CMS Scientific Council: Flyway Working Group Reviews

Review 2:

Review of Current Knowledge of Bird Flyways, Principal Knowledge Gaps and Conservation Priorities

Compiled by:

JEFF KIRBY

Just Ecology
Brookend House, Old Brookend,
Berkeley, Gloucestershire, GL13 9SQ, U.K.

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Contents

Executive summary

A review of current knowledge for migratory birds at the flyway scale, including threats, has been undertaken, from which conservation priorities and recommendations are identified.

The many different types of migration that birds undertake are first described as well as the flyways and strategies that they use to complete their migratory journeys. The great complexity in bird migration is evident and brings with it a requirement for a multitude of conservation approaches. International collaboration is a key element in any strategy for migratory bird conservation and the signatories to the Convention on Migratory Species (CMS) have a key role to play.

Analysis of status and trends was carried out for a total of 2,274 CMS-defined migratory species (23% of the world's birds). Migratory birds are found in all regions of the world, however, the Americas and Asian regions stand out with more than 1,000 species each.

At a global level, 14% (317) of the included species are currently considered threatened or near-threatened according to the IUCN Red List. Since 1988, 53 species have deteriorated in status (sufficiently to be uplisted to higher categories of extinction risk on the IUCN Red List) while only nine species have improved (sufficiently to be downlisted to lower categories). Listing of species on CMS appendices (these being species identified as deserving of specific attention) does not yet appear to have resulted in an improvement in overall status.

There is increasing evidence of regional declines, although regional and taxonomic differences exist. Population trend data show that more Nearctic–Neotropical migrants have declined than increased in North America since the 1980s, and more Palearctic–Afrotropical migrants breeding in Europe declined than increased during 1970–2000. The East Asia–Australasia region has the highest proportion of threatened migratory waterbirds (20%); Africa–Eurasia, Central Asia and East Asia–Australasia having the highest proportions of threatened soaring birds (c.30% each); and the Americas, Africa–Eurasia and East Asia–Australasia the highest proportions of threatened seabirds (c.30%). On a flyway scale, the East Asia–Australasia flyway has the highest proportion of threatened migratory waterbirds (19%), and the highest proportions of threatened soaring birds (24–34%) was recorded for the Black Sea–Mediterranean, East Asia–East Africa, Central Asia and East Asia–Australasia flyways. These and other data reviewed indicate that a significant proportion of migratory birds are at high risk and have an unfavourable conservation status.

Analysis of the main threats to migratory species evaluated as threatened and near-threatened on the 2010 IUCN Red List shows that important threats include land-use change, illegal hunting and taking, non-native species, diseases, pollution, climate change, natural system modifications, infrastructure development, human disturbance, fishing, energy production and distribution. Published literature on key threats has been collated and reviewed.

Key information needs are identified that relate to our knowledge of the status, trends and threats to migratory bird species, and information needed in order to more effectively pursue their conservation. These include the continuing need for robust information on status and trends, distribution and ecology, and for further information on the wide variety of threats to migratory birds.

There is a need to determine the ‘ideal’ landscape for migratory birds in each geographical region of the world, where landscape-scale conservation is key to the protection of migratory birds. To facilitate migratory movements, it is vital to find ways to improve the connectivity of habitats critical to population survival currently and in the future. A continuation of monitoring and research into the impacts of climate change on migratory species, as well as the ability of species and populations to adapt, remains important. This knowledge is vital to identify key limiting factors, the ‘weakest link’, upon which each species’ survival hinges, and to provide essential building blocks for policy guidance.

Conservation priorities have been identified that address the key identified threats. Protection of habitats, and the resources they provide, is identified as being of vital importance to migratory birds, and this should be afforded the highest priority of all.

Migratory species that depend on a network of sites along their flyways will strongly benefit from the proper protection and management of these sites. The degree of protection afforded to network sites is at present insufficient. Effective management of key sites for migratory birds needs to address the whole range of factors that cause direct mortality (e.g. hunting, trapping, collisions, predation, pollution etc.), and those that reduce food supplies or destroy or degrade habitats. Best practice habitat management needs to be shared.

Specific threats highlighted by this review that are of particular significance for migratory birds include: wind turbine developments; power line collisions and electrocutions; illegal trapping and shooting; reclamation of wetlands; and pollution, overfishing and the by-catch of seabirds during long-line and trawl fishing operations. These threats are identifiable and will need continued effort to address particular impacts on particular species.

Climate change impacts are likely to be critical for a range of migratory birds and this defines climate change adaptation as one of the key conservation priorities for coming years. A network of critical sites, not least along the world’s flyways, is likely to maximise the potential of migratory birds to adapt to climate change.

A total of 72 specific recommendations for action were generated on the basis of this review but not all will be applicable to all engaged in migratory bird conservation world-wide. Thus, eight key recommendations are provided for CMS to consider, each crucial to improving the fortunes of the world’s migratory birds.

Extended summary

Introduction

This report presents a review of current knowledge for migratory birds at the flyway scale, key threats and conservation priorities and makes recommendations for further action to improve knowledge and assist with the conservation of migratory birds on a global scale. The review was commissioned by the Convention on the Conservation of Migratory Species of Wild Animals (CMS) which aims to bring range states together in order to facilitate the international coordination of conservation action on a species- or population-specific basis.

Migration, flyways and flyway conservation

The types of migration that birds undertake are described, and some of the key migratory strategies are identified, including north–south, south–north, longitudinal, loop, leap-frog, walk and swim migrations. The great complexity in bird migration is evident and brings with it a requirement for a multitude of conservation approaches, which invariably need to be applied at an international scale.

Sites and ecosystems within flyways provide migrating birds with the key resources they need. Different species use different strategies to complete their migrations including moving on a broad-front across the landscape, migrating only within narrow corridors of habitat or passing through ‘bottleneck’ sites that are crucial to the completion of the migratory journey. Non-stop migration is the exception rather than the rule and most migrants have one or more staging posts or stop-over sites; somewhere to rest and replenish their fuel reserves. It follows that the availability of appropriate stop-over sites is critical to the successful migration of many bird species, as well as rich feeding areas in departure and arrival locations.

Migratory bird flyways are defined, including several alternative flyway groupings that are used in conservation practice today. Flyway definitions have proved useful in organizing conservation action on an international scale, but it is important to note that flyway definitions are generalizations and there are many migratory species that do not necessary adhere to specific flyway boundaries.

International collaboration is a key element in any strategy for migratory bird conservation. CMS is the key global treaty, with flyway-scale conservation at its core. Many other policy mechanisms and international frameworks exists that can assist with migratory bird conservation, including: the Convention on Wetlands of International Importance (the Ramsar Convention); the Convention on the Conservation of European Wildlife (the Berne Convention); the European Union’s Birds Directive; the African–Eurasian Migratory Waterbird Agreement; the Asia–Pacific Migratory Waterbird Conservation Strategy; the East Asian–Australasian Flyway Partnership; the North American Bird Conservation Initiative; the North American Landbird Conservation Plan; the North American Waterfowl Management Plan; the North American Waterbird Conservation Plan; Partners in Flight (covering the Americas); Waterbird Conservation for the Americas; the Western Hemisphere

Migratory Species Initiative; and the Western Hemisphere Shorebird Reserve Network. Mechanisms such as these provide an extremely useful basis for international collaboration, providing the framework for a series of important actions, including the definition and protection of important sites, site networks and the implementation of action plans for migratory bird species.

Status and trends

The CMS definition of migratory species was adopted for this review and a total of 2,274 migratory species (23% of the world's birds) has been considered for analyses of status and trends. For convenience species have been considered within four main groups—landbirds, waterbirds, seabirds and soaring birds. In total, nearly 800 of these species (35%) are explicitly covered by CMS and related instruments. Migratory birds are found in all regions of the world, however, the Americas and Asian regions stand out with more than 1,000 species each.

At a global level, 14% (317) of the included species are considered threatened or near-threatened (17 Critically Endangered, 50 Endangered, 128 Vulnerable, and 122 Near Threatened) based on the 2010 IUCN Red List. Analysis of the number of species moving between Red List categories shows that, since 1988, 53 species have deteriorated in status (sufficiently to be uplisted to higher categories of extinction risk owing to genuine changes only) while only nine species have improved (sufficiently to be downlisted to lower categories). Listing of species on CMS appendices (these being species identified as deserving of specific attention) does not yet appear to have resulted in an improvement in overall status.

Analyses of the global trends of waterbirds shows that 40% of populations are declining, 34% are stable and just 17% are increasing. These figures are similar to those obtained from an analysis of the global trend data (for the migrants considered in this review) held in BirdLife's World Bird Database: 39% of species for which trend data are available are decreasing, 44% are stable, and just 15% are increasing.

Analyses of regional status highlights some regional differences, with the East Asia–Australasia region having the highest proportion of threatened migratory waterbirds (20%); Africa–Eurasia, Central Asia and East Asia–Australasia having the highest proportions of threatened soaring birds (c.30% each); and the Americas, Africa–Eurasia and East Asia–Australasia the highest proportions of threatened seabirds (c.30%). On a flyway scale, the East Asia–Australasia flyway has the highest proportion of threatened migratory waterbirds (19%), and the highest proportions of threatened soaring birds (24–34%) was recorded for the Black Sea–Mediterranean, East Asia–East Africa, Central Asia and East Asia–Australasia flyways.

There is also increasing evidence of regional declines. Population trend data show that more Nearctic–Neotropical migrants have declined than increased in North America since the 1980s, and more Palearctic–Afrotropical migrants breeding in Europe declined than increased during 1970–2000. Reviews of the status of migratory raptors show unfavourable conservation for more than half of the species in the African–Eurasian region (in 2005) and more than one-third of species in Central, South and East Asia (in 2007).

These and other data reviewed indicate that a significant proportion of migratory birds are at high risk and have an unfavourable conservation status.

Threats to migratory species

Analysis of the main threats to migratory species evaluated as threatened and near-threatened on the 2010 IUCN Red List shows that important threats include land-use changes (from agriculture, forestry and development); illegal hunting and taking; impacts from invasive and non-native species; emerging diseases; pollution, especially in the marine environment; climate change and severe weather; natural system modifications (owing to, e.g., dams, wetland drainage, modification of tidal regimes); infrastructure development (causing habitat loss and mortality owing to artificial structures); human disturbance; fishing resulting in bycatch (of seabirds); energy production (e.g. wind turbines) and energy distribution (e.g. power lines). Published literature has been collated and reviewed for many of these threats.

In all continents of the world, habitat loss and degradation is a widespread and very significant threat to migratory birds and seems only likely to increase as a pressure as economic development adversely impacts the environment. Many key habitats and sites for birds are classified as threatened and under serious threat.

Hunting of migratory birds takes place on an enormous scale but for many countries there are no estimates of take available. A key concern is where hunting is illegal and unsustainable, with very high impacts documented for parts of Africa, Asia and the Mediterranean. Trade in live wild birds is a high impact activity also, certainly in parts of Africa and Asia, where particular species may be specifically targeted for trade. Although the practice has been reduced, migratory falcons, eagles and other raptors, and their eggs, are still taken from the wild for falconry purposes. If these activities are to continue, they need to be managed sustainably along all flyways in order to secure a favourable status for migratory birds.

All bird species are exposed to disease, which sometimes cause great mortality and are sometimes exacerbated by anthropogenic factors. Waterbirds in particular are prone to periodic outbreaks of infectious disease (e.g. botulism) at sites where they congregate at any time of year. Such outbreaks have increased as a cause of mortality in wild waterbirds and significantly impact some populations. The emergence of a highly pathogenic avian influenza virus in 2005 is of concern. Though resulting in only localized mortalities, the potential role of migratory birds in the transmission of this virus to domestic stock and humans along flyways is high on the political agenda. Conversely the role of domestic birds in transmitting the disease to vulnerable wild species (e.g. up to 10% of world population of bar-headed goose at Qinghai) is also of concern.

Non-native animals and plants impact on migratory birds in a number of ways. Of most significance have been predation impacts on breeding waterbird and seabird colonies, most commonly by introduced rats, mice, mustelids and feral cats. Island nesting birds are particularly vulnerable and some local extinctions have occurred. Invasive plants can pose immense management problems and result in ecosystem degradation with impacts on dependent bird species. All over the world overgrazing by non-native animals (goats, pigs etc.) is a serious problem, especially in semi-arid regions, and can lead to the removal of much natural vegetation.

Human activities, including all forms of work or leisure activity taking place in close proximity to birds, may cause disturbance. Assessing the significance of disturbance has proved to be complex, with the need to record and consider many interacting variables and take account of many differing species attributes, situations and sensitivities. Displacement effects have been documented and disturbance can reduce breeding success. Overall, such effects are likely to be widespread and, whilst we generally do not know whether there are population-level impacts, local effects may be substantial.

Mortality caused by human infrastructure, such as power lines, wind turbines, gas flares and telecommunications masts has been documented as severe and can result in the death of very significant numbers of migratory birds. Further information is needed, for example, on the impact of modern wind turbine developments, where the scale of bird losses is as yet unclear. High collision mortality rates have been recorded at several large, poorly sited windfarms in areas where concentrations of birds are present, especially migrating birds, large raptors or other large soaring species. As turbines continue to be constructed, they could collectively begin to impose a more significant drain on migratory bird populations, whether on land or in shallow coastal areas.

Power lines also pose a significant collision risk for many larger migrant birds (e.g. swans, geese, raptors etc.), especially if sited across flight lines or close to congregatory sites such as wetlands. Furthermore, electrocution on poorly designed medium-voltage lines is a significant cause of mortality in large perching species such as raptors. Glass and other reflective materials may cause serious problems for migratory birds. In the United States there is a vast and growing amount of evidence supporting the interpretation that, except for habitat destruction, collisions with clear and reflective sheet glass and plastic cause the deaths of more birds than any other human-related avian mortality factor.

Marine pollution, overfishing and bycatch are three key factors that impact negatively on migratory seabirds (and sometimes waterbirds). Oily substances on the sea surface represent a significant observable cause of death for a wide range of marine and coastal bird species, and pose a serious threat to seabird populations occurring in large concentrations near shipping lanes and oil production facilities. Added to this is mortality from chemical residues and heavy metals, and the accidental consumption of plastic and hooks and entanglement with discarded fishing line and nets, all of which impact negatively on birds at sea.

The over exploitation of fish prey species by humans is a serious problem where it reduces and alters the food supply for many seabirds. Where fish stocks have collapsed, seabirds have suffered widespread breeding failures and some populations have declined. This is expected to be of continuing concern as fishery operators switch to targeting smaller prey fish and invertebrates such as krill as they “fish down the food chain”.

Despite a ban on their use in the high seas, gillnet fisheries continue in coastal waters of many countries in northern Europe and indeed in many other parts of the world. The evidence suggests that seabird bycatch mortality in gillnets could be relatively high locally, and could potentially impact on populations at a larger scale.

Longline fishing fleets, which operate throughout the world‘s oceans, impact negatively on particular bird species. Baited hooks attract albatrosses and other seabirds, which get caught, dragged below the water surface and drown, with an estimated 100,000 albatrosses killed each year putting them in real danger of extinction.

Climate change has been shown to affect migratory birds in many ways and is the subject of a vast amount of published literature. Bird responses include altered timing and patterns of migrations, and there is evidence that some migratory bird species may be disadvantaged and increasingly threatened by climate change impacts within breeding and non-breeding locations, both on land and at sea. Species and population vulnerability has been assessed in some studies and, whilst widespread impacts are expected, the extent to which climate change will cause population-level impacts remains unclear. Of particular significance will be the cumulative impact of climate change which is expected to cause other pressures on migratory birds by altering habitats, affecting competition between species, affecting the spread of disease, and changing the distribution and availability of surface and ground water. Climate change will constrain water resources, further increasing competition among agricultural, municipal, industrial and wildlife uses.

The majority of migratory bird species are already at high risk from anthropogenic pressures. The predicted negative socio-economic impacts of current climate change on humans will ultimately result in increased anthropogenic pressures on species and natural systems.

Knowledge gaps

Key information needs are identified that relate to our knowledge of the status, trends and threats to migratory bird species, and information needed in order to more effectively pursue the conservation priorities defined below.

These include the continuing need for robust information on status and trends for migratory bird species in order to detect current or future declines and target action to address them. There remain considerable gaps in our understanding of the status of some species or populations.

Much more also needs to be known about the distribution and ecology of migratory species, and especially the migration routes that they follow. This is fundamental to knowing which Range States have a responsibility for which migratory species, assessing threats, and to taking conservation action in the right places at the right time.

The wide variety of threats to migratory birds all requires urgent attention. Some can be addressed through landscape scale or site-based conservation management, while other threats require targeted campaigns, focused on particular species or species groups or on particular threat types.

There is a need to determine the 'ideal' landscape for migratory birds in each geographical region of the world, where landscape-scale conservation is key to the protection of migratory birds. This in itself is a significant challenge but is already being attempted in some parts of the world.

To facilitate migratory movements, it is vital to improve the connectivity of habitats critical to population survival currently and in the future. CMS is already involved in developing critical site networks, but there is an urgent need to identify and protect further critical site networks with species range shifts in mind. By maintaining viable habitats and reducing current threats, stakeholders may be able to improve the resilience of some species to cope with and adapt to climate change.

There is a need to determine what kind of network of sites (including the size, proximity and number of sites) would be needed to support healthy populations of different migratory species at all stages of their annual cycle and in all parts of the world. Very importantly, in answering this question, we should also seek to maximise the resilience of such networks in the face of global climate change.

Promoting good management of sites for birds (including reducing threats) is relatively easy and involves a continued sharing of best practice habitat guidance.

Unfortunately, little is currently known about migratory species' capacity for adaptation to climate change. To understand this better, intensive monitoring and research is needed. This knowledge is vital to identify key limiting factors, the 'weakest link', upon which each species' survival hinges, and to provide essential building blocks for policy guidance.

In addressing the conservation challenges of climate change, a multi-functional approach is likely to be most successful. This approach entails considering the benefits of ecosystem conservation from a holistic viewpoint, considering both the anthropogenic and wildlife benefits. It is much more likely that conservation goals will be achieved if they are part of ecosystem management with wider aims such as floodplain management, coastal protection or preventing deforestation to reduce soil erosion. Frameworks for integrated land-use planning exist in a number of different parts of the world, and they could valuably be developed and implemented more widely elsewhere.

In terrestrial systems adaptation measures may be successful in maintaining or restoring a secure conservation status for many species. In marine systems, however, mitigation of climate change may be the only solution (i.e. reduction in anthropogenic greenhouse gas emissions), as habitat management at a sufficient scale will be virtually impossible. Climate change may be the 'last straw' for many marine species, which are already under severe anthropogenic pressure. Strengthening protection for marine species and ecosystems should improve their ability to adapt to changing climatic conditions.

Priorities for migratory bird conservation

Conservation priorities have been identified that address the key identified threats, as follows:

- Work to protect and retain and, where feasible, recreate / restore high quality bird habitats on a flyway and landscape scale.
- Work to safeguard and manage networks of critical sites, key to the migration and survival of migratory species.
- Actions to address specific threats that are known to threaten the survival of individual species and species groups.
- Attempts to mitigate the effects of climate change, affording migratory species the best possible chance of survival.

Protection of habitats, and the resources they provide, is identified as being of vital importance to migratory birds, and this should be afforded the highest priority of all. Broad-front migrants, for example, will benefit from modifications to extensive land-use along their migratory routes, related to agriculture or forestry practice. Migrants following narrower flyways will require a coherent site network, with each network site providing safety and plentiful resources for the birds.

Migratory species that depend on a network of sites along their flyways strongly benefit from the proper protection and management of these sites. The degree of protection afforded to network sites is at present insufficient, e.g. 56% of 8,400 Important Bird Areas (IBAs) identified for migratory birds worldwide have less than 10% of their area formally protected, while nearly 40% of 2,250 IBAs in the AEWA area lack either statutory national protection or formal international recognition. Similarly, few IBA bottleneck sites for migrating raptors in Africa and Eurasia have adequate protection. Implicated in the decline of waterbirds in Asia is poor protection overall of key sites, leading to habitat damage and destruction.

An important recent initiative to review the adequacy of sites as a network of breeding, non-breeding and passage areas for migratory birds is the 'Wings Over Wetlands' (WOW) project in the AEWA region. Effective management of key sites for migratory birds needs to address the whole range of factors that cause direct mortality (e.g. shooting, trapping, collisions, predation, pollution etc.), and those that reduce food supplies or destroy or degrade habitats.

Specific threats highlighted by this review that are of particular significance for migratory birds include: wind turbine developments; power line collisions and electrocutions; illegal trapping and shooting; reclamation of wetlands; and pollution, overfishing and the by-catch of seabirds during long-line and trawl fishing operations. These threats are identifiable and will need continued effort to address particular impacts on particular species. CMS has a mandate to do this. Parties to CMS must prohibit the taking of species on Appendix I ("endangered" species, including many globally threatened migrant birds) and assume responsibility for the species' habitats and the obstacles to migration (including buildings, power lines, wind turbines and loss of stopover sites).

Climate change impacts are likely to be critical for a range of migratory birds and this defines climate change adaptation as one of the key conservation priorities for coming years. If species cannot adapt to climate change and cannot be maintained at their present locations, they will only survive if they move into new areas.

A network of critical sites, not least along the world's flyways, is likely to maximise the potential of migratory birds to adapt to climate change. Such a network would provide a mosaic of the widest possible range of available habitat. Although networks of protected areas provide one means of aiding species dispersal, there is also a need to manage the wider countryside in a manner that favours dispersal. This is best achieved by integrating appropriate management into existing policy frameworks such as agri-environment schemes. All conservation programmes must be expanded to include climate change impacts in biological planning, conservation design and habitat protection initiatives.

Key recommendations from the review

A total of 72 specific recommendations for action were generated on the basis of this review (see Annex 5) and there is no doubt that others could be identified. Not all of these will be applicable to all engaged in migratory bird conservation world-wide. Similarly, not all will be relevant to all migratory bird groups and the different specialist groups focusing on their particular conservation requirements.

From the full list of recommendations a more focused selection of key recommendations have been identified for broadscale action, as follows:

1. *Ensuring effective implementation*: With 14% of migratory bird species considered globally threatened or near-threatened, nearly 40% declining overall, and extinction risk increasing (including for those species specifically listed on CMS appendices and related agreements), continuing effective implementation of existing conservation efforts under CMS auspices remains an urgent priority.

2. *Reviewing CMS species selection*: With nearly 800 migratory bird species (35% of the total considered in this review) explicitly covered by different elements of the Convention, there is already considerable taxonomic

coverage. However, additional consideration should be given to selected species with the highest extinction risk not currently listed on the appendices or its instruments. In addition, specific consideration should be given to declining species or groups of species that would complement / add to existing initiatives where CMS is well placed to extend its current remit. Species should only be chosen after careful review and ideally chosen as flagships whose conservation will address wider issues.

3. *Covering flyways*: With many flyway-scale conservation initiatives already established by CMS and other international collaborations and partnerships, there is already considerable geographic coverage of migratory species. For CMS, the East Asia–Australasia region deserves particular attention on account of the high proportion of threatened migratory bird species (waterbirds, soaring birds and seabirds) found there.

Selected species groups not currently listed on CMS appendices or other instruments

Species Group	Region	Total number species	Number (%) declining	Number (%) threatened or near-threatened
Petrels, shearwaters[1]	Global	74	38 (51%)	27 (37%)
Waterbirds[2]	East Asia–Australasia	61	23 (38%)	15 (25%)
Storks / Ibises[2]	East Asia	8	5 (63%)	5 (63%)
Bustards / Floricans	Africa–Eurasia, C. Asia, E. Asia	4	4 (100%)	4 (100%)
Pigeons / Parrots	East Asia–Australasia	65	22 (34%)	11 (17%)
Pigeons / Parrots	Americas	61	25 (41%)	15 (25%)
Passerines[3]	Americas	434	133 (31%)	25 (6%)
New world[3] warblers	Americas	50	22 (44%)	4 (8%)
Passerines	Africa–Eurasia	188	64 (34%)	3 (2%)
Passerines	Central Asia	125	46 (37%)	0 (0%)
Passerines	East Asia–Australasia	315	93 (30%)	10 (3%)
Larks	Africa–Eurasia, C. Asia, E. Asia	33	15 (46%)	0 (0%)

Notes The species groups above were identified on the basis of four or more declining species facing similar threats and none currently listed on CMS appendices or associated instruments. 1. 29 species of albatrosses and petrels are already covered by ACAP. 2. These species are technically covered by the East Asian–Australasian Flyway Partnership but not specifically listed. 3. These species are covered by the 'Partners in Flight' initiative.

4. *Addressing issues at the broad scale*: With threats leading to habitat degradation and destruction having the greatest impact on migratory species, addressing issues at the wider landscape scale remains a considerable challenge. In this review, some specific terrestrial habitats have been identified as deserving of particular attention, including:

    a. halt conversion of *intertidal wetlands in East Asia*, especially in the Yellow Sea
    b. protect remaining *lowland forest in South-East Asia* from conversion to plantation agriculture
    c. reform the Common Agricultural Policy to promote *diverse farmlands in the European Union* that supports biodiversity and rural livelihoods.
    d. support efforts to reduce and reverse desertification and loss of flood plain habitat in the *drylands of the African Sahel*, using approaches

that protect and restore native vegetation and conserve natural flood regimes

e. protect remaining *lowland and montane forests in Central America and the tropical Andes*
f. protect key *grasslands in South America* and maintain traditional, extensive grassland ranching practices.

5. *Conserving important sites*: With increasing recognition of the importance of critical sites for migratory birds during breeding, non-breeding and on passage, and their poor protection (e.g. 56% of 8,400 Important Bird Areas having less than 10% of their area formally protected), it is a priority to ensure identification and effective management of a network of sites along migration flyways as a whole, including:

   a. supporting the development of flyway-scale networks such as the Western Hemisphere Shorebird Reserve Network in the Americas, the East Asia–Australasian Flyway Site Network and the West / Central Asian Site Network for Siberian Cranes and other waterbirds, and through applying the critical site network approach (as developed by the ‘Wings over Wetlands’ Project) to other regions and taxonomic groups
   b. listing important sites on CMS instruments for particular attention / management plans (as is currently done under the Agreement on the Conservation of Albatrosses and Petrels and the Memorandum of Understanding on the Conservation of Migratory Birds of Prey in Africa and Eurasia)
   c. evaluating the effectiveness of current protection / management of sites
   d. seeking protection of sites through formal designations or voluntary measures.

6. *Tackling species-specific issues*: With migratory bird species facing a multitude of complex, often interacting, threats, it would be important for CMS to focus on those where CMS can add value and / or is / could be a leader of best practice, including:

   a. addressing unsustainable trapping and shooting, ensuring full implementation and adherence to hunting regulations, especially in the Mediterranean basin
   b. ensuring best practice, and exercising extreme caution, in the location and construction of man-made structures in sensitive areas for migratory birds, especially wind turbines and power transmission and telecommunication infrastructure.

7. *Facilitating international cooperation*: Given that efforts to conserve migratory birds in one part of the range are less effective if unaddressed threats are reducing populations and habitats along migration flyways as a whole,

international collaboration and coordinated action are key elements in conserving migratory birds, including, for example:

a. mainstreaming migratory bird issues through other UN conventions, including the Convention on Biological Diversity, United Nations Framework Convention on Climate Change, United Nations Convention to Combat Desertification, and the Convention for the Prevention of Marine Pollution
b. supporting and strengthening implementation of relevant regional conventions and initiatives, e.g. the Abidjan and Nairobi Conventions through the African Ministerial Conference on the Environment and the Africa Union, and the *Alliances* initiative for the conservation of the South American Southern Cone grasslands.
c. supporting the Agreement for the Conservation of Albatrosses and Petrels (ACAP) to address bycatch of seabirds during long-line and trawl fishing operations, including in international waters
d. coordinating and implementing action across critical site networks
e. conserving important trans-boundary sites
f. coordinating and adhering to international legal protection for globally threatened and declining species.

8. *Supporting monitoring*: In order to detect declines early and implement appropriate action rapidly, it is recommended that CMS uses its influence to promote monitoring of migratory bird populations across all its projects and programmes (including, e.g., through Important Bird Area and International Waterbird Census coordinated monitoring).

Introduction

Animal migration has never ceased to amaze humankind. The arrival and departure of migrants is a spectacular natural phenomenon with migratory birds being amongst the most distant of travelers. Migratory birds offer an extraordinary opportunity for international collaboration, and were one of the initial drivers for international conservation legislation, e.g. the 1916 North American Migratory Birds Treaty between USA and UK (on behalf of Canada). Despite this, many migratory bird species are declining in response to major environmental pressures (e.g. Kirby *et al.* 2008).

The convention on migratory species

Migratory species conservation is highly challenging because the ranges of migratory species often span several countries, each governed by their individual jurisdiction and national conservation strategies. Out of this need, the Convention on the Conservation of Migratory Species of Wild Animals (CMS) was born to bring range states together in order to facilitate the international coordination of conservation action on a species- or population-specific basis.

CMS and its related agreements— the 'Bonn Convention'—is a global treaty that was concluded in 1979 in Bonn, Germany. It requires Parties (i.e. member countries) to strive towards the conservation and sustainable use of migratory species listed in Appendices I and II of the Convention. Appendix I lists endangered migratory species that have been categorized as being in danger of extinction throughout all or a significant proportion of their range. Appendix II lists species that can be conserved through 'Agreements', which are migratory species that have an unfavourable conservation status or would benefit significantly from international co-operation organised by tailored agreements. For this reason, the Convention encourages the range states to conclude global or regional Agreements for the conservation and management of individual species or, more often, of a group of species listed on Appendix II. A total of 78 bird species are currently listed on Appendix I of the Convention; Appendix II contains 112 species/populations or groups of species (see www.cms.int/documents/appendix/Appendices_COP9_E.pdf for full details), covering some 750 species in total.

Agreements in place for birds already include the Agreement on the Conservation of African-Eurasian Migratory Waterbirds (AEWA) covering 255 species and the Agreement on the Conservation of Albatrosses and Petrels (ACAP) covering 29 species, whilst a series of MoUs and Single Species Action Plans are in place to focus conservation action on particular bird species (covering 94 species as of April 2010). In total, nearly 800 migratory bird species (35% of the total, see below) are explicitly covered by different elements of the Convention.

Study brief

At the ninth Conference of the Parties held in December 2008, CMS established an open-ended working group on global bird flyways. It acts as a think tank on flyways and frameworks, as the basis for future CMS policy on flyways, and thus contributes to the future shape of CMS.

The working group has requested an up-to-date review of key knowledge for migratory birds from which information gaps and conservation priorities can be defined. In particular the brief was to '*undertake a desk study to review CMS and non-CMS publications, existing reviews, research papers and related documents on migratory birds, flyways and conservation initiatives*'. The report was to include an overview of the knowledge of bird flyways globally, status and trend information, and an overview of conservation threats, major knowledge gaps and conservation priorities.

This is the purpose of this review, which we hope will be important in addressing the future requirements of migratory bird species. The review has built on a paper addressing key conservation issues of migratory birds (Kirby *et al.* 2008) although altered to reflect the CMS definition of migratory species, to include a new suite of species and seabirds, and more detailed flyway definitions. The review has also significantly expanded and updated this work to cover different issues and threats, and to provide a more detailed description of gaps in knowledge, conservation priorities and recommendations for CMS to consider. Many additional publications have also been reviewed, especially those from recent years, although this should be recognised as an endless task and thus only a selection of key / major papers have been considered.

Migratory birds

There are several ways of defining which birds are migratory (see, e.g., Boere and Stroud 2006, Kirby *et al.* 2008) but for this CMS review we adopted the CMS definition, whereby 'migratory species' are defined as *'the entire population or any geographically separate part of the population of any species or lower taxon of wild animals, a significant proportion of whose members cyclically and predictably cross one or more national jurisdictional boundaries'.*

For a biological definition, the crossing of national jurisdictional boundaries is of course not necessary. BirdLife International, for example, make no mention of political boundaries, defining migratory species as those where a substantial proportion of the global or a regional population makes regular cyclical movements beyond the breeding range, with predictable timing and destinations (see Annex 4: migratory status also including separate definitions for altitudinal migrant and nomadic species). The BirdLife definition is more inclusive in this respect (with some 200 migratory species being single-country endemics), although perhaps more stringently applied in terms of the predictability and cyclical nature of movements (with 83 species listed on the Convention appendices regarded as non-migratory by BirdLife).

For this review, we adopt the CMS definition of migratory species and have covered 2,274 species in total (see Table 1 for rationale) amounting to 23% of the world's birds.

Table 1. Migratory bird species covered by this review

Migratory status (BirdLife definition)	Total numbers (A)	Country distribution: numbers in one country only (B)	Numbers in one country only but on CMS appendices (C)	Numbers included in this review (=A-B+C)
Full migrant	1851	85	12	1778
Altitudinal migrant	344	52	1	295
Nomadic migrant	181	64	1	118
Non-migrant but on CMS appendices	83	2	2	83
Total	**2459**	**203**	**16**	**2274**

Notes There is no definitive CMS list or official database of migratory species and thus the species included in this review (and associated data for analyses) are from BirdLife's World Bird Database, based on BirdLife's migratory status and country distribution. However, all species on the CMS appendices, whether regarded as non-migrants and / or single-country endemics by BirdLife are included. Conversely, some taxa listed on CMS appendices and instruments are not currently recognized by BirdLife as species, and have been excluded, including: Entre Rios Seedeater *Sporophila zelichi* (CMS Appendix 1), Mascarene Reef Egret *Egretta dimorpha*, Heuglin's Gull *Larus heuglini*, and Armenian Gull *L.armenicus* (all listed under AEWA). Caspian Gull *L.cachinnans* and Yellow-legged Gull *L. michahellis* are treated as separate species by BirdLife and so both are included (although they are treated as the single species Yellow-legged Gull *L. cachinnans* on the official AEWA list).

Migratory patterns

Migratory birds travel from breeding to non-breeding areas, and back again, either on a broad front through the landscape or via clearly defined, and sometimes narrow, routes. Elphick (2007) documents why birds chose to migrate and describes the great variety of migratory patterns that exist (see also Able 1999, Alerstam 1990, Burton 1992, Berthold 1993 and Annex 4: migratory patterns). Brouwer (2009) outlines the biological, cultural and economic significance of migratory birds; see

Murillo *et al.* (2008) for a similar account from the Americas. See also Boere and Dodman (2010) for a detailed account of the complexities of bird migration.

From movements of a few hundred metres to flights that circumnavigate the globe, from north to south and east to west, birds' migratory journeys are as varied as the species that undertake them. Defining types or patterns of migration is not easy (Elphick 2007). However, some commonalities can be discerned which are important for conservation focus and planning.

North–south migration

One of the commonest migratory patterns is for birds to breed in the temperate, boreal or Arctic biomes of the northern hemisphere during the northern summer, and then to spend the non-breeding season in the warmer biomes of the tropics, with fewer species migrating very long distances to reach the temperate zones of the southern hemisphere during the southern summer (Kirby *et al.* 2008). Archetypical, long-distance, north–south migrants include some populations of Red Knot *Calidris canutus* and Arctic Tern *Sterna paradisaea*. Another common pattern is for intra-tropical migrants to follow the productive "wet season" as it oscillates annually from the Tropic of Cancer to the Tropic of Capricorn and back again (e.g. Roseate Tern *Sterna dougallii*).

South–north migration

The predominant migratory pattern in the southern hemisphere is for birds to breed in the temperate latitudes of South America, Africa and Australasia, and then to migrate north to the tropics and subtropics in the southern winter. However, probably mainly because there is so much less land in the southern than in the northern hemisphere, many fewer species are involved (Kirby *et al.* 2008).

Longitudinal migration

Bird migration does not always occur along a south–north axis. Some species also show a considerable east–west and west–east component in their migration (e.g. Redwing *Turdus iliacus,* White-winged Scoter *Melanitta deglandi*), usually birds taking advantage of the better winter climate provided by the sea at the edge of a continent (Elphick 2007). Although they must breed on land, seabirds spend most of their lives far out to sea, often moving long distances between seasons, not just over one ocean, but sometimes flying between them. Many albatross and petrel species that breed in southern latitudes, during the non-breeding season ride the westerlies over the Southern Ocean, circumnavigating the Antarctic region in an eastward direction (Elphick 2007). Using radar observations, Alerstam *et al.* (2008) have demonstrated that great-circle migration occurs for some arctic passerines (in addition to shorebirds) travelling between Alaska and Old World winter quarters. The benefits of this, as opposed to a more conventional, north–south strategy remain poorly understood.

Loop migration

A special phenomenon, so-called ‘loop migration’, is where birds take a different route back to their breeding areas from the one they took to get to their non-breeding areas (e.g. for Curlew Sandpiper; Wilson *et al.* 1980). A broad range of species from all over the world exhibit loop migration, and species conservation measures for these birds are required along both the outward and inward flyways, adding a different dimension to their conservation requirements.

Moult migration

Another special form of migration is ‘moult migration’. Some species, particularly Anatidae, undertake special migrations for the purpose of moulting (e.g. Common Eider *Somateria mollissima*, Common Shelduck *Tadorna tadorna*, Eurasian Goosander *Mergus merganser* etc.), and whilst flightless at moulting sites such birds can be vulnerable (Elphick 2007).

Leapfrog migration

To add to the complexity of migration, different populations of a species, or sub-populations, may well adopt different strategies. For example, ‘leapfrog’ migration involves autumn movement by the northern breeding element of a population to winter quarters which lie further to the south than those occupied by the southern breeding element of that population. Thus the northern birds 'leapfrog' over the southern birds, which may be resident or move much shorter distances on migration than the northern birds. This situation is common among birds whose breeding distribution extends across both arctic and temperate latitudes. For example, in the Dunlin *Calidris alpina*, British breeders do not move far for the winter, whereas those from the Arctic migrate not only to the British Isles but also as far south as the equator.

Walk migration

Also, it is not always necessary for birds to fly to their migration destination. Ostrich *Struthio camelus* and Emu *Dromaius novaehollandiae,* both species of arid and semi-arid areas, cannot fly, and their movements are regulated by the availability of food and water (UNEP/CMS 2009). In areas where they need to move to find new food or water, those movements are often nomadic, showing no regular pattern. However, in parts of the Sahel, Ostriches tend to walk north during the rains and south again when it is dry. In Western Australia, Emus walk towards the coastal areas in the south for the winter rains there and to inland areas further north for any summer monsoonal rains (UNEP/CMS 2009). Adding to the complexity are birds that can fly but, under some circumstances, chose not to, for example when attending young not able to fly (e.g. Lesser Flamingo *Phoenicopterus minor*). Birds such as Ostrich and Emu may conveniently be labelled as ‘walking migrants’ (Elphick 2007).

Swim migration

In marine environments, Antarctic penguin species swim northward at the onset of the cold season, away from the pack ice; they are ‘swimming migrants’ (Elphick 2007). To breed they swim south again, and some walk (UNEP/CMS 2009). Emperor Penguin *Aptenodytes forsteri* start their breeding in the cold season up to 200 km from the open sea, and for them there is only one way to get there: on foot. By the time the young become independent, in January–February, the Antarctic summer, the open water is much closer. Auk species also migrate long distances by swimming (Elphick 2007).

It is clear from this brief overview of migratory patterns (which is certainly incomplete; consider altitudinal migration, narrow-front migration, nomadism and semi-nomadism, and other strategies—see, e.g. Boere and Dodman 2010), that there is great complexity in bird migration, making generalisation difficult and potentially mis-leading. The complexity of bird migration also brings with it a requirement for a multitude of conservation approaches, often to be applied at an international scale.

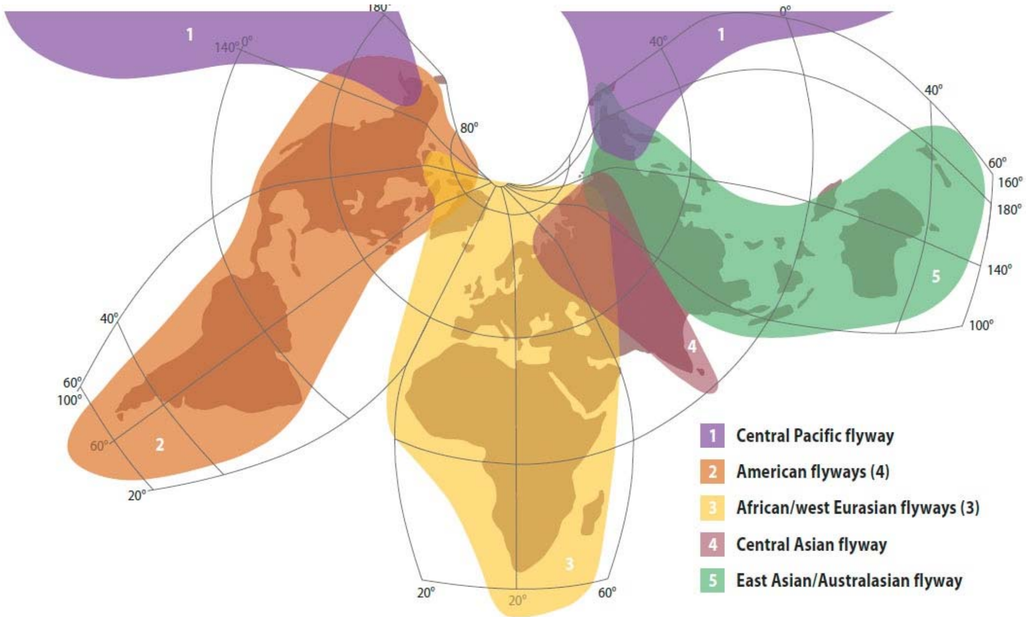
Flyways

The total geographic area used by a population, species or group of species throughout its annual cycle is termed a flyway (Kirby *et al.* 2008). Boere and Stroud (2006) provided a more detailed definition of a flyway: *‘…the entire range of a migratory bird species (or groups of related species or distinct populations of a single species) through which it moves on an annual basis from the breeding grounds to non-breeding areas, including intermediate resting and feeding places as well as the area within which the birds migrate*’.

Such flyways have been delineated by interpretation of morphological differences between some populations, analysis of genetic differences, ringing/banding results, study of stable-isotope ratios in feathers, and satellite-based and geolocation tracking. Relatively good knowledge allows some bird flyways to be quite clearly described, e.g. for shorebirds, waterfowl etc. (see Elphick 2007, Zalles and Bildstein 2000, Boere and Stroud 2006, Brouwer 2009, UNEP/CMS 2009); the routes taken by many land and sea birds however are generally less well understood and consequently remain less distinctly defined.

UNEP/CMS (2009) recognized that various flyway systems have been proposed during the last 50 years, at both global and regional levels. The International Wader Studies Group (1998; later reproduced by Wohl 2006) defined five major flyway groupings (see Figure 1a).

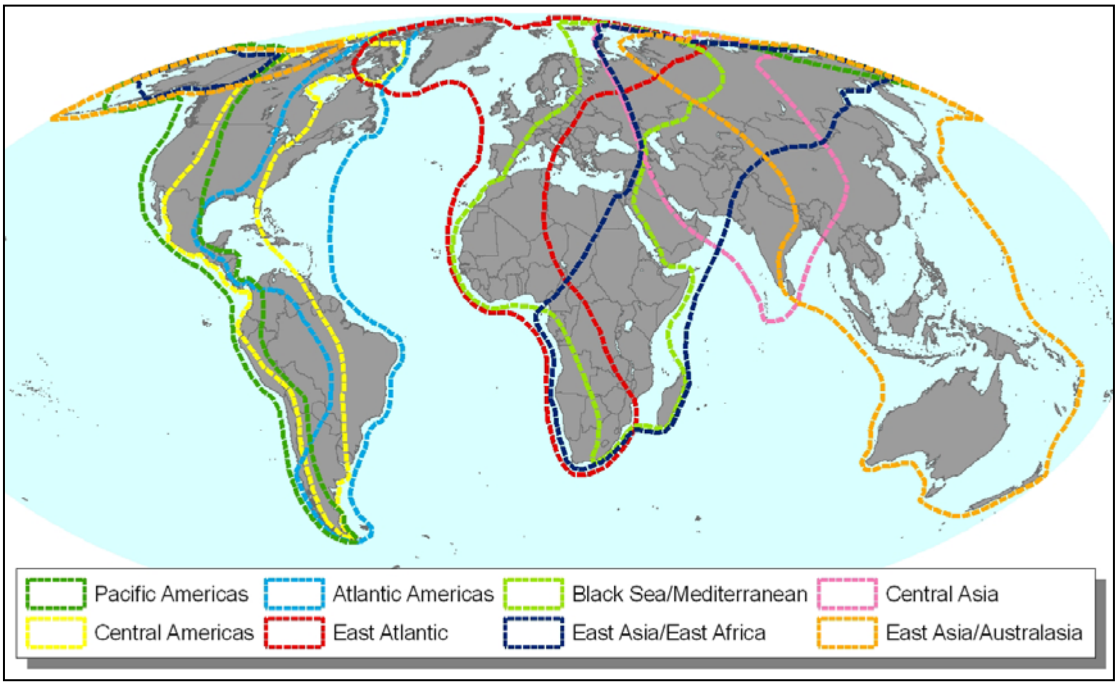
Figure 1a. Major global flyways for migratory shorebirds



Though useful, these flyway definitions do not reflect well the pelagic flyways used by the majority of migratory seabirds. Furthermore, well-known component flyways within each of the five major groupings are aggregated; for example those for Anatidae in North America, or the East Atlantic Flyway in Africa–Eurasia.

A finer breakdown, as portrayed in Figure 1b, involves the recognition of eight over-lapping flyways, which may prove useful for finer scale analyses of bird migration knowledge and conservation initiatives (BirdLife International, unpublished). This is the more detailed level of flyway definition that we have adopted for our review, although recognizing that even this does not portray the full complexity of flyways omitting, for example, intra-tropical flyways and those of pelagic seabirds.

Figure 1b. Major global flyways for migratory land and waterbirds



Notes The methodology used to assign species to the flyways is as follows:

a. they are considered fully migratory by BirdLife;
b. they undertake a regular biannual movement;
c. they move between a distinct breeding area and a distinct non-breeding area;
d. the direction of movement is essentially latitudinal (N-S):
e. all individuals in a population migrate in the same direction; and
f. they move a “substantial” (100s rather than 10s of km) distance along some portion of the flyway.

The limits of the flyways are broadly defined by the species that charaterise them and the names assigned reflect their geography. Species assigned to these flyways do not necessarily migrate between large-scale biogeographic realms (e.g. between the Palearctic and Sub-Saharan Africa; or between Asia and Australasia; or between the Nearctic and Neotropic). For example, the East Atlantic Flyway includes not only trans-Saharan migrants, such as Barn Swallow and Common Cuckoo, but also Pink-footed Geese that migrate between Greenland and the UK (solely within Europe) and Damara Terns that migrate along the Atlantic coast between Southern Africa and West Africa (solely within Sub-Saharan Africa). It could be argued that there are few similarities in migratory behaviour to justify grouping these species together and that only migrants between Eurasia and Sub-Saharan Africa should be treated as belonging to a “global flyway”. This is certainly a debate worth having, however, it would be necessary to apply the same rationale to the flyways in Asia, Australasian and the Americas. In these regions, however, there are far fewer inter-continental migrants and the number of species in these flyways would be much reduced. The main benefit of this global flyways concept is as a tool that can focus attention on the conservation of long-distance migrants and help foster international cooperation between countries.

Sometimes, a high-level aggregation of flyways is also useful for applications where the finer detail is not needed. Three or four major flyway groupings have been recognized for this purpose, as indicated in Figures 1c (from Stroud *et al.* 2006) and 1d (from Birdlife: www.birdlife.org/flyways/index.html). The latter is the high-level and simplified global aggregation used for BirdLife International programmes (following country boundaries and with Russia divided into European, Central Asian and Asian regions). It should not be considered to portray the boundaries of flyways with any particular accuracy, but has proved useful in structuring elements of our review.

Figure 1c. Aggregation of flyways for migratory waterbirds following Stroud *et al.* (2006).

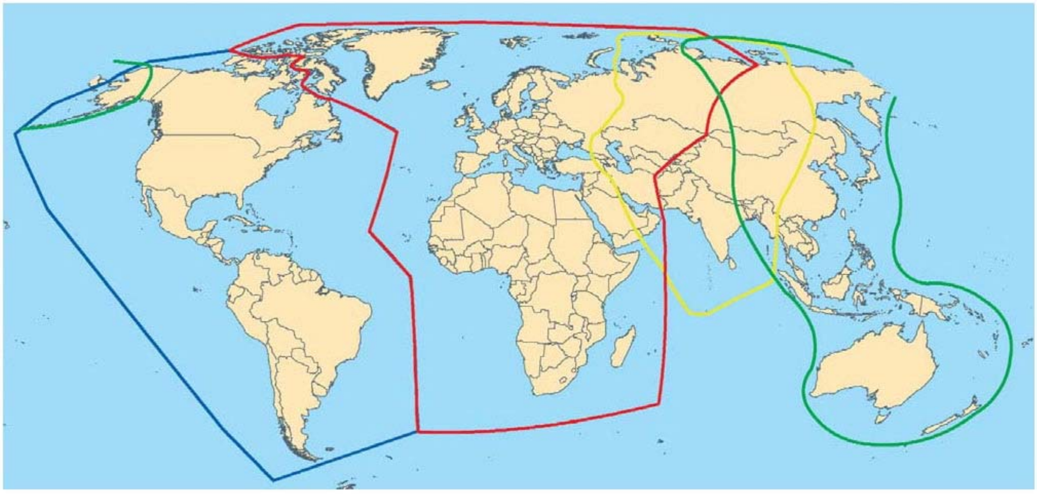
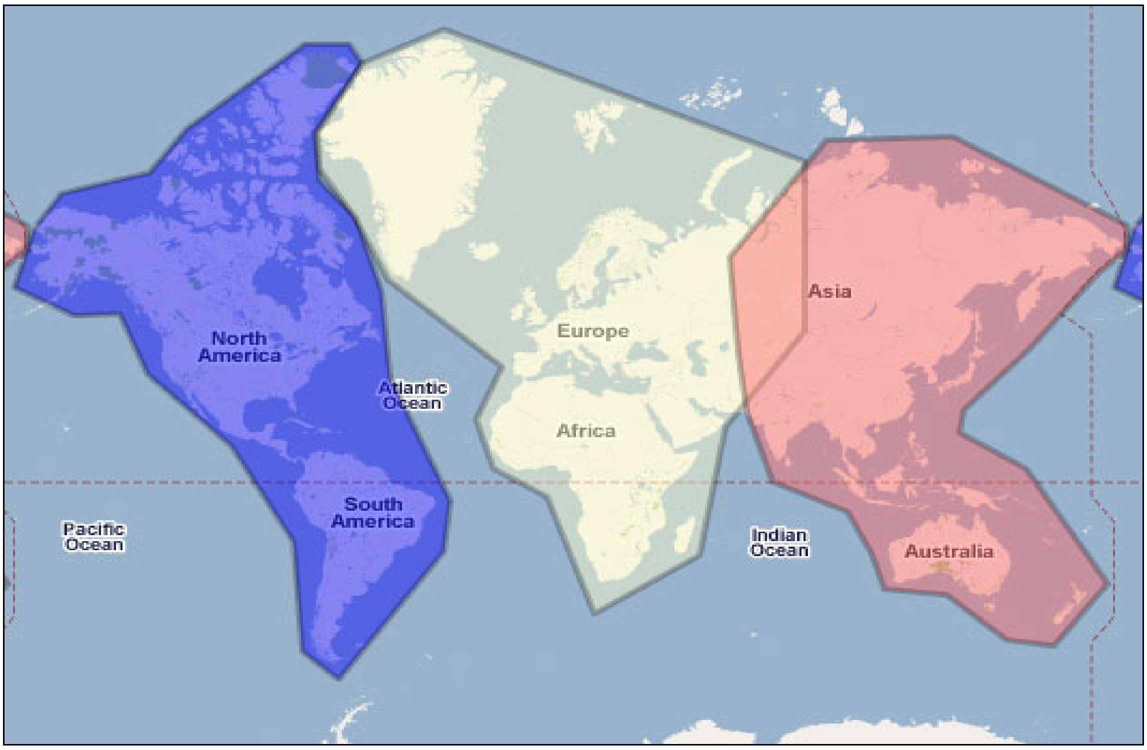


Figure 1d. Aggregation of global flyways for migratory birds following BirdLife International



Many publications and research papers provide flyway details for individual or groups of species, or for individual populations of species. Elphick (2007) has provided an excellent compilation and presents flyway details for different bird groups in all regions of the world. For waders in Africa and Western Eurasia, see also Delany *et al.* (2009). It should be remembered, however, that flyways are mere generalizations and there are many migratory species that do not necessary adhere to these flyway boundaries; each species essentially follows its own flyway, but nevertheless flyway definitions have proved crucial to organizing conservation action on an international scale (see also Boere and Dodman 2010).

Migratory techniques and critical sites

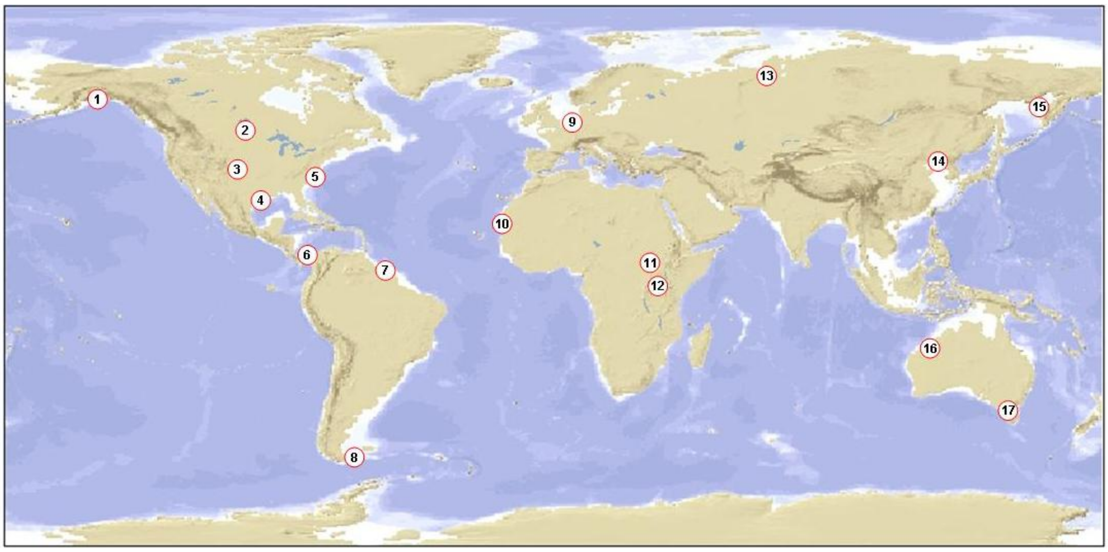
Sites and ecosystems within flyways provide migrating birds with the key resources they need, primarily with suitable habitat for feeding, resting or moulting (Kirby *et al.* 2008). 'Bottleneck' sites, discussed below, can be considered to be critical as these allow certain birds to pass from one region to another whilst on migration.

Birds that complete their migratory journeys non-stop are the exception rather than the rule. Most migrants have one or more staging posts or stop-over sites; somewhere to rest and replenish their fuel reserves (Elphick 2007). This varies amongst species and groups. For some species suitable habitats may be more or less continuous along the flyway; broad-front migrants including some landbirds may make short flights and move on a broad-front between closely-spaced patches of habitat in the landscape. However, where suitable habitat areas are more restricted and are widely spaced, the corridors of flight between these key sites are narrower and more easily recognizable as flyways. Thus, some staging posts are extensive and the birds not particularly concentrated or apparent to observers. On the other hand, some species gather in spectacular numbers in clearly defined areas. The location of a migration stopover for a species may differ in spring and autumn.

Soaring birds, including some waterbirds and birds of prey, tend to follow routes that provide good opportunities for soaring flight, even if not the most direct. Migratory soaring birds have great difficulty crossing large bodies of water, because in much of the world sufficiently strong thermals can only form over land. The birds must therefore follow routes that avoid long sea-crossings, by using land-bridges (often referred to as "bottlenecks") or by taking the shortest possible sea-crossings. Mountain ranges also cause funneling of soaring birds, in this case through the lowest available mountain passes. These constraints tend to mean that massive concentrations of soaring birds are dependent on a relatively small number of critical sites.

A few examples of staging areas where it is known that large numbers of migrants become concentrated are indicated in the map below (Figure 2, adapted from Elphick 2007). Not all migrants use easily defined stopovers. Examples include Reed Warbler *Acrocephalus scirpaceus* from western Europe, which become concentrated down the Portuguese coast in August/September; Blackpoll Warbler *Dendroica striata* from much of eastern Canada, which spend time in Massachusetts in the autumn; and Pied Flycatcher *Ficedula hypoleuca* from across western Europe into Asia, which are found in northwestern Iberia in the autumn (from Elphick 2007).

Figure 2. Examples of internationally important staging areas for congregatory migrants



Notes These are just a small number of the hundreds of sites known to support large concentrations of migrants 1. Copper River Delta, USA; 2. Delta Marsh, Canada; 3. Cheyenne Bottoms, USA; 4. Upper Texas Coast, USA; 5. Delaware Bay, USA; 6. Upper Bay of Panamá, Panamá; 7. French Guiana Coast, French Guiana; 8. Tierra del Fuego, Argentina; 9. Wadden Sea, Netherlands/Germany; 10. Banc d'Arguin National Park, Mauritania; 11. Sudd (Bahr-el-Jebel system), Sudan; 12. Lutembe Bay, Uganda; 13. Lover Ob', Russia; 14. Yellow Sea Region, including Yalu Jiang Estuary, China; 15. Moroshechnaya river, Russia; 16. Eighty Mile Beach, Australia; 17. Port Phillip Bay, Australia.

Various strategies are used by migrant birds to move between key sites. Piersma (1987) describes the “hop, skip and jump” migration strategies of shorebirds, whereby some fly relatively short distances every day/night with “hops” taking the birds from site-to-site along the migration route. These birds require closely interspersed habitats. Other species chose to “skip” or fly without stopping for great distances. In this scenario the habitats at each end of this migration are particularly important. The final group of migrants makes incredible flights that are truly a long-distance “jump”, sometimes from one hemisphere to another. After perhaps more than doubling in weight, these birds depart and fly non-stop, making truly amazing journeys in order to reach their final destination (e.g. Bar-tailed Godwit *Limosa lapponica* that fly from Alaska to New Zealand; 11000 km in 8 days non-stop; S. Delany *in litt*., see also Boere and Dodman 2010).

It is clear that appropriate stop-over sites are critical to the successful migration of many bird species, as well as rich feeding areas in departure and arrival locations. Recognition of this requirement has led to the concept of critical site networks, an approach to conservation that we will return to later within this review.

Flyway conservation

International collaboration is a key element in any strategy for migratory bird conservation. Various relevant policy mechanisms exist, but CMS is the key global treaty, with flyway-scale conservation being implicit within its policies and programmes. Another global treaty that exerts key influence on the conservation of migratory birds is the Convention on Wetlands (Ramsar Convention), whose signatories designate sites of international importance for waterbirds. BirdLife International's Important Bird Area programme is similarly important to the protection of key sites along migratory bird flyways worldwide.

At a regional level, other mechanisms exist that assist with flyway bird conservation globally. In Europe, the Convention on the Conservation of European Wildlife (the 'Bern Convention') has played a key role over many years, and the European Union's Birds Directive is an important instrument for the conservation of all bird species and the protection of key sites for migratory birds. The AEWA, developed under CMS, is an active programme of conservation action focused on waterbirds in Europe, the Middle East, Central Asia and Africa. For this region also, the BirdLife International/ UNDP/Global Environment Facility's (GEF) "Migratory Soaring Birds" project (http://www.birdlife.org/flyways/africa_eurasia/soaringbirds/index.html) places a focus on raptors, storks and other soaring bird species, and an MoU on the conservation of migratory birds of prey in Africa and Eurasia has recently been concluded under CMS (www.cms.int/species/raptors/index.htm).

In the Americas, there are several international collaborations that seek to safeguard the future for migratory birds, including the Western Hemisphere Migratory Species Initiative, the North American Waterfowl Management Plan, the North American Waterbird Conservation Plan, the North American Landbird Conservation Plan, Partners in Flight, Waterbird Conservation for the Americas and the Western Hemisphere Shorebird Reserve Network. Added to this is the North American Bird Conservation Initiative (NABCI), whose goal is to ensure that the combined effectiveness of these separate programs to far exceed the total of their parts (NABCI 2009, 2010). NABCI have developed a strategy for the conservation of North American birds.

In the Asia–Pacific region, the Asia–Pacific Migratory Waterbird Conservation Strategy has evolved to become the East Asian–Australasian Flyway Partnership (Mundkur 2006). The partnership has developed an implementation strategy and action plans under various working groups.

Strategies such as these provide an extremely useful basis for international collaboration, providing the framework for a whole series of important actions, including the definition and protection of site networks and action plans for migratory birds. Site networks themselves serve as a focus for site-based conservation efforts, including networking, training, awareness raising, research and sound management of key habitats and key sites, through international cooperation and resource mobilisation. An excellent example is the GEF AEWA 'Wings Over Wetlands' (WOW) project in the African–Eurasian region which is aiming 'to improve the conservation of African–Eurasian migratory waterbirds through implementing measures to conserve the critical network of sites that these birds require to complete their annual cycle, including stop-over sites during migration and in wintering grounds' (Zandri and Prentice 2009, Barnard *et al.* 2010, www.wingsoverwetlands.org). WOW has produced significant information to guide the conservation of migratory waterbirds through a comprehensive training kit (Boere and Dodman 1010, Dodman and Boere 2010), whilst a functional portal is being established for migratory waterbirds and critical sites (see further information below).

Status and trends

Included species

A total of 2,274 migratory species has been considered as part of this review (Annex 2 provides the data for globally threatened, near-threatened and data deficient species; a spreadsheet of all species and associated data is also available from BirdLife International). For convenience, this global list of species is sub-divided into four main groups—landbirds, waterbirds, seabirds and soaring birds. There is some overlap between these groups, for example for seabirds (e.g. cormorants, sea-ducks), which fall into both the seabird and waterbird groups, and for soaring birds which include a mixture of land- and waterbird species that migrate primarily by soaring-gliding flight.

Migratory landbirds (1,588 species in total) include species such as tyrant-flycatchers (116), buntings and New World sparrows (94), Old World warblers (126), birds of prey (144), chats and Old World flycatchers (88), pigeons and doves (71), swallows and martins (52), New World warblers (52) and cuckoos (49).

Migratory waterbirds (538 species) include many ducks, geese and swans (112), shorebirds (146), loons, grebes, flamingos, storks, ibises, spoonbills, bitterns, herons, egrets, pelicans, rails and cranes (172 species combined).

Migratory seabirds (260 species) include species such as penguins (10), albatrosses, storm-petrels, petrels and shearwaters (112), gulls and terns (81) and seaducks (15).

The soaring bird category (157 species) includes many birds of prey such as eagles and hawks, but also some waterbirds, including storks, spoonbills and pelicans. These broad-winged migratory birds cannot maintain active flapping flight over long distances and rely on columns of rising hot air (thermals) to enable them to migrate by a more passive soar-and-glide method.

Global status and trends

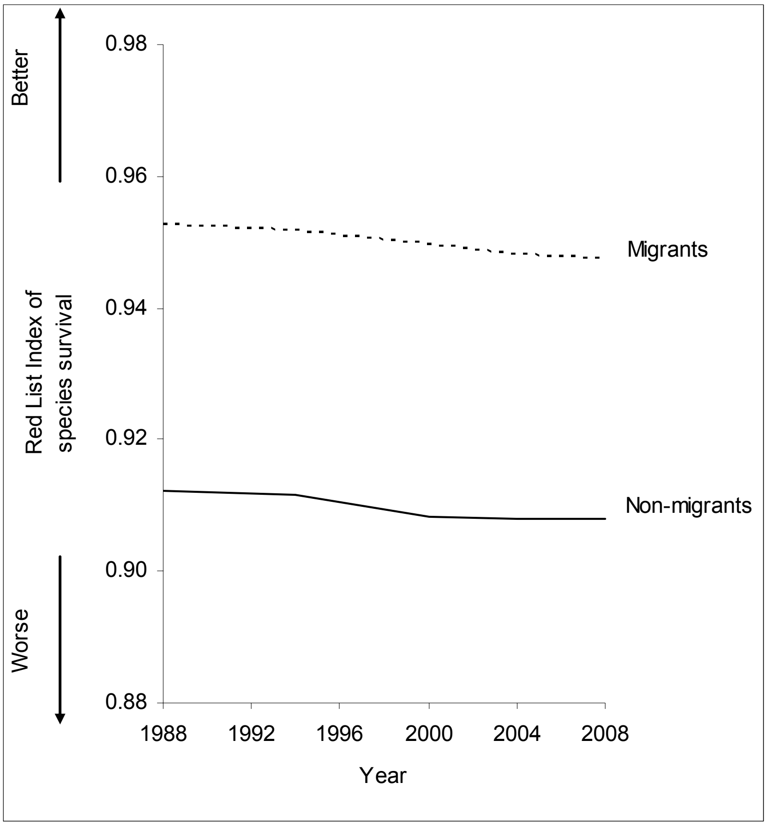
Insights into the global status of the included migratory species can be gained from BirdLife International's assessments of the extinction risk of bird species on the IUCN Red List. In 2010, of the 2,274 migrants included here, 317 (14%) were considered threatened or near-threatened (17 Critically Endangered, 50 Endangered, 128 Vulnerable, and 122 Near Threatened; see Annex 2). It should be noted that the extinction risk of different sub-species and populations may vary within a species, which is important in the context of CMS, but this information is not available.

Trends in extinction risk can be examined by analysis of the number of species moving between Red List categories as a result of genuine deterioration or improvement in status (Butchart *et al*. 2004, 2007). Red List Indices (which illustrate net change in overall extinction risk of sets of species) for migratory species (see Figure 3) shows that, since 1988, 53 species have deteriorated in status while only nine species have improved (67 genuine category changes overall, see Annex 4: IUCN Red List Index for more details of methodology and Annex 2 for details of species).

Migrants appear to be less threatened on average than non-migrants (14% threatened or near-threatened compared to 23% for non-migrants; see also Figure 3). This may be because overall migratory species tend to have larger ranges (and hence populations) than non-migratory species, as many breed at high northern hemisphere latitudes and there is a general trend of declining median range area from high northern latitudes to high southern ones (Orme *et al*. 2006). Thus they are most likely to qualify as threatened on account of population declines alone (with species requiring declines of at least 30% over 10 years or three generations in order to qualify as Vulnerable under IUCN Red List criterion A). Conversely many non-migrant threatened species are from islands or have limited distributions, where small populations and ranges, specialisation and limited habitat render them especially susceptible to declines as a result of human impacts (thereby qualifying as Vulnerable under IUCN Red List criteria A, B, C and D).

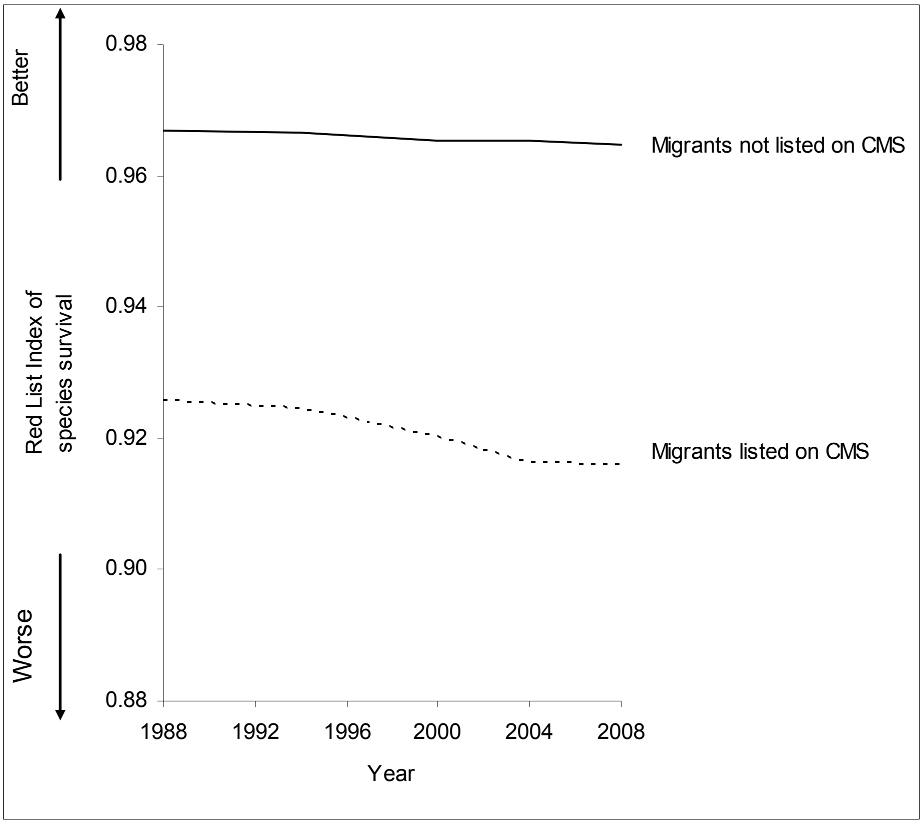
Migrants listed on the CMS appendices and its associated instruments are more threatened on average than those not listed (21% compared to 10%) and appear to be deteriorating faster in status. This is to be expected as these species have been identified as deserving of specific attention. However, it would seem that such listing has not turned their fortunes around yet as the Red List Index for this set of species shows an overall increase in extinction risk since 1988 (see Figure 4), with 34 species having deteriorated in status and only 5 species having improved.

Figure 3. The Red List Index of species survival for migratory species and non-migratory species



Notes For migrants, n=2,263 (excluding eight Data Deficient species and one species classified as Critically Endangered Possibly Extinct in 1988); for non-migrants, n=7,563 (excluding 54 Data Deficient, 130 Extinct and six Critically Endangered Possibly Extinct species in 1988). An RLI value of 1.0 equates to all species being categorised as Least Concern, and indicates that no species is expected to go extinct in the near future; an RLI value of zero indicates that all species have gone extinct (see Annex 4).

Figure 4. The Red List Index of species survival for migratory species listed and not-listed on CMS



Notes For migrants listed on CMS, n=796 (excluding one Data Deficient species and one species classified as Critically Endangered Possibly Extinct in 1988); for migrants not listed on CMS, n=1,467 (excluding seven Data Deficient species in 1988),. An RLI value of 1.0 equates to all species being categorised as Least Concern, and indicates that no species is expected to go extinct in the near future; an RLI value of zero indicates that all species have gone extinct (see Annex 4).

It is also possible to examine the global trends of waterbirds (irrespective of IUCN Red List category changes) owing to the regular status reviews coordinated by Wetlands International and published in the Waterbird Population Estimates series. According to Delany and Scott (2006), 40% of populations for which trend data are available at the global level are decreasing, 34% are stable, and only 17% are increasing (note, however, that although the majority of waterbirds included in these figures are migratory, separate figures are not available for just the migratory populations). A further 52 populations (4%) have already become extinct. These figures are similar to those obtained from an analysis of the global trend data (for the migrants considered in this review) held in BirdLife's World Bird Database: 39% of species for which trend data are available are decreasing, 44% are stable, and just 15% are increasing.

Regional status and trends

The numbers of migratory species can be summarised according to region and country (see Table 2 and Annex 1). All regions are important. However, the Americas and Asian regions stand out with more than 1,000 species each.

The countries with the highest numbers (>400) of migratory species (with regular native occurrence when breeding, non-breeding or on passage) include: Canada and the USA in North America; Mexico in Central America; Colombia, Peru, Brazil, Argentina in South America; and Myanmar, Thailand, Vietnam, China, Asian Russia, Pakistan, Nepal, and India in Asia.

An overview of regional status of the included migratory species can be gained from IUCN Red List categorisation. Some regional differences are apparent, notably with the East Asia–Australasia region having the highest proportion of threatened migratory waterbirds (20%); Africa–Eurasia, Central Asia and East Asia–Australasia having the highest proportions of threatened soaring birds (c.30% each); and the Americas, Africa–Eurasia and East Asia–Australasia the highest proportions of threatened seabirds (c.30%) (see Table 2).

Table 2. Numbers and percentages of threatened and near-threatened migratory species by type and region

Broad regions	Landbirds	Waterbirds	Soaring birds	Seabirds	TOTAL
Americas	63/716[1] 9%[2]	31/297 10%	3/49 6%	58/198 29%	**142/1,129** **13%**
Africa–Eurasia	35/460 8%	40/269 15%	23/82 27%	39/152 26%	**104/809** **13%**
Central Asia	19/326 6%	21/154 14%	13/49 27%	2/40 5%	**40/484** **8%**
East Asia–Australasia	65/756 9%	56/281 20%	26/85 31%	53/173 31%	**167/1,142** **15%**

Notes The sum of the totals by region or type exceeds the total number of migratory species (2,274) because some species occur in more than one region, soaring birds are not exclusive of landbirds or waterbirds, and seabirds are not exclusive of waterbirds. [1] Number of threatened and near-threatened migratory species / total number of migratory species occurring in the region. [2] Percentage of the total number of migratory species occurring in the region that is threatened or near-threatened.

The numbers of migratory species can also be summarised according to flyways, showing the importance of all the major global flyways (see Table 3). Some differences are apparent, notably with the East Asia–Australasia flyway having the highest proportion of threatened migratory waterbirds (19%), and the Black Sea–

Mediterranean, East Asia–East Africa, Central Asia and East Asia–Australasia flyways having the highest proportions of threatened soaring birds (24–34%).

Table 3. Numbers and percentages of threatened and near-threatened migratory species by type and flyway

Flyway	Landbirds	Waterbirds	Soaring birds	Seabirds	TOTAL
Pacific Americas	4/191[1] 2%[2]	5/128 4%	1/20 5%	4/49 8%	**9/319** **3%**
Central Americas	17/286 6%	6/92 7%	1/30 3%	0/15 0%	**23/378** **6%**
Atlantic Americas	17/253 7%	6/138 4%	0/26 0%	1/42 2%	**23/391** **6%**
East Atlantic	6/172 3%	11/126 9%	3/28 11%	4/42 10%	**17/298** **6%**
Black Sea–Mediterranean	13/194 7%	10/108 9%	9/37 24%	0/25 0%	**23/302** **8%**
East Asia–East Africa	19/208 9%	14/124 11%	12/42 29%	0/25 0%	**33/332** **10%**
Central Asia	17/199 9%	13/108 12%	11/37 30%	0/16 0%	**30/307** **10%**
East Asia–Australasia	27/293 9%	34/178 19%	15/44 34%	5/45 11%	**61/471** **13%**

Notes Only species assigned to these flyways (1,276) have been included in this analysis. The sum of the totals by flyway or type exceeds the total number of migratory species assigned because some species occur in more than one flyway, soaring birds are not exclusive of landbirds or waterbirds, and seabirds are not exclusive of waterbirds. [1] Number of threatened and near-threatened migratory species / total number of migratory species occurring in the flyway. [2] Percentage of the total number of migratory species occurring in the flyway that is threatened or near-threatened.

Regional status in the America flyways

In North America, declines have been reported for landbirds from studies of individual species, geographical areas and migration sites, and from the results of continent-wide monitoring. For example, Robbins *et al*. (1989), Sauer and Droege (1992) and Peterjohn *et al*. (1995) have documented pronounced declines in Nearctic–Neotropical migrants in eastern North America during the late 1970s and 1980s, more so than in resident birds and exceeding those documented in both central and western regions of the continent. More recent analyses suggest that these declines have continued and spread in geographical extent. During 1980–2005, 62% of Nearctic–Neotropical migrants in the eastern Breeding Bird Survey (BBS) region showed negative population trends, while in the western BBS region, an area not previously recognized for its dwindling migrant populations, 65% were categorized as declining (Sauer *et al*. 2005).

By contrast, the upward trend for wetland birds in the U.S. is described as a testament to the amazing resilience of bird populations where the health of their habitat is sustained or restored (NABCI 2009). The overwhelming success of waterfowl management, coordinated continentally among Canada, the United States, and Mexico, can serve as a model for conservation in other habitats (although expanded populations can cause problems for mankind, e.g. goose impacts on agriculture).

According to a 2009 status report for the birds of the U.S. (NABCI 2009), other bird groups are not faring so well with at least 39% of the U.S. birds restricted to ocean habitats declining and dramatic declines in grassland and aridland birds signalling alarming neglect and degradation of these habitats. For shorebirds, half of all coastally migrating species have declined; for example, Red Knot *Calidris canutus* has declined by an alarming 82%. Because of their relatively small and highly threatened global populations, shorebirds are of high conservation concern (NABCI 2009).

Although not studied to the same extent as birds within the U.S., research in South America has also documented migrant bird declines. Stotz *et al*. (1996) identified 68 species to be of conservation concern in the short to medium term. At particular risk was a group of species—typified by several species of seedeater *Sporophila* spp.—that rely on grassland habitats in southern South America.

Regional status in African–Eurasian flyways

Declines in migratory landbirds are not only evident from the Americas. Continent-wide analysis of the trends of European breeding birds showed that, during 1970–2000, populations of Palearctic–African migrant birds have undergone a pattern of sustained, often severe, decline (Sanderson *et al.* 2006). Interestingly, the trends of intercontinental migrants were significantly more negative than those of short-distance migrants or residents, with 48 (40%) of 119 exhibiting substantial negative population trends. These negative trends appeared to be largely, although not entirely, restricted to species spending the northern winter in dry, open habitats in Africa. Analyses of trends of 30 closely related pairs of species, one a long-distance migrant and the other not, indicated significantly more negative trends in the former, irrespective of breeding habitat, suggesting that migrant birds were in trouble.

Delany *et al.* (2007) reviewed the status of waterbirds covered by the AEWA specifically and considered that, overall, the trend status of waterbirds in the Agreement area worsened between 1999 and 2006. However, this was mainly because of a decrease in the proportion of known populations estimated to be increasing, from 25% in 1999 to 22% in 2006; the proportion estimated to be decreasing stayed at about the same level, 41–42%.

Red List change analyses like the ones applied globally above can be applied to different regions of the world and to particular sub-sets of species. In 2008, of 234 species listed by the AEWA, 26 were listed by BirdLife International on the IUCN Red List as globally threatened and 16 as Near Threatened. Between 1988 and 2008, there were genuine changes in the Red List status of 11 AEWA listed waterbird species; of these 10 species deteriorated in status sufficiently to qualify for a higher threat category (BirdLife International 2008b).

According to Goriup and Tucker (2007) at least 39 (51%) of 77 migratory raptor species in Africa and Eurasia are globally threatened, near-threatened or declining. In Europe, a particularly high proportion (62%) of raptor species has an unfavourable conservation status (see Table 4). Furthermore, analysis of their population trends indicated that nearly a third are declining rapidly (i.e. by more than 1% per annum) and 21% have suffered large declines averaging over 3% per year in the last 10 years. Through similar analysis of one major migration route in the region, the Rift Valley–Red Sea Flyway, Tucker (2005) found that 27 (69%) of 39 soaring birds assessed had an unfavourable conservation status. Generally, however, there is little accurate knowledge about the status of breeding and non-breeding raptor populations in Africa–Eurasia, so declines may well be overlooked.

Table 4. The status of breeding populations of migratory raptors in Europe, Asia, the Middle East and Africa (adapted from Goriup and Tucker 2007)

Conservation Status[1]	Europe[2]	Asia[3]	Middle East	Africa
Unfavourable	18	9	1	4
Unfavourable (uncertain)[4]	11	5	1	2
Total unfavourable	**29**	**14**	**2**	**6**
Favourable	8	4	0	0
Favourable (uncertain)	10	9	4	8
Unknown	0	34	11	17
Total number migratory raptor spp.	**47**	**61**	**17**	**31**

Notes [1] Conservation status is defined in accordance with CMS Article 1(c) and includes populations that are small and non-marginal, declining more than moderately (i.e. >1% per year), depleted following earlier declines, or are highly localised. [2] Based on Birds in Europe (BirdLife International 2004a). [3] Excluding countries in the Middle East. [4] Defined for Europe as species that have a provisional European Threat Status and are not globally threatened.

The general status of intra-African migrants is not well known, and in need of assessment.

Regional status in East Asian–Australasian flyways

The status of migratory birds in this region has not yet been the focus of detailed, continental analysis, as for the Nearctic and Palearctic migrants. However, South-

East Asia, which is a major non-breeding area for migrants from eastern Asia, is affected by extensive deforestation, so declines in Asian landbirds, many of which gather in subtropical and tropical forests, may reasonably be expected. For example, Wells (2007) cites recent historical loss of more than 90% of the Thai–Malay Peninsula's mangroves and at least 80% of lowland inland forest. He notes that, at this regional scale, mangrove specialist birds only rarely have a status more favourable than Near-Threatened, and species within well-structured forest below 150m are all classified as Endangered.

In Japan, Amano and Yamaura (2007) used distributional data for breeding birds (from 1978 and 1998–2002) to reveal that species with certain traits (of which long-distance migration was one) have indeed experienced severe range contractions.

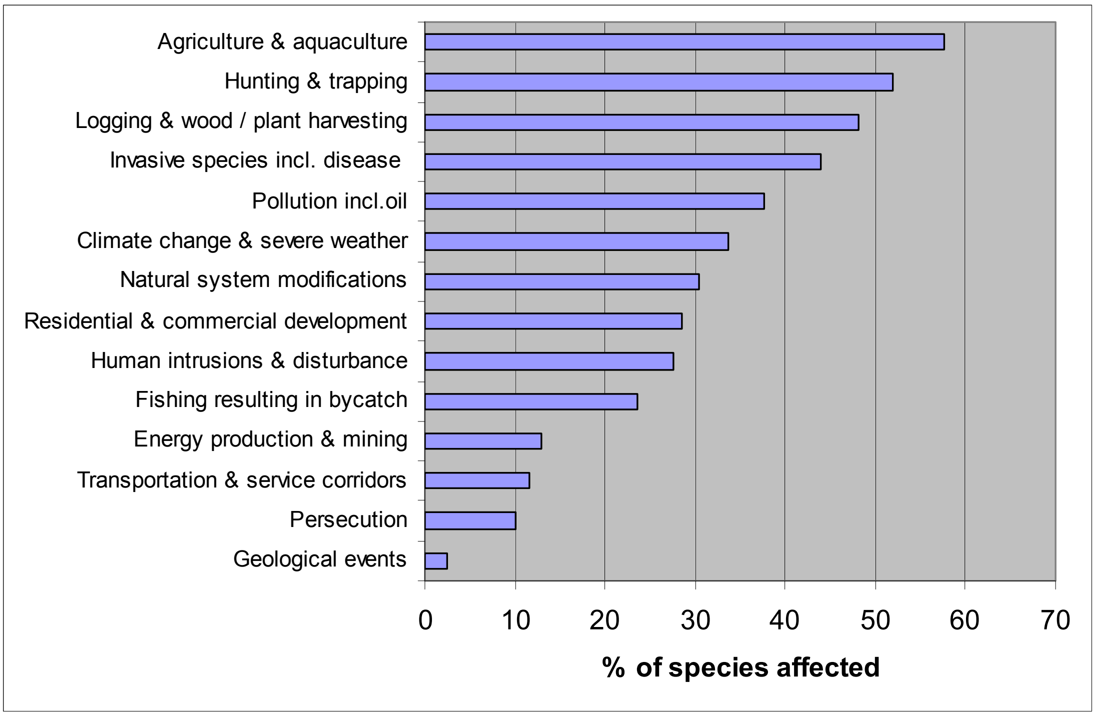
In addition, Asia is the continent of greatest concern with respect to waterbird trends. Delany and Scott (2006) found that 62% of waterbird populations with known trends were decreasing or have become extinct and only 10% show an increasing trend. Results from twenty years of waterbird monitoring in Asia (1987–2007) have recently been published (Li *et al.* 2009). For the first time using rigorous statistical methods, this analysis indicates that four of the eight most numerous dabbling duck species in East Asia are declining. Of these, the species identified to be in strongest decline in East Asia is Mallard *Anas platyrhynchos*, decreasing by around 10% per year over the past ten years. Furthermore, example trend graphs indicate Northern Pintail *Anas acuta*, Common Teal *Anas crecca* and Spot-billed Duck *Anas poecilorhyncha* decreased around 1% per year between 1998 and 2007. The news is not all bad, however. Baikal Teal *Anas formosa* and Black-faced Spoonbill *Platalea minor* in East Asia have increased over the monitored period.

There is concern that migratory shorebird populations that visit Australia may be declining as a result of extensive intertidal reclamation in the Yellow Sea Region (R. Jaensch and P. O'Neill *in litt*.). A review of questionnaire responses from raptor specialists on the status of migratory raptors in central, southern and eastern Asia (Goriup and Tucker 2007) indicated that 17 (33%) of the 51 migratory raptors considered currently exhibit an unfavourable conservation status, although the status of many species is uncertain.

Key threats

Analysis of the main threats to migratory species evaluated as threatened and near-threatened on the 2010 IUCN Red List (see Figure 5, also Annex 4: threat analysis) shows that the two key pressures come agricultural activities (affecting 60%) resulting in detrimental land-use changes and from hunting and trapping (affecting 50%). Other important threats include the impacts of logging resulting in deforestation, invasive and non-native species (including emerging diseases), pollution especially in the marine environment, climate change and severe weather, natural system modifications (owing to, e.g., dams, wetland drainage, modification of tidal regimes), residential and commercial development (causing habitat loss and mortality owing to artificial structures), human disturbance, fishing resulting in bycatch (of seabirds), energy production (e.g. wind turbines), service corridors (especially power lines) and persecution.

Figure 5. Main threats to threatened and near-threatened migratory bird species



Notes Categories of threat follow Salafsky *et al*. (2008).

These threats are common to birds generally, whether considered globally threatened or not. For example, Tucker and Goriup (2005, updated in Goriup and Tucker 2007) found that the main threats to raptors in Africa and Eurasia with an unfavourable conservation status are those causing habitat loss and degradation (see Table 5). Other threats include shooting (especially in the Mediterranean basin, for sport and trophies), poisoning, electrocution by power lines, deliberate persecution and disturbance during the breeding period. Collisions with wind turbines may become a significant problem, and many existing threats are likely to be exacerbated by climate change.

Many of these threats to birds have been highlighted for a long time (see, e.g. Biber and Salathé 1991), but the scale and intensity of pressures on birds have surely increased as economies and human populations have grown. Some of these threats— including that from climate change—are explored further in the following sections, concentrating especially on threats of particular relevance to migratory birds.

Table 5. Summary of threats to migratory raptors in Africa and Eurasia that have an Unfavourable Conservation Status[1] (adapted from Goriup and Tucker 2007)

Key Magnitude of impacts: **L**ow = unlikely to cause detectable population impacts in most species; **M**oderate = likely to cause local population impacts in most species, or population declines in some species; **H**igh = likely to cause population declines in most species. Blank = threat currently unknown in region.

Threat types	Number spp. impacted		Magnitude of impacts[2]			
	Breeding	Non-breeding	Europe	Asia[3]	Middle East	Africa
Habitat Loss/Degradation						
• Loss to agriculture and agricultural intensification	28	12	H	H	M?	H
• Abandonment	10	1	M	M	?	-
• Over-grazing	5	5	L	M?	M?	H?
• Forest loss and management	9	1	M	M	L	M
• Afforestation	12	0	M	-	-	-
• Wetland loss and degradation	13	4	M	H	H	M
• Burning / fire	6	2	M	L	-	M
• Development	6	0	M	M	M	-
Taking of birds (harvesting / hunting)						
• Trade (collections, falconry)	8	8	L	M	M	L
• Egg-collection	7	0	L	L	L	-
• Shooting and trapping	6	17	M	L?	H	L
Accidental mortality[4]						
• Collision with man-made structures	3	3	L	L	L	L
• Electrocution on power lines	11	0	M	H	L	L
• Poisoning (e.g. by baits for other species)	12	14	L	M	M	L (H in parts)
• Nest destruction	0	0	L	L	-	L
Persecution						
• Persecution	22	4	L	M	M	L
Pollution						
• Land pollution[5]	3	1	L	L	L	-
• Water pollution[5]	5	5	L	M	L	L
• Toxic pesticides	17	13	L	M?	M?	M?
Disturbance						
• Disturbance (human)	21	2	H	L	M	M

Threat types	Number spp. impacted		Magnitude of impacts[2]			
	Breeding	Non-breeding	Europe	Asia[3]	Middle East	Africa
Other						
• Other	7	5				

Notes [1] Conservation status is defined in accordance with CMS Article 1(c). [2] The magnitude of the impact is based on a subjective assessment for the next 10 years, taking into account each threat's average extent, severity and predicted trends across all African-Eurasian migratory raptor species (see Goriup and Tucker 2007, Table 7 for details). [3] Excluding countries in the Middle East. [4] Individuals are killed accidentally (but see Pollution where this may also be the case) rather than intentionally (see Hunting, Persecution).[5] Land/water pollution does not include pesticides, which are coded separately.

Land-use pressures

Delany and Scott (2006) cited land-use changes and resulting habitat destruction as the most frequent known cause of population decrease in waterbirds, highlighting concerns in Asia where the "…frantic pace of economic development is clearly having adverse impacts on the environment, including numbers and population trends of waterbirds". This was further emphasized by Stroud *et al.* (2006), reviewing the conservation status of wading birds in the East Asian–Australasian flyway, noting the enormous pressures in the region, which contains perhaps 45% of the world's human population as well as some of the world's fastest-growing economies. Consequences include over 80% of wetlands in East and South-East Asia classified as threatened, with more than half under serious threat. In South Korea, 43% of inter-tidal wetlands have been destroyed by land reclamation (with more underway), while in China the figure is 37%. Li *et al.* (2009) considered rapid and poorly-planned human development leading to a lack of adequate official conservation of their important wetland sites to be key reasons for declining waterbird numbers in Asia, with wetland reclamation being the most destructive cumulative threat to the wetlands and their use by waterbirds. Reclamation is perhaps not always detrimental to waterbirds—some wintering populations of cranes and Anatidae can benefit by an increase in safe refuges (reservoirs/lakes created as water storages for new ricefields) and increasing food supplies (fallen rice grains in dry fields) (R. Jaensch *in litt.*).

As noted above, habitat loss and degradation is a widespread threat to migratory raptors in Africa and Eurasia. This is mainly as a result of agricultural expansion and intensification, which is widespread in developing regions and continues in more developed countries. Overgrazing (which reduces prey populations) is also a major problem in many parts of Africa, and probably Asia and the Middle East, although quantified data on actual impacts are lacking. In fact, whilst many apparent pressures were identified, Goriup and Tucker (2007) were unable to attribute population declines in migratory raptors to impacts encountered specifically during migration, as opposed to impacts on the breeding or non-breeding areas.

In Europe, the decline in birds breeding on farmland from about 1970 onwards is well documented and largely attributable to agricultural intensification on that continent (e.g. Pain and Pienkowski 1997, Donald *et al.* 2001). Sanderson *et al.* (2006), however, concluded that agricultural impacts on the breeding grounds were unlikely to be the sole cause of declines in Palearctic migrants. Instead, the negative trends they documented appeared to be largely driven by declines in species spending the northern winter in dry, open habitats in Africa. Newton (2004) also noted that declines in Palearctic–African migrants have mainly involved species that spend the northern winter in, or pass through, the semi-arid savannas of tropical Africa, which have suffered from the effects of drought and increasing desertification. In addition to climate change, Newton (2004) highlighted the importance of factors such as overgrazing, burning, woodcutting, drainage of wetlands and pesticide use which reduce the quantity and quality of habitats available to migrant birds during the non-breeding season.

In North America, numerical declines in migrant landbirds have affected many forest species. For Neotropical migrants at least, forest fragmentation in breeding areas has been shown to be important in contributing to the declines of these birds (Robbins *et al*. 1989, Terborgh 1989, Newton 2008, Ewing *et al*. 2008). Tropical deforestation in the non-breeding areas of Central America and on the Caribbean islands may also be important, but Ewing *et al*. (2008) found insufficient evidence to make a general case for migrant bird populations being currently limited by non-breeding habitat quantity and/or quality.

According to NABCI (2009), dramatic declines in grassland and aridland birds in North America signal alarming neglect and degradation of these habitats. Incentives for wildlife-compatible agricultural practices in grasslands and increased protection of fragile desert, sagebrush, and chaparral ecosystems are urgently needed to reverse these declines.

Although forest birds have fared better overall than birds in other habitats in North America, many species have suffered steep declines and remain threatened by unplanned and sprawling urban development, unsustainable logging, increased severity of wildfires, and a barrage of exotic forest pests and diseases (NABCI 2009). At least 39% of the U.S. birds restricted to ocean habitats are also declining. These birds face threats from pollution, over-fishing, and warming sea temperatures caused by climate change, as well as threats at island and coastal nesting sites.

Habitat destruction and degradation at special sites

Newton (2004) noted that population sizes might be limited by severe competition at restricted stop-over sites, where bird densities are often high and food supplies heavily depleted. To date, the evidence for population regulation through factors at migration sites is limited, but at least one study has demonstrated that it may be very significant. This concerns the Red Knot *Calidris canutus rufa* subspecies that migrates annually between the Canadian Arctic and Tierra del Fuego. This population has undergone a drastic recent decline, from 100,000 individuals in 1989 to just 17,200 in 2006. Although the causes are not yet fully understood, the decline is mainly attributed to the low availability of Horseshoe Crab *Limulus polyphemus* eggs, a key food resource for Red Knot, in Delaware Bay, the final staging-post before the non-stop flight to its Arctic breeding grounds. The lack of eggs has been linked to an elevated harvest of adult crabs for bait in the conch and eel fishing industries (see, e.g., Baker *et al*. 2004, USFWS 2007). Within another flyway, the recent loss of one site, Saemangeum in north-east Asia, may prove equally catastrophic for Great Knot *Calidris tenuirostris*, although the trend there is still emerging (R. Jaensch *in litt*.).

Another species that has undergone a recent dramatic decline (of up to 70% since the 1970s) is Spoon-billed Sandpiper *Eurynorhynchus pygmeus* with just 350–380 pairs estimated to remain in 2005 (Zöckler and Bunting 2006), and not more than 150–320 pairs in 2008 (Zöckler and Syroechkovskiy, in prep.). It breeds on a small strip of coastal Arctic tundra in Chukotka, north-east Russia, and winters along coasts in South and South-East Asia, depending on the rich tidal coasts of the Yellow Sea for refueling. Habitat destruction along this flyway, notably recent massive land claim at the important staging area of Saemangeum in South Korea, has been listed as a contributory factor in the decline (see also Tomkovich *et al.* 2002).

Hunting and taking

Hunting

Hunting of wild birds takes place all over the world and for a variety of reasons including for subsistence and recreation. Hunting is often carried out sustainably and hunting communities may contribute to the conservation of migratory birds through, for example, habitat provision, positive habitat management and the control of mammalian predators.

The sheer scale of hunting activity is not fully known but Brouwer (2009) presents some recent annual migratory bird harvesting totals, from hunting for food and market as well as recreational hunting (Table 6).

These numbers, from countries in different part of the world, are enormous, and almost all concern migratory birds. For many countries, however, there are no estimates available.

Table 6. Some examples of annual bird harvests in various parts of the world (reproduced from Brouwer 2009). Note that reliable harvest data are scarce, hence also the lack of very recent information.

Country/region	Number of hunters	Type of hunting	Species hunted	Number of birds taken per year	Period
USA	1,600,000	1% subsistence	ducks	max 19,000,000	1998–2002
USA	1,000,000	3% subsistence	geese	3,500,000	1998–2002
Canada	~ 165 000	35% subsistence	ducks	1,960,000	2002
Canada	included above	35% subsistence	geese	1,380,000	2002
Siberia, spring hunting			geese	300,000	
Indonesia, Cirebon & Indramayu regencies		professional	63 species, mostly waterbirds	1,000,000	1979
Iran, Gilan province		professional	waterbirds	394,000	Nov 2001–Feb 2002
Denmark	165,000	recreational	waterbirds	700,000	2002
Mediterranean region (inc. Italy, France & Malta)		mostly recreational		500,000,000	2004–2007
Italy		mostly recreational	mostly passerines	100–150,000,000	
France		mostly recreational	mostly passerines	55,000,000	
Malta		mostly recreational	mostly passerines	4,000,000	
Malawi, Lake Chilwa	460	professional	waterbirds	1,200,000	1999
Mali, Inner Niger Delta		professional	waterbirds	2–400,000	early 1990s
Mali, Inner Niger Delta		professional	waterbirds	63,000 17,000	1999 2000
Nigeria, Cross River State			Barn Swallows	200,000	mid-1990s

Notes For information sources, see Brouwer (2009).

In Canada, about a third of the hunting activity is for subsistence purposes by indigenous people. In developing countries as well, most if not all of the harvesting is for subsistence or income purposes. Generally this is carried out by a limited number of specialist hunters, and only during a part of the year, but it provides animal protein to a much larger group of people.

Where hunting is mostly for recreational purposes, the number of hunters involved is much greater. In the USA there were in 2001 an estimated three million migratory bird hunters, taking mostly waterfowl and doves. Together these made 24 million hunting trips for a total of 29 million hunting days in 2001. In 1991, 22 million days had been spent hunting migratory birds, so there was a growth of 30% in ten years (USFWS 2002).

Hunting is significant activity in other parts of the world also. In Syria, it is estimated that there are 500,000 hunters. About 20,000 are estimated to do this for a living (BirdLife International 2008c). In Lebanon, it is estimated that more than 10% of the population of four million hunts (those 400,000 are much more than the 20,000 officially registered). By comparison, in Finland, 6% of the population hunts, in Ireland 3.4%, in Denmark 3% and in France 2.6%. The 10,000 hunters along the north coast of Egypt constitute more than 10% of the local population. Hunting is an important socio-economic activity in the Mediterranean region as a whole, particularly in rural areas: in total one half to one billion migratory birds are killed each year, some 10 million hunters are involved.

Illegal and poor hunting practices are a cause for concern because regulation is important to sustainability. In Syria, it is estimated that there are 200,000 illegal hunters (from 500,000), but that must not be taken as a guide for the other countries of the region. In the Mediterranean island state of Malta, a location central to important migratory routes in the African–Eurasian Flyway system, Raine (2007) revealed that at least 75 migratory species, from 35 countries, had been killed there, a high proportion being protected birds of prey (including Red-footed Falcon *Falco vespertinus* and Lesser Kestrel *F. naumanni*), and concluded that illegal hunting in Malta alone could have serious repercussions on the overall conservation status of many migratory species. The estimated four million birds killed annually in Malta consist of three million finches, half a million swallows and martins, half a million thrushes, 80,000 Eurasian Orioles *Oriolus oriolus*, 13,000 shearwaters, 1,000 Black-winged Stilts *Himantopus himantopus*, etc. (Collar *et al.* 2008).

For soaring birds that concentrate at bottleneck sites, hunting may result in high mortality, for example when birds are forced to fly low or come to ground because of bad weather (Porter 2005). Although there has been no systematic assessment of numbers of soaring birds killed at bottleneck sites in the Middle East and north-east Africa, Porter (2005) noted that hunting was common in at least four countries and was perceived as the most serious threat at seven (32%) of 22 bottleneck sites evaluated.

The hunting of birds of prey remains a significant threat in many areas of the African–Eurasian region (Tucker and Goriup 2005). Huge numbers of such birds have routinely been shot in many countries for sport and trophies, particularly in the Mediterranean region and parts of the Middle East (e.g. Baumgart *et al.* 1995, 2003; Bijlsma 1990, Giordano *et al.* 1998, Portelli 1994, van Maanen *et al*. 2001). There is little up-to-date information on current shooting levels on migration routes, and recent legislation and better enforcement may have reduced mortality rates; even so, and although population-level impacts are not currently measurable for any migratory raptor species, the numbers taken annually are probably sufficient to have significant impacts on some species, especially already threatened species with low reproductive rates (Tucker and Goriup 2007).

Many researchers have considered whether mortality from harvesting is compensatory (not causing extra deaths overall) or additive (Newton 1998). For waterbirds at least (reviewed by Kirby *et al.* 2004), when harvests exceed a critical threshold compensation does not appear possible and populations can be driven into decline (e.g. Lesser White-fronted Goose *Anser erythropus*).

Cases of bird populations responding positively to a reduced hunting pressure (e.g. Trumpeter Swan *Cygnus buccinator*, Canada Goose *Branta canadensis*) indicate that populations may well be maintained at lower than "normal" levels by hunting. That hunting can also have a positive effect is shown by Snow Goose *Anser caerulescens* in North America. Formerly, higher hunting may have compensated for man-made improvements in conditions on the wintering grounds, and kept numbers in check. More recently, a reduction in hunting pressure has led to such an increase in its numbers that its habitat in arctic breeding areas is suffering from overgrazing by too many Snow Geese.

In Western Europe, waterbird populations have responded positively to the establishment of refuges and stronger legal protection under a wider package of measures governed by the EC Wild Birds Directive. The reduction of harvesting that was the result of these measures will have positively contributed to these changes in numbers. Dalmatian Pelican *Pelecanus crispus* and White Pelican *P. onocrotalus* in Europe are recovering in response to good implementation of legal protection measures (Kirby *et al.* 2004).

Trade in wild birds

Trade in live wild birds is a significant activity that impacts on migratory birds as well. Many bird species are kept for their beauty or their song. In Senegal, it is thought that as many as 25 million birds may be taken and caged each year (Elphick 2007). Caging is common too in South-East Asia, with birds here also eaten and used in traditional medicine (Elphick 2007). In Asia as well there is an enormous trade in wild birds. Mostly they will be sedentary birds, but a certain percentage consists of migratory species (Brouwer 2009). Some species are specifically targeted for trade: Black Crowned Crane *Balearica pavonina* has been extirpated from parts of its range in West Africa largely due to local demand for live birds as pets, for body parts for use in traditional medicine and for the international live bird trade (Williams *et al.* 2003).

Falconry

Although the practice has been reduced, migratory falcons, eagles and other raptors, and their eggs, are still taken from the wild for falconry purposes. Not only migratory falcon species, but also a number of favourite falconer prey species, including some migratory large bustard species, are threatened by unsustainable falconry practices (Brouwer 2009). In addition, up to tens of thousands of smaller falcons are used as decoys to catch the more valuable ones, while large birds of prey that may disturb the catching are shot.

Harvesting and hunting of birds of prey (including egg collecting, chick collecting for falconry, and shooting) remain a significant threat in many areas of the African–

Eurasian region, despite being illegal in most places (Tucker and Goriup 2005). If the custom of falconry is to continue, it must be made sustainable, and both the raptors and their prey species need to be managed sustainably all along their flyways (BirdLife International 2008c, Collar *et al.* 2008). A Memorandum of Understanding for the Conservation of Eurasian–African Birds of Prey, developed under CMS and adopted in October 2008 in Abu Dhabi, has been agreed to help address such problems.

Disease and parasites

All species are exposed to disease but anthropogenic factors—including loss and/or degradation of habitat, pollution, over-harvesting, increased interface between wild and domestic/captive/human populations, intensive management of wildlife and global climate change—can disturb this balance and sometimes cause great mortality.

Botulism

Waterbirds in particular are prone to periodic outbreaks of infectious disease at sites where they congregate at any time of year. Such outbreaks have increased as a cause of mortality in wild waterbirds and significantly impact on some populations (e.g. Friend 2006; Kuiken *et al*. 2006; Rocke 2006a). A notorious source of mass mortality among migrant waterbirds is botulism, caused by a neurotoxin in the bacillus *Clostridium botulinum*. The occurrence of botulism is largely controlled by environmental factors and is not dependent on waterbird density, and thus this disease has the potential to cause significant population declines in some species, seriously impeding conservation efforts. Year-to-year losses from botulism are highly variable, but they can be substantial: 4–5 million waterfowl deaths were attributed to botulism in the western United States in 1952 (see Newton 2008). In 2002–2003, a botulism outbreak in Taiwan killed more than 5% (73 birds) of the world population of the globally threatened Black-faced Spoonbill *Platalea minor* (Yu 2003). In 1996, an outbreak at the Salton Sea, California, killed nearly 15% of the western population of American White Pelican *Pelecanus erythrorhynchos*. Rocke (2006b) indicates that, on a world-wide basis, avian botulism is the most significant disease of waterbirds.

Avian influenza

Avian influenza viruses are found in a wide range of bird species, especially aquatic ones, including ducks, geese, swans, waders and gulls, which act as a reservoir for the low pathogenic forms of the virus. These viruses live in balance with their natural hosts and do not normally cause population effects.

From 2005, however, there has been an emergence of a highly pathogenic avian influenza (HPAI) virus (H5N1) in South-East Asia and H5N1 has been detected in birds from other parts of the world thereafter: in the northern autumn and winter 2005–2006, 700 dead wild birds were recovered in 13 countries in Western Europe, including migratory birds such as Whooper Swans *Cygnus cygnus* (FAO 2006; see also FAO 2008).

Many wild birds die from HPAI H5N1 infection, resulting in localised waterbird die-offs, though susceptibility is species-specific (e.g. Brown *et al.* 2006, 2008). Some wild bird species are little affected, but can potentially transmit the virus along migratory routes, although it is unknown to what extent this actually happens. Some spread of the virus appears attributable to migratory bird movements, but the relative significance of different modes of spread is poorly understood at present (e.g. Kilpatrick *et al.* 2006, Gauthier-Clerc *et al.* 2007, UNEP/AEWA 2008, Fang *et al.* 2008, Newman *et al.* 2009, Prosser *et al.* 2009). HPAI H5N1 does appear to pose a threat to some migratory waterbird species that congregate at only a few specific sites, as shown by the loss of 10% of the world population of Bar-headed Goose *Anser indicus* on Qinghai Lake in China in 2005 (Liu *et al*. 2005). An international Scientific Task Force on Avian Influenza and Wild Birds has been established as a liaison mechanism between organisations knowledgeable about the relationship between wild birds and the disease (UNEP/AEWA 2008). The United Nation's Food and Agriculture Organisation (FAO) is also undertaking and facilitating a range of collaborative activities to study the epidemiology and ecology of HPAI H5N1 in wild birds and the migratory habits of these species (see www.fao.org/avianflu/en/wildlife/sat_telemetry.htm).

Threats from non-native species

Non-native animals and plants may impact on migratory birds in many ways, e.g. through predation, hybridization, competition, impacts on habitats or food resources. A number of excellent reviews of the effects of non-native species on native species are available (e.g. Eno 1997, Lowe *et al.* 2000, Barnard and Waage 2004, Hill *et al.* 2005, Mooney *et al.* 2005, Banks *et al.* 2008, Dodman and Boere 2010).

Non-native birds

Non-native bird species may impact on native bird species through hybridization and competition for resources. Banks *et al.* (2008) reviewed the status and potential impacts of non-native introduced waterbirds in countries falling within the African–Eurasian Waterbird Agreement (AEWA) area.

Twenty-seven introduced species had been recorded to breed between one and five times in the AEWA region during the past 20 years, or breeding had been suspected but not confirmed. A further 45 waterbird species had been introduced but were not thought to have bred in the AEWA area.

Hybridization with native species was recorded or suspected for 18 introduced species, but for most of these species hybridization is rare. Two species that have hybridized regularly with native species, and therefore give the greatest cause for concern with respect to hybridization, are Mallard *Anas platyrhynchos* (which produces hybrids with several native species including Yellow-billed Duck *Anas undulata* and the globally threatened Meller's Duck *Anas melleri*) and Ruddy Duck *Oxyura jamaicensis* (which has hybridized with the globally threatened White-headed Duck *Oxyura leucocephala* in Spain).

A range of potential problems for native species, caused by introduced waterbirds, were either known to occur or suspected to occur. Competitive exclusion of and/or aggression towards native species was reported for thirteen introduced waterbird species, with some reports of extreme aggression leading to native species being killed by territorial introduced waterbirds. Seven introduced species were thought to cause eutrophication of waterbodies, although usually on a local scale. Six introduced species caused damage to natural or semi-natural habitats, either by grazing or trampling, and three species caused damage to man-made habitats or crops. One species (Sacred Ibis *Threskiornis aethiopicus*) was reported to predate the eggs or young of native species.

In most cases, the magnitude and importance of the effects of introduced waterbirds on native species and habitats has not been well studied, and therefore little is known about how introduced species may affect the population trends and distribution of native species (see also Dodman and Boere 2010).

<u>Non-native animals</u>

The introductions of other non-native animals can also impact waterbirds. A good example is the introduction of the highly predatory non-native fish, the Asian Snakehead *Channa* cf. *striata*, to Madagascar, which has spread to infest all Madagascar's major lakes (Sparks and Stiassny 2003). This fish has been strongly implicated in the marked decline of grebes on which it is suspected as being an efficient predator, at Lac Alaotra, even contributing to the extinction of the Alaotra Little Grebe *Tachybaptus rufolavatus* (Mutschler 2003).

Many seabird colonies and breeding waterbirds have also been impacted by non-native predators, which feed on bird's eggs and chicks. The most common non-native predators are rats, mice and feral cats. Island nesting birds, particularly seabirds, are very vulnerable since they mostly nest on the ground or in burrows and are easily predated by rats, foxes, cats, dogs, and mongooses (NABCI 2009).

The presence of predators, especially mammals, may have a profound impact on seabird populations and distributions by precluding species from using otherwise suitable breeding sites. Where non-native predators have been introduced, often due to human activities, then local extinctions have often resulted (Atkinson 1985). In Europe, probably the single most serious seabird conservation problem concerns the predation by rats and cats on Zino's petrel *Pterodroma madeira* on Madeira, which threatens to drive this species extinct (Zino *et al.* 1996). Over most of the rest of Europe, rats and American mink *Mustela vison* may cause the most serious problems, and for many Mediterranean seabirds, rat predation may limit populations (references in Tucker and Evans 1997).

One bird that has suffered from non-native predators is the Tristan Albatross *Diomedea dabbenena* of the Tristan da Cunha islands in the Southern Atlantic Ocean. The bird used to breed in reasonable numbers on Inaccessible Island, where chicks were eaten by pigs (before they were eradicated), whilst on Gough Island chicks are predated by mice, which seriously impact the population (Ryan 2007). The House Mouse *Mus musculus* is the only non-native predator on Gough (Wanless *et al.* 2007). In New Zealand, predation by non-native mammals is a major problem for seabird species.

Other non-native animals have their greatest effect on habitat. All over the world overgrazing is a serious problem, especially in semi-arid regions. Where animals become feral, they can soon proliferate, especially on islands where other competitors. Animals such as goats and pigs can increase rapidly on islands, where they are capable of removing much of the natural vegetation.

Invasive plants

Invasive plants can pose immense management problems, for example in wetlands across the world (Dodman and Boere 2010). These can also directly impact waterbirds. Africa has a particular problem with invasive plants of origins in South and Central America. Most invasive wetland plants spread by various methods, such as water currents, wind, introductions, vehicles, mammals and birds. One plant that has spread widely in African wetlands is the Giant Sensitive Plant *Mimosa pigra*. This shrub can rapidly spread and form dense thickets that crowd the edges of lakes and wetlands and encroach far across floodplains (Howard and Matindi 2003), as has happened at Zambia's Kafue Flats, where the shrub now dominates large parts of the natural floodplain. By taking over lake edge habitat, the plant removes access for wading birds, whilst it can also remove important breeding and feeding areas on floodplains. Other invasive plants such as Water Lettuce *Pistia stratiotes*, Water Fern *Salvinia molesta*, Water Hyacinth *Eichhornia crassipes* and Azolla *Azolla filiculoides* are floating plants that can cover the water surface of wetlands. They can have significant impacts on wetland ecology, including encouraging their conversion to non-wetland habitats, all impacts that can change the importance of sites for migratory waterbirds (Dodman and Boere 2010).

Human disturbance

Human activities, including all forms of work or leisure activity taking place in close proximity to birds, may cause disturbance (Woodfield and Langstone 2004). Disturbance is also an important indirect consequence of hunting (see, e.g., Madsen and Fox 1995, Mainguy *et al*. 2002, Kirby *et al.* 2004). Overall, such effects are likely to be widespread and, whilst we generally do not know whether there are population-level impacts, local effects may be substantial.

Assessing the significance of disturbance has proved to be complex, with the need to record and consider many interacting variables and take account of many differing species attributes, situations and sensitivities.

Large-scale field experiments (see Madsen 1998a, b, Mainguy *et al*. 2002) have demonstrated potentially important effects of hunting disturbance in depressing the size of waterbird populations. In addition, breeding-season research has demonstrated that human disturbance can force incubating birds off nests, separate adults from free-ranging young, lead to increased nest predation, prevent access to preferred feeding areas by adults and/or young, and increase energy costs if birds are forced to move when resting (examples in Kirby *et al.* 2004).

During the non-breeding season, disturbance may frequently cause displacement, either between or within sites, influence feeding and resting behaviour, result in increased daily and seasonal energy expenditure overall, and increase the chance of predation (reviewed by Kirby *et al.* 2004). This may affect the condition and fitness of migratory species. However, at present we know of no evidence that displacement has affected non-breeding birds at the population level.

Mortality owing to artificial structures

Newton (2007) collated information on bird mortality caused by human artefacts, such as powerlines, wind turbines, gas flares and telecommunications masts. Tall buildings and ceilometers (lights used for measuring cloud height) and tall illuminated masts used for radio, television and mobile telephone transmission all kill many migrant birds (mainly by collision), especially those flying at night. In North America in the 1970s, an estimated 1.3 million migrants were killed in this way each year (Banks 1979, cited in Newton 2007). By 2000, tower numbers had increased roughly fourfold, as had the associated death toll, reaching an estimated 4–5 million birds per year (USFWS 2002 in Newton 2007). About 350 species have been recorded as casualties, the vast majority being Nearctic–Neotropical migrants that fly at night, including a variety of warbler (Parulidae) species.

<u>Wind turbines</u>

Modern wind turbines are known to kill migrants by night or day, but information is only just beginning to emerge on the scale of these losses (which generally seem relatively small, being estimated at a total of 33,000 birds per year in the United States: USFWS 2002 in Newton 2007). The greatest losses seem to occur at wind farms situated on narrow migration routes (with, for example, many raptors killed in south-west Spain), or near wetlands, which attract large numbers of gulls and other large birds (de Lucas *et al*. 2007; see Desholm 2009 for information on species vulnerability). An analysis of the impact of windfarms on birds (Langston and Pullan 2004) identified the main potential hazards as disturbance leading to displacement and exclusion, collision mortality, and loss of, or damage to, habitat, but acknowledged that there had been few comprehensive studies, and even fewer published, peer-reviewed scientific papers. Langston and Pullan (2004) noted that most studies have quoted low collision mortality rates per turbine, but in many cases these are based only on corpses found, leading to under-recording of the actual number of collisions. Moreover, relatively high collision mortality rates have been recorded at several large, poorly sited windfarms in areas where concentrations of birds are present, especially migrating birds, large raptors or other large soaring species. As turbines continue to be constructed, they could collectively begin to impose a more significant drain on migratory bird populations, whether on land or in shallow coastal areas.

Commercial wind power development in the U.S. continues to grow at an exponential rate. With slightly more than 23,000 turbines installed and operating on the landscape (in 2008), and more than 155,000 turbines projected to be operating by 2020 (Manville 2009), there are serious concerns about current and potential impacts which continue to grow exponentially.

While the wind power industry currently estimates that turbines kill 58,000 birds per year in the U.S. (National Wind Coordinating Collaborative Wildlife Workgroup 2009 statistic), others estimate annual mortality at 440,000 birds (Manville 2005). Until a robust, scientifically rigorous cumulative impacts analysis is performed, we will not know with a high degree of certainly the true level of mortality.

Europe is currently undergoing a rapid proliferation of wind farms in the marine environment. Winds at sea tend to be stronger and more consistent, and weighty turbine components are more easily transported at sea permitting larger turbines to be constructed. In addition, offshore wind farms typically encounter less resistance from local communities (Dolman *et al*. 2003). However, there are growing concerns that offshore wind farms can have detrimental impacts on wildlife. Significant bird fatalities have been reported at marine wind turbines situated close to breeding colonies (Everaert and Stienen 2007) and several studies suggest that offshore wind farms present a serious barrier to seabird movements (Petersen *et al*. 2003, Desholm and Kahlert 2005, Fox *et al*. 2006).

Powerlines

Powerlines also pose a significant collision risk for many larger migrant birds (e.g. swans, geese, raptors etc.), especially if sited across flight lines or close to congregatory sites such as wetlands. Furthermore, electrocution on poorly designed medium-voltage lines is a significant cause of mortality in large perching species such as raptors (Bevanger 1998, Haas *et al.* 2003, Demmer *et al.* 2006).

In the early 1970s an investigation of eagle mortalities in the western United States revealed that, while numerous birds were shot or poisoned, others had been electrocuted on power lines (Olendorff *et al.* 1981). Likewise, collisions of Whooping Cranes *Grus americana* with power lines in the 1980s led to increased awareness of bird-power line collisions. Moseikin (2003) (cited in BirdLife International 2004b) reported at least 311 raptor electrocutions over a 100-km section of 10 kV power line in Kazakhstan over one year. Of particular concern, in central Mongolia, is the electrocution of Saker Falcon *Falco cherrug* (a globally threatened species), with this factor apparently the primary cause of adult mortality in the region (Gombobaatar *et al.* 2004). Demmer *et al.* (2006) refers to numerous studies that have documented electrocution as one of the most frequent causes of death among large endangered bird species worldwide. So-called ecosystem “flagship-species” such as White Stork *Ciconia ciconia* and Black Stork *Ciconia nigra*, Spanish Imperial Eagle *Aquila adalberti*, Lesser Spotted Eagle *Aquila pomarina*, Greater Spotted Eagle *Aquila clanga* and Steppe Eagle *Aquila nipalensis* are at great risk, with most species falling within the highest conservation status as listed in the appendices to CMS.

Efforts to document and reduce bird electrocutions and collisions with power lines have been ongoing in the United States since the 1970s (Liguori 2009). In habitats with prey concentrations and few natural perches, raptors and corvids may be attracted to power poles as perch or nest sites. If the poles are not configured for avian safety, electrocutions can occur.

Glass and other reflective materials

Klem (2009) reports on a vast and growing amount of evidence supporting the interpretation that, except for habitat destruction, collisions with clear and reflective sheet glass and plastic cause the deaths of more birds than any other human-related avian mortality factor. From published estimates, an upper level of 1 billion annual kills in the U.S. alone is likely conservative; the worldwide toll is expected to be billions. Though not specific to migratory birds, it is certain that large numbers of migratory species will be included.

Birds in general act as if sheet glass and plastic in the form of windows and noise barriers are invisible to them. Casualties die from head trauma after leaving a perch from as little as one metre away in an attempt to reach habitat seen through, or reflected in, clear and tinted panes. There is no window size, building structure, time of day, season of year, or weather conditions during which birds escape the lethal hazards of glass in urban, suburban, or rural environments.

As noted by Klem (2009), glass is an indiscriminate killer, taking the fittest individuals of species of special concern as well as common and abundant species. Preventive techniques range from physical barriers, adhesive films and decals to novel sheet glass and plastic, but no universally acceptable solution is currently available for varying human structures and landscape settings.

Specific threats in the marine environment

Understanding of the factors affecting seabirds at sea is complicated by the fact that the dynamics of marine systems operate to create greater and more rapid fluctuations and change than are usual on land. From the literature reviewed, three key factors are widely cited as having a major effect on seabirds at sea, namely marine pollution, overfishing and bycatch.

Pollution

Oil, chemical residues (PCBs), heavy metals and marine debris are the major pollutants that harm ocean birds.

Oily substances on the sea surface represent a significant observable cause of death for a wide range of marine and coastal bird species and pose a serious threat to seabird populations occurring in large concentrations near shipping lanes and oil production facilities. Beached bird surveys provide an important tool for monitoring the level of oil pollution at sea using the proportion of oiled bird corpses of the total number of beached birds found.

Observations from one study in Denmark (Larsen *et al.* 2006) showed significantly negative trends for the proportion of oiled Northern Fulmar *Fulmarus glacialis* and auks in the west coast of Jutland indicating a decline in the oil pollution level in offshore areas of the Eastern North Sea and Skagerrak. Trends in the proportion of oiled birds for the Kattegat were negative for most wildfowl but positive for Common Scoter *Melanitta nigra*. Although Common Eider *Somateria mollissima* and gulls showed negative trends in the Danish part of the Wadden Sea the trends were non-significant indicating no-change in the oil pollution level or insufficiency of data. The results show an improvement in the oil pollution situation in the offshore parts of the North Sea, in the Wadden Sea and in near-shore parts of the Kattegat but a worsening in offshore areas of the Kattegat. This is detrimental for species like Velvet Scoter *Melanitta fusca*, Common Eider and Razorbill *Alca torda*, for which the Kattegat serves as a globally important wintering area.

There is no doubt that major oil spills can kill huge numbers of seabirds. Careful estimates of the worst incidents in Europe suggest that kills of up to 500,000 birds have occurred (Mormat and Guermeur 1979, Piatt *et al.* 1990, Wiens 1995). Although spills from tankers receive most media attention, most oil enters the sea from land-based sources and deliberate discharges from ships, such as when cleaning tanks. Most seabird mortality occurs as a result of oil from such chronic pollution rather than accidents. Although it has been documented that oil pollution from major incidents and chronic inputs kill large numbers of birds, the long-term population effects are less well understood (Dunnet 1987, Furness 1993, Nisbet 1995, Wiens 1995). In many oil-producing areas, e.g. in coastal Africa, little information is available on the impacts of oil spills on wildlife, although oil spills are known to occur.

Chemical residues and heavy metals within the marine environment are a significant problem for ocean birds, with migrant seabirds typically having concentrations 1-2 orders higher than residents (at least in polar/subpolar regions) (J. Croxall, *in litt.*).

Many seabirds consume floating plastic and may feed it to their chicks. Ninety percent of Laysan Albatross *Phoebastria immutabilis* surveyed on the Hawaiian Islands had plastic debris in their stomachs (NABCI 2009). Added to this are damage to seabirds from ingested hooks and entanglement with discarded fishing line and nets.

Overfishing

Overfishing by humans reduces and alters the food supply for many seabirds. Where fish stocks have collapsed, seabirds have suffered widespread breeding failures and some populations have declined (e.g. Bailey *et al.* 1991, Anker-Nilssen 1991, Monaghan *et al.* 1992). Over-exploitation of forage fish, especially sardine and anchovy, has been attributed to major seabird declines in Peru and South Africa, associated with such fisheries (J. Croxall, *in litt.*).

In the UK sandeel fishery grew rapidly in response to the systematic overfishing of larger, piscivorous fish such as cod, mackerel and herring. By the 1990s, annual landings of sandeel were approaching one million tonnes, making it by far the biggest single-species fishery in the North Sea. Research has shown that fishing on this scale almost certainly depleted the sandeel supply for breeding seabirds. A summer fishery for sandeels off the east coast of Scotland was linked to a precipitous decline in surface-feeding Black-legged Kittiwake *Rissa tridactyla* which, unlike auks and shags, had no opportunity to forage deep in the water column (Furness 2002, Frederiksen *et al.* 2004, Daunt *et al.* 2008).

The switch to targeting the sandeel, a small prey fish, reflects a global trend of "fishing down the food chain" (Pauly *et al*. 1998). The same trend has also led to exploitation of invertebrates such as krill in the Southern Ocean, which has potential implications for populations of penguins, some albatross species and many other seabirds (Croxall and Nicol 2004, Kock *et al*. 2007).

Whilst there are clear examples of seabird declines linked to over-exploitation of forage fish, the extent to which such collapses in stocks of short-lived fish can be attributed to fishing effort rather than natural factors remains the subject of much debate (e.g. Furness 1993, 1995, Wright and Bailey 1993).

<u>Bycatch</u>

Unfortunately marine birds are sometimes attracted to fishing vessels or encounter fishing equipment and so interactions between them are inevitable. Despite a ban on their use in the high seas, gillnet fisheries continue in coastal waters of many countries in northern Europe and indeed in many other parts of the World. On the basis of a review of case studies, Zydelis *et al.* (2006) concluded that seabird bycatch mortality in gillnets could be relatively high locally, and could potentially impact on populations at a larger scale. For example, the seabird mortality associated with the salmon driftnet fishery in Russia's Exclusive Economic Zone (EEZ) is considerable. Between 1993 and 1999 about 482,500 seabirds, predominately Procellariids and Alcids, perished in nets set by Japanese boats alone (Spiridonov and Nikolaeva 2004).

The current status of some seabird species is critical because of an interaction with the fishing industry. Longline fishing fleets, which operate throughout the world's oceans, target vast numbers of tuna, swordfish, Patagonian tooth fish and other species. The boats set fishing lines that can stretch for up to 130 kilometres into the ocean. Each line carries many thousands of hooks baited with squid and fish. These attract albatrosses and other seabirds, which get caught, dragged below the water surface and drown.

An estimated 100,000 albatrosses die each year on fishing hooks (UNEP/CMS 2009). Albatrosses are exceptionally susceptible to longlining and cannot breed fast enough to cope with the rate at which they are being killed. This is putting them in real danger of extinction. Twenty of twenty-one species of albatross are threatened with extinction and the remaining one is near-threatened (BirdLife International 2010). Five large petrel species are also threatened for this reason. The primary threat comes from fisheries bycatch, longline primarily, but also trawling. The concentration of the threat is in southern oceans where the species and the most damaging types of fisheries are concentrated.

Climate change

Climate change is expected to affect migratory birds through changed weather and environmental conditions, such as temperatures, rainfall, sea level rises, and the acidification and circulation of the world's oceans. The effects will be direct or indirect through changes in habitat availability, quality and food resources, with some of the indirect effects occurring naturally or brought about by human reaction to a changing climate. Climate change effects, and the observed responses of birds, are the subject of a growing body of literature including, but not limited, to several reviews: Anon (undated), Butler (2000), Zöckler and Lysenko (2000), Sillett *et al.* (2000), Bairlein and Huppop (2004), Robinson *et al.* (2005), UNEP/CMS (2006), Huntley *et al*. (2007), and Maclean *et al.* (2008). Together they synthesize much complex information about the possible impacts on birds and interactions with other pressures affecting bird populations.

<u>Increasing temperatures</u>

Biome shifts, caused for example by temperature changes, is expected to result in the reduction of certain habitats for migratory species. For example, tundra habitat cannot advance polewards as temperatures rise due to its position at the northern extent of the Eurasian and North American landmasses. These higher temperatures are causing forests to invade areas which were originally treeless tundra, greatly reducing suitable habitat area for some species. Siberian Crane *Grus leucogeranus*, for example, is currently affected by these changes as the open tundra that it requires to nest disappears (Anon undated).

Migratory species rely on a number of isolated high quality habitats during their annual cycle. Any disturbance or alteration to a required habitat can leave a species vulnerable. As temperatures rise, the distances between suitable habitats can increase. This threat is particularly pronounced when geological features or human developments limit suitable habitats, when there are barriers to migration, or when food abundances occur in different locations to traditional migratory routes. As an example, the distance between the breeding and feeding sites of Balearic Shearwater *Puffinus mauretanicus* is increasing due to shifts in prey abundances, linked to changing sea surface temperatures (Anon undated). The extra energy required for this migration increases the species' vulnerability.

Many migratory seabird species might be affected. Most species (e.g. Humboldt Penguin *Spheniscus humboldti*, Balearic Shearwater *Puffinus mauretanicus*, Bermuda Petrel *Pterodroma cahow* and Short-tailed Albatross *Phoebastria albatrus*) are reliant on abundant zooplankton either directly, or to nourish their prey: krill, fish and cephalopod populations (Anon undated). These species will be negatively affected by changes in marine ecosystems and food-webs as increasing sea temperatures cause zooplankton abundance to decline. Climate change is likely to have a profound impact on 'high-productivity' ocean systems around the world. In recent decades, ocean surface temperatures along the west coast of North America have increased significantly leading to a dramatic decline in plankton biomass (Roemmich and McGowan 1995). This reduced ocean productivity has had a knock-on effect further up the food chain. Most dramatically, the number of visiting Sooty Shearwater *Puffinus griseus* dropped by 90% during a period of ocean warming between 1987 and 1994 (Veit *et al.* 1997).

The behavioural, social and life-history traits of seabirds may render them particularly sensitive to climate change (Grémillet and Boulinier 2009). Generally, seabirds have highly specialised diets, being reliant on just a few prey species, the abundance and distribution of which can alter dramatically in response to abrupt environmental changes. Seabirds' behavioural and life-history characteristics may constrain their adaptation to such changes. A seabird colony can take decades to establish and many birds display considerable breeding site philopatry—sometimes remaining faithful to an area even after conditions have become unfavourable (Grémillet *et al*. 2008); coupled with long delayed sexual maturity in most seabird species, they are particularly liable to slow response to rapid change.

Marine primary production is the basis of ocean ecosystems and a key component of the carbon cycle. By increasing water temperatures and freshwater discharge from melting ice sheets, climate change will affect nutrient supplies and is likely to change the ocean circulation system (Anon undated). All marine species are likely to be vulnerable to these changes, although there remains a high spatial and temporal uncertainty as to the extent and magnitude of these impacts (Anon undated).

<u>Changes in precipitation</u>

The projected increase in global temperatures will intensify the hydrological regime whilst increasing the spatial variability of precipitation. The overall projected patterns show a reduction of rainfall in the subtropics and an increase in rainfall near the equator and at high latitudes. Changes in rainfall patterns may be critical in already arid regions and affect habitat suitability for migrant land and water birds (Anon undated, Chambers 2008, Maclean *et al.* 2008).

Many bird species are particularly dependent on wetland habitats during vital stages of their life cycles. Reduced precipitation in these areas will negatively impact many species. Decreased precipitation coupled with increased evaporation rates has been identified as a key threat that will cause a reduction in the number of wetland stop-over habitats available to migratory birds (Anon undated). Changes in rainfall patterns will mean that wetlands in some regions will get drier, most critically in the Sahel Region of Africa (Maclean *et al.* 2008).

More variable rainfall is likely to affect the breeding success of many birds, especially those nesting in close proximity to water. Many waterbirds, for example, are very sensitive to changes in water levels as they require low-lying islands on freshwater lakes or coastal lagoons for nesting. Precipitation across breeding habitats is expected to increase in variability, with the potential for reducing the breeding success of many species (Anon undated). Altered patterns of precipitation were the reason for an altered time of migration in south-west Australian birds, in contrast to the findings from most northern hemisphere studies where changes in temperature patterns seemed to be better correlated (Chambers 2008).

Sea level rise

By 2100, the Intergovernmental Panel on Climate Change (IPCC) predict sea levels will have risen by 0.18–0.59m compared to 1980–1999 levels. However, other models indicate a much greater magnitude of sea level rise by the end of the century, with some predicting it to be in the range of 0.5–1.4m (Anon undated). This will have an impact on numerous migratory species utilising coastal habitats, especially species breeding at sea-level (e.g. many seabirds throughout the Indo-Pacific oceans, some of which are migrants). Amongst the key threats facing migrant breeding seabirds in Bermuda (including hurricanes and tropical storms, rising sea level, invasive animal species, and loss of habitat) major floodings of nesting islands as a result of hurricane and tropical storm activity are identified as a principal cause for concern (Dobson and Madeiros 2009).

Finlayson (in UNEP/CMS 2006) showed that wetlands in eastern Asia and northern Australia are under threat from climate change and sea-level rise, with implications for migratory birds on the East Asian–Australasian Flyway. In an overview of threats for the African–Eurasian Flyway Region, sea level rises were considered detrimental to waterbirds, causing nests to flood and habitats to be damaged or destroyed (Maclean *et al.* 2008).

Species responses to climate change

Migratory birds are already responding to changes in weather and environmental conditions. Robinson *et al.* (2005) demonstrated many changes in bird populations that they attributed to the effects of climate change, including changes in:

- Range and timing and direction of migratory routes, which may be beneficial for many temperate species but deleterious for high Arctic and montane species (a high proportion of which are migratory) as the area of suitable habitat is likely to decline markedly.

- Timing of breeding, beneficial if allowing more breeding attempts, deleterious if leading to asynchrony with food supplies (although many migratory species have changed the timing of their migrations in response to changed conditions, others have not).

- Survival of birds, potentially beneficial for temperate migrants by increasing winter temperatures near the limits of the breeding range (and decreasing mass mortality events), deleterious for trans-equatorial migrants if precipitation declines as predicted.

- Productivity of birds, beneficial among many species over the last few decades, but potentially deleterious to some ground-nesting species which may be adversely impacted by increased precipitation.

Newton (2008), reviewing evidence for north–south migrants breeding in the northern hemisphere, concluded that many bird species have changed some aspect of their migratory behaviour during the last century or more, in response to changed conditions, with (1) earlier arrival in spring, (2) earlier or later departure in autumn, (3) shortening or lengthening of migration routes, (4) directional changes, and (5) reduced or enhanced duration/distance of migration, reflected in changes in ratios of resident to migratory individuals in breeding areas, and in the occurrence of wintering birds in areas previously lacking them. Almost all these changes were associated with changes in food availability or with climatic conditions likely to have affected food supplies, such as milder winters. Most cases of increasing duration/distance involved species that have extended their breeding ranges into higher latitudes where overwintering is impossible or risky. Visser *et al.* (2009) demonstrate a reduction in migration distance based on an analysis of ringing recovery data, with a shortening of distances to suitable overwintering areas.

Huntley *et al*. (2007) projected how the ranges of 430 European breeding bird species (including many migratory land- and waterbirds) may shift by the end of this century in response to climate change. Three alternative future climate scenarios, differing in the magnitude of the range changes that result, were applied to models of species' current distribution and in all cases produced the same general results. Species' breeding ranges will generally shift north-eastwards and by large distances (several hundred kilometres for many species), and on average will be 20% smaller than they are now, with limited overlap (c.40%) with their present breeding distributions. For at least some high arctic breeders, climate change modelling shows an almost complete loss of breeding habitat (Zöckler and Lysenko 2000).

Impacts of climate change on long-distance migrants are likely to be complex (Sanderson *et al.* 2006). The rate, direction and variability of climate change differ considerably between regions (IPCC 2001). These effects could change the timing of resource availability, affecting the timing of migration or movement between staging areas (Schaub *et al*. 2005) and leading to asynchrony between resource availability and resource requirements. Climate change impacts may also mediate competition between short- and long-distance migrants by allowing short-distance migrants to return earlier to their shared breeding grounds, and possibly by enhancing overwinter survival of birds remaining in Europe, leaving intercontinental migrants at a competitive disadvantage (Sanderson *et al*. 2006; Mezqueda *et al.* 2007). Climate change may also affect resource competition between resident and migratory bird species by changing the interval between their onsets of breeding or by altering their population densities. Ahola *et al.* (2007) found evidence of this for Pied Flycatchers *Ficedula hypoleuca* and Great Tits *Parus major* in Finland where the frequency of tits killing the flycatchers in nest-hole disputes increased with a reduced inter-specific laying date interval and with increasing densities of both tits and flycatchers. The authors concluded that climate change has a great potential to alter the competitive balance between these two species.

As noted above, recent rapid climatic changes are associated with dramatic changes in phenology of plants and animals, with optimal timing of reproduction advancing considerably in the northern hemisphere. However, some species may not have advanced their timing of breeding sufficiently to continue reproducing optimally relative to the occurrence of peak food availability, thus becoming mis-matched compared with their food sources. The degree of mis-match may differ among species, and species with greater mis-match may be characterized by declining populations**.**

Relating changes in spring migration timing by 100 European bird species since 1960 to their population trends, Møller *et al.* (2008) found that species that declined in the period 1990–2000 did not advance their spring migration, whereas those with stable or increasing populations advanced their migration considerably. On the other hand, population trends during 1970–1990 were predicted by breeding habitat type, northernmost breeding latitude, and winter range (with species of agricultural habitat, breeding at northern latitudes, and wintering in Africa showing an unfavourable conservation status), but not by change in migration timing. These findings imply that ecological factors affecting population trends can change over time and suggest that ongoing climatic changes could increasingly threaten vulnerable migratory bird species, augmenting their extinction risk.

Coppack and Both (2002) showed that in Western Europe European Pied Flycatchers *Ficedula hypoleuca* had advanced both spring arrival and egg laying dates over the past 20 years. However the advancement of spring arrival had not kept pace with the advancement of spring. Using the breeding dates of 25 long-term studied populations of migratory *Ficedula* flycatchers across Europe, Both *et al*. (2004) found that across populations the advancement of laying date was stronger in areas where the spring temperatures increased more, giving support to the theory that climate change causally affects breeding date advancement. However, while some degree of advancement in the timing of breeding is possible, Pied Flycatchers (and other Afro–Palearctic migrants) may be unable to advance arrival on the breeding grounds and therefore egg-laying sufficiently to keep pace with phenological advances in peak prey abundance. This is because the cues that the birds use to initiate migration are uninformative of conditions on the breeding grounds and timing of egg-laying is likely to be constrained by arrival date. Thus phenological responses of prey populations to climate change may lead to birds failing to breed at the time of maximal food abundance. In a comparison of nine populations of European Pied Flycatcher breeding in The Netherlands, Both *et al.* (2006) found that populations have declined over the past two decades in areas where the food for provisioning nestlings peaks early in the season and the birds' reproduction is currently mistimed.

It should be noted that although there is increasing evidence that some migratory species are advancing timing of their breeding in response to climate change, the evidence for problems through mis-timed breeding versus peak food abundance is currently restricted to just a few studies. Both *et al.* (2009) have demonstrated habitat differences in the trends of migrants in forest and marsh habitats, with forest birds declining more than marsh birds and later arriving forest species declining more than earlier arriving ones. Climate-induced, trophic mis-matches were considered responsible in habitats with highly seasonal food supplies such as forests. Jones and Creswell (2010), examining population trends for 193 Palearctic and Nearctic migrants found differences between regions. In the Nearctic, phenology mismatch was correlated with population declines as predicted, but in the Palaearctic, distance was more important. The authors concluded that differential global climate change may be responsible for contributing to some migrant species' declines, but its effects may be more important in the Nearctic. More research is needed on this topic before we can tell whether this is likely to be a widespread problem or one that affects just a relatively few species.

Despite the scale of the observed and documented effects on migratory birds as overviewed above, population level impacts attributable to climate change have yet to be demonstrated. The difficulty of isolating cause from a wide range of interacting influences makes obtaining the proof for 'cause and effect' both technically and financially difficult to achieve.

Species and population vulnerability

Species sensitivity and vulnerability has been assessed in a number of studies. In his assessment, Crick (in UNEP/CMS 2006) indicated that most species (84%) listed on the Appendices of the CMS have the potential to be affected by climate change in some way: 53% from changes to water regime (droughts, lowered water tables, etc.), 24% from mis-matches with food supplies, 18% from sea-level rise, 17% from habitat shifts, 17% from changes in prey range and 7% from increased storm frequency.

In an analysis specific to waterbirds in the African–Eurasian Region, species with small populations and ranges, globally threatened status, fragmented distributions, with specialist food requirements or that occur in vulnerable habitats were considered most likely to be the most affected by climate change (Maclean *et al.* 2008). Application of these criteria resulted in the following waterbirds and seabirds (from Annex 3 of the AEWA Agreement) being identified as particularly vulnerable to climate change: Cape Gannet *Morus capensis*, Crowned Cormorant *Phalacrocorax coronatus*, Bank Cormorant *Phalacrocorax neglectus*, Slaty Egret *Egretta vinaceigula*, Northern Bald Ibis *Geronticus eremite*, White-winged Flufftail *Sarothrura ayresi*, Madagascar Pratincole *Glareola ocularis*, Slender-billed Curlew *Numenius tenuirostris* and Damara Tern *Sterna balaenarum.*

The same authors noted the significance of biogeographic populations in conservation legislation and that populations were even more vulnerable to climate change than entire species. Although this is to be expected, this serves to illustrate the importance of using a population based approach to conserving species in the face of climate change. Applying the criteria described above to individual waterbird populations, Maclean *et al.* (2008) identified the following as being particularly vulnerable to climate change: White Stork *Ciconia ciconia* (Southern Africa), Northern Bald Ibis *Geronticus eremita (*South-west Asia and South Asia winter), Northern Bald Ibis *Geronticus eremita (*Morocco), Sacred Ibis *Threskiornis aethiopicus* (Iraq and

Iran), Cape Teal *Anas capensis* (Lake Chad basin), White-headed Duck *Oxyura leucocephata* (Algeria and Tunisia), Siberian Crane *Grus leucogeranus* (Iran winter), Common Crane *Grus grus* (Turkey and Georgia breeeding), Demoiselle Crane *Grus virgo* (Turkey breeding), Demoiselle Crane *Grus virgo* (Black Sea, Ukraine, and North-east Africa), White-winged Flufftail *Sarothrura ayresi* (Ethiopia and Eastern Africa), Chestnut-banded Plover *Charadrius pallidus venustus* (Eastern Africa), Slender-billed Curlew *Numenius tenuirostris (*Central Siberia and Mediterranean and SW Asia).

In a comprehensive review for birds in North America, NABCI (2010) presents an assessment of the vulnerability of bird species to climate change, based on five biological aspects of sensitivity to climate change (migration status, breeding habitat obligate, dispersal ability, niche specificity, and reproductive potential), as well as the exposure of each species' habitat to climate change in the near future. Birds in every terrestrial and aquatic habitat were considered to be affected by climate change, although individual species in each habitat are likely to respond differently.

All 67 oceanic bird species, including albatrosses, petrels, tropical terns, tropicbirds, frigatebirds, and puffins were classified as vulnerable because of their low reproductive potential, use of islands for nesting, and reliance on rapidly changing marine ecosystems. Seabirds such as Laysan Albatross *Phoebastria immutabilis* and Bonin Petrel *Pterodroma hypoleuca* that are restricted to nesting on low-lying islands are in danger of losing their breeding habitat as sea levels rise (NABCI 2010).

Rising sea levels are expected to inundate or fragment low-lying habitats such as salt marshes, sandy beaches, barrier islands, and mudflats. Increasing frequency and severity of storms and changes in water temperatures will impact quality and quantity of coastal habitats and alter marine food webs. Beach-nesting terns, highly specialized Saltmarsh Sparrows *Ammodramus caudacutus*, and birds dependent on marine waters are among the most vulnerable species (NABCI 2010).

Increased temperatures will drastically alter surface water and vegetation in the arctic, resulting in major changes in bird abundance and distribution. Species that depend on grass-sedge tundra for breeding, such as the Black Turnstone *Arenaria melanocephala*, could lose their tundra breeding habitat.

Predicted changes in temperature and rainfall will probably reduce vital habitats for waterfowl and other wetland birds. Climate change could reverse the positive effects of conservation actions that have increased waterfowl populations. In the Prairie Pothole region alone, increased drought conditions and loss of wetlands could lead to significant reductions in breeding waterfowl.

Aridlands and grasslands are predicted to become warmer and drier. Many aridland birds are at increased risk because of drought and the potential for summertime temperatures greater than they can tolerate. Important wintering areas for many grassland birds may become unsuitable due to increased drought, invasive species, and invasion by woody shrubs (NABCI 2010).

Forests will gradually change as precipitation changes, and as fire, insect pests, and diseases alter forest communities. Forest types in eastern states are predicted to shift northward, whereas western forest types will shift to higher elevations. These changes will alter bird communities, although most forest birds will probably be resilient because of their large distributions and high reproductive rate (NABCI 2010). However, long-distance migrants, especially aerial insect-eaters such as swifts and nightjars, may face multiple challenges such as the timing of food resource availability throughout their migratory range.

Cumulative impacts

Of course climate change effects and impacts on birds do not occur in isolation from all other threats and pressures. Climate change is expected to exacerbate these other pressures on migratory birds (Anon undated, Sanderson *et al.* 2006, Tucker and Goriup 2007). Examples quoted by NABCI (2010) were as follows:

- Altering habitats, allowing for the increase of invasive species. As invasive species expand, they can out-compete native species, leading to the reduction or loss of native plants and wildlife.

- Spreading disease. Distribution of disease patterns and changes in wildlife occurrence will affect the transmission of diseases. It is also expected that infectious diseases will emerge more frequently and in new areas due to climate change.

- Exacerbating the impacts of storm-surge flooding and shoreline erosion. Increasingly developed coastal communities and rising sea level will limit potential habitat for coastal birds.

- Changing the distribution and availability of surface and ground water. Climate change will constrain water resources, further increasing competition among agricultural, municipal, industrial, and wildlife uses.

The majority of migratory bird species are already at high risk from anthropogenic pressures (as discussed earlier in this review). The predicted negative socio-economic impacts of current climate change on humans will ultimately result in increased anthropogenic pressures on species and natural systems. For example, harvested species are likely to be even more heavily exploited. Wetland habitats will be starved of water as it becomes increasingly diverted for human use. Sea level rise will encourage the construction of coastal defences, which are likely to negatively impact species reliant on coastal habitats. Climate change has the capacity to act synergistically with current anthropogenic threats, so that species are not only dealing with the direct impacts of climate change, but also consequences of climate change impacts on humans. This adds to the complexity of effecting mitigation for climate change impacts on migratory birds and represents a significant challenge for conservationists to overcome.

CMS Parties have made several decisions that prioritise actions to reduce climate change impacts on migratory species. In 2005, Resolution 8.13 included, amongst other things, for the Scientific Council to identify which migratory species, based on best available evidence, are particularly threatened by climate change. More recently in 2008, Resolution 9.7 called upon Parties to mitigate climate change and aid adaptation of species to these changes. CMS has clearly already recognised its role in addressing this most significant of threats to the future survival of migratory bird species.

Knowledge gaps

Key information needs are identified here that relate to our knowledge of the status, trends and threats to migratory bird species, and information needed in order to more effectively pursue the conservation priorities defined above.

Status and trends

Reliable and, ideally, complete information on global population sizes for migratory species is a fundamental requirement, in order to detect current or future declines and target action to address them. The data available on individual populations has grown steadily within the last century. Nevertheless, there are still considerable gaps in our understanding of the status of some species or populations.

Repeat survey and population estimation allows trends to be examined, for it is vitally important to know how the status of a species is changing over time. Critically we need to identify which migratory species are declining in which regions and the principle reasons for their declines. This is particularly important in Asia (including the Indian subcontinent) and South America where information is generally poor in comparison with other regions of the world. It is vital to continue the monitoring already underway (e.g. the International Waterbird Census, Common Bird Monitoring in Europe and Breeding Bird Surveys in North America etc.) in order to detect changes, including future declines, and the success (or not) of conservation measures. Where possible, the robustness of methodologies should be peridocially assessed and improved where necessary. Moreover, it is critical to extend the coverage of these types of monitoring schemes both in geographic terms—extending to other sites and regions not currently covered—as well as in temporal terms—extending to different seasons (e.g. covering both spring and autumn migrations). This monitoring activity comes at a price, and governments with a shared responsibility for migratory species need to realize the importance of monitoring and thus become motivated to fund this essential basic monitoring work, in order to effectively underpin appropriate conservation action for migratory species.

Migratory patterns

Much more needs to be known about the distribution and ecology of migratory species, and especially the migration routes that they follow. This is fundamental to knowing which Range States have a responsibility for which migratory species, assessing threats, and to organising conservation action in the right places at the right time.

These gaps in information need to be filled by ongoing and developing programmes of research. Ringing, banding and colour-marking activities must be continued but a wholesale increase in such programmes is probably unrealistic to achieve. Fortunately, relatively new technologies, such as radio and satellite tracking, geolocators and genetic analyses, are available and can be extremely useful and provide more detailed information than classic marking studies (see, e.g. Bobek *et al.* 2008, Fawen *et al.* 2009, Kelly *et al.* 2008, Lindsell *et al.* 2008, Sanpera *et al.* 2007, Yohannes *et al.* 2007, Hobson *et al.* 2009). Radio and satellite tracking has been successfully tested on a wide size range of wetland and non wetland species, including cranes, swans, geese, pelicans, shorebirds, gulls, eagles, storks, bustards and others (see, e.g., www.fao.org/avianflu/en/wildlife/sat_telemetry.htm). Also, recent advances in remote sensing and the ingenuity of the scientific community, such as the development of micro-transmitters and geolocators, are producing a wealth of new information about bird movements and their use of environmental cues to locate food and other resources.

In order to fully understand the migratory patterns of seabirds, disparate data must be aggregated in common, multiple species databases. For example, the Global Procellariiform Tracking Database (http://www.seabirdtracking.org/) incorporates around 90% of existing remote tracking data for albatross and petrel species. Since being established in 2003, the database has proven invaluable in understanding the range and distribution of these species, both in terms of expanding understanding of their ecology and demography, and in identifying key foraging areas and overlaps with threats, specifically with respect to bycatch issues.

Data from marking and counting programmes already exist but much data remains unanalysed or has the potential to be better analysed. Thus we need improved international analysis of existing satellite telemetry, ringing (banding) and count data. This must synthesise information on the routes and timing of bird migration, especially of poorly known intra-African migrants, and birds using Central Asian, Asia–Pacific and Neotropical flyways. We need to strengthen bird research worldwide, especially in areas where little or no ringing and counting schemes have operated in the past. We need to publish the results of these studies and other relevant data in new flyway atlases freely available on the internet. To optimally conserve the many species travelling along the flyways of the world, a great deal more migration data is required.

Vulnerability and threats to migratory birds

A wide variety of threats to migratory birds exist, and all require some degree of conservation action. Some can be addressed through landscape scale or site-based conservation management and these are considered further below. For other threats a more focused approach is required—targeted campaigns focused on particular species or species groups or on particular threat types. Examples include campaigns to address illegal hunting and trapping, electrocution in birds, non-native species impacts, glass window, wind turbine and power line collisions, or over-fishing and bycatch mortality amongst seabirds. In all cases it is important to identify the key threats, defined here as those that are known to threaten the survival of individual migratory species.

Identifying the key threats that might be targeted by such campaigns requires some form of vulnerability or population viability assessment to be undertaken for migratory species worldwide. Maclean *et al.* (2008) presents a good example of how species and population vulnerability may be identified, in this case to the threat of climate change (a large topic that will require more than just a campaign and is so treated separately below) (see also NABCI 2010). There may be other approaches worthy of development also. Such analyses should be undertaken for all potentially important threats on a species-by-species or population-by-population basis, in order to identify key threats and the birds detrimentally affected by each.

From this information, targeted campaigns need to be developed, or where appropriate campaigns exist already, will need to be maintained, expanded or refocused, as a form of action plan for addressing the key threats. The success of the campaigns should be monitored to ensure effectiveness and to allow continuous re-evaluation of the threat, hopefully documenting each threat as it diminishes.

Landscape scale conservation

There is a need to determine the ‘ideal’ landscape for migratory birds in each geographical region of the world, where landscape-scale conservation is key to the protection of migratory birds. This in itself is a significant challenge but is being attempted in some parts of the world.

In North America, Partners in Flight have been promoting the ‘Five Elements’ approach which is worthy of consideration for application in other parts of the world. Outline details are provided by Will *et al.* (2005): the Five Elements is a conceptual approach through which conservation partners work together to assess current habitat conditions and ownership patterns, evaluate current species distributions and bird-habitat relationships, and determine where on the landscape sufficient habitat of different types can be delivered for supporting bird population objectives. The Five Elements process is intended to facilitate explicit, science-based recommendations on where habitat protection, enhancement, or management would be most efficiently implemented to achieve stated population objectives. The Five Elements of work involved in this process may be summarized as follows:

> **1. Landscape Characterization and Assessment.** A landscape-scale characterization of the current amount and condition of habitat types across an ecoregion and an assessment of their ability to support and sustain bird populations is fundamental to the development of meaningful population based habitat objectives. The characterization should not only describe the current amounts of different habitat types across an ecoregion but also summarise patch characteristics and landscape configurations that define the ability of a landscape to sustain healthy bird populations.

2. Bird Population Response Modelling. Incorporated with the macro-scale relationships from Element 1, more sophisticated models relating to micro-scale vegetation structure with demographic parameters provide powerful tools for assessing, predicting, and monitoring how bird populations will respond to landscape change and land management activities. Such tools need to be more widely developed and applied, with the recognition that they will require a greater commitment of resources. These models should help us to evaluate the potential effects of different management alternatives on bird populations within an ecoregion and thereby allow us to develop hypotheses regarding what set of management actions are most likely to result in population responses that will move existing bird populations toward stated population objectives.

3. Conservation Opportunities Assessment. Not all patches of similar habitat will have similar futures, depending in part on who owns and manages the land. Models developed in Elements 1 and 2 can be used to quantify the cumulative contributions of current holdings in the traditional conservation estate (mostly public lands) as well as the capacity of (mostly private) lands owned by others to contribute toward population objectives for priority species within an ecoregion. The assessment of conservation opportunity should also include recommendations on how land management activities might be modified to improve both the quantity and quality of priority habitats.

4. Optimal Landscape Design. A huge challenge of all bird conservation planning is the development of synthetic models that bring together conservation strategies and landscape design models that integrate the needs of priority species, landscape capability, opportunity cost (economics), and partnership potential into proposed optimal solutions for meeting the conservation objectives of the entire set of priority bird/habitat suites within an ecoregion.

5. Monitoring and Evaluation. In principle, incorporation of Element 5 into the recommended framework for achieving continental objectives seems self-evident: we need to monitor in order to gauge our progress and success, and we need to evaluate the validity of the assumptions used in meeting the other four Elements. In practice, however, very careful thought needs to go into the selection and design of appropriate monitoring and evaluation tools, and these tools are in turn intimately related to the careful articulation of clear objectives and purposeful models.

Partners in Flight hopes this approach to turning bird conservation plans into habitat implementation actions will be more widely and consistently applied by organizations participating in efforts to conserve North American avifauna. It would appear to have some applicability to other parts of the World also.

Critical site networks

The advantage that migratory species have in comparison with most non-migratory taxa is their ability to move over large distances. To facilitate this movement, it is vital to improve the connectivity of habitats critical to population survival currently and in the future. CMS is already involved in developing critical site networks and tools such as the Critical Site Network Tool developed through the WOW Project in the area of the African-Eurasian Waterbird Agreement (Barnard *et al.* 2010). There is an urgent need to identify and protect further critical site networks with species range shifts in mind. By maintaining viable habitats and reducing current threats, stakeholders may be able to improve the resilience of some species to cope and adapt to climate change.

There are two fundamental aspects to the effective provision of a network of sites for migratory birds. First, that important sites are recognized and protected. Second, that such sites are optimally managed for the birds that they support.

Rather than approach the first of these requirements piecemeal, we need to determine what kind of network of sites (including the size, proximity and number of sites) would be needed to support healthy populations of different migratory species at all stages of their annual cycle and in all parts of the world. Very importantly, in answering this question, we should also seek to maximise the resilience of such networks in the face of global climate change.

We then need to compare current provisions (e.g. IBAs, Ramsar Sites, WHSRN Sites, East Asian–Australasian Flyway Sites, West/Central Asian Sites *etc.*) with these "ideal, climate-proofed states" and determine how they might be improved, most probably through the addition of extra sites or the expansion of sites, and through appropriate management in the face of predicted changes. An assessment of the feasibility of creating these more effective habitat/site networks would then follow, with a view to prioritizing the addition of sites in locations where it is most feasible to do so. Although voluntary networks have a key role to play and should be encouraged, adequate formal protection for network sites would also be of vital importance and this needs to follow their formal recognition as network sites.

By comparison, promoting good management for birds (including reducing threats) at network sites is relatively easy and should draw upon a synthesis of knowledge of the ecological requirements of migrant birds at different stages of the annual cycle (to define favourable condition), and best practice habitat management prescriptions (much of which is already available).

Climate change adaptation

Unfortunately, little is currently known about migratory species' capacity for adaptation to climate change. To understand this better, intensive monitoring and research is needed. This knowledge is vital to identify key limiting factors, the 'weakest link', upon which each species survival hinges, and to provide essential building blocks for policy guidance.

The large geographic extent of many migratory species' ranges will make the design of adaptation strategies, aimed at minimising climate change impacts, very challenging (Anon undated). For instance, the global population of Siberian Crane

Grus leucogeranus global is c.3000 individuals which nest over an area of 26,000 km². Even if adaptation is facilitated, such as by shifting migratory routes with imprinting and micro light plane guidance (e.g. Flight of Hope project: www.sibeflyway.org/Reintroduction-Flight-of-Hope-Project-web.html), these measures require a large investment both in terms of time and money.

Unfortunately, even high levels of investment will not ensure viable populations if greenhouse gas emissions surpass critical thresholds, as many of the threats highlighted above will be difficult to control and adapt to once levels are breached. Furthermore, populations currently dependent on habitats located on the most northerly or southerly ends of landmasses, as well as those close to mountain tops, are particularly vulnerable since migration to follow their climatic niche is not an option. There is potential for the translocation of species to new areas through assisted colonisation/migration, but this again is costly and should only be used as a last resort once adequate research has been done on the long term affects of such drastic interventions. On a species-by-species basis, provisions to aid adaptation could be feasible in the short to medium term, but it is clear that for a multitude of species such actions will be too costly and ultimately not sufficient to ensure their survival, especially if rapid levels of climate change are allowed to occur. It is therefore vital that a dual approach be taken where proactive adaptation measures are applied to species already threatened by committed levels of climate change alongside considerable and rapid emissions abatement to limit further impacts. This is the only cost effective and practical way to safeguard migratory species into the future.

In addressing the conservation challenges of climate change, a multi-functional approach is likely to be most successful. This approach entails considering the benefits of ecosystem conservation from a holistic viewpoint, considering both the anthropogenic and wildlife benefits. It is much more likely that conservation goals will be achieved if they are part of ecosystem management with wider aims such as floodplain management, coastal protection or preventing deforestation to reduce soil erosion. Frameworks for integrated land-use planning exist in a number of different parts of the world, and they could valuably be developed and implemented more widely elsewhere.

In terrestrial systems adaptation measures may be successful in maintaining or restoring a secure conservation status for many species. In marine systems, however, mitigation of climate change may be the only solution (i.e. reduction in anthropogenic greenhouse gas emissions), as habitat management at a sufficient scale will be virtually impossible. Climate change may be the ‘last straw’ for many marine species, which are already under severe anthropogenic pressure. Strengthening protection for marine species and ecosystems should improve their ability to adapt to changing climatic conditions.

Knowledge gap constraint

Although knowledge gaps have been reviewed above, they are unlikely to be complete, despite an intention to be comprehensive. Easy access to key information from which to assess knowledge and define gaps is difficult. Indeed, many datasets have already been collected and much information is already known about the distributions of species, and the natural and anthropogenic factors affecting their populations. However, these data are often contained within disparate databases and knowledge is described in thousands of publications.

There is a continuing need to consolidate existing data into data management and presentation systems, such as:

- IUCN's Species Information Service (SIS) for managing species attribute and Red List assessment data.

- BirdLife's Global Procellariiform Tracking Database (http://www.seabirdtracking.org/) for collating and disseminating information on individually tracked birds.

- The UNEP-GEF African–Eurasian Flyways (WOW) Project Critical Site Network Tool (about to be launched) for identifying and presenting priority sites for the conservation of migratory species.

- BirdLife's Worldbirds (www.worldbirds.org/mapportal/worldmap.php) for collating and disseminating observation and monitoring data.

- Cornell University's Avian Knowledge Network (www.avianknowledge.net) for understanding patterns of bird populations across the western hemisphere.

  And,

- The Integrated Biodiversity Assessment Tool (IBAT) (www.ibatforbusiness.org) presenting data to support critical business decisions, to name just a few.

The data held within such systems can then be used to test hypotheses as well as evaluate spatial and temporal trends in bird populations in ways that extend beyond the extent and scope of individual projects. Similarly, there is a need to consolidate the results of previous research currently held in disparate spreadsheets or databases into such systems and others that can be analysed both quantitatively and qualitatively.

The importance of effectively transmitting research results to end users (bird conservation planners, implementers, and regulators) cannot be overstated. It is particularly important that data are made available back to the locations where they were collected (e.g. returning data/results to the country or the land management agency where they were collected).

Conservation priorities

Key conservation priorities have been defined here on the basis of this review of migratory birds and the threats they face. The priorities are to:

- Work to protect and retain and, where feasible, recreate / restore high quality bird habitats on a flyway and landscape scale.
- Work to safeguard and manage networks of critical sites, key to the migration and survival of migratory species.
- Address specific threats that are known to threaten the survival of individual species and species groups.
- Attempt to mitigate the effects of climate change, affording migratory species the best possible chance of survival.

Of course there are many other priorities of particular relevance to migratory birds including the need to achieve political and practical engagement in migratory bird conservation, for example through:

- Communication, education and public awareness.
- Capacity building, especially amongst conservation managers, site managers, non-governmental organisations, research institutions *etc.*).
- Engagement of local communities.
- Economic and cultural valuation of migratory birds

These fall outside of the scope of the current review but are comprehensively covered in other recent reviews, e.g. Dodman & Boere (2010).

Conserving quality habitats at the landscape scale

The key threats identified from this review are biological resource use and habitat destruction from activities such as agriculture and aquaculture. It follows that the protection of habitats, and the resources they provide, is therefore of vital importance to migratory birds, and this should be afforded the highest priority of all. Of course different migratory species will benefit from different approaches aimed at habitat protection. Broad-front migrants, for example, will benefit from modifications to extensive land-use along their migratory routes, related to agriculture or forestry practice for example. Migrants following narrower flyways will require a coherent site network, with each network site providing safety and plentiful resources for the birds, an issue considered further below.

For broad-front terrestrial migrants, the retention and, where feasible, restoration of suitable migratory habitats, such as wildlife friendly field margins, hedgerows, small copses, wetlands and ponds have potential to assist bird migration. Where they exist, agricultural schemes for farmers, or grassland and woodland management schemes can provide an excellent means of bringing about such changes at the landscape scale. Sadly, in many countries, such schemes cannot be afforded.

In areas with remaining habitat of value to migratory birds, the creation of protected trans-boundary habitat corridors is likely to be a great benefit. This will help broad-front migrants as well as migrants at the beginning and end of their migrations. Currently it is an approach applied particularly in the Americas, e.g. the Meso-American Corridor, through Central America.

The priority for adapting to change in the marine environment will be to manage human impacts on the resources required by migratory species through ecosystem-based management. One way to achieve this is through the management/ designation of Marine Protected Areas (MPAs) and the establishment of 'no-take zones' for the prey of migratory birds at key sites. However, the locations of such areas are often not known, are likely to change over time, and thus long-term protection will be challenging. MPAs already in existence play an important role and networks of MPAs will be needed as part of critical site networks for migratory birds.

Many migratory species are widely dispersed in their distributions, especially passerines, and most species that congregate do so only in certain phases of their life cycle. Stopping and reversing declines in migratory species requires addressing the human-induced changes to migratory bird habitats in the broader landscape, in addition to species and site-based work. Habitat transformation—such as agricultural intensification in Europe, conversion of natural rangelands to soy plantations in South America, desertification in the Sahel, loss of intertidal habitat in the Yellow Sea Region, tropical deforestation in South-East Asia and Central and South America, and forest fragmentation in North America, all of which are implicated in migratory bird declines—can be most feasibly addressed through changes in economic policy and land-use planning.

Smaller landbird species tend to move on a broad front across the landscape on each continent, in some cases encountering significant obstacles to movement, such as deserts, seas or mountain ranges, which they either cross or bypass, depending on their evolutionary adaptations. Optimal terrestrial landscapes for these species on migration are ones that offer suitable and sufficient habitat in which to forage and rest, before and after such long flights and during stop-overs. It follows that the availability and maintenance of such habitats in the landscape is a key conservation requirement for these birds.

With climate change increasingly also implicated in migratory bird declines, and likely to have profound impacts in the future, the magnitude of the challenge of landscape conservation only grows, and it remains as a key conservation priority.

Safeguarding a network of important sites

Conservation of migratory species that depend on a network of sites along their flyways strongly benefits from the proper management of these sites. This is perhaps best illustrated for waterbirds, whose flyway movements can often take place along relatively narrow corridors of habitat.

Many waterbirds either overfly or detour around large inhospitable expanses of land or sea that lack suitable wetlands for resting and refueling. They thus concentrate at key sites which serve as staging posts until birds are ready to depart towards the next key site in the network. Where the number of such staging posts is limited, waterbirds can congregate in spectacular fashion, and these sites are crucial to the success of their migratory journeys. In these cases, the loss of one site can have a potentially devastating impact on the population as a whole (e.g. Baker *et al.* 2004).

Effective management of critical sites, and coordinated planning and management along migration flyways as a whole, are vital to many migratory birds. Various initiatives have been established across the world to promote such conservation efforts; BirdLife International's global network of IBAs; WHSRN in the Americas; the East Asian–Australasian Flyway Site Network and the West/Central Asian Site Network for Siberian Cranes and other waterbirds (WCASN) (see UNEP/CMS 2009).

As an example, BirdLife International's IBA programme provides a platform for planning, prioritizing, advocating and taking action for sites, as well as monitoring the effectiveness of this action. Although initially land-based, the protection of key areas for seabirds is now receiving attention (thanks to the increasing knowledge on seabird distribution patterns at sea), and the IBA programme is being extended to the marine environment (e.g. Hyrenbach *et al.* 2000, BirdLife International 2004d, Manuel *et al.* 2009).

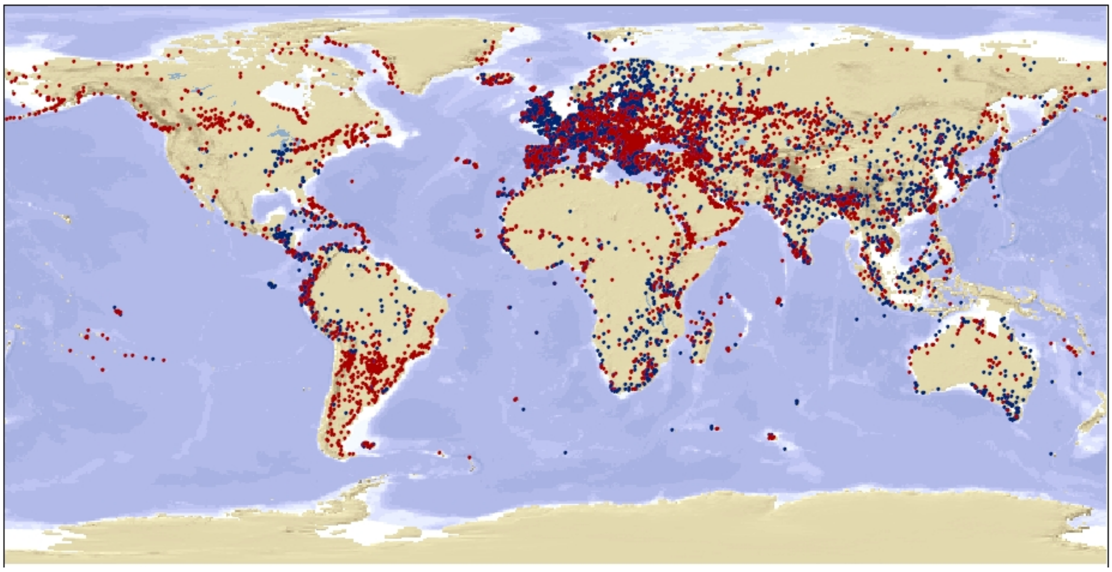
IBAs are identified on the basis of the presence of birds that are globally threatened and near-threatened, spatio-temporally concentrated, geographically restricted, and biome-restricted (details in Annex 4: Global Important Bird Area criteria). To date, over 8,400 sites have been identified worldwide on the basis of migratory "trigger" species (see Table 7). Of these, 56% have less than 10% of their area formally protected (Figure 6).

Table 7. Numbers of IBAs identified for significant numbers of migratory species by type and region

Regions	Landbirds	Waterbirds	Soaring birds	Seabirds	TOTAL
Africa	222	526	235	224	**654**
Antarctica	1	9	0	24	**24**
Asia	705	1155	877	284	**1460**
Australasia	28	133	14	102	**185**
Caribbean	40	82	3	82	**125**
Central America	57	22	3	5	**98**
Central Asia	216	258	256	132	**367**
Europe	2180	2843	1891	1318	**4000**
Middle East	207	210	172	117	**330**
North America	64	333	42	222	**451**
Oceania	0	2	0	7	**28**
South America	549	226	128	94	**694**
TOTAL	**4269**	**5799**	**3621**	**2611**	**8416**

Notes Data are taken from BirdLife's World Bird Database; additional sites may have been identified but are not yet included in the database. Although inventories are progressing, few IBAs for migratory species have been identified in Antarctica, Australasia and Oceania. The sum of the totals by type by region exceeds the total number of IBAs by region as IBAs can be identified for both land- and waterbirds, soaring birds are not exclusive of landbirds or waterbirds, and seabirds are not exclusive of waterbirds. All totals refer to IBAs of global importance. Some IBA criteria are applied at the level of species-assemblage rather than individual species or otherwise cover a mixture of species and have therefore not been analyzed here.

Figure 6. IBAs identified for migratory species (≥ 10% protected = blue; < 10% protected = red)



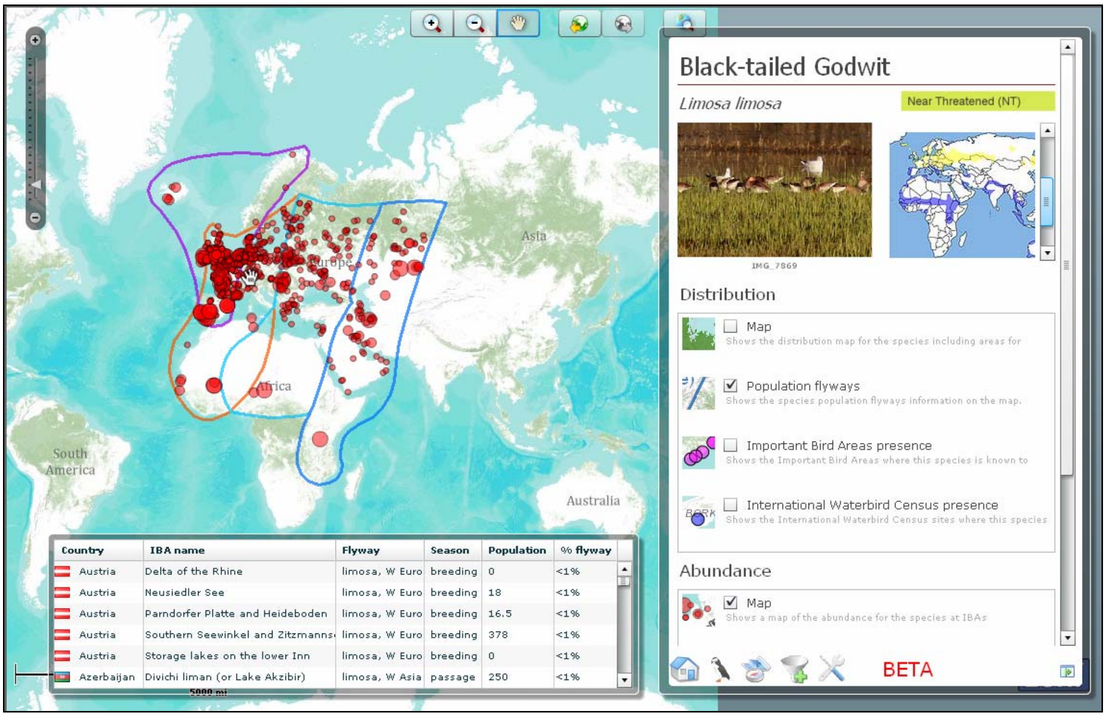
The adequacy of these sites as a network of breeding, non-breeding and passage areas is regularly reviewed by BirdLife International, but through collaboration it is possible to extend these efforts further. An important recent initiative is the ‘Wings Over Wetlands’ (WOW) project in the AEWA region (see, e.g. Zandri and Prentice 2009, Barnard *et al.* 2010). WOW aims “to improve the conservation of African–Eurasian migratory waterbirds through implementing measures to conserve the critical network of sites that these birds require to complete their annual cycle, including stop-over sites during migration and in wintering grounds”. The project is a collaborative effort between Wetlands International and BirdLife International, supported by the UNEP-GEF (The Global Environment Facility), The Government of Germany and a wide range of other donors and partners (see www.wingsoverwetlands.org). Central to the project’s rationale is the creation of a comprehensive flyway-scale “Critical Site Network Tool" (CSN Tool) to provide public access to the most up-to-date information about waterbird populations and the network of sites they depend upon,within the African-Eurasian region. Using data on IBAs and International Waterbird Census (IWC) sites as the starting point, the adequacy of the existing site network has been assessed season by season for each population (of close to 300 waterbird species) and the most important (Critical) sites in the region are highlighted in the CSN Tool population by population.(see Figure 7 for example). The CSN Tool is designed to help a range of different users, from site managers to national authorities and international organizations to access information on waterbirds and the sites they use, and to view it in a flyway context to aid conservation decision-making, allowing weaknesses in site networks to be identified and addressed. The tool directly supports the implementation of AEWA and the Ramsar Convention, and is also very relevant to the EU Birds Directive and the Bern Convention’s Emerald Network. The threats facing waterbirds are similar in other regions and urgent conservation action is needed to stem the alarming declines recorded in many populations. The CSN approach could be of great value in highlighting conservation priorities in other regions.

Identifying Important Bird Areas (and, similarly, other network sites) is the first step towards conserving them. Protection should ideally follow. In the AEWA area, hosting over 2,250 IBAs known to support at least one species of migratory waterbird, nearly 40% are currently lacking either statutory national protection or international recognition as Ramsar Sites, natural World Heritage Sites or Biosphere Reserves (unpublished data held in BirdLife's World Bird Database). Few IBA bottleneck sites for migrating raptors in Africa and Eurasia have adequate protection (Goriup and Tucker 2007). Fishpool *et al.* (2009) identified IBAs important to a selection of Palearctic–West African migratory bird species in five countries (Mauritania, Senegal, Gambia, Guinea-Bissau and Guinea) on the East Atlantic Flyway. Forty-three IBAs were identified as being of global significance for the numbers of migratory species that they regularly hold, however over 50% of these have no formal protection. In the tropical Andes, where IBAs for migratory birds have been recently identified, 43 (37%) are not protected (BirdLife World Bird Database data).

Implicated in the decline of waterbirds in Asia is poor protection overall of key sites there, leading to damage and destruction of wetlands. The results of an analysis of the status of waterbirds in Asia include information on waterbird numbers at a large variety of sites designated under various international and national instruments including: 116 Ramsar sites, nine World Heritage sites, eight Association of South East Asian Nations (ASEAN) Heritage sites, nine Man and Biosphere (MAB) reserves, 502 Important Bird Areas, 55 East Asian–Australasian Flyway Network sites and 417 nationally protected areas. Out of 6,700 wetland sites in Asia covered by this analysis only 1,116 have some form of protected status (Li *et al.* 2009). The CSN approach pioneered through the WOW project in the African-Eurasian region could be extended to help identify site conservation priorities for waterbirds in Asia.

Effective management of key sites for migratory birds needs to address the whole range of factors that cause direct mortality (e.g. shooting, trapping, collisions, predation, pollution etc.), and those that reduce food supplies or destroy or degrade habitats. Any unnecessary disturbance (e.g. interference, hunting or persecution) that causes birds to expend energy in flight or increase their vigilance should be avoided, and the development of infrastructure such as wind-power, telecommunications and power transmission structures should take proper account of potential impacts on migratory birds.

Figure 7. The Critical Site Network Tool displaying the four populations of Black-tailed Godwit *Limosa limosa* which occur within the African-Eurasian region, and the percentage of each population recorded at IBAs during different stages of the annual cycle.



Addressing species-specific threats

Specific threats highlighted by this review that are of particular significance for migratory birds include: wind turbine developments; power line collisions and electrocutions; illegal trapping and shooting; reclamation of wetlands; and pollution, overfishing and the by-catch of seabirds during long-line and trawl fishing operations. These threats are identifiable and will need continued effort to address particular impacts on particular species. It should be noted that CMS has a mandate to do this. Parties to CMS must prohibit the taking of species on Appendix I (“endangered” species, including many globally threatened migrant birds) and assume responsibility for the species’ habitats and the obstacles to migration (including buildings, power lines, wind turbines and loss of stopover sites).

An issue to address is the cumulative impacts of wind turbine developments, particularly where they might collectively cause high levels of mortality for migratory birds. There is a need to understand better the individual impacts of turbine developments, especially bird mortality from collisions, and consider what cumulative effect this may have on migratory bird populations, and especially populations in an unfavourable state.

Power line and power pole electrocutions are a significant problem for several flagship bird species. The full scale and the significance of the problem for individual species need to be understood. Building on the work of Demmer *et al.* (2006), political and practical measures need to be developed, promoted and implemented to continue to combat electrocution of migrant birds, especially where such a problem is critical. Electrocutions can be prevented by framing poles with sufficient spacing to accommodate large birds, or by covering exposed energized parts. Collisions can be reduced by conspicuously marking power lines with appropriate devices. Electric utilities can develop and implement Avian Protection Plans to minimize bird mortality risks while enhancing power reliability (Liguori 2009). All such measures should be promoted and encouraged.

Strict legal protection is at the heart of CMS and yet there are documented examples of instances where hunting and taking continues illegally and/or in an unsustainable way. Illegal hunting and trapping have been successfully confronted in some regions such as parts of the northern Mediterranean and eastern Asia (e.g. Taiwan). Following on from a multi-stakeholder Sustainable Hunting Project, a regional action plan has been developed for the southern and eastern Mediterranean region that aims to foster 'responsible' hunting (BirdLife International 2007), providing useful guidance for others to follow. These examples show that this threat can be managed and tackled by the signatories to CMS. There are also many examples of sustainably-managed hunting and significant benefits arising from hunting, for example in the form of habitat conservation and protection.

Many international conventions and agreements concern pollution at seas. The most important in the context of seabird conservation are the Convention for the Prevention of Marine Pollution by Dumping of Wastes and Other Matter and Amendments, the International Convention for the Prevention of Pollution from Ships and Protocol of 1978, and the United Nations Convention on the Law of the Sea. At a regional level, conventions, agreements and protocols concerning various types of marine pollution have also been concluded for many sea areas (see Scott 1998). Many international instruments and regional agreements are also available to assist and make special provisions for protected areas and wildlife; some call for the establishment of marine and coastal protected areas. Pollution incidents can largely be avoided but responses towards polluters need to be made faster and penalties for these offences made higher (Larsen *et al.* 2006). A serious concern regarding all of these instruments, however, is a lack of enforcement, which can be especially challenging on the high seas for enforcement agencies.

There are numerous international agreements concerned with fisheries and other marine fauna, many of which are of considerable relevance to seabirds because of their role in the maintenance of the fish stocks and marine food chains. There is a need to continue to work with, and influence, fishery operators so that detrimental impacts on seabirds can be avoided or, at the very least, managed. Comprehensive assessment of gillnet fishery impact on seabird populations is lacking and is an important gap in our knowledge.

Longline and trawlfishing operations in their original form are considered the most important threat to albatrosses and were a major reason for the founding of ACAP. Around a third of albatross deaths are caused by illegal, unreported and unregulated fishing fleets. Government action to stamp out pirate fishing could stop many thousands of albatrosses from dying. It is, however, also necessary to reduce by-catch of albatrosses in legal fisheries. The FAO of the United Nations has developed detailed guidelines to support implementation of its International Plan of Action (IPOA) for combating the bycatch of seabirds within longline fisheries under their regulation (FAO 2009). Fortunately, there are already many simple and inexpensive ways to adjust equipment and ship practices to reduce fishery bycatch (e.g. Robertson 2006.

Fishermen are often unaware of the simple, cost effective techniques that can rapidly reduce albatross deaths. Dramatic results can be achieved by showing them how to use these techniques and telling them about how albatross numbers are declining. Recognising the gap between knowledge, policy and actual action on the deck of fishing vessels, BirdLife's Global Seabird Programme created the Albatross Task Force (ATF) in 2005 to work directly with fishermen, and raise awareness of seabird bycatch and the practical solutions to combat it. Many nations already have the authority to recommend, require and enforce bycatch reduction measures. International instruments for seabird conservation are available to assist and include the UN global driftnet ban, the FAO Code of Conduct for Responsible Fisheries, the FAO's International Plan of Action (IPOA) for Seabirds, and the ACAP. Better engagement with the relevant Regional Fisheries Management Organisations (RFMOs) to encourage implementation of improved mitigation practices is particularly important (Phillips *et al.* 2006).

Significant progress has been made in the reduction of bycatch of albatrosses and several other species of seabirds during longline and trawlfishing operations, but this remains as a high conservation priority. CMS has a mandate to intervene and an opportunity to influence; draft resolutions on the conservation of southern hemisphere albatrosses (6.4) and on addressing bycatch (6.10) have previously been prepared (UNEP/CMS undated a, b) and remain relevant today.

To benefit species on Appendix II, parties must seek agreements, ten of which for birds are currently in operation or under development, ranging from single species treaties (e.g. Aquatic Warbler *Acrocephalus paludicola*, Siberian Crane *Grus leucogeranus*) to those covering huge geographical areas and large numbers of species (e.g. the African–Eurasian Waterbird Agreement). Single Species Action Plans have also been prepared by a range of other organisations such as the Western Hemisphere Shorebird Reserve Network, BirdLife International and Wetlands International.

Many migratory species have benefited from such international agreements, and species action plans and management programmes have had a positive impact for some (e.g. Black-faced Spoonbill *Platalea minor* in East Asia, Kirtland's Warbler *Dendroica kirtlandii* in North America, and Puna Flamingo *Phoenicoparrus jamesi* in the Andes). Conservation priorities for particular species can be addressed through such action plans, but thematic campaigns that address specific impacts for all species affected also have an important role to play. It is vital, however, that action plans and programmes are correctly managed and resourced and so do not suffer from the common issues of lack of resources, lack of focus, absence of key range states, difficulties with enforcement, poor cross-compliance and coordination (see, e.g., Goriup and Tucker 2005).

As noted by Davidson and Stroud (2006), however, species-focused arguments may not influence decision-makers. More persuasive are likely to be arguments that stress the importance of maintaining and enhancing habitat biodiversity and natural processes which, in turn maintain the ecosystem services upon which both birds and humans depend. A similar message is apparent from UNEP/GEF projects, including WOW and the Siberian Crane Wetland Project (SCWP), whereby promoting flyway conservation from a combination of local, regional or trans-boundary perspectives, with emphasis on multiple conservation and socio-economic benefits rather than purely on bird conservation needs, has demonstrated greater chances of success especially in terms of engaging politicians and decision makers in conservation-oriented decisions (Zandri and Prentice 2009).

Assist climate change adaptation

As reviewed above, climate change impacts are likely to be critical for a range of migratory birds and this defines climate change adaptation as one of the key conservation priorities for coming years. If species cannot adapt to climate change and cannot be maintained at their present locations, they will only survive if they move into new areas. To facilitate species dispersal a coherent network of protected areas must be established (as discussed above), particularly towards the colder extremities of a species' range and in areas predicted to become drier.

A network of critical sites, not least along the world's flyways, is likely to maximise the potential of migratory birds to adapt to climate change. Such a network would provide a mosaic of the widest possible range of available habitat. Thus, whichever way the climate might locally change, such a diverse critical site network would keep as many doors as possible open to provide potentially suitable habitat in future. The WOW project discussed above provides a promising start to support the development and management of critical sites along avian flyways (Zandri and Prentice 2009, Barnard *et al.* 2010). It is important to establish and manage these networks to cope with the predicted habitat and species changes facing our planet in the future. Habitat composition is already changing throughout the world in connection with direct anthropogenic land use, but also more indirectly through climatic factors. The spatial and temporal migratory behaviour of many birds such as Trans-Saharan songbirds are also shifting. It is evident that international cooperation is urgently needed as a framework to facilitate the wide-reaching conservation action required.

Although networks of protected areas provide one means of aiding species dispersal, there is also a need to manage the wider countryside in a manner that favours dispersal. This is best achieved by integrating appropriate management into existing policy frameworks such as agri-environment schemes.

For some species, and in some areas, the only option is to minimise other impacts. To this end, limiting wetland drainage, landfilling and degradation and changes to hydrological regimes is important as this will buffer waterbirds against prolonged periods of drought and will also ensure that species can disperse adequately as climate changes.

To provide oceanic bird populations with the best chances of adapting to climate change, existing threats from overfishing, fisheries bycatch and pollution must be addressed. Proactive measures are also needed, such as removing invasive species and protecting existing or potential breeding colonies on high islands (e.g. NABCI 2010).

Conservation programmes must be expanded to include climate change impacts in biological planning, conservation design and habitat protection initiatives. Habitat corridors will be vital to allow birds to move to more suitable areas. Habitat conservation and the protection of core areas in cooperation with farmers and graziers will be required for grassland and aridland birds. The protection of large forest blocks and connecting landscapes by creating corridors will be vital for forest birds. Conserving coastal habitats will require planning and management to facilitate birds' movement and resilience (e.g. minimizing reclamation of intertidal wetlands and protecting foreshores as high tide roost sites is critical for the survival of migratory shorebirds). Minimizing human-caused disturbance to low-lying tundra and high-elevation alpine habitats may help the most vulnerable species adapt to changes (NABCI 2010).

References

Cited literature

Able, K. P. (1999) *Gatherings of angels. Migrating birds and their ecology*. Cornell University Press.

Ahola, M. P., Laaksonen, T., Eeva, T. and Lehikoinen, E. (2007) Climate change can alter competitive relationships between resident and migratory birds. *J. Anim. Ecol.* 76: 1045–1052.

Alerstam, T. (1990) *Bird migration*. Cambridge, U.K.: Cambridge University Press.

Alerstam, T., Backman, J., Strandberg, R., Gudmundsson, G. A., Hedenstrom, A, Henningsson, S. S. Karlsson, H. and Rosen, M. (2008) Great-circle migration of Arctic passerines. *Auk* 125: 831–838.

Amano, T. and Yamaura, Y. (2007) Ecological and life-history traits related to range contractions among breeding birds in Japan. *Biol. Conserv.* 37: 271–282.

Anker-Nilssen, T. (1991) Census of puffins in the area at risk from oil pollution from the central Norweigan continental shelf. In J. A. Borresen, and K. A. Moe, eds *AKUP Annual Report 1990*. Oslo: Mininstry of Oil and Energy.

Anon (undated). Climate change impacts on migratory species—the path ahead. ZSL/UNEP/CMS.

Atkinson, I. A. E. (1985) The spread of commensal species of *Rattus* to oceanic islands and their effect on island avifaunas. Pp. 35–81 in P. J. Moors, ed. *Conservation of island birds*. Cambridge, UK: International Council for Bird Preservation (Technical Publication).

Bailey, R. S., Furness, R. W., Gauld, J. A. and Kunzlik, P. A. (1991).Recent changes in the population of the sandeel at Shetland in relation to estimates of seabird predation. *ICES Mar. Sci. Symp.* 193: 209–216.

Bairlein, F. and Hűppop, O. (2004) Migratory fuelling and global climate change. *Adv. Ecol. Res*. 35: 33–47.

Baker, A. J., Gonzalez, P. M., Piersma, T., Niles, L. J., deLima Serraro do Nascimento, I., Atkinson, P. W., Clark, N. A., Minton, C. D. T., Peck, M. K. and Aarts, G. (2004) Rapid population decline in Red Knots: fitness consequences of decreased refuelling rates and late arrival in Delaware Bay. *Proc. R. Soc. Lond. B.* 271: 875–882.

Banks, A. N., Wright, L. J., Maclean, I. M. D., Hann, C. and Rehfisch, M. M. (2008) *Review of the status of introduced non-native waterbird species in the area of the African–Eurasian Waterbird Agreement: 2007 update*. Thetford: BTO (BTO Research Report No. 489).

Barnard, J., Bennun, L., Iyer, S., Keil, F. and Ponziani, C., eds (2010) *Wings Over Wetlands (WOW)—flyway conservation at work across Africa and Eurasia. Enhancing the conservation of the critical network of sites required by migratory waterbirds on the African–Eurasian Flyways.* UNEP-GEF.

Barnard, P. and Waage, J. K. (2004) Tackling species invasions around the world: regional responses to the invasive alien species threat. Cape Town: Global Invasive Species Programme.

Baumgart, W., Kasparek, M. and Stephan, B. (1995, 2003) [*Birds of Syria*]. Max Kasparek / Verlag. English edition by the Ornithological Society of the Middle East, Berlin.

Berthold, P. (1993) *Bird migration: a general survey*. Oxford: Oxford University Press.

Bevanger, K. (1998) Biological and conservation aspects of bird mortality caused by electricity power lines: a review. *Biol. Conserv*. 86: 67–76.

Biber, J.-P. and Salathé, T. (1991) Threats to migratory birds. Pp. 17–35 in T. Salathé, ed. *Conserving migratory birds*. Cambridge, U.K.: International Council for Bird Preservation (Technical Publication No. 12).

Bijlsma, R. G. (1990) Bottleneck areas for migratory birds in the Mediterranean region: an assessment of the problems and recommendations for action. Cambridge, U.K.: International Council for Bird Preservation.

BirdLife International (2000) *Threatened birds of the world*. Cambridge, U.K. and Barcelona, Spain: BirdLife International and Lynx Edicions.

BirdLife International (2004a) *Birds in Europe: population estimates, trends and conservation status*. Cambridge, U.K.: BirdLife International.

BirdLife International (2004b) *State of the world's birds 2004: indicators for our changing world*. Cambridge, U.K.: BirdLife International.

BirdLife International (2004c) *Threatened birds of the world 2004*. CD-ROM. Cambridge, U.K.: BirdLife International.

BirdLife International (2004d) Tracking ocean wanderers: the global distribution of albatrosses and petrels. Results from the Global Procellariiform Tracking Workshop. 1–5 September 2003, Gordon's Bay, South Africa. Canbridge, U.K.: BirdLife International.

BirdLife International (2007) Regional Action Plan for moving towards responsible hunting and the conservation of migratory birds in the Southern and Eastern Mediterranean region (2008–2013). Cambridge, U.K.: BirdLife International (Report for the European Commission LIFE Third Countries Project LIFE 04/TCY/INT/000054).

BirdLife International (2008a) *Threatened birds of the world 2008*. CD-ROM. Cambridge, U.K.: BirdLife International.

BirdLife International (2008b) A Red List Index for species listed on the Agreement on the Conservation of African-Eurasian Migratory Waterbirds (AEWA). Unpublished Report to UNEP/AEWA Secretariat.

BirdLife International (2008c) The Sustainable Hunting Project. Building capacity for the sustainable hunting of migratory birds in Mediterranean Third Countries. Report for the European Commission LIFE Third Countries Project (LIFE 04/TCY/INT/000054).

BirdLife International (2010) The BirdLife Checklist of the birds of the world with conservation status and taxonomic sources. Version 3.

Bobek, M., Hampl, R., Peske, L., Pojer, F., Simek, J. and Bures, S. (2008) African Odyssey project—satellite tracking of Black Storks *Ciconia nigra* breeding at a migratory divide. *J. Avian Biol.* 39: 500–506.

Boere, G. and Dodman, T. (2010) The flyway approach to the conservation and wise use of waterbirds and wetlands: a training kit. Module 1: Understanding the flyway approach. GEF AEWA ‘Wings Over Wetlands’ Project.

Boere, G. C. and Stroud, D. A. (2006) The flyway concept: what it is and what it isn't. Pp. 40–47 in G. Boere, C. Galbraith, and D. Stroud, eds, *Waterbirds around the world*. Edinburgh, U.K.: The Stationery Office.

Both, C., Artemyev, A. V., Blaauw, B., Cowie, R. J., Dekhuijzen, A. J., Eeva, T., Enemar, A., Gustafsson, L., Ivankina, E. V., Järvinen, A., Metcalfe, N. B., Nyholm, E. I., Potti, J., Ravussin, P., Sanz, J. J., Silverin, B., Slater, F. M., Sokolov, L. V., Török, J., Winkel, W., Wright, J., Zang, H. and Visser, M. E. (2004) Large-scale geographical variation confirms that climate change causes birds to lay earlier. *Proc. R. Soc. Lond*. B 271: 1657–1662.

Both, C., Sanz, J. J., Artemyev, A. V., Blaauw, V., Cowie, R. J., Dekhuizen, A. J., Enemar, A., Jarvinen, A., Nyholm, N. E. I., Potti, J., Ravussin, P. A., Silverin, B., Slater, F. M., Sokolov, L. B., Visser, M. E., Winkel, W., Wright, J. and Zang, H. (2006).Pied Flycatchers travelling from Africa to breed in Europe: differential effects of winter and migration conditions on breeding date. *Ardea* 94: 511–525.

Both, C., Van Turnhout, C. A. M., Bijlsma, R. G., Siepel, H., Van Strien, A. J. and Foppen, R. P. B. (2009) Avian population consequences of climate change are most severe for long-distance migrants in seasonal habitats. *Proc. R. Soc. Lond. Ser. B* doi:10.1098/RSPB.2009.1525.

Brouwer, J. (2009) The flyway approach to conserving migratory birds. Its necessity and value. Report to UNEP/CMS, Bonn, March 2009. Bennekom, The Netherlands: Brouwer Envir. & Agric. Consultancy.

Brown, J. D., Stallknecht, D. E., Beck, J. R., Suarez, D. L. and Swayne, D. E. (2006) Susceptibility of North American ducks and gulls to H5N1 Highly Pathogenic Avian Influenza viruses. *Emerging Infectious Diseases* 12(11): 1663–1670.

Brown, J. D., Stallknecht, D. E. and Swayne, D. E. (2008) Experimental infection of swans and geese with Highly Pathogenic Avian Influenza virus (H5N1) of Asian lineage. *Emerging Infectious Diseases* 14(1): 136–142.

Burton, R. (1992) Bird migration. Aurum Press, London; Facts on File, New York.

Butchart, S. H. M., Akçakaya, H. R., Chanson, J., Baillie, J. E. M., Collen, B., Quader, S., Turner, W. R., Amin, R., Stuart, S. N., Hilton-Taylor, C. and Mace, G. M. (2007) Improvements to the Red List Index. *Public Lib. Sci. One* 2(1): e140.

Butchart, S. H. M., Stattersfield, A. J., Bennun, L. A., Akçakaya, H. R., Baillie, J. E. M., Stuart, S. N., Hilton-Taylor, C. and Mace, G. M. (2005) Using Red List Indices to measure progress towards the 2010 target and beyond. *Phil. Trans. Roy. Soc.* 1454: 255–268.

Butchart, S. H. M., Stattersfield, A. J., Bennun, L. A., Shutes, S. M., Akçakaya, H. R., Baillie, J. E. M., Stuart, S. N., Hilton-Taylor, C. and Mace, G. M. (2004) Measuring global trends in the status of biodiversity: Red List Indices for birds*. Public Lib. Sci. Biol.* 2: 2294–2304.

Butler, R. W. (2000) Stormy seas for some North American songbirds: are declines related to severe storms during migration? *Auk* 117: 518–522.

Chambers, L. E. (2008) Trends in timing of migration of south-western Australian birds and their relationship to climate. *Emu* 108: 1–14.

Collar, N. J. and Andrew, P. (1988) *Birds to watch: the ICBP world checklist of threatened birds*. Cambridge, UK: International Council for Bird Preservation and International Union for Conservation of Nature and Natural Resources.

Collar, N. J., Crosby, M. J. and Stattersfield, A. J. (1994) *Birds to watch 2: the world list of threatened birds*. Cambridge, UK: BirdLife International.

Collar, N. J., Long, A. J., Robles Gil, P. and Rojo J. (2008) *Birds and people: bonds in a timeless journey*. Mexico City: CEMEX, Agrupación Sierra Madre and BirdLife International.

Coppack, T and Both, C. (2002) Predicting life-cycle adaptation of migratory birds to global climate change. *Ardea* 90: 369–378.

Croxall, J. P. and Nicol, S. (2004) Management of Southern Ocean resources: global forces and future sustainability. *Antarct. Sci.* 16: 569–584.

Daunt, F., Wanless, S., Greenstreet, S. P. R., Jensen, H., Hamer, K. C. and Harris, M. P. (2008) The impact of the sandeel fishery closure on seabird consumption, distribution, and productivity in the northwestern North Sea. *Can. J. Fish. Aquat. Sci.* 65: 362–381.

Davidson, N. C. and Stroud, D. A. (2006) African–Western Eurasian Flyways: current knowledge, population status and future challenges. Pp. 63–73 in G. C. Boere, C. A. Galbraith and D. A. Stroud. eds *Waterbirds around the world.* Edinburgh, U.K.: The Stationery Office.

Delany, S., Scott, D., Dodman, T. and Stroud, D., eds (2009) An atlas of wader populations in Africa and Western Eurasia. Wageningen: Wetlands International.

Delany, S. and Scott, D. (2006) *Waterbird Population Estimates*. Fourth Edition. Wageningen: Wetlands International.

Delany, S., Scott, D. A., Helmink, T. and Martakis, G. (2007) *Report on the conservation status of migratory waterbirds in the Agreement area*. Third edition. Bonn, Germany: AEWA (Technical Series No.13).

Demmer, B., Nohlen, N. and Heimberg, J., eds (2006) Caution: electrocution! Suggested practices for bird protection on power lines. Bundesverband: NABU.

Desholm, M. (2009) Avian sensitivity to mortality: prioritising migratory bird species for assessment at proposed wind farms. *Journal of Environmental Management* 90: 2672–2679.

Desholm, M. and Kahlert, J. (2005) Avian collision risk at an offshore wind farm. *Biol. Lett.* 1: 296–298.

Dobson, A. F. and Madeiros, J. (2009).Threats facing Bermuda's breeding seabirds: measures to assist future breeding success. In T. D. Rich, C. Arizmendi, D. Demarest, and C. Thompson, eds *Tundra to tropics: connecting birds, habitats and people*. Proceedings of the 4th International Partners in Flight Conference, 13–16 February 2008. McAllen, TX: Partners in Flight.

Dodman, T. and Boere, G. (2010) The flyway approach to the conservation and wise use of waterbirds and wetlands: a training kit. Module 2: Applying the flyway approach to conservation. GEF AEWA 'Wings Over Wetlands' Project.

Dodman, T. and Diagana, C. (2007) Movements of waterbirds within Africa and their conservation implications. *Ostrich* 78: 149–154.

Dolman, S. J., Simmonds, M. P. and Keith, S. (2003) Marine wind farms and cetaceans. Paper submitted to the Scientific Committee of the IWC (IWC/SC/55/E4).

Donald, P. F., Green, R. E. and Heath, M. F. (2001) Agricultural intensification and the collapse of Europe's farmland bird populations. *Proc. R. Soc. Lond. Ser. B Biol. Sci.* 268: 25–29.

Dunnet, G.M. (1987) Seabirds and North Sea oil. *Phil. Trans. R. Soc. Lond. B* 316: 513–524.

Elphick, J. (2007) *The atlas of bird migration: tracing the great journeys of the world's birds*. London: Natural History Museum.

Eno., N. C., Clark, R. A. and Sanderson, W. G., eds (1997) Non-native marine species in British waters: a review and directory. Peterborough: Joint Nature Conservation Committee.

Everaert, J. and Stienen, E. W. M. (2007) Impact of wind turbines on birds in Zeebrugge (Belgium). *Biodiv. Conserv.* 16: 3345–3359.

Ewing, S. R., Pain, D., Smith, K. W. and Grice, P. V. (2008) *A* review of population declines amongst Afro-Palearctic migratory birds, and lessons to be learned from the study of the population declines of Neotropical migrants**.** Sandy, U.K.: Royal Society for the Protection of Birds (unpublished internal report).

Fang, L. Q., de Vlas, S. J., Liang, S., Looman, C. W. N., Gong, P., Xu, B., Yan, L., Yang, H., Richardus, J. H. and Cao, W. C. (2008) Environmental factors contributing to the spread of H5N1 Avian Influenza in mainland China. *Plos One* 3: e2268.

FAO (2006) EMPRES Watch. Evolution of Highly Pathogenic Avian Influenza type H5N1 in Europe: review of disease ecology, trends and prospects of spread in autumn-winter 2006. Rome: Food and Agriculture Organization of the United Nations, Animal Health Division-EMPRES.

FAO (2008) FAO EMPRES-I database. Rome: Food and Agriculture Organization of the United Nations, Emergency Centre for Transboundary Animal Diseases (ECTAD), Animal Health Service.

FAO (2009) *Fishing operations. 2. Best practices to reduce incidental catch of seabirds in capture fisheries*. Rome: FAO (FAO Technical Guidelines for Responsible Fisheries. No. 1, Suppl. 2).

Fawen Qian, Heqi Wu, Libo Gao, Huige Zhang, Fengshan Li, Xingyao Zhong, Xiaojun Yang and Guangmei Zheng (2009) Migration routes and stopover sites on Black-necked Cranes determined by satellite tracking. *J. Field Ornithol.* 80: 19–26.

Fishpool, L., Bunting, G., May, I. and Stattersfield, A. (2009). Priority sites for conservation along the East Atlantic flyway: a review of migratory bird species and Important Bird Areas in five countries. Cambridge, U.K.: BirdLife International (unpublished report).

Frederiksen, M., Wanless, S., Harris, M. P., Rothery, P. and Wilson, L. J. (2004) The role of industrial fishery and oceanographic change on the decline of North Sea black-legged kittiwakes. *J. Appl. Ecol.* 41: 1129–1139.

Friend, M. (2006) Evolving changes in diseases of waterbirds. Pp. 412–417 in G. C. Boere, C. A. Galbraith and D. A. Stroud. eds *Waterbirds around the world.* Edinburgh, U.K.: The Stationery Office.

Furness, R. W. (1993) *An assessment of human hazards to seabirds in the North Sea*. Godalming, U.K.: World Wide Fund for Nature.

Furness, R. W. (1995) Are industrial fisheries a threat to seabirds? In M. L. Tasker, ed. *Threats to seabirds: Proceedings of the 5th International Seabird Group Conference*. Sandy, U.K.: The Seabird Group.

Furness, R. W. (2002) Management implications of interactions between fisheries and sandeel-dependent seabirds and seals in the North Sea. *ICES J. Mar. Sci.* 59: 261–269.

Gauthier-Clerc, M., Lebarbenchon, C. and Thomas, F. (2007) Recent expansion of highly pathogenic avian influenza H5N1: a critical review. *Ibis* 149: 202–214.

Giordano, A., Ricciardi, D., Candiano, G., Celesti, S. and Irrera, A. (1998) Anti-poaching on the Straits of Messina: results after 15 years of activities. Pp. 623–630 in B.-U. Meyburg, R. D. Chancellor, and J. J. Ferrero, eds. *Holarctic birds of prey*. Berlin: ADENEX-World Working Group on Birds of Prey and Owls.

Gombobaatar, S., Sumiya, D., Shagdarsuren, O., Potapov, E. and Fox, N. (2004) Saker Falcon (*Falco cherrug milvipes* Jerdon) mortality in Central Mongolia and population threats. *Mongolian J. Biol. Sci*. 2: 13–21.

Goriup, P. and Tucker, G. (2005) *Assessment of the merits of an instrument under the Convention on Migratory Species covering migratory raptors in the African-Eurasian region*. Bristol. U.K.: DEFRA.

Goriup, P. and Tucker, G. (2007) *Assessment of the merits of a CMS instrument covering migratory raptors in Africa and Eurasia*. Bristol, U.K.: DEFRA.

de Grammont, P. C. and Cuarón, A. D. (2006) An evaluation of threatened species categorization systems used on the American continent. *Conserv. Biol.* 20: 14–27.

Grémillet, D., Pichegru, L., Kuntz, G., Woakes, A. G., Wilkinson, S., Crawford, R. J. M. and Ryan, P. G. (2008) A junk-food hypothesis for gannets feeding on fishery waste. *Proc. R. Soc. Lond. Ser. B* 275: 1149–1156.

Grémillet, D. and Boulinier, T. (2009) Spatial ecology and conservation of seabirds facing global climate change: a review. *Mar. Ecol. Prog. Ser*. 391: 121–137.

Haas, D., Nipkow, M., Fiedler, G., Schneider, R., Haas, W. and Schürenberg, B. (2003) *Protecting birds from powerlines: a practical guide on the risks to birds from electricity transmission facilities and how to minimise any such adverse effects*. Strasbourg: Council of Europe.

Hayes, F. E. (1995) Definitions for migrant birds: what is a Neotropical migrant. *Auk* 112(2): 521–523.

Hill, M., Baker, R., Broad, G., Chandler, P. J., Copp, G. H., Ellis, J., Jones, D., Hoyland, C., Laing, I., Longshaw, M.,Moore, N., Parrott, D., Pearman, D., Preston, C., Smith, R.M. and Waters, R. (2005) Audit of non-native species in England. Peterborough: English Nature (English Nature Research Report 662).

Hobson, K. A., Wunder, M. B., Van Wilgenburg, S. L., Clark, R. G. and Wassenaar, L. I. (2009) A method for investigating population declines of migratory birds using stable isotopes: origins of harvested Lesser Scaup in North America. *Plos One* 4: e7915.

Howard, G.W. and Matindi, S.W. (2003). Alien invasive species in Africa's wetlands: Some threats and solutions. IUCN EARO, Nairobi, Kenya. 15pp.

Huntley, B., Green, R. E., Collingham, Y. C. and Willis, G. (2007) *A climatic atlas of European breeding birds*. Barcelona: Durham University, RSPB and Lynx Editions.

Hyrenbach, K. D., Forney, K. A. and Dayton, P. K. (2000) Marine protected areas and ocean basin management. *Aquatic Conservation-Marine and Freshwater Ecosystems* 10:437-458.

IPCC (2001) Climate change: the scientific basis. See http://www.grida.no/climate/ipcc_tar/wg1/index.htm.

IUCN (2001) *IUCN Red List categories and criteria: version 3.1*. Gland, Switzerland and Cambridge, U.K.: Species Survival Commission, IUCN.

IUCN (2005) Guidelines for using the IUCN Red List categories and criteria. Version 8.0. Available from http://intranet.iucn.org/webfiles/doc/SSC/RedList/RedListGuidelines.pdf.

Jones, T. and Cresswell, W. (2010) The phenology mismatch hypothesis: are declines of migrant birds linked to uneven global climate change? *Journal of Animal Ecology* 79: 98–108.

Kelly, J. F., Johnson, M. J., Langridge, S. and Whitfield, M. (2008) Efficacy of stable isotope ratios in assigning endangered migrants to breeding and wintering sites. *Ecol. Appl.* 18: 568–576.

Kilpatrick, M., Chmura, A. A., Gibbons, D. W., Fleischer, R. C., Marra, P. P. and Daszak, P. (2006) Predicting the global spread of H5N1 avian influenza. *Proceedings of the National Academy of Sciences* 103(15): 19368–19373.

Kirby, J., Davidson, N., Giles, N., Owen, M. and Spray, C. (2004) *Waterbirds and Wetland Recreation Handbook: a review of issues and management practice*. Slimbridge, U.K.: Wildfowl and Wetlands Trust.

Kirby, J. S., Stattersfield, A. J., Butchart, S. H. M., Evans, M. I., Grimmett, R. F. A., Jones, V. R., O'Sullivan, J., Tucker, G. M. and Newton, I. (2008) Key conservation issues for migratory land- and waterbird species on the world's major flyways. *Bird Conserv. Int.* 18: S74–S90.

Klem, D. (2009) Avian mortality at windows: the second largest human source of bird mortality on earth. In T. D. Rich, C. Arizmendi, D. Demarest, and C. Thompson, eds *Tundra to tropics: connecting birds, habitats and people*. Proceedings of the 4th International Partners in Flight Conference, 13–16 February 2008. McAllen, TX: Partners in Flight.

Kock, K.-H., Reid, K., Croxall, J. P. and Nicol, S. (2007) Fisheries in the Southern Ocean—an ecosystem approach. *Phil. Trans. R. Soc. Lond.* 362: 2333–2349.

Kuiken, T., Fouchier, R. A. M., Rimmelzwaan, G. F. and Osterhaus A. D. M. E. (2006) *Emerging viral diseases in waterbirds.* Pp. 418–421 in G. C. Boere, C. A. Galbraith and D. A. Stroud. eds *Waterbirds around the world.* Edinburgh, U.K.: The Stationery Office.

Langston, R. H. W. and Pullan, J. D. (2004) *Effects of wind farms on birds*. Strasbourg: Council of Europe Publishing (Nature and Environment No. 139).

Larsen, J. L., Durinck, J. and Skov, H. (2006) Trends in chronic marine oil pollution in Danish waters assessed through 22 years of beached bird surveys. In *Seabird populations under pressure*. 9th International Conference, Aberdeen: The Seabird Group.

Li, Z. W. D., Bloem, A., Delany S., Martakis G. and Quintero J. O. (2009) Status of waterbirds in Asia. Results of the Asian Waterbird Census: 1987–2007. Kuala Lumpur: Wetlands International.

Liguori, S. (2009) Protecting birds while powering America: an overview of efforts by the electric utility industry to reduce bird mortality and improve power reliability. In T. D. Rich, C. Arizmendi, D. Demarest, and C. Thompson, eds *Tundra to tropics: connecting birds, habitats and people*. Proceedings of the 4th International Partners in Flight Conference, 13–16 February 2008. McAllen, TX: Partners in Flight.

Lindsell, J. A., Serra, G., Peske, L., Abdullah, M. S., Qaim, G. al, Kanani, A. and Wondafrash, M. (2009) Satellite tracking reveals the migration route and wintering area of the Middle East population of Critically Endangered Northern Bald Ibis *Geronticus eremita*. *Oryx* 43: 329–335.

Liu, J., Xiao, H., Lei, F., Zhu, Q., Qin, K., Zhang, X., Zhang, X., Zhao, D., Wang, G., Feng, Y., Ma, J., Liu, W., Wang, J. and Gao, F. (2005) Highly pathogenic H5N1 influenza virus infection in migratory birds. *Science Online.* Available from http://www.sciencemag.org/cgi/content/abstract/309/5738/1206.

Lowe S., Browne M. and Boudjelas, S. (2000) *100 of the world's worst invasive alien species—a selection from the Global Invasive Species Database*. Auckland: IUCN/SSC Invasive Species Specialist Group.

de Lucas, M., Janss, G. F. E. and Ferrer, M. (2007) *Birds and wind farms*. Madrid: Quercus.

van Maanen, E., Goradze, I., Gavashelishvili, A. and Goradze, R. (2001) Trapping and hunting of migratory raptors in western Georgia. *Bird Conserv. International* 11: 77–92.

Maclean, I. M. D., Rehfisch, M. M., Delany, S. and Robinson, R. A. (2008) *The effects of climate change on migratory waterbirds within the African–Eurasian Flyways*. Bonn: AEWA (Technical Series No.21).

Madsen, J. (1998a) Experimental refuges for migratory waterfowl in Danish wetlands. I. Baseline assessment of the disturbance effects of recreational activities. *J. Applied Ecol.* 35: 386–397.

Madsen, J. (1998b) Experimental refuges for migratory waterfowl in Danish wetlands. II. Tests of hunting disturbance effects. *J. Applied Ecol.* 35: 398–417.

Madsen, J. and Fox, A. D. (1995) Impacts of hunting disturbance on waterbirds: a review. *Wildlife Biology* 1: 193–203.

Mainguy, J. Bêty, J., Gauthier, G. and Giroux, G. F. (2002) Are body condition and reproductive effort of laying Greater Snow geese affected by the spring hunt? *Condor* 104: 156–161.

Manuel, A. J.,Bécares, J., Rodríguez, B., Viada, C. and Ruiz, A. (2009) Seabird conservation through site-based protection at sea: the first marine IBA inventory in Spain. In 10th International Conference, Brugge, Belguim. Aberdeen: The Seabird Group (Vliz Special Publication 42: Communications of the Research Institute for Nature and Forest – INBO.M.2009.1).

Manville, A. M. (2005) Bird strikes and electrocutions at power lines, communication towers, and wind turbines: state of the art and state of the science—next steps toward mitigation. Pp. 1051–1064 in C. J. Ralph, and T. D. Rich, eds *Bird conservation implementation in the Americas*. Proceedings of the 3rd International Partners in Flight Conference 2002. Albany, CA: Pacific Southwest Research Station (USDA Forest Service General Technical Report PSW-GTR-191).

Manville, A. M. (2009) Towers, turbines, power lines, and buildings—steps being taken by the U.S. Fish and Wildlife Service to avoid or minimize take of migratory birds at these structures. In T. D. Rich, C. Arizmendi, D. Demarest and C. Thompson, eds Tundra to tropics: connecting birds, habitats and people. Proceedings of the 4th International Partners in Flight Conference, 13–16 February 2008. McAllen, TX: Partners in Flight.

Mezquida, E.T., Villaran, A. and Pascual-Parra, J. (2007) Timing of autumn bird migration in central Spain in light of recent climate change. *Ardeola* 54: 251–259.

Møller, A. P., Rubolini, D. and Lehikoinen, E. (2008) Populations of migratory bird species that do not show a phenological response to climate change are declining. *Proceedings of the National Academy of Sciences* 105: 16195–16200.

Monaghan, P., Uttley, J. D. and Burns, M. D. (1992) Effect of changes in food availability on reproductive effort in Arctic terns. *Ardea* 80: 71–81.

Mooney, H. A., Mack, R. N., McNeely, J. A., Neville, L. E., Schei, P. J., and Waage, J. K., eds (2005) *Invasive alien species: a new synthesis***.** Covelo, California: Island Press.

Mormat, J. Y. and Guermeur, Y. (1979) *L'Amoco Cadiz et les oiseaux*. Ministerie de l'Environment et du Cadre de Vie.

Moseikin, V. (2003) The operation and construction of fatal powerlines in Russia and Kazaksthan. Sixth world conference on birds of prey and owls, Budapest, Hungary (poster).

Mundkur, T. (2006) Successes and challenges of promoting conservation of migratory waterbirds and wetlands in the Asia–Pacific region: nine years of a regional strategy. Pp. 81–87 in G. C. Boere, C. A. Galbraith and D. A. Stroud, eds *Waterbirds around the world.* Edinburgh, U.K.: The Stationery Office.

Murillo, K., Prado S., Pesquero M. and Drews, C. (2008) Migratory species: biological, cultural and economic assets of the Americas. San José, Costa Rica: WHMSI, USFWS and WWF.

Mutschler, T. (2003). Lac Alaotra. p. 1530–1534 in: Goodman, S.M. & Benstead, J.P. (eds.), The Natural History of Madagascar. The University of Chicago Press, Chicago.

NABCI (2009) The state of the birds, United States of America, 2009. Report from the North American Bird Conservation Initiative, U.S. Committee. Washington, DC: U.S. Department of Interior.

NABCI (2010) The state of the birds, 2010. Report on climate change, United States of America. Report from the North American Bird Conservation Initiative, U.S. Committee. Washington, DC: U.S. Department of Interior.

Newman, S. H., Iverson, S. A., Takekawa, J. Y., Gilbert, M. and Prosser, D. J. (2009) Migration of Whooper Swans and outbreaks of Highly Pathogenic Avian Influenza H5N1 virus in eastern Asia. *PLoS ONE* 4(5): e5729. doi:10.1371/journal.pone.0005729.

Newton, I. (1998) *Population limitation in birds*. London: Academic Press.

Newton, I. (2004) Population limitation in migrants. *Ibis* 146: 197–226.

Newton, I. (2007) Weather-related mass-mortality events in migrants. *Ibis* 149: 453–467.

Newton, I. (2008) *The ecology of bird migration*. London: Academic Press.

Nicholson, D. (2007) Migratory species: working together towards a vision for 2020. Seminar at the Smithsonian Institution; Washington DC. Bonn: UNEP / CMS Secretariat.

Nisbet, I. C. T. (1995) Seabirds off the east coast of the USA: status, trends and threats. In M. L. Tasker, ed. Threats to seabirds: *Proceedings of the 5th International Seabird Group Conference*. Sandy, U.K.: The Seabird Group.

Olendorff, R. R., Miller, A. D. and Lehman, R. R. (1981) Suggested practices for raptor protection on power lines—the state-of-the-art in 1981. St. Paul, MN: Raptor Res. Found. (Raptor Res. Rep. No. 4).

Orme, C. D. L., Davies, R. G., Olson, V. A., Thomas, G. H., Ding, T-S., Rasmussen, P. C., Ridgeley, R. S., Stattersfield, A. J., Bennett, P. M., Owens, I. P. F. , Blackburn, T. M. and Gaston, K. J. (2006) Global patterns of geographic range size in birds. *PLoS Biology* 4(7): e208.

Pain, D. J. and Pienkowskil, M. W. (1997) *Farming and birds in Europe: the Common Agricultural Policy and its implications for bird conservation*. London: Academic Press.

Pauly, D., Christensen, V., Dalsgaard, J., Froese, R. and Torres Jr, F. (1998) Fishing down marine food webs. *Science* 279: 860–863.

Peterjohn, B. G., Sauer, J. R. and Robbins, C. S. (1995) Population trends from the North American Breeding Bird Survey. Pp. 3–39 in T. E. Martin and D. M. Finch, eds, *Ecology and management of Neotropical migratory birds: a synthesis and review of critical issues*. Oxford: Oxford University Press.

Petersen, I. K., Fox, A. D. and Clausager, I. (2003) *Distribution and numbers of birds in Kattegat in relation to the proposed offshore wind farm south of Læsø – Ornithological impact assessment*. Department of Wildlife Ecology and Biodiversity, National Environmental.

Phillips, R. A., Small, C., Silk, J. R. D and Croxall, J. P. (2006) Conservation of albatrosses and petrels from South Georgia: population declines, overlap with fisheries and RFMO engagement. In *Seabird populations under pressure*. 9th International Conference, Aberdeen, Scotland. Aberdeen: The Seabird Group.

Piatt, J. F., Lensink, C. J., Butler, W., Kendziorek, M. and Nysewander, D. R. (1990) Immediate impact of the Exxon Valdez oil spill on marine birds. Auk 107: 387–397.

Piersma, T. (1987) Hop, skip, jump? Constraints on migration of arctic waders by feeding, fattening, and flight speed. *Limosa* 60: 185–194.

Portelli, P. (1994) Large-scale shooting of raptors in the Maltese Islands. Pp. 799 in B.-U. Meyburg, and R. D. Chancellor, eds. *Raptor conservation today*. Mountfield, U.K.: Pica Press.

Porter, R. F. (2005) Soaring bird migration in the Middle East and North East Africa: the bottleneck sites. Report to BirdLife International for the UNDP/GEF “Migratory Soaring Birds” project.

Prosser, D. J., Takekawa, J. Y., Newman, S. H., Yan, B., Douglas, D. C., Hou, Y., Xing, Z., Zhang, D., Li, T., Li, Y., Zhao, D., Perry, W. M. and Palm, E. C. (2009) Satellite-marked waterfowl reveal migratory connection between H5N1 outbreak areas in China and Mongolia. *Ibis* 151: 1–9.

Raine, A. F. (2007) The international impact of hunting and trapping in the Maltese Islands. BirdLife Malta (internal report).

Ramsar Bureau (1999) Strategic Framework and guidelines for the future development of the List of Wetlands of International Importance of the Convention on Wetlands (Ramsar, Iran, 1971). Gland, Switzerland: Ramsar.

Regan, T. J., Burgman, M. A., McCarthy, M. A., Master, L. L., Keith, D.A., Mace, G. M. and Andelman, S. J. (2005) The consistency of extinction risk classification protocols. *Conserv. Biol*. 19: 1,969–1,977.

Robbins, C. S., Sauer, J. R., Greenberg, R. S. and Droege, S. (1989) Population declines in North American birds that migrate to the Neotropics. *Proc. Nat. Acad. Sci*. 86: 7658–7662.

Robertson, C. J. R. (2006) New Zealand trawl fisheries and seabird interaction. In *Seabird populations under pressure*. 9th International Conference, Aberdeen, Scotland. Aberdeen: The Seabird Group.

Robinson, R. A., Learmouth, J. A., Hutson, A. M., MacLeod, C. D., Sparks, T. H., Leech, D. I., Pierce, G. J., Rehfische, M. M. and Crick, H. Q. P. (2005) *Climate change and migratory species*. Thetford, U.K.: British Trust for Ornithology.

Rocke, T. (2006a) Disease emergence and impacts in migratory waterbirds. Workshop introduction. Pp. 410–411 in G. C. Boere, C. A. Galbraith and D. A. Stroud. eds *Waterbirds around the world.* Edinburgh, U.K.: The Stationery Office.

Rocke, T. E. (2006b) The global importance of avian botulism. Pp. 422–426 in G. C. Boere, C. A. Galbraith and D. A. Stroud. eds *Waterbirds around the world.* Edinburgh, U.K.: The Stationery Office.

Rodrigues, A. S. L., Pilgrim, J. D., Lamoreux, J. F., Hoffman, M. and Brooks, T. M. (2006) The value of the IUCN Red List for conservation. *Trends Ecol. Evol*. 21: 71–76.

Roemmich, D. and McGowan, J. A. (1995) Climatic warming and the decline of zooplankton in the California Current. *Science* 267: 1324–1326.

Ryan, P.G. (ed.) (2007). Field Guide to the Animals and Plants of Tristan da Cunha and Gough Island. Pisces Publications, Newbury, UK.

Salafsky, N., Salzer, D., Stattersfield, A. J., Hilton-Taylor, C., Neugarten, R., Butchart, S. H. M., Collen, B., Cox, N., Master, L. L., O'Connor, S. and Wilkie, D. (2008) A standard lexicon for biodiversity conservation: unified classifications of threats and actions. *Conservation Biology* 22: 897–911.

Sanderson, F. J., Donald, P. F., Pain, D. J., Burfield, I. J. and van Bommel, F. P. J. (2006) Long-term population declines in Afro–Palearctic migrant birds. *Biol. Conserv*. 131: 93–105.

Sanpera, C., Ruiz, X., Moreno, R., Jover, L. and Waldron, S. (2007) Mercury and stable isotopes in feathers of Audouin's Gulls as indicators of feeding habits and migratory connectivity. *Condor* 109: 268–275.

Sauer, J. R. and Droege, S. (1992). Geographic patterns in population trends of Neotropical migrants in North America. Pp. 26–42 in J. M. Hagan and D. W. Johnston, eds, *Ecology and conservation of Neotropical migrant landbirds.* Washington, D. C.: Smithsonian Institution Press.

Sauer, J. R., Hines, J. E. and Fallon, J. (2005) *The North American Breeding Bird Survey, results and analysis 1966–2005*. Laurel, MD: USGS Patuxent Wildlife Research Centre.

Schaub, M., Kania, W. and Koppen, U. (2005) Variation of primary production during winter induces synchrony in survival rates in migratory white storks *Ciconia ciconia*. *J. Anim. Ecol*. 74: 656–666.

Scott, D. A. (1998) Global overview of the conservation of migratory arctic breeding birds outside the arctic. Iceland: CAFF (Wetlands International Publication No. 45/CAFF Technical Report No. 4).

Sillett, T. S., Holmes, R. T. and Sherry, T. W. (2000) Impacts of a global climate cycle on population dynamics of a migratory songbird. *Science* 288: 2040–2042.

Sparks, J.S. & Stiassny, M.L.J. 2003. Introduction to the Freshwater Fishes. p. 849–863 in: Goodman, S.M. & Benstead, J.P. (eds.), The Natural History of Madagascar. The University of Chicago Press, Chicago.

Spiridonov, V. A. and Nikolaeva, N. G. (2005) *Driftnet fishery for salmon in the Pacific and its influence on marine ecosystem*. Moscow: WWF.

Stotz, D. F., Fitzpatrick, J. W., Parker, T. A. and Moskovits, D. K. (1996) *Neotropical birds: ecology and conservation.* Chicago: University of Chicago Press.

Stroud, D. A., Baker, A., Blanco, D. E., Davidson, N. C., Delany, S., Ganter, B., Gill, R., González, P., Haanstra, L., Morrison, R. I. G., Piersma, T., Scott, D. A., Thorup, O.,West, R.,Wilson, J. and Zöckler, C. (on behalf of the International

Wader Study Group) (2006) The conservation and population status of the world's waders at the turn of the millennium. Pp. 643–648 in G. C. Boere, C. A. Galbraith and D. A. Stroud. eds *Waterbirds around the world.* Edinburgh, U.K.: The Stationery Office.

Terborgh, J. (1989). *Where have all the birds gone?* Princeton: Princeton University Press.

Tomkovich, P. S., Syroechkovski, E. E. Jr., Lappo, E. G. and Zöckler, C. (2002) First indications of a sharp population decline in the globally threatened Spoon-billed Sandpiper *Eurynorhynchus pygmeus. Bird Conservation International* 12: 1–18.

Tucker, G. (2005) Conservation of birds in the eastern sector of the African–Eurasia flyway system. Migratory soaring birds: review of status, threats and priority conservation actions. Huntingdon, U.K.: Ecological Solutions (report to BirdLife International for the UNDP/GEF "Migratory Soaring Birds" project).

Tucker, G. M. and Evans, M. I. (1997) *Habitats for birds in Europe: a conservation strategy for the wider environment*. Cambridge, UK: BirdLife International.

Tucker, G. and Goriup, P. (2005) *Assessment of the merits of an instrument under the Convention on Migratory Species covering migratory raptors in the African-Eurasian region: status report*. Bristol. U.K.: DEFRA.

UNEP/AEWA (2008) Avian Influenza and wild birds—what is their actual role in the spread of the virus? Bonn: AEWA,.

UNEP/CMS (undated a) Convention on the Conservation of Migratory Species of Wild Animals. By-catch: draft resolution 6.10 (Rev 1). UNEP and CMS.

UNEP/CMS (undated b) Convention on the Conservation of Migratory Species of Wild Animals. Draft resolution 6.4 (Rev 1): Southern hemisphere Albatross conservation.

UNEP/CMS. (2006). Migratory species and climate change—impacts of a changing environment on wild animals. UNEP/CMS/DEFRA.

UNEP/CMS (2009) A bird's eye view on flyways—a brief tour by the Convention on the Conservation of Migratory Species of Wild Animals. UNEP/CMS.

USFWS (2007) Status of the Red Knot (*Calidris canutus rufa*) in the western hemisphere. Pleasantville, New Jersey: USFWS.

USFWS (2002) 2001 National Survey of fishing, hunting and wildlife-associated recreation. US Fish and Wildlife Service, US Dept of Commerce, and US Census Bureau.

Veit, R. R., McGowan, J. A., Ainley, D. G., Wahl, T. R. and Pyle, P. (1997) Apex marine predator declines 90% in association with changing oceanic climate. *Glob. Change Biol.* 3: 23–28.

Visser, M. E., Perdeck, A. C., van Balen, J. H. and Both, C. (2009) Climate change leads to decreasing bird migration distances. *Glob. Change Biol.* 15: 1859–1865.

Visser, M. E., Perdeck, A. C., van Balen, J. H. and Both, C. (2009) Climate change leads to decreasing bird migration distances. *Global Change Biology* 15: 1859–1865.

Wanless, R.M., Angel, A., Cuthbert, R.J., Hilton, G.M. & Ryan, P.G. 2007. Can predation by invasive mice drive seabird extinctions? Biol. Lett. (2007) 3, 241–244.

Wells, D. R. (2007) *The birds of the Thai–Malay Peninsula, 2: passerines*. London: Christopher Helm.

Wiens, J. A. (1995) Is oil pollution a threat to seabirds? Lessons from the Exxon Valdez oil spill. In M. L. Tasker, ed. *Threats to seabirds: Proceedings of the 5th International Seabird Group Conference.* Sandy, U.K.: The Seabird Group.

Will, T. C, Ruth, J. M., Rosenberg, K. V., Krueper, D., Hahn, D., Fitzgerald, J., Dettmers, R. and Beardmore, C. J. (2005) *The five elements process: designing optimal landscapes to meet bird conservation objectives*. Partners in Flight (Technical Series No. 1).

Williams, E. T. C., Beilfuss, R. D. and Dodman, T. (2003) Status survey and conservation Action Plan for the Black Crowned Crane *Balearica pavonina*. Dakar and Baraboo, Wisconsin: Wetlands International and International Crane Foundation.

Wilson, J. R., Czajkowski, M. A. and Pienkowski, M. W. (1980) The migration through Europe and wintering in west Africa of Curlew Sandpipers. *Wildfowl* 31: 107–122.

Wohl K. D. (2006) The Arctic—origin of flyways. Pp. 120–123 in G. C. Boere, C. A. Galbraith and D. A. Stroud, eds *Waterbirds around the world*. Edinburgh, U.K.: The Stationery Office.

Woodfield, E. and Langstone, R. (2004) *Literature review on the impact of bird populations of disturbance due to human access on foot*. Sandy: Royal Society for the Protection of Birds.

Wright, P. J. and Bailey, M. C. (1993) Biology of sandeels in the vicinity of seabird colonies at Shetland. Aberdeen: SOAFD.

Yohannes, E., Hobson, K. A. and Pearson, D. J. (2007) Feather stable-isotope profiles reveal stopover habitat selection and site fidelity in nine migratory species moving through sub-Saharan Africa. *J. Avian Biol.* 38: 347–355.

Yu, Y. T. (2003) *International Black-faced Spoonbill census: 24–26 January 2003.* Hong Kong: Hong Kong Birdwatching Society.

Zalles, J. I. and Bildstein, K. L. (2000) *Raptor watch: a global directory of raptor migration sites*. Cambridge, U.K.: Birdlife International and Hawk Mountain Sanctuary.

Zandri, E and Prentice, C., eds (2009) The experience of UNEP GEF and partners in flyway conservation. Nairobi: UNEP GEF (Portfolio Outlook and Evolution. Biodiversity Issue Paper BD/001).

Zino, F., Heredia, B. and Biscoito, M. J. (1996).Action Plan for Zino's petrel. In B. Heredia, L. Rose, and M. Painter, eds Globally threatened birds in Europe: Action Plans. Strasbourg: Council of Europe and BirdLife International.

Zöckler, C. and Bunting, G. (2006) International single species Action Plan for the conservation of the Spoon-billed Sandpiper *Eurynorhynchus pygmeus*. ArcCona Ecological Consulting.

Zöckler, C. and Lysenko, I. (2000) *Waterbirds on the edge*. Cambridge, U.K.: UNEP-World Conservation Monitoring Centre (WCMC Biodiversity Series No. 11).

Žydelis, R., Sims, M. and Dagys, M. (2006) Bird bycatch in coastal gillnets—local impact or significant threat to waterbird populations? In Seabird populations under pressure. 9th International Conference, Aberdeen, Scotland. Aberdeen: The Seabird Group.

Additional literature (not reviewed - not cited)

Bamford, M., Watkins, D., Bancroft, W., Tischler, G. and Wahl, J. (2008) Migratory shorebirds of the East Asian–Australasian Flyway: population estimates and internationally important sites. Canberra: Wetlands International - Oceania.

Beaumont, L. J., McAllan, A. W. and Hughes, L. (2006) A matter of timing: changes in the first date of arrival and last date of departure of Australian migratory birds. *Glob. Change Biol.* 12: 1339–1354.

Bensusan, K. J., Garcia, E. F. J. and Cortes, J. E. (2007) Trends in abundance of migrating raptors at Gibraltar in Spring. *Ardea* 95: 83–90.

Blancher, P. J., Jacobs, B., Couturier, A., Beardmore, C. J., Dettmers, R., Dunn, E. H., Easton, W., Iñigo-Elias, E. E., Rich, T. D., Rosenberg, K. V. and Ruth, J. M. (2006) *Making connections for bird conservation: linking states, provinces & territories to important wintering and breeding grounds*. Partners in Flight (Technical Series No. 4).

Bregnballe, T., Noer, H., Christensen, T. K., Clausen, P., Asferg, T., Fox, A. D. and Delany, S. (2006) Sustainable hunting of migratory waterbirds: the Danish approach. In G. C. Boere, C. A. Galbraith and D. A. Stroud, eds *Waterbirds around the world*. Edinburgh, U.K.: The Stationary Office.

Brookes, K and Thompson, P. M. (2006) Assessing the impact of offshore windfarms on seabirds. In Seabird populations under pressure. 9th International Conference, Aberdeen, Scotland. Aberdeen: The Seabird Group.

Chesser, R. T. (1994) Migration in South America: an overview of the austral system. *Bird Conserv. Int.* 4: 91–107.

Dingle, H. (2008). Bird migration in the southern hemisphere: a review comparing continents. *Emu* 108: 341–359.

Dodman, T. (2009) Conservation of migratory birds and their habitats along the west coast of Africa. BirdLife International (Workshop Report for the the MAVA Foundation, Dakar, Senegal 19–22 November 2009).

Drewitt, A. L. and Langston, R. H. W. (2008) Collision effects of wind-power generators and other obstacles on birds. *Annals of the New York Academy of Sciences* 1134: 233–266.

Egevang, C, Stenhouse, I. J., Phillips, R. A., Petersen, A., Fox, J. W. and Silk, J. R. D. (2010) Tracking of Arctic terns *Sterna paradisaea* reveals longest animal migration. *Proc. Nat. Acad. Sci. USA.* 107: 2078–2081.

Evans, W. R. and Manville, A. M., eds (2000) *Avian mortality at communication towers*. Ithaca, New York: Cornell University.

Fox, A. D., Desholm, M, Kahlert, J., Christensen, T. K. and Petersen, I. K. (2006) Information needs to support environmental impact assessment of the effects of European marine offshore wind farms on birds. *Ibis* 148: 129–144.

Gehring, J., Kerlinger, P. and Manville, A. M. (2009) Communication towers, lights, and birds: successful methods of reducing the frequency of avian collisions. *Ecological Applications* 19: 505–514.

Gill, R. E., Tibbitts, T. L., Douglas, D. C., Handel, C. M., Mulcahy, D. M., Gottschalck, J. C., Warnock, N., McCaffery, B. J., Battley, P. F. and Piersma, T. (2009) Extreme endurance flights by landbirds crossing the Pacific Ocean: ecological corridor rather than barrier? *Proc. Biol. Sci.* 276: 447–457.

Hahn, S., Bauer, S. and Liechti, F. (2009). The natural link between Europe and Africa-2.1 billion birds on migration. *Oikos* 118: 624-626.

Heldbjerg, H. and Fox, T. (2008). Long-term population declines in Danish trans-Saharan migrant birds. *Bird Study* 55: 267-279.

Hewson, C. M. and Noble, D. G. (2009) Population trends of breeding birds in British woodlands over a 32-year period: relationships with food, habitat use and migratory behaviour. *Ibis* 151: 464-486.

Hilgerloh, G. (2009). The desert at Zait Bay, Egypt: a bird migration bottleneck of global importance. *Bird Conservation International* 19: 338-352.

International Wader Study Group (1998) The Odessa Protocol on international co-operation on migratory flyway research and conservation. In H. Hötker, E. Lebedeva, P. S. Tomkovich, J. Gromadzka, N. C. Davidson, J. Evans, D. A. Stroud and R. B. West, R.B., eds Migration and international conservation of waders. Research and conservation on North Asian, African and European flyways. *International Wader Studies* 10: 17–19.

Jones, J., Norris, D.R., Girvan, M.K., Barg, J.J., Kyser, T.K. and Robertson, R.J. (2008). Migratory connectivity and rate of population decline in a vulnerable songbird. *Condor* 110: 538-544.

Kanstrup, N. (2006) Sustainable harvest of waterbirds. A global review. In G.C. Boere, C.A. Galbraith and D.A. Stroud, eds *Waterbirds around the world*. Edinburgh, U.K.: The Stationary Office.

Krijgsveld, K. L., Akershoek, K., Schenk, F., Dijk, F. and Dirksen, S. (2009) Collision risk of birds with modern large wind turbines. *Ardea* 97: 357–366.

La Sorte, F. A. and Thompson, F. R. (2007) Poleward shifts in winter ranges of North American birds. *Ecology* 88: 1803–1812.

Madsen, J. (1995) Impacts of disturbance on migratory waterfowl. *Ibis* 137: S67–74.

Masden, E. A., Haydon, D. T., Fox, A. D., Furness, R. W., Bullman, R. and Desholm, M. (2009) Barriers to movement: impacts of wind farms on migrating birds. *Ices Journal of Marine Science* 66: 746–753.

Mehlman, D. W., Mabey, S. E., Ewert, D. N., Duncan, C., Abel, B., Cimprich, D., Sutter, R.and Woodfrey, M. (2005) Conserving stop-over sites for forest-dwelling migratory landbirds. *Auk* 122(4): 1–11.

Møller, A. P. and Rubolini, D. (2008) Populations of migratory bird species that did not show a phenological response to climate change are declining. *Proc. Natl. Acad. Sci. USA* 105: 16195–16200.

Nebel, S., Porter, J. L. and Kingsford, R. T. (2008) Long-term trends of shorebird populations in eastern Australia and impacts of freshwater extraction. *Biol. Conserv.* 141: 971–980.

Nevoux, M., Barbraud, J.-C. and Barbraud, C. (2008) Nonlinear impact of climate on survival in a migratory White Stork population. *J. Anim. Ecol.* 77: 1143–1152.

Newson, S. E., Mendes, S., Crick, H. Q. P., Dulvy, N. K., Houghton, J. D. R., Hays, G. C., Hutson, A. M., Macleod, C. D., Pierce, G. J. and Robinson, R. A. (2008) Indicators of the impact of climate change on migratory species. *Endang. Spec. Res.* 7: 101–113.

Newton, I. (2006) Can conditions experienced during migration limit the population levels of birds? *J. Orn*. 147: 146–166.

Olsen, B., Munster, V. J., Wallenstein, A., Waldenström, J., Osterhaus, A. D. M. E. and Fouchier, R. A. M. (2006) Global patterns of Influenza A virus in wild birds. *Science* 312:384–388.

Percival, S. (2005) Birds and wind farms: what are the real issues? British Birds 98: 194–204.

Podolsky, R. H. (2006) Environmental challenges and status report on North American offshore wind power as it relates to marine birds. In *Seabird populations under pressure*. 9th International Conference, Aberdeen, Scotland. Aberdeen: The Seabird Group.

Rich, T. D., Arizmendi, C., Demarest, D. and Thompson, C., eds (2009) *Tundra to tropics: connecting birds, habitats and people*. Proceedings of the 4th International Partners in Flight Conference, 13–16 February 2008. McAllen, TX: Partners in Flight.

Rich, T. D., C. J. Beardmore, H. Berlanga, P. J. Blancher, M. S. W. Bradstreet, G. S. Butcher, D. W. Demarest, E. H. Dunn, W. C. Hunter, E. E. Iñigo-Elias, J. A. Kennedy, A. M. Martell, A. O. Panjabi, D. N. Pashley, K. V. Rosenberg, C. M. Rustay, J. S. Wendt and T. C. Will. (2004) *Partners in Flight North American Landbird Conservation Plan*. Ithaca, NY: Cornell Lab of Ornithology.

Russell, D. J. (2006) Modelling the effects of climate change on seabird distribution and population dynamics. In *Seabird populations under pressure*. 9th International Conference, Aberdeen, Scotland. Aberdeen: The Seabird Group.

Saino, N., Rubolini, D., Lehikoinen, E., Sokolov, L. V., Bonisoli-Alquati, A., Ambrosini, R., Boncoraglio, G. and Møller, A. P. (2009) Climate change effects on migration phenology may mismatch brood parasitic cuckoos and their hosts. *Biol. Lett.* 5: 539–541.

Skov, H., Maclean, I. M. D, Piper, W. and Rehfisch, M. M. (2006) Assessment of potential bird displacement effects arising from the construction and operation of offshore wind farms. In *Seabird populations under pressure*. 9th International Conference, Aberdeen, Scotland. Aberdeen: The Seabird Group.

Takekawa, J. Y., Heath, S. R., Douglas, D. C., Perry, W. M., Javed, S., Newman, S. H., Suwal, R. N., Rahmani, A. R., Choudhury, B. C., Prosser, D. J., Yan, B., Hou, Y., Batbayar, N., Natsagdorj, T., Bishop, C. M., Butler, P. J., Frappell, P. B., Milsom, W. K., Scott, G. R., Hawkes, L. A. and Wikelski, M. (2009) Geographic variation in Bar-headed Geese *Anser indicus*: connectivity of wintering areas and breeding grounds across a broad front. *Wildfowl* (2009) 59: 100–123.

Telleria, J. L. (2009) Potential impacts of wind farms on migratory birds crossing Spain. *Bird Conservation International* 19: 131–136.

Telleria, J.L., Ramirez, A., Galarza, A., Carbonell, R, Perez-Tris, J and Santos, T. (2009). Do migratory pathways affect the regional abundance of wintering birds? A test in northern Spain. *Journal of Biogeography* 36: 220-229.

Zwarts, L., Bijlsma, R.G., van der Kamp, J and Wymenga E. 2009. Living on the edge: Wetlands and birds in a changing Sahel. KNNV publishing, Zeist.

Appendices

Annex 1. Numbers of migratory bird species by type, region and country

Region 1: Americas					
Sub-region	**Landbirds**	**Waterbirds**	**Soaring birds**	**Seabirds**	**TOTAL**
North America	**357**	**208**	**36**	**123**	**621**
Canada	271	172	27	89	471
USA	354	207	36	123	617
Central America	**385**	**173**	**38**	**100**	**603**
Costa Rica	226	107	29	44	353
Guatemala	229	96	28	28	335
Honduras	216	88	27	21	309
Mexico	328	162	37	94	531
Panama	216	88	26	28	315
South America	**464**	**195**	**36**	**126**	**744**
Argentina	302	141	29	64	487
Bolivia	290	95	29	3	385
Brazil	268	118	30	59	423
Chile	121	135	18	90	320
Colombia	285	119	33	45	425
Ecuador	224	112	29	43	355
Peru	257	127	29	56	417
Venezuela	228	103	29	25	340
Caribbean	**233**	**144**	**28**	**55**	**398**
Region 2: Europe, Central Asia, Africa & Middle East					
Sub-region	**Landbirds**	**Waterbirds**	**Soaring birds**	**Seabirds**	**TOTAL**
Europe	**266**	**164**	**49**	**82**	**458**
Azerbaijan	187	123	42	32	312
France	168	124	34	58	310
Greece	179	123	41	38	307
Italy	175	122	35	46	307
Russia (European)	213	143	44	56	369
Spain	174	126	38	63	322
Turkey	205	131	42	37	340
Central Asia	**327**	**154**	**49**	**41**	**485**
Afghanistan	221	98	37	16	319
Kazakhstan	253	133	45	28	386
Russia (Central Asian)	216	126	41	37	346
Turkmenistan	205	125	39	29	332
Uzbekistan	197	116	40	22	313
Middle East	**282**	**169**	**55**	**64**	**468**
Iran, Islamic Republic of	240	149	49	46	395
Iraq	200	127	41	27	328
Israel	200	121	40	37	329
Saudi Arabia	185	117	44	30	307

Africa	**363**	**224**	**75**	**122**	**657**
Egypt	184	126	43	38	318
Ethiopia	196	133	60	13	329
Kenya	192	150	57	30	349
South Africa	151	142	49	77	342
Sudan	214	152	61	21	366
Tanzania	182	154	53	29	341
Region 3: Asia–Pacific					
Sub-region	**Landbirds**	**Waterbirds**	**Soaring birds**	**Seabirds**	**TOTAL**
Asia	**708**	**267**	**81**	**105**	**1015**
Bangladesh	200	122	35	17	325
Bhutan	291	58	35	6	349
China (mainland)	541	198	66	62	755
India	453	173	58	47	638
Indonesia	205	121	30	35	343
Japan	174	167	32	77	373
Laos	264	80	34	6	344
Mongolia	197	110	41	19	307
Myanmar	352	134	45	21	488
Nepal	360	119	52	16	479
Pakistan	280	148	48	36	434
Russia (Asian)	253	183	49	68	458
South Korea	172	150	35	42	333
Thailand	298	130	38	27	437
Vietnam	294	134	39	24	432
Australasia	**118**	**98**	**18**	**95**	**289**
Oceania	**55**	**80**	**9**	**62**	**187**

Notes The sum of the totals by region or type exceeds the total number of migratory species (2,453) because some species occur in more than one region, soaring birds are not exclusive of landbirds or waterbirds, and seabirds are not exclusive of waterbirds. Countries are assigned to regions according to BirdLife's programmatic approach. Only the 50 countries with highest numbers of migratory species are shown. Some countries are very poorly documented particularly in passage areas and thus numbers of species may be under-recorded.

Annex 2. Threatened and Near Threatened migratory bird species

Species Name				Type				Region					Global Flyway								IBAs		CMS Instruments					
Scientific	**Common**	**Migration type**	**Population trend**	**Landbird**	**Soaring bird**	**Waterbird**	**Seabird**	**Americas**	**Africa-Eurasia**	**Central Asia**	**East Asia-Australasia**	**Number of countries**	**Pacific Americas**	**Central Americas**	**Atlantic Americas**	**East Atlantic**	**Black Sea-Mediterranean**	**East Asia-East Africa**	**Central Asia**	**East Asia-Australasia**	**Number of IBAs**	**Number of proposed IBAS**	**CmsAppx1**	**CmsAppx2**	**AEWA**	**ACAP**	**AEBOP**	**MoU**
Critically Endangered (CR)																												
Tadorna cristata	Crested Shelduck	F				Y					Y	2																
Phoebastria irrorata	Waved Albatross	F	↓				Y	Y				4									4			Y		Y		
Diomedea amsterdamensis	Amsterdam Albatross	F	↓				Y					1									1		Y			Y		
Diomedea dabbenena	Tristan Albatross	F	↓				Y	Y	Y			7									2			Y		Y		
Pterodroma phaeopygia	Galapagos Petrel	F	↓				Y	Y				6									7		Y					
Pseudobulweria becki	Beck's Petrel	F	↓				Y				Y	2																
Puffinus mauretanicus	Balearic Shearwater	F	↓				Y		Y			8											Y					
Puffinus auricularis	Townsend's Shearwater	F	↓				Y	Y			Y	4																
Geronticus eremita	Northern Bald Ibis	F	↓			Y			Y			10						Y			9	1	Y	Y	Y			
Houbaropsis bengalensis	Bengal Florican	F	↓	Y							Y	5								Y	37							
Grus leucogeranus	Siberian Crane	F	↓		Y	Y			Y	Y	Y	13						Y	Y	Y	55	1	Y	Y	Y			Y
Vanellus gregarius	Sociable Lapwing	F	↓			Y			Y	Y	Y	26						Y	Y		51	1	Y	Y	Y			

Species Name				Type				Region					Global Flyway								IBAs		CMS Instruments					
Scientific	Common	Migration type	Population trend	Landbird	Soaring bird	Waterbird	Seabird	Americas	Africa-Eurasia	Central Asia	East Asia-Australasia	Number of countries	Pacific Americas	Central Americas	Atlantic Americas	East Atlantic	Black Sea-Mediterranean	East Asia-East Africa	Central Asia	East Asia-Australasia	Number of IBAs	Number of proposed IBAS	CmsAppx1	CmsAppx2	AEWA	ACAP	AEBOP	MoU
Numenius borealis	Eskimo Curlew	F				Y		Y				5		Y	Y								Y	Y				Y
Numenius tenuirostris	Slender-billed Curlew	F	↓			Y			Y	Y		24					Y	Y			42		Y	Y	Y			Y
Eurynorhynchus pygmeus	Spoon-billed Sandpiper	F	↓			Y					Y	16								Y	42		Y	Y				
Sterna bernsteini	Chinese Crested Tern	F	↓			Y	Y				Y	6								Y	4		Y					
Vermivora bachmanii	Bachman's Warbler	F		Y				Y				2			Y													
Endangered (EN)																												
Branta ruficollis	Red-breasted Goose	F	↓			Y			Y	Y	Y	24					Y				115		Y	Y	Y			
Aythya baeri	Baer's Pochard	F	↓			Y					Y	15								Y	124		Y	Y				
Mergus squamatus	Scaly-sided Merganser	F	↓			Y					Y	9								Y	55			Y				
Oxyura leucocephala	White-headed Duck	F	↓			Y			Y	Y	Y	28					Y	Y	Y		173	10	Y	Y	Y			
Eudyptes moseleyi	Northern Rockhopper Penguin	F	↓				Y		Y			2																
Spheniscus demersus	African Penguin	F	↓				Y		Y			4									13			Y	Y			
Phoebastria nigripes	Black-footed Albatross	F	↑				Y	Y			Y	12									4	1		Y		Y		
Diomedea sanfordi	Northern Royal Albatross	F	↓				Y	Y	Y		Y	12										1		Y		Y		

Species Name				Type				Region					Global Flyway								IBAs		CMS Instruments					
Scientific	**Common**	**Migration type**	**Population trend**	**Landbird**	**Soaring bird**	**Waterbird**	**Seabird**	**Americas**	**Africa-Eurasia**	**Central Asia**	**East Asia-Australasia**	**Number of countries**	**Pacific Americas**	**Central Americas**	**Atlantic Americas**	**East Atlantic**	**Black Sea-Mediterranean**	**East Asia-East Africa**	**Central Asia**	**East Asia-Australasia**	**Number of IBAs**	**Number of proposed IBAS**	**CmsAppx1**	**CmsAppx2**	**AEWA**	**ACAP**	**AEBOP**	**MoU**
Phoebetria fusca	Sooty Albatross	F	↓				Y	Y	Y		Y	8									12			Y		Y		
Thalassarche melanophrys	Black-browed Albatross	F	↓				Y	Y	Y		Y	15									18	10		Y		Y		
Thalassarche chlororhynchos	Atlantic Yellow-nosed Albatross	F	↓				Y	Y	Y			8									4			Y		Y		
Thalassarche carteri	Indian Yellow-nosed Albatross	F	↓				Y		Y		Y	8									4			Y		Y		
Pterodroma baraui	Barau's Petrel	F	↓				Y		Y		Y	2									2							
Pterodroma atrata	Henderson Petrel	F	↓				Y				Y	1									1		Y					
Pterodroma alba	Phoenix Petrel	F	↓				Y				Y	3									1	1						
Pterodroma madeira	Zino's Petrel	F	↔				Y		Y			2									1							
Pterodroma cahow	Bermuda Petrel	F	↑				Y	Y				2									1		Y					
Pterodroma hasitata	Black-capped Petrel	F	↓				Y	Y				6									3							
Pterodroma incerta	Atlantic Petrel	F	↓				Y	Y	Y			7									2							
Puffinus huttoni	Hutton's Shearwater	F	↔				Y				Y	2																
Nesofregetta fuliginosa	White-throated Storm-petrel	F	↓				Y	Y			Y	4									1	2						
Oceanodroma homochroa	Ashy Storm-petrel	F	↓				Y	Y				2									2	1						

Species Name				Type				Region					Global Flyway								IBAs		CMS Instruments					
Scientific	**Common**	**Migration type**	**Population trend**	**Landbird**	**Soaring bird**	**Waterbird**	**Seabird**	**Americas**	**Africa-Eurasia**	**Central Asia**	**East Asia-Australasia**	**Number of countries**	**Pacific Americas**	**Central Americas**	**Atlantic Americas**	**East Atlantic**	**Black Sea-Mediterranean**	**East Asia-East Africa**	**Central Asia**	**East Asia-Australasia**	**Number of IBAs**	**Number of proposed IBAS**	**CmsAppx1**	**CmsAppx2**	**AEWA**	**ACAP**	**AEBOP**	**MoU**
Pelecanoides garnotii	Peruvian Diving-petrel	F	↓				Y	Y				2									3	6	Y					
Podiceps gallardoi	Hooded Grebe	F	↔			Y		Y				2									8	1						
Ciconia stormi	Storm's Stork	F	↓		Y	Y					Y	5									47							
Ciconia boyciana	Oriental Stork	F	↓		Y	Y					Y	7								Y	89		Y					
Leptoptilos dubius	Greater Adjutant	F	↓		Y	Y					Y	8							Y	Y	42							
Platalea minor	Black-faced Spoonbill	F	↓		Y	Y					Y	10								Y	76		Y					
Gorsachius magnificus	White-eared Night-heron	F	↓			Y					Y	2									12							
Gorsachius goisagi	Japanese Night-heron	F	↓			Y					Y	8								Y	16		Y					
Ardeola idae	Madagascar Pond-heron	F	↓			Y			Y			15						Y			36		Y	Y	Y			
Phalacrocorax neglectus	Bank Cormorant	C	↓			Y	Y		Y			2									9			Y	Y			
Falco cherrug	Saker Falcon	F	↓	Y	Y				Y	Y	Y	55					Y	Y	Y	Y	177	8		Y			Y	
Neophron percnopterus	Egyptian Vulture	F	↓	Y	Y				Y	Y	Y	77				Y	Y	Y	Y		176	8	Y	Y			Y	
Sypheotides indicus	Lesser Florican	F	↓	Y							Y	3							Y		20							
Sarothrura ayresi	White-winged Flufftail	F	↓			Y			Y			3									9		Y	Y	Y			
Grus americana	Whooping Crane	F	↑		Y	Y		Y				2		Y							9			Y				
Grus japonensis	Red-crowned Crane	F	↓		Y	Y					Y	6								Y	101		Y	Y				

Species Name				Type				Region					Global Flyway								IBAs		CMS Instruments					
Scientific	**Common**	**Migration type**	**Population trend**	**Landbird**	**Soaring bird**	**Waterbird**	**Seabird**	**Americas**	**Africa-Eurasia**	**Central Asia**	**East Asia-Australasia**	**Number of countries**	**Pacific Americas**	**Central Americas**	**Atlantic Americas**	**East Atlantic**	**Black Sea-Mediterranean**	**East Asia-East Africa**	**Central Asia**	**East Asia-Australasia**	**Number of IBAs**	**Number of proposed IBAS**	**CmsAppx1**	**CmsAppx2**	**AEWA**	**ACAP**	**AEBOP**	**MoU**
Tringa guttifer	Spotted Greenshank	F	↓			Y					Y	18								Y	62		Y	Y				
Sterna lorata	Peruvian Tern	C	↓			Y	Y	Y				3									6	6	Y					
Anodorhynchus hyacinthinus	Hyacinth Macaw	F	↓	Y				Y				3									26							
Rhynchopsitta pachyrhyncha	Thick-billed Parrot	N	↓	Y				Y				2										6						
Aratinga solstitialis	Sun Parakeet	N	↓	Y				Y				2									2							
Brotogeris pyrrhoptera	Grey-cheeked Parakeet	C	↓	Y				Y				2									24		Y					
Amazona vinacea	Vinaceous Amazon	N	↓	Y				Y				3									31							
Tachycineta cyaneoviridis	Bahama Swallow	F	↓	Y				Y				3			Y						5							
Acrocephalus griseldis	Basra Reed-warbler	F	↓	Y					Y			13						Y			14		Y	Y				
Zoothera guttata	Spotted Ground-thrush	F	↓	Y					Y			6						Y			25		Y	Y				
Dendroica chrysoparia	Golden-cheeked Warbler	F	↓	Y				Y				6		Y							5	14						
Sporophila palustris	Marsh Seedeater	F	↓	Y				Y				4			Y						39		Y	Y				Y
Vulnerable (VU)																												
Tragopan melanocephalus	Western Tragopan	A	↓	Y							Y	2									23							
Tragopan blythii	Blyth's	A	↓	Y							Y	4									34							

Species Name				Type				Region					Global Flyway								IBAs		CMS Instruments					
Scientific	**Common**	**Migration type**	**Population trend**	**Landbird**	**Soaring bird**	**Waterbird**	**Seabird**	**Americas**	**Africa-Eurasia**	**Central Asia**	**East Asia-Australasia**	**Number of countries**	**Pacific Americas**	**Central Americas**	**Atlantic Americas**	**East Atlantic**	**Black Sea-Mediterranean**	**East Asia-East Africa**	**Central Asia**	**East Asia-Australasia**	**Number of IBAs**	**Number of proposed IBAS**	**CmsAppx1**	**CmsAppx2**	**AEWA**	**ACAP**	**AEBOP**	**MoU**
Lophophorus sclateri	Tragopan Sclater's Monal	A	↓	Y							Y	3									14							
Anser cygnoides	Swan Goose	F	↓			Y				Y	Y	8								Y	145		Y	Y				
Anser erythropus	Lesser White-fronted Goose	F	↓			Y			Y	Y	Y	41				Y	Y			Y	206		Y	Y	Y			
Anas formosa	Baikal Teal	F	↓			Y				Y	Y	9								Y	110	1	Y	Y				
Marmaronetta angustirostris	Marbled Teal	F	↓			Y			Y	Y	Y	28				Y		Y	Y		137	6	Y	Y	Y			
Polysticta stelleri	Steller's Eider	F	↓			Y	Y	Y	Y	Y	Y	13				Y				Y	24	2	Y	Y	Y			
Eudyptes chrysocome	Southern Rockhopper Penguin	F	↓				Y	Y	Y		Y	6																
Eudyptes chrysolophus	Macaroni Penguin	F	↓				Y	Y	Y			9									15	4						
Spheniscus humboldti	Humboldt Penguin	F	↓				Y	Y				2									6	16	Y					
Phoebastria albatrus	Short-tailed Albatross	F	↑				Y	Y			Y	9									4		Y			Y		
Diomedea exulans	Wandering Albatross	F	↓				Y	Y	Y		Y	17									13	2		Y		Y		
Diomedea antipodensis	Antipodean Albatross	F	↓				Y	Y			Y	4										5		Y		Y		
Diomedea epomophora	Southern Royal Albatross	F	↔				Y	Y	Y		Y	12									1	3		Y		Y		
Thalassarche	Campbell	F	↑				Y				Y	7										1		Y		Y		

Species Name				Type				Region					Global Flyway								IBAs		CMS Instruments					
Scientific	**Common**	**Migration type**	**Population trend**	**Landbird**	**Soaring bird**	**Waterbird**	**Seabird**	**Americas**	**Africa-Eurasia**	**Central Asia**	**East Asia-Australasia**	**Number of countries**	**Pacific Americas**	**Central Americas**	**Atlantic Americas**	**East Atlantic**	**Black Sea-Mediterranean**	**East Asia-East Africa**	**Central Asia**	**East Asia-Australasia**	**Number of IBAs**	**Number of proposed IBAS**	**CmsAppx1**	**CmsAppx2**	**AEWA**	**ACAP**	**AEBOP**	**MoU**
impavida	Albatross																											
Thalassarche eremita	Chatham Albatross	F	↔				Y	Y			Y	9										2		Y		Y		
Thalassarche salvini	Salvin's Albatross	F					Y	Y	Y		Y	8									1	3		Y		Y		
Thalassarche chrysostoma	Grey-headed Albatross	F	↓				Y	Y	Y		Y	14									9	4		Y		Y		
Pterodroma externa	Juan Fernandez Petrel	F	↔				Y	Y			Y	5										1						
Pterodroma sandwichensis	Hawaiian Petrel	F	↓				Y	Y			Y	2										1	Y					
Pterodroma solandri	Providence Petrel	F	↑				Y	Y			Y	9									2							
Pterodroma pycrofti	Pycroft's Petrel	F	↑				Y	Y			Y	4																
Pterodroma longirostris	Stejneger's Petrel	F	↔				Y	Y			Y	9										1						
Pterodroma leucoptera	Gould's Petrel	F	↓				Y	Y			Y	11									3							
Pterodroma cookii	Cook's Petrel	F	↑				Y	Y			Y	13									1							
Pterodroma cervicalis	White-necked Petrel	F	↑				Y	Y			Y	17									1							
Procellaria aequinoctialis	White-chinned Petrel	F	↓				Y	Y	Y		Y	17									6	4		Y		Y		
Procellaria conspicillata	Spectacled Petrel	F	↑				Y	Y	Y			6									1			Y		Y		
Procellaria westlandica	Westland Petrel	F	↔				Y	Y			Y	2										4		Y		Y		

Species Name				Type				Region					Global Flyway								IBAs		CMS Instruments					
Scientific	**Common**	**Migration type**	**Population trend**	**Landbird**	**Soaring bird**	**Waterbird**	**Seabird**	**Americas**	**Africa-Eurasia**	**Central Asia**	**East Asia-Australasia**	**Number of countries**	**Pacific Americas**	**Central Americas**	**Atlantic Americas**	**East Atlantic**	**Black Sea-Mediterranean**	**East Asia-East Africa**	**Central Asia**	**East Asia-Australasia**	**Number of IBAs**	**Number of proposed IBAS**	**CmsAppx1**	**CmsAppx2**	**AEWA**	**ACAP**	**AEBOP**	**MoU**
Procellaria parkinsoni	Parkinson's Petrel	F	↔				Y	Y			Y	10										3		Y		Y		
Puffinus bulleri	Buller's Shearwater	F	↑				Y	Y			Y	17									1							
Puffinus creatopus	Pink-footed Shearwater	F					Y	Y				9									2	5	Y					
Puffinus heinrothi	Heinroth's Shearwater	F	↔				Y				Y	2																
Phoenicoparrus andinus	Andean Flamingo	F	↓			Y		Y				4									33	5	Y	Y				Y
Mycteria cinerea	Milky Stork	F	↓		Y	Y					Y	3									35							
Leptoptilos javanicus	Lesser Adjutant	F	↓		Y	Y					Y	13									223							
Geronticus calvus	Southern Bald Ibis	F	↓			Y			Y			3									30							
Egretta vinaceigula	Slaty Egret	C	↓			Y			Y			7									10			Y	Y			
Egretta eulophotes	Chinese Egret	F	↓			Y					Y	14								Y	93		Y					
Balaeniceps rex	Shoebill	C	↓			Y			Y			9									23			Y	Y			
Pelecanus crispus	Dalmatian Pelican	F	↓		Y	Y			Y	Y	Y	31					Y		Y	Y	258		Y	Y	Y			
Morus capensis	Cape Gannet	C	↓				Y		Y		Y	13									10			Y	Y			
Phalacrocorax nigrogularis	Socotra Cormorant	F	↓			Y	Y		Y			10									24			Y	Y			
Falco naumanni	Lesser Kestrel	F	↓	Y	Y				Y	Y	Y	91				Y	Y	Y			334	17	Y	Y			Y	
Haliaeetus leucoryphus	Pallas's Fish-eagle	F	↓	Y	Y				Y	Y	Y	19						Y	Y		149		Y	Y			Y	

Species Name				Type				Region					Global Flyway								IBAs		CMS Instruments					
Scientific	**Common**	**Migration type**	**Population trend**	**Landbird**	**Soaring bird**	**Waterbird**	**Seabird**	**Americas**	**Africa-Eurasia**	**Central Asia**	**East Asia-Australasia**	**Number of countries**	**Pacific Americas**	**Central Americas**	**Atlantic Americas**	**East Atlantic**	**Black Sea-Mediterranean**	**East Asia-East Africa**	**Central Asia**	**East Asia-Australasia**	**Number of IBAs**	**Number of proposed IBAS**	**CmsAppx1**	**CmsAppx2**	**AEWA**	**ACAP**	**AEBOP**	**MoU**
Haliaeetus pelagicus	Steller's Sea-eagle	F	↓	Y	Y						Y	5								Y	51		Y	Y			Y	
Gyps coprotheres	Cape Vulture	F	↓	Y	Y				Y			5									30			Y				
Circaetus beaudouini	Beaudouin's Snake-eagle	N	↓	Y	Y				Y			15										1						
Circus maurus	Black Harrier	F	↔	Y	Y				Y			4				Y		Y			23						Y	
Aquila clanga	Greater Spotted Eagle	F	↓	Y	Y				Y	Y	Y	78					Y	Y	Y	Y	357	3	Y	Y			Y	
Aquila adalberti	Spanish Imperial Eagle	C	↑	Y	Y				Y			2									28		Y	Y			Y	
Aquila heliaca	Eastern Imperial Eagle	F	↓	Y	Y				Y	Y	Y	64					Y	Y	Y	Y	369	11	Y	Y			Y	
Otis tarda	Great Bustard	F	↓	Y					Y	Y	Y	37						Y		Y	257	16	Y	Y				Y
Chlamydotis undulata	Houbara Bustard	F	↓	Y					Y	Y	Y	35						Y	Y	Y	45		Y	Y				Y
Coturnicops exquisitus	Swinhoe's Rail	F	↓			Y					Y	6								Y	9							
Rallus antarcticus	Austral Rail	F	↓			Y		Y				2									4	1						
Balearica pavonina	Black Crowned Crane	C	↓		Y	Y			Y			20									9			Y	Y			
Balearica regulorum	Grey Crowned Crane	C	↓		Y	Y			Y			15												Y	Y			
Grus antigone	Sarus Crane	F	↓		Y	Y					Y	9								Y	100							
Grus vipio	White-naped Crane	F	↓		Y	Y					Y	6								Y	78		Y	Y				

Species Name				Type				Region					Global Flyway								IBAs		CMS Instruments					
Scientific	**Common**	**Migration type**	**Population trend**	**Landbird**	**Soaring bird**	**Waterbird**	**Seabird**	**Americas**	**Africa-Eurasia**	**Central Asia**	**East Asia-Australasia**	**Number of countries**	**Pacific Americas**	**Central Americas**	**Atlantic Americas**	**East Atlantic**	**Black Sea-Mediterranean**	**East Asia-East Africa**	**Central Asia**	**East Asia-Australasia**	**Number of IBAs**	**Number of proposed IBAS**	**CmsAppx1**	**CmsAppx2**	**AEWA**	**ACAP**	**AEBOP**	**MoU**
Grus paradisea	Blue Crane	C	↓		Y	Y			Y			3									28			Y	Y			
Grus carunculatus	Wattled Crane	C	↓		Y	Y			Y			11									52			Y	Y			
Grus monacha	Hooded Crane	F	↓		Y	Y				Y	Y	7								Y	65		Y	Y				
Grus nigricollis	Black-necked Crane	A	↓		Y	Y					Y	4									47		Y	Y				
Anarhynchus frontalis	Wrybill	F	↓			Y					Y	1												Y				
Gallinago nemoricola	Wood Snipe	F	↓			Y					Y	6							Y	Y	41			Y				
Numenius tahitiensis	Bristle-thighed Curlew	F	↓			Y		Y			Y	22									5	4		Y				
Numenius madagascariensis	Far Eastern Curlew	F	↓			Y		Y			Y	25								Y	36			Y				
Calidris tenuirostris	Great Knot	F	↓			Y			Y		Y	30							Y	Y	34			Y	Y			
Glareola ocularis	Madagascar Pratincole	F	↓			Y			Y			5						Y			4			Y	Y			
Larus atlanticus	Olrog's Gull	F	↓			Y	Y	Y				3			Y						18		Y					
Larus saundersi	Saunders's Gull	F	↓			Y	Y				Y	9								Y	55		Y					
Larus relictus	Relict Gull	F	↓			Y				Y	Y	6									25		Y					
Rissa brevirostris	Red-legged Kittiwake	F	↓			Y	Y	Y			Y	3									3	1						
Sterna nereis	Fairy Tern	F	↓			Y	Y				Y	3								Y	36							

Species Name				Type				Region					Global Flyway								IBAs		CMS Instruments					
Scientific	**Common**	**Migration type**	**Population trend**	**Landbird**	**Soaring bird**	**Waterbird**	**Seabird**	**Americas**	**Africa-Eurasia**	**Central Asia**	**East Asia-Australasia**	**Number of countries**	**Pacific Americas**	**Central Americas**	**Atlantic Americas**	**East Atlantic**	**Black Sea-Mediterranean**	**East Asia-East Africa**	**Central Asia**	**East Asia-Australasia**	**Number of IBAs**	**Number of proposed IBAS**	**CmsAppx1**	**CmsAppx2**	**AEWA**	**ACAP**	**AEBOP**	**MoU**
Rynchops albicollis	Indian Skimmer	F	↓			Y					Y	7									44							
Synthliboramphus wumizusume	Japanese Murrelet	C	↓				Y				Y	3									17		Y					
Columba eversmanni	Pale-backed Pigeon	F	↓	Y					Y	Y	Y	10							Y		23							
Patagioenas oenops	Peruvian Pigeon	F	↓	Y				Y				2									7							
Leptotila ochraceiventris	Ochre-bellied Dove	F	↓	Y				Y				2									19							
Ducula pickeringii	Grey Imperial-pigeon	N	↓	Y							Y	4									17							
Charmosyna palmarum	Palm Lorikeet	N	↓	Y							Y	2																
Ara militaris	Military Macaw	A	↓	Y				Y				7									36	7						
Leptosittaca branickii	Golden-plumed Parakeet	N	↓	Y				Y				3									36							
Touit costaricensis	Red-fronted Parrotlet	A	↓	Y				Y				2									11							
Hapalopsittaca pyrrhops	Red-faced Parrot	A	↓	Y				Y				2									9							
Amazona pretrei	Red-spectacled Amazon	F	↓	Y				Y				2									5							
Apus acuticauda	Dark-rumped Swift	F	↔	Y							Y	3									9							
Dendrocopos dorae	Arabian Woodpecker	A	↓	Y					Y			2									12							

Species Name				Type				Region					Global Flyway								IBAs		CMS Instruments					
Scientific	Common	Migration type	Population trend	Landbird	Soaring bird	Waterbird	Seabird	Americas	Africa-Eurasia	Central Asia	East Asia-Australasia	Number of countries	Pacific Americas	Central Americas	Atlantic Americas	East Atlantic	Black Sea-Mediterranean	East Asia-East Africa	Central Asia	East Asia-Australasia	Number of IBAs	Number of proposed IBAS	CmsAppx1	CmsAppx2	AEWA	ACAP	AEBOP	MoU
Pitta nympha	Fairy Pitta	F	↓	Y							Y	9								Y	43							
Piprites pileata	Black-capped Piprites	A	↓	Y				Y				2									8							
Procnias tricarunculatus	Three-wattled Bellbird	A	↓	Y				Y				4									26							
Procnias nudicollis	Bare-throated Bellbird	F	↓	Y				Y				3									52							
Cephalopterus glabricollis	Bare-necked Umbrellabird	A	↓	Y				Y				2									9							
Xolmis dominicanus	Black-and-white Monjita	F	↓	Y				Y				3									34							
Alectrurus tricolor	Cock-tailed Tyrant	F	↓	Y				Y				4									19		Y	Y				Y
Alectrurus risora	Strange-tailed Tyrant	F	↓	Y				Y				4									26		Y	Y				Y
Macgregoria pulchra	Ochre-winged Honeyeater	N	↓	Y							Y	2																
Vireo atricapilla	Black-capped Vireo	F	↓	Y				Y				2		Y								6						
Oriolus mellianus	Silver Oriole	F	↓	Y							Y	3								Y	13							
Hirundo atrocaerulea	Blue Swallow	F	↓	Y					Y			10						Y			26		Y	Y				
Chaetornis striata	Bristled Grassbird	F	↓	Y							Y	4							Y		11							
Locustella pleskei	Pleske's Grasshopper-warbler	F	↓	Y							Y	5								Y	21			Y				
Acrocephalus paludicola	Aquatic Warbler	F	↓	Y					Y	Y		23				Y	Y				47	9	Y	Y				Y

Species Name				Type				Region					Global Flyway								IBAs		CMS Instruments					
Scientific	Common	Migration type	Population trend	Landbird	Soaring bird	Waterbird	Seabird	Americas	Africa-Eurasia	Central Asia	East Asia-Australasia	Number of countries	Pacific Americas	Central Americas	Atlantic Americas	East Atlantic	Black Sea-Mediterranean	East Asia-East Africa	Central Asia	East Asia-Australasia	Number of IBAs	Number of proposed IBAS	CmsAppx1	CmsAppx2	AEWA	ACAP	AEBOP	MoU
Acrocephalus sorghophilus	Streaked Reed-warbler	F	↓	Y							Y	3								Y	4		Y	Y				
Acrocephalus tangorum	Manchurian Reed-warbler	F	↓	Y							Y	6								Y	8			Y				
Phylloscopus ijimae	Izu Leaf-warbler	F	↓	Y							Y	3								Y	10			Y				
Sitta formosa	Beautiful Nuthatch	A	↓	Y							Y	7									39							
Toxostoma bendirei	Bendire's Thrasher	F	↓	Y				Y				2		Y														
Catharus bicknelli	Bicknell's Thrush	F	↓	Y				Y				8			Y						25			Y				
Turdus feae	Grey-sided Thrush	F	↓	Y							Y	5								Y	10			Y				
Luscinia ruficeps	Rufous-headed Robin	F	↓	Y							Y	2								Y	4			Y				
Luscinia obscura	Black-throated Blue Robin	F	↓	Y							Y	2								Y	4			Y				
Saxicola insignis	White-throated Bushchat	F	↓	Y						Y	Y	7							Y		18			Y				
Rhinomyias brunneatus	Brown-chested Jungle-flycatcher	F	↓	Y							Y	5								Y	35			Y				
Ficedula subrubra	Kashmir Flycatcher	F	↓	Y							Y	4							Y		20			Y				
Cinclus schulzi	Rufous-throated Dipper	A	↓	Y				Y				2									26							
Anthus spragueii	Sprague's Pipit	F	↓	Y				Y				3		Y							2	4						

Species Name				Type				Region					Global Flyway								IBAs		CMS Instruments					
Scientific	Common	Migration type	Population trend	Landbird	Soaring bird	Waterbird	Seabird	Americas	Africa-Eurasia	Central Asia	East Asia-Australasia	Number of countries	Pacific Americas	Central Americas	Atlantic Americas	East Atlantic	Black Sea-Mediterranean	East Asia-East Africa	Central Asia	East Asia-Australasia	Number of IBAs	Number of proposed IBAS	CmsAppx1	CmsAppx2	AEWA	ACAP	AEBOP	MoU
Serinus syriacus	Syrian Serin	F	↓	Y					Y			7									8		Y					
Dendroica cerulea	Cerulean Warbler	F	↓	Y				Y				18		Y	Y						36		Y					
Xanthopsar flavus	Saffron-cowled Blackbird	C	↓	Y				Y				4									30		Y	Y				
Euphagus carolinus	Rusty Blackbird	F	↓	Y				Y				3		Y	Y						10							
Sturnella defilippii	Pampas Meadowlark	F	↓	Y				Y				3			Y						6							
Emberiza aureola	Yellow-breasted Bunting	F	↓	Y					Y	Y	Y	24							Y	Y	13	3	Y					
Emberiza sulphurata	Yellow Bunting	F	↓	Y							Y	7								Y	5							
Sporophila cinnamomea	Chestnut Seedeater	F	↓	Y				Y				4			Y						42		Y	Y				Y
Conirostrum tamarugense	Tamarugo Conebill	F	↑	Y				Y				2									3	6						
Near Threatened (NT)																												
Coturnix japonica	Japanese Quail	F	↓	Y							Y	11								Y								
Tragopan satyra	Satyr Tragopan	A	↓	Y							Y	4																
Chen canagica	Emperor Goose	F	↓			Y		Y			Y	2								Y	26	1		Y				
Speculanas specularis	Spectacled Duck	F	↔			Y		Y				2			Y						13	4						
Anas falcata	Falcated Duck	F	↓			Y				Y	Y	17								Y	13			Y				

Species Name				Type				Region					Global Flyway								IBAs		CMS Instruments					
Scientific	Common	Migration type	Population trend	Landbird	Soaring bird	Waterbird	Seabird	Americas	Africa-Eurasia	Central Asia	East Asia-Australasia	Number of countries	Pacific Americas	Central Americas	Atlantic Americas	East Atlantic	Black Sea-Mediterranean	East Asia-East Africa	Central Asia	East Asia-Australasia	Number of IBAs	Number of proposed IBAS	CmsAppx1	CmsAppx2	AEWA	ACAP	AEBOP	MoU
Aythya nyroca	Ferruginous Duck	F	↓			Y			Y	Y	Y	81				Y	Y	Y	Y		302	28	Y	Y	Y			
Oxyura maccoa	Maccoa Duck	C	↓			Y			Y			13									4			Y	Y			
Pygoscelis papua	Gentoo Penguin	F	↓				Y	Y				7									29							
Spheniscus magellanicus	Magellanic Penguin	F	↓				Y	Y				5									34	7						
Gavia adamsii	Yellow-billed Loon	F	↓			Y	Y	Y	Y	Y	Y	15	Y			Y				Y	2			Y	Y			
Phoebastria immutabilis	Laysan Albatross	F	↔				Y	Y			Y	7										2		Y		Y		
Phoebetria palpebrata	Light-mantled Albatross	F	↓				Y	Y	Y		Y	10									5	2		Y		Y		
Thalassarche cauta	Shy Albatross	F					Y		Y		Y	3												Y		Y		
Thalassarche steadi	White-capped Albatross	F	↓				Y		Y		Y	4										1		Y		Y		
Thalassarche bulleri	Buller's Albatross	F	↔				Y	Y			Y	4										5		Y		Y		
Pterodroma feae	Fea's Petrel	F	↑				Y		Y			3									3							
Pterodroma ultima	Murphy's Petrel	F	↓				Y				Y	2									2							
Pterodroma inexpectata	Mottled Petrel	F	↓				Y	Y			Y	6																
Pseudobulweria rostrata	Tahiti Petrel	F	↓				Y				Y	7									3	1						
Procellaria cinerea	Grey Petrel	F	↓				Y	Y	Y		Y	10									6	1		Y		Y		
Puffinus griseus	Sooty	F	↓				Y	Y	Y		Y	25									6	12						

Species Name				Type				Region					Global Flyway								IBAs		CMS Instruments					
Scientific	**Common**	**Migration type**	**Population trend**	**Landbird**	**Soaring bird**	**Waterbird**	**Seabird**	**Americas**	**Africa-Eurasia**	**Central Asia**	**East Asia-Australasia**	**Number of countries**	**Pacific Americas**	**Central Americas**	**Atlantic Americas**	**East Atlantic**	**Black Sea-Mediterranean**	**East Asia-East Africa**	**Central Asia**	**East Asia-Australasia**	**Number of IBAs**	**Number of proposed IBAS**	**CmsAppx1**	**CmsAppx2**	**AEWA**	**ACAP**	**AEBOP**	**MoU**
	Shearwater																											
Puffinus yelkouan	Yelkouan Shearwater	F	↓				Y		Y			27									47	7						
Puffinus opisthomelas	Black-vented Shearwater	F					Y	Y				2										3						
Bulweria fallax	Jouanin's Petrel	F	↑				Y		Y			3									6							
Phoenicopterus chilensis	Chilean Flamingo	F	↓			Y		Y				8									109	21		Y				
Phoeniconaias minor	Lesser Flamingo	N	↓			Y			Y		Y	30									65			Y	Y			
Phoenicoparrus jamesi	Puna Flamingo	F	↓			Y		Y				4									20	6	Y	Y				Y
Threskiornis melanocephalus	Black-headed Ibis	F	↓			Y					Y	15								Y	12							
Egretta rufescens	Reddish Egret	F	↑			Y		Y				29									6	4						
Pelecanus philippensis	Spot-billed Pelican	F	↓		Y	Y					Y	9							Y		127							
Pelecanus thagus	Peruvian Pelican	F	↑		Y	Y	Y	Y				2	Y									1						
Phalacrocorax coronatus	Crowned Cormorant	C	↔			Y	Y		Y			2									9			Y	Y			
Phalacrocorax capensis	Cape Cormorant	C	↕			Y	Y		Y			5									12			Y	Y			
Vultur gryphus	Andean Condor	A	↓	Y	Y			Y				7									123	13		Y				
Falco vespertinus	Red-footed Falcon	F	↓	Y	Y				Y	Y	Y	76					Y	Y			99	5		Y			Y	

Species Name				Type				Region					Global Flyway								IBAs		CMS Instruments					
Scientific	Common	Migration type	Population trend	Landbird	Soaring bird	Waterbird	Seabird	Americas	Africa-Eurasia	Central Asia	East Asia-Australasia	Number of countries	Pacific Americas	Central Americas	Atlantic Americas	East Atlantic	Black Sea-Mediterranean	East Asia-East Africa	Central Asia	East Asia-Australasia	Number of IBAs	Number of proposed IBAS	CmsAppx1	CmsAppx2	AEWA	ACAP	AEBOP	MoU
Falco concolor	Sooty Falcon	F	↓	Y	Y				Y		Y	30					Y	Y			24			Y			Y	
Elanus scriptus	Letter-winged Kite	N	↕	Y	Y						Y	1									2			Y				
Milvus milvus	Red Kite	F	↓	Y	Y				Y	Y		45									96	65		Y			Y	
Gyps rueppellii	Rueppell's Vulture	C	↓	Y	Y				Y			27									2	1		Y				
Aegypius monachus	Cinereous Vulture	F	↓	Y	Y				Y	Y	Y	41						Y	Y	Y	108	5		Y			Y	
Terathopius ecaudatus	Bateleur	C	↓	Y	Y				Y															Y			Y	
Circus macrourus	Pallid Harrier	F	↓	Y	Y				Y	Y	Y	98					Y	Y	Y	Y	123	2		Y			Y	
Neotis denhami	Denham's Bustard	F	↓	Y					Y			36																
Tetrax tetrax	Little Bustard	F	↓	Y					Y	Y	Y	25				Y	Y	Y	Y		158							
Laterallus jamaicensis	Black Rail	F	↓			Y		Y				15		Y	Y						6	3						
Porzana paykullii	Band-bellied Crake	F	↓			Y					Y	8								Y								
Pluvianellus socialis	Magellanic Plover	F	↔			Y		Y				2									12	2						
Haematopus moquini	African Oystercatcher	C	↑			Y			Y			2									20			Y	Y			
Charadrius melodus	Piping Plover	F	↑			Y		Y				19		Y	Y						24	2		Y				
Charadrius pallidus	Chestnut-banded Plover	C	↔			Y			Y			8									5			Y	Y			
Charadrius peronii	Malaysian Plover	C	↓			Y					Y	9									2			Y				

Species Name				Type				Region					Global Flyway								IBAs		CMS Instruments					
Scientific	**Common**	**Migration type**	**Population trend**	**Landbird**	**Soaring bird**	**Waterbird**	**Seabird**	**Americas**	**Africa-Eurasia**	**Central Asia**	**East Asia-Australasia**	**Number of countries**	**Pacific Americas**	**Central Americas**	**Atlantic Americas**	**East Atlantic**	**Black Sea-Mediterranean**	**East Asia-East Africa**	**Central Asia**	**East Asia-Australasia**	**Number of IBAs**	**Number of proposed IBAS**	**CmsAppx1**	**CmsAppx2**	**AEWA**	**ACAP**	**AEBOP**	**MoU**
Charadrius montanus	Mountain Plover	F	↓			Y		Y				3	Y	Y							3	3		Y				
Phegornis mitchellii	Diademed Plover	A	↓			Y		Y				4									12	2						
Gallinago media	Great Snipe	F	↓			Y			Y	Y	Y	84				Y	Y	Y			137	2		Y	Y			
Gallinago stricklandii	Fuegian Snipe	F	↓			Y		Y				3									17	3						
Limnodromus semipalmatus	Asian Dowitcher	F	↓			Y				Y	Y	26							Y	Y	13			Y				
Limosa limosa	Black-tailed Godwit	F	↓			Y		Y	Y	Y	Y	132				Y	Y	Y	Y	Y	206	24		Y	Y			
Numenius arquata	Eurasian Curlew	F	↓			Y		Y	Y	Y	Y	143				Y	Y	Y	Y	Y	128	12		Y	Y			
Tryngites subruficollis	Buff-breasted Sandpiper	F	↓			Y		Y			Y	35		Y	Y						25		Y	Y				Y
Glareola nordmanni	Black-winged Pratincole	F	↓			Y			Y	Y		50					Y	Y			100	1		Y	Y			
Larus heermanni	Heermann's Gull	F	↑			Y	Y	Y				3	Y								3	4						
Larus leucophthalmus	White-eyed Gull	C	↔			Y	Y		Y			9									28		Y	Y	Y			
Larus audouinii	Audouin's Gull	F	↔			Y	Y		Y			21				Y					80	4	Y	Y	Y			
Pagophila eburnea	Ivory Gull	F	↓			Y	Y	Y	Y		Y	6									10							
Sterna elegans	Elegant Tern	F	↕			Y	Y	Y				10	Y								5	9						
Sterna balaenarum	Damara Tern	F	↔			Y	Y		Y			12				Y					20			Y	Y			

Species Name				Type				Region					Global Flyway								IBAs		CMS Instruments					
Scientific	**Common**	**Migration type**	**Population trend**	**Landbird**	**Soaring bird**	**Waterbird**	**Seabird**	**Americas**	**Africa-Eurasia**	**Central Asia**	**East Asia-Australasia**	**Number of countries**	**Pacific Americas**	**Central Americas**	**Atlantic Americas**	**East Atlantic**	**Black Sea-Mediterranean**	**East Asia-East Africa**	**Central Asia**	**East Asia-Australasia**	**Number of IBAs**	**Number of proposed IBAS**	**CmsAppx1**	**CmsAppx2**	**AEWA**	**ACAP**	**AEBOP**	**MoU**
Larosterna inca	Inca Tern	F	↓			Y	Y	Y				4									1	5						
Rynchops flavirostris	African Skimmer	F	↓			Y			Y			36				Y		Y			16			Y	Y			
Columba janthina	Japanese Wood-pigeon	F	↓	Y							Y	2																
Caloenas nicobarica	Nicobar Pigeon	N	↓	Y							Y	11																
Treron formosae	Whistling Green-pigeon	F	↓	Y							Y	3																
Ptilinopus jambu	Jambu Fruit-dove	F	↓	Y							Y	5																
Charmosyna meeki	Meek's Lorikeet	N	↓	Y							Y	2																
Charmosyna multistriata	Striated Lorikeet	N	↓	Y							Y	2																
Psittinus cyanurus	Blue-rumped Parrot	N	↓	Y							Y	6																
Psittacula longicauda	Long-tailed Parakeet	N	↓	Y							Y	7																
Aratinga erythrogenys	Red-masked Parakeet	F	↓	Y				Y				2									38							
Nannopsittaca dachilleae	Amazonian Parrotlet	N	↓	Y				Y				2									8							
Alipiopsitta xanthops	Yellow-faced Amazon	N	↓	Y				Y				2									18							
Amazona tucumana	Tucuman Amazon	A	↓	Y				Y				2									39			Y				
Amazona dufresniana	Blue-cheeked Amazon	F	↓	Y				Y				4									6	1						

Species Name				Type				Region					Global Flyway								IBAs		CMS Instruments					
Scientific	Common	Migration type	Population trend	Landbird	Soaring bird	Waterbird	Seabird	Americas	Africa-Eurasia	Central Asia	East Asia-Australasia	Number of countries	Pacific Americas	Central Americas	Atlantic Americas	East Atlantic	Black Sea-Mediterranean	East Asia-East Africa	Central Asia	East Asia-Australasia	Number of IBAs	Number of proposed IBAS	CmsAppx1	CmsAppx2	AEWA	ACAP	AEBOP	MoU
Cuculus vagans	Moustached Hawk-cuckoo	F	↓	Y							Y	7																
Strix occidentalis	Spotted Owl	A	↓	Y				Y				3									1	7						
Batrachostomus stellatus	Gould's Frogmouth	A	↓	Y							Y	4																
Eleothreptus anomalus	Sickle-winged Nightjar	F	↓	Y				Y				4									28							
Chaetura pelagica	Chimney Swift	F	↓	Y				Y				27		Y	Y													
Eriocnemis derbyi	Black-thighed Puffleg	A	↓	Y				Y				2									16							
Harpactes wardi	Ward's Trogon	A	↓	Y							Y	5																
Priotelus roseigaster	Hispaniolan Trogon	A	↓	Y				Y				2									13							
Pharomachrus mocinno	Resplendent Quetzal	A	↓	Y				Y				7									14	5						
Coracias garrulus	European Roller	F	↓	Y					Y	Y	Y	103				Y	Y	Y			129	19		Y				
Andigena laminirostris	Plate-billed Mountain-toucan	N	↓	Y				Y				2									10							
Melanerpes erythrocephalus	Red-headed Woodpecker	F	↓	Y				Y				3		Y	Y						3							
Phibalura flavirostris	Swallow-tailed Cotinga	F	↓	Y				Y				4			Y						5							
Polystictus pectoralis	Bearded Tachuri	F	↓	Y				Y				10		Y	Y						46	2		Y				Y

Species Name				Type				Region					Global Flyway								IBAs		CMS Instruments					
Scientific	Common	Migration type	Population trend	Landbird	Soaring bird	Waterbird	Seabird	Americas	Africa-Eurasia	Central Asia	East Asia-Australasia	Number of countries	Pacific Americas	Central Americas	Atlantic Americas	East Atlantic	Black Sea-Mediterranean	East Asia-East Africa	Central Asia	East Asia-Australasia	Number of IBAs	Number of proposed IBAS	CmsAppx1	CmsAppx2	AEWA	ACAP	AEBOP	MoU
Pseudocolopteryx dinelliana	Dinelli's Doradito	F	↓	Y				Y				3		Y							16			Y				
Contopus cooperi	Olive-sided Flycatcher	F	↓	Y				Y				23	Y	Y	Y						24	5						
Spartonoica maluroides	Bay-capped Wren-spinetail	F	↓	Y				Y				4									45							
Vireo bellii	Bell's Vireo	F	↓	Y				Y				6	Y	Y							8	11						
Terpsiphone atrocaudata	Japanese Paradise-flycatcher	F	↓	Y							Y	13								Y				Y				
Petroica phoenicea	Flame Robin	F	↓	Y							Y	1								Y	22			Y				
Bombycilla japonica	Japanese Waxwing	F	↓	Y							Y	6								Y								
Pycnonotus melanoleucos	Black-and-white Bulbul	N	↓	Y							Y	4																
Andropadus montanus	Cameroon Montane Greenbul	A	↓	Y					Y			2									14							
Locustella pryeri	Marsh Grassbird	F	↓	Y							Y	5								Y	11			Y				
Bradypterus major	Long-billed Bush-warbler	A	↓	Y							Y	3									1							
Phylloscopus tytleri	Tytler's Leaf-warbler	F	↓	Y						Y	Y	4							Y		1			Y				
Lioptilus nigricapillus	Bush Blackcap	A	↓	Y					Y			2									16							
Luscinia pectardens	Firethroat	F	↓	Y							Y	2							Y					Y				

Species Name				Type				Region					Global Flyway								IBAs		CMS Instruments					
Scientific	Common	Migration type	Population trend	Landbird	Soaring bird	Waterbird	Seabird	Americas	Africa-Eurasia	Central Asia	East Asia-Australasia	Number of countries	Pacific Americas	Central Americas	Atlantic Americas	East Atlantic	Black Sea-Mediterranean	East Asia-East Africa	Central Asia	East Asia-Australasia	Number of IBAs	Number of proposed IBAS	CmsAppx1	CmsAppx2	AEWA	ACAP	AEBOP	MoU
Phoenicurus alaschanicus	Ala Shan Redstart	A	↓	Y							Y	1												Y				
Ficedula semitorquata	Semi-collared Flycatcher	F	↓	Y					Y			32					Y				22	1		Y				
Carpodacus cassinii	Cassin's Finch	F	↓	Y				Y				3	Y									2						
Vermivora chrysoptera	Golden-winged Warbler	F	↓	Y				Y				20		Y	Y						39	1						
Vermivora crissalis	Colima Warbler	F	↓	Y				Y				2	Y									7						
Dendroica kirtlandii	Kirtland's Warbler	F	↑	Y				Y				3			Y						3		Y					
Emberiza cineracea	Cinereous Bunting	F	↓	Y					Y			19					Y	Y			23	6						
Emberiza yessoensis	Ochre-rumped Bunting	F	↓	Y							Y	6								Y								
Calcarius ornatus	Chestnut-collared Longspur	F	↓	Y				Y				3		Y							2	2						
Ammodramus henslowii	Henslow's Sparrow	F	↓	Y				Y				2		Y	Y						12							
Sporophila ruficollis	Dark-throated Seedeater	F	↓	Y				Y				5									54			Y				Y
Sporophila hypochroma	Rufous-rumped Seedeater	F	↓	Y				Y				5		Y							27		Y	Y				Y
Passerina ciris	Painted Bunting	F	↓	Y				Y				11		Y	Y						20	14						

Data Deficient (DD)																
Oceanites gracilis	White-vented Storm-petrel	F	↔				Y	Y				4				
Oceanodroma markhami	Markham's Storm-petrel	F					Y	Y				4				
Oceanodroma matsudairae	Matsudaira's Storm-petrel	F					Y		Y		Y	8			1	
Oceanodroma hornbyi	Ringed Storm-petrel	F					Y	Y				2				
Pseudochelidon eurystomina	African River-martin	F	↓	Y					Y			5			5	
Progne sinaloae	Sinaloa Martin	F	↔	Y				Y				2		Y		
Mirafra pulpa	Friedmann's Lark	N	↓	Y					Y			3			4	
Acrocephalus orinus	Large-billed Reed-warbler	F		Y						Y		1				Y

Key Migration type categories are as follows: **F** = full migrant; **A** = altitudinal migrant; **N** = nomadic; **C** = species recognised by CMS as migratory but not by BirdLife International. Population trend categories are as follows: ↑ = increasing; ↓ = decreasing; ↔ = stable; ↕ = fluctuating. Other acronyms used include: **IBA** = Important Bird Area; **CMS** = Convention on Migratory Species; **AEWA** = African–Eurasian Waterbird Agreement; **ACAP** = Agreement on the Conservation of Albatrosses and Petrels; **AEBOP** = Memorandum of Understanding on the Conservation of Migratory Birds of Prey in Africa and Eurasia; **MoU** = Memorandum of Understanding.

Annex 3. Genuine IUCN Red List changes 1988-2008

* (F = full migrant; A = altitudinal migrant; N = nomadic; C = species recognised by CMS as migratory but not by BirdLife International)

Scientific name	Common name	Period	Category at start of period	Category at end of period	Notes	Migrant status for 2010 CMS review *	On CMS appendices or instruments
Branta ruficollis	Red-breasted Goose	2000-2004	VU	EN	The population increased from the late 1970s to a peak of 88,425 individuals in 2000. Since then it declined to 32,100 individuals in 2005, with the 5-year average decline exceeding 50% during 2000-2004, qualifying the species for uplisting to Endangered under criterion A2. During 1988-2000 it would have qualifed as Vulnerable under criterion B2. Drivers of declines are a combination of hunting, habitat loss and other threats.	F	Y
Aythya baeri	Baer's Pochard	2004-2008	VU	EN	Widespread evidence suggests that the rate of decline exceeded 50% over ten years by 2008, leading to uplisting from Vulnerable to Endangered under criteria A2 and A3. The year that the threshold was crossed is difficult to quantify, but is placed in the period 2004-2008, as by 2008 numbers were said to have "very sharply declined in the last 10 years" (M. Barter in litt. 2007). Drivers of declines are believed to be hunting and loss of wetland habitat.	F	Y
Polysticta stelleri	Steller's Eider	2000-2004	NT	VU	Alaskan populations of this species declined from 137,904 individuals in 1992 to 77,329 individuals in 2003. Given the proportion of the global population they form, the global population decline rate would have exceeded 30% over three generations (12 years) in 2000, qualifying the species for uplisting from Near Threatened to Vulnerable under criterion A2 in 2000. The main drivers of these declines are unknown.	F	Y
Oxyura leucocephala	White-headed Duck	1994-2000	VU	EN	The population of this species underwent a rapid population decline during 1991-2001 in Turkey (10,927 birds in 1991 to 653 in 2001) and further east (eg Turkmenistan), outweighing increases in Spain (in particular) plus Israel, Syria, Greece, Bulgaria and Romania. The overall trend is negative, and the decline is suspected to have exceeded 50% over ten years during 1994-2000, with habitat loss and hunting among the main drivers, qualifying the species for uplisting from Vulnerable to Endangered under criterion A2 by 2000.	F	Y
Spheniscus demersus	African Penguin	2004-2008	VU	EN	The rate of decline experienced by this species increased above 50% over three generations (31 years) in 2007, qualifying it for uplisting from Vulnerable (under the criterion A2a,c,e; A3a,c,e; A4a,c,e) to Endangered (under the same criterion) during 2004-2008, owing to commercial fishing and shifts in prey populations.	F	Y
Spheniscus humboldti	Humboldt Penguin	1994-2000	NT	VU	The population of this species declined from 10,000-12,000 individuals in 1995-1996 to 3,300 individuals in 1999, probably owing to the 1997-1998 ENSO in combination with overfishing, hence crossing the threshold of 10,000 mature individuals and qualifying the species for uplisting from Near Threatened to Vulnerable under criterion A2 and C1 by 2000.	F	Y
Phoebastria irrorata	Waved Albatross	2000-2004	VU	CR	Awkerman (2006) showed that adult survival declined between 1999 and 2004. There is some evidence to suggest that the population also declined between 1994 and 2001 (e.g. counts at Punta Suarez - Punta Cevallos from Anderson et al 2002), but the population counts provide lower quality data than the mark-recapture estimates of annual survival (D. Anderson in litt. 2006). Given the very restricted breeding range, the species therefore met the thresholds for criterion B2 at the Critically Endangered level during 2000-2004, having previously qualified as Vulnerable (under criterion D2) during 1988-2000. Declines are believed to have primarily been driven by intentional harvesting as well as mortality within inshore fisheries.	F	Y
Phoebastria nigripes	Black-footed Albatross	1994-2000	LC	VU	Declines resulting from bycatch in commercial long-line fisheries are believed to have increased through the 1990s and were projected to exceed 30% over three generations (56 years) by 1994 (which would have qualified the species for uplisting from Least Concern to Vulnerable under criterion A4). By 2004, modelled declines exceeded 50% over three generations, qualifying the species as Endangered (under criterion A4).	F	Y
		2000-2004	VU	EN			
Diomedea dabbenena	Tristan Albatross	1988-1994	EN	CR	The main driver of population declines is very low adult survival which is probably correlated to longline fishing effort, so decreases of around 80% have probably been happening since the advent of large-scale fishing effort in the western Southern Ocean, which spiked upwards in the late 1980s and continued at high levels into the 1990s (Tuck et al. 2003). Therefore, the population trend is suspected to have exceeded 80% over three generations during 1988-1994, and hence the species qualifed for uplisting from EN to CR under criterion A4 by 1994.	F	Y

Scientific name	Common name	Period	Category at start of period	Category at end of period	Notes	Migrant status for 2010 CMS review *	On CMS appendices or instruments
Phoebetria fusca	Sooty Albatross	2000-2004	VU	EN	The rate of population decline is suspected to have exceeded 50% over three generations (90 years) during 2000-2004 owing to increased mortality as incidental bycatch on longline fisheries, and hence qualifying the species for uplisting from Vulnerable to Endangered under criterion A4 by 2004.	F	Y
Thalassarche melanophrys	Black-browed Albatross	1994-2000	NT	EN	The rate at which the population of this species is declining is suspected to have exceeded 50% over three generations (22 years) by 2000 (e.g. the Falklands population, comprising 80% of the total, declined by 82% during 1996-2001) owing to increased mortality as incidental bycatch on longline fisheries, qualifying the species for uplisting from Near Threatened to Endangered under criterion A4 by 2000.	F	Y
Pterodroma baraui	Barau's Petrel	1988-1994	EN	CR	In the early 1990s, intensive hunting may have killed up to half the breeding population, with trends over three generations (45 years) believed to have exceeded 80% by 1994 (qualifying the species to be uplisted to Critically Endangered under criterion A). However, successful banning of hunting then reduced the suspected rate of decline, such that the species only qualifed as Endangered (under criterion B) by 2000 (which it would have also qualifed as in 1988).	F	N
		1994-2000	CR	EN			
Pterodroma alba	Phoenix Petrel	2000-2004	VU	EN	Black rats were found to have become established on Kiritimati in 2002, leading to projected declines of 50-79% percent over three generations (45 years) and hence qualifying the species for uplisting from Vulnerable to Endangered by 2004 under criterion A3.	F	N
Pterodroma cookii	Cook's Petrel	2004-2008	EN	VU	This species qualified for downlisting from Endangered (under criterion B2a+b) to Vulnerable (under criterion D2) during 2004-2008 owing to the improving status of the population (with increasing trends) and habitat, in particular following the successful eradication of the last introduced predators (Pacific rat) on Little Barrier Island (where by far the largest numbers breed), leading to an increase in fledging success from 5% to 70%. This key step in turning the fortunes of the species followed the earlier eradication of cats from Little Barrier Island in 1980, and Weka from Codfish Island in the early 1980s. (Note that Cook's Petrel may have been effectively extinct as a reproductively viable population on Great Barrier Island for several decades, although tiny numbers still occur there.)	F	N
Puffinus mauretanicus	Balearic Shearwater	1994-2000	VU	EN	The population of this species declined more steeply during the 1990s and 2000s, falling from 3,300 pairs in 1991 to 1,447-2,125 pairs in 2002-2003, apparently owing to increases in numbers of cats at the breeding colonies. By 2004, the projected decline within three generations (54 years) had reached 98% (qualifying the species for uplisting to Critically Endangered under criterion A4), and declines of >50% over three generations (qualifying the species as Endangered under criterion A4) are inferred to have been reached by 2000, compared to >30% over three generations (qualifying the species as Vulnerable) during 1988-1994.	F	Y
		2000-2004	EN	CR			
Puffinus opisthomelas	Black-vented Shearwater	2000-2004	VU	NT	The population of this species declined through the 1990s as a result of cat predation and the impacts of other invasive species, but successful eradication of goats and sheep in 1997-1998 and cats in 1999 from Natividad (which holds the vast majority of the world population) reduced mortality dramatically in the 2000s, qualifying the species for downlisting from Vulnerable to Near Threatened under criterion A2 by 2004.	F	N
Podiceps gallardoi	Hooded Grebe	2000-2004	NT	VU	This species qualifed for uplisting to Endangered (under criterion A2b,c,e) during 2004-2008 owing to declines of >40% over 21 years (three generations) since the late 1990s (based on data from censuses on the wintering grounds). It is likely to have been declining at >30% over three generations by 2004 (when it would have qualifed as Vulnerable under A2b,c,e) and at rates approaching 30% over three generations by 2000 (when it would have qualifed as Near Threatened, approaching the thresholds for A2 and C2ai). Declines appear to have been driven by a mixture of impacts, including introduced salmonids, nest predation by Kelp Gulls, human disturbance, volcanic activity, and overgrazing at lake margins.	F	N
		2004-2008	VU	EN			
Phoenicopterus chilensis	Chilean Flamingo	1988-1994	LC	NT	The rate of population decline of this species is suspected to have approached 30% over ten years during 1988-1994 owing to intensification of several different threats, including hunting, egg-collecting and habitat loss, qualifying the species for uplisting from Least Concern to Near Threatened under criterion A2 by 1994.	F	Y
Phoenicoparrus jamesi	Puna Flamingo	1994-2000	VU	NT	Following a historical decline, this species's population is now increasing owing to successful conservation programmes, with a particularly good breeding season in 1999-2000. The overall trend over three generations (assumed to be 48 years in this species) is still negative however. The decline is suspected to have fallen below 30% during 1994-2000, qualifying the species for downlisting from Vulnerable to Near Threatened under criterion A2 by 2000.	F	Y

Scientific name	Common name	Period	Category at start of period	Category at end of period	Notes	Migrant status for 2010 CMS review *	On CMS appendices or instruments
Platalea minor	Black-faced Spoonbill	1994-2000	CR	EN	This species's population was projected to undergo an 80% decline over ten years in 1994 owing to a number of threats. However, the implementation of a Species Action Plan from 1995 onwards raised awareness and helped to mitigate some of the threats leading to a much reduced rate of decline (30% over ten years) by 2000, qualifying the species for downlisting from Critically Endangered to Endangered under criterion A3. Note that the population estimate of <250 individuals in 1994 was an underestimate, and it should have been closer to the 1,480 estimated in 2005, which qualifies the species as Endangered under criterion C2ai.	F	Y
Gorsachius goisagi	Japanese Night-heron	1988-1994	VU	EN	The population size is suspected to have fallen below 1,000 mature individuals by 1994 following declines in 1980s and early 1990s, qualifying the species for uplisting from Vulnerable to Endangered under criterion C2 by 1994. Declines have primarily been driven by deforestation in its breeding and wintering ranges.	F	Y
Ardeola idae	Madagascar Pond-heron	1988-1994	VU	EN	This species's population has been in long-term decline owing primarily to exploitation for eggs and young, with the current minimum estimate of 2,000 mature individuals qualifying the species as Endangered under criterion C2. The population is assumed to have fallen below the threshold of 2,500 mature individuals during 1988-1994, and hence would have qualified as Vulnerable in 1988.	F	Y
Pelecanus crispus	Dalmatian Pelican	1994-2000	VU	NT	During the early and mid-1990s, the global population appeared to increase, owing largely to increases in Greece as a consequence of protection of a key breeding colony (with increases also occurring in Bulgaria). The species would therefore have qualified for downlisting from Vulnerable to Near Threatened during 1994-2000. However, the status of eastern populations then deteriorated during the late 1990s and early 2000s, owing to political changes and breakdown of law enforcement, and these declines outweighed increases in south-east Europe (in Montenegro to Romania and Turkey), giving a global decline that exceeded 30% over ten years (and hence qualifed the species as Vulnerable again under criteria A2 and A3) during 2000-2004.	F	Y
		2000-2004	NT	VU			
Phalacrocorax neglectus	Bank Cormorant	1994-2000	VU	EN	The rate at which the population of this species is declining is suspected to have exceeded 50% over three generations (22 years) during 1994-2000 owing to a number of threats (e.g. steep declines were recorded on Mercury and Ichaboe Islands owing to a decreased abundance of goby off central Namibia from 1994 onwards), qualifying the species for uplisting from Vulnerable to Endangered under criterion A2 by 2000.	C	Y
Falco cherrug	Saker Falcon	1994-2000	LC	NT	The species is believed to have had stable or slowly declining populations trends prior to 1990 but declined from 13,000-27,000 pairs in 1990 to 9,500-17,000 pairs in 2010 owing to unsustainable levels of exploitation, so the rate of decline is estimated to have approached 30% over three generations (19 years) during 2004-2008 (when it would have qualified for uplisting from Least Concern to Near Threatened under criteria A2 & A3), exceeding 30% over three generations by 2009 (when it qualified for uplisting to Vulnerable under criteria A2&A3), and reaching 32% over three generations (based on median estimates) by 2010.	F	Y
Milvus milvus	Red Kite	1994-2000	LC	NT	The European population declined by almost 20% during 1990-2000, equating to almost 30% over three generations (18 years). Germany holds the largest proportion of the European population (42-73%); numbers increased from 1988 to 1991, and then declined until 1997 when they stabilised. The majority of the decline was during 1994-1997, so the species would have qualified for uplisting from Least Concern to Near Threatened (approaching the thresholds for A criteria) by 2000. Declines have been driven by deliberate and accidental poisoning and land use changes.	F	Y
Haliaeetus albicilla	White-tailed Eagle	1994-2000	NT	LC	The European population (representing 50-74% of the global range) grew from 6,600-7,600 individuals in 1990 to 10,000-13,000 individuals in 2000 owing to conservation measures. Taking the mid-point of the estimates, and assuming it represented 74% of the global population, the global population would have exceeded 15,000 birds (an approximate threshold for Near Threatened under criterion C) in the late 1990s and hence qualifying the species for downlisting to Least Concern by 2000. Eastern populations (eg in Kazakhstan) are also increasing.	F	Y

Scientific name	Common name	Period	Category at start of period	Category at end of period	Notes	Migrant status for 2010 CMS review *	On CMS appendices or instruments
Neophron percnopterus	Egyptian Vulture	2000-2004	LC	EN	Cuthbert et al (2006) indicate that in India the species started undergoing rapid decline (35% per year) in about 1999, and declined by 68% between 2000 and 2003, owing to increasing use of the toxic veterinary drug diclofenac. European populations have declined >50% in the last three generations, and West, East and Southern African populations also appear to have declined significantly owing to a variety of threats. Global declines are therefore estimated to have exceeded 50% over three generations (42 years) in 2000-2004, qualifying the species as Endangered. Declines prior to 1999 are estimated to have approached 30% over three generations, so the species would have qualified as Near Threatened during 1988-2000.	F	Y
Chlamydotis undulata	Houbara Bustard	1994-2000	LC	NT	Population numbers in Kazakhstan decreased by 60% between autumn 1998 and spring 2003, and in China by 77% between 1998 and 2002. The hunting pressure driving these trends is believed to have intensified during the latter part of the 1990s, with global trends inferred to be approaching 30% over three generations by 2000 (which would have qualified the species as NT under the A criteria by 2000) and exceeding this threshold by 2004 (qualifying the species as Vulnerable under criteria A2,A3,A4 by then). (Note that declines in the Canary islands have little impact on the global trends, given the small size of the population there).	F	Y
		2000-2004	NT	VU			
Neotis denhami	Denham's Bustard	1994-2000	LC	NT	The rate of decline of this species's population is suspected to have approached 30% over ten years during 1994-2000, owing to intense levels of hunting combined with habitat loss, qualifying the species for uplisting from Least Concern to Near Threatened under criterion A by 2000.	F	N
Houbaropsis bengalensis	Bengal Florican	2004-2008	EN	CR	Large areas of habitat at the species's stronghold in Cambodia were converted to rice paddies during 2004-2006, causing the rate of decline over three generations to exceed 80% (hence qualifying the species to be uplisted from Endangered to Critically Endangered under criteria A3+A4) during 2004-2008.	F	N
Sypheotides indicus	Lesser Florican	1988-1994	CR	EN	The population size of this species declined by nearly 60% (from 4,374 to 1,672 birds) during 1982-1989, but then increased by 32% to 2,206 birds by 1994 (in both cases in response to breeding season rainfall patterns); these trends meant that the decline over ten years fell below 80% during 1988-1994 and that the species qualified for downlisting from Critically Endangered to Endangered under criterion A2 by 1994.	F	N
Balearica pavonina	Black Crowned-crane	1988-1994	LC	NT	Based on populations estimates available for 1985, 1994 and 2004, the rate of population decline of this species is estimated to have approached 30% over 39 years (three generations) during 1998-1994 and exceeded 30% over 39 years during 1994-2000 owing to habitat loss, hunting and other threats, qualifying the species for uplisting from Least Concern to Near Threatened under criterion A2, A3, A4 during 1988-1994 and from Near Threatened to Vulnerable (under the same criteria) during 1994-2000.	C	Y
		1994-2000	NT	VU			
Grus monacha	Hooded Crane	1994-2000	NT	VU	The number of sites at which this species is concentrated in winter fell to ten (covering an area of <2000 km2) during 1994-2000 owing to the abandonment of one site in South Korea (Taegu) owing to greenhouse construction, and the loss of sites in the Yangtze wetlands (including Longgan Hu) owing to agricultural development. This qualified the species for uplisting from Near Threatened to Vulnerable under criterion B2 by 2000.	F	Y
Vanellus gregarius	Sociable Lapwing	2000-2004	EN	CR	The rate of population decline was suspected to have exceeded 80% over ten years during 2000-2004, on the basis of surveys showing very steep recent declines that were projected to continue, leading to uplisting from Endangered to Critically Endangered under criteria A3 and A4 by 2004. Reasons for the decline remain poorly understood.	F	Y
Limosa limosa	Black-tailed Godwit	2000-2004	LC	NT	This species declined by 14-33% between 1990 and 2005. Taking the upper value, the decline rate would have exceeded 25% (the approximate threshold for NT under the A criteria) during the period 2000-2004 and it has therefore been uplisted to Near Threatened. These declines were largely driven by trends in Europe (caused by changing agricultural practises), outweighing apparently stable trends in Central Asia and increases in Iceland.	F	Y
Numenius arquata	Eurasian Curlew	1994-2000	LC	NT	The population decline of this species is suspected to have approached 30% over three generations (15 years) during 1994-2000, leading to the species qualifying as Near Threatened under the A criteria by 2000. This was largely driven by declines in Europe (including the key population in the UK), but also partly as a consequence of large scale habitat changes following the collapse of the Soviet Union in 1991 (e.g. a substantial decrease in state livestock numbers in Kazakhstan led to significantly higher and denser vegetation in many areas of long-grass and forest steppe).	F	Y

Scientific name	Common name	Period	Category at start of period	Category at end of period	Notes	Migrant status for 2010 CMS review *	On CMS appendices or instruments
Eurynorhynchus pygmeus	Spoon-billed Sandpiper	1994-2000	VU	EN	The population of this species is suspected to have fallen below 2,500 mature individuals during 1994-2000, (surveys in 2000 and 2002 indicated severe recent declines, with the population estimated to number <2,500 individuals by 2002), qualifying the species for uplisting from Vulnerable to Endangered under criterion C2a(ii) by 2000. The population then declined further between 2000 and 2005, at a rate equivalent to 94-96% over three generations (15 years) qualifying the species for uplisting to Critically Endangered under criterion A2 by 2004. Declines are driven by uncertain factors, but climate change induced habitat changes on the breeding grounds and loss of coastal wetland sites used during the non-breeding season are suspected to be the drivers.	F	Y
		2004-2008	EN	CR			
Larus relictus	Relict Gull	1994-2000	NT	VU	The population size of this species is suspected to have declined below 10,000 mature individuals during 1994-2000, qualifying the species for uplisting from Near Threatened to Vulnerable under criterion C2aii by 2000. Declines have been driven by climate change and human disturbance at breeding colonies along with reclamation of coastal wetlands for development.	F	Y
Sterna nereis	Fairy Tern	2004-2008	NT	VU	The population of this species fell below 10,000 mature individuals, and the decline rate exceeded 10% over three generations (30 years) during 2004-2008, owing in particular to the collapse of the population at Coorong, South Australia (where, for example <5% of the birds counted were juveniles each year during 2003-2007 despite most individuals attempting to breed each year), owing to inappropriate water level management (and hence collapsed fish stocks) plus predation by introduced foxes. This qualified the species for uplisting to Vulnerable under criterion C1 by 2008. It would previously have qualified as Near Threatened.	F	N
Rynchops flavirostris	African Skimmer	1988-1994	LC	NT	The population size of this species is suspected to have declined during 1988-1994 to 15,000-25,000 birds (and hence approaching the thresholds for Vulnerable under criteria C1 and C2) owing to a number of threats, qualifying the species for uplisting from Least Concern to Near Threatened by 1994.	F	Y
Columba eversmanni	Pale-backed Pigeon	1988-1994	NT	VU	The suspected rate of population decline increased (owing to dramatic declines in central Asia in particular) to exceed 30% over ten years by 1994, qualifying the species to be uplisted from Near Threatened to Vulnerable under criterion A2 by 1994. Declines have been driven by hunting and habitat loss.	F	N
Ptilinopus jambu	Jambu Fruit-dove	1994-2000	LC	NT	Accelerating habitat loss in the Sundaic lowlands through the 1990s is believed to have caused the rate of population decline to approach 30% over ten years by 2000, hence qualifying the species as Near Threatened (under the A criteria) by 2000.	F	N
Psittacula longicauda	Long-tailed Parakeet	1994-2000	LC	NT	Accelerating habitat loss in the Sundaic lowlands through the 1990s is believed to have caused the rate of population decline to approach 30% over ten years by 2000, hence qualifying the species as Near Threatened (under the A criteria) by 2000.	N	N
Anodorhynchus hyacinthinus	Hyacinth Macaw	1994-2000	VU	EN	The rate of decline of this species's population is suspected to have exceeded 50% over ten years during 1994-2000, owing to intensifying exploitation for the cagebird trade, in combination with other threats, qualifying the species for uplisting from Vulnerable to Endangered under criterion A2 by 2000.	F	N
Brotogeris pyrrhoptera	Grey-cheeked Parakeet	1988-1994	VU	EN	The rate of population decline of this species is suspected to have exceeded 50% over ten years during 1988-1994 (owing to intensified trapping for the cage-bird trade), qualifying the species for uplisting from Vulnerable to Endangered under criterion A2 by 1994.	C	Y
Hapalopsittaca pyrrhops	Red-faced Parrot	1988-1994	NT	VU	The species's population has declined owing to habitat destruction, with the rate of decline believed to have increased from below 30% over ten years in 1988 (when the species qualified as Near Threatened) to >30% over ten years by 1994 and subsequently (qualifying the species as Vulnerable under criterion A2). Similarly, the population size is likely to have fallen below 10,000 mature individuals during 1988-1994 owing to these declines.	A	N
Cuculus vagans	Moustached Hawk-cuckoo	1994-2000	LC	NT	Accelerating habitat loss in the Sundaic lowlands through the 1990s is believed to have caused the rate of population decline to approach 30% over ten years by 2000, hence qualifying the species as Near Threatened (under the A criteria) by 2000.	F	N
Batrachostomus stellatus	Gould's Frogmouth	1994-2000	LC	NT	Accelerating habitat loss in the Sundaic lowlands through the 1990s is believed to have caused the rate of population decline to approach 30% over ten years by 2000, hence qualifying the species as Near Threatened (under the A criteria) by 2000.	A	N

Scientific name	Common name	Period	Category at start of period	Category at end of period	Notes	Migrant status for 2010 CMS review *	On CMS appendices or instruments
Coracias garrulus	European Roller	1994-2000	LC	NT	Although populations on this species in central Asia are apparently apparently stable, the European population (occupying 50-74% of the global breeding range) declined moderately during 1970-1990 (Tucker & Heath 1994) and declined severely during 1990-2000, when up to 25% of birds were lost (including key populations in Turkey and European Russia), with the global population decline estimated to approach 30% in three generations (15 years) during that period, and hence the species would have qualified for uplisting to Near Threatened (under the A criteria) by 2000. Declines have been driven by a number of factors including habitat loss and degradation, and hunting	F	Y
Procnias nudicollis	Bare-throated Bellbird	2000-2004	NT	VU	The rate of population decline is suspected to have exceeded 30% during 2000-2004 owing to increased trapping pressure and continuing habitat loss, qualifying the species for uplisting from Near Threatened to Vulnerable under criterion A2 by 2004.	F	N
Pycnonotus melanoleucos	Black-and-white Bulbul	1994-2000	LC	NT	Accelerating habitat loss in the Sundaic lowlands through the 1990s is believed to have caused the rate of population decline to approach 30% over ten years by 2000, hence qualifying the species as Near Threatened (under the A criteria) by 2000.	N	N
Acrocephalus griseldis	Basra Reed-warbler	1994-2000	NT	VU	The species has lost habitat owing to drainage of marshes since the 1950s, with rates over ten years suspected to have approached 30%, (qualifying the species as Near Threatened) during 1988-1994. Habitat loss accelerated during the 1990s and early 2000s, with declines suspected to have reached >30% over the previous ten years by 2000 (which would have qualified the species as Vulnerable under the A criteria then), and >50% over ten years (qualifying the species as Endangered under the A criteria) by 2004.	F	Y
		2000-2004	VU	EN			
Serinus syriacus	Syrian Serin	1994-2000	NT	VU	The small population, previously thought to be stable, declined at key sites during 1996-2000, principally due to the effects of a drought, qualifying the species for uplisting from Near Threatened to Vulnerable under criterion C1.	F	Y
Vermivora bachmanii	Bachman's Warbler	1988-1994	CR	CR(PE)	The last reasonably convincing record was in 1988, since when the species is likely to have gone extinct; hence this species qualified as Possibly Extinct by 1994. Past declines were driven by habitat loss on its breeding and wintering grounds.	F	N
Dendroica kirtlandii	Kirtland's Warbler	1988-1994	VU	NT	The area of suitable habitat for this species doubled between 1987 and 1990, leading to a population increase (reaching 500 singing males by 1994). This meant that by 1994 it no longer would have qualified as Vulnerable under criterion D2 because it was no longer so restricted in distribution and so susceptible to stochastic events and human activities, and hence would have been downlisted to Near Threatened (under criteria C2 and D2).	F	Y
Emberiza aureola	Yellow-breasted Bunting	1994-2000	NT	VU	The rate of population decline of this species is suspected to have exceeded 30% over ten years during 1994-2000 owing to intensification of trapping pressures during the late 1990s, qualifying the species for uplisting from Near Threatened to Vulnerable under criterion A2 by 2000.	F	Y
Chaetura pelagica	Chimney Swift	1994-2000	LC	NT	The rate of decline shown by this species based on data from the Breeding Bird Survey increased above 25% over three generations (16 years) in 1997, qualifying it for uplisting from Least Concern to Near Threatened (almost meeting criterion A2b,c) during the period 1994-2000. The primary driver of declines is believed to be the ongoing reduction in availability of suitable nesting habitat in buildings.	F	N

Annex 4. Analytical methods

Migratory status

All bird species are coded in BirdLife's World Bird Database according to their migratory status (see definitions below and BirdLife International 2010). This assessment of migratory status has drawn on a small number of key references including Stotz *et al*. (1996), *Handbook of the birds of the world* (ed. J. del Hoyo *et al*. 1992–present, Barcelona: Lynx Edicions) and the Global Register of Migratory Species (see www.groms.de), regional handbooks, fieldguides and family monographs, as well as expert opinion synthesised in BirdLife's Species Factsheets and range maps (see www.birdlife.org/datazone/species/index.html). The World Bird Database is constantly being updated and revised; the analyses in this paper were based on data accessed on 1st April 2010).

Migratory—a substantial proportion of the global or regional population makes regular or seasonal cyclical movements beyond the breeding range, with predictable timing and destinations. This includes species that may be migratory only in part of their range or part of their population, short-distance migrants and full migrants that may also occasionally respond to unusual conditions in a semi-nomadic way. Migratory species may require conservation action (at specific sites, or beyond sites) along migration routes. Following the definitions of Dodman and Diagana (2007), this excludes "rains migrants/arid migrants" i.e. species which move with unpredictable timing and destination in response to irregular rainfall patterns, "nutrition migrants/post-roost dispersers" i.e. species that disperse daily from roosts to forage, "post-breeding dispersers" which may not make cyclical movements i.e. dispersers that may not return to the same breeding area, and "environmental response migrants" i.e. species that move opportunistically in response to irregular environmental conditions such as rainfall, fire, locust eruptions etc..

Altitudinal migrant—regularly/seasonally makes cyclical movements to higher / lower elevations with predictable timing and destinations. Altitudinal migrants might not be best conserved at the site scale alone, if individual sites do not encompass the full altitudinal range of the species.

Nomadic species—moves in response to resources that are sporadic and unpredictable in distribution and timing, sometimes wandering widely through an extremely large home range. Nomadic species may congregate, but not predictably in terms of location and timing. Nomadic species usually cannot be conserved at the site scale alone. This excludes "environmental response migrants" (Dodman and Diagana 2007) i.e. species that are largely resident but move opportunistically in response to irregular environmental conditions such as rainfall, fire, locust eruptions etc..

Non-migratory—not nomadic (q.v.) or migratory (q.v).

Migratory patterns

In the Americas, there are two fundamentally distinct patterns of long-distance latitudinal migration: 1) birds breeding in temperate North America that migrate south to warmer climes for the winter; 2) birds breeding in temperate South America that migrate north to winter in warmer climes. Since the 1980s, the term “Neotropical migrant” has often been used to refer to the first category of species. As a result, the term “Austral migrant” has had to be used for Neotropical bird species migrating within the Neotropical realm. However, “Austral migrant” could equally be applied to birds breeding in southern Africa, Antarctica or Australia and migrating north for the winter. One solution that has been proposed is the use of the term “Neotropical migrant” for all bird species wintering within the Neotropics, but then how can the two major systems of migration be differentiated? The primary difference between species wintering within the tropical regions of the world is where they breed. It makes better sense to name the migrants/migration patterns after the biogeographical realms where they breed. The following terms, mostly suggested by Hayes (1995), have therefore been used in this paper, where appropriate:

Austral migrant—any species of bird or population of a species that breeds in the southern hemisphere and regularly migrates northward during the non-breeding season.

Australian migrant—any species of bird or population of a species that breeds in the Australasian realm and that regularly migrates northward during the non-breeding season.

Boreal migrant—any species of bird or population of a species that breeds in the northern hemisphere and regularly migrates southward during the non-breeding season.

Intra-African migrant—any species of bird or population of a species breeding in Africa that regularly migrates within Africa during the non-breeding season.

Intra-tropical migrant—any species of bird or population of a species that breeds in the tropics, and regularly migrates to another area within the tropics.

Nearctic migrant—any species of bird or population of a species that breeds in North America and regularly migrates southward during the non-breeding season.

Neotropical migrant—any species of bird or population of a species that breeds in the Neotropics and regularly migrates northward during the non-breeding season.

Palearctic migrant—any species of bird or population of a species that breeds in the Palearctic and regularly migrates southward during the non-breeding season.

In order to distinguish between, e.g., (1) Nearctic migrants that migrate entirely within the Nearctic and (2) those that migrate to the Neotropics, the following additional terms are used: “Nearctic–Nearctic migrants” and “Nearctic–Neotropical migrants”, respectively, with other combinations as appropriate.

IUCN Red List Index

The IUCN Red List is widely recognised as the most authoritative and objective system for classifying species by their risk of extinction (see, e.g. Regan *et al.* 2005, de Grammont and Cuarón 2006, Rodrigues *et al.* 2006). It uses quantitative criteria based on population size, rate of decline, and area of distribution to assign species to categories of relative extinction risk (IUCN 2001, 2005). BirdLife International, as the Red List Authority for birds, provides the evaluations and documentation for all birds on the IUCN Red List.

The Red List Index (RLI) has been developed as an indicator of trends in the status of biodiversity. It is based on the movement of species through the categories of the IUCN Red List (Butchart *et al*. 2004, 2005, 2007). The RLI shows changes in the overall extinction risk of sets of species, with RLI values relating to the proportion of species expected to remain extant in the near future without additional conservation action.

The RLI is calculated from the number of species in each Red List category (Least Concern, Near Threatened, Vulnerable, Endangered, Critically Endangered), and the number changing categories between assessments as a result of genuine improvement or deterioration in status (category changes owing to improved knowledge or revised taxonomy are excluded). The methodology is described in detail in Butchart *et al*. (2004, 2005), updated by Butchart *et al*. (2007). An RLI value is calculated as follows:

$$RLI_t = 1 - \frac{\sum_s W_{c(t,s)}}{W_{\mathrm{EX}} \cdot N}$$

where Wc(t,s) is the weight of category c for species s at time t, which ranges from 1 for Near Threatened to 5 for Extinct (WEX), and N is the number of assessed (non-data deficient) species. Put simply, the number of species in each Red List category is multiplied by the category weight, these products are summed, divided by the maximum possible product (the number of species multiplied by the maximum weight), and subtracted from one. This produces an index that ranges from 0 to 1 (see below).

These conditions are met by back-casting all “non-genuine” category changes (i.e. those resulting from improved knowledge or revised taxonomy, rather than genuine improvement or deterioration in the status of species) to the year of first assessment (1988 for birds). In other words, for birds, we assume that species should have been classified at their current Red List category since 1988, apart from those species for which genuine category changes have occurred, in which case the category changes are assigned to appropriate time periods, corresponding to the dates in which all species were reassessed (see Collar and Andrew 1988, Collar *et al*. 1994, BirdLife International 2000, BirdLife International 2004c, BirdLife International 2008a). To determine these genuine cases, all category changes during 1988–2008 were assigned a “reason for change”, allowing genuine ones to be distinguished from those resulting from improved knowledge or taxonomic revisions (see Butchart *et al.* 2004, 2005, 2007 for further details).

RLI values relate to the proportion of species expected to remain extant in the near future without conservation action. An RLI value of 1.0 equates to all species being categorised as Least Concern, and hence that none are expected to go extinct in the near future. An RLI value of zero indicates that all species have gone Extinct. A downwards trend in the graph line (i.e. decreasing RLI values) means that the expected rate of species extinctions is increasing i.e. that the rate of biodiversity loss is increasing. A horizontal graph line (i.e. unchanging RLI values) means that the expected rate of species extinctions is unchanged. An upward trend in the graph line (i.e. increasing RLI values) means that there is a decrease in expected future rate of species extinctions (i.e. a reduction in the rate of biodiversity loss).

Threat analysis

All threatened and near-threatened bird species are coded in BirdLife’s World Bird Database according to the threats that impact on them and contribute to the IUCN Red List criteria and categories assigned. The hierarchical classification scheme of threats follows Salafsky *et al*. (2008) (see http://conservationmeasures.org). These threats can be in the past and/or present and/or future, using a time frame of three generations or ten years, whichever is the longer (not exceeding 100 years in the future) as required by the Red List criteria. The scheme has three different levels: each first-level threat is subdivided into several second-level threats which are, in turn, subdivided into numerous third-level threats. For the analysis of main threats to threatened and near-threatened migratory species (Figure 5), a combination of “level 1” and “level 2” threats were considered, irrespective of magnitude, in order to give a general overview.

Global Important Bird Area criteria

A1. Globally threatened species

The site qualifies if it is known, estimated or thought to hold a population of a species categorized by the IUCN Red List as Critically Endangered, Endangered or Vulnerable. In general, the regular presence of a Critical or Endangered species, irrespective of population size, at a site may be sufficient for a site to qualify as an IBA. For Vulnerable species, the presence of more than threshold numbers at a site is necessary to trigger selection. Thresholds are set regionally, often on a species by species basis. The site may also qualify under this category if it holds more than threshold numbers of other species of global conservation concern in the Near Threatened, Data Deficient and, formerly, in the no-longer recognised Conservation Dependent categories. Again, thresholds are set regionally.

A2. Restricted-range species
The site forms one of a set selected to ensure that, as far as possible, all restricted-range species of an Endemic Bird Area (EBA) or Secondary Area (SA) are present in significant numbers in at least one site and, preferably, more. The term "significant component" is intended to avoid selecting sites solely on the presence of one or more restricted range species that are common and adaptable within the EBA and, therefore, occur at other chosen sites. Sites may, however, be chosen for one or a few species that would, e.g. because of particular habitat requirements, be otherwise under-represented.

A3. Biome-restricted species
The site forms one of a set selected to ensure, as far as possible, adequate representation of all species restricted to a given biome, both across the biome as a whole and, as necessary, for all of its species in each range state. The "significant component" term in the category definition is intended to avoid selecting sites solely on the presence of one or a few biome-restricted species that are common, widespread and adaptable within the biome and, therefore, occur at other chosen sites. Additional sites may, however, be chosen for the presence of one or a few species which would, e.g. for reasons of particular habitat requirements, be otherwise under-represented.

A4. Congregations

i. This applies to "waterbird" species as defined by Delany and Scott (2006), and is modelled on criterion 6 of the Ramsar Convention for identifying wetlands of international importance. Depending upon how species are distributed, the 1% thresholds for the biogeographic populations may be taken directly from Delaney and Scott, they may be generated by combining flyway populations within a biogeographic region or, for those for which no quantitative thresholds are given, they are determined regionally or inter-regionally, as appropriate, using the best available information.
ii. This includes those seabird species not covered by Delany and Scott (2006). Quantitative data are taken from a variety of published and unpublished sources.
iii. This is modelled on citerion 5 of the Ramsar Convention for identifying wetlands of international importance. Where quantitative data are good enough to permit the application of A4i and A4ii, the use of this criterion is discouraged.
iv. The site is known or thought to exceed thresholds set for migratory species at bottleneck sites. Thresholds are set regionally or inter-regionally, as appropriate.

Annex 5. Recommendations important to migratory bird conservation

General

1. Given the vast body of literature on migratory birds, a series of thematic reviews are recommended that should be updated on a 5-yearly rolling basis, at least until the topics of the reviews diminish in importance. Key reviews needed include:

    - Impacts of coastal development projects, particularly intertidal wetland reclamation, on migratory waterbird populations.
    - Impacts of habitat loss and degradation on migratory birds.
    - Impacts of agriculture and aquaculture on migratory birds.
    - Impacts of human population growth and projected landuse changes in different continents on migratory birds.
    - Impacts of renewable energy projects, including wind turbine installations and power distribution infrastructure, on migratory birds.
    - Harvesting, shooting and trapping impacts, including illegal persecution.
    - Fishery impacts on marine migratory birds.
    - Non-native species impacts on migratory birds.

    Do not halt political nor practical conservation action whilst waiting for these reviews. Actions must be taken now to protect and benefit migratory birds; the reviews will merely help assess priorities and monitor the effectiveness of action implementation.

2. In the interests of promoting migratory waterbird conservation, make these reviews, as well as status reports, flyway atlases and other key documents, freely available over the internet and in attractive and user-friendly formats.

3. Review data management initiatives and consider how best to link and develop migratory bird knowledge and shared access to research data and outputs.

Monitoring

4. Continue to support and stregthen monitoring migratory bird populations so that changes can be detected early and appropriate action implemented rapidly, e.g. applicable to the International Waterbird Census Scheme, IBA monitoring *etc.*.

5. Develop a list of objective questions to aid biologists and managers in evaluating their monitoring programme's effectiveness in advancing local and flyway-scale monitoring goals.

6. Increase the capacity of monitoring organisations to provide more effective monitoring leadership at the flyway scale, especially for species thought or known to be declining across their range.

7. Facilitate further and better analysis of existing data from marking and counting programmes.

8. Where possible expand the geographical and temporal coverage of monitoring programmes to ensure complete (sampled) coverage of species' ranges and coverage of all periods of active migration.

9. Develop and implement coordinated, region wide programmes to collect, assess, and distribute data to better assess the status of seabird populations.

10. Establish and continue trend analyses, and further analyse existing data-sets, in order to provide key information on understudied groups, such as many long-distance migrants from outside of Europe and intra-African migrants.

11. Collate and present more information on the distribution and ecology of migratory species, and especially the migration routes that they follow, to all key stakeholders.

12. Maintain, and if possible increase (where alternative methods do not offer better return for investment), current levels of ringing, banding and colour-marking activity, in order to improve knowledge of the movements and survival of migratory birds.

13. Further exploit the capability of relatively new technologies, such as radio and satellite tracking, remote sensing and genetic analyses, to research flyways and the migration routes of birds.

14. Strengthen bird research worldwide, especially in areas where little or no marking and counting schemes have operated in the past.

<u>Threats</u>

15. Continue to collate and review threat information for migratory birds with a view to quantifying the significance of each and the scale and intensity of pressures on birds.

16. Promote sustainable agricultural policy and land-use policy.

17. Provide alternative livelihood schemes to those that lead to deforestation.

18. Research whether the mortality from threats is compensatory (not causing extra deaths overall) or additive, to provide key information for the identification of population-level impacts.

19. Carry out vulnerability analyses to more clearly identify main threats and link to local action and advocacy.

20. Develop a sensitivity map for windmills, powerlines etc. along the flyways.

21. Review impacts of hunting and hunting regulations, and identify gaps in enforcement and legislation, linked to specific areas / species where this is a real priority.

22. Seek to ensure full implementation of, and adherence to, species protection and hunting regulations.

23. Encourage coordinated international legal protection for species at risk.

24. Collate up-to-date information on the current shooting and trapping levels on migration routes, including a systematic assessment of the numbers of soaring birds killed at bottleneck sites by hunters.

25. Review and assess the significance of human disturbance (from hunting, sport and leisure) in displacement from key sites and in depressing the size of bird populations.

26. Identify areas of high risk from new energy infrastructure to bird populations throughout their life cycle, including migration, with sufficient statistical power to determine the effectiveness of regulations, practices, and mitigation.

27. Ensure best practice, and exercise extreme caution, in the location and construction of man-made structures in sensitive areas for migratory birds, especially wind turbines and power transmission and telecommunication cables.

28. Continue and expand education and practical measures to address the problem of bird electrocutions, especially where this impacts on endangered bird species worldwide.

29. Research the risk of collision with glass to migratory birds in different regions of the world.

30. Continue to research the relative significance of different modes of spread of diseases (e.g. avian influenza HPAI H5N1) by migratory birds.

31. Support the investigations of the international Scientific Task Force on Avian Influenza and Wild Birds (and other similar fora including FAO).

32. Support and encourage the continuation and expansion of beached bird surveys which provide an important tool for monitoring the level of oil pollution at sea.

33. Encourage research to understand the long-term effects of pollution, especially marine pollution, on migratory bird populations.

34. Carry out a comprehensive assessment of gillnet fishery impact on migratory bird populations.

35. Encourage research on the extent to which collapses in fish stocks of significance to marine birds can be attributed to fishing effort rather than natural factors.

36. Continue to work with, and influence, fishery operators so that detrimental impacts on seabirds can be avoided or, at the very least, managed (e.g. for longline and gillnet fisheries).

37. Strive for effective implementation of the many international instruments for the prevention and control of marine pollution and the regulation of fishing activities, in order to provide for the welfare of pelagic seabirds.

38. Research the significance of predation by domestic and feral cats and other non-native species on migratory birds.

39. Support programmes for the eradication of non-native species, especially where there is a significant threat to island nesting birds, particularly seabirds.

40. Research the cumulative impacts of key threats, both individually and collectively.

41. Ensure that existing and future species action plans are adequately resourced and well managed, and review their effectiveness regularly.

42. Review the effectiveness of single species action plans as opposed to multi-taxa plans and threat or habitat-based plans.

43. Identify and develop campaigns that will be effective in addressing the most significant of migratory bird threats.

Landscape measures

44. Carry out work to determine how best to configure landscapes for migratory birds, including the retention and re-creation of protected trans-boundary

habitat corridors and suitable and sufficient habitat in which to forage and rest, before and after long migratory flights and during stop-overs.

45. Promote landscape-level natural resource planning that will lead to retention in all parts of migratory bird ranges, of sufficient and suitably diverse habitat for sustaining healthy bird populations.

46. Seek to influence strategies for human development, including urbanization and major infrastructure development, to protect important landscapes and guide development away from key areas for migratory birds.

47. Seek to reform agricultural policy and practice to promote diverse, environmentally sustainable farming that supports healthy migratory bird populations.

48. Support efforts to reduce and reverse desertification in regions such as the African Sahel, using approaches that protect and restore native vegetation and conserve natural flood regimes.

49. Seek to counter forest fragmentation and tropical deforestation, including protecting remaining lowland and montane forests in Asia, Central America and the tropical Andes.

50. Seek to counter over-grazing and to protect key grasslands in South America and maintain traditional, extensive grassland ranching practices.

51. Develop and support bird-friendly guidelines for agriculture, forestry, energy industry, urban planning, water management, and other human activities that have the most impact on bird habitats.

<u>Site networks</u>

52. Review the coverage of current site networks and identify an 'ideal' state for each, noting the need to factor in exploitation and degradation of sites, and resilience to climate change, including flexibility to take account of the potential for shifts in the range of species due to climate change.

53. Continue to support the development of flyway-scale site networks, especially where they are least developed, to include the widest possible range of available habitat for migratory birds.

54. Foster trans-boundary collaboration where appropriate.

55. Ensure that key migratory stop-over sites are identified to form part of coherent site networks for migratory species.

56. Protect key sites, on land and at sea, for migratory bird species within flyway networks, through formal designations or voluntary measures.

57. Lobby for the protection of key sites, as appropriate, at national and international levels.

58. Implement existing site management plans and develop new ones where needed at key sites.

59. Share best practice on the management of sites for birds more proactively and in a way of immediate practical utility to site managers.

60. Make information on site networks and the sites within networks easily available, further developing initiatives modeled on the AEWA critical site network tool.

Climate change

61. Continue to research, collate and disseminate information on climate change effects on migratory birds and observed responses, identifying the most sensitive and vulnerable species and populations.

62. Improve our knowledge of the significance of mis-matches between migratory birds and their key resources, including in breeding, staging and non-breeding destination areas.

63. Continue research to identify potential population level impacts attributable to climate change.

64. Investigate where changes in rainfall patterns are predicted to occur, which may be critical to habitat suitability for migrant birds.

65. Expand conservation programmes to include climate change impacts in biological planning, conservation design, and habitat protection initiatives.

66. Develop and promote a multi-functional approach which involves expressing the benefits of ecosystem preservation from a holistic viewpoint, considering both the anthropogenic and wildlife benefits.

67. Engage in the lobby to reduce greenhouse gas emissions and keep them below critical levels.

Other

68. Encourage international treaties and policies that protect species, habitats, and the environment either directly or indirectly.

69. Consider the development of an ‘African Birds Directive’.

70. Support the strengthening of implementation of relevant regional conventions.

71. Provide adequate funding and effective implementation of regional and global agreements, strategies and action plans, which is essential to safeguard the future of the world’s migratory birds.

72. Focus on the goal of maintaining large population sizes of migratory birds. Successful recovery from threats and adaptation to changed climatic factors (and consequently habitat) will require sufficient genetic variation present in each population, which will be related to population size.