Bird Conservation International (2020), page 1 of 18.
doi:10.1017/S0959270920000349

Expert knowledge assessment of threats and conservation strategies for breeding Hen Harrier and Short-eared Owl across Europe

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(Received 21 August 2019; revision accepted 30 March 2020)

Summary

Hen Harrier *Circus cyaneus* and Short-eared Owl *Asio flammeus* are open-country birds of prey with overlapping distributions. Although both species face similar conservation threats across their ranges, work to date has largely been undertaken at a national scale with few attempts to collate and assess factors relevant to their conservation at an international scale. Here we use an expert knowledge approach to evaluate the impact of conservation threats and the effectiveness of conservation strategies for each species across Europe. We report results of responses to a questionnaire from 23 Hen Harrier experts from nine countries and 12 Short-eared Owl experts from six countries. The majority of responses for both species reported declines in breeding numbers. The perceived impact of threats was broadly similar for both species: ecological factors (predation, extreme weather and prey availability), changes in land use (habitat loss and agricultural intensification) and indirect persecution (accidental nest destruction) were considered to be the greatest threats to breeding Hen Harrier and Short-eared Owl. Short-eared Owl experts also highlighted lack of knowledge and difficulties associated with monitoring as a major conservation challenge. Despite broad-scale similarities, geographical variation was also apparent in the perceived importance of conservation threats, with some threats (such as direct persecution, large-scale afforestation or habitat degradation) requiring country-specific actions. Implementation of different conservation strategies also varied between countries, with the designation of protected areas reported as the most widespread conservation strategy adopted, followed by species and habitat management. However, protected areas (including species-specific protected areas) were perceived to be less effective than active management of species and habitats. These findings highlight the overlap between the conservation requirements of these two species, and the need for collaborative international research and conservation approaches that prioritise pro-active conservation strategies subject to continued assessment and with specific conservation goals.

Keywords: *Asio flammeus*, *Circus cyaneus*, conservation effectiveness, expert knowledge, questionnaire

Introduction

Hen Harrier *Circus cyaneus* and Short-eared Owl *Asio flammeus* are open-country birds of prey with overlapping Palearctic distributions (BirdLife International 2019). Outside of Eurasia, Short-eared Owl populations overlap with Hen Harrier sister species (*Circus hudsonius and Circus cinereus*) in North and South America (Bierregaard *et al*. 2019, Del Hoyo *et al*. 2019). In Europe, both species breed from Spain, Ireland, and the UK in the west, through central Europe and Nordic countries to Eastern Europe and Russia, while migratory movements extend as far as northern Africa (BirdLife International 2019). Both species nest on the ground in a variety of landscapes across Europe, including tundra, upland moors and bogs, agricultural grasslands and crops, or coastal dune habitats (Olsen *et al*. 2019, Orta *et al*. 2019). As well as sharing breeding habitats, there are also overlaps between the prey range used by both species. Hen Harriers feed mainly on birds, small mammals and lagomorphs, with the relative importance of different prey groups depending on the habitat, season and region within Europe (Orta *et al*. 2019). Short-eared Owls have a similar diet, but are more dependent on small mammals, especially voles *Microtus* spp., that experience important population fluctuations (Olsen *et al*. 2019). As a result of their broadly similar diets, nesting and foraging habitat requirements, the two species are affected by similar conservation pressures and threats (European Environment Agency 2012, Olsen *et al*. 2019, Orta *et al*. 2019). Though previously abundant, both species have suffered declines in recent decades (BirdLife International 2004) and are now listed as Annex I species on the EU Birds Directive (2009/147/EC), as Annex II species on the Bern Convention, and as species of conservation concern at a national level across Europe (in 20 and in 33 countries for Hen Harrier and Short-eared Owl respectively; Staneva and Burfield 2017). Substantial breeding population declines have been reported for Hen Harrier across many European countries (European Environment Agency 2012), while Short-eared Owl breeding population trends are surrounded by uncertainty (BirdLife International 2004) due to fluctuating populations (Calladine *et al*. 2012) and to difficulties associated with reliably monitoring this species (Calladine *et al*. 2010). Despite the overlap in ecological patterns and conservation concern for both species across their entire European range, most research and monitoring has focused on populations at a national or regional scale. Furthermore, there is a lack of published research from large parts of their European range and the information that is available is often in the form of grey literature and national survey or monitoring reports. As a result, assessing the conservation status of these species and identifying patterns relevant for their conservation at an international scale remains problematic. The Birds Directive reporting under Article 12 seeks to address this issue by providing an overview of the status and trends of bird populations in member states (European Environment Agency 2012). However, gaps remain in our current knowledge regarding practical conservation approaches for both species.

Expert knowledge approaches can provide a useful tool to improve our understanding of complex conservation problems (Martin *et al*. 2012). Here we aim to complement existing knowledge on the status and trends of Hen Harrier and Short-eared Owl (e.g. European Environment Agency 2012) with expert perceptions of the relative impact of threats and the effectiveness of different conservation strategies in place for each species across Europe. We used an expert knowledge-based approach in conjunction with the first International Hen Harrier and Short-eared Owl meeting held in the Netherlands in 2019 (Bos *et al*. 2020) to provide an overview of expert views on (i) conservation threats to Hen Harrier and Short-eared Owl breeding populations across Europe, and (ii) effectiveness of conservation strategies in place for each species in different European countries.

Methods

We assessed expert knowledge on threats and conservation strategies for Hen Harrier and Short-eared Owl breeding populations across Europe by means of a questionnaire. The aim of the questionnaire was to characterise (i) the study population of each expert, (ii) conservation threats

to each species and (iii) the effectiveness of any conservation strategies in place (see the online supplementary material for the full questionnaire). To trial the questionnaire, we sent a pilot version to 10 individuals with relevant experience in bird conservation and research. We received six responses which helped improve the format and resolve any technical issues. The final questionnaire was circulated to 60 Hen Harrier and Short-eared Owl experts from 14 countries who had been invited to attend the 2019 International Hen Harrier and Short-eared Owl meeting and to five other experts identified by meeting attendees (n = 65). As respondents' experience covered different geographical areas, some of which overlapped or were nested within each other, the unit of study for this research was the questionnaire response (rather than the population covered by each response). Furthermore, questionnaires were perception-based and thus sought to complement, rather than repeat work carried out by Article 12 reporting under the Birds Directive (European Environment Agency 2012).

Respondents were first asked to describe the number of breeding pairs and trend (i.e. increasing, stable, decreasing, unknown) in their area. Experts were then asked to rate the relative impact of conservation threats and the effectiveness of conservation strategies in their study area. A list of threats and strategies was provided based on the IUCN conservation threats and actions classification schemes (IUCN 2012a, 2012b) and Salafsky *et al.* (2008), adapted to Hen Harrier and Short-eared Owl ecology and conservation (BirdLife International 2019, Olsen *et al.* 2019, Orta *et al.* 2019). A total of 23 threats and 14 conservation strategies were included in the questionnaire, grouped into six and four categories, respectively (Table 1). Questionnaires included space to list and rate additional threats and strategies not captured by the list provided as well as to provide any additional relevant information. Respondents rated conservation threats on a scale of 1 to 5, from "lowest or negligible impact" to "highest impact". Respondents assigned a value of 'NA' to threats that they considered not to occur in their study area. Two specific threats (prey availability and extreme weather) were not listed in the original questionnaire but were highlighted in several responses in the sections provided for additional threats. To obtain an accurate representation of the importance of these particular threats, all respondents were contacted again and asked to evaluate these two threats in the same way as in the original questionnaire. Responses on these threats were then incorporated into the analysis. Respondents were asked to similarly rate the effectiveness of conservation strategies on a scale of 1 to 5, from "ineffective; breeding success is similar to what would be expected without that strategy" to "very effective; breeding success is optimised under that strategy". Conservation strategies not in place in a respondent's study area were identified as 'NA'.

To calculate the relative impact of conservation threats, all threats not reported in an area (NA) were given a value of 0. This avoided overestimating the importance of threats which were reported only in one area (e.g. parasites were only highlighted as an issue in one response, if treating responses from all other questionnaires as NA, the importance of parasites at a European scale would be overestimated). As multiple questionnaires were received for some countries / regions, we first evaluated conservation threats at a national scale by calculating a national mean value for each threat. A European mean value was then calculated from the national means to evaluate the relative importance of conservation threats across Europe. This avoided overestimating the importance of threats from countries with multiple responses. A similar process was followed to evaluate the effectiveness of conservation strategies, but in this case, NA values were omitted from calculations. The reason for this was that threats could be treated as a continuous variable, from not occurring (0), to having a low impact (1), to having a high impact (5), whereas conservation strategies could not be treated as continuous (they are in place (yes/no), once in place they can then be considered to be ineffective (1) to very effective (5).

Some of the questionnaire responses covered relatively small numbers of breeding pairs (< 10). As small populations are known to have increased vulnerability to extinction through stochastic events (Melbourne and Hastings 2008), we assessed whether the perceived importance of threats was consistent across responses covering different numbers of breeding pairs. For each questionnaire response, we calculated the mean value of each threat category (six categories consisting of 3–6 threats each; Table 1). We then fitted a linear model to highlight any trends between the

Table 1. Summary of conservation threats and strategies for Hen Harrier and Short-eared Owl assessed by European experts through the questionnaire.

Conservation threats		Conservation strategies	
Category	Threat	Category	Strategy
Ecological	Predation	Protection	Protected area
	Extreme weather		Species-specific protected area (SPA)
	Prey availability	Species management	Nest protection (from direct or indirect persecution)
	Parasites		Supplementary feeding
Direct persecution	Shooting		Brood management
	Poisoning		Predator control (nest scale)
	Nest destruction		Predator control (landscape scale)
Indirect persecution	Secondary poisoning	Habitat management	Improvement of nesting habitat
	Accidental nest destruction (e.g. by crop harvesting)		Improvement of foraging habitat
Collision	Wind turbines		Improvement of linear features
	Power lines		Improvement of grazing regimes
	Cars / trains	Policy and legislation	Regulation of afforestation and forestry activities
	Fences		Regulation of recreation
Disturbance	Forestry		Rodenticide use regulation
	Agriculture		
	Burning		
	Recreational activities		
Anthropogenic habitat change	Habitat loss		
	Afforestation		
	Agricultural intensification		
	Grazing regimes		
	Recreation infrastructures		
	Developments (e.g. renewable energy)		

perceived importance of each threat category and the number of breeding pairs covered by the questionnaire responses. To maximise sample size, and as the two species share ecological traits and conservation threats, data for both species were pooled for this analysis. In some cases, different questionnaire responses corresponded to overlapping or nested geographical areas. To avoid pseudo-replication, we also performed this analysis excluding multiple responses from the same area. Specifically, for areas that were covered by more than one response, we only used data from the response covering the largest number of pairs to avoid pseudo-replication. However, as results were the same for both analyses (Figure 4 and Figure S1), we present the data including all questionnaire responses.

Results

We received 36 responses from experts in 10 different countries across the European range of both species. Geographical coverage was best in central and western Europe, with gaps in Nordic and eastern European countries. Expert respondents were from a range of backgrounds including conservation organisations, research centres, government bodies, survey and monitoring programmes, and consultancy and environmental impact studies. One response on Hen Harrier referred to a wintering population which was therefore excluded from further analyses. The remaining questionnaires included 23 responses on breeding Hen Harrier from nine countries and 12 responses on breeding Short-eared Owl from six countries. Seventy percent of Hen Harrier and 58% of Short-eared Owl responses reported declining trends (Hen Harrier: 4 stable, 16 declining, 2 extinct, 1 unknown; Short-eared Owl: 1 increasing, 2 stable, 7 declining, 1 extinct, 1 unknown). Figure 1 summarises the number of pairs, trends and countries covered by the questionnaire responses.

The conservation threats with the greatest perceived impact (≥ 2.4) for breeding Hen Harrier populations in Europe were agricultural intensification, habitat loss, accidental nest destruction and prey availability (Figure 2). However, the impact of these threats was variable across Europe (large SD values in Figure 2 and variation in Figure 3). For Short-eared Owl breeding populations, the most important threats (≥ 2.4) were prey availability, extreme weather, habitat loss, agricultural intensification, and predation (Figure 2), with similar geographical variability (Figure 3). Overall, the patterns of the different threats were broadly similar for both species: the mean difference between both species for each threat was 0.46 (SD = 0.35), with most threats showing a difference of less than 0.7. Short-eared Owls were perceived as more vulnerable to changes in prey availability, car and train collisions, and extreme weather events (difference with Hen Harrier mean value of 1.5, 1 and 0.8 respectively). Disturbance from forestry activities was considered more important for Hen Harrier (difference of 1 with Short-eared Owl mean value). Within countries with multiple expert responses, scoring of threats was generally most similar for those threats perceived as most important (indicated by SD values in Tables S2 and S3).

Threat categories (i.e. ecological, direct persecution, indirect persecution, collision, disturbance, anthropogenic habitat change) had different impacts depending on the number of breeding pairs (Figure 4). All threat categories had variable impact at small population sizes, but for large populations ecological factors, direct persecution and anthropogenic habitat change had a larger impact. On the other hand, the perceived impact of indirect persecution declined for larger populations, while the perceived impact of collisions and disturbance appeared to be independent of population size.

The most frequently applied conservation strategies for breeding Hen Harrier and Short-eared Owl across European countries covered by questionnaires were the designation of protected areas, followed by species and habitat management (Table 2). Overall, ratings of the effectiveness of conservation strategies were more variable (average SD = 1.32, Figure 5) than those of conservation threats (average SD = 0.76, Figure 2). The conservation strategies perceived to be most effective were those targeting the improvement of nesting and foraging habitat and those related to control of predation (Figure 5). Protected areas (including those specifically designated for Hen

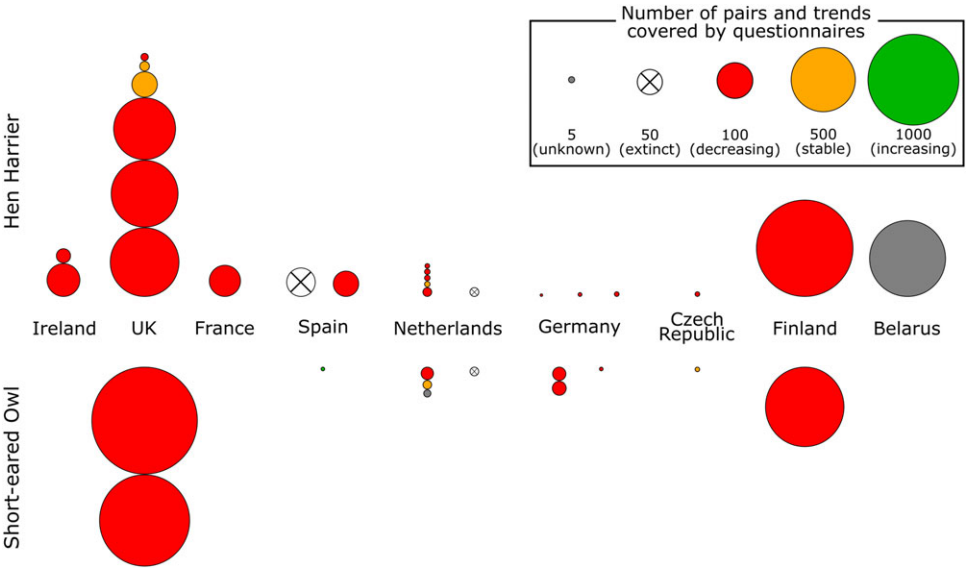

Figure 1. Geographic distribution of responses to Hen Harrier (top) and Short-eared Owl (bottom) questionnaires. Circle sizes indicate the number of pairs covered by each questionnaire (range: 1–1,375 pairs), circle colour indicates the trend reported by each questionnaire. Where two or more questionnaires covered overlapping or nested geographical areas, these are vertically aligned (e.g. six responses on Hen Harrier from the UK covered the entire UK and subpopulations; as a comparison, the two responses from Spain covered separate areas and so are horizontally aligned). Where populations are marked as extinct, the population size shown corresponds to the population size 10 years prior to extinction.

Harrier or Short-eared Owl) were considered to have low effectiveness, despite being one of the most widely applied conservation strategies in Europe (Table 2). The effectiveness of conservation strategies was perceived to be roughly similar for both species, with a mean absolute difference of 0.87 (SD = 0.53) between species.

Discussion

Our expert knowledge approach resulted in broad geographical coverage of European Hen Harrier and Short-eared Owl breeding populations (Figure 3). Responses highlighted a general decline in breeding numbers of both species across Europe, in line with reported national trends (European Environment Agency 2012, Staneva and Burfield 2017). It is worth noting that we obtained considerably more responses for Hen Harrier (n = 23) than Short-eared Owl (n = 12) and that some areas were covered by multiple questionnaire responses (notably the UK and the Netherlands) while other areas had poor coverage (Nordic and eastern European countries). These patterns in numbers of responses partly reflect the disparity in research and conservation efforts for both species throughout Europe and also the strong spatio-temporal fluctuations of Short-eared Owl breeding populations (Mikkola 2010). Poor coverage in eastern Europe and Russia also reflects a broader concern about ecological knowledge transfer and access to literature between east and west (Henry and Douhovnikoff 2008, Smith *et al.* 2014, Doi and Takahara 2016). Despite these gaps, questionnaire responses provided a good representation of the conservation threats and strategies of both species' populations across central and western Europe.

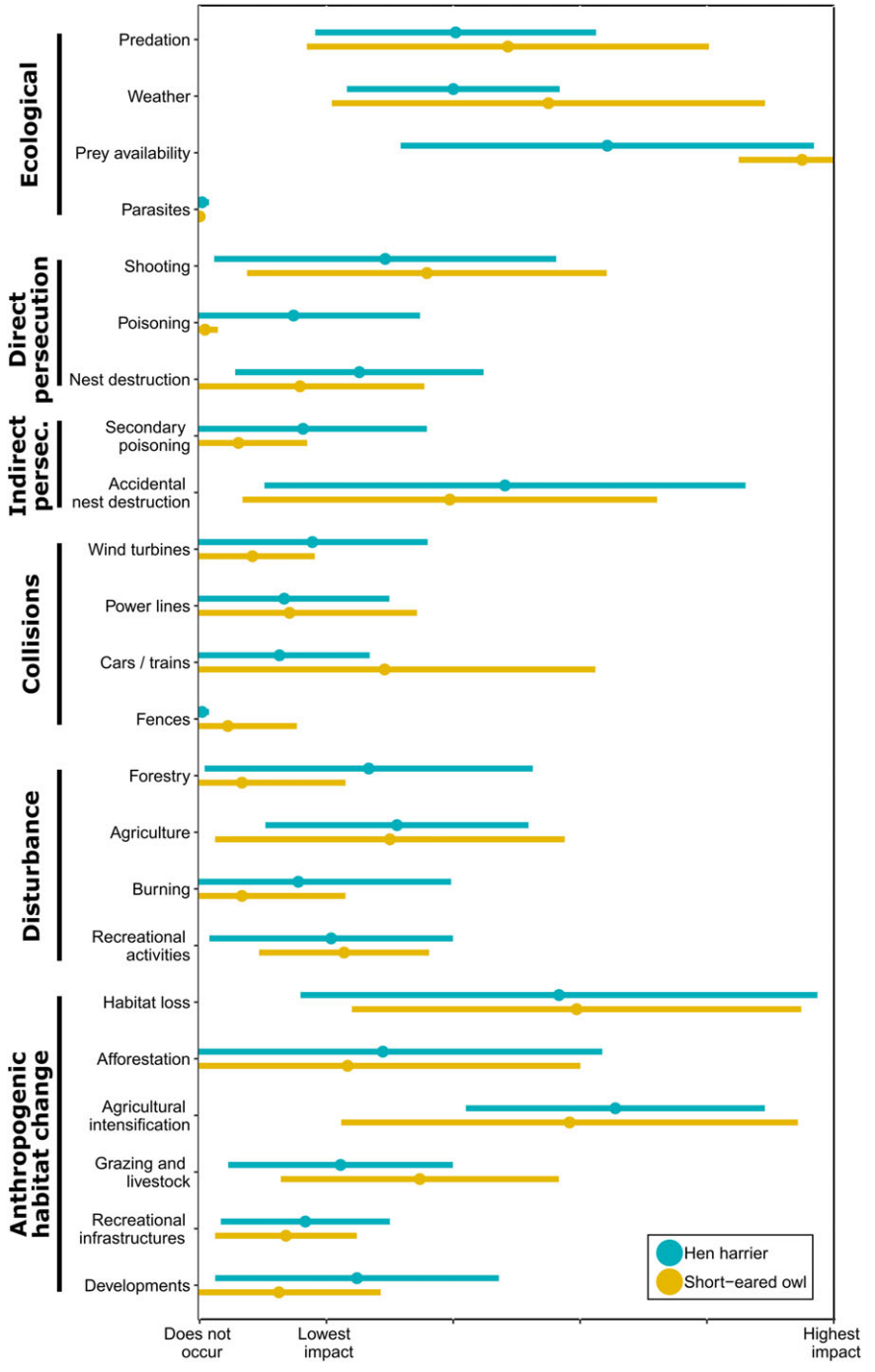

Figure 2. Perceived impact of conservation threats to breeding Hen Harrier and Short-eared Owl assessed by European experts through questionnaires (n = 23 responses from nine countries for Hen Harrier; n = 12 responses from six countries for Short-eared Owl). Dots indicate mean values for each threat across all countries, lines indicate standard deviation. See Table S1 for mean and standard deviation values.

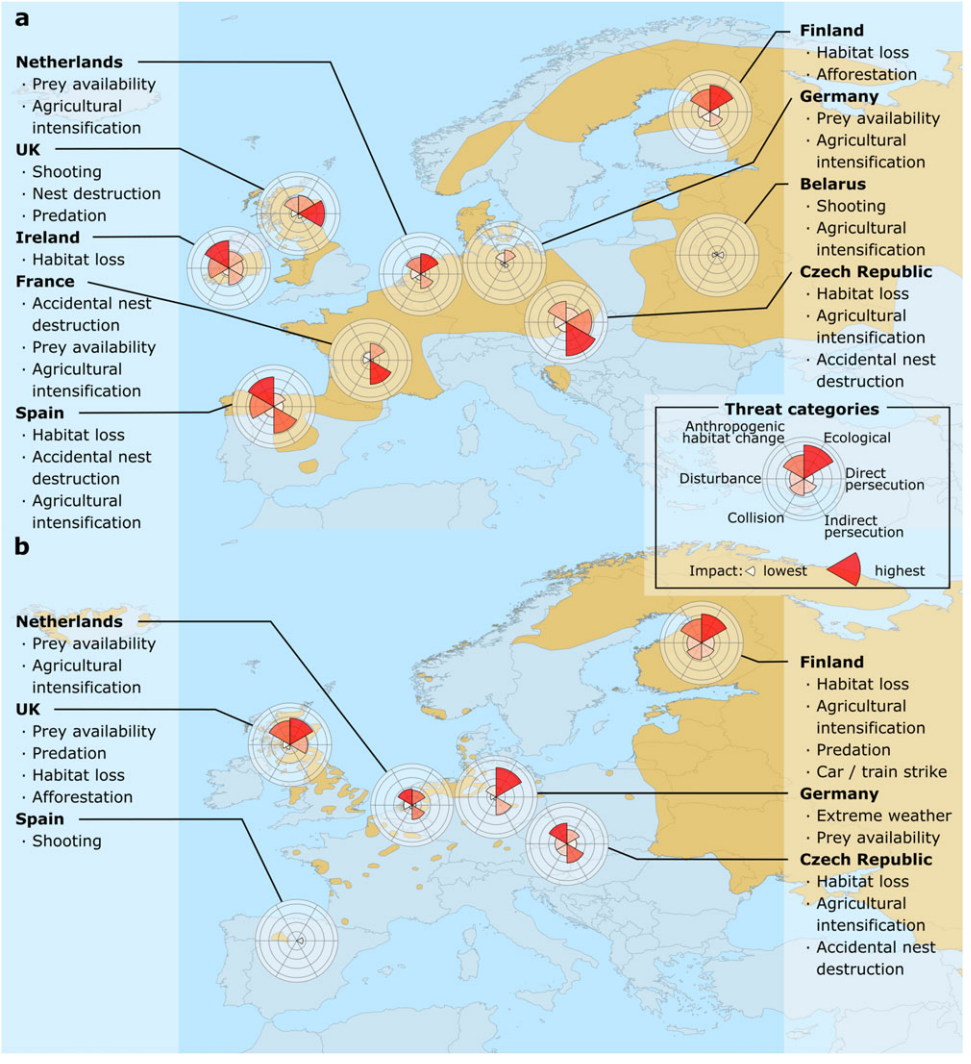

Figure 3. Conservation threats to breeding Hen Harrier (a) and Short-eared Owl (b) assessed by European experts through questionnaires. Circle section size and colours indicate the estimated impact of the different threat categories (see legend). Lists indicate specific threats perceived to be most important in each country (i.e. in the upper quartile based on threat scores for each country). See Tables S2 and S3 for full list of threats and perceived impact values in each country. Breeding distribution maps based on BirdLife International and HBW (2018).

The perceived impact of threats to Hen Harrier and Short-eared Owl showed some interesting patterns. Firstly, the impact of the different threats was broadly similar for both species, underlining the overlap in ecological requirements and conservation concerns for these species. Where threat impacts differed, this could be linked to ecological differences. For example, due to their strong reliance on small mammals, Short-eared Owl populations are more vulnerable to natural fluctuations in prey availability (Korpimaki and Norrdahl 1991), and their partly nocturnal foraging behaviour makes them more vulnerable to collisions with cars and trains (Village 1987,

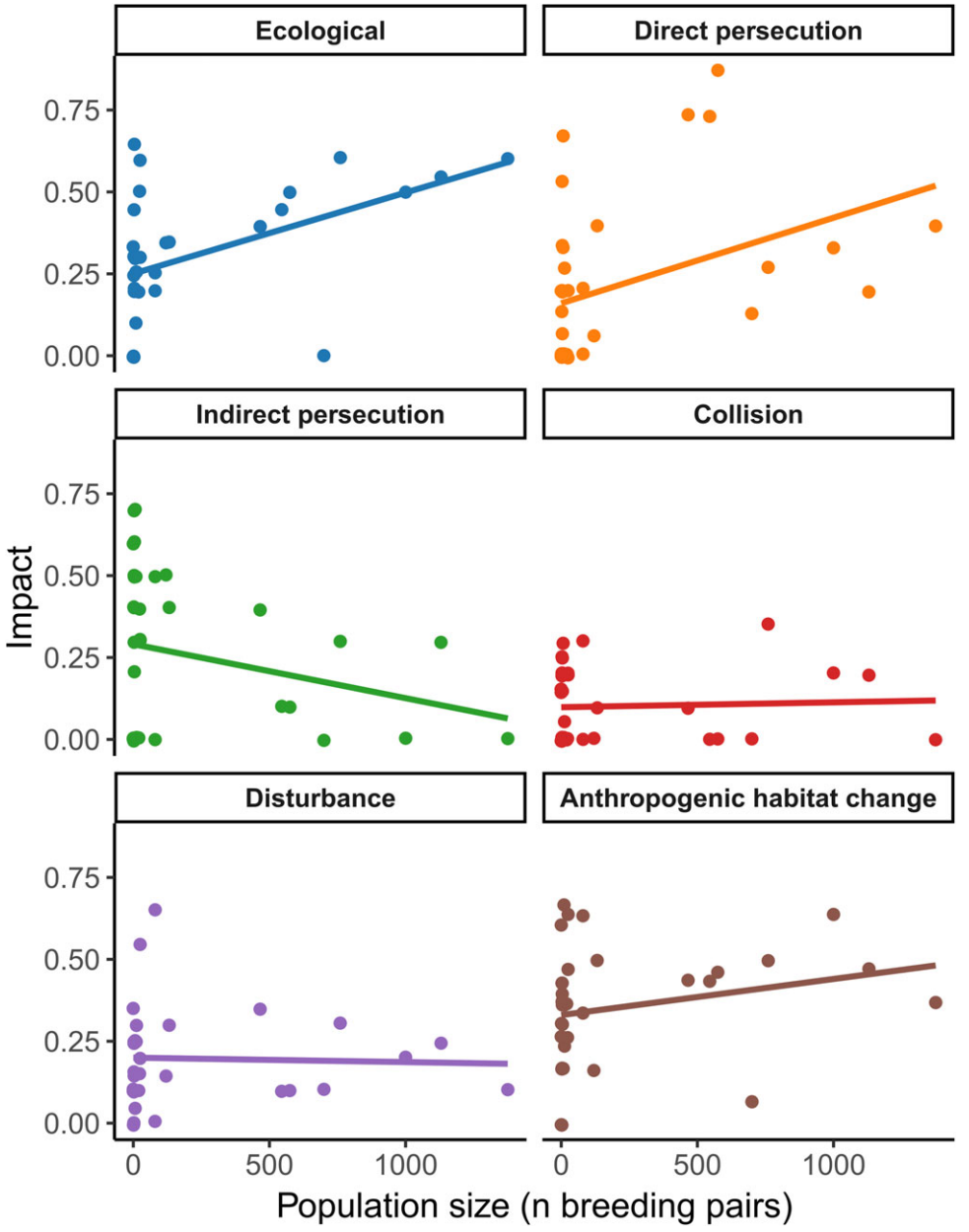

Figure 4. Perceived impact of different threats to breeding Hen Harrier and Short-eared Owl populations reported by European experts in relation to number of breeding pairs covered by each questionnaire (data for Hen Harrier, n = 23, and Short-eared Owl, n = 12, are pooled).

Calladine *et al.* 2012). Secondly, our results highlighted the importance of ecological factors (predation, extreme weather, and prey availability), anthropogenic habitat change (habitat loss and agricultural intensification) and indirect persecution (accidental nest destruction) for both species. Human activities influence not only the latter two (anthropogenic habitat change and

Table 2. Conservation strategies reported for breeding Hen Harrier (green / dark dots) and Short-eared Owl (orange / light dots) by European experts through questionnaires. Note that this table reflects conservation strategies from respondents' study areas, and are therefore not necessarily representative of conservation strategies at a national scale (e.g. a respondents' study may be outside protected areas, and therefore this strategy was not marked in their response; conversely, respondents may have local experience of a conservation strategy, such as supplementary feeding, which is not part of a national scheme).

Conservation strategies		Country									
Category	Strategy	BY	CZ	DE	ES	FI	FR	GB	IE	NL	Total countries
Protection	Protected area	●	●●	●●	●	●●		●●	●	●●	8
	Species-specific protected area (SPA)		●●	●●	●			●●	●	●●	6
Species management	Nest protection (from direct or indirect persecution)		●	●●	●			●	●	●●	6
	Supplementary feeding							●	●	●	3
	Brood management				●			●			2
	Predator control (nest scale)			●●	●		●	●●		●●	5
	Predator control (landscape scale)			●●		●●		●●	●	●●	5
Habitat management	Improvement of nesting habitat			●●		●●		●	●	●●	5
	Improvement of foraging habitat	●		●●				●	●	●●	5
	Improvement of linear features					●		●	●	●	4
	Improvement of grazing regimes			●				●	●	●●	4
Policy and legislation	Regulation of afforestation and forestry activities			●		●●		●	●		4
	Regulation of recreation			●				●	●	●●	4
	Rodenticide use regulation			●●							1

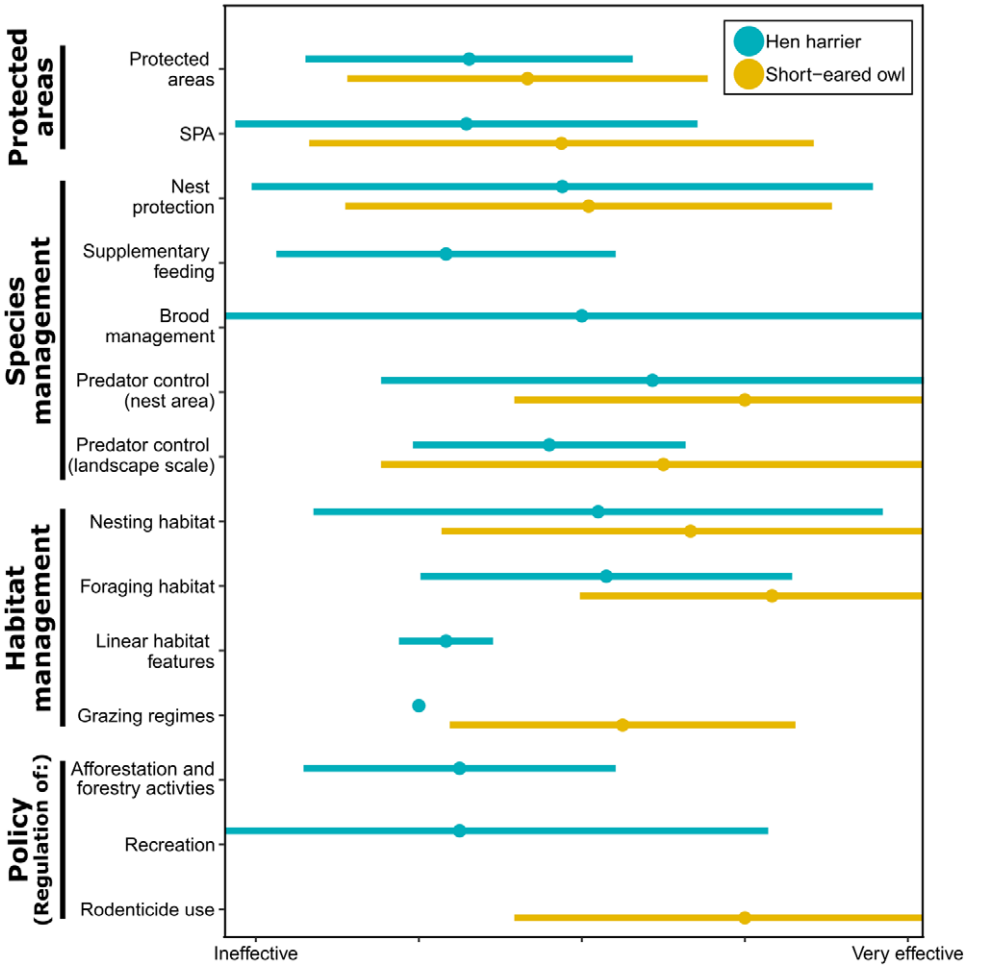

Figure 5. Perceived effectiveness of conservation strategies for breeding Hen Harrier and Short-eared Owl assessed by European experts through questionnaires (n = 23 responses from nine countries for Hen Harrier; n = 12 responses from six countries for Short-eared Owl). Dots indicate mean values for each conservation strategy across all countries, lines indicate standard deviation. See Table S4 for mean and standard deviation values.

indirect persecution), but can also modulate ecological factors (e.g. predation rates and prey availability can be affected by habitat loss, agricultural intensification or species introductions, Millon *et al.* 2002, Amar and Redpath 2005, Fraser *et al.* 2015). Many of these threats affecting Hen Harrier and Short-eared Owl populations are thus likely to be exacerbated in the coming decades under current predictions of climate and land use change (Rounsevell *et al.* 2006, European Environment Agency 2019). For example, increased frequency of extreme weather events can magnify fluctuations in prey populations, while predicted afforestation and agricultural intensification will lead to loss and deterioration of foraging and nesting habitats. These patterns highlight the urgent need for identification and implementation of effective conservation strategies. In this sense, the similarities in threat scores are suggestive of the potential for joint conservation actions to benefit Hen Harrier and Short-eared Owl populations, such as common strategies to reduce

predation risk (through management of predator species and nesting habitat) or to increase prey availability (through improvement of foraging habitats).

While our findings underline broad similarities between conservation issues faced by Hen Harrier and Short-eared Owl, they also highlight regional differences. Indeed, some specific threats appear to be very important in some areas but not in others. Examples of these include direct persecution in the UK, afforestation in Ireland, agricultural intensification in the Netherlands, or accidental nest destruction by harvesting operations in farmland nesting habitats in France and Spain. Therefore, while European-wide strategies would prove effective for the conservation of both species, any such broad scale approaches should be combined with country-specific actions to address regional threats. Our findings also highlight how small populations are perceived to be vulnerable to a broader range of threats than larger populations. This reflects the increased importance of stochastic events for small populations (Melbourne and Hastings 2008). Thus, at a European scale, conservation efforts for both species should prioritise actions that address factors highlighted as important for larger populations (ecological and anthropogenic habitat change). At a national scale and for smaller populations, conservation actions must rely on region-specific studies to identify key threats and conservation recommendations for those areas. Although the analysis of perceived importance of threats in relation to number of breeding pairs provides useful insights, it is important to note that this assessment is limited by the number of responses obtained from some countries and by the number of pairs covered by each response. For instance, although France holds one of the largest European populations of Hen Harrier (5,300–8,000 breeding pairs, European Environment Agency 2012), we only obtained a single response from this country covering 120 pairs. This may explain the apparent reduced importance of indirect persecution (including accidental nest destruction) in our analysis, despite its recognised importance for French Hen Harrier populations (Millon *et al.* 2002). Similarly, although direct persecution appeared to be important for large populations, this is partially influenced by the importance of shooting and intentional nest destruction for the UK populations, which had good coverage by the questionnaire responses (but see Figure S1 and Tables S2 and S3 for its importance in other areas).

Assessments of threats in areas not covered by our questionnaire are complicated in some countries where the species are abundant and not of conservation concern (Staneva and Burfield 2017) and therefore not the focus of research (e.g. Sweden, N. Kjellén pers. comm.). However, in other areas, there are overlaps between threats to both species similar to the patterns described here (A. V. Sharikov, A. Sokolov, S. Volkov pers. comm.). For example, in Russia, abandonment of agricultural lands (and subsequent succession and afforestation) along with intensification of agriculture is negatively affecting Hen Harrier and Short-eared Owl populations through habitat loss and reductions in prey availability (Volkov *et al.* 2009, Sharikov *et al.* 2019). In Iceland, Short-eared Owls are most affected by extreme weather events and habitat loss due to afforestation, with conservation efforts complicated by limited knowledge of the species' ecology and difficulties associated with monitoring (G. T. Hallgrimsson pers. comm.), similarly to patterns observed elsewhere in Europe.

There was more variation between expert perceptions of conservation strategy effectiveness than perceptions of importance of threats. This difference may be explained by higher region-specificity of conservation strategy effectiveness (i.e. a strategy effective in one region may be ineffective in another), or by lower consensus among European experts on the effectiveness of conservation strategies. Despite this, responses for both species were still broadly similar. Interestingly, the most effective conservation strategies according to responses were considered to be those relating to management of habitats(nesting and foraging) and species (nest protection and predator control). This suggests that effective conservation of Hen Harrier and Short-eared Owl populations should prioritise active management strategies rather than passive protection measures.

Protected areas were rated as having intermediate or low effectiveness, despite being the most common conservation strategy (Table 2), with surprisingly little difference between species-specific areas (Special Protection Areas) and other protected areas (national parks, reserves, etc.). These perceptions can be better understood in the context of the much-debated contribution of

protected areas towards biodiversity conservation (Fuller *et al*. 2010, Geldmann *et al*. 2019). Protected areas are sometimes considered little more than 'paper parks', i.e. high-protection/low-enforcement (Di Minin and Toivonen 2015, Coad *et al*. 2019), and research at a global scale suggests that the effectiveness of protected areas hinges on local resources and management (Leverington *et al*. 2010, Watson *et al*. 2014, Kuempel *et al*. 2018). Furthermore, while protected areas are shown to help conserve habitats, there is mixed evidence for their effectiveness at maintaining species populations (Geldmann *et al*. 2013). For Hen Harrier and Short-eared Owl European populations, this may be partially explained by the species' ecology. Migratory and dispersal movements by both species extend far beyond the size of most protected areas. In the case of Short-eared Owl, their reliance on small mammal population outbreaks that occur at irregular intervals over large spatial scales (Olsen *et al*. 2019) further emphasize the shortcomings of current protected areas that do not account for such spatial variations. Moreover, as ground-nesters, both species are highly vulnerable to predation as well as to nest destruction, both accidental (from mowing and harvesting activities) and intentional (see references in Bos *et al*. 2020). Therefore, proactive nest protection (e.g. predator control, nest protection or guarding) is often necessary to maintain breeding populations, even inside protected areas. In the context of the questionnaire responses, the fact that different types of protected areas are rated similarly could indicate deficiencies in designation of species-specific protected areas (i.e. location and size not matched to breeding and foraging ranges) or that management of these areas is not sufficiently adequate for the species' requirements. Another possible explanation for the perceived ineffectiveness of protected areas may be linked to the timing of designation – as many of the protected areas considered here would have been designated relatively recently under the Birds Directive. In these cases, much of the habitat loss would have already occurred and therefore the designation may have been successful in halting further habitat loss but not in restoring habitats, with the result that the populations of target species have not increased since designation. Our findings suggest that combining protected areas (currently seen as ineffective) with habitat and species management measures (perceived as most effective) can improve current conservation approaches. The implementation of targeted and region-specific habitat and species management measures would thus serve to enhance the performance of protected areas. The perceived low effectiveness of the most widely employed strategy (SPAs) also highlights the importance of continued assessment and monitoring of the effectiveness of protected areas in particular and of conservation strategies in general after implementation. In this context, establishing conservation objectives and monitoring programmes should be a requirement for the designation of protected areas.

Results on the effectiveness of proactive conservation strategies can help inform which ones may be implemented in combination with existing or future protected areas. Although nest protection was considered effective, other proactive management measures were considered ineffective (e.g. supplementary feeding and brood management for Hen Harrier). In some cases, ineffective strategies were also characterised by a lack of expert consensus underlined by large SD values, as in the case of brood management (the removal of eggs or chicks from a nest for rearing and release into other areas, a strategy mostly relevant to the UK at the time questionnaire respondents were contacted; Barkham 2019, St John *et al*. 2019). For Short-eared Owl, management of grazing regimes and regulation of rodenticide use through policy were also considered to be effective. The different perception of the relevance of these strategies compared to those for Hen Harrier relates to the ecological differences between both species, as Short-eared Owl diet is more strongly dominated by small mammals which are more likely to be affected by grazing regimes and rodenticides. In the case of rodenticide use, it is important to note that there is a gap in current knowledge on the rodenticide exposure of either species in Europe and that exposure may not necessarily be related to the importance of small mammals in the diet (Hughes *et al*. 2013, Lohr 2018).

Although questionnaire responses identified the conservation strategies perceived as most effective, different ecological aspects of European Hen Harrier and Short-eared Owl populations important for their conservation remain understudied. Knowledge gaps considered to be hindering effective conservation of both species were identified following discussions with delegates at the

International Hen Harrier and Short-eared Owl meeting (Bos *et al*. 2020). Three key actions were defined to address knowledge gaps regarding European Hen Harrier populations: (i) an assessment and comparison of Hen Harrier breeding output across European countries (measured as number of fledglings per breeding attempt to account for failed nesting pairs); (ii) a pan-European tagging programme to improve current understanding of dispersal, juvenile mortality and low recruitment rates; (iii) research on male mortality by means of tagging studies to understand the skewed sex ratios (and high numbers of unpaired females) reported for several populations. Short-eared Owl conservation faces even greater challenges for research, as even basic aspects of the species' ecology are poorly understood. Difficulties stemming from the species' fluctuating population and range were identified as a major hurdle for research (e.g. year-to-year explosions and drops in breeding numbers in response to small mammal population cycles). Such difficulties and lack of knowledge on this species are reflected by our results, with just one third of questionnaire responses concerning Short-eared Owl. International collaboration can benefit both species, by collating information on methodologies and best practice for specific conservation strategies in place across their range that can be applied at a European scale or in combination with the protected areas approach.

Finally, this study serves to highlight the value of expert knowledge approaches in conservation (Martin *et al*. 2012). These can provide valuable insights when empirical data are lacking and represent a cost- and time-effective method to collate information on a broad range of topics which would otherwise require many separate ecological studies (e.g. assessment of 24 threats and 14 conservation strategies for two species across multiple countries). Furthermore, they serve to capture knowledge which may otherwise remain unpublished or inaccessible. This is especially relevant as new conservation strategies are trialled or amended for these species across Europe, e.g. results-based agri-environment schemes (Hen Harrier Project 2018), grouse moor licencing (Grouse Moor Management Review Group 2019), allowing for assessments of their effectiveness and providing a platform to disseminate and share knowledge with policy makers and the wider conservation and research communities. Expert knowledge consultations are not, however, without limitations. As an assessment of perceptions, such approaches can be subject to different forms of bias (e.g. under- or over-estimating the importance of threats), although these can be accounted for with appropriate study design (Martin *et al.* 2012, Drescher *et al*. 2013). Availability of experts across all study areas or topics can also limit the relevance or applicability of findings. This is exemplified in our study by the limited coverage of Nordic and eastern European countries (limiting the relevance of our findings in those areas), and by the reduced number of responses on Short-eared Owl compared to Hen Harrier (which reflect the lack of knowledge and difficulty in studying this species). Despite such considerations, and perhaps most importantly in our study, this approach encapsulates experts' willingness for knowledge-sharing and international collaboration that are necessary for the long-term conservation of these species, and represents an opportunity for continued growth in this direction (e.g. expanding knowledge sharing to areas poorly represented here, repeating the questionnaire in future once a wider network of experts is established).

Implications for conservation

Our work provides an overview of current knowledge on the conservation scenario for Hen Harrier and Short-eared Owl in Europe. The expert knowledge approach helps identify some important patterns for the conservation of both species. Firstly, it highlights the need for international collaboration on both research and conservation initiatives. Despite being studied as separate populations, Hen Harrier and Short-eared Owl from different European countries are ecologically connected (Mead 1973, Calladine *et al*. 2012, Klaassen *et al*. 2014, Murphy 2019, Schaub and Klaassen 2019) and are affected by many of the same threats. Identification of similarities between countries (see for example Figure 3 and Tables S2 and S3) can provide a first avenue for establishing international collaborations and knowledge-sharing on best practice to address conservation threats. Furthermore, the overlap of conservation threats described in this paper emphasises the potential value of multi-species conservation approaches. Effectiveness of conservation strategies can be dramatically increased if single actions are designed that can benefit multiple species.

Secondly, the findings of this study underline specific shortcomings in current conservation approaches. The perceived ineffectiveness of passive conservation (protected areas) versus the effectiveness of active conservation (species and habitat management) provides an opportunity for improving current strategies. Protected areas, and in particular those designated for particular species, are perceived to be ineffective as stand-alone conservation strategies. Our findings suggest that designation of protected areas should be combined with species specific conservation strategies (e.g. species and habitat management measures) that benefit the species populations' (see Bos *et al*. 2020 for examples of species and habitat management strategies for Hen Harrier and Short-eared Owl). This study also highlights that a number of measures currently implemented to improve the conservation status of Hen Harrier and Short-eared Owl are perceived to be ineffective and therefore represent poor use of resources. This underscores the need to evaluate the performance of species-specific conservation measures to allow for adaptive management strategies. Determining the response of the target species to specific conservation measures (for example monitoring population size and/or breeding performance before, during and after the implementation of conservation measures) is essential to identify the effectiveness of such measures (e.g. in Ireland, five-yearly national Hen Harrier surveys have identified continued declines within SPAs, resulting in allocation of resources to yearly monitoring and habitat management in these areas; Ruddock *et al*. 2016, Hen Harrier Project 2018). Setting measurable Conservation Objectives or Favourable Reference Values as recommended under EU Birds and Habitats Directive (Bijlsma *et al*. 2018) allows the performance of conservation measures to be measured over time. Defining specific conservation objectives or targets (e.g. number of pairs in a population, prey abundance, cover of a specific type of habitat) which can be monitored on a regular basis, enables a flexible conservation approach that can adapt to ongoing changes (e.g. population size and trends, land use changes, development pressures).

Finally, this study indicates worrying trends in populations of Hen Harrier and Short-eared Owl across Europe. While this does not represent a comprehensive assessment of the status and trends of either species, it does confirm continued declines across large parts of their ranges. For Hen Harrier, these findings suggest that it may be necessary to consider the need for a pan-European species action plan (including country-specific strategies for regional threats), for countries to reassess the species' national status in light of their conservation status across Europe, and to re-assess the species' IUCN global conservation status (Bos *et al*. 2020). In the case of Short-eared Owl, the fluctuating nature of the population complicates status assessments. Indeed, the main issue raised by European experts on this species is our current lack of knowledge on its ecology and population trends. International initiatives would be a strong first step towards improving our understanding of a species with such a fluctuating breeding range. The long-term future of breeding populations of both species in Europe will depend on the development and implementation of collaborative international monitoring, research, and conservation strategies.

Supplementary Material

To view supplementary material for this article, please visit https://doi.org/10.1017/S0959270920000349

Acknowledgements

We thank all anonymous experts who replied to the pilot and final versions of the questionnaire. The International Hen Harrier and Short-eared Owl meeting on 20-22 March 2019 in the Netherlands was organised under the umbrella of the 'Wadvogels van Allure' project funded by Waddenfonds, the Dutch provinces North-Holland and Friesland, the Prins Bernard Cultuurfonds and the Bettie Wiegman Fonds. This study was funded by the Irish Department of Agriculture, Food & the Marine, with additional funding provided by MKO Research.

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Supplementary Materials

Expert knowledge assessment of threats and conservation strategies for Hen Harrier and Short-eared Owl across Europe

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Contents

Figure S1. Perceived impact of different threats reported by questionnaire responses in relation to number of breeding pairs covered by each questionnaire. For this figure, for areas that were covered by more than one response, we only used data from the response covering the largest number of pairs to avoid pseudo-replication (final n = 13 for Hen Harrier, n = 8 for Short-eared Owl). As these results were similar to the analysis including all responses, the latter result is presented in the main text (Fig. 4).

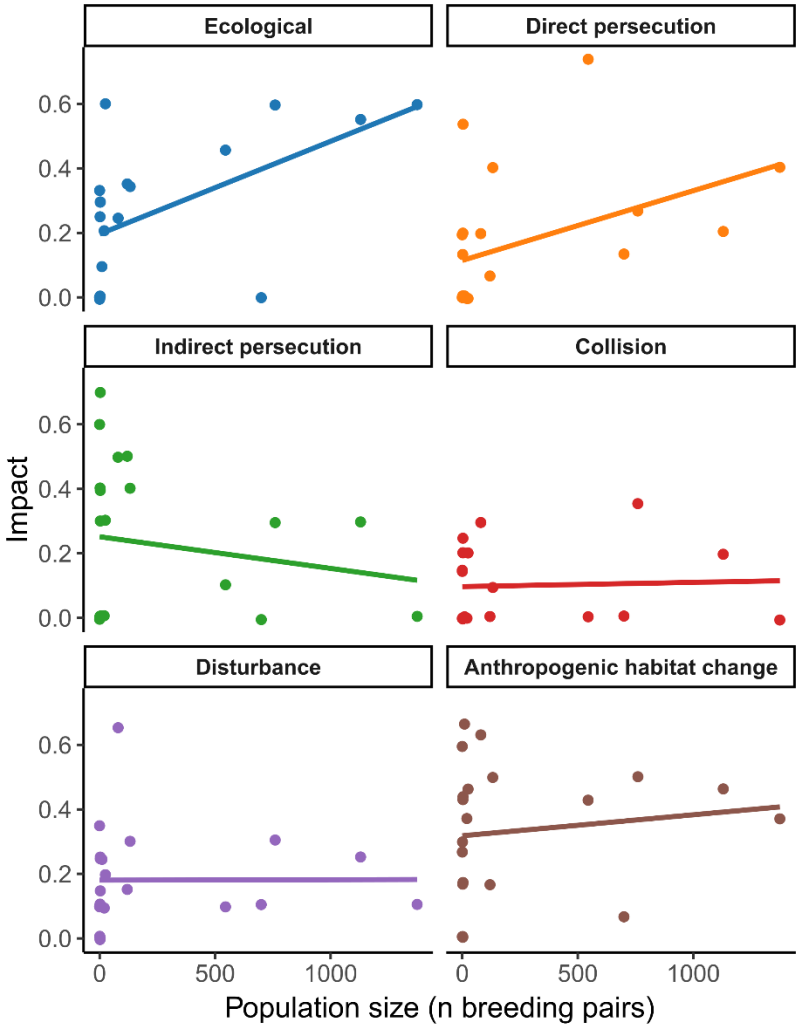

Table S1. Perceived impact of conservation threats to breeding Hen Harrier and Short-eared Owl across Europe, assessed through questionnaires (n = 23 responses from 9 countries for Hen Harrier; n = 12 responses from 6 countries for Short-eared Owl).

Species	Threat category	Threat	Mean impact	SD
Hen Harrier	Ecological	Predation	2.0	1.1
		Extreme weather	1.9	0.9
		Prey availability	2.8	1.5
		Parasites	0.0	0.1
	Persecution	Shooting	1.5	1.3
		Poisoning	0.7	1.0
		Nest destruction	1.3	1.0
	Indirect persecution	Secondary poisoning	0.8	1.0
		Accidental nest destruction	2.4	1.9
	Collision	Wind turbines	0.9	0.9
		Power lines	0.7	0.8
		Cars / trains	0.6	0.7
		Fences	0.0	0.1
	Disturbance	Forestry	1.3	1.3
		Agriculture	1.6	1.0
		Burning	0.8	1.2
		Recreational activities	1.0	1.0
	Anthropogenic habitat change	Habitat loss	2.8	2.0
		Afforestation	1.4	1.7
		Agricultural intensification	3.3	1.2
		Grazing regimes	1.1	0.9
		Recreation infrastructures	0.8	0.7
		Developments	1.2	1.1
Short-eared owl	Ecological	Predation	2.4	1.6
		Extreme weather	2.8	1.7
		Prey availability	4.3	1.0
		Parasites	0.0	0.0
	Persecution	Shooting	1.8	1.4
		Poisoning	0.0	0.1
		Nest destruction	0.8	1.0
	Indirect persecution	Secondary poisoning	0.3	0.5
		Accidental nest destruction	2.0	1.6
	Collision	Wind turbines	0.4	0.5
		Power lines	0.7	1.0
		Cars / trains	1.5	1.7
		Fences	0.2	0.5
	Disturbance	Forestry	0.3	0.8
		Agriculture	1.5	1.4
		Burning	0.3	0.8
		Recreational activities	1.1	0.7
	Anthropogenic habitat change	Habitat loss	3.0	1.8
		Afforestation	1.2	1.8
		Agricultural intensification	2.9	1.8
		Grazing regimes	1.7	1.1
		Recreation infrastructures	0.7	0.6
		Developments	0.6	0.8

Table S2. Perceived importance of conservation threats to breeding Hen Harrier by country assessed through questionnaires (n = 23 responses from 9 countries). Threats are ordered by perceived importance, mean and standard deviation values are given for countries with multiple responses.

Country	Threat	Threat category	Impact	SD
Belarus	Agricultural intensification	Anthropogenic habitat change	2	-
(n = 1)	Shooting	Persecution	2	-
	Agriculture	Disturbance	1	-
	Forestry	Disturbance	1	-
Czech Republic	Agricultural intensification	Anthropogenic habitat change	5	-
(n = 1)	Habitat loss	Anthropogenic habitat change	5	-
	Accidental nest destruction	Indirect persecution	4	-
	Agriculture	Disturbance	3	-
	Poisoning	Persecution	3	-
	Predation	Ecological	3	-
	Secondary poisoning	Indirect persecution	3	-
	Shooting	Persecution	3	-
	Car / train	Collision	2	-
	Development	Anthropogenic habitat change	2	-
	Forestry	Disturbance	2	-
	Nest destruction	Persecution	2	-
	Power lines	Collision	2	-
	Grazing regimes	Anthropogenic habitat change	1	-
Finland	Afforestation	Anthropogenic habitat change	4	-
(n = 1)	Habitat loss	Anthropogenic habitat change	4	-
	Agricultural intensification	Anthropogenic habitat change	3	-
	Extreme weather	Ecological	3	-
	Forestry	Disturbance	3	-
	Predation	Ecological	3	-
	Accidental nest destruction	Indirect persecution	3	-
	Nest destruction	Persecution	2	-
	Power lines	Collision	2	-
	Agriculture	Disturbance	1	-
	Car / train	Collision	1	-
	Development	Anthropogenic habitat change	1	-
	Grazing regimes	Anthropogenic habitat change	1	-
	Recreation infrastructures	Anthropogenic habitat change	1	-
	Recreational activities	Disturbance	1	-
	Shooting	Persecution	1	-
	Wind turbines	Collision	1	-
France	Agricultural intensification	Anthropogenic habitat change	5	-
(n = 1)	Prey availability	Ecological	5	-
	Accidental nest destruction	Indirect persecution	5	-
	Agriculture	Disturbance	3	-
	Extreme weather	Ecological	1	-
	Nest destruction	Persecution	1	-
	Predation	Ecological	1	-
Germany	Prey availability	Ecological	3	0
(n = 3)	Habitat loss	Anthropogenic habitat change	2.3	1.6
	Agricultural intensification	Anthropogenic habitat change	2	0
	Recreation infrastructures	Anthropogenic habitat change	1.7	1.2
	Recreational activities	Disturbance	1.7	1.2
	Predation	Ecological	1.3	1.2
	Wind turbines	Collision	1.3	1.8
	Extreme weather	Ecological	1	0
	Secondary poisoning	Indirect persecution	1	1.4
	Grazing regimes	Anthropogenic habitat change	0.3	0.4

(Table S2 continued)

Country	Threat	Threat category	Impact	SD
Ireland	Habitat loss	Anthropogenic habitat change	5	0
(n = 2)	Afforestation	Anthropogenic habitat change	3.5	0.5
	Agricultural intensification	Anthropogenic habitat change	3	0
	Development	Anthropogenic habitat change	3	1
	Predation	Ecological	3	0
	Burning	Disturbance	2.5	0.5
	Forestry	Disturbance	2.5	0.5
	Recreational activities	Disturbance	2.5	1.5
	Extreme weather	Ecological	2	0
	Prey availability	Ecological	2	0
	Shooting	Persecution	2	0
	Accidental nest destruction	Indirect persecution	2	0
	Wind turbines	Collision	2	0
	Grazing regimes	Anthropogenic habitat change	1.5	0.5
	Nest destruction	Persecution	1.5	0.5
	Secondary poisoning	Indirect persecution	1.5	0.5
	Agriculture	Disturbance	1	0
	Poisoning	Persecution	1	1
	Recreation infrastructures	Anthropogenic habitat change	1	1
	Car / train	Collision	0.5	0.5
	Power lines	Collision	0.5	0.5
Netherlands	Prey availability	Ecological	4	0.5
(n = 5)	Agricultural intensification	Anthropogenic habitat change	3.3	2
	Habitat loss	Anthropogenic habitat change	2.5	2.2
	Accidental nest destruction	Indirect persecution	2.5	2.2
	Predation	Ecological	2.3	1.6
	Agriculture	Disturbance	2.2	1.3
	Grazing regimes	Anthropogenic habitat change	1.7	1.4
	Recreational activities	Disturbance	1.7	0.9
	Development	Anthropogenic habitat change	1.5	1.5
	Recreation infrastructures	Anthropogenic habitat change	1.3	1.3
	Car / train	Collision	1.2	0.9
	Extreme weather	Ecological	1	0.9
	Nest destruction	Persecution	0.8	1.1
	Wind turbines	Collision	0.7	0.7
	Power lines	Collision	0.5	0.5
	Secondary poisoning	Indirect persecution	0.5	0.7
	Poisoning	Persecution	0.3	0.4
	Shooting	Persecution	0.3	0.4
	Afforestation	Anthropogenic habitat change	0.2	0.3
	Burning	Disturbance	0.2	0.3
	Fences	Collision	0.2	0.3
	Forestry	Disturbance	0.2	0.3

(Table S2 continued)

Country	Threat	Threat category	Impact	SD
Spain	Habitat loss	Anthropogenic habitat change	5	0
(n = 2)	Accidental nest destruction	Indirect persecution	4.5	0.5
	Agricultural intensification	Anthropogenic habitat change	4	1
	Afforestation	Anthropogenic habitat change	3	2
	Burning	Disturbance	3	1
	Extreme weather	Ecological	3	
	Forestry	Disturbance	3	2
	Development	Anthropogenic habitat change	2.5	1.5
	Grazing regimes	Anthropogenic habitat change	2.5	0.5
	Wind turbines	Collision	2.5	1.5
	Agriculture	Disturbance	2	1
	Recreational activities	Disturbance	2	1
	Predation	Ecological	1.5	0.5
	Recreation infrastructures	Anthropogenic habitat change	1.5	0.5
	Car / train	Collision	1	0
	Nest destruction	Persecution	1	0
	Poisoning	Persecution	1	0
	Power lines	Collision	1	0
	Prey availability	Ecological	1	0
	Secondary poisoning	Indirect persecution	1	0
	Shooting	Persecution	1	0
UK	Shooting	Persecution	3.8	1.7
(n = 6)	Nest destruction	Persecution	3	2.1
	Predation	Ecological	3	1.2
	Afforestation	Anthropogenic habitat change	2.3	1.8
	Extreme weather	Ecological	2.3	0.4
	Agricultural intensification	Anthropogenic habitat change	2.2	1.7
	Grazing regimes	Anthropogenic habitat change	2	1.7
	Prey availability	Ecological	2	0.8
	Habitat loss	Anthropogenic habitat change	1.7	1.3
	Burning	Disturbance	1.3	1.1
	Poisoning	Persecution	1.3	1.3
	Development	Anthropogenic habitat change	1.2	1.2
	Recreation infrastructures	Anthropogenic habitat change	1	1.8
	Agriculture	Disturbance	0.8	1
	Accidental nest destruction	Indirect persecution	0.7	0.7
	Recreational activities	Disturbance	0.5	0.5
	Wind turbines	Collision	0.5	0.7
	Forestry	Disturbance	0.3	0.7
	Secondary poisoning	Indirect persecution	0.3	0.7
	Parasites	Ecological	0.2	0.3

Table S3. Perceived importance of conservation threats to breeding Short-eared Owl by country assessed through questionnaires (n = 12 responses from 6 countries). Threats are ordered by perceived importance, mean and standard deviation values are given for countries with multiple responses.

Country	Threat	Threat category	Impact	SD
Czech Republic	Agricultural intensification	Anthropogenic habitat change	5	-
(n = 1)	Habitat loss	Anthropogenic habitat change	5	-
	Accidental nest destruction	Indirect persecution	4	-
	Agriculture	Disturbance	3	-
	Car / train	Collision	3	-
	Predation	Ecological	3	-
	Shooting	Persecution	3	-
	Development	Anthropogenic habitat change	2	-
	Power lines	Collision	2	-
	Recreational activities	Disturbance	2	-
	Grazing regimes	Anthropogenic habitat change	1	-
Finland	Agricultural intensification	Anthropogenic habitat change	4	-
(n = 1)	Car / train	Collision	4	-
	Habitat loss	Anthropogenic habitat change	4	-
	Predation	Ecological	4	-
	Afforestation	Anthropogenic habitat change	3	-
	Agriculture	Disturbance	3	-
	Extreme weather	Ecological	3	-
	Grazing regimes	Anthropogenic habitat change	3	-
	Prey availability	Ecological	3	-
	Accidental nest destruction	Indirect persecution	3	-
	Forestry	Disturbance	2	-
	Nest destruction	Persecution	2	-
	Power lines	Collision	2	-
	Shooting	Persecution	2	-
	Recreation infrastructures	Anthropogenic habitat change	1	-
	Recreational activities	Disturbance	1	-
	Wind turbines	Collision	1	-
Germany	Extreme weather	Ecological	5	0
(n = 3)	Prey availability	Ecological	5	0
	Habitat loss	Anthropogenic habitat change	2.3	1.6
	Predation	Ecological	2.3	2.0
	Accidental nest destruction	Indirect persecution	2.3	1.6
	Agricultural intensification	Anthropogenic habitat change	2	2.1
	Grazing regimes	Anthropogenic habitat change	1.7	1.6
	Fences	Collision	1.3	1.8
	Recreation infrastructures	Anthropogenic habitat change	1.3	1.2
	Recreational activities	Disturbance	1.3	1.2
	Secondary poisoning	Indirect persecution	1.3	1.8
	Agriculture	Disturbance	1	1.4

(Table S3 continued)

Country	Threat	Threat category	Impact	SD
Netherlands	Agricultural intensification	Anthropogenic habitat change	4	1.2
(n = 4)	Prey availability	Ecological	4	0
	Habitat loss	Anthropogenic habitat change	2.5	1.8
	Accidental nest destruction	Indirect persecution	2.5	2.5
	Grazing regimes	Anthropogenic habitat change	2.3	1
	Agriculture	Disturbance	2	2.1
	Recreational activities	Disturbance	1.5	0.8
	Predation	Ecological	1.3	1.2
	Extreme weather	Ecological	1	0
	Car / train	Collision	0.8	1.2
	Development	Anthropogenic habitat change	0.8	1.2
	Nest destruction	Persecution	0.8	1.2
	Recreation infrastructures	Anthropogenic habitat change	0.8	0.8
	Secondary poisoning	Indirect persecution	0.5	0.8
	Wind turbines	Collision	0.5	0.8
	Poisoning	Persecution	0.3	0.4
	Power lines	Collision	0.3	0.4
	Shooting	Persecution	0.3	0.4
Spain	Shooting	Persecution	2	-
(n = 1)				
UK	Prey availability	Ecological	5	0
(n = 2)	Afforestation	Anthropogenic habitat change	4	1
	Habitat loss	Anthropogenic habitat change	4	1
	Predation	Ecological	4	1
	Shooting	Persecution	3.5	0.5
	Agricultural intensification	Anthropogenic habitat change	2.5	0.5
	Grazing regimes	Anthropogenic habitat change	2.5	0.5
	Extreme weather	Ecological	2	2
	Burning	Disturbance	2	0
	Nest destruction	Persecution	2	0
	Car / train	Collision	1	1
	Development	Anthropogenic habitat change	1	1
	Recreation infrastructures	Anthropogenic habitat change	1	1
	Recreational activities	Disturbance	1	1
	Wind turbines	Collision	1	1

Table S4. Perceived effectiveness of conservation strategies for breeding Hen Harrier and Short-eared Owl across Europe, assessed through questionnaires (n = 23 responses from 9 countries for Hen Harrier; n = 12 responses from 6 countries for Short-eared Owl).

Species	Threat category	Threat	Mean effectiveness	SD
Hen Harrier	Protection	Protected area	2.3	1.0
		Species-specific protected area (SPA)	2.3	1.4
		Nest protection (from direct or indirect persecution)	2.9	1.9
	Species management	Supplementary feeding	2.2	1.0
		Brood management	3.0	2.8
		Predator control (nest scale)	3.4	1.7
		Predator control (landscape scale)	2.8	0.8
	Habitat management	Improvement of nesting habitat	3.1	1.7
		Improvement of foraging habitat	3.2	1.1
		Improvement of linear features	2.2	0.3
		Improvement of grazing regimes	2.0	0.0
	Policy and legislation	Regulation of afforestation and forestry activities	2.3	1.0
		Regulation of recreation	2.3	1.9
		Rodenticide use regulation	3.0	-
Short-eared owl	Protection	Protected area	2.7	1.1
		Species-specific protected area (SPA)	2.9	1.5
		Nest protection (from direct or indirect persecution)	3.0	1.5
	Species management	Supplementary feeding	-	-
		Brood management	-	-
		Predator control (nest scale)	4.0	1.4
	Habitat management	Predator control (landscape scale)	3.5	1.7
		Improvement of nesting habitat	3.7	1.5
		Improvement of foraging habitat	4.2	1.2
		Improvement of linear features	3.0	-
		Improvement of grazing regimes	3.3	1.1
	Policy and legislation	Regulation of afforestation and forestry activities	1.0	-
		Regulation of recreation	-	-
		Rodenticide use regulation	4.0	1.4

CONSERVATION OF BREEDING HEN HARRIERS AND SHORT-EARED OWLS

Note that there are separate questionnaires referring to the conservation of breeding hen harriers (questions 3-10) and of breeding short-eared owls (questions 11-18). Please answer the questionnaire corresponding to the species which you are familiar with / study. If this includes both species, please answer both.

Instructions for answering the questionnaire:

This file may open in "read only" mode. Press "Esc" or click on "View / Edit document" to Answer the questions.

Boxes:

☐ *To mark the corresponding answer, click on the box.*
You can mark ***multiple boxes****.*

Drop-down menus (identifiable by red text):

Example drop-down menu. *Click on the text, then on the inverted triangle and select your response.*

Fill-in text boxes (identifiable by grey text):

Example text box *Click on the text and type in your answer (unlimited space).*

Additional answers (identifiable by the text " To add more fields…."):*

Option 1.	yes/no
Option 2.	yes/no
Other, specify.	yes/no

If you wish to add more fields, use the plus icon (⊞) that appears when you click on the last row.

If any of the above examples do not work on your version of Word, please download a format-free version of the questionnaire here.

Please send completed questionnaires and any questions to dfernandezbellon@ucc.ie by March 1st, 2019.

1. Organization you belong to / are a member of (*in relation to hen harriers / short-eared owls*):

Choose an option If other, please specify here.

Type of work you do:

☐ Conservation ☐ Research ☐ Consultancy / impact studies
☐ Habitat / species management ☐ Surveys / monitoring If other, please specify here.

2. Contact details (*answering this question is optional; all data will be treated anonymously and details will only be used to contact respondents if clarification on answers is required*).

Name: Name
E-mail: E-mail
Organization: Organization

BREEDING HEN HARRIERS

Fill in this questionnaire if hen harriers are your study species / area of expertise.

3. Study area.

Country: Country
Region/s (if country-wide, write "all"): Region/s

4. List habitats used by breeding hen harriers in your area for nesting and foraging.

Habitats	Mark if nesting habitat	Mark if foraging habitat
Type in habitat	☐	☐
Type in habitat	☐	☐
Type in habitat	☐	☐
Type in habitat	☐	☐
Type in habitat	☐	☐
Type in habitat	☐	☐
Type in habitat	☐	☐

**To add more fields, use the plus icon (+) that appears when you click on the last row.*

5. Approximate number of breeding pairs in your study area.

Number of breeding pairs
(If unknown, please provide a rough estimate using '>' or '<' here*)*

6. Population trend in your study area.

☐ Increasing
☐ Stable
☐ Decreasing
☐ Unknown

Are population trends (especially declines) a consequence of processes occurring during the breeding season, wintering season or both?

☐ Breeding season.
☐ Wintering season.
☐ Both.

Provide any additional information on population trends here (e.g time period for trends, causes for trends, gaps in knowledge of causes)

7. Direct threats (threats to nesting birds, nest or chick survival). *Note that **indirect threats and strategies are discussed in question 8** (e.g. habitat loss and habitat management).*

Rate the impact of the following threats on breeding success in your area from 1 (lowest or negligible impact) to 5 (highest impact) and indicate if there is documented evidence of that threat. *Use "N/A" if the listed threat does not occur in your area.*

Predation (*mark the appropriate option/s*) ☐ by native species. ☐ by non-native species. ☐ by avian predators. ☐ by mammalian predators.	N/A	Evidence y/n
Shooting of adults or fledglings.	N/A	Evidence y/n
Intentional poisoning.	N/A	Evidence y/n
Secondary poisoning.	N/A	Evidence y/n
Intentional nest destruction.	N/A	Evidence y/n
Accidental nest destruction, specify (e.g. harvesting).	N/A	Evidence y/n
Human disturbance from forest management.	N/A	Evidence y/n
Human disturbance from burning activities.	N/A	Evidence y/n
Human disturbance from agricultural activities.	N/A	Evidence y/n
Human disturbance from recreational activities.	N/A	Evidence y/n
Collision with wind turbines.	N/A	Evidence y/n
Electrocution / collision with power lines.	N/A	Evidence y/n
Road mortality.	N/A	Evidence y/n
Extreme weather.	N/A	Evidence y/n
Food availability.	N/A	Evidence y/n
Other, specify here.	N/A	Evidence y/n
Other, specify here.	N/A	Evidence y/n

**To add more fields, use the plus icon (⊞) that appears when you click on the last row.*

Rate the effectiveness of conservation strategies targeting direct threats in your area from 1 (ineffective; breeding success is similar to what would be expected without that strategy) to 5 (very effective; breeding success is optimized under that strategy). *Use "N/A" if the listed strategy is not in place in your area.*

Location of active nests and protection on a seasonal basis.	N/A
Nest protection / guarding.	N/A
Predator control / fences.	N/A
Brood management.	N/A
Supplementary feeding.	N/A
Predator control at landscape scale.	N/A
Other, specify here.	N/A
Other, specify here.	N/A
Other, specify here.	N/A
Other, specify here.	N/A

**To add more fields, use the plus icon (⊞) that appears when you click on the last row.*

Provide any additional information on direct threats & conservation strategies here

8. Indirect threats. *Note that due to the nature of indirect threats and conservation strategies, **some answers in this section may overlap**.*

Rate the impact of following threats in your area on breeding populations from 1 (lowest or negligible impact) to 5 (highest impact). *Use "N/A" if the listed threat does not occur in your area.*

Habitat loss and fragmentation (specify cause here).	N/A
Grazing and livestock.	N/A
Agricultural intensification.	N/A
Afforestation.	N/A
Wind farm development.	N/A
Recreational activities.	N/A
Other, specify here.	N/A
Other, specify here.	N/A
Other, specify here.	N/A
Other, specify here.	N/A

**To add more fields, use the plus icon (+) that appears when you click on the last row.*

Rate the effectiveness of conservation strategies targeting indirect threats in your study area from 1 (ineffective; the strategy does not benefit breeding populations) to 5 (very effective; breeding populations are optimized under that strategy). *Use "N/A" if the listed strategy is not in place in your area.*

Protected areas		
	Protected areas not exclusively designed for the species' protection (reserves, national parks).	N/A
	Protected areas designed for the species (SPAs, red zones)	N/A
Habitat management / agri-environmental schemes		
	Creating / enhancing conditions for nesting (describe briefly).	N/A
	Creating / enhancing conditions for foraging (describe briefly).	N/A
	Improving the value of existing linear features (describe briefly).	N/A
	Reducing / increasing grazing, livestock rates, etc (describe briefly).	N/A
	Other management / scheme: specify & describe briefly.	N/A
Other		
	Regulating forest management activities.	N/A
	Regulating recreational activities.	N/A
	Other, specify here.	N/A
	Other, specify here.	N/A
	Other, specify here.	N/A
	Other, specify here.	N/A

**To add more fields, use the plus icon (+) that appears when you click on the last row.*

Provide any additional information on indirect threats and conservation strategies here

9. Are there any weaknesses / strengths of particular conservation strategies you would like to highlight?

Conservation strategies' weaknesses / strengths

Would you recommend the implementation of alternative conservation strategies, and if so, please describe briefly.

Alternative conservation strategies

Do you consider that these alternative strategies require testing or that there is sufficient evidence in place to implement them immediately? *Please reference any relevant literature.*

Evidence for alternative strategies

10. Please provide any additional comments.

Comments

Thank you for your time!

(*Short-eared owl survey on next page*)

BREEDING SHORT-EARED OWLS

Fill in this questionnaire if short-eared owls are your study species / area of expertise.
(If you are answering both questionnaires, the "same as for hen harriers" option can be used if the same reply applies to both species)

11. Study area.

Country: Country
Region/s (if country-wide, write "all"): Region/s

☐ *Same as for hen harriers.*

12. List habitats used by breeding short-eared owls in your area for nesting and foraging.

Habitats	Mark if nesting habitat	Mark if foraging habitat
Type in habitat	☐	☐
Type in habitat	☐	☐
Type in habitat	☐	☐
Type in habitat	☐	☐
Type in habitat	☐	☐
Type in habitat	☐	☐
Type in habitat	☐	☐

**To add more fields, use the plus icon (+) that appears when you click on the last row.*

☐ *Same as for hen harriers.*

13. Approximate number of breeding pairs in your study area.

Number of breeding pairs
(If unknown, please provide a rough estimate using '>' or '<' here*)*

14. Population trend in your study area.

☐ Increasing
☐ Stable
☐ Decreasing
☐ Unknown

Are population trends (especially declines) a consequence of processes occurring during the breeding season, wintering season or both?

☐ Breeding season.
☐ Wintering season.
☐ Both.

Provide any additional information on population trends here (e.g time period for trends, causes for trends, gaps in knowledge of causes)

15. Direct threats (threats to nesting birds, nest or chick survival). *Note that **indirect threats and strategies are discussed in question 16** (e.g. habitat loss and management).*

Rate the impact of the following threats on breeding success in your area from 1 (lowest or negligible impact) to 5 (highest impact) and indicate if there is documented evidence of that threat. *Use "N/A" if the listed threat does not occur in your area.*

Predation (*mark the appropriate option/s*) ☐ by native species. ☐ by non-native species. ☐ by avian predators. ☐ by mammalian predators.	N/A	Evidence y/n
Shooting of adults or fledglings.	N/A	Evidence y/n
Intentional poisoning.	N/A	Evidence y/n
Secondary poisoning.	N/A	Evidence y/n
Intentional nest destruction.	N/A	Evidence y/n
Accidental nest destruction, specify (e.g. harvesting).	N/A	Evidence y/n
Human disturbance from forest management.	N/A	Evidence y/n
Human disturbance from burning activities.	N/A	Evidence y/n
Human disturbance from agricultural activities.	N/A	Evidence y/n
Human disturbance from recreational activities.	N/A	Evidence y/n
Collision with wind turbines.	N/A	Evidence y/n
Electrocution / collision with power lines.	N/A	Evidence y/n
Road mortality.	N/A	Evidence y/n
Extreme weather.	N/A	Evidence y/n
Food availability.	N/A	Evidence y/n
Other, specify here.	N/A	Evidence y/n
Other, specify here.	N/A	Evidence y/n

**To add more fields, use the plus icon (⊞) that appears when you click on the last row.*

Rate the effectiveness of conservation strategies targeting direct threats in your area from 1 (ineffective; breeding success is similar to what would be expected without that strategy) to 5 (very effective; breeding success is optimized under that strategy). *Use "N/A" if the listed strategy is not in place in your study area.*

Location of active nests and protection on a seasonal basis.	N/A
Nest protection / guarding.	N/A
Predator control / fences.	N/A
Brood management.	N/A
Supplementary feeding.	N/A
Predator control at landscape scale.	N/A
Other, specify here.	N/A
Other, specify here.	N/A
Other, specify here.	N/A
Other, specify here.	N/A

**To add more fields, use the plus icon (⊞) that appears when you click on the last row.*

Provide any additional information on direct threats & conservation strategies here

16. Indirect threats. *Note that due to the nature of indirect threats and conservation strategies,* ***some answers in this section may overlap****.*

Rate the impact of following threats in your area on breeding populations from 1 (lowest or negligible impact) to 5 (highest impact). *Use "N/A" if the listed threat does not occur in your study area.*

Habitat loss and fragmentation (specify cause).	N/A
Grazing and livestock.	N/A
Agricultural intensification.	N/A
Afforestation.	N/A
Wind farm development.	N/A
Recreational activities.	N/A
Other, specify here.	N/A
Other, specify here.	N/A
Other, specify here.	N/A
Other, specify here.	N/A

**To add more fields, use the plus icon (⊞) that appears when you click on the last row.*

Rate the effectiveness of conservation strategies targeting indirect threats in your study area from 1 (ineffective; the strategy does not benefit breeding populations) to 5 (very effective; breeding populations are optimized under that strategy). *Use "N/A" if the listed strategy is not in place in your study area.*

Protected areas		
	Protected areas not exclusively designed for the species' protection (reserves, national parks).	N/A
	Protected areas designed for the species (SPAs, red zones)	N/A
Habitat management / agri-environmental schemes		
	Creating / enhancing conditions for nesting (describe briefly).	N/A
	Creating / enhancing conditions for foraging (describe briefly).	N/A
	Improving the value of existing linear features (describe briefly).	N/A
	Reducing / increasing grazing, livestock rates, etc (describe briefly).	N/A
	Other management / scheme: specify & describe briefly.	N/A
Other		
	Regulating forest management activities.	N/A
	Regulating recreational activities.	N/A
	Other, specify here.	N/A
	Other, specify here.	N/A
	Other, specify here.	N/A
	Other, specify here.	N/A

**To add more fields, use the plus icon (⊞) that appears when you click on the last row.*

Provide any additional information on indirect threats and conservation strategies here

17. Are there any weaknesses / strengths of particular conservation strategies you would like to highlight?

Conservation strategies' weaknesses / strengths

Would you recommend the implementation of alternative conservation strategies, and if so, please describe briefly.

Alternative conservation strategies

☐ *Same as for hen harriers.*

Do you consider that these alternative strategies require testing or that there is sufficient evidence in place to implement them immediately? *Please reference any relevant literature.*

Evidence for alternative strategies

☐ *Same as for hen harriers.*

18. Please provide any additional comments.

Comments

Thank you for your time!