Received: 8 October 2020 | Accepted: 21 December 2021

DOI: 10.1002/pan3.10325

PEOPLE AND NATURE | BRITISH ECOLOGICAL SOCIETY

RESEARCH ARTICLE

UK wildlife recorders cautiously welcome range-shifting species but incline against intervention to promote or control their establishment

James Cranston[1] | Sarah L. Crowley[1,2] | Regan Early[1]

[1]Centre for Ecology and Conservation, College of Life and Environmental Sciences, University of Exeter, Penryn, UK

[2]Centre for Geography and Environmental Science, College of Life and Environmental Sciences, University of Exeter, Penryn, UK

Correspondence
James Cranston
Email: j.cranston@protonmail.com

Regan Early
Email: r.early@exeter.ac.uk

Funding information
Natural Environment Research Council, Grant/Award Number: NE/N008669/1

Handling Editor: Helen Roy

Abstract

1. The global redistribution of species due to climate change and other anthropogenic causes is driving novel human–wildlife interactions with complex consequences. On the one hand, range-shifting species could disrupt recipient ecosystems. On the other hand, these species may be contracting in their historic range, contributing to loss of biodiversity there. Given that arriving range-shifting species could also perhaps have positive effects on recipient ecosystems, there is [in principle] a net benefit equation to be calculated. Thus, public opinion on these species may be divided and they may present a unique challenge to wildlife management.
2. We surveyed the opinion of wildlife recorders about the establishment and management of eight birds and eight insects whose ranges have recently shifted into the United Kingdom. We asked whether respondents' attitudes were explained by the species' or respondents' characteristics, and whether or not climate change was emphasised as a cause of range-shift. We also conducted qualitative analysis of the recorders' text responses to contextualise these results.
3. Attitudes to range-shifting species were mostly positive but were more ambivalent for less familiar taxa and for insects compared with birds. Respondents were strongly opposed to eradicating or controlling new range-shifters, and to management aimed to increase their numbers. Whether climate change was presented as the cause of range-shifts did not affect attitudes, likely because respondents assumed climate change was the driver regardless.
4. These findings suggest that it will be difficult to generate support for active management to support or hinder species' redistribution, particularly for invertebrate or overlooked species among wildlife recorders. However, the positive attitudes suggest that on the whole range-shifting species are viewed sympathetically. Engaging with wildlife recorders may represent an opportunity to garner support for conservation actions which will benefit both currently native and arriving species, such as improvements to habitat quality and connectivity.

KEYWORDS
attitudes, citizen science, climate change, human–wildlife interaction, public opinion, range-shift, species' redistribution, wildlife management

1 | INTRODUCTION

Many species' distributions are shifting rapidly in the 21st century as they track climate and habitat change (Pecl et al., 2017). The number and abundance of these 'range-shifting' species moving across national boundaries is rapidly increasing (Chen et al., 2011; Gurney, 2015; Latombe et al., 2020) and studies of their effects on current ecosystems are still few in number. Range expansions into new regions, while being crucial to species adaptation to environmental change, also have the potential to alter and perturb existing ecosystems (Wallingford et al., 2020). There is therefore a pressing need to explicitly consider the role of range-shifting species in conservation and wildlife management. Management implications will vary for different ecosystems, societies and stakeholders (Tebboth et al., 2020) in part due to different ecological conditions but also because of differing public reactions to range-shifting species—the focus of this paper. Species perceived as harmful may encounter negative reactions, while those viewed as threatened may receive more positive ones.

The patterns of movement for these range-shifting species which are moving without human assistance may be complex. Some species may only change their distributions within their historic range while others may show expansions or retractions at range edges (Lenoir & Svenning, 2015). Differing patterns could affect public reactions. Here, we focus solely on those species which are contracting or static in their distribution in historic regions but are expanding into new regions (here after range-shifting species) and the implications of these arrivals for their new regions. Climate change's role in shaping these perceptions is unknown despite its being a well-established driver of range-shift. On the one hand, climate change's association with newly arriving species could tarnish them as dangerous 'climate opportunists' as climate change is considered a serious threat to humanity and mostly harmful to biodiversity (Newbold, 2018). On the other hand, climate change is anthropogenic in origin, therefore people could view arriving species as 'ecological refugees', which we have a moral responsibility to protect (Urban, 2020).

The importance of public attitudes in shaping ecological outcomes has been demonstrated by research into biological invasions (Andreu et al., 2009), species reintroductions (Klich et al., 2018) and human–wildlife interactions (Baruch-Mordo et al., 2009). A compelling example of how public opposition can hinder conservation efforts was the Scottish government's campaign to lethally eradicate non-native hedgehogs from South Uist (after a deliberate introduction in 1974), which subsequently provoked a reactive coalition made up of opposed NGOs—the 'Uist Hedgehog Rescue' (Crowley et al., 2017). A better understanding of what shapes people's attitudes to species may help inform conservation strategies. For example, species that are viewed as charismatic could act as flagship species (Ma et al., 2016), leveraging public support for conservation of associated range-shifting species. Alternatively, species that are viewed negatively which may be more challenging to conserve, for example wasps (Sumner et al., 2018). Awareness of negative attitudes could suggest a need for public outreach and education if these attitudes were rooted in misunderstanding (Bath, 1989). Other species may pass beneath the public's notice altogether, which could avoid concern, but could also make it more difficult to enact measures that promote or restrict their establishment. Of course, attitudes can vary greatly between human communities so differences between stakeholder groups is important to inform future management strategies. In addition, attitudes can shift over time (Jones et al., 2020). Therefore, surveying current attitudes can serve as a benchmark for future monitoring, which could then be used to inform policy for example evidence of hardening attitudes in future studies might suggest a backlash against a particular management strategy and a possible need for review.

Investigating attitudes to range-shifters is timely (Naujokaitis-Lewis et al., 2018). The rate of climate change continues to accelerate, and it is uncertain how many species will be able to shift quickly enough to track their climatic niche across increasingly human-dominated landscapes (Schloss et al., 2012). This has led some scientists to advocate new and bold approaches, such as assisted translocation (Lunt et al., 2013). For species which require large-scale interventions, public attitudes are likely to be important, particularly in densely populated areas or where there is potential conflict (O'Rourke, 2014). In either scenario, the evidence strongly suggests that management is more effective when stakeholders are successfully engaged (Crowley et al., 2017; Redpath et al., 2013). Apart from the evidence for its efficacy, stakeholder engagement is a normative concern. Democratic governance relies on accountability to citizens and public opinion therefore forms an important input into legitimising decisions (Berry et al., 2019; Kiss, 2014).

Wildlife recorders are a key group with whom to engage when considering range-shifting species. We defined wildlife recorders as volunteers contributing to datasets of the times and locations of species occurrences, often as part of a local or national scheme. Recorders are often the first to both identify and report invasive species and also note the arrival of range-shifters (Brown et al., 2018). In addition, they provide much of the raw data underpinning conservation decisions in the United Kingdom (Pocock et al., 2015). As such, wildlife recorders are a group likely to have greater awareness of range-shifts than the wider population, meaning that their attitudes may be more developed and better informed. Furthermore, recorders are interesting in their own right, as their attitudes could indicate their willingness to adapt their recording to better inform decision-making on range-shift management. The United Kingdom provides a useful case study, as it has a well-documented fauna and

a very active volunteer recording community. There have also been a considerable number of arriving range-shifters over recent years (Gurney, 2015).

Many factors, aside from climate change, might influence wildlife recorders' attitudes to range-shifters. There is considerable evidence that taxonomic group has a strong effect on public attitudes, and there is a growing body of theory covering possible mechanisms (Troudet et al., 2017). Furthermore, recorders are a heterogeneous group (Dawson & Martin, 2015). Individuals' attitudes might also differ based on their personal attributes, including level of knowledge about range-shift or their views on the relationship between humans and nature (Sharp et al., 2011).

Our study explores how range-shifting species are viewed by wildlife recorders in the United Kingdom through an online survey. Specifically, we sought to learn how aware recorders were of different range-shifting species and whether they viewed range-shifters predominantly positively or negatively. We asked the extent to which the identity of the range-shifting species, and the attributes of respondents, affect attitudes. Finally, we asked what attitudes recorders expressed towards potential management of range-shifters/new arrivals, including both positive management aimed to help them establish and spread, and negative management to control or prevent arrival. This was coupled with additional thematic analysis of respondents' written answers that explained their attitudes to the species and their management as well as how they perceived climate change as affecting those attitudes. If attitudes are positive, then future management may be drawn towards assisting range-shifting species and it may be harder to protect recipient ecosystems from any that are harmful. On the other hand, negative attitudes could drive management to make it harder for threatened species to shift their ranges.

2 | MATERIALS AND METHODS

2.1 | Survey participant selection

UK wildlife recorders' perspectives on range-shifting species were collected using the online survey software LimeSurvey (http://www.limesurvey.org). A targeted sampling strategy was used to maximise the response rate from our population of interest and the survey was open for responses between 15 April 2019 and 1 June 2019. A link to the survey was distributed to recorders using selected Facebook groups. These groups were identified using two methods. Initially, all schemes from the Biological Records Centre and British Trust for Ornithology affiliated bird clubs which had a detectable presence on Facebook were contacted. Second, Facebook groups were searched for using the following terms: 'Field', 'Natural History', 'Naturalist' and 'Record*'. A link to the survey was also posted on the National Biodiversity Network website and in the National Forum for Biological Recorders newsletter. The survey design and administration for this study was approved by the College of Life and Environmental Sciences' Ethics Committee (Penryn) at the University of Exeter, reference eCORN000039. We ensured that respondent's written informed consent was obtained before they participated. No compulsory questions were included to avoid steering respondents to answer questions on which they had no opinion and minimise the effects of survey fatigue. A full copy of the questionnaire is available in Appendix 1, including the welcome page where respondents were provided with contact details for the lead researcher, the purpose of the study and a check box to indicate their consent to participate.

2.2 | Survey design

2.2.1 | Recording behaviour, level of knowledge and relationship with nature

Three questions were asked to characterise respondents' recording behaviour. First, respondents were asked which taxonomic groups they recorded from a checklist. Two questions then assessed the respondents' level of engagement: respondents were asked how long they had been sharing or submitting wildlife sightings or records, then respondents identified which recording activities they performed. This was treated as an ordered factor with four options: sharing wildlife sightings informally (e.g. via Facebook) (1—least engaged), submitting sightings as records for a Scheme (2), verifying biological records (3) and organising a recording Scheme (4—most engaged). The maximum engagement level of each respondent was recorded.

Level of knowledge was analysed similarly to Verbrugge et al. (2013): respondents were asked whether they had heard of any species establishing in the United Kingdom having arrived under their own powers of dispersal. It was clarified that this did not include human-introduced species. If confident, respondents were asked to name a naturally establishing species. Three response levels were recorded: no (0); yes, but could not name a correct example (1); yes, and named a correct example (2).

We characterised the respondent's relationship with nature using a shortened survey from (Verbrugge et al., 2013). This consisted of 12 Likert-type questions, with three testing each of four theoretical modes of relationship: master (humans stand above nature and can exploit if for their needs), steward (humans stand above nature but have a responsibility to preserve it), partner (humans and nature are separate entities which should work equally together to develop) and participant (humans are both biologically and spiritually part of nature, no dualistic ontology) outlined in de Groot et al. (2011) and de Groot and van den Born (2003). We recorded the participant's mean score for each set of three questions evaluating their manner of human–nature relationship. We interpreted the mode with the highest score as indicating the strongest alignment.

Respondents' age, gender, level of education and postcode were collected to contextualise the results and to help control sources of potential unknown variation. Employment in the wildlife sector was also included as it has been demonstrated to affect attitudes to species management in the literature on invasive and pest species (Bremner & Park, 2007).

2.2.2 | Climate change experimental approach

In our experimental approach we either presented an image of a road sign against a neutral background displaying the term 'climate change' or a control image identical but displaying the word 'information'. Each image was accompanied with a brief explanation that new species were establishing in the United Kingdom, either referencing climate change (experimental treatment) or not (control). Respondents were then asked to think about climate change (experimental treatment) or species range-shift (control) and write down the first word(s) or phrases which came to mind (Appendix S1). Later in the survey we asked respondents whether they thought that the arrival of species due to climate change had distinct management implications, compared to other drivers of range-shift.

2.2.3 | Attitudes to species and their management

Each respondent was shown four species vignettes: two vertebrate and two invertebrate range-shifters selected at random from a pool of 16 animals (Table S1). These species were chosen to represent a broad taxonomic range, were all recent arrivals (<30 years) and had English common names and photos available. Vignettes were presented in a random order to avoid order effects (Auspurg & Jäckle, 2017). The vignette consisted of a header repeating the information shown previously in the climate change experimental treatment or control as appropriate, followed by an image of the species obtained from Flickr. We attempted to choose neutral images, where the subjects were at rest, in centre frame against natural backgrounds, similarly to Borgi and Cirulli (2015). We also presented the common and scientific species names, a written description of its appearance, its habitat preference and average body length in centimetres. As information on impacts and distribution were not equally available across our chosen species we did not incorporate information on these aspects in the vignettes.

For each species, we asked respondents whether they had seen the species in the United Kingdom. They were then asked how they felt about the species establishing in the United Kingdom on a response scale of seven options from very negative (1) to very positive (7). Respondents were then presented with five different management actions for each species (Table 1), about which they rated their feelings along the same scale. Respondents could also respond to some open text questions on the attitude and management questions, which we used for qualitative analysis.

TABLE 1 Management options for species presented to respondents. The common species name from the vignette was used in place of the 'species' placeholder

Management options
Remove—management should actively try to reduce 'Species X' populations and if feasible remove them
Mitigate—management should try to decrease 'Species X' populations where possible and control them if not
Non-intervention—management of 'Species X' should be avoided where possible and minimal where not
Adapt—management should try to increase 'Species X' populations where possible and conserve them if not
Support—management should actively try to increase 'Species X' populations and if feasible introduce them

2.3 | Statistical methods

We constructed a multinomial logit model in R (R Core Team, 2020) to describe respondent attitudes to arriving range-shifters and infer which factors affected those attitudes. Answers to questions regarding attitudes were collapsed into three categories for each response: positive (original response = 5 (a bit positive), 6 or 7 (very positive)), negative (original response = 1 (very negative), 2 or 3 (a bit negative)), or neutral (original response = 4 [neutral]). We modelled these three categories using a Bayesian multinomial model using the R package BRMS (Bürkner, 2018). We investigated the fixed effects of respondent gender, education, age, years recording, level of knowledge, employment in the wildlife sector, engagement with recording, the climate change experimental treatment and whether they had seen the species or if it was part of a group they recorded. We also included species and respondent as random effects.

To help regularise the model, all fixed effects were estimated using a horseshoe prior. Following (Piironen & Vehtari, 2017) we determined the global scale parameter from an a priori assumption of the expected ratio of zero to non-zero coefficients. We chose 0.33. The prior for the standard deviation of both random effects was weakly informative (Student's t, $df = 3$, mean = 0, scale = 2.5). Model convergence was assessed using visual examination of trace plots and the Gelman–Rubin diagnostics (Brooks & Gelman, 1998), which for all parameters was under 1.05. Bulk and tail estimated sample sizes were >1000 for all parameters. We followed the same process to model respondents' attitudes to the five different management options as a multivariate model, but we also included attitude to the species as a fixed effect. We report the posterior mean and lower (LCI) and upper (UCI) 95% credible intervals for all model parameters stated in the results.

2.4 | Assessing the rationale underlying attitudes through thematic coding

We explored the written answers accompanying each quantitative question on attitudes in order to identify 'themes' in the underlying rationales which might explain respondents' attitudinal responses to range-shifters. Coding was carried out in NVivo 12 (QSR International, 1999) using an inductive approach to create a novel framework to describe the responses. In order to tie themes to attitudes, we had to adopt two approaches. For the question on attitudes to species we simply calculated, by theme or subtheme, the proportion of reference coded that came from a respondent with a

positive, neutral or negative attitude to that species. However, for the question on attitudes to species management, we had to classify respondents' attitudes into clusters due to the multidimensional nature of the question (five management aspects), using multiple correspondence analysis (MCA) (Rouanet & Le Roux, 2010). We then plotted the proportion of references coded that came from a respondent with a given attitude (first question) or assigned cluster (second question) for each theme or subtheme.

3 | RESULTS

3.1 | Respondent characteristics

In total, 506 respondents clicked on the survey link and 315 continued to survey completion (median time to complete 21 mins). The respondents had a median age of 56 (Q1 = 44; Q3 = 63), older than the UK median (39), were significantly male biased compared to the 2011 UK population census (63.5% male, Figure S1), and had attained higher levels of educational qualification than expected relative to the 2011 census (Figure S2). We found 98% of our respondents were aware of range-shifting species before taking the survey, with most able to name at least one recently arrived species (Figure S3). Respondents represented a spectrum of involvement with UK recording (Median years recording = 10, Q1 = 5, Q3 = 25, Figure S4). 40.6% of respondents self-identified as working in the wildlife sector. Respondents most strongly aligned with a 'stewardship' vision of nature (Stewardship = 241, Participant = 9, Partner = 3, Master = 1, Tied scores = 61). Respondents were distributed across the whole of the United Kingdom (Figure S5).

3.2 | Wildlife recorders attitudes to range-shifting species

Respondents held positive attitudes to range-shifting species, with 60.2% being 'a bit positive' or more, 35.6% neutral, and only 4.2% 'a bit negative' or more (Figure 1). Results broken down by species and taxonomic groups showed that bird species were viewed most positively, followed by dragonflies; the shield bugs and the wasp (*D. saxonica*) were viewed least positively. However, even for *D. saxonica* the majority of people held a neutral rather than negative attitude (Figure S6).

3.3 | Factors important to attitudes on range-shifting species

The climate change treatment did not appear to effect respondents' attitudes to range-shifting species and respondent's frequently mentioned climate change when prompted for words they associated with range-shift. Of our explanatory variables only two were effective predictors of attitudes to range-shifting species. We found that when respondents had seen the species that they were being asked about (Parameter log-odds $_{\text{positive vs.}}$ negative response mean = 1.76, LCI = 0.34, UCI = 2.51) or when it was part of a group they were involved in recording (Parameter log-odds $_{\text{positive vs.}}$ negative response mean = 1.45, LCI = 0.87, UCI = 2.06) they were more likely to have a positive attitude towards it (Figure 2a). All other fixed effects (see Section 2.3) in the converged model were small (95% credible intervals overlapped 0). However, the effect of respondent (Std. Dev. log-odds *positive* vs. *negative response*: mean = 2.52, LCI = 1.95, UCI = 3.15) and species (Std. Dev. log-odds *positive* vs. *negative response* mean = 1.53, LCI = 0.96, UCI = 2.40) was large relative to the effect of whether the species was in a recorded group or whether it had been seen, Figure 2b. All of our species groups were recorded by at least a third of recorders in our sample (Figure S7).

3.4 | Attitudes to management intervention either to promote or restrict range-shifting species

Wildlife recorders most favoured a non-interventionist approach, which was the only option with more positive attitudes

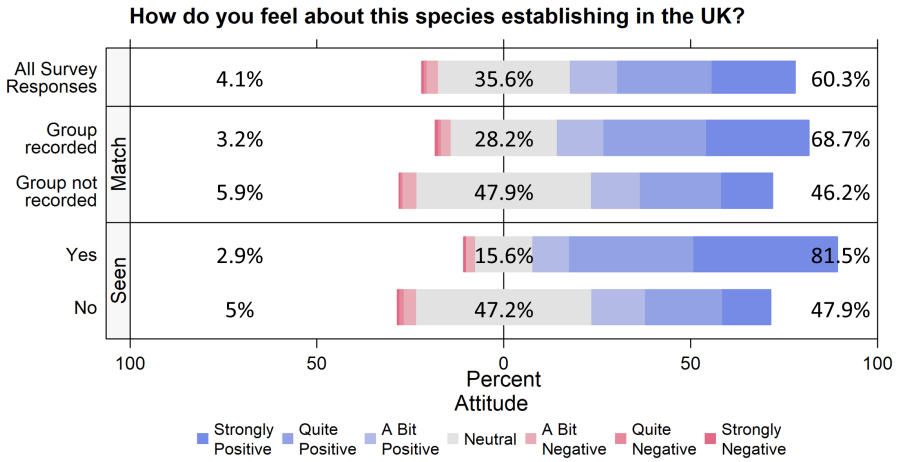


FIGURE 1 Respondent attitudes towards the establishment of new range-shifters in the United Kingdom. Positive attitudes are shown in blue, neutral in grey and negative in red. All responses are summarised at the top, responses below are split by those who had seen the range-shifter or not and those who did or did not habitually record that species' taxonomic group

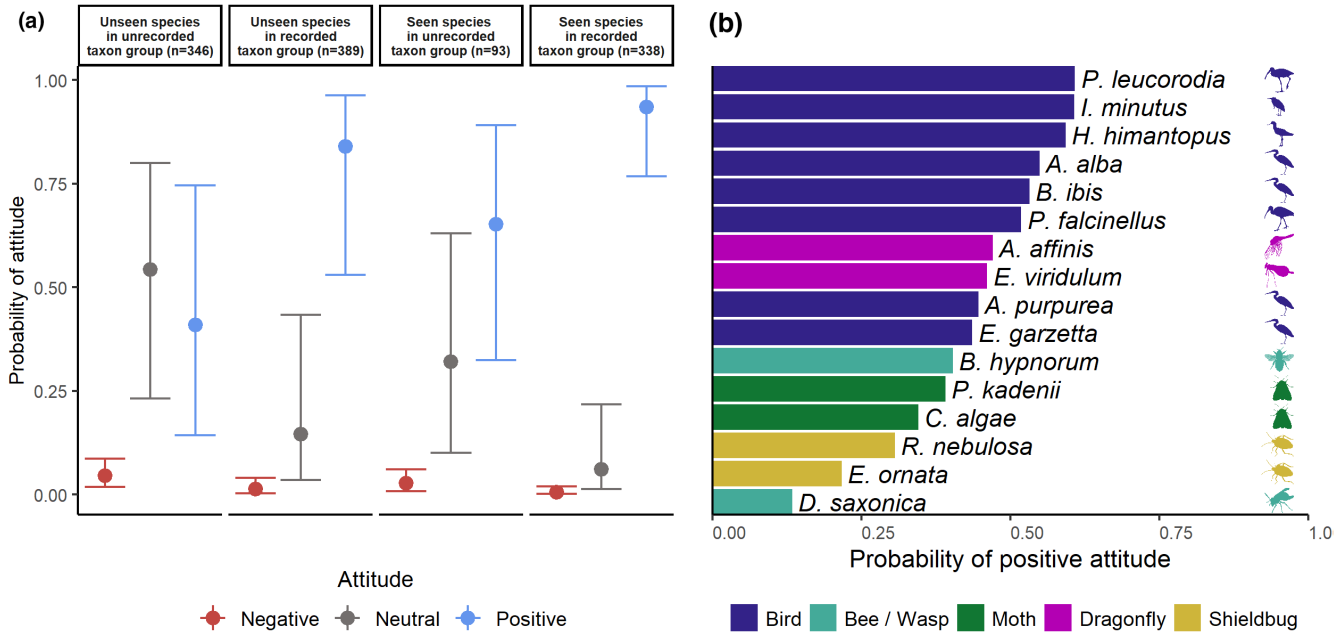


FIGURE 2 (a) The predicted probability of a respondent having a positive (blue), neutral (grey) or negative (red) attitude to a species depending on whether they had seen the species and whether it was in a taxonomic group they recorded. The point shows the median of the posterior probability and the bars the 95% credible intervals. (b) The predicted probability of a respondent having a positive attitude for a given species (coloured by taxonomic group)

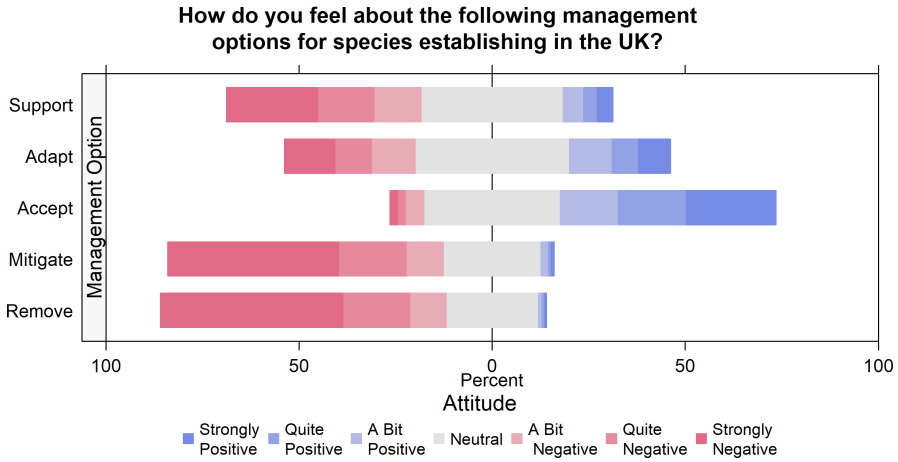


FIGURE 3 Respondent attitudes to the five management options presented in full in Table 1, attitudes are colour coded from very negative (dark pink) through neutral (grey) to very positive (dark blue)

(56.2%) than negative (8.6%) (Figure 3 and Figure S8). Adapting existing ecosystems to cope with range-shifters (P[Pro], mean = 0.26 LCI = 0.24, UCI = 0.29) was viewed more favourably than supporting range-shifters (P[Pro], mean = 0.13, LCI = 0.11, UCI = 0.15). There was less opposition to supporting range-shifters (P[Anti], LCI = 0.48, UCI = 0.53) than there was to controlling (P[Anti], mean = 0.71, LCI = 0.69, UCI = 0.74) or removing them (P[Anti], mean = 0.74, LCI = 0.72, UCI = 0.76). There was no difference in approval between mitigation and removal. Attitudes to management options for any given species were strongly related to the attitudes respondents held to the species themselves (Figure S9).

MCA found four clusters in the quantitative responses to questions about range-shifters' management, and we interpret them as loosely representing four putative attitude groups: range-shifter supporters, non-interventionists, neutrals and range-shifter wary (Figure S10).

3.5 | Emerging themes from qualitative analysis surrounding attitudes to range-shift

Our thematic coding of the free text responses highlighted several recurring themes in our respondents' answers. We identified four

themes which cut across both respondents' explanations for their attitudes to the species themselves (Table S2) and their attitudes to species management (Table 2). However, the prevalence of each theme differed, and different subthemes were identified for attitudes to species themselves and their management. With respect to attitudes to species, the most common theme was the potential direct costs and benefits of the arriving species, both socio-economic and ecological. There was a strong emphasis on social benefits here, often related to personal experiences. The second most recurrent theme was that of generalised principles about human intervention in nature and whether these range-shifters were arriving 'naturally'. Some respondents noted a mixed feeling: they felt positive about the species' establishment but worried about its perceived anthropogenic driver—climate change. The third theme was the respondents' perceived feasibility of managing the range-shifters and only appeared infrequently for this question. The final theme was the idea of nativeness, where some respondents argued that native species should be prioritised over range-shifters.

With respect to species management, the most common theme arising was the costs and benefits of the species in question. However, unlike responses to species themselves, respondents raised the potential costs of range-shifting species and most stated that they would consider management if range-shifters caused negative impacts. Those who thought range-shifters could have a positive impact were more likely to be range-shift supporters, while those who thought that a negative impact was possible were more likely to be neutral (Table 2). The theme around human intervention in nature was expressed more commonly in relation to management than in relation to species themselves, revolving around ideas of letting a range-shifter develop its own path naturally without management. Animal rights emerged as a minor subtheme within this theme. The theme of costs and benefits of management action received substantial attention, with considerable scepticism of the potential efficacy of management. On the theme of nativeness, there was a majority view that management should protect native species over range-shifters. However, a minority argued that all arriving range-shifters should effectively be viewed as native and therefore any negative impacts should be managed similarly to impacts from resident problematic species.

With respect to whether respondents thought that a causal effect of climate change on species range-shifts had implications for management we found a range of perspectives (Table S3). Some respondents thought that climate-driven range-shifters deserved specific attention as they might be losing range elsewhere, would be important for future climate adaptation, and due to a moral responsibility arising from humanity's culpability for climate change as 'they are being pushed out of their range, and it's our fault!'. A similar number of respondents thought that management to restrict climate-driven range-shifters was futile, arguing that the focus should be on the climate change 'cause' not the species 'symptoms'; preventing the arrival of even harmful species was too difficult and, even though climate change was anthropogenic, the species dispersal response to it was natural and should be accepted:

> I think that this is a paradox as global warming is a direct result of human impact yet in species colonisation context[s] humans should stay out of it.

Finally, around a third of references coded suggested that climate change was not the most important factor in forming a management response to these species. Instead, these participants thought that the impact of range-shifting species on the recipient ecosystem should shape the response, or that people's responsibility is to protect biodiversity as a whole rather than to focus on specific cases.

4 | DISCUSSION

This study aimed to discover how range-shifting species are viewed by a key stakeholder group, and consider how far these perspectives might reflect public opinion and impact wildlife management. We found that awareness of the presence of range-shifting species was high. Moreover, most recorders had positive attitudes towards these species establishing. The species in question and recorder familiarity with the species both predicted recorders' attitudes to the establishment. However, this positivity did not manifest as favouring active forms of management to assist establishment. Instead, most favoured non-intervention in the range-shift process. Recorders were also strongly against efforts to hinder range-shift.

These positive responses indicate that wildlife recorders value range-shifters. The sources of this value emerged in the qualitative comments. Many respondents talked about personal experiences with the species, for example 'fabulous bird, what a joy to see them', others about ecosystem services (principally pollination) and reduced extinction risk (Table S2). This value suggests that people perceive socio-ecological benefits from the arrival of range-shifters.

The variation that we found among recorders' attitudes towards different species suggests that there will be winners and losers in the battle for positive public reception. This finding supports the existing literature on taxonomic biases which finds that invertebrates are often perceived more negatively than vertebrates when considering reintroductions (Seddon et al., 2005) and invasions (Bremner & Park, 2007). This effect is lessened for aesthetically attractive species like dragonflies and butterflies (Shipley & Bixler, 2017), as we found. In fact, it is perhaps surprising that attitudes were mostly neutral rather than negative for less aesthetic invertebrates. This probably reflects recorders' desire for further information on which to base their judgements. Their opinions were often balanced, for instance that some scary or unpopular species such as wasps also provided important ecosystem services such as pest control. This more reserved stance may not be shared by less informed groups. Species charisma has been shown to be very influential in both the management and spread of invasive species (Jaric et al., 2020) and our results suggest that this may also be the case for range-shifters. Further research could refine what attributes that people are responding to distinguish better and less popular species to better inform management decisions. For instance, by highlighting which

TABLE 2 Our coding framework's themes applied to written responses about range-shifting species management, each illustrated by a quote. RC indicates the number of references coded. The bar chart accompanying each theme and subtheme shows the percentage of references coded that were from each group of respondents within each theme (support range-shifters = blue, non-intervention = yellow; neutral = grey, wary of range-shifters = red. Dashed lines show intervals of 25%)

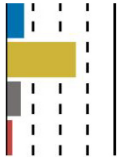
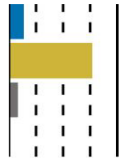
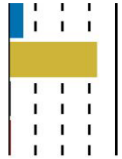
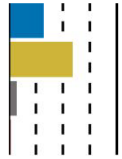
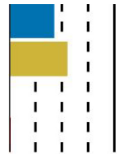
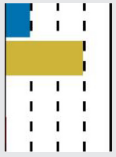
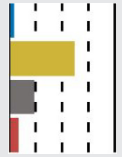
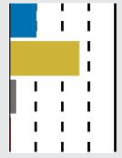
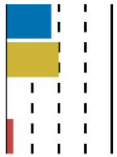
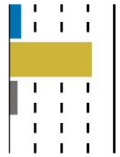
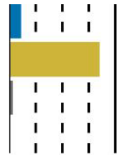
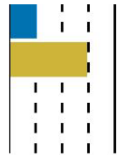
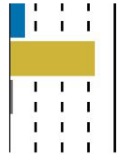
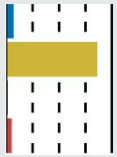
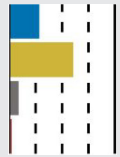
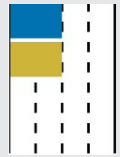
Theme	Subtheme	Summary	Example quote
Cost/Benefit ratio from arrival of range-shifting species (RC = 539) 	Positive effects on recipient ecosystems (RC = 51) 	Range-shifters will affect the recipient ecosystem positively, via both ecological (e.g. increased resilience) and social (e.g. eco-tourism) mechanisms	'Climate change may mean native species can no longer tolerate conditions so better to have a replacement species rather than none at all'
	Minimal effects on recipient ecosystems (RC = 150) 	Range-shifters will have minimal effects, either positive or negative, on the recipient ecosystem	'There is no reason to control this species since it is not harmful'
	Negative effects on recipient ecosystems (RC = 273) 	Range-shifters are perceived as having potentially negative effects on the recipient ecosystem, with a focus on risk rather than proven effects	'As a non native species with potential to become invasive (I would assume) they shouldn't be actively encouraged to establish. It's challenging to control populations and would be costly and resource heavy to do so to the extent of extermination'
	Conservation status of the range-shifter (RC = 65) 	Threatened range-shifters deserve conservation assistance, actions to promote the global conservation status of a species are important	'Species specific actions should only be prioritised against species that are threatened'
Human intervention in nature (RC = 274) 	Animals' rights (RC = 14) 	Management must respect the rights of sentient creatures to exist	'Every living thing has the right not to be persecuted'
	Allowing nature to take its course is preferable to human intervention. (RC = 260) 	Allowing natural processes to shape range-shifts will result in better outcomes than trying to manage them directly	'Let things alone and Mother Nature will look after itself without any interference'

TABLE 2 (Continued)

Theme	Subtheme	Summary	Example quote
Cost/Benefit ratio of management actions (RC = 197) 	Management to control range-shifters will have negative ecological costs (RC = 27) 	Management to control range-shifters will have associated negative effects on the recipient ecosystem, for example, insecticide use	'It seems likely that reduction by 'management' would have unforeseen undesirable implications for other species'
	Management to help range-shifters will have additional positive benefits (RC = 23) 	Management to help range-shifting species will have additional positive effects on the recipient ecosystem, for example, habitat improvement	'Providing habitat for these colonisers often provides much needed habitat for other struggling UK species'
	Management to assist range-shifters gives no additional benefit (RC = 90) 	Management to assist range-shifters establish will not convey any additional benefit to the chances of establishment success	'There is no need to actively conserve/increase the species as it is spreading naturally and numbers are rising'
	Management to reduce risk from range-shifters is too difficult (RC = 57) 	Management attempts to control range-shifters will be very expensive and ineffective, some may be politically or practically infeasible	'I suspect it's pretty impossible to do anything to stop (or help) this species'
Nativeness (RC = 57) 	Natives should be prioritised for support (RC = 46) 	Native species should be our priority. We should conserve native species rather than support range-shifters and protect native species in favour of range-shifters	'I think we should be focusing our conservation efforts on our native species first'
	Range-shifters should be managed as if they were native (RC = 11) 	There should be no difference in our treatment of range-shifters or native species. The arrival of range-shifters is 'natural' so they should be considered equal	'As they arrived of their own accord might as well be considered native and managed as native wildlife'

harmful species would represent a risk of public resentment against control efforts or, conversely, which species might be used to attract funding or public engagement.

Our results may not generalise to less ecologically informed publics or other demographic groups (Figure S4). In the future, it would be useful to compare these results with those of other stakeholders, such as landowners, land managers and scientists to better understand potential differences. The United Kingdom is an outlier compared to most countries in its human population density and GDP. Evidence suggests that more established economies have greater environmental concern (Franzen & Vogl, 2013) and distance to wildlife (mediated by population density) also affects attitudes (Karlsson & Sjöström, 2007). Therefore, it would be valuable to compare how attitudes might vary across different regions, including developing countries with less influential conservation movements. The possibility of a defensive 'island mentality' from the presence of a geographic barrier (such as the English Channel) may also create more negative attitudes to range-shift than in more connected regions like North America or mainland Europe.

Our finding that participants were more positive about species with which they had some experience suggests that familiarity can make it easier to mobilise support. Public engagement, through recording or events such as BioBlitz, may therefore be a powerful tool to increase positive public opinion (Postles & Bartlett, 2018). We interpreted both having seen the species and recording the species' taxonomic group as linking to the same latent construct: familiarity. This is important as familiarity is unlikely to have a fixed relationship with attitude over time. For example, as Lynx continue re-establishing in Eastern Europe, attitudes to them appeared to have worsened as they became more abundant and more negative impacts appeared (Červený et al., 2019). Similarly, changes have occurred in the case of non-native parakeets establishing in the United Kingdom, with some groups hardening views as impacts emerge and some growing more tolerant as the parakeets integrate into their sense of place (Crowley et al., 2019). Future studies will be needed to investigate how attitudes may change over time and the extent to which familiarity might mediate these changes to produce complex dynamics. As well as range-shifters, the number of invasive alien species establishing is forecast to increase with climate change (Beaury et al., 2020). Wildlife recorders appeared able to distinguish these two different but related phenomena, but it may be that attitudes towards the phenomena could interact with each other. The relationship between attitudes to invasive species and attitudes to range-shifting species may be an important area of future research. The effects on attitudes found where the species matched the recorders' group of interest or had been seen by them might not have been mediated by familiarity but rather by other intermediate factors, such as physical proximity, species abundance, recorder behaviour or positive interactions leading to differing affective relationships (Lorimer, 2007). However, our first interpretation is supported by the absence of a spatial pattern in attitudes and the qualitative data's emphasis on personal experience.

The climate change experimental treatment did not affect respondents' attitudes. This ties into the thematic analysis (Table S3), where we saw 40 respondents argue that the focus should be on species impacts rather than cause of arrival, echoing previous research on attitudes towards invasive species (Van der Wal et al., 2015). However, it is also possible that the experimental treatment was ineffective as most respondents attributed range-shift to climate change, with or without the prompt. This interpretation is supported by the text responses given to the control treatment where there were frequent references to climate change without any prompt. The significant remaining individual variation in attitudes in our models hints that the complexity in predicting responses may be derived from highly personal factors such as individuals' belief systems.

Disentangling these factors is likely to require a mixed of quantitative and qualitative approaches. In addition researchers will need to recognise the subjectivity that they bring to their studies and implement approaches to account for this in research practices (Brittain et al., 2020). We suggest that more direct metrics such as risk perception (Taylor et al., 2014) and views on the 'dynamism vs balance of nature' (Ladle & Gillson, 2008) may be a productive avenue in future research exploring individual variation. For applied regional studies, the local contexts and respondents' sense of place may also be important (Masterson et al., 2017). Understanding the different lenses with which people view range-shifting species would allow bespoke communications to different stakeholders and potentially a predictive model for potential for conflict (McCleery, 2009).

The metrics we used to categorise respondents' engagement with recording had little apparent effect on attitudes, although this could be because small differences were not detectable with our obtained sample size. Our study focused solely on wildlife recorders and there are likely to be differences between our findings for this group and the views of other publics. An important distinction is that wildlife recorders are likely to be more scientifically aware of nature than the general public (Figure S4). Therefore, they may be more likely to hold views on range-shifting species, one way or the other compared to others who have not previously considered the issue. Even if the latter use and enjoy the same natural spaces, other public groups may be more likely to draw from more indirect material when forming their opinions such as media articles or attitudes to wildlife in general (Brossard & Nisbet, 2007). Wildlife recorders may also be more aware of the ecological roles of less popular species like wasps and therefore happier to tolerate arriving range-shifters (Schönfelder & Bogner, 2017). Most wildlife recorders in our sample aligned with 'stewardship' in their relationship with nature and other alignments might indicate different attitudes towards range-shifters. For example, we could imagine supporters of 'compassionate conservation' such as animal rights activists taking a stronger stand against controlling harmful arrivals, or against assisted translocation if it were seen to compromise welfare (Callen et al., 2020; Griffin et al., 2020). Those who derive payment from ecosystem services such as developers or farmers could seek to incorporate these species into such schemes such as biodiversity offsets with ramifications for broader conservation.

The strong relation between attitudes to species and to their management is intuitive but not inevitable (Lindemann-Matthies, 2016).

The demonstration of this relationship shows that changing views of species are likely to have knock-on effects on management through changes in public support. However, our study did not cover all management scenarios and some information that could have informed respondents' attitudes towards management was not available, for example estimates of cost, feasibility, effectiveness, species impact and welfare implications. It will be important to investigate in the future how these self-reported attitudes translate when respondents are given more detailed scenarios, or real case studies. But there is some evidence that experimental surveys such as this can align well with real world behaviour (Hainmueller et al., 2015).

The predominance of support for non-intervention echoes Ohsawa and Jones (2017) who found a majority of surveyed park managers preferred not to intervene at the prospect of species range-shifting through the Japanese archipelago. However, the support for the non-interventionist management option is striking as it sits at odds with the typical style of conservation management in the United Kingdom, which is frequently characterised as interventionist (Adams, 1997). Therefore, the finding that most respondents expressed a 'stewardship' relationship with nature could be further deconstructed into two more precisely defined 'stewardship'-type relationships. The first more traditional aspect of stewardship is the archetype of the pragmatist farmer manager who inventories and actively supervises nature. The second is a more passive stewardship, protecting nature as its own agent for future generations. The thematic analysis suggests that respondents' preferences for non-intervention could be aligned to both of these aspects of stewardship. Many aligned with pragmatic stewardship, believing that intervention would be ineffective and 'there is no point being like King Cnut and trying to hold the tide back' and seeing 'no need to throw money into trying to increase numbers of a naturally increasing species'. Others aligned with more passive stewardship, emphasising the importance of allowing 'nature' to choose its own path, espousing 'Nature ebbs and flows, …—that's just how it is', and 'if we intervine (*sic*) then it is being farmed'. The prevalence of passive stewardship ideals, in contrast to the UK's typical pragmatic style of conservation, could be linked to the increasing discourse around rewilding and a desire to reduce the intensity of management (Root-Bernstein et al., 2018). A need for wild agency emerges from another comment on range-shifting little egrets:

> No huge sums of money thrown at them, none of this rubbish as per White Storks at Knepp or Ospreys at Rutland—this was the real deal, they colonised by themselves.

Finally, rather than indicating a pragmatic or passive stewardship perspective a preference, support for non-intervention could represent a non-committal 'sitting on the fence' option. This interpretation is supported by qualitative responses from respondents who indicated that they felt they lacked necessary information to make decisions on range-shift management at this time (Sturgis et al., 2014). Untangling these perspectives and their prevalence will help conservationists to understand the public mood in their management of range-shifters.

The lack of support for interventions to support range-shifters could hinder future attempts to translocate species that are unable to move fast enough to track their climatic niche. A previous study on assisted translocation found opposition against moving species outside their current ranges among the British Columbian public (Peterson St-Laurent et al., 2018). In both ours and Peterson's results interventions to reintroduce locally extinct species were not opposed. In our study, attitudes to management often favoured native species over range-shifters when there was a conflict, for example: 'If it's [the range-shifter is] having a deleterious effect on native wildlife then I would support action against it'. We interpret this attitude as an aspect of a 'balance of nature' paradigm, where respondents feel we should protect the natural world from anthropogenic change (a common belief expressed by our respondents, Table 2). However, this paradigm contains implicit value judgements often using a fixed historical baseline as pointed out by another respondent, 'There is an innate compulsion to resist change, to turn the clock back, to control and label species as good or bad'. Conservationists may therefore need to communicate more clearly the alternate paradigm of chaotic, dynamic nature, which is now relatively widespread in academia (Wu & Loucks, 1995) but may be less prevalent among recorders. Recognition of this dynamism will be vital to allow range-shifts to protect vulnerable species from extinction while mitigating the threat to endangered natives (Scheffers & Pecl, 2019).

The opposition to measures to remove range-shifters (Figure 3) superficially suggests that managers may face opposition if they take such action. However, the text responses elucidate this feeling as being contingent on the perception that range-shifters pose little threat. Many respondents were willing to intervene if a threat became apparent. This focus on demonstrated threat appears in conflict with the precautionary principle often invoked in invasion biology, that is, better not to introduce taxa just in case there is a risk (Finnoff et al., 2007). We interpret this as a pragmatic response, demonstrating awareness that efforts to control the propagule pressure and spread of range-shifting species could be more challenging than for introduced species (Essl et al., 2019). In addition, this reluctance to intervene suggests that respondents perceive the threat range-shifters pose to recipient ecosystems is lower than the perceived benefits of action, and points to the need for urgent research into such threats. Respondents favoured adapting recipient ecosystems more than controlling range-shifters themselves, thus they might be more supportive of management if presented with information on vulnerability of recipient ecosystems rather than the riskiness of range-shifters.

In conclusion, we found that wildlife recorders viewed range-shifters more as vulnerable 'ecological refugees' than as threatening 'climate opportunists'. Recorders aligned with a stewardship perspective on range-shifters but were willing to shift their opinions in response to evidence of harm to native species. Different scenarios of range-shifter impact could therefore guide how policy makers might anticipate support and control options being received. Policy

makers should recognise the distinctness of these new range-shifting species from introduced species (Essl et al., 2019). The strong support for non-interventionist management indicates a need for stronger scientific advocacy for vulnerable species of minimal risk—if, in the future, conserving them is predicted to require active measures such as assisted translocation.

ACKNOWLEDGEMENTS

I acknowledge the support of my NERC GW4+ Doctoral Training Partnership studentship from the Natural Environment Research Council NERC grant NE/N008669/1. The wildlife recorders who responded to and helped disseminate the survey. The National Biodiversity Network for and Henry Häkkinen for his help with using CSS in the survey design.

CONFLICT OF INTEREST

Sarah Crowley is an Associate Editor for people and nature, but was not involved in the peer review and decision-making process

AUTHORS' CONTRIBUTIONS

J.C. and R.E. conceived the scope and questions of the study; S.L.C. supported the development of the methodology and refinement of the research questions; J.C. designed the survey instrument with feedback from R.E. and S.L.C.; J.C. distributed the survey and collected the responses; J.C. led the analysis and interpretation of the data with the input of R.E. and S.L.C. All authors contributed critically to the drafts and gave final approval for publication.

DATA AVAILABILITY STATEMENT

The survey design and responses available on the dryad data repository (Cranston et al., 2022). Code for the analysis is available in a public GitHub repository and accessible at https://doi.org/10.5281/zenodo.6371204.

ORCID

James Cranston https://orcid.org/0000-0002-1009-4763
Sarah L. Crowley https://orcid.org/0000-0002-4854-0925
Regan Early https://orcid.org/0000-0003-4108-5904

REFERENCES

Adams, W. M. (1997). Rationalization and conservation: Ecology and the Management of Nature in the United Kingdom. *Transactions of the Institute of British Geographers*, *22*(3), 277–291. https://doi.org/10.1111/j.0020-2754.1997.00277.x

Andreu, J., Vilà, M., & Hulme, P. E. (2009). An assessment of stakeholder perceptions and Management of Noxious Alien Plants in Spain. *Environmental Management*, *43*(6), 1244–1255. https://doi.org/10.1007/s00267-009-9280-1

Auspurg, K., & Jäckle, A. (2017). First equals Most important? Order effects in vignette-based measurement. *Sociological Methods & Research*, *46*(3), 490–539. https://doi.org/10.1177/0049124115591016

Baruch-Mordo, S., Breck, S. W., Wilson, K. R., & Broderick, J. (2009). A tool box half full: How social science can help solve human–wildlife conflict. *Human Dimensions of Wildlife*, *14*(3), 219–223. https://doi.org/10.1080/10871200902839324

Bath, A. J. (1989). The public and wolf reintroduction in Yellowstone National Park. *Society & Natural Resources*, *2*(1), 297–306. https://doi.org/10.1080/08941928909380693

Beaury, E. M., Fusco, E. J., Jackson, M. R., Laginhas, B. B., Morelli, T. L., Allen, J. M., Pasquarella, V. J., & Bradley, B. A. (2020). Incorporating climate change into invasive species management: Insights from managers. *Biological Invasions*, *22*(2), 233–252. https://doi.org/10.1007/s10530-019-02087-6

Berry, L. H., Koski, J., Verkuijl, C., Strambo, C., & Piggot, G. (2019). *Making space: How public participation shapes environmental decision-making*. Stockholm Environment Institute.

Borgi, M., & Cirulli, F. (2015). Attitudes toward animals among kindergarten children: Species preferences. *Anthrozoös*, *28*(1), 45–59. https://doi.org/10.2752/089279315X14129350721939

Bremner, A., & Park, K. (2007). Public attitudes to the Management of Invasive non-Native Species in Scotland. *Biological Conservation*, *139*, 306–314. https://doi.org/10.1016/j.biocon.2007.07.005

Brittain, S., Ibbett, H., de Lange, E., Dorward, L., Hoyte, S., Marino, A., Milner-Gulland, E. J., Newth, J., Rakotonarivo, S., Veríssimo, D., & Lewis, J. (2020). Ethical considerations when conservation research involves people. *Conservation Biology*, *34*, 925–933. https://doi.org/10.1111/cobi.13464

Brooks, S. P., & Gelman, A. (1998). General methods for monitoring convergence of iterative simulations. *Journal of Computational and Graphical Statistics*, *7*(4), 434–455. https://doi.org/10.2307/1390675

Brossard, D., & Nisbet, M. C. (2007). Deference to scientific authority among a low information public: Understanding U.S. opinion on agricultural biotechnology. *International Journal of Public Opinion Research*, *19*, 24–52. https://doi.org/10.1093/ijpor/edl003

Brown, P. M. J., Roy, D. B., Harrower, C., Dean, H. J., Rorke, S. L., & Roy, H. E. (2018). Spread of a model invasive alien species, the harlequin ladybird Harmonia axyridis in Britain and Ireland. *Scientific Data*, *5*(1), 180239. https://doi.org/10.1038/sdata.2018.239

Bürkner, P.-C. (2018). Advanced Bayesian multilevel modeling with the R package brms. *The R Journal*, *10*(1), 395–411. https://doi.org/10.32614/RJ-2018-017

Callen, A., Hayward, M. W., Klop-Toker, K., Allen, B. L., Ballard, G., Beranek, C. T., Broekhuis, F., Bugir, C. K., Clarke, R. H., Clulow, J., Clulow, S., Daltry, J. C., Davies-Mostert, H. T., Di Blanco, Y. E., Dixon, V., Fleming, P. J. S., Howell, L. G., Kerley, G. I. H., Legge, S. M., … Wüster, W. (2020). Envisioning the future with 'compassionate conservation': An ominous projection for native wildlife and biodiversity. *Biological Conservation*, *241*, 108365. https://doi.org/10.1016/j.biocon.2019.108365

Červený, J., Krojerová-Prokešová, J., Kušta, T., & Koubek, P. (2019). The change in the attitudes of Czech hunters towards Eurasian lynx: Is poaching restricting lynx population growth? *Journal for Nature Conservation*, *47*, 28–37. https://doi.org/10.1016/j.jnc.2018.11.002

Chen, I.-C., Hill, J., Ohlemüller, R., Roy, D. B., & Thomas, C. (2011). Rapid range shifts of species associated with high levels of climate warming. *Science (New York N.Y.)*, *333*, 1024–1026. https://doi.org/10.1126/science.1206432

Cranston, J., Crowley, S., & Early, R. (2022). Results from an online survey on attitudes to arriving range-shifting species in the UK amongst British wildlife recorders. *Dryad Digital Repository*, https://doi.org/10.5061/dryad.dfn2z3543

Crowley, S. L., Hinchliffe, S., & McDonald, R. A. (2017). Conflict in invasive species management. *Frontiers in Ecology and the Environment*, *15*(3), 133–141. https://doi.org/10.1002/fee.1471

Crowley, S. L., Hinchliffe, S., & McDonald, R. A. (2019). The parakeet protectors: Understanding opposition to introduced species management. *Journal of Environmental Management*, *229*, 120–132. https://doi.org/10.1016/j.jenvman.2017.11.036

Dawson, N., & Martin, A. (2015). Assessing the contribution of ecosystem services to human wellbeing: A disaggregated study in western Rwanda. *Ecological Economics*, *117*, 62–72. https://doi.org/10.1016/j.ecolecon.2015.06.018

de Groot, M., Drenthen, M., & de Groot, W. T. (2011). Public visions of the human/nature relationship and their implications for environmental ethics. *Environmental Ethics*, *33*(1), 25–44. https://doi.org/10.5840/enviroethics20113314

de Groot, W. T., & van den Born, R. J. G. (2003). Visions of nature and landscape type preferences: An exploration in The Netherlands. *Landscape and Urban Planning*, *63*(3), 127–138. https://doi.org/10.1016/S0169-2046(02)00184-6

Essl, F., Dullinger, S., Genovesi, P., Hulme, P. E., Jeschke, J. M., Katsanevakis, S., Kühn, I., Lenzner, B., Pauchard, A., Pyšek, P., Rabitsch, W., Richardson, D. M., Seebens, H., van Kleunen, M., van der Putten, W. H., Vilà, M., & Bacher, S. (2019). A conceptual framework for range-expanding species that track human-induced environmental change. *Bioscience*, *69*, 908–919. https://doi.org/10.1093/biosci/biz101

Finnoff, D., Shogren, J. F., Leung, B., & Lodge, D. (2007). Take a risk: Preferring prevention over control of biological invaders. *Ecological Economics*, *62*(2), 216–222. https://doi.org/10.1016/j.ecolecon.2006.03.025

Franzen, A., & Vogl, D. (2013). Two decades of measuring environmental attitudes: A comparative analysis of 33 countries. *Global Environmental Change*, *23*(5), 1001–1008. https://doi.org/10.1016/j.gloenvcha.2013.03.009

Griffin, A. S., Callen, A., Klop-Toker, K., Scanlon, R. J., & Hayward, M. W. (2020). Compassionate conservation clashes with conservation biology: Should empathy, compassion, and deontological moral principles drive conservation practice? *Frontiers in Psychology*, *11*. https://doi.org/10.3389/fpsyg.2020.01139

Gurney, M. (2015). Gains and losses: Extinctions and colonisations in Britain since 1900. *Biological Journal of the Linnean Society*, *115*(3), 573–585. https://doi.org/10.1111/bij.12503

Hainmueller, J., Hangartner, D., & Yamamoto, T. (2015). Validating vignette and conjoint survey experiments against real-world behavior. *Proceedings of the National Academy of Sciences of the United States of America*, *112*(8), 2395–2400. https://doi.org/10.1073/pnas.1416587112

Jaric, I., Courchamp, F., Correia, R. A., Crowley, S. L., Essl, F., Fischer, A., González-Moreno, P., Kalinkat, G., Lambin, X., Lenzner, B., Meinard, Y., Mill, A., Musseau, C., Novoa, A., Pergl, J., Pyšek, P., Pyšková, K., Robertson, P., von Schmalensee, M., … Jeschke, J. M. (2020). The role of species charisma in biological invasions. *Frontiers in Ecology and the Environment*, *18*(6), 345–352. https://doi.org/10.1002/fee.2195

Jones, L. P., Turvey, S. T., Massimino, D., & Papworth, S. K. (2020). Investigating the implications of shifting baseline syndrome on conservation. *People and Nature*, *2*, 1131–1144. https://doi.org/10.1002/pan3.10140

Karlsson, J., & Sjöström, M. (2007). Human attitudes towards wolves, a matter of distance. *Biological Conservation*, *137*(4), 610–616. https://doi.org/10.1016/j.biocon.2007.03.023

Kiss, G. (2014). Why should the public participate in environmental decision-making? Theoretical arguments for public participation. *Periodica Polytechnica Social and Management Sciences*, *22*(1), 13–20. https://doi.org/10.3311/PPso.7400

Klich, D., Olech, W., Łopucki, R., & Danik, K. (2018). Community attitudes to the European bison Bison bonasus in areas where its reintroduction is planned and in areas with existing populations in northeastern Poland. *European Journal of Wildlife Research*, *64*(5), 61. https://doi.org/10.1007/s10344-018-1219-5

Ladle, R. J., & Gillson, L. (2008). *The (im)balance of nature: A public perception time-lag?*. Public Understanding of Science. https://doi.org/10.1177/0963662507082893

Latombe, G., Essl, F., & McGeoch, M. A. (2020). The effect of cross-boundary management on the trajectory to commonness in biological invasions. *NeoBiota*, *62*, 241–267. https://doi.org/10.3897/neobiota.62.52708

Lenoir, J., & Svenning, J.-C. (2015). Climate-related range shifts—A global multidimensional synthesis and new research directions. *Ecography*, *38*, 15–28. https://doi.org/10.1111/ecog.00967

Limesurvey GmbH. *LimeSurvey: An open source survey tool*. LimeSurvey GmbH. Retrieved from http://www.limesurvey.org

Lindemann-Matthies, P. (2016). Beasts or beauties? Laypersons' perception of invasive alien plant species in Switzerland and attitudes towards their management. *NeoBiota*, *29*, 15–33. https://doi.org/10.3897/neobiota.29.5786

Lorimer, J. (2007). Nonhuman charisma. *Environment and Planning D: Society and Space*, *25*(5), 911–932. https://doi.org/10.1068/d71j

Lunt, I. D., Byrne, M., Hellmann, J. J., Mitchell, N. J., Garnett, S. T., Hayward, M. W., Martin, T. G., McDonald-Maddden, E., Williams, S. E., & Zander, K. K. (2013). Using assisted colonisation to conserve biodiversity and restore ecosystem function under climate change. *Biological Conservation*, *157*, 172–177. https://doi.org/10.1016/j.biocon.2012.08.034

Ma, K., Liu, D., Wei, R., Zhang, G., Xie, H., Huang, Y., Li, D., Zhang, H., & Xu, H. (2016). Giant panda reintroduction: Factors affecting public support. *Biodiversity and Conservation*, *25*(14), 2987–3004. https://doi.org/10.1007/s10531-016-1215-6

Masterson, V. A., Stedman, R. C., Enqvist, J., Tengö, M., Giusti, M., Wahl, D., & Svedin, U. (2017). The contribution of sense of place to social-ecological systems research: A review and research agenda. *Ecology and Society*, *22*(1). Retrieved from https://www.jstor.org/stable/26270120

McCleery, R. A. (2009). Improving attitudinal frameworks to predict behaviors in human–wildlife conflicts. *Society & Natural Resources*, *22*(4), 353–368. https://doi.org/10.1080/08941920802064414

Naujokaitis-Lewis, I., Pomara, L. Y., & Zuckerberg, B. (2018). Delaying conservation actions matters for species vulnerable to climate change. *Journal of Applied Ecology*, *55*(6), 2843–2853. https://doi.org/10.1111/1365-2664.13241

Newbold, T. (2018). Future effects of climate and land-use change on terrestrial vertebrate community diversity under different scenarios. *Proceedings of the Royal Society B: Biological Sciences*, *285*(1881), 20180792. https://doi.org/10.1098/rspb.2018.0792

O'Rourke, E. (2014). The reintroduction of the white-tailed sea eagle to Ireland: People and wildlife. *Land Use Policy*, *38*, 129–137. https://doi.org/10.1016/j.landusepol.2013.10.020

Ohsawa, T., & Jones, T. E. (2017). How can protected area managers Deal with nonnative species in an era of climate change? *Natural Areas Journal*, *37*(2), 240–253. https://doi.org/10.3375/043.037.0213

Pecl, G. T., Araújo, M. B., Bell, J. D., Blanchard, J., Bonebrake, T. C., Chen, I.-C., Clark, T. D., Colwell, R. K., Danielsen, F., Evengård, B., Falconi, L., Ferrier, S., Frusher, S., Garcia, R. A., Griffis, R. B., Hobday, A. J., Janion-Scheepers, C., Jarzyna, M. A., Jennings, S., … Williams, S. E. (2017). Biodiversity redistribution under climate change: Impacts on ecosystems and human well-being. *Science*, *355*(6332), eaai9214. https://doi.org/10.1126/science.aai9214

Peterson St-Laurent, G., Hagerman, S., & Kozak, R. (2018). What risks matter? Public views about assisted migration and other climate-adaptive reforestation strategies. *Climatic Change*, *151*(3), 573–587. https://doi.org/10.1007/s10584-018-2310-3

Piironen, J., & Vehtari, A. (2017). Sparsity information and regularization in the horseshoe and other shrinkage priors. *Electronic Journal of Statistics*, *11*(2), 5018–5051. https://doi.org/10.1214/17-EJS1337SI

Pocock, M. J. O., Roy, H. E., Preston, C. D., & Roy, D. B. (2015). The biological records Centre: A pioneer of citizen science. *Biological Journal*

of the Linnean Society, *115*(3), 475–493. https://doi.org/10.1111/bij.12548

Postles, M., & Bartlett, M. (2018). The rise of BioBlitz: Evaluating a popular event format for public engagement and wildlife recording in the United Kingdom. *Applied Environmental Education & Communication*, *17*(4), 365–379. https://doi.org/10.1080/1533015X.2018.1427010

QSR International. (1999). *NVivo Qualitative Data Analysis Software (Version NVivo 12)*. Retrieved from https://qsrinternational.com/nvivo/nvivo-products/

R Core Team. (2020). R: A language and environment for statistical computing (Version 4.0.2). R Foundation for Statistical Computing. Retrieved from https://www.R-project.org/

Redpath, S. M., Young, J., Evely, A., Adams, W. M., Sutherland, W. J., Whitehouse, A., Amar, A., Lambert, R. A., Linnell, J. D. C., Watt, A., & Gutiérrez, R. J. (2013). Understanding and managing conservation conflicts. *Trends in Ecology & Evolution*, *28*(2), 100–109. https://doi.org/10.1016/j.tree.2012.08.021

Root-Bernstein, M., Gooden, J., & Boyes, A. (2018). Rewilding in practice: Projects and policy. *Geoforum*, *97*, 292–304. https://doi.org/10.1016/j.geoforum.2018.09.017

Rouanet, H., & Le Roux, B. (2010). *The method of multiple correspondence analysis. In quantitative applications in the social sciences: Multiple correspondence analysis*. SAGE Publications, Inc. https://doi.org/10.4135/9781412993906

Scheffers, B. R., & Pecl, G. (2019). Persecuting, protecting or ignoring biodiversity under climate change. *Nature Climate Change*, *9*(8), 581–586. https://doi.org/10.1038/s41558-019-0526-5

Schloss, C. A., Nuñez, T. A., & Lawler, J. J. (2012). Dispersal will limit ability of mammals to track climate change in the Western Hemisphere. *Proceedings of the National Academy of Sciences*, *109*, 8606–8611. https://doi.org/10.1073/pnas.1116791109

Schönfelder, M. L., & Bogner, F. X. (2017). Individual perception of bees: Between perceived danger and willingness to protect. *PLoS ONE*, *12*, e0180168. https://doi.org/10.1371/journal.pone.0180168

Seddon, P. J., Soorae, P. S., & Launay, F. (2005). Taxonomic bias in reintroduction projects. *Animal Conservation*, *8*(1), 51–58. https://doi.org/10.1017/S1367943004001799

Sharp, R. L., Larson, L. R., & Green, G. T. (2011). Factors influencing public preferences for invasive alien species management. *Biological Conservation*, *144*(8), 2097–2104. https://doi.org/10.1016/j.biocon.2011.04.032

Shipley, N. J., & Bixler, R. D. (2017). Beautiful bugs, bothersome bugs, and FUN bugs: Examining human interactions with insects and other arthropods. *Anthrozoös*, *30*(3), 357–372. https://doi.org/10.1080/08927936.2017.1335083

Sturgis, P., Roberts, C., & Smith, P. (2014). Middle alternatives revisited: How the neither/nor response acts as a way of saying 'I Don't know'? *Sociological Methods & Research*, *43*(1), 15–38. https://doi.org/10.1177/0049124112452527

Sumner, S., Law, G., & Cini, A. (2018). Why we love bees and hate wasps. *Ecological Entomology*, *43*(6), 836–845. https://doi.org/10.1111/een.12676

Taylor, A. L., Dessai, S., & Bruine de Bruin, W. (2014). Public perception of climate risk and adaptation in the UK: A review of the literature. *Climate Risk Management*, *4–5*, 1–16. https://doi.org/10.1016/j.crm.2014.09.001

Tebboth, M. G. L., Few, R., Assen, M., & Degefu, M. A. (2020). Valuing local perspectives on invasive species management: Moving beyond the ecosystem service-disservice dichotomy. *Ecosystem Services*, *42*, 101068. https://doi.org/10.1016/j.ecoser.2020.101068

Troudet, J., Grandcolas, P., Blin, A., Vignes-Lebbe, R., & Legendre, F. (2017). Taxonomic bias in biodiversity data and societal preferences. *Scientific Reports*, *7*(1), 9132. https://doi.org/10.1038/s41598-017-09084-6

Urban, M. C. (2020). Climate-tracking species are not invasive. *Nature Climate Change*, *10*, 382–384. https://doi.org/10.1038/s41558-020-0770-8

Van der Wal, R., Fischer, A., Selge, S., & Larson, B. M. H. (2015). Neither the public nor experts judge species primarily on their origins. *Environmental Conservation*, *42*(4), 349–355. https://doi.org/10.1017/S0376892915000053

Verbrugge, L., Born, R., & Lenders, H. (2013). Exploring public perception of non-native species from a visions of nature perspective. *Environmental Management*, *52*, 1562–1573. https://doi.org/10.1007/s00267-013-0170-1

Wallingford, P. D., Morelli, T. L., Allen, J. M., Beaury, E. M., Blumenthal, D. M., Bradley, B. A., Dukes, J. S., Early, R., Fusco, E. J., Goldberg, D. E., Ibanez, I., Laginhas, B. B., Vila, M., & Sorte, C. J. B. (2020). Adjusting the lens of invasion biology to focus on the impacts of climate-driven range shifts. *Nature Climate Change*, *10*, 398–405. https://doi.org/10.1038/s41558-020-0768-2

Wu, J., & Loucks, O. L. (1995). From balance of nature to hierarchical patch dynamics: A paradigm shift in ecology. *The Quarterly Review of Biology*, *70*(4), 439–466. https://doi.org/10.1086/419172

SUPPORTING INFORMATION

Additional supporting information may be found in the online version of the article at the publisher's website.

How to cite this article: Cranston, J., Crowley, S. L. & Early, R. (2022). UK wildlife recorders cautiously welcome range-shifting species but incline against intervention to promote or control their establishment. *People and Nature*, *4*, 879–892. https://doi.org/10.1002/pan3.10325