0.691	0.731
Treelined	9	7	0.137	1.497
Tall emergent	9	8	0.476	0.982

3.3 Avian community diversity in drained and non-drained channels

Not surprisingly, channels with extensive tall emergent vegetation or extensive treelines supported more species and individual birds than open rivers, irrespective of drainage history (Figure 3). The Shannon diversity index also revealed the open sites as impoverished compared to the other habitat types (Table 3). This was similarly true when river channels were compared by habitat type only, irrespective of drainage history.

Table 3: Shannon diversity index scores

Habitat	Shannon_H	N
Tall emergent (drained)	3.22	8
Tall emergent (non-drained)	2.83	9
Treelined (drained)	3.02	9
Treelined (non-drained)	3.01	7
Open (drained)	2.67	5
Open (non-drained)	2.86	7

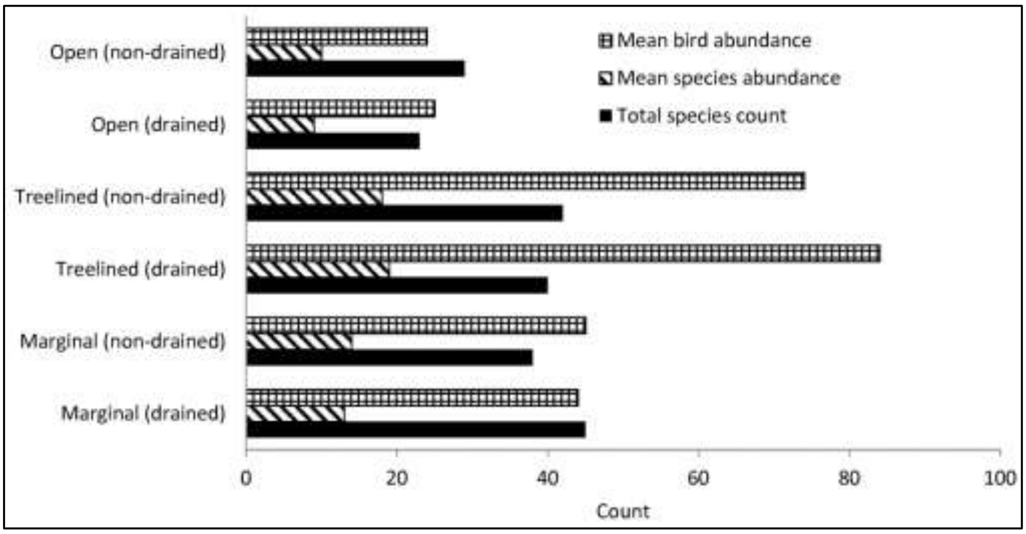

Figure 3: Avian community metrics recorded in different habitat types. Results are shown for drained and non-drained river channels. Total species count, mean species abundance and mean bird abundance are displayed.

There was no significant difference in mean species abundance between the same habitat types regardless of drainage history (Mann-Whitney U, $p>0.05$). In addition, tall emergent and treelined river channel sites were not significantly different from each other in mean species abundance (p>0.05), but both were significantly different from open river sites (p<0.05).

There was no significant difference in mean bird abundance between the same habitat types regardless of drainage history, whereas habitat types were significantly different when compared (Table 4 and 5). Significantly more birds were recorded in treelined sites than the other habitat types (Table 4 and 5), with open sites accounting for the least

Table 4: Mann-Whitney test comparing drained and non-drained sites

Treatment	N (drained)	N (non-drained)	p-value
Open	5	7	0.743
Treelined	9	7	0.56
Tall emergent	9	8	0.809

Table 5: Mann-Whitney test comparing drained and non-drained sites

Treatment	p-value
Tall emergent (N=17) v Treelined (N=16)	0.001
Tall emergent (N=17) v Open (N=12)	0.006
Open (N=12) v Treelined (N=16)	0.001

4 Discussion

4.1 The influence of habitat and drainage history on avian community composition

Results from the present study suggest that habitat availability in drained and non-drained rivers determines avian species richness and diversity, rather than any long-term effect of arterial drainage/maintenance. No differences were evident in species richness or diversity between drained and non-drained rivers. River sites with extensive tall emergent vegetation or tree cover were used by a diverse range of bird species. The value of the habitat heterogeneity that these provide for bird species is reflected in the survey results. River channel reaches with vegetation and/or trees provide better cover, nesting areas and food for bird species than reaches where this habitat is absent. The overlap in species composition between open and tall emergent sites was likely due to the low sward height of immature emergent vegetation during the spring surveys i.e. it was very similar to an open site in terms of available habitat.

This study did not quantify the distribution of each habitat type throughout drained or non-drained catchments as this would have been a substantial undertaking. Therefore, while it is not possible to say whether drained or non-drained channels support more bird communities, it is possible to say that the quality of the habitat within each defined type i.e. open, tall emergent or treelined is similar from a bird perspective regardless of drainage. This has clear implications for bird conservation measures in drained channels. Firstly, that the avian species diversity and avian habitat within the immediate river corridor has the potential to recover following declines associated with the initial drainage schemes (Watson 1984, Williams *et al.*, 1988). Of course, this is dependent on any river operations being ecologically sensitive. Secondly, the provision and expansion of good quality riparian habitat for birds in drained rivers is feasible and worthwhile in drained rivers.

In line with previous studies, the results also demonstrated that the avian community using different habitat types vary (Gibbons, Reid, Chapman, Ornithologists' Club, & Conservancy 1993; Marchant and Hayde 1980; Vaughan *et al.* 2007). This is not surprising given that different species have adapted to exploit different niches. Species that prefer tree cover are typically associated with hedgerows, scrub/ woodland (Sweeney, Wilson, Irwin, Kelly, & O'Halloran 2010) and these species were duly recorded in this habitat regardless of its proximity to a river channel. In contrast, species such as sedge warbler and reed bunting were recorded in sites with tall marginal reeds because they require this habitat for nesting, fledging and feeding (Vaughan, Noble, & Ormerod 2007).

Previous studies (Campbell 1988; Garrison, Humphrey, & Laymon 1987; Moffatt, Crone, Holl, Schlorff, & Garrison 2005 ;Raven 1986; Williamson 1971) cite habitat loss, principally vegetation clearance and insensitive bank protection as a primary factor in decreases of individual birds and species. In this study, bird species diversity and abundance were greatest in sites that retained good vegetative cover. The current study did not assess the impact of bank protection on species that nest in bank faces e.g. sand martins, since the sample sites were not suitable.

The results of this study may not be applicable at the species level where some birds have very specific habitat requirements. For example, dippers (*Cinclus cinclus*) are adapted to feeding in riffle areas ((Gibbons, Reid, Chapman, Ornithologists' Club & Conservancy 1993, reviewed in Tyler 2010), whereas the gravels necessary to form riffles are often lacking in drained channels (O'Grady 2006). Species such as kingfishers, that are thinly, but widely distributed in Ireland (Nairn & O'Halloran 2012) are not accounted for in the survey methodology. Furthermore, it only assessed differences at the abundance and species diversity level. This study does not account for any potential impacts at the individual species. A targeted sampling methodology would be necessary to accurately assess if any significant differences exist between drained and non-drained channels for a particular species. Additionally, functioning floodplains are an important ecological component for riverine bird species (Van Turnhout *et al.* 2012). The loss of floodplain connectivity that is inherent in drained channels and any effect on the avian community that utilise this habitat was beyond the scope of this study.

4.2 Implications for land management

The results have a number of implications for bird conservation, land management and channel maintenance in relation to land drainage and flood control. In order to maintain diverse bird communities in lowland river corridors, it is crucial that tall emergent vegetation and tree cover is protected. Avian communities that rely on stands of trees are probably more robust given that this habitat is more widely available in hedgerows, wooded areas, parkland etc., than tall emergent vegetation. In contrast, tall macrophytes are limited to the riparian margins of lowland rivers, lakes and some wetlands. Riparian habitat is often under excessive pressure from livestock and channel maintenance. The open sites that were surveyed were generally in this condition due to over grazing by livestock, although this can also arise from excessive vegetation clearance during drainage maintenance operations. Species such as the reed bunting (*Emberiza schoeniclus* L.) and sedge warbler (*Acrocephalus schoenobaenus* L.), which are indicative of this type of habitat (Marchant & Hayde 1980; Vaughan, Noble, & Ormerod 2007) were rare or absent when this habitat was absent compared to sites where it was present. Similarly, species diversity and densities of warbler species have been reported as substantially reduced where tall macrophyte vegetation has been removed (Graveland 1999; Vadasz *et al.* 2008).

It has been established that avian species richness and abundance increases with riparian width (Darveau *et al.* 1995; Keller, Robbins, & Hatfield 1993; Stauffer and Best 1980). Furthermore, the influence of the surrounding land management on the avian community increases with more intensive land use (e.g. woodland to native pasture to crop) (Martin *et al.* 2006; Martin and McIntyre 2007). Previous studies demonstrated that avian species respond significantly to changes in both riparian habitat condition and land use, while fewer species are significantly influenced by land use or riparian habitat condition alone (Martin, McIntyre, Catterall, & Possingham 2006; Martin & McIntyre 2007). When considered together with the findings of this study, evidence suggests it is not enough to conserve riparian vegetation alone. Bird conservation and restoration plans must also weigh up the extent of riparian habitat and adjacent land use by the various stakeholders, particularly when land is intensively managed. Provision of fencing (Clary 1999; Kauffman *et al.* 1997; O'Grady *et al.* 2002) coupled with sympathetic maintenance offer a simple and cost effective tool to allow regeneration of riparian vegetation. Taken together with sensitive management of the adjacent land e.g. meaningful buffer strips, this provides a practical and achievable approach to bird conservation. This is apparent when we consider that a number of species that are of conservation concern were recorded during this study (Table 6). While some species are typical of freshwater environments e.g. swallow, teal, little grebe, others such as grasshopper warbler and yellowhammer may simply utilise the tall rank vegetation or trees that are often found on river banks, but may be scarce elsewhere. River corridors can provide a variety of habitats that are relatively unmanaged when compared to the modern intensively farmed landscape and are important to riverine and non-riverine bird species.

5 Conclusions

Results from the present study suggest that arterial drainage and on-going channel maintenance does not appear to have had a long term impact on avian community species richness or diversity within the immediate river corridor, as long as vegetated habitat is available. Other factors such as changes in agriculture, land use, land management and water quality have also impacted on the avian communities that use river corridors. In light of this study, quantification of habitats within river corridors would be a useful tool in helping identify bird communities and setting objectives for bird conservation in terms of habitat protection or enhancement. The value of habitat retention, riparian restoration and appropriate land management cannot be overstated with regard to bird conservation. It is essential that current maintenance operations practiced by the OPW continue to be sympathetic in their approach to riparian vegetation. Maintenance works that encourage a mosaic of habitats and associated micro-habitats can provide diverse conditions likely to increase diversity of not only birds, but a range of biota. Land management of public and private lands that protects riparian vegetation and provides appreciable buffer strips along river corridors will also have a positive impact. Fencing of degraded river banks together with sympathetic land use is likely the best and most cost effective method in protecting/conserving avian communities.

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