# Coat of many colours: colour pattern polymorphism and invasion by the harlequin ladybird *Harmonia axyridis*

Helen Roy, Clare Kessel, Richard Comont and Beth Purse

# *Harmonia axyridis*

**"The Ladybird has Landed!**

A new ladybird has arrived in Britain. But not just any ladybird: this is *Harmonia axyridis*, the most invasive ladybird on Earth."

Press Release
5th October 2004

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www.ladybird-survey.org

…more than 45 000 records received by the UK Ladybird Survey

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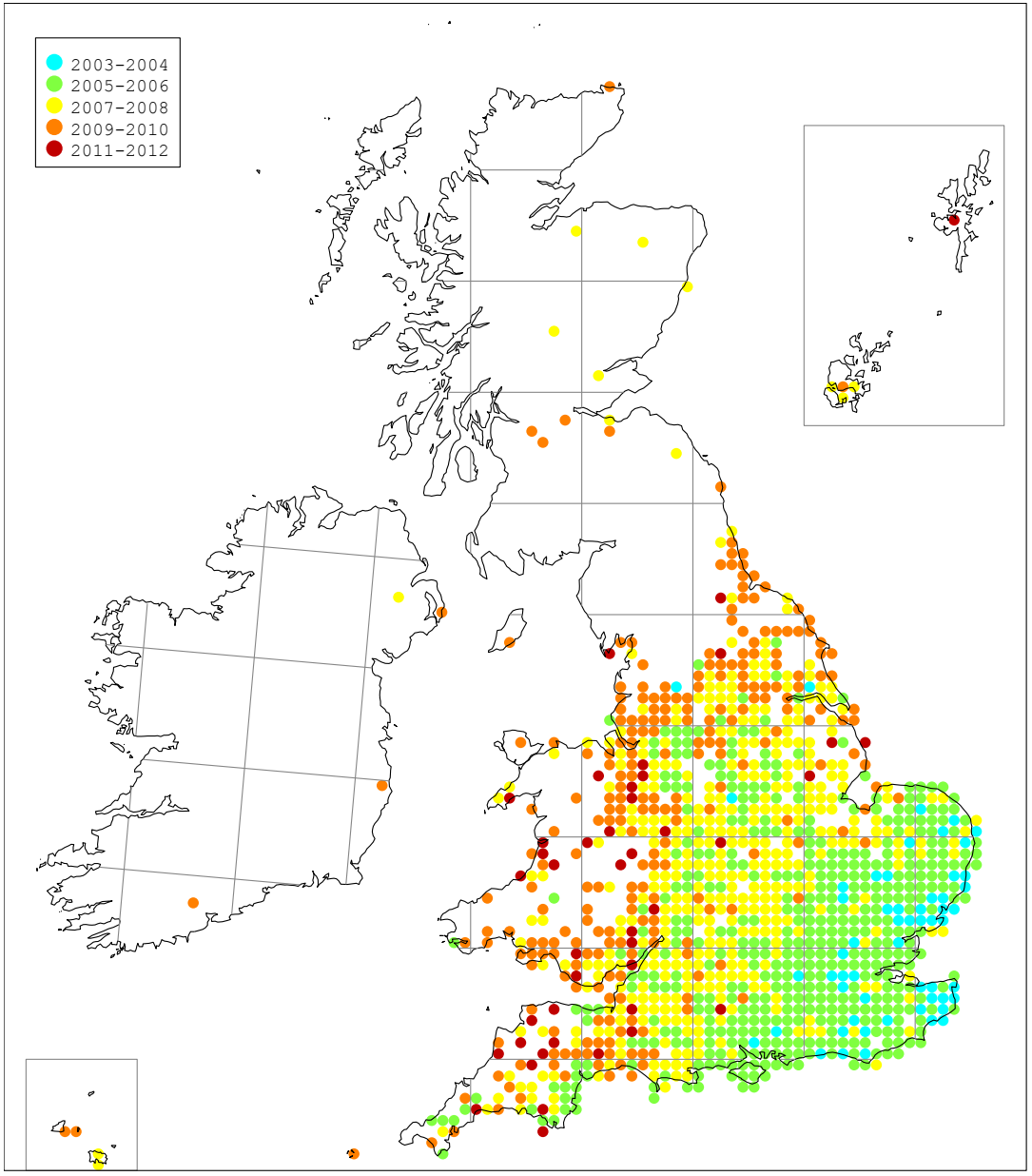
# Spread of the Harlequin ladybird



# Spread and distribution in Europe

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## *Harmonia axyridis* in Europe: spread and distribution of a non-native coccinellid

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**Abstract** Native to Asia, *Harmonia axyridis* (Pallas) (Coleoptera: Coccinellidae) is considered an invasive alien ladybird in Europe and North America, where it was widely introduced as a biological control agent of aphids and coccids. In Europe, *H. axyridis* was sold by various biological control companies from 1995 in France, Belgium and the Netherlands, and was also intentionally released in at least nine other countries. It has spread very rapidly, particularly since 2002, and is now regarded as established in thirteen European countries. The established range extends from Denmark in the north to southern

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# Impacts on native ladybirds across Europe

*Diversity and Distributions, (Diversity Distrib.)* (2012) **18**, 717–725

BIODIVERSITY RESEARCH

## Invasive alien predator causes rapid declines of native European ladybirds

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### ABSTRACT

**Aim** Invasive alien species (IAS) are recognized as major drivers of biodiversity loss, but few causal relationships between IAS and species declines have been documented. In this study, we compare the distribution (Belgium and Britain) and abundance (Belgium, Britain and Switzerland) of formerly common and widespread native ladybirds before and after the arrival of *Harmonia axyridis*, a globally rapidly expanding IAS.

**Location** Europe

**Methods** We used generalized linear mixed-effects models (GLMMs) to assess the distribution trends of eight conspicuous and historically widespread and common species of ladybird within Belgium and Britain before and after the arrival of *H. axyridis*. The distribution data were collated largely through public participatory surveys but verified by a recognized expert. We also used GLMMs to model trends in the abundance of ladybirds using data collated through systematic surveys of deciduous trees in Belgium, Britain and Switzerland.

**Results** Five (Belgium) and seven (Britain) of eight species studied show substantial declines attributable to the arrival of *H. axyridis*. Indeed, the two-spot ladybird, *Adalia bipunctata*, declined by 30% (Belgium) and 44% (Britain) over 5 years after the arrival of *H. axyridis*. Trends in ladybird abundance revealed similar patterns of declines across three countries.

**Main conclusion** Together, these analyses show *H. axyridis* to be displacing native ladybirds with high niche overlap, probably through predation and competition. This finding provides strong evidence of a causal link between the arrival of an IAS and decline in native biodiversity. Rapid biotic homogenization at the continental scale could impact on the resilience of ecosystems and severely diminish the services they deliver.

**Keywords**

**Biological control, biological invasions, citizen science, Coccinellidae, *Harmonia axyridis*, population decline.**

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Roy et al. 2012 Diversity and Distributions 18: 717-725

# Coat of many colours

# Thermal melanism

- *Adalia bipunctata* (2-spot ladybird) has both melanic and non-melanic colour forms
- In the Netherlands (Brakefield & Wilmer, 1985), and in Britain (Muggleton, et al., 1975) melanic individuals inhabit colder areas than non-melanic individuals
- In Asia melanic *Harmonia axyridis* occur more often in cooler areas while non-melanics are found in hot, arid areas
- Laboratory studies have demonstrated that melanic ladybirdshave lower thermal optima than non-melanic ladybirds
- Thermal melanism has been proposed as the explanation for these temperature clines

# Aims

- Is there any difference in the spread of different colour forms?
- Do environmental factors differentially affect the distribution patterns of the different colour forms?

**Melanic = conspicua and spectabilis**

**Non-melanic = succinea**

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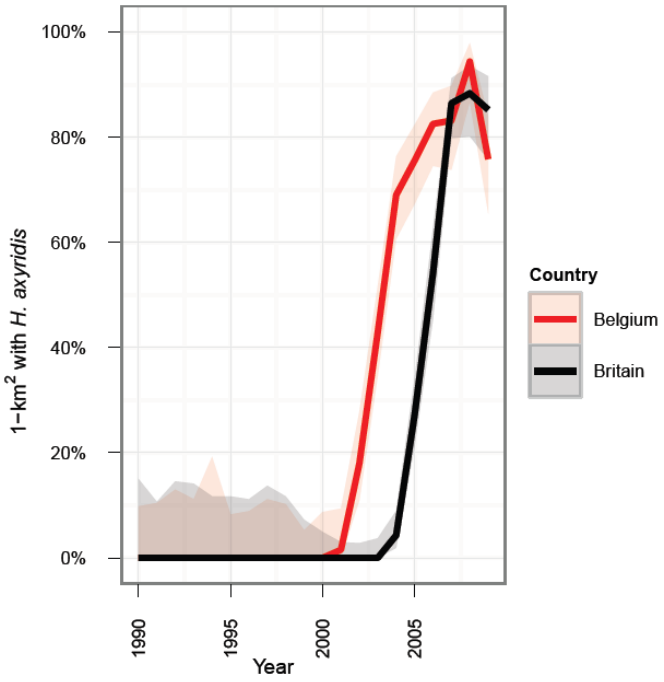
# Number of 10-km$^2$ colonised each year

| | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 |
|---|---|---|---|---|---|---|---|---|---|
| Non-melanic | - | - | 9 | 357 | 256 | 120 | 57 | 9 | 12 |
| Melanics | - | - | 8 | 259 | 247 | 102 | 64 | 8 | 10 |
| Colour form unknown | 3 | 51 | 120 | 318 | 286 | 101 | 149 | 66 | 25 |

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# Ladybird data

- Two datasets:
  - complete dataset (2003-2011)
  - main wave of invasion (2003-2007)
- Each of these two datasets were further subdivided into three:
  - all *H. axyridis* records (including those with no recorded colour form),
  - non-melanic (succinea)
  - melanic ladybirds (spectabilis and conspicua) combined.
- UK Ladybird Survey mainly contains presence-only data

# Habitat and climatic data

- Percentage cover of each habitat type in each grid square of the Land Cover Map of Great Britain
  - coniferous woodland, broadleaf woodland, natural grassland and urban areas
- Met Office's UK Climate Projections (UKCP09) data set
  - rainfall (mean annual rainfall in millimetres) and growing degree-days (above 5.5°C)

# Covariates

- Recording intensity
- Distance from invasion

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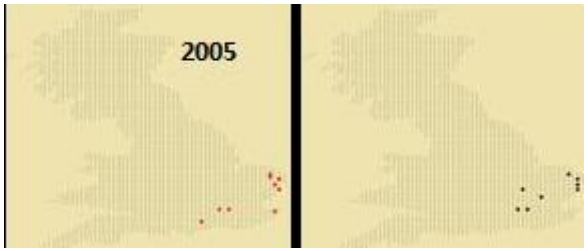
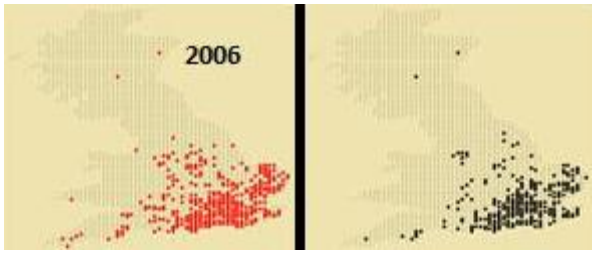
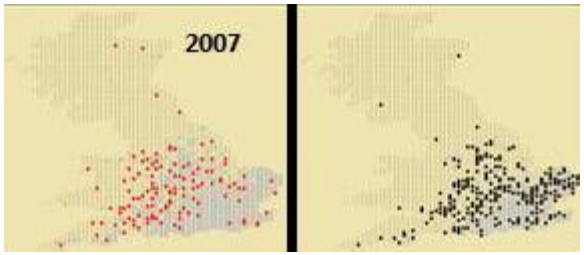
# Analysis

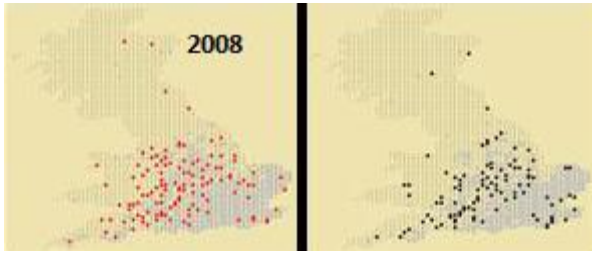
- Cox Proportional Hazard Regression (a type of survival regression) was used to model the spread of *H. axyridis* across Britain
  - Survival regression, although originally used to study death events can also be used to study a variety of events such as time to colonisation
- Final model for each dependant variable was selected using a backwards stepwise selection procedure based on Akaike's information criterion (AIC) values

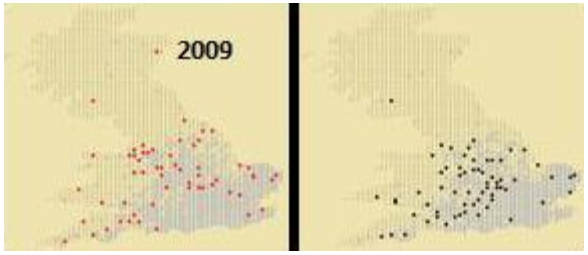
# Spread of *Harmonia axyridis:* non-melanic (red dots) and melanic (black dots)

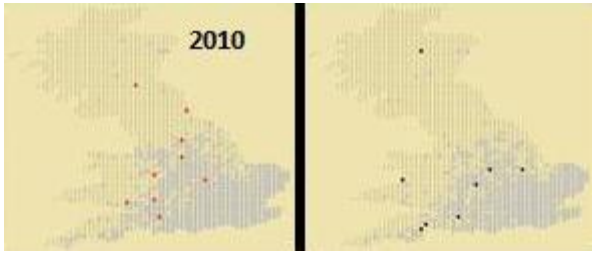


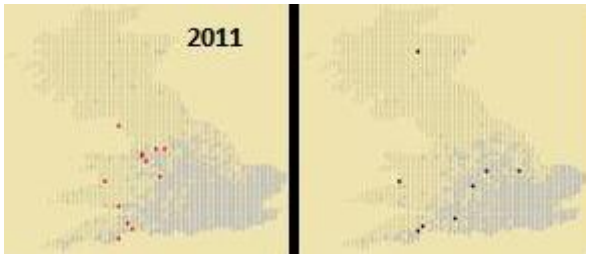

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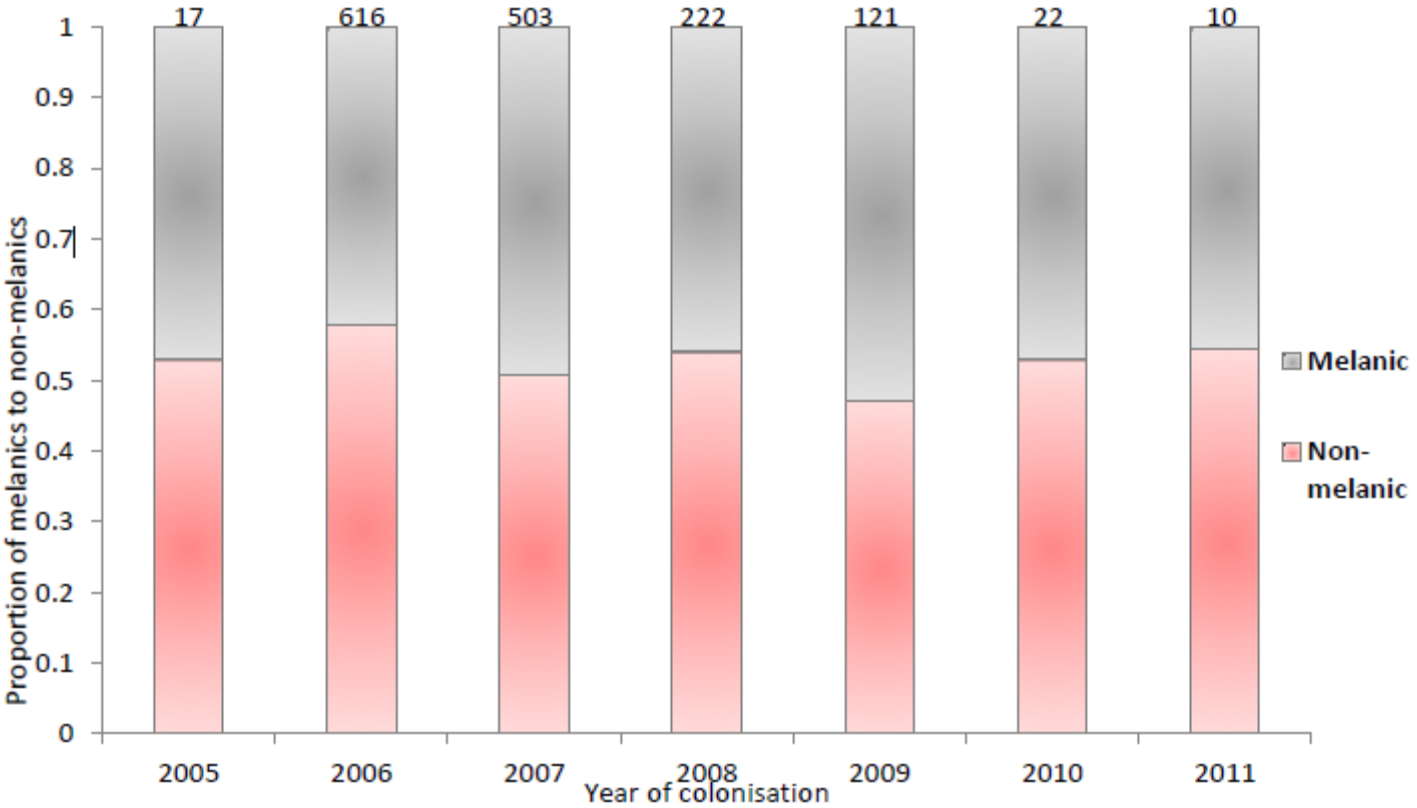
# No difference in proportion of new squares colonised by melanic and non-melanic *H. axyridis* over time

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# Results for complete dataset (2003-2011)

- Colonisation across Britain for all *H. axyridis* was positively affected by broadleaf woodland, urban areas and growing-degree days (GDD)
  - non-melanic forms: broadleaf woodland, GDD and urban areas positively affected colonisation
  - melanic ladybird: broadleaf woodland, GDD, urban areas and rainfall positively affected colonisation) BUT coniferous woodlands negatively affected colonisation

# Results for invasion wave (2003-2007)

- Colonisation across Britain for all *H. axyridis* (no difference between non-melanic and melanic forms) was positively affected by broadleaf woodland, urban areas and GDD

# Influence of covariates

- For both datasets:
  - distance to invasion point was positively correlated with rain and negatively correlated with GDD
  - recording intensity positively correlated with urban areas
  - growing degree-days were found to be negatively correlated with rain, and coniferous woodland, while coniferous woodland was also found to be positively correlated with rain
- So colonisations less likely to occur where it is cold, rainy and in coniferous woodland

# Summary

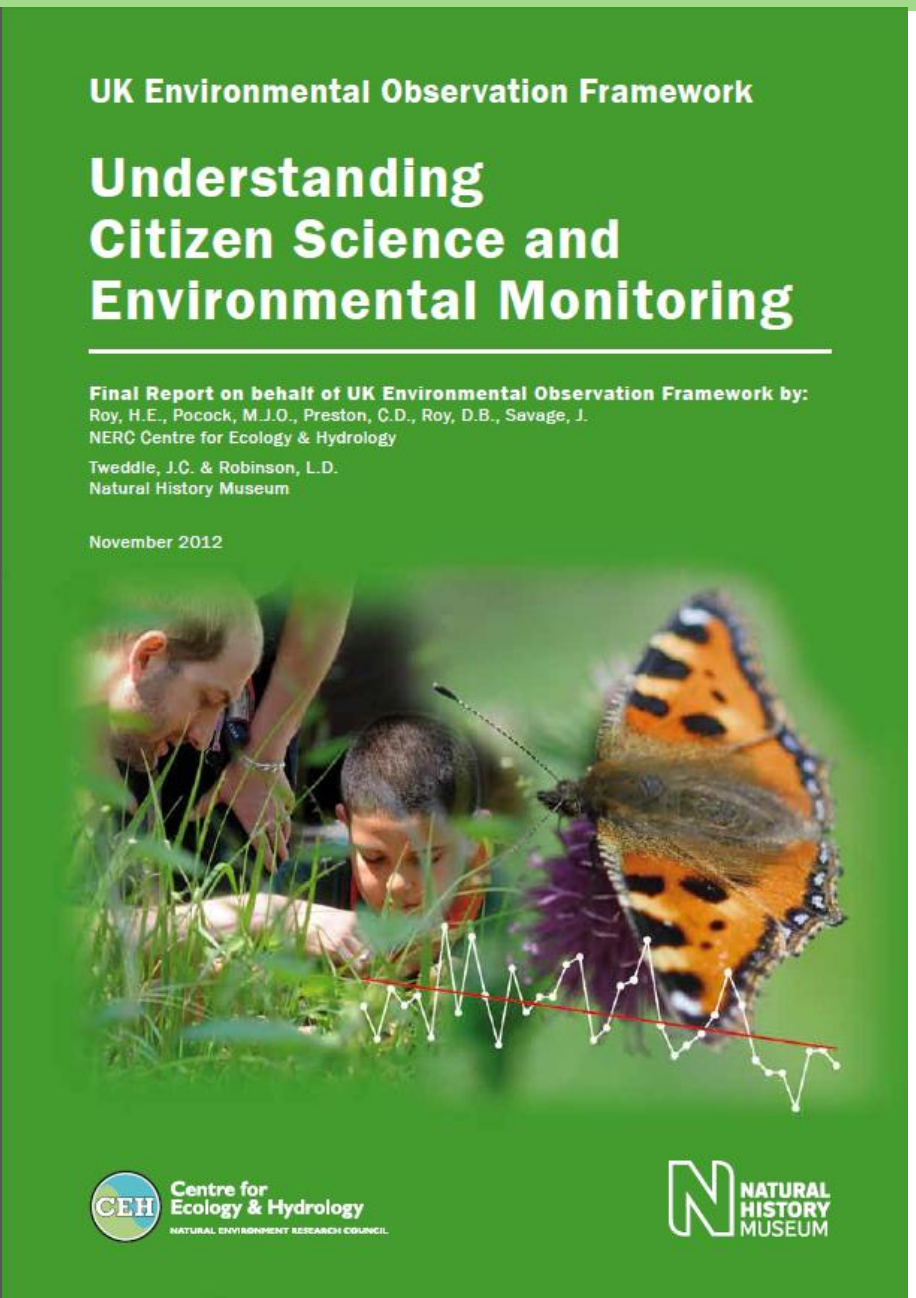
- Broadleaf woodland, urban areas and GDD had the main influence on colonisation events
- No difference found in the distribution patterns between the melanic and non-melanic forms of *Harmonia axyridis*
- …but GDD stronger influence on non-melanic compared to melanic *Harmonia axyridis*

# Non-melanic?

# Next steps

- Time dependent covariates – is spread more likely in warmer years, where more GDD are accumulated (so far we contrasted 10-km$^2$ that are warm on average with ones that are cold on average)
- Quantify spread as wave front rather than between grid cells – understand better how landscape heterogeneity influences spread (e.g. do corridors of suitable habitat increase risk of invasion in some areas?)

# Interested in citizen science…




- UK-EOF commissioned report just out
  - Systematic review of citizen science
  - Case studies
  - Interviews with end users of data
- Practical guide available today

Both also available from:

www.ukeof.org.uk

# Acknowledgements