Avian community responses to variability in river hydrology

Alexander Royan[1]*, David M Hannah[1], S James Reynolds[2], David G Noble[3] & Jonathan P Sadler[1]

[1]School of Geography, Earth and Environmental Sciences, University of Birmingham, Birmingham B15 2TT, UK
[2]School of Biosciences, University of Birmingham, Birmingham B15 2TT, UK
[3]British Trust for Ornithology, Thetford, Norfolk IP24 2PU, UK
*email for correspondence: **axr196@bham.ac.uk**

@Alex_Royan

1. BACKGROUND

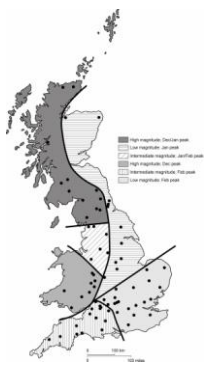
River flow is a major driver of morphological structure and community dynamics in riverine-floodplain ecosystems. By regulating processes such as production and nutrient fluxes flow variability creates ecologically dynamic systems, promoting diversity and variability in functional traits[1,2]. Perturbations in the organisation of lower trophic levels are conveyed through the food web and result in deflated food availability for consumer species [3,4].

River birds are sensitive to spatial and phenological mismatches with prey following flow disturbances[4,5]. This suggests that river birds may be vulnerable to the creation of novel flow regimes caused by global climate change. Despite this, the relationship between river bird distribution and flow is poorly quantified.

Aim:

To investigate how the probability of river bird species' occurrence is influenced by hydrological variability.

2. METHODS



Bird survey data from the BTO's **Waterways Breeding Bird Survey (WBBS)** were combined with **National River Flow Archive (NRFA)** data at 73 river locations.

Presence/absence data then extracted for river bird species.

Investigated the relationship between species' presence and **5 indices** of river flow:

1. **Flow Magnitude** (Mean daily flow/median)
2. **Low Flow Variability** (3 day minimum/median)
3. **High Flow Variability** (3 day maximum/median)
4. **High Flow Frequency** (Number of flow days > 3 x median)
5. **April Flow Variation** (Standard Deviation of April flows)

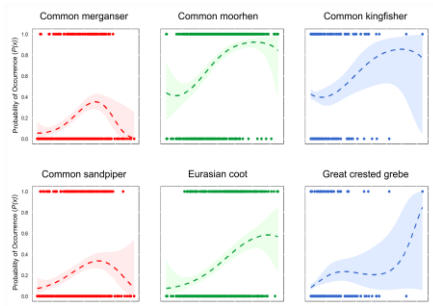
Relative importance of flow parameters in explaining species' presence assessed using **Generalized Additive Models (GAMs)**[6] and the Information-Theoretic (IT) model averaging approach[7].

Models evaluated using **Cohen's Kappa statistic (*K*)** and **AUC**.

3. RESULTS

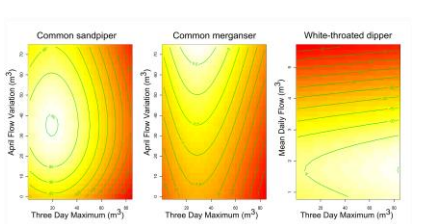
Table showing the selection probabilities (*Sps*) of the five hydrological indices and the direction of the relationship with species' occurrence for seven example species . Parameters included in a greater proportion of the best-supported models have larger *Sps*, thereby demonstrating strong support for their inclusion in the best approximating model. According to *K* and AUC, success in relating species' occurrence varied considerably between species.

Species	Three Day Maximum	Three Day Minimum	High Flow Frequency	April Flow Variation	Mean Daily Flow	Models < ΔAIC 2	*K*	AUC
Common kingfisher *Alcedo atthis*	0.535(±)	0.402	0.391	0.998(+)	0.312	7	0.261	0.738
Common merganser *Mergus merganser*	0.533(±)	0.318	0.467(±)	0.858(+)	0.415	9	0.499	0.910
Common sandpiper *Actitis hypoleucos*	0.995(±)	0.439	0.982(±)	0.999(±)	0.360	4	0.891	0.994
Great cormorant *Phalacrocorax carbo*	0.693(+)	0.949(+)	0.285	0.999(+)	0.546(-)	4	0.377	0.822
Great crested grebe *Podiceps cristatus*	0.295	0.330	0.307	0.999(±)	0.360	5	0.533	0.945
Sand martin *Riparia riparia*	0.341	0.320	0.386	0.999(±)	0.353	5	0.526	0.891
White-throated dipper *Cinclus cinclus*	0.947(+)	0.620(-)	0.967(±)	0.596(±)	0.999(-)	3	0.868	0.986



Examples of non-linear relationships between species' probability of occurrence and three hydrological indices.

Differences in hydrological associations were consistent with species' respective life-history traits.



Surface plots showing the interactive effects of two hydrological indices on species' occurrence, where lighter areas illustrate a stronger influence When considered independently, the indices have limited effects on occurrence compared to the combined effect of both indices.

4. SUMMARY

We quantitatively demonstrated that the distribution of river birds is influenced by river flow variability.

Species' distributions are characterised by complex responses to:

1. variability around extremes of high and low flows;
2. measures of flow frequency;
3. the timing of flow events;
4. and measures of flow magnitude.

Success in relating flow data to river bird distribution indicates a potential vulnerability to the impacts of climate change-induced flow variability. This also highlights the need for the incorporation of flow data into climate change impacts models of species' distributions and the need to account for the effects of altered flows in planning for river bird conservation.

REFERENCES

[1]Poff *et al.* (1997) The natural flow regime. *BioScience* **47**: 769-784. [2]Junk *et al.* (1989) The flood pulse concept in river-floodplain systems. *Can. Spec. Publ. Fish. Aquat. Sci* **106**: 110-127. [3]Ledger *et al* (2013) Drought alters the structure and functioning of complex food webs. *Nature Clim Chang* **3**: 223-227. [4]Chiu *et al.* (2013) Impact of extreme flooding on the annual survival of a riparian predator, the Brown Dipper *Cinclus pallasii*. *Ibis* **155**: 377-383. [5]Chiu *et al.* (2008) Effects of flooding on avian top-predators and their invertebrate prey in a monsoonal Taiwan stream. *Freshw Biol* **53**: 1335-1344. [6]Wood, S (2006) *Generalized Additive Models: An Introduction with R*. London: Chapman & Hall/CRC. [7]Burnham KP, Anderson DR (2002) *Model Selection and Multi-model Inference: a Practical Information-theoretic Approach*. New York: Springer.

ACKNOWLEDGMENTS

Rob Fuller, Mark Hulme & John Marchant, BTO
Mean daily flows were extracted from the National River Flow Archive by NERC CEH staff.