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3 **The conservation of Afro-Palaeartic migrants: what we are learning and what we need to**
4 **know**

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30 Abstract

31 The global long-term decline of migrant birds represents an important and challenging issue for
32 conservation scientists and practitioners. This review draws together recent research directed at the
33 major Afro-Palaeartic flyway, and considers its implications for conservation research and action.
34 Greatest advances in knowledge have been made in the field of tracking. These studies reveal many
35 species to be highly dispersed in the non-breeding season, suggesting that site-level conservation at
36 a small number of locations will almost certainly be of limited value for the majority of species.
37 Instead, widespread but 'shallow' land-sharing solutions are likely to be more effective but, because
38 any local changes in Africa will affect many European populations, a positive or negative impact will
39 be extremely difficult to detect through breeding ground monitoring. Targeted action to boost
40 productivity in Europe may help halt declines of some species, but reversing declines for many
41 species is also likely to require these 'shallow' land-sharing approaches in wintering and staging
42 areas. The retention or planting of native trees in the humid and arid zone within Africa may be one
43 such generic conservation tool, although more detailed knowledge of tree preferences will enhance
44 the effectiveness of this approach. Overall, and despite a growing wealth of knowledge, we remain
45 largely unable to progress beyond general flyway-level actions, such as maintaining suitable habitat
46 across an increasingly anthropogenic landscape for generalists, targeted site-based conservation for
47 specialists and at stop-over sites, protection of species from hunting and individual species-level
48 solutions. In broad terms, we remain unable to assess the cost-effectiveness of any more specific
49 conservation action, mainly because of uncertainty around how migrant populations are affected by
50 conditions during passage and on the wintering ground as well as around ease of implementation of
51 actions particularly in non-breeding areas. For advances in knowledge to develop and implement
52 effective conservation, scientific approaches need to be better coordinated and integrated across
53 the full annual cycle. However, we urge the use of scientific results we already have to start to act
54 rather than wait for complete knowledge and understanding and combining these with monitoring
55 and adaptive interdisciplinary action across the flyway.

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57 Key words

58 Connectivity, dispersal, tree establishment, trial solutions, East Atlantic flyway

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61 Résumé

62 Le déclin global à long terme des oiseaux migrateurs représente un problème important et un défi
63 pour les scientifiques et les professionnels de la conservation. Cette revue rassemble les recherches

64 récentes sur la principale voie de migration afro-paléarctique et examine leurs implications pour la
65 recherche et les actions de conservation. De grands progrès en matière de connaissances ont été
66 réalisées dans le domaine du suivi. Ces études révèlent que de nombreuses espèces sont très
67 dispersées pendant la saison de non reproduction, ce qui suggère que la conservation à l'échelle de
68 site au niveau d'un petit nombre de zones sera presque certainement d'une valeur limitée pour la
69 majorité des espèces. En revanche, les solutions de partage des terres, répandues mais
70 "superficielles", seront probablement plus efficaces. Toutefois, étant donné que tout changement
71 local en Afrique affectera de nombreuses populations européennes, il sera extrêmement difficile de
72 détecter un impact positif ou négatif par le biais du suivi des zones de reproduction. Une action ciblée
73 visant à stimuler la productivité en Europe pourrait contribuer à enrayer le déclin de certaines
74 espèces, mais pour inverser le déclin de nombreuses espèces, il est probable qu'il faille également
75 recourir à ces approches de partage des terres "superficielles" dans les zones d'hivernage et de
76 transit. La conservation ou la plantation d'arbres indigènes dans les zones humides et arides
77 d'Afrique peut être un de ces outils de conservation générique, bien qu'une connaissance plus
78 détaillée des arbres de préférence améliorera l'efficacité de cette approche. Dans l'ensemble, malgré
79 une masse croissante de connaissances, nous restons largement dans l'incapacité de progresser au-
80 delà des actions générales à l'échelle de la voie de migration, telles que le maintien d'un habitat
81 approprié dans un paysage de plus en plus anthropique pour les généralistes, la conservation ciblée
82 sur les sites pour les spécialistes et les sites d'escale, la protection des espèces contre la chasse et les
83 solutions individuelles à l'échelle d'espèce. Dans l'ensemble, nous restons largement dans
84 l'incapacité d'évaluer le rapport coût-efficacité de toute action de conservation spécifique, en raison
85 de l'incertitude quant à la manière dont les populations migrantes sont affectées par les conditions
86 pendant la migration et sur les zones d'hivernage, ainsi que sur la facilité de mise en œuvre des
87 actions, en particulier dans les zones de non reproduction. Pour que les progrès des connaissances
88 permettent de développer et de mettre en œuvre une conservation efficace, les approches
89 scientifiques doivent être mieux coordonnées et intégrées sur l'ensemble du cycle annuel.
90 Cependant, nous insistons sur l'utilisation des résultats scientifiques dont nous disposons déjà pour
91 commencer à agir plutôt que d'attendre une connaissance et une compréhension complètes et de
92 les combiner avec le suivi et l'action interdisciplinaire adaptative à travers la voie de migration.

93

94 **Mots clés**

95 Connectivité, dispersion, plantation d'arbres, solutions d'essai, voie de migration de l'Atlantique Est.

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98 Migrant birds have been in decline in all major flyways across the globe for decades (Robbins *et al.*
99 1989, Berthold *et al.* 1998, Sanderson *et al.* 2006, Studds *et al.*, 2017, Rosenberg *et al.*, 2019). Their
100 extraordinary journeys and movements, crossing geographic barriers and linking distant continents,
101 make these species, and their ongoing declines, of particular concern and importance in scientific,
102 political and public arenas. At the same time, their highly complex annual life cycles, with long
103 migration routes and a dependence on different sites at different times of the year makes the
104 diagnosis of their declines and subsequent conservation action particularly challenging. Developing
105 and implementing cost-effective solutions to arrest, and ultimately reverse, population declines of
106 any species, usually requires knowing whether they are driven by insufficient breeding success or
107 survival. Intensive studies of single species or single sites has produced such information for only a
108 small number of migrant bird species, particularly waders and raptors, but almost none of the small
109 migrant passerines (but see e.g. Marra *et al.* 1998 & 2015, Kamp *et al.* 2015), particularly within the
110 Afro-Palaeartic flyway (Vickery & Adams 2020).

111 In an earlier synthesis of evidence for the importance of different factors in driving the
112 declines of Afro-Palaeartic migrants, Vickery *et al.* (2014) concluded that, whilst our knowledge of
113 declining species is generally better in the breeding than the non-breeding season, significant gaps
114 exist throughout the annual cycle for many species. On the breeding grounds, degradation of
115 breeding habitats emerged as a key factor, particularly within agricultural and woodland or forest
116 habitats. In the non-breeding areas, the interacting factors of anthropogenic habitat degradation
117 and climatic conditions, particularly drought in the Sahel zone, appeared to be the most important
118 factors. Four priority areas were identified for research for diagnosing the causes of declines and
119 informing development of solutions to stem and reverse them. These were: (i) use of new and
120 emerging tracking technologies; (ii) detailed field studies of migrant birds in sub-Saharan Africa; (iii)
121 use of survey and demographic data from the European breeding grounds; and (iv) use of remote
122 sensing earth observation data of land cover change in sub-Saharan west Africa in relation to its
123 impact on migrant bird populations.

124 In the eight years since this review, populations of Afro-Palaeartic migrants have
125 continued to decline. There have been advances in all four of priority research areas, and yet new
126 knowledge has not contributed to the development of new policies to address declines. In this
127 paper, we assess the new knowledge acquired since 2014 in the light of the needs of conservation
128 policy and action on the Afro-Palaeartic flyway. We do this in three sections. First, we provide up
129 to date population trend data for Afro-Palaeartic migrant birds derived from Europe-wide survey
130 and census data and ask to what extent these declines have changed in the last 10-20 years.
131 Second, we assess the extent to which our knowledge and understanding has advanced through

132 each of the four key areas identified by Vickery *et al.* (2014) and how this new information informs
133 conservation. In the final, concluding section we draw this new information together to derive
134 recommendations for future conservation science, policy and practice for migrant birds in the Afro-
135 Palaeartic flyway.

136 We searched Web of Science and Google Scholar for papers matching key search terms in
137 either 'Topic' (title, abstract, author key words and Keywords Plus) or 'All Fields', with a publication
138 date of 2014 onwards. Different search terms were used for different sections of our review (see
139 SOM for details) but they generally included 'Afro-Pal(a)earctic' OR individual species names
140 (common name OR scientific name) AND other broad terms e.g. 'Africa', 'migration', 'land cover',
141 'tracking', 'demography', OR more specific terms e.g. individual tracking methods or demographic
142 parameters. Returned papers were assessed for relevance based on their abstracts, and reference
143 lists of included papers checked to ensure no relevant literature had been missed by the online
144 searches.

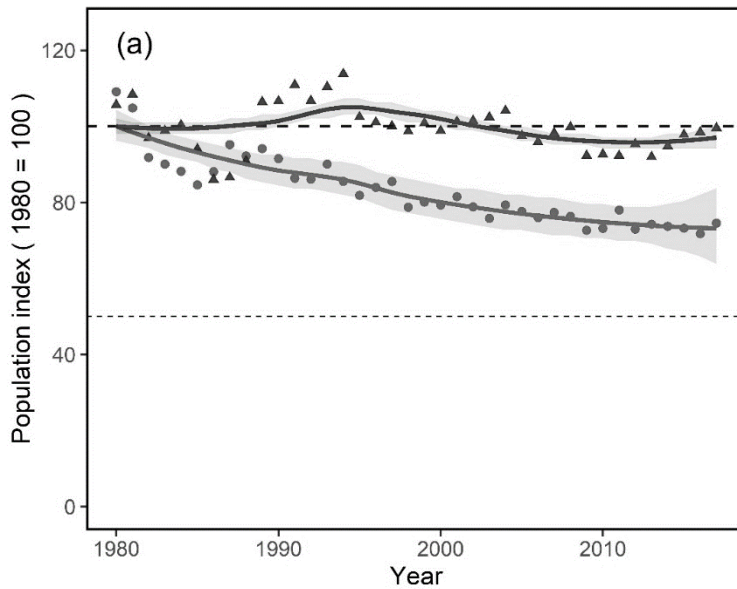
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146 **POPULATION TRENDS OF AFRO-PALAEARCTIC MIGRANT BIRDS**

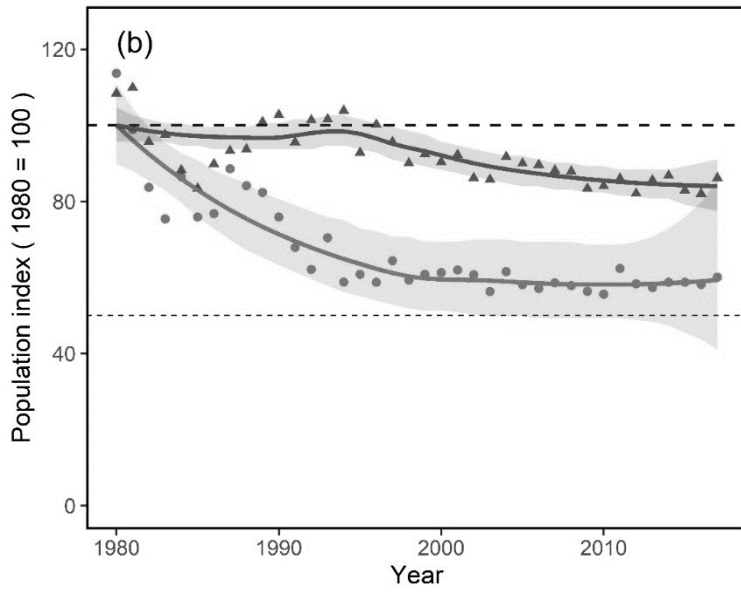
147 We define Afro-Palaeartic migrant species as species in which at least part of the population moves
148 between breeding areas in the Palaeartic region and non-breeding grounds in sub-Saharan Africa
149 each year (as defined in Vickery *et al.* 2014 and following the classification of migratory strategy
150 outlined by BirdLife International 2004). Breeding population data are available for a subset of 62
151 species of long-distance migrants in Europe (Brlík *et al.* 2021: <https://pecbms.info/>). The aggregate
152 population trajectory of this group in Europe, derived from the Pan-European Common Bird
153 Monitoring Scheme (Brlík *et al.* 2021: is significantly negative between 1980 and 2017 (Fig. 1a: long-
154 term change = -26.7%, SE = 5.2%, $P < 0.01$), whereas the trend for residents and short-distance
155 migrants combined is stable (Fig. 1a: long-term change = -3.0%, SE = 1.9%, NS). These trends are
156 significantly different from each other (trend difference = -0.0071, SE = 0.0013, $P < 0.05$). Population
157 trends of long-distance migrants that predominantly winter in arid northern Sahelian and Sudan
158 savannah zones (Fig. 2) show a significantly different pattern from those that winter in the humid,
159 more tropical southern areas (Fig 1b and Fig 2: trend difference = -0.008, SE = 0.004, $P < 0.05$). Birds
160 wintering in the arid zone fell in abundance between 1980 and 2017 (long-term change = -39.5%, SE
161 = 12.1%, $P < 0.01$), especially early in the time series, and their populations are now much depleted
162 when compared to the baseline of 1980. Over the same period, birds wintering in the humid tropics
163 of West and Central Africa and wet-season savannahs of southern Africa have also fallen in
164 abundance overall (change = -15.7%, SE= 4.1%, $P < 0.01$), but the pattern appears different with the
165 declines starting later. Overall, these analyses suggest a continuing long-term downward trend in the

166 abundance of long-distance migrant birds in Europe compared to other bird groups. They also
 167 suggest that, while both the arid-zone wintering and humid and southern-zone wintering species
 168 have declined, that trend has flattened for the former group of birds but not for the latter.
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171 Figure 1. Aggregate multi-species indices for widespread and common European (a) long-distance migrants (62
 172 species: circles) and short-distance migrants and resident breeding birds (108 species: triangles), and (b) long-
 173 distance migrants wintering predominantly in the arid zone (22 species: circles) and humid & southern zones
 174 (29 species: triangles) of Africa. Horizontal dashed lines mark index values of 100 and 50. Trend data from 1980
 175 to 2017 come from 28 countries covered by the Pan-European Common Bird Monitoring Scheme (Brlík *et al.*
 176 2021: <https://pecbms.info/>). Statistically smoothed indices are derived using the Multi Species Indices Tool
 177 (MSI-tool: Soldaat *et al.* 2017) and fixed to a value of 100 in 1980 with grey shaded 95% confidence limits. We
 178 also used the MSI-tool to test for significant differences in trend slopes and statistical change points in the
 179 slopes based on Monte Carlo procedures (Soldaat *et al.* 2017). The predominant wintering zone of long-
 180 distance migrants in Africa is classified broadly as either as 'arid' or 'humid & southern' following the studies of
 181 Hewson and Noble (2009), Thaxter *et al.* (2010), and Ockendon *et al.* (2012). For full details see SOM Table 1
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187 Figure 2. Climate zones of Africa and the western Palearctic: Köppen-Geiger climate classifications for present
 188 day (1980-2016) from Beck *et al.* (2018). First level classifications are shown except for the "arid" category,
 189 which has been subdivided using level 2 categories to make the distinction between desert climate and the
 190 Sahel, which has a steppe climate.

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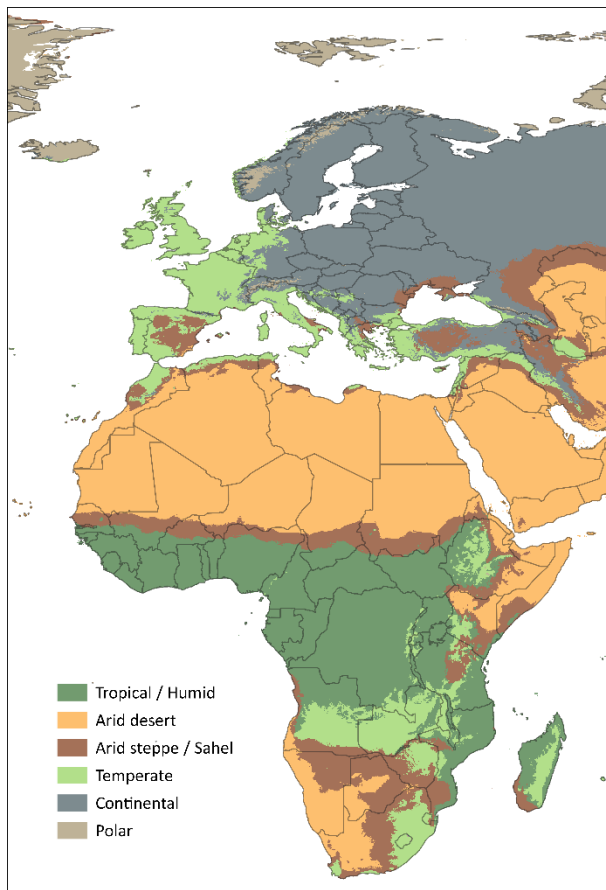
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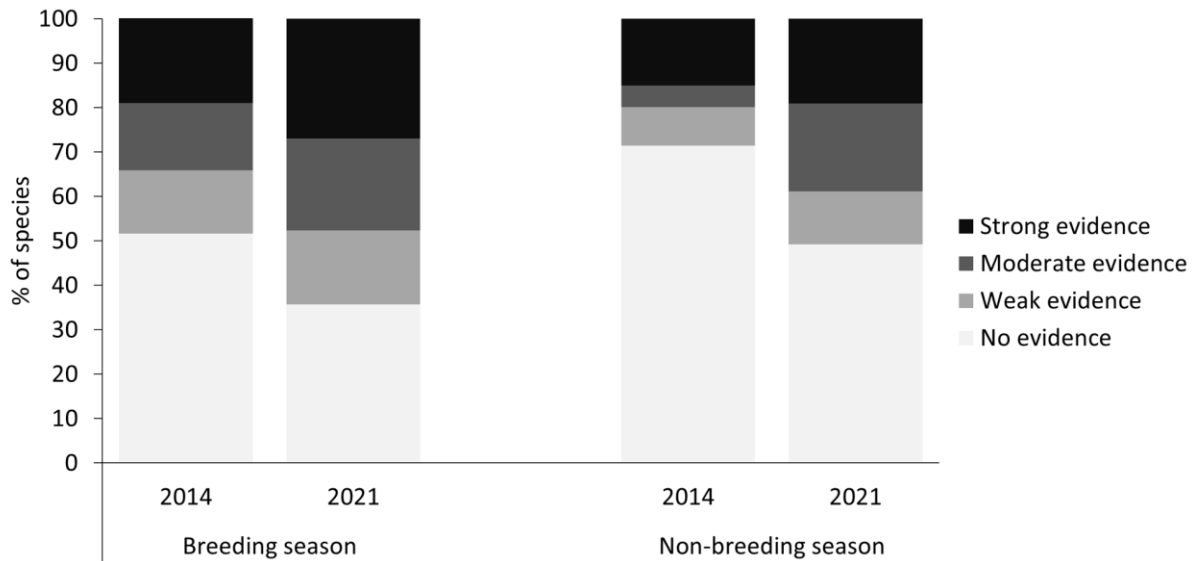
209 Vickery *et al.* (2014) report that information on potential factors impacting on migrant
210 species, regardless of population trend, was available for 48% of those species in the breeding
211 season, but for only 27% during the non-breeding season (n=126 species). To assess whether, and
212 if so to what extent, this has changed, we reviewed the new literature available in relation to
213 factors shown to affect individual Afro-Palaeartic migrants at different points during the annual
214 cycle. We considered each of the studies published between 2014 and 2021 and assessed the
215 extent to which they provided evidence for factors operating during the breeding and non-breeding
216 (wintering and staging sites) seasons (for details of new publications for each species see SOM
217 Table S2). The evidence was categorised as strong, moderate or weak and the strongest level
218 identified for each species in each season was assigned to that species. In Vickery *et al.* (2014)
219 strength of evidence was categorised as 'strong' if factors were shown to have a population-level
220 effect, 'moderate' if they affected survival or breeding success and 'weak' if they influenced only
221 habitat selection. However, a number of the studies that suggest population level effects in winter
222 are based on correlations between population change and broad measures of environmental
223 conditions in Africa. Beresford *et al.* (2019) suggest the use of the term 'strong evidence' in relation
224 to these studies is misleading given the spatial variation in environmental parameters across Africa,
225 coupled with the lack of data on non-breeding distributions. Although we continue to use this term
226 to retain consistency between this review and Vickery *et al.* 2014, we recognise evidence from
227 these correlative studies is not as strong as this term suggests. the number of species with strong
228 moderate or weak evidence available

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236 Figure 3. Summary of the extent of evidence available in 2014 and 2021 in relation to environmental factors
 237 likely to influence population trends of 126 Afro-Palaeartic migrant species during the breeding and non-
 238 breeding seasons. For each species, evidence from published studies catalogued in Table S2 was categorized
 239 as either 'strong' (a population-level effect), 'moderate' (effects on survival or breeding success) or 'weak' (an
 240 effect on habitat selection). The strongest level identified for each species in each season was assigned and
 241 the total number of species in each level counted.

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244 Our knowledge about factors that may affect migrant birds has increased in both seasons (Fig. 3),
 245 across a broad range of habitats and particularly in the non-breeding season, with information now
 246 existing for 51% of species compared with 29% previously (Table S2). However, although this
 247 represents a welcome increase in knowledge it is important to note that, as in 2014 (Adams et al
 248 2014), very few of these new studies have generated new empirical data from the non-breeding
 249 grounds. The majority are large scale correlations of breeding population data with environmental
 250 variables derived from non-breeding grounds.

251 In their review, Vickery *et al.* (2014) concluded that the most important factors driving
 252 declines on the breeding grounds were linked to human-related habitat change, particularly within
 253 farmland. There was relatively little evidence for other factors, such as climate change, collision
 254 with power lines and hunting, having a widespread effect. This overall assessment remains
 255 unchanged; of 103 breeding season studies published since 2014, 61% (n = 63) have considered
 256 habitat preferences and / or land-use change, and 15% (n=15) of studies have linked climatic
 257 variables to demographic parameters, with widespread population responses to climate change

258 reported (e.g. Pearce-Higgins & Crick 2019). There have, however, also been advancements in two
259 important areas: increasing evidence of widespread insect declines in Europe, a key food resource
260 for many AP migrants, and the scale and impact of legal and illegal hunting.

261 There is growing concern, globally, regarding the plight of insect populations, with a number
262 of large-scale studies suggesting dramatic declines in the total biomass and abundance of entire
263 insect assemblages (e.g. Dirzo *et al.* 2014, van Klink 2020). For example, it has been estimated that
264 67% of monitored invertebrate populations globally show mean abundance declines of 45% (Dirzo
265 *et al.* 2014). In Europe, declines of terrestrial insect abundance have averaged ca 9% per decade
266 since the 1960s, and have accelerated since 2005 (van Klink *et al.* 2020). National and regional
267 studies have reported similar results for the insect community as a whole (e.g. Germany, Hallmann
268 *et al.* 2017, Seibold *et al.* 2019), or key taxonomic groups (e.g. micro moths, Valtonen *et al.* 2017
269 and butterflies, Thomas *et al.* 2004). It should be noted, however, that other long-term studies,
270 both in Europe (Macgregor *et al.* 2019), and North America (Crossley *et al.* 2020), have found no
271 consistent trends across invertebrate taxonomic groups. Although no studies actually show a direct
272 effect on birds, a number have suggested that declines in insect populations may have contributed
273 to parallel declines in insectivorous birds, including migrants, (e.g. Bowler *et al.* 2019, Hallmann *et al.*
274 *et al.* 2014). Insect declines have been reported globally including in tropical regions (Outhwaite *et al.*
275 2022 although, little data exists for trends of invertebrates in most of Africa (Sánchez-Bayo &
276 Wyckhuys 2021).

277 A second area where there has been important progress is in relation to hunting which,
278 although unlikely to be an important driver of widespread declines of AP migrants, is undoubtedly
279 important for some species. The demographic impact of legal and illegal killing on bird population
280 size is difficult to determine, especially given the uncertainty over both the estimates of the
281 numbers of individuals killed and the flyway population size. However, even given such
282 uncertainties, hunting of one species, European turtle dove *Streptopelia turtur*, characterised as
283 'Vulnerable' to extinction (Birdlife International 2017b) and legal quarry in 10 European countries
284 (Fisher *et al.* 2018), has been shown to be unsustainable under all realistic estimates of bag size and
285 demographic parameters (Lormée *et al.* 2020). Furthermore, measures put in place to regulate bag
286 size have proved to be ineffective in limiting the number of turtle doves killed (Moreno-Zárate *et al.*
287 2021). By identifying from which breeding populations hunted birds originated, Jiguet *et al.* (2019)
288 were able to show that legal hunting of Ortolan Buntings *Emberiza hortulana* in France was also
289 unsustainable. While there are a number of legal quarry species that are Afro-Palaeartic migrants,
290 there is also widespread illegal killing of many species. In reviews of illegal hunting in the
291 Mediterranean and Middle East (Brochet *et al.* 2016, 2019), it has been estimated that tens of

292 millions of individual birds of hundreds of species may be killed/taken illegally every year (11 – 36
293 million in the Mediterranean alone). The potential impact of such illegal killing has been illustrated
294 in the East Asian flyway, where the recent widespread decline and range contraction of the once-
295 abundant Yellow-breasted Bunting *Emberiza aureola* across Asia, has been associated with
296 increased trapping of songbirds across the region (Kamp *et al.* 2015).

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299 **RECENT ADVANCES IN KNOWLEDGE AND UNDERSTANDING FROM THE USE OF NEW AND** 300 **EMERGING TRACKING TECHNOLOGIES**

301 The ability to track individual birds throughout their annual migratory cycle has the potential to link
302 annual cycle events to populations and population trends. Since the publication of Vickery *et al.*
303 (2014), we have identified 216 papers related to the tracking of Afro-Palaeartic migrants (see
304 Supplementary information for the complete reference list of tracking studies). Almost half of these
305 (101) were considered to have contributed significant information for the conservation of these
306 species. Prior to the current review period, stable isotopes were in widespread use for attempted
307 elucidation of patterns of connectivity of Afro-Palaeartic migrants (e.g. Hobson *et al.* 2014) but their
308 resolution and accuracy for this purpose is such that conclusions may be superseded by even
309 preliminary tracking evidence (Burgess *et al.* in press) and they have provided no significant recent
310 advances. Nonetheless, where it is necessary to assign individuals within a breeding population to
311 divergent migratory groups, these methods may still be valuable, especially combined with other
312 approaches (e.g. Liedvogel *et al.* 2014), whilst recently-developed genoscoping methods may in
313 future provide a higher resolution alternative to isotopes for connectivity studies, such as seen
314 recently in North America (e.g. Bay *et al.* 2021).

315 At their most basic, tracking studies provide essential information on migration routes and
316 strategies, and the location of wintering and stopover sites. This is fundamental information for
317 conservation, helping to identify the nature of potential threats and drivers of decline (Burgess *et al.*
318 2020, Rodriguez-Ruiz *et al.* 2019), key sites in need of protection (Horns *et al.* 2016, Buechley *et al.*
319 2018, Salewski *et al.* 2019; also, Tonra *et al.* 2019), and sites at which to target detailed ecological
320 studies on specific populations and stages of the annual cycle. Recent papers present extensive new
321 information on routes (e.g. Trierweiler *et al.* 2014, Sara *et al.* 2019), stopovers (e.g. van der Winden
322 *et al.* 2014, Salewski *et al.* 2019), and wintering areas (e.g. Willemoes *et al.* 2014, Finch *et al.* 2015,
323 Ouwehand *et al.* 2016). They confirm that non-soaring migrants migrate on broad fronts to and from
324 Europe (supported by a positive correlation between breeding and wintering longitudes reported by
325 Briedis *et al.* 2020), rather than following narrow corridors such as those used by soaring migrants.

326 They are also beginning to reveal some unexpected patterns. The first is the extensive mid-winter
327 use of the Congo Basin and immediately adjacent areas by species such as Common Swift *Apus apus*,
328 Common Cuckoo *Cuculus canorus* and European Nightjar *Caprimulgus europaeus*, (Åkesson *et al.*
329 2020, Hewson *et al.* 2016, Evens *et al.* 2017) as well as some open country species like Great Snipe
330 *Gallinago media* and Corncrake *Crex crex* (Klaassen *et al.* 2011, Green 2020). The second is the
331 detour that many populations make from the Congo Basin area to West Africa on their spring
332 migration (Åkesson *et al.* 2011, Willemoes *et al.* 2014, Norevik *et al.* 2019).

333 These studies have also advanced knowledge regarding, for instance, timing of annual
334 events (e.g., Ouweland & Both 2017, van Wijk *et al.* 2017, Briedis *et al.* 2018, Tomotani *et al.* 2019,
335 Brlík *et al.* 2020) and patterns of connectivity between breeding and wintering populations (e.g.,
336 Hahn *et al.* 2013, Åkesson *et al.* 2020). Several species have been shown to move between multiple
337 sites in the tropics during the winter (Åkesson *et al.* 2012, Willemoes *et al.* 2014, Kolecek *et al.* 2016,
338 2018, Thorup *et al.* 2017), allowing birds to track food resources across rainfall gradients with small
339 (Montagu's Harriers *Circus pygargus*, Schlaich *et al.* 2016, Great Reed Warblers *Acrocephalus*
340 *arundinaceus* Kolecek *et al.* 2018a and 2018b, Pallid Swifts *Apus pallidus* Norevik *et al.* 2019) and/or
341 larger-scale movements (e.g. Common Cuckoo, Red backed Shrike *Lanius collurio* and Thrush
342 Nightingale *Luscinia luscinia*; Thorup *et al.* 2017). This dependence on multiple locations makes
343 identification of site-level drivers very difficult. It also means that the conservation of single sites is
344 likely to be of limited effectiveness for many generalist species but may be valuable for some habitat
345 specialists (e.g. wetland species such as Aquatic Warbler *Acrocephalus paludicola*)

346 For migrant birds, as for all species, events in one stage of the annual cycle may carry over to
347 subsequent stages, and tracking studies provide insights into the timing of annual events (Lisovski *et*
348 *al.* 2012, Briedis *et al.* 2018, Pederson *et al.* 2018), as well as the dependencies and carry-over
349 effects between them (Emmenegger *et al.* 2016, Briedis *et al.* 2017, Brlík *et al.* 2020). Most studies
350 actually suggest little or no linkage between timing of events early and late in the annual cycle, due
351 to the buffering effects of variable mid-winter periods (Ouweland *et al.* 2017, van Wijk *et al.* 2017,
352 Briedis *et al.* 2018, Tomotani *et al.* 2019), although in a combined multi-species analysis, Briedis *et*
353 *al.* (2020) found weaker carry-over across midwinter for males only.

354 There may, however, be strong linkages between directly successive seasons (e.g. the timing
355 of departure from the winter grounds and arrival on the breeding grounds for Pied Flycatchers
356 *Ficedula hypoleuca* (Ouweland *et al.* 2017) and breeding season conditions and overwinter survival
357 for Alpine Swifts *Tachymarptis melba* (Robinson *et al.* 2020). Thus, while effects of conditions during
358 one season are unlikely to carry over into the same season in the next annual cycle, they may impact
359 fitness in the following season (e.g. Robinson *et al.* 2020).

360 Tracking studies are also invaluable in understanding the strength of connectivity between
361 breeding and non-breeding populations, with important implications for understanding declines
362 and how to stem them (Cresswell 2014). The concept of connectivity can be defined in different
363 ways but here we refer to a species as having low connectivity if individuals from the same
364 breeding population spread over a large non-breeding area, resulting in different breeding
365 populations sharing the same non-breeding area to a large degree. In contrast, a species has high
366 connectivity if individuals from the same breeding population occupy a small non-breeding area
367 (Finch *et al.* 2017), resulting in different breeding populations having different non- breeding areas
368 The results of studies in which multiple populations have been tracked (see references in Finch *et*
369 *al.* 2017; also , van Wijk *et al.* 2018, Prochazka *et al.* 2018) show that levels of connectivity vary
370 greatly across species. However, breeding populations of most Afro-Palaeartic migrants show
371 relatively low connectivity (for example, high levels of spread in non-breeding areas, with mean
372 inter-individual distance between individuals from the same breeding population across all studies
373 being 743km; Finch *et al.* 2017), with the Common Nightingale *Luscinia megarhynchos* (Hahn *et al.*
374 2013) amongst the lowest thus far (mean inter-individual distance in winter for three breeding
375 populations 484, 490 & 697km), and Red-backed Shrikes (2918 km on average, data from two
376 breeding populations; Pedersen *et al* 2019) and Willow Warblers *Phylloscopus trochilus* (1734 km
377 on average, data from two breeding populations; Lerche-Jørgensen *et al.* 2017) among the highest.

378 Connectivity in migrant birds has important implications for their resilience to habitat
379 change, habitat loss and climate change: low connectivity is associated with selection for generalist
380 species able to exist in anthropogenically modified habitats, susceptibility to outright habitat loss
381 but resilience to climate change (Cresswell 2014, Finch *et al.* 2017, Patchett *et al.* 2018). It also has
382 implications for our ability to identify where population limitation occurs. Given almost all long-
383 term monitoring of populations is on the breeding grounds and that many migrants are highly
384 dispersed in winter, any localized reduction in carrying capacity in non-breeding areas, unless at an
385 extremely large scale, e.g., drought in the Sahel (e.g., Peach *et al.* 1991), is unlikely to be detected
386 in breeding trend data (Cresswell *et al.* 2020) . This is because any impact is effectively diluted
387 across the large breeding range and will be masked by the many individuals wintering in unaffected
388 areas (Finch *et al.* 2017). (Of course, the same situation would arise if we monitored population
389 trends on the wintering grounds, with birds widely dispersed across the European breeding range.)
390 This may mean we are less likely to pick up changes in survival rate driving population trends or
391 detect future effects of any African conservation interventions in Europe.

392 Tracking also potentially provides a means by which to link individual behaviour to
393 population trends. Such studies remain rare as they require non-archival tags that provide

394 information on mortality events (Klaassen *et al.* 2014, Oppel *et al.* 2015, Ibanez-Alamo 2019,
 395 Loonstra *et al.* 2019), but that are too large for most species. For example, Common Cuckoos in the
 396 UK follow two different southward migration routes to a common wintering area in western Central
 397 Africa which are associated with different levels of mortality. The proportion of birds in local
 398 breeding populations using the less successful route correlated with the extent of population decline
 399 (Hewson *et al.* 2016), suggesting a role of conditions encountered during the migration and/or the
 400 pre-migratory fattening period in the UK. A second study (Egyptian Vultures *Neophron percnopterus*;
 401 Buechley *et al.* 2021) highlights variation in survival in time and space with lower survival during
 402 periods of migration, and on the northerly breeding grounds, compared to sub-Saharan Africa, and
 403 for birds originating from eastern compared to western Europe.

404 The growing network of automated radio receiver stations in Europe affiliated to the MOTUS
 405 network (Taylor *et al.* 2017) has huge potential for linking demography and migration of smaller
 406 species in the future, as do future developments in space-based radio tracking, which allow
 407 increasing miniaturisation of non-archival tags (Jetz *et al.* 2021). The MOTUS system allows a large
 408 number of tags to be deployed with the receiver array serving as a 'virtual mistnet' registering any
 409 passing bird over a large area. The system has been used to track Barn Swallows *Hirundino rustica* to
 410 assess survival over relatively short time periods (Evans *et al.* 2020), and carry over effects of
 411 breeding on autumn migration (Imlay *et al.* 2021). Solar-powered nano-tags allowing individuals to
 412 be tracked across their entire life and an extensive receiver network along the flyway, could allow
 413 partitioning of mortality across routes and major parts of the annual cycle, as well as help identify
 414 key stopover sites as it has done in the Neotropical-Nearctic flyway (e.g. Gomez *et al.* 2017).

415

416 **RECENT ADVANCES IN KNOWLEDGE AND UNDERSTANDING FROM FIELD STUDIES OF MIGRANT** 417 **BIRDS IN SUB-SAHARAN AFRICA**

418 A number of recent studies in the non-breeding season have collected new empirical data relating
 419 to the distributions, movements and habitat associations of migrant birds. The biggest advances
 420 made since 2014 have been in two areas although in both cases the findings relate to a relatively
 421 small number of species (between 2 and 12). First, a number of studies, have highlighted the
 422 importance of certain species of tree on the non-breeding grounds; and secondly, some studies
 423 have suggested that anthropogenic land cover change may not be detrimental to overwintering
 424 Afro-Palaeartic migrants.

425 It has long been recognised that a large proportion of migrant birds that cross the Sahara
 426 spend the winter in the Sahel region (Moreau 1972). Numbers decline as one travels south
 427 (although large numbers have recently been estimated in West African mangroves (Zwarts *et al.*

428 2014)), and recent studies have attributed this to birds' preferences for a relatively small
429 proportion of the tree and bush species available (Zwarts *et al.* 2015a, b). Migrants were absent in
430 69% of all tree species present, favouring thorny trees such as *Faidherbia albida* and other *Acacias*,
431 that are adapted to high grazing/browsing pressure through mechanical (thorns) rather than
432 chemical defence and thus support relatively high invertebrate abundance. The main exception is
433 the berry-bearing *Salvadora persica*, long known to be favoured by migrant birds, such as *Sylvia*
434 warblers, that are at least partially frugivorous during the non-breeding season (Stoate & Moreby
435 1995, Fransson *et al.* 2008, Iwajomo *et al.* 2017).

436 Similarly, further south in the Sudan savannah and Guinea forest zones, various warbler
437 species show preferences for taller trees compared with their immediate surroundings (Mallord *et*
438 *al.* 2016, Awa II *et al.* 2018, Willemoes *et al.* 2018), while certain groups of tree species such as
439 *Acacia* (Willemoes *et al.* 2018) are often favoured. In some cases, individual tree species can be
440 important: for instance, Wood Warblers *Phylloscopus sibilatrix* at a stopover site in the Sudan
441 savanna strongly preferred *Anogeissus leiocarpus*, accompanied by a marked avoidance of other,
442 more common, species, e.g., Shea *Vitellaria paradoxa* and Neem *Azadirachta indica* (Mallord *et al.*
443 2016), also highlighting the importance of native trees (Douglas *et al.* 2014). Meanwhile, in the
444 Guinea forest-savanna further south, *Albizia zygia* was favoured.

445 To the extent that they can be considered habitat generalists (Cresswell 2014, Iwajomo &
446 Cresswell 2016), migrant birds may be unlikely to be limited by the availability of suitable habitat
447 on the wintering grounds in Africa. Recent studies suggest this may be particularly the case for
448 open country species, e.g., Whinchats *Saxicola rubetra* (Hulme & Cresswell 2012, Blackburn &
449 Cresswell 2015, 2016a,b), which may tolerate some agriculture-related habitat change. In contrast,
450 migrant species reliant on more wooded habitats may be much less tolerant of habitat degradation
451 and tree cover loss (Jones *et al.* 1996, Vickery *et al.* 2014). However, species preferring open
452 woodlands may exhibit some resilience to loss of tree cover, e.g., Wood Warbler *Phylloscopus*
453 *sibilatrix* (Mallord *et al.* 2016, 2018, Buchanan *et al.* 2020), due to a preference for well-wooded
454 farmland (Mallord *et al.* 2016), including cocoa plantations (Awa II *et al.* 2018, Jarrett *et al.* 2021).
455 This may be true of other migrant species that prefer moderate, rather than dense forest cover,
456 e.g., Willow Warblers *Phylloscopus trochilus* (Willemoes *et al.* 2018, Thorup *et al.* 2019).

457 Conditions in the Sahel have long been known to have an impact on survival and
458 population trends of migrant birds (e.g., Winstanley *et al.* 1974, Peach *et al.* 1991, Norman & Peach
459 2013). Droughts have an immediate impact upon food availability, and a longer-lasting effect on
460 vegetation cover and species composition in the region (Zwarts *et al.* 2009). Severe losses of woody
461 cover in the dry northern Sahel since the 1960s, caused by drought, cutting, grazing and fire, may

462 equate to the loss of habitat for 300-400 million migrant birds (Zwarts *et al.* 2015, 2018). This
463 dramatic loss in wooded habitat may be exacerbated in the future by growing climatic variability
464 associated with climate change (Simkins 2019).

465 Other migrants are highly mobile and are able to track variation in resource abundance
466 over wide areas. Raptors such as Montagu's Harriers *Circus pygargus*, for example, track the
467 abundance of grasshoppers (Trierweiler *et al.* 2013) as conditions in sub-Saharan Africa become
468 drier through the non-breeding season (Augiron *et al.* 2015, Schlaich *et al.* 2016). Changes in food
469 availability has also been shown to alter the migratory behaviour of Iberian-breeding White Storks
470 *Ciconia ciconia* (Gilbert *et al.* 2016), and the foraging strategies of Eurasian Reed Warblers
471 *Acrocephalus scirpaceus* (Vafidis *et al.* 2014).

472 We have greatly advanced knowledge for a small number of species but overall
473 understanding of non-breeding ecology and distribution remains poor. There have only been 31
474 papers published since 2014 based on newly-collected empirical data from the wintering grounds in
475 sub-Saharan Africa. Furthermore, of these, 12 have been based on data collected in just three
476 studies (distribution of migrants in the Sahel, Whinchats in Nigeria and Wood Warblers in Ghana).
477 Nevertheless, certain, somewhat novel, conclusions have been reached, firstly regarding the
478 preference for a small number of tree species, and secondly, the apparent resilience to
479 anthropogenic land-use change, especially loss of trees, of some Afro-Palaeartic migrants.
480 However, it is important to emphasise that many of these studies represent a small sub set off
481 migrant bird species. For example, apparent resilience to land use is based on detailed work on just
482 two species, whinchat (Blackburn & Cresswell 2015, 2016a,b) and wood warbler (Mallord *et al.*
483 2018) and only a sub set of 8 of the 21 species studied in the arid zone (Zwarts *et al.* 2015b). This
484 work is challenging and expensive and, if the goal is to gather information to conserve these birds,
485 we suggest the return on investment of this area of work is low and unlikely to change.

486

487

488 **RECENT ADVANCES IN KNOWLEDGE AND UNDERSTANDING FROM THE USE OF SURVEY AND** 489 **DEMOGRAPHIC DATA FROM THE EUROPEAN BREEDING GROUNDS**

490 The abundance of breeding bird species in Europe is monitored under the Pan-European Common
491 Bird Monitoring Scheme (PECBMS: <https://pecbms.info/>), with additional data from schemes
492 collated under Birds in Europe/European Red List of Birds (ERLoB; Birdlife International 2017).
493 Demographic data is collected by standardised mist netting across 20 countries under the European
494 Constant Effort Site (Euro-CES) scheme. The spatial and temporal resolution of these data mean
495 that they can be used to explore both large and local -scale patterns in population trends and

496 demography across species ranges. Studies include quantifying large-scale changes in abundance
497 and demography across European breeding grounds, identifying within- and between-species
498 variation in population trends and demography, examining the role of environmental processes on
499 the breeding and non-breeding grounds on population declines and considering the nature and
500 impact of changes in timing of arrival and breeding on European breeding grounds.

501 Detailed exploration of changes in abundance and demography of migrant birds across
502 European breeding grounds has highlighted differences at the regional and site level. Growing
503 evidence suggests that sites where migrants are doing well are also the sites where residents are
504 also doing well in the UK (Ockendon *et al.* 2012; Balmer *et al.* 2013; Morrison *et al.* 2013; Morrison
505 *et al.* 2016) and at the European level; (Morrison *et al.* 2021). Analysis of one species (Willow
506 Warbler *Phylloscopus trochilus*) in Great Britain, has shown that, whereas long term declines in
507 geographically separate populations have been caused by several years of poor survival,
508 populations have recovered only in areas with high productivity (Morrison *et al.* 2016). Thus,
509 although declines may often be driven by poor conditions outside the breeding grounds, they could
510 be addressed by targeted actions to improve productivity at poor sites. However, in the long term,
511 halting and even reversing survival-driven population declines is also likely to require non-targeted
512 environmental protection across non-breeding ranges (Morrison *et al.* 2021).

513 Survey and demographic data have also been used to quantify the role of environmental
514 processes on the breeding and non-breeding grounds on population declines including spring
515 temperature (Meller *et al.* 2018), breeding habitat types (Sullivan *et al.* 2015), and degree of
516 habitat modification, e.g. through agriculture (Jørgensen *et al.* 2016, Sanderson *et al.* 2016,
517 Gamero *et al.* 2017, Knaus 2018, Moreno-Zarate *et al.* 2020).

518 Studies relating European breeding bird data to large-scale habitat and environmental
519 processes in Africa have failed to find any clear regional patterns (e.g. Ockendon *et al.* 2014,
520 Jørgensen *et al.* 2016, Halupka *et al.* 2017, Beresford *et al.* 2019). This failure may well be linked to
521 marked spatial variation in patterns of environmental change in Africa combined with limited
522 information about non-breeding and habitat requirements (e.g. Mallord *et al.* 2016, 2018,
523 Beresford *et al.* 2019, Buchanan *et al.* 2020) and the large non-breeding area that individuals from
524 a population may occupy (Finch *et al.* 2017).

525 Long-term demographic data have also provided insight into the effects of phenological
526 change on migrant populations (Samplonius *et al.* 2020). Several studies in the UK have linked
527 population trends to long-term datasets on timing of arrival, departure or egg laying and shown that
528 those species that are least flexible exhibit the most negative population trends (Franks *et al.* 2018,
529 Newson *et al.* 2016). While several studies continue to suggest an impact of changes in breeding

530 ground temperature on changes in the timing (Ockendon *et al.* 2013) or success (Arlt and Part 2017)
531 of nesting attempts, there is little evidence of the importance of phenological changes on the
532 breeding grounds. For example, for three insectivorous passerines, carry-over effects from passage
533 regions had consistently stronger impacts on breeding phenology than breeding climate (Finch *et al.*
534 2014). In one of these species, Wood Warbler, a failure to advance breeding to match the
535 advancement in peak prey (caterpillar) emergence did not impact on subsequent productivity,
536 suggesting no marked effect of phenological mismatch (Mallord *et al.* 2017), and that individuals
537 take advantage of alternative food types. Similarly, a UK-wide multi-species study found no
538 latitudinal variation in the timing of peak nestling demand relative to peak caterpillar biomass for
539 any of the three species studied (Burgess *et al.* 2018).

540 Studies of large-scale survey and demographic data from the breeding grounds to identify
541 demographic drivers of migrant population declines yield complex results that differ between
542 species, populations, regions and habitats. Rainfall in the wintering grounds continues to emerge as
543 an important factor influence and phenological mismatch is apparent in some insectivorous migrant
544 birds but there is little evidence that this is linked to population trends. Importantly, for some
545 species, recovery may be possible through targeted action to improve productivity on the breeding
546 grounds, even if the drivers of their population trends are operating elsewhere.

547

548 **RECENT ADVANCES IN KNOWLEDGE AND UNDERSTANDING FROM THE USE OF REMOTE SENSING** 549 **OF LAND COVER CHANGE IN SUB-SAHARAN AFRICA**

550 Rapid change in land use and land cover in sub-Saharan Africa is well documented. Recent
551 assessments show an increasing area of agricultural land under 'shifting agriculture' (Curtis *et al.*
552 2018, Faour *et al.* 2018), particularly in more northerly zones and countries (Potapov *et al.* 2021,
553 Knauer *et al.* 2017, Schulte to Bühne *et al.* 2017) with associated large scale tree loss (e.g. Fensholt
554 *et al.* 2015, Zomer *et al.* 2016). There is also evidence of long-term changes to wetland habitats
555 throughout the Sahel and tropical Africa, although these vary between countries and regions, and in
556 relation to climate and human-induced pressures (Moser *et al.* 2014; Schroeder *et al.* 2015).

557 Determining the extent to which these changes are linked to changes in migrant bird populations is
558 fundamentally compromised by the lack of basic empirical information on distribution and habitat
559 use of these species in their non-breeding ranges (e.g. Beresford *et al.* 2019). Fourteen studies have
560 been published since 2014 that have related migrant bird population trends to remote sensed land
561 cover either using Normalized Difference Vegetation Index (n=12) or tree cover data (n=2).

562 The recent studies using remote sensed land cover data to examine whether declines of
563 migrants could be related to land cover changes in Africa, using NDVI (Normalized Difference

564 Vegetation Index) as a measure of vegetation development or primary productivity, have produced
565 mixed results (e.g. Ockendon *et al.* 2014). A number of these use over-simplistic single
566 environmental parameters across the entire African continent in which vegetation phenology
567 varies enormously (Beresford *et al.* 2019) and/or lack crucial information on non-breeding
568 distribution species-habitat relationships (e.g. Howard *et al.* 2020).

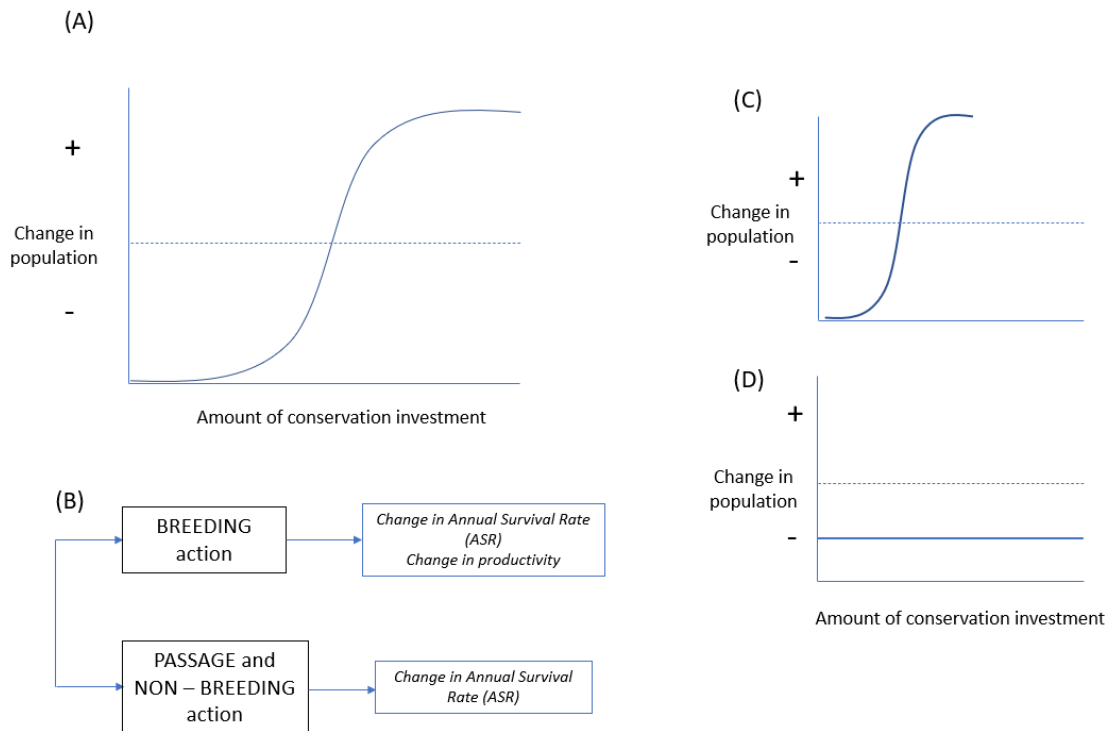
569 Only one study to date has incorporated known species-habitat relationships (Mallord *et al.*
570 2016) with remote sensed data on land cover and land cover change (Hansen *et al.* 2013) to
571 quantify, firstly, optimal habitat across an Afro-Palaeartic migrant's entire non-breeding African
572 range and, secondly, estimate the change in cover of such habitat over time (Buchanan *et al.* 2020).
573 This suggested that between 2000 and 2014, there was a 47% increase in the extent of optimal
574 open woodland habitat for this species with the degradation of pristine forest. Thus, while our
575 understanding of land cover change in Sub-Saharan Africa has increased greatly, our ability to
576 relate these changes to habitat availability for and/or population trends of migrant birds has not.
577 This area of research is fundamentally constrained by our lack of knowledge about the distribution,
578 abundance, and species-habitat relationships of most migrant birds in the non-breeding season and
579 unless this knowledge gap is addressed, such large-scale analyses will remain of little value for
580 conservation.

581

582 **HOW MUCH CAN THESE RECENT ADVANCES INFORM CONSERVATION ACTION?**

583 Ultimately any research into migrant declines must be turned into conservation action. Key to this is
584 the identification of stage(s) in the annual cycle where an action can cost effectively increase
585 populations. The cost-effectiveness of any conservation action, measured as money and/or effort is
586 always likely to be an S-shaped function, where a small amount of resource makes no difference,
587 and a large amount of resource sees diminishing returns (the "conservation investment function",
588 Fig 4A). The function shape will vary according to the strength of the relationship between
589 investment and the population response to it, and will be species- and stage-specific (Fig. 4B).

590



591

592

593 **Figure 4:** (A) The relationship between investment and population response (the conservation
 594 investment function). (B) The crucial stages in any conservation decision analysis to determine which
 595 stage would give the best return for any conservation investment to address the decline of a migrant
 596 species. The success of any intervention will depend, firstly, upon how ecologically relevant it is to a
 597 given population and, secondly, the ease of implementation. Even if the stage at which the drivers of
 598 decline are operating is known, variation in the ease of implementation can result in very different
 599 functional relationships (C, D).

600

601

602 For example, western Ortolan Bunting populations may currently have the steepest
 603 relationship between change in population and amount of conservation investment on passage,
 604 where hunting is the main driver of population declines (Jiguet *et al.* 2019), whereas for Whinchats
 605 the steepest relationship is likely to be on the breeding grounds (Bastian & Feulner 2015). Thus,
 606 when a conservation investment increases population size, its ranking amongst all possible
 607 interventions will depend on the steepness of the slope and the absolute change in population,
 608 relative to other possible interventions at other stages in the annual cycle. There are at least two
 609 important sources of uncertainty that influence these relationships. The first is whether the actions
 610 taken will actually reverse species' declines. A second uncertainty will be linked to the ease of
 611 implementation. For example, the underlying causes of the population declines of Corncrakes *Crex*
crex and European Turtle Doves in the UK are well established (Green *et al.* 1997) and relatively well

612 established respectively (Browne & Aebischer 2004,). In both declines are associated with changes in
613 farming practices, and conservation investment has been provided for both species. In the case of
614 the Corncrake, the declines were caused by reduced productivity as a result of high chick mortality
615 through inappropriate mowing of their grassland habitat (Green *et al.* 1997, Tyler *et al.* 1998).
616 Payments were made to farmers to alter the mowing regime (Green *et al.* 1997) and as a result,
617 populations of Corncrakes in the UK increased (cf. Fig. 4B) (Wotton *et al.* 2015). The cause of the
618 Turtle Dove's decline is also a reduction in productivity, linked to a changing food supply and shifts in
619 diet from wild to cultivated seeds (Browne & Aebischer 2003, 2004). In contrast, for Turtle Dove, a
620 large amount of investment, especially in terms of management interventions within UK
621 government agri-environment schemes (Dunn *et al.* 2015), this has not resulted in population
622 recovery (cf. Fig. 4C) (Woodward *et al.* 2020). Differences in population response are likely to be due
623 to differences in the ease of implementation; Corncrakes are geographically confined to a relatively
624 small area in the UK, so that management can be more precisely targeted. Turtle Doves are more
625 widespread and the precise cause of the decline less certain. Understanding whether the failure of a
626 particular conservation intervention is due to the nature of the action or its implementation will be
627 important in terms of replicating the measures more widely.

628 Ordering the various potential conservation interventions, therefore, depends
629 fundamentally on a reasonable quantification of how population changes arise from variables that
630 are amenable to conservation action, and the cost of influencing these variables. For example,
631 habitat quality in terms of retained larger trees on the non-breeding grounds in Guinea savannah
632 landscapes across Africa is likely to be important for many Palaearctic migrant populations (e.g.
633 Mallord *et al.* 2016). Tree and natural habitat retention or management could be encouraged
634 through direct payments or indirect incentives to landowners (Brown *et al.* 2021). The costs and
635 population consequences of this, relative to conservation action on the breeding grounds (Mallord
636 *et al.* 2012), would require establishment of the functional relationship between levels of
637 investment and population response. Each relationship is straightforward, but it requires
638 ornithologists and conservationists working in countries throughout a particular migrant species'
639 range to make such empirical measurements. The complexity arises because there are many stages
640 in the annual cycle of a migrant, and many possible conservation actions, whose implementation will
641 be dependent on geographical, political and socio-economic factors – and will be different for each
642 species.

643 The key question in the context of this review is, therefore, have we modelled sufficient
644 conservation investment functions to be able to start halting and ultimately reversing migrant
645 population declines effectively? The answer remains no, partly because we are still limited by the

646 lack of studies of how migrant populations are affected by conditions during passage and on the
647 non-breeding grounds. As Figure 3 shows, we lack complete annual cycle data on most populations,
648 and those species which are well studied (e.g., European Cuckoo, Turtle Dove, Whinchat, Pied
649 Flycatcher, Wood Warbler), knowledge is restricted to a very limited number of populations. Perfect
650 knowledge across the flyway may not be necessary; for example, population recovery may be
651 possible through increasing productivity / survival at stages where implementation is easiest, even if
652 the drivers of decline are operating at other stages (Morrison *et al.* 2021), although this remains
653 untested.

654

655 **SUMMARY AND CONCLUSIONS**

656 Despite so much recent research, there has been rather little *real* progress identifying the
657 causes of migrant bird declines, linked, in no small part, to the extraordinary complexity of the
658 system and diversity of species involved. The 'full annual cycle approach' (Marra *et al.* 2015) is
659 often viewed as key to understanding these sorts of systems. Whilst possible for a species like
660 American Redstart *Setophaga ruticilla*, with relatively low non-breeding dispersion, it is rarely
661 possible or cost effective for species with high non-breeding dispersion which is often the case for
662 Afro-Palaeartic migrants. This is particularly true where those non-breeding grounds are in remote
663 and often politically unstable areas. There are a small number of examples where individuals have
664 been linked to specific (or, at least, flyway) populations, confirming that hunting pressure is
665 unsustainable and the likely cause of population declines and / or lack of recovery, e.g., Ortolan
666 Bunting and European Turtle Dove.

667 We argue that there is now an urgent need to shift from diagnosing declines to trialling
668 potential solutions, based on the best available evidence, combined with monitoring and adaptive
669 actions. The escalating scale of Afro-Palaeartic bird declines suggests that conservation action
670 cannot await the outcome of future research investment focussing purely or largely on 'diagnosis'.
671 This review of conservation-relevant science can be used to identify valuable policy and/or land-
672 based experiments. Such experiments, if effectively monitored, could help indicate where the
673 steepest parts of the 'population response and conservation investment' curve are (Fig. 4), in the
674 absence of prior understanding of such relationships, to support decision analysis.

675 The substantial advances in recent knowledge from tracking and particularly results relating
676 to the extent of dispersion are important in this context. In broadest terms these show that
677 individuals from the same population end up spread over a very large non-breeding area, leading to
678 breeding populations sharing the same areas extensively during passage and the non-breeding
679 season (i.e. relatively low connectivity). This suggests (i) any one site that is conserved will only

680 benefit a very small fraction of the population, although any suitable habitat site, more or less
 681 anywhere, will conserve some individuals of many breeding populations, (ii) land-sharing solutions
 682 may be more effective than site-based conservation; (iii) that any local changes in Africa will affect
 683 many European populations, and these local changes will be averaged across many breeding sites
 684 making it very difficult to pick up changes in survival rate on the non-breeding ground driving
 685 population trends, or to detect future effects of any localised African conservation interventions and
 686 (iv) if factors driving declines of species do operate on the wintering grounds, they must do so at a
 687 relatively large scale to have significant impact on any one breeding population (e.g. climate change
 688 or large scale land use change).

689 Thus the degree of connectivity and number of sites required by a species helps identify
 690 general principles for conservation action and approaches. There are a smaller number of species,
 691 often specialists, that migrate along defined routes and bottlenecks (e.g. Aquatic Warbler
 692 *Acrocephalus paludicola*, Salewski *et al.* 2013 and Ortolan Bunting, Jiguet *et al.* 2016), that rely on
 693 a small number of key sites and may benefit from targeted site-based conservation action at
 694 multiple sites across the flyway. Although a relatively small number of specialist species may
 695 benefit from widespread small scale site-level interventions, a significant proportion of migrants
 696 show low connectivity between breeding and non-breeding grounds and so are widely spread out
 697 across the latter. These species will be best served by broad landscape scale action (e.g. land
 698 sharing solutions (Green *et al.* 2005) and nature based solution approaches (Seddon *et al.* 2020).
 699 This includes habitat generalists that migrate on broad fronts (e.g. Whinchat, Blackburn *et al.* 2017
 700 and Great Reed Warbler, Lemke *et al.* 2013).

701 On the breeding grounds, work to understand the habitat conditions associated with good
 702 sites for key species may help identify the sorts of habitats to replicate and/or scale up and
 703 implement targeted action to boost productivity (Morrison *et al.* 2021). On non-breeding grounds
 704 where implementing management action is challenging, there is great potential in monitoring the
 705 benefits, for both migrant and resident birds, of Aid and Development initiatives that are linked to
 706 enhancing tree cover to improve livelihoods (Bizikova *et al.* 2015, Graves *et al.* 2019, Le Hou  rou,
 707 1977). These range from large scale initiatives, such as The Great Green Wall for the Sahara and the
 708 Sahel Initiative (GGWSSI or Great Green Wall GGW; FAO 2014, Bozzano *et al.* 2014,
 709 <https://www.greatgreenwall.org>) to smaller scale projects (e.g. The Acacia Operation Project,
 710 Bozzano *et al.* 2014; Bocage system, Girard *et al.* 2008; Zai pits, Danjuma & Mohammed 2015,
 711 Sawadogo, 2011 and Ecovillages, ANEV Online 2015. <http://www.Ecovillages.sn/>, GENSEN 2015)
 712 that often adapt traditional agricultural practices to grow native trees and shrubs (Berrang-Ford, *et*
 713 *al.* 2011). The extent to which they will benefit biodiversity, and indeed climate, depends to a very

714 great extent on the number and species of trees planted and surviving (e.g. Douglas *et al.* 2014,
715 Seddon *et al.* 2020) . However, very few currently include biodiversity monitoring (though see Stout
716 *et al.* 2018, Delaney *et al.* 2020), and integrating such monitoring could provide valuable evidence
717 on ways to enhance benefits for biodiversity and climate.

718 We also urge greater collaboration and integration between research projects and
719 programmes, sites, geographic regions and scientific disciplines. In the case of tracking, for example,
720 the most significant advances for conservation will be made by combining tracking studies and using
721 them in combination with other approaches in a hypothesis-driven way. This will reveal generalities
722 and differences between, for example, migration routes and wintering locations between western
723 and eastern Europe or increasing and decreasing European populations. Pooling data will also allow
724 the identification of ‘hotspots’ or ‘regions’ used by multiple species and populations. Ecological
725 studies can be more usefully targeted and used to link population change to land use and land use
726 change and conservation action.

727 In summary, if we are to stem the declines of these widespread migrant birds we need to
728 use the scientific results we have to start to act rather than wait for complete knowledge and
729 understanding. This means identifying and evaluating potentially valuable policy and land based
730 ‘natural experiments’, where possible guiding their establishment in ways to yield the best
731 understanding. We need to connect bird and land use researchers along the flyway, for research to
732 be carried out and understood and applied locally, involving local communities where possible. This
733 will demand a much larger scientific capacity and a new scientific literacy within policy
734 encompassing biodiversity, human development, business and industry (Chapman *et al.* 2022). And
735 finally, we need to recognize that the decline of widespread relatively common species carries a
736 stronger warning about the health of our natural world than the decline of rare and threatened
737 species, and to afford them a higher priority.

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1503 SUPPLEMENTARY INFORMATION

1504

1505 **The decline of Afro-Palaeartic migrants: the implications of recent research**
 1506 **insights for conservation science and action**

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2410 Supplementary Table 1:

Count	Widespread and common European long-distance migrants (62 species), wintering predominantly in the arid zone (A: 22 species) and humid & southern zones (H:29 species)		Widespread and common European short-distance migrants and resident breeding birds (108 species)
1	<i>Acrocephalus arundinaceus</i>	(H)	<i>Accipiter nisus</i>
2	<i>Acrocephalus palustris</i>	(H)	<i>Aegithalos caudatus</i>
3	<i>Acrocephalus schoenobaenus</i>	(A)	<i>Alauda arvensis</i>
4	<i>Acrocephalus scirpaceus</i>	(H)	<i>Alcedo atthis</i>
5	<i>Actitis hypoleucos</i>	(H)	<i>Alectoris rufa</i>
6	<i>Anthus campestris</i>	(A)	<i>Anas platyrhynchos</i>
7	<i>Anthus trivialis</i>	(H)	<i>Anthus pratensis</i>
8	<i>Apus apus</i>	(H)	<i>Ardea cinerea</i>
9	<i>Calandrella brachydactyla</i>	(A)	<i>Bombycilla garrulus</i>
10	<i>Carpodacus erythrinus</i>		<i>Bonasa bonasia</i>
11	<i>Ciconia ciconia</i>	(H)	<i>Bubulcus ibis</i>
12	<i>Circus aeruginosus</i>	(H)	<i>Burhinus oediconemus</i>
13	<i>Clamator glandarius</i>		<i>Buteo buteo</i>
14	<i>Cuculus canorus</i>	(H)	<i>Calcarius lapponicus</i>
15	<i>Delichon urbica</i>	(H)	<i>Carduelis cannabina</i>
16	<i>Emberiza hortulana</i>	(A)	<i>Carduelis carduelis</i>
17	<i>Emberiza melanocephala</i>		<i>Carduelis chloris</i>
18	<i>Emberiza rustica</i>		<i>Carduelis flammea</i>
19	<i>Ficedula albicollis</i>	(H)	<i>Carduelis spinus</i>
20	<i>Ficedula hypoleuca</i>	(H)	<i>Certhia brachydactyla</i>
21	<i>Hippolais icterina</i>	(H)	<i>Certhia familiaris</i>
22	<i>Hippolais pallida</i>	(H)	<i>Cettia cetti</i>
23	<i>Hippolais polyglotta</i>	(H)	<i>Cisticola juncidis</i>
24	<i>Hirundo daurica</i>	(H)	<i>Coccothraustes coccothraustes</i>
25	<i>Hirundo rustica</i>	(H)	<i>Columba oenas</i>
26	<i>Jynx torquilla</i>	(A)	<i>Columba palumbus</i>
27	<i>Lanius collurio</i>	(H)	<i>Corvus corax</i>
28	<i>Lanius minor</i>	(H)	<i>Corvus corone+cornix</i>
29	<i>Lanius senator</i>	(A)	<i>Corvus frugilegus</i>
30	<i>Limosa limosa</i>		<i>Corvus monedula</i>
31	<i>Locustella fluviatilis</i>	(H)	<i>Cyanopica cyanus</i>
32	<i>Locustella naevia</i>	(A)	<i>Cygnus olor</i>
33	<i>Luscinia luscinia</i>	(H)	<i>Dendrocopos major</i>
34	<i>Luscinia megarhynchos</i>	(H)	<i>Dendrocopos medius</i>
35	<i>Luscinia svecica</i>	(A)	<i>Dendrocopos minor</i>
36	<i>Merops apiaster</i>	(H)	<i>Dendrocopos syriacus</i>
37	<i>Motacilla flava</i>	(A)	<i>Dryocopus martius</i>
38	<i>Muscicapa striata</i>	(H)	<i>Egretta garzetta</i>
39	<i>Numenius phaeopus</i>		<i>Emberiza cia</i>
40	<i>Oenanthe cyprica</i>	(A)	<i>Emberiza cirulus</i>
41	<i>Oenanthe hispanica</i>	(A)	<i>Emberiza citrinella</i>

42	<i>Oenanthe oenanthe</i>	(A)	<i>Emberiza schoeniclus</i>
43	<i>Oriolus oriolus</i>	(H)	<i>Erithacus rubecula</i>
44	<i>Phoenicurus phoenicurus</i>	(A)	<i>Falco tinnunculus</i>
45	<i>Phylloscopus bonelli</i>	(A)	<i>Fringilla coelebs</i>
46	<i>Phylloscopus collybita</i>	(A)	<i>Fringilla montifringilla</i>
47	<i>Phylloscopus sibilatrix</i>	(H)	<i>Fulica atra</i>
48	<i>Phylloscopus trochilus</i>	(H)	<i>Galerida cristata</i>
49	<i>Pluvialis apricaria</i>		<i>Galerida theklae</i>
50	<i>Saxicola rubetra</i>	(H)	<i>Gallinago gallinago</i>
51	<i>Streptopelia turtur</i>	(A)	<i>Gallinula chloropus</i>
52	<i>Sylvia borin</i>	(H)	<i>Garrulus glandarius</i>
53	<i>Sylvia cantillans</i>	(A)	<i>Grus grus</i>
54	<i>Sylvia communis</i>	(A)	<i>Haematopus ostralegus</i>
55	<i>Sylvia curruca</i>	(A)	<i>Hirundo rupestris</i>
56	<i>Sylvia hortensis</i>	(A)	<i>Larus ridibundus</i>
57	<i>Sylvia nisoria</i>	(A)	<i>Lullula arborea</i>
58	<i>Tringa erythropus</i>		<i>Melanocorypha calandra</i>
59	<i>Tringa glareola</i>		<i>Miliaria calandra</i>
60	<i>Tringa nebularia</i>		<i>Motacilla alba</i>
61	<i>Tringa ochropus</i>		<i>Motacilla cinerea</i>
62	<i>Upupa epops</i>	(A)	<i>Nucifraga caryocatactes</i>
63			<i>Numenius arquata</i>
64			<i>Parus ater</i>
65			<i>Parus caeruleus</i>
66			<i>Parus cristatus</i>
67			<i>Parus major</i>
68			<i>Parus montanus</i>
69			<i>Parus palustris</i>
70			<i>Passer domesticus</i>
71			<i>Passer montanus</i>
72			<i>Perdix perdix</i>
73			<i>Petronia petronia</i>
74			<i>Phasianus colchicus</i>
75			<i>Phoenicurus ochruros</i>
76			<i>Pica pica</i>
77			<i>Picus canus</i>
78			<i>Picus viridis</i>
79			<i>Podiceps cristatus</i>
80			<i>Prunella modularis</i>
81			<i>Pyrhacorax pyrrhocorax</i>
82			<i>Pyrrhula pyrrhula</i>
83			<i>Regulus ignicapilla</i>
84			<i>Regulus regulus</i>
85			<i>Saxicola torquata</i>
86			<i>Serinus citrinella</i>
87			<i>Serinus serinus</i>
88			<i>Sitta europaea</i>
89			<i>Streptopelia decaocto</i>

90	<i>Sturnus unicolor</i>
91	<i>Sturnus vulgaris</i>
92	<i>Sylvia atricapilla</i>
93	<i>Sylvia melanocephala</i>
94	<i>Sylvia melanothorax</i>
95	<i>Sylvia undata</i>
96	<i>Tachybaptus ruficollis</i>
97	<i>Tadorna tadorna</i>
98	<i>Tetrao tetrax</i>
99	<i>Tetrax tetrax</i>
100	<i>Tringa totanus</i>
101	<i>Troglodytes troglodytes</i>
102	<i>Turdus iliacus</i>
103	<i>Turdus merula</i>
104	<i>Turdus philomelos</i>
105	<i>Turdus pilaris</i>
106	<i>Turdus torquatus</i>
107	<i>Turdus viscivorus</i>
108	<i>Vanellus vanellus</i>

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2413 **Supplementary Table 2:**2414 **Table S2. Summary of our understanding of factors impacting Afro-Palearctic migrants on their breeding, nonbreeding and staging**

2415 **grounds.** The objective of Table S2 is to summarise, in broad terms, what we know about factors potentially linked to population change of migrants
2416 separately on their European breeding grounds and staging/African nonbreeding grounds, and also to identify where there are gaps in our current
2417 knowledge. This updates a similar exercise conducted by Vickery *et al.* (2014, table S2). In developing this table, we conducted a detailed search of
2418 the recent literature in Web of Science and Google Scholar for each of the A-P migrants listed in Birdlife International (2004). We searched for
2419 papers with “*common name*” OR “*scientific name*” in the “Topic” (title, abstract, author key words and Keywords Plus) AND a publication date of 2014
2420 to present (Sept 2021). Returned papers were assessed for relevance based on their abstracts, discarding any not related to population change,
2421 demography, habitat selection or threats, or where the study system was outside the African-Palearctic region. For A-P migrants on their breeding
2422 and nonbreeding/ staging grounds, we sought to identify factors with supporting evidence of an impact, and species for which there is no evidence
2423 to base an assessment. We differentiate between papers included in Vickery *et al.* 2014 (normal type) and those newly identified in this review
2424 (bold type). Newly identified threats and parameters, or those for which additional evidence has been published since 2014 are given in bold.
2425 Diagonal hatching indicates no evidence for that species in that season. The threat categories highlighted for individual migrants in the table are
2426 necessarily broad, and the mechanisms by which these are linked to individual species differs. Habitat change in farmland, for example, may refer to
2427 the effects of the intensification of grassland management in one species, and the effects of a reduction of pastoralism in another. The strength of
2428 evidence linking threat categories to individual migrants also varies widely. We have attempted to partially account for differences in the quality of
2429 the evidence base by restricting our literature search to studies that consider the effects of threats on important ecological (habitat selection, H) and
2430 demographic parameters (breeding success, B; survival, S; population size/change, P). Even restricting the pool of studies in this way, there are still
2431 fairly marked differences in the strength of evidence, but we present for each species the particular parameters (P, S, B or H) via which studies have
2432 linked them to threat categories, which offers additional insights into the quality of the evidence base. For example, we would have more confidence
2433 that a threat is truly of importance where it has been demonstrated to have an effect on the population size of a migrant, rather than one that has
2434 only been shown to influence a species’ habitat selection. Because studies differed markedly in the types of evidence they presented, one of the
2435 challenges in developing this table was deciding on the criteria that they should meet for a migrant to be assigned P, S, B or H. We decided that to be

2436 allocated an 'H' in the table studies should demonstrate either that a species shows a preference for a habitat type/feature or occurs at higher
2437 densities in a habitat type that is at risk of loss due to changes in land management. For the P, S, and B classifications, the criteria were not as
2438 restrictive, and we accepted evidence from a wide range of study types as support of the impact of a factor, including: correlative studies (e.g. Peach
2439 *et al.* 1991, Ambrosini *et al.* 2012); studies documenting the effects of (experimental) manipulations (e.g. Birrer *et al.* 2007, Arlettaz *et al.* 2010);
2440 studies examining habitat-specific demography (e.g. Arlt *et al.* 2008, Hollander *et al.* 2011); studies using simulated population models (e.g. Foppen
2441 *et al.* 1999, Toral *et al.* 2010); and studies quantifying (unsustainable) mortality/breeding failure due to particular factors (e.g. Schaub & Pradel
2442 2004, Votier *et al.* 2006). A few additional points to note are as follows. Firstly, habitat change on the non-breeding grounds as specified here may
2443 be either anthropogenic or natural in origin. For most migrants, it is difficult to differentiate between the effects of habitat change due to drought in
2444 the Sahel and those due to changes in land management. Secondly, for climate change to be recognised as a potential threat for a migrant, studies
2445 need to at least have demonstrated a link between a demographic parameter and a climate variable subject to directional change. We do not
2446 consider changes in phenology as constituting evidence of an impact of climate change, because the repercussions of such changes on fitness are
2447 often unclear. Thirdly, where we have identified two or more studies that have starkly conflicting viewpoints on the effects of a threat category, we
2448 have erred on the side of caution by not including them, but there were relatively few occasions where this was the case. Finally, we have tried to
2449 conduct as comprehensive a literature search as possible for this review, but given the large number of species under consideration and the
2450 extensive nature of the literature, it is possible that we may have overlooked some references.

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Species	Factors affecting A-P migrants on breeding grounds			Factors affecting A-P migrants on nonbreeding/staging grounds		
	Threat(s)	Parameter(s)	References	Threat(s)	Parameter(s)	References
Manx Shearwater <i>Puffinus puffinus</i>	Climate change Light pollution Collision with infrastructure	B S S	Riou <i>et al.</i> 2011 Atchoi <i>et al.</i> 2020 Sypozis <i>et al.</i> 2018	Light pollution Collision with infrastructure Climate change	S S S	Atchoi <i>et al.</i> 2020 Sypozis <i>et al.</i> 2018 Tavares <i>et al.</i> 2019
Leach's Storm-petrel <i>Oceanodroma leucorhoa</i>	Predation	P	Phillips <i>et al.</i> 1999, Votier <i>et al.</i> 2006			
Little Bittern <i>Ixobrychus minutus</i>	Habitat change	P, H	Aouadi <i>et al.</i> 2021 Scheckenhofer <i>et al.</i> 2013			
Black-crowned Night Heron <i>N. nycticorax</i>	Habitat change Inter-species competition	P P, H	Ramo <i>et al.</i> 2013 Giammarino <i>et al.</i> 2021	Habitat change (wetland)	P	Zwarts <i>et al.</i> 2009
Squacco Heron <i>Aredola ralloides</i>	Habitat change	P	Ramo <i>et al.</i> 2013	Habitat change (wetland)	P	Zwarts <i>et al.</i> 2009
Purple Heron <i>Ardea purpurea</i>	Habitat change (wetland)	P, H	Barbraud <i>et al.</i> 2002	Habitat change (wetland)	P	den Held 1981, Cavé 1983, Barbraud & Hafner 2001

Species	Factors affecting A-P migrants on breeding grounds			Factors affecting A-P migrants on nonbreeding/staging grounds		
	Threat(s)	Parameter(s)	References	Threat(s)	Parameter(s)	References
Black Stork <i>Ciconia nigra</i>	Collision with infrastructure	S	Smeraldo <i>et al.</i> 2020	Persecution/Hunting	S	Brochet <i>et al.</i> 2016
White Stork <i>Ciconia ciconia</i>	Habitat change (wetland) Collision with infrastructure	B, H S	Nowakowski 2003 Hmamouchi <i>et al.</i> 2020 Schaub & Pradel 2004	Habitat change (savannah) Habitat change (stopover sites)	P, S S	Kanyamibwa <i>et al.</i> 1990, 1993 Schaub <i>et al.</i> 2005
Glossy Ibis <i>Plegadis falcinellus</i>	Habitat change (wetland)	S	Toral <i>et al.</i> 2012	Habitat change (wetland)	P	Zwarts <i>et al.</i> 2009
Garganey <i>Anas querquedula</i>	Persecution/Hunting	S	Brochet <i>et al.</i> 2019	Habitat change (wetland) Hunting	P, S S	Polet 2000, Zwarts <i>et al.</i> 2009 Zwarts <i>et al.</i> 2009
European Honey Buzzard <i>Pernis apivorus</i>	Persecution/Hunting Habitat change	S H	Brochet <i>et al.</i> 2016 Tapia <i>et al.</i> 2017	Persecution/Hunting Habitat change	S P	Brochet <i>et al.</i> 2016 Howes <i>et al.</i> 2019

Species	Factors affecting A-P migrants on breeding grounds			Factors affecting A-P migrants on nonbreeding/staging grounds		
	Threat(s)	Parameter(s)	References	Threat(s)	Parameter(s)	References
Black Kite <i>Milvus migrans</i>	Habitat change (wetland/farmland)	B, H	Sergio <i>et al.</i> 2003, Tanferna <i>et al.</i> 2013	Habitat change Displacement by infrastructure	H H	Buij & Croes 2013 Marques <i>et al.</i> 2019
Egyptian Vulture <i>Neophron percnopterus</i>	Habitat change (farmland) Collision with infrastructure Persecution/Hunting Disturbance	P P, S P, S B	Carrete <i>et al.</i> 2007, Carrete <i>et al.</i> 2009 Hernandez & Margalida 2009, Mateo-Tomás & Olea 2010, Garcia-Ripolles & Lopez 2011 Zuberogoitia <i>et al.</i> (2014)	Habitat change (savannah) Collision with infrastructure Persecution/Hunting	S S S	Grande <i>et al.</i> 2008 Angelov <i>et al.</i> 2012 Brochet <i>et al.</i> 2016
Short-toed Eagle <i>Circaetus gallicus</i>	Habitat change (forest) Persecution/Hunting Disturbance Collision with infrastructure	H S H S	López-Iborra <i>et al.</i> 2011 Brochet <i>et al.</i> 2016, Martinez <i>et al.</i> 2016 Cauli <i>et al.</i> 2021 Martinez <i>et al.</i> 2016			
Pallid Harrier <i>Circus macrourus</i>	Habitat change (farmland)	B, H	Terraube <i>et al.</i> 2009, 2012 Brochet <i>et al.</i> 2019	Habitat change (wetland)	H	Buij <i>et al.</i> 2012 Liminana <i>et al.</i> 2015

Species	Factors affecting A-P migrants on breeding grounds			Factors affecting A-P migrants on nonbreeding/staging grounds		
	Threat(s)	Parameter(s)	References	Threat(s)	Parameter(s)	References
	Persecution/Hunting	P		Persecution/Hunting	P	Brochet <i>et al.</i> 2016
Montagu's Harrier <i>Circus pygargus</i>	Habitat change (farmland)	P, B, H	Koks <i>et al.</i> 2001, Arroyo <i>et al.</i> 2002 Santangeli <i>et al.</i> 2014, Tapia <i>et al.</i> 2017	Habitat change (wetland)	H, S	Buij <i>et al.</i> 2012 Millon <i>et al.</i> 2019, Trierweiler <i>et al.</i> 2013
	Predation	B	Berger-Geiger <i>et al.</i> 2019 Hernandez-Pliego <i>et al.</i> 2015, Schaub <i>et al.</i> 2019			
	Collision with infrastructure	S				
Levant Sparrowhawk <i>Accipiter brevipes</i>	Persecution/Hunting	S	Brochet <i>et al.</i> 2019	Persecution/Hunting	S	Brochet <i>et al.</i> 2016
Lesser Spotted Eagle <i>Aquila pomarina</i>	Habitat change (farmland)	H	Mirski 2009, Zub <i>et al.</i> 2010 Mozgeris <i>et al.</i> 2021, Vali <i>et al.</i> 2017	Persecution/Hunting	S	Brochet <i>et al.</i> 2016
Booted Eagle <i>Hieraetus pennatus</i>	Persecution/Hunting	S	Brochet <i>et al.</i> 2016, Martinez <i>et al.</i> 2016 Lopez-Lopez <i>et al.</i> 2016			
	Habitat change	H S	Martinez <i>et al.</i> 2016			

Species	Factors affecting A-P migrants on breeding grounds			Factors affecting A-P migrants on nonbreeding/staging grounds		
	Threat(s)	Parameter(s)	References	Threat(s)	Parameter(s)	References
	Collision with infrastructure					
Osprey <i>Pandion haliaetus</i>	Oil pollution	S	Monti 2020	Oil pollution Habitat change	S H	Monti 2020 Crawford & Long 2017
Lesser Kestrel <i>Falco naumanni</i>	Habitat change (farmland) Pollution/Pesticides Climate change	P, B, H S, B B	Donazar <i>et al.</i> 1993, Hiraldo <i>et al.</i> 1996, Rodriguez <i>et al.</i> 2006, Rodriguez & Bustamante 2003, 2008 Catry <i>et al.</i> 2014 Ortego <i>et al.</i> 2007 Marcelino <i>et al.</i> 2020	Habitat change (savannah)	S	Mihoub <i>et al.</i> 2010
Red-footed Falcon <i>Falco vespertinus</i>	Habitat change (farmland)	H	Palatitz <i>et al.</i> 2011			
Eurasian Hobby <i>Falco subbuteo</i>	Habitat change (farmland)	H	Sergio & Bogliani 2000			
Eleonora's Falcon <i>Falco eleonora</i>						

Species	Factors affecting A-P migrants on breeding grounds			Factors affecting A-P migrants on nonbreeding/staging grounds		
	Threat(s)	Parameter(s)	References	Threat(s)	Parameter(s)	References
Common Quail <i>Coturnix coturnix</i>	Habitat change Persecution/hunting	P, H P	Sarda-Palomera <i>et al.</i> 2012 Faria & Morales 2020 Brochet <i>et al.</i> 2019	Persecution/hunting	P, S	Baha el Din & Salama 1991 Brochet <i>et al.</i> 2016 Caruana-Galizia & Fenech 2016 Eason <i>et al.</i> 2016
Spotted Crake <i>Porzana porzana</i>						
Little Crake <i>Porzana parva</i>	Habitat change	H	Jedlikowski <i>et al.</i> 2014, 2016			
Baillon's Crake <i>Porzana pusilla</i>				Persecution/Hunting	S	Brochet <i>et al.</i> 2016
Corncrake <i>Crex crex</i>	Habitat change (farmland)	P, S, B, H	Green & Stowe 1993, Green <i>et al.</i> 1997, Tyler <i>et al.</i> 1998, O'Brien <i>et al.</i> 2006			
Demoiselle Crane <i>Grus virgo</i>						
Black-winged Stilt Himantopus himantopus				Persecution/Hunting	S	Brochet <i>et al.</i> 2016

Species	Factors affecting A-P migrants on breeding grounds			Factors affecting A-P migrants on nonbreeding/staging grounds		
	Threat(s)	Parameter(s)	References	Threat(s)	Parameter(s)	References
Collared Pratincole <i>Glareola pratincola</i>	Habitat change (farmland)	B, H	Calvo 1994, Calvo & Furness 1995			
Black-winged Pratincole <i>Glareola nordmanni</i>	Habitat change (farmland)	H	Kamp <i>et al.</i> 2009a			
Little Ringed Plover <i>Charadrius dubius</i>	Habitat change (wetland)	P, H	Arlettaz <i>et al.</i> 2011 Conway <i>et al.</i> 2019			
Caspian Plover <i>Charadrius asiaticus</i>						
Sociable Lapwing <i>Vanellus gregarius</i>	Habitat change (farmland)	B, H	Watson <i>et al.</i> 2006, Kamp <i>et al.</i> 2009b	Habitat change Persecution/hunting	H P,S	Donald <i>et al.</i> 2020 Sheldon <i>et al.</i> 2013
Red Knot <i>Calidris canutus</i>				Habitat change (stopover sites)	P, S S	Kraan <i>et al.</i> 2010 Rakhimberdiev <i>et al.</i> 2015 van Gils <i>et al.</i> 2016

Species	Factors affecting A-P migrants on breeding grounds			Factors affecting A-P migrants on nonbreeding/staging grounds		
	Threat(s)	Parameter(s)	References	Threat(s)	Parameter(s)	References
				Climate change (carry over effect from breeding grounds)		
Little Stint <i>Calidris minuta</i>				Persecution/Hunting	S	Brochet <i>et al.</i> 2016
Temminck's Stint <i>Calidris temminckii</i>						
Curlew Sandpiper <i>Calidris ferruginea</i>						
Ruff <i>Philomachus pugnax</i>				Habitat change (stopover sites) Habitat change (wetland) Hunting	P, S S S	Verkuil <i>et al.</i> 2012, Rakhimberdiev <i>et al.</i> 2011, Zwarts <i>et al.</i> 2009 Schmaltz <i>et al.</i> 2015 Zwarts <i>et al.</i> 2009
Great Snipe <i>Gallinago media</i>	Habitat change (wetland)	H	Lofaldi <i>et al.</i> 1992, Kalas <i>et al.</i> 1997			
Black-tailed Godwit <i>Limosa limosa</i>	Habitat change (farmland)	B, H, P	Schekkerman & Beintema 2007, Schekkerman <i>et al.</i> 2009, Kentie <i>et al.</i> 2013 Kentie <i>et al.</i> 2018	Habitat change (farmland/wetland)	H, P	Kleijn <i>et al.</i> 2010b Marquez-Ferrando <i>et al.</i> 2014

Species	Factors affecting A-P migrants on breeding grounds			Factors affecting A-P migrants on nonbreeding/staging grounds		
	Threat(s)	Parameter(s)	References	Threat(s)	Parameter(s)	References
	Climate change Predation	B, P B	Kleijn <i>et al.</i> 2010a Kentie <i>et al.</i> 2018 Schekkerman <i>et al.</i> 2009 Kentie <i>et al.</i> 2015, Tamis & Heemskerk 2020			
Whimbrel <i>Numenius phaeopus</i>	Habitat change (farmland)	H	Grant <i>et al.</i> 1992 a,b, c			
Marsh Sandpiper <i>Tringa stagnatilis</i>				Persecution/Hunting	S	Brochet <i>et al.</i> 2016
Common Greenshank <i>Tringa nebularia</i>				Persecution/Hunting	S	Brochet <i>et al.</i> 2016
Wood Sandpiper <i>Tringa glareola</i>				Habitat change (wetland)	S	Zwarts <i>et al.</i> 2009
Terek Sandpiper <i>Xenus cinereus</i>						

Species	Factors affecting A-P migrants on breeding grounds			Factors affecting A-P migrants on nonbreeding/staging grounds		
	Threat(s)	Parameter(s)	References	Threat(s)	Parameter(s)	References
Common Sandpiper <i>Actitis hypoleucos</i>	Habitat change (wetland) Climate change	P H	Yalden 1986, Arlettaz <i>et al.</i> 2011 Royan <i>et al.</i> 2016	Habitat change	H	Summers <i>et al.</i> 2019
Red-necked Phalarope <i>Phalaropus lobatus</i>						
Pomarine Skua <i>Stercorarius pomarinus</i>						
Sabine's Gull <i>Xema sabini</i>						
Gull-billed Tern <i>Sterna nilotica</i>	Habitat change	H	Britto <i>et al.</i> 2018			
Caspian Tern <i>Sterna caspia</i>				Habitat change (wetland) Hunting	S S	Zwarts <i>et al.</i> 2009 Zwarts <i>et al.</i> 2009
Sandwich Tern <i>Sterna sandvichensis</i>						

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	Threat(s)	Parameter(s)	References	Threat(s)	Parameter(s)	References
Roseate Tern <i>Sterna dougallii</i>				Persecution/Hunting	P	Cabot <i>et al.</i> 1996
Common Tern <i>Sterna hirundo</i>	Habitat change (marine) Predation	B B	Daenhardt & Becker 2011, Szostek & Becker 2012, Ratcliffe <i>et al.</i> 2008	Habitat change	H	Szostek & Becker 2015
Arctic Tern <i>Sterna paradisaea</i>	Habitat change (marine) Predation Climate change (prey shortage)	B B S	Monaghan <i>et al.</i> 1989, Nordstrom <i>et al.</i> 2004 Petersen <i>et al.</i> 2020			
Little Tern <i>Sterna albifrons</i>	Climate change Predation	B, H B	Ivajnsic <i>et al.</i> 2017, Ramos <i>et al.</i> 2013 Smart & Amar 2018			
Whiskered Tern <i>Chlidonias hybrida</i>						
Black Tern <i>Chlidonias niger</i>	Habitat change (wetland)	P, B	van der Winden & van Horssen 2008, Beintema <i>et al.</i> 2010			
White-winged Tern						

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	Threat(s)	Parameter(s)	References	Threat(s)	Parameter(s)	References
<i>Chlidonias leucopterus</i>						
European Turtle Dove <i>Streptopelia turtur</i>	Habitat change (farmland) Persecution/hunting Predation	P, B, H P B	Browne & Aebischer 2003, 2004, Browne <i>et al.</i> 2004, 2005 Moreno-Zarate <i>et al.</i> 2020 Boutin 2001 Lormee <i>et al.</i> 2019 Mansouri <i>et al.</i> 2020	Habitat change (savannah) Persecution/hunting	S, P P	Eraud <i>et al.</i> 2009, Zwarts <i>et al.</i> 2009 Ockenden <i>et al.</i> 2014 Brochet <i>et al.</i> 2016, Caruana-Galizia & Fenech 2016, Eason <i>et al.</i> 2016
Great Spotted Cuckoo <i>Clamator glandarius</i>						
Common Cuckoo <i>Cuculus canorus</i>	Climate change Habitat change	B, P P	Douglas <i>et al.</i> 2010 Pearce-Higgins & Crick 2019 Møller <i>et al.</i> 2011 Denerley <i>et al.</i> 2019	Habitat change	S	Hewson <i>et al.</i> 2016
European Nightjar <i>Caprimulgus europaeus</i>	Habitat change (forest) Disturbance	H H	Sierra <i>et al.</i> 2001, Verstraeten <i>et al.</i> 2011 Evens <i>et al.</i> 2017, 2020, Sharps <i>et al.</i> 2015 Lowe <i>et al.</i> 2014, Pouwels <i>et al.</i> 2020 Sierra & Erhardt 2019			

Species	Factors affecting A-P migrants on breeding grounds			Factors affecting A-P migrants on nonbreeding/staging grounds		
	Threat(s)	Parameter(s)	References	Threat(s)	Parameter(s)	References
	Light pollution	H				
Red-necked Nightjar <i>Caprimulgus ruficollis</i>	Habitat change (forest)	H	Moreno-Mateos <i>et al.</i> 2011 Camacho <i>et al.</i> 2014			
Common Swift <i>Apus apus</i>						
Pallid Swift <i>Apus pallidus</i>						
Blue-cheeked Bee-eater <i>Merops persicus</i>						
European Bee-eater <i>Merops apiaster</i>	Climate change	B	Arbeiter <i>et al.</i> 2016			

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	Threat(s)	Parameter(s)	References	Threat(s)	Parameter(s)	References
European Roller <i>Coracias garrulus</i>	Habitat change (farmland)	P, B, H	Samwald & Samwald 1989, Avilés & Parejo 2004, Brotons <i>et al.</i> 2004 Catry <i>et al.</i> 2017	Habitat change	H	Rodriguez-Ruiz <i>et al.</i> 2019
Hoopoe <i>Upupa epops</i>	Habitat change (farmland)	P, B, H	Fournier & Arlettaz 2001, Arlettaz <i>et al.</i> 2010, Schaub <i>et al.</i> 2010, Tagmann-loset <i>et al.</i> 2012			
Eurasian Wryneck <i>Jynx torquilla</i>	Habitat change (farmland/forest)	H	Gjerde & Saetersdal 1997, Mermod <i>et al.</i> 2009, Coudrain <i>et al.</i> 2010, Schaub <i>et al.</i> 2010, Weisshaupt <i>et al.</i> 2011	Habitat change (savannah)	P, H	Zwarts <i>et al.</i> 2009 Wijk & Tizón 2016
Greater Short-toed Lark <i>Calandrella brachydactyla</i>						
Sand Martin <i>Riparia riparia</i>				Habitat change (wetland)	P, S	Szép 1995, Norman & Peach 2013
Barn Swallow <i>Hirundo rustica</i>	Habitat change (farmland)	P, B, H	Evans <i>et al.</i> 2003, Grübler <i>et al.</i> 2010, Ambrosini <i>et al.</i> 2011, 2012	Habitat change (various habitats) Habitat change (stopover sites)	P, S, B P	Saino <i>et al.</i> 2004, Robinson <i>et al.</i> 2008 Robinson <i>et al.</i> 2003

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	Threat(s)	Parameter(s)	References	Threat(s)	Parameter(s)	References
Red-rumped Swallow <i>Hirundo daurica</i>						
House-martin <i>Delichon urbica</i>	Habitat change	B	Kettel <i>et al.</i> 2021	Habitat change (forest)	S, B	Robinson <i>et al.</i> 2008 Lopez-Calderon <i>et al.</i> 2017
Tawny Pipit <i>Anthus campestris</i>	Habitat change (farmland)	H	Fonderflick <i>et al.</i> 2010			
Tree Pipit <i>Anthus trivialis</i>	Habitat change (forest)	B, H, P	Gjerde & Saetersdal 1997, Summers 2007, Burton 2009 Burgess <i>et al.</i> 2015, Schwarz <i>et al.</i> 2018	Habitat change	P	Ockenden <i>et al.</i> 2014
Red-throated Pipit <i>Anthus cervinus</i>						
Yellow Wagtail <i>Motacilla flava</i>	Habitat change (farmland)	B, H, P, S	Verhulst <i>et al.</i> 2004, Gilroy <i>et al.</i> 2008, 2009, 2011 Broyer <i>et al.</i> 2014, Shitikov <i>et al.</i> 2020			

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	Threat(s)	Parameter(s)	References	Threat(s)	Parameter(s)	References
Rufous-tailed Scrub Robin <i>Erythropygia galactotes</i>						
Thrush Nightingale <i>Luscinia luscinia</i>						
Common Nightingale <i>Luscinia megarhynchos</i>	Habitat change (forest) Climate change	P, H S	Holt <i>et al.</i> 2010, Newson <i>et al.</i> 2011 Holt <i>et al.</i> 2014 Remacha <i>et al.</i> 2020			
White-throated Robin <i>Irania gutturalis</i>						
Common Redstart <i>Phoenicurus phoenicurus</i>	Habitat change (farmland/ forest)	B, H	Gjerde & Saetersdal 1997, Summers 2007, Schaub <i>et al.</i> 2010, Martinez 2012 Assandri <i>et al.</i> 2017	Habitat change (forest)	P	Zwarts <i>et al.</i> 2009 Ockenden <i>et al.</i> 2014
Whinchat <i>Saxicola rubetra</i>	Habitat change (farmland)	P, S, B	Müller <i>et al.</i> 2005, Britschgi <i>et al.</i> 2006, Grübler <i>et al.</i> 2008, Broyer <i>et al.</i> 2011 Broyer <i>et al.</i> 2014, Sanderson <i>et al.</i> 2013, Shitikov <i>et al.</i> 2020, Tome <i>et al.</i> 2020	Habitat change (farmland)	H, P	Hulme & Cresswell 2012 Blackburn & Cresswell 2015, 2016

Species	Factors affecting A-P migrants on breeding grounds			Factors affecting A-P migrants on nonbreeding/staging grounds		
	Threat(s)	Parameter(s)	References	Threat(s)	Parameter(s)	References
Northern Wheatear <i>Oenanthe oenanthe</i>	Habitat change (farmland) Predation Climate change Pollution/pesticides	P, B, H S S, B B	Woodhouse <i>et al.</i> 2005, Arlt <i>et al.</i> 2008 Douglas <i>et al.</i> 2017, Paquet <i>et al.</i> 2019 Low <i>et al.</i> 2010 Arlt & Part 2017 van Oosten <i>et al.</i> 2019	Habitat change (savannah)	H	Wilson & Cresswell 2010
Pied Wheatear <i>Oenanthe pleschanka</i>						
Rufous-tailed Wheatear <i>Oenanthe xanthopyrna</i>						
Rufous-tailed Rock Thrush <i>Monticola saxatilis</i>						
Common Grasshopper- warbler <i>Locustella naevia</i>	Habitat change (farmland)	H	Gilbert 2012 Budka <i>et al.</i> 2019			

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	Threat(s)	Parameter(s)	References	Threat(s)	Parameter(s)	References
River Warbler <i>Locustella fluviatilis</i>						
Savi's Warbler <i>Locustella luscinioides</i>	Habitat change	H	Budka <i>et al.</i> 2019			
Aquatic Warbler <i>Acrocephalus paludicola</i>	Habitat change (wetland)	P, H	Kozulin & Flade 1999, Tanneberger <i>et al.</i> 2008, 2010 Budka <i>et al.</i> 2019, Kloskowski <i>et al.</i> 2015, Musseau <i>et al.</i> 2021	Habitat change (wetland)	H	Arbeiter & Tegetmeyer 2011 Dariusz & Magdalena 2020
Sedge Warbler <i>Acrocephalus schoenobaenus</i>	Habitat change (wetland/farmland)	P, H	Graveland 1998, Foppen <i>et al.</i> 1999, Surmacki 2005 Budka <i>et al.</i> 2019	Habitat change (wetland)	P, S	Peach <i>et al.</i> 1991, Baillie & Peach 1992, Foppen <i>et al.</i> 1999 Johnston <i>et al.</i> 2016, Ockenden <i>et al.</i> 2014
Marsh Warbler <i>Acrocephalus palustris</i>	Habitat change (wetland/farmland)	H, P	Surmacki 2005 Sanderson <i>et al.</i> 2013			
Eurasian Reed Warbler	Habitat change (wetland/farmland) Climate change	H B	Graveland 1999, Foppen <i>et al.</i> 2000, Surmacki 2005 Halupka <i>et al.</i> 2008, Douglas <i>et al.</i> 2010	Habitat change	P, S, H	Halupka <i>et al.</i> 2017, Johnston <i>et al.</i> 2016, Ockenden <i>et al.</i> 2014, Vafidis <i>et al.</i> 2014

Species	Factors affecting A-P migrants on breeding grounds			Factors affecting A-P migrants on nonbreeding/staging grounds		
	Threat(s)	Parameter(s)	References	Threat(s)	Parameter(s)	References
<i>Acrocephalus scirpaceus</i>						
Great Reed Warbler <i>Acrocephalus arundinaceus</i>	Habitat change (wetland)	H	Graveland 1998	Habitat change	B, S	Sorensen <i>et al.</i> 2016
Olivaceous Warbler <i>Hippolais pallida</i>				Habitat change (forest)	H	Stoate <i>et al.</i> 1998 Zwarts <i>et al.</i> 2015
Upcher's Warbler <i>Hippolais languida</i>				Persecution/hunting	S	Brochet <i>et al.</i> 2016
Olive-tree Warbler <i>Hippolais olivetorum</i>						
Icterine Warbler <i>Hippolais icterina</i>						
Melodious Warbler <i>Hippolais polyglotta</i>	Habitat change (farmland/forest)	P, H	Birrer <i>et al.</i> 2007 Meichtry-Stier <i>et al.</i> 2018	Habitat change	H	Willemoes <i>et al.</i> 2018
Subalpine Warbler <i>Sylvia cantillans</i>	Habitat change	H	Brambilla <i>et al.</i> 2017	Habitat change (savannah)	H	Jones <i>et al.</i> 1996, Wilson & Cresswell 2006 Vafidis <i>et al.</i> 2014
Rüppell's Warbler						

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	Threat(s)	Parameter(s)	References	Threat(s)	Parameter(s)	References
<i>Sylvia rueppelli</i>						
Orphean Warbler <i>Sylvia hortensis</i>				Persecution/hunting	S	Brochet <i>et al.</i> 2016
Barred Warbler <i>Sylvia nisoria</i>	Habitat change (farmland)	H	Verhulst <i>et al.</i> 2004 Pestka <i>et al.</i> 2018, Szymanski <i>et al.</i> 2013			
Lesser Whitethroat <i>Sylvia curruca</i>	Habitat change (farmland)	H	Mason & MacDonald 2000 Jahnig <i>et al.</i> 2018	Habitat change (savannah) Persecution/hunting	H P	Jones <i>et al.</i> 1996, Wilson & Cresswell 2006 Brochet <i>et al.</i> 2016
Common Whitethroat <i>Sylvia communis</i>	Habitat change (farmland/ forest)	P, H	Mason & MacDonald 2000, Stoate & Szczur 2001, Verhulst <i>et al.</i> 2004, Birrer <i>et al.</i> 2007 Denac <i>et al.</i> 2021, Meichtry- Stier <i>et al.</i> 2018, Szymanski <i>et al.</i> 2013	Habitat change (savannah)	P, S, H	Jones <i>et al.</i> 1996, Baillie & Peach 1992, Vickery <i>et al.</i> 1999, Wilson & Cresswell 2006 Johnston <i>et al.</i> 2016, Ockenden <i>et al.</i> 2014
Garden Warbler <i>Sylvia borin</i>	Habitat change (forest)	H	Fuller & Henderson 1992, Holt <i>et al.</i> 2011 MacColl <i>et al.</i> 2014	Habitat change	P	Ockenden <i>et al.</i> 2014
Bonelli's Warbler <i>Phylloscopus bonelli</i>						

Species	Factors affecting A-P migrants on breeding grounds			Factors affecting A-P migrants on nonbreeding/staging grounds		
	Threat(s)	Parameter(s)	References	Threat(s)	Parameter(s)	References
Wood Warbler <i>Phylloscopus sibilatrix</i>	Habitat change (forest) Predation Climate change	H, B, P B, H B	Adamik <i>et al.</i> 2003, Mallord <i>et al.</i> 2012a Bellamy <i>et al.</i> 2018, Huber <i>et al.</i> 2016, 2017 Grendelmeier <i>et al.</i> 2018, Pasinelli <i>et al.</i> 2016, Szymkowiak & Kuczynski 2015 Wesołowski & Maziarz 2009 Mallord <i>et al.</i> 2017	Habitat change	H	Awa <i>et al.</i> 2018, Buchanan <i>et al.</i> 2020, Mallord <i>et al.</i> 2016, 2018
Willow Warbler <i>Phylloscopus trochilus</i>	Habitat change (forest)	P, H	Reijnen & Foppen 1994, Gjerde & Sättersdal 1997, Hausner <i>et al.</i> 2003, Adamik <i>et al.</i> 2003, Newson <i>et al.</i> 2011 MacColl <i>et al.</i> 2014	Habitat change (forest)	P, S, H	Salewski <i>et al.</i> 2002 Johnston <i>et al.</i> 2016, Ockenden <i>et al.</i> 2014, Thorup <i>et al.</i> 2019, Willemoes <i>et al.</i> 2018
Spotted Flycatcher <i>Muscicapa striata</i>	Habitat change (forest) Predation	H B	Gjerde & Saetersdal 1997, Adamik <i>et al.</i> 2003 Stoate & Szczur 2006, Stevens 2008	Habitat change	P	Ockenden <i>et al.</i> 2014

Species	Factors affecting A-P migrants on breeding grounds			Factors affecting A-P migrants on nonbreeding/staging grounds		
	Threat(s)	Parameter(s)	References	Threat(s)	Parameter(s)	References
Semicollared Flycatcher <i>Ficedula semitorquata</i>	Habitat change	H	Georgiev <i>et al.</i> 2018			
Collared Flycatcher <i>Ficedula albicollis</i>	Habitat change (forest) Predation Climate change	H B B	Adamik <i>et al.</i> 2003, Kralj <i>et al.</i> 2009 Adamik & Kral 2008 Czeszczewik <i>et al.</i> 2020			
Pied Flycatcher <i>Ficedula hypoleuca</i>	Habitat change (forest) Climate change Atmospheric pollution	B, H P, B B, H	Gezelius <i>et al.</i> 1984, Gjerde & Saetersdal 1997, Kuitunen <i>et al.</i> 2003 Goodenough 2014 Both & Visser 2001, Both <i>et al.</i> 2006 Gonzalez-Broajos <i>et al.</i> 2017, Samplonius & Both 2019, Wittwer <i>et al.</i> 2015 Bel'skii & Lyakhov 2020, Eeva <i>et al.</i> 2020	Habitat change (forest)	H	Salewski <i>et al.</i> 2002 Thorup <i>et al.</i> 2019, Willemoes <i>et al.</i> 2018
Eurasian Golden-oriole <i>Oriolus oriolus</i>						

Species	Factors affecting A-P migrants on breeding grounds			Factors affecting A-P migrants on nonbreeding/staging grounds		
	Threat(s)	Parameter(s)	References	Threat(s)	Parameter(s)	References
Red-backed Shrike <i>Lanius collurio</i>	Habitat change (farmland)	P, B, H	Verhulst <i>et al.</i> 2004, Birrer <i>et al.</i> 2007, Brambilla <i>et al.</i> 2007, 2010, Golawski & Meissner 2008, Hollander <i>et al.</i> 2011, 2013 Meichtry-Stier <i>et al.</i> 2018	Habitat change (savannah)	P, H	Bruderer 1994, Herremans 1997, Pasinelli <i>et al.</i> 2011
Lesser Grey Shrike <i>Lanius minor</i>	Habitat change (farmland)	B, H	Wirtitsch <i>et al.</i> 2001, Giralt <i>et al.</i> 2008 Chiatante <i>et al.</i> 2013	Habitat change (savannah)	H	Herremans 1997
Woodchat Shrike <i>Lanius senator</i>	Habitat change	H	Brambilla <i>et al.</i> 2017, Chiatante <i>et al.</i> 2013	Habitat change	H	Papageorgiou <i>et al.</i> 2017
Masked Shrike <i>Lanius nubicus</i>				Persecution/hunting	P	Brochet <i>et al.</i> 2016
Ortolan Bunting <i>Emberiza hortulana</i>	Habitat change (farmland)	B, H	Vepsalainen <i>et al.</i> 2005, Berg <i>et al.</i> 2008, Menz <i>et al.</i> 2009 Brambilla <i>et al.</i> 2016, 2017, Salek <i>et al.</i> 2019	Habitat change	P	Jiguet <i>et al.</i> 2019

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