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Journal of Environmental Management 84 (2007) 586–605

Journal of Environmental Management

www.elsevier.com/locate/jenvman

Bird distributions relative to remotely sensed habitats in Great Britain: Towards a framework for national modelling

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Received 6 July 2005; received in revised form 8 May 2006; accepted 12 July 2006
Available online 26 September 2006

Abstract

This paper develops a comprehensive and objective picture of bird distributions relative to habitats across Britain. Bird species presence/absence data from an extensive field survey and habitat data from the remotely sensed UK Land Cover Map 2000 were analysed in 36,920 tetrads (2 km × 2 km) across Britain (a 65% sample of Britain's *c.* 240 000 km^2). Cluster analysis linked birds to generalised landscapes based on distinctive habitat assemblages. Maps of the clusters showed strong regional patterns associated with the habitat assemblages. Cluster centroid coordinates for each bird species and each habitat were combined across clusters to derive individualised bird–habitat preference indices and examine the importance of individual habitats for each bird species. Even rare species and scarce habitats showed successful linkages. Results were assessed against published accounts of bird–habitat relations. Objective corroboration strongly supported the associations. Relatively scarce coastal and wetland habitats proved particularly important for many birds. However, extensive arable farmland and woodland habitats were also favoured by many species, despite reported declines in bird numbers in these habitats. The fact that habitat-specialists do not or cannot move habitat is perhaps a reason for declining numbers where habitats have become unsuitable.

This study showed that there are unifying principles determining bird–habitat relations which apply and can be quantified at the national scale, and which corroborate and complement the cumulative knowledge of many and varied surveys and ecological studies. This 'generality' suggests that we may be able, reliably and objectively, to integrate and scale up such disparate studies to the national scale, using this generalised framework. It also suggests the potential for a landscape ecology approach to bird–habitat analyses. Such developments will be important steps in building models to develop and test the sustainable management of landscapes for birds.

Keywords: Bird; Habitat; Map; Remote sensing; Biodiversity; Landscape; Ecology; Modelling

1. Introduction

The UK Government's strategy for sustainable development (Anon, 1999a) includes wild bird populations among 15 'Headline Indicators of Quality of Life' (http://www.sustainable-development.gov.uk/). The strategy sets an objective (Anon, 1999b; Gregory et al., 2004) to reverse declines in birds of woodland (Fuller et al., 2005a) and farmland (Fuller et al., 1995; Siriwardena et al., 1998; Chamberlain et al., 2000; Newton, 2004).

A wealth of field observations, survey data and autecological studies of birds in Britain can, by expert interpretation, inform such policy. Yet, it is hard to synthesise that understanding of birds' environmental requirements to give a meaningful picture at the macro-scale at which policy is designed and operated. If we are objectively to model bird response to land use changes on a national scale, or if we want the flexibility to test local impacts of changing landscapes across Britain, we need to draw on a comprehensive framework of bird and habitat data. Whilst the existing national surveys characterise bird distributions, most include little information about habitats; and, being sample-based, neither the bird nor the

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0301-4797/$ - see front matter © 2006 Elsevier Ltd. All rights reserved.
doi:10.1016/j.jenvman.2006.07.001

habitat data offer a comprehensive national picture. Though generality of ecological models is demonstrable (e.g. Whittingham et al., 2003), it is usually unsafe to extrapolate disparate local observations of bird–habitat relations to draw conclusions at the national scale (Fielding and Haworth, 1995). Indeed, Grice et al. (2004) commented that our wealth of knowledge provides only a qualitative understanding of the issues, with a need to focus on solutions which can objectively and quantitatively test policy-decisions aimed at population improvements. BirdLife International (2004) noted the difficulty of accessing autecological research and similarly called for an evidence-based approach to biodiversity management. If such processes are to advance, especially if they are to be geographically relevant, with comprehensive and site-specific outputs, then a spatial framework is needed to interpret in the wider geographical context the findings of more detailed local research (Grice et al., 2004). This paper considers such a spatial framework based on comprehensive, remotely sensed map of land cover in Britain, to complement existing bird data, facilitate their use, and increase their usefulness.

An earlier paper (Fuller et al., 2005c) reviewed the contribution of remote sensing to biodiversity assessment and landscape ecology. It demonstrated the development of bird–habitat 'preference[1] indices' for birds of south-eastern England. A land cover map from remote sensing helped to link birds to habitats and vice versa. The paper envisaged extending coverage to all of Britain. That extension and the ensuing conclusions are the subjects of the present paper. It examines all but the very rarest of Britain's breeding birds, with an overview of all of Britain's habitats. Freed of the usual focus on localised areas and one or a few species, this comprehensive bird–habitat study is exceptional in terms of its scope; given the comprehensive nature of the habitat data, it is perhaps unique in terms of its potential.

This paper describes: the bird and land cover data; the clustering process used to link these; the generation of bird–habitat preference indices from cluster coordinates; bird associations with habitats and the relative values of different habitats to birds; objective corroboration against published observations. The findings are then discussed in relation to bird conservation and land use intensification issues, examining how they support published observations and if they provide further insights. Finally the paper considers the relevance of this generalised approach: first, as a potential framework for integrating and scaling up the wealth of information coming from disparate surveys and autecological studies; second, for the development of bird landscape ecology models; third, for modelling land management scenarios for the maintenance and enhancement of bird populations.

[1]N.B. the use of the word 'preference' and any similar terms herein is not meant to imply that the mechanism of selection is one of 'choice' by the birds; it might equally be the 'natural selection' of birds fit or unfit for particular habitats.

2. Data

2.1. Bird presence/absence

Bird presence/absence data had been collected for an atlas of breeding birds in Britain and Ireland (Gibbons et al., 1993). Data for Britain covered 36,920 tetrads (2 km × 2 km) of the British National Grid (BNG) giving 65% coverage of Britain's *c.* 240 000 km^2. Surveyors recorded at least 8 and up to 25 tetrads in each 10 km × 10 km BNG square, ensuring representative coverage of all of Britain. The original aim was to determine the frequencies of bird-occurrence in the 10 km × 10 km, not to map at the tetrad level. However, the tetrad data were used here, to exploit more fully the available resolution of the land cover data.

Only tetrads centred on land were included. Birds present in each tetrad were listed in 2 h of survey: generally as two 1-h visits (one early, one late in the breeding season); sometimes a single mid-season visit had to suffice. Either way, 2 h of survey did not provide a comprehensive species list, just 'an idea' of the species assemblages in the tetrads (Gibbons et al., 1993). The observers only recorded birds 'using' the tetrad; those passing through were ignored; and late over-wintering migrants were excluded; the survey's distinction of breeding birds is not used here. Bird species nomenclature follows that of the British Ornithologists' Union (http://www.bou.org.uk).

The bird data show a tendency for lower numbers of species to occur in uplands and the north of Britain and greater numbers in lowlands and the south (see Gibbons et al. (1993) for generalised diversity maps). These variations reflect the typical latitudinal gradients of animal diversity relating to climate (Currie et al., 2004) and energy variables (Hawkins et al., 2003), with the altitudinal patterns mimicking the effect. Otherwise, the bird data show a variable picture, with high and low diversity tetrads as near-neighbours throughout Britain.

2.2. Land cover data

The UK Land Cover Map 2000 (LCM2000), a component of the UK Countryside Survey 2000 (CS2000—Haines-Young et al., 2000), is based on spectral image data recorded by Earth observation satellites (Fuller et al., 2002b). Image segmentation (Devereux et al., 2004) outlined the two-dimensional landscape structure, broadly at a field-by-field scale. A consortium of end-users specified a thematic classification based on widespread 'Broad Habitats' of terrestrial and inshore environments (Jackson, 2000). A spectral maximum likelihood classifier (Schowengerdt, 1997) labelled each image segment with one of 72 cover classes (Fuller et al., 2005b). These were simplified to 23 'habitats' here (Table 1). The study covered all of