Module 1: Understanding the Flyway Approach to Conservation

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A flock of Common Terns *Sterna hirundo* in South Africa (photo: Mark Anderson)

Contents

1. Introduction to bird migration: ecological advantages and implications

1.1 General introduction

Key messages

Bird migration is a fascinating and impressive phenomenon, which involves a great variety of movements by millions of birds across the globe. Other animals also migrate, and the Convention on Migratory Species of Wild Animals focuses conservation attention on them.

Bird migration has always fascinated man. In history there are numerous stories describing the migration of birds, or at least their appearance and disappearance, without people knowing what was actually happening. These stories often related to mass occurrences of birds at a specific time of the year, or year after year at the same places, often where birds were trapped, harvested and marketed as a necessary livelihood. Many of these places are still favoured by migratory birds today, and certain techniques to catch birds have been developed at these sites. Sites such as Falsterbö in southern Sweden, Gibraltar, the Bosporus in Turkey, the Jordan Valley, Eilat (on the Jordan-Israel border) and the Rift Valley are still famous for their intensive bird migrations, although counting and ringing birds has to a large extent replaced previous preferences for catching and eating them.

One of the most well-known examples of migratory birds in historical times is 'The Geese of Meidum', a painting found on the wall of the Mastaba of Nefermaat tomb of Ancient Egypt dating back some 4,500 years (Figure 1.1). The painting shows three species of migratory geese, two of which are no longer found in Egypt, but were clearly well-known visitors to the fields of the Nile Valley in times gone by.

Figure 1.1. The Geese of Meidum: Two Bean Goose *Anser fabalis*, two Red-breasted Goose *Branta ruficollis* and two Greater White-fronted Goose *Anser albifrons* are portrayed in this wall painting from the Mastaba of Nefermaat at Meidum, Egypt, dating back to about 2500 BC.

The early records of bird concentrations in such areas were the first indications, now generally known, that many migratory birds tend to use the same routes every year and that these routes can have a relatively narrow geographical range. Although some migration routes may be quite wide from a species point of view, there is much evidence from bird ringing and other research that *individual birds* are using the same routes and resting places year after year. This applies to many waterbirds, as well as smaller passerine species.

It is only relatively recently that details of international migratory routes, having existed and probably changed over periods of thousands of years, have become known. Whilst modern technology such as satellite tracking has given, for some species, huge insights into the details of migration and stopover places used, this has built on a broad body of knowledge derived from over a hundred years of bird ringing using inscribed metal rings and individual colour-markers (see e.g. Davidson *et al.* 1999).

For the Wings over Wetlands (WOW)/African Eurasian Migratory Waterbird Agreement (AEWA) region, which embraces all of Africa, the Middle

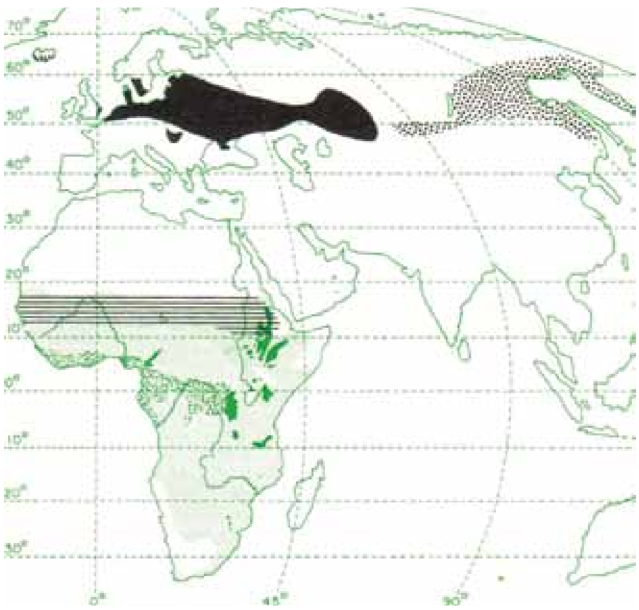


Figure 1.2. Breeding areas of the two sub-species of Black-tailed Godwit and the wintering area of *Limosa limosa*; after Moreau (1972).

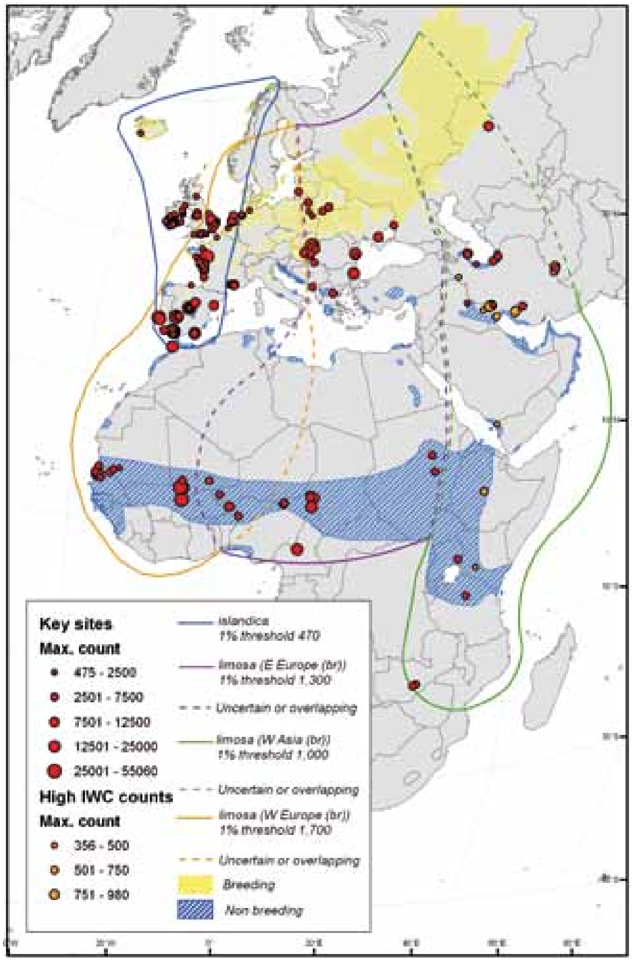


Figure 1.3. Breeding area, important sites, generalised migration routes and wintering areas of Black-tailed Godwit *Limosa limosa*, based on present knowledge (Delany *et al.* 2009).

East and Eurasia (Figure 1), there is a reasonable amount of literature available on bird migration, with good published overviews. These include '*The Palaearctic-African Bird Migration Systems*' (Moreau 1972), a classic work and still a valuable reference source for waterbirds, although our knowledge on details of migratory routes and important sites has substantially improved. This may be seen by comparing Figures 1.2 and 1.3: one from Moreau, the other from the new Wader Atlas (Delany *et al.* 2009) illustrating Black-tailed Godwit *Limosa limosa* migration. It is noteworthy that the wintering area of Black-tailed Godwit as already mapped out by Moreau in the 1970s does not differ that much from our present knowledge.

<u>Convention on Migratory Species</u>
The migration phenomenon is not restricted to birds alone, but widely spread among many animal families, including butterflies, whales and dolphins, marine turtles, terrestrial mammals and fish. On an international level, it is the Convention on the Conservation of Migratory Species of Wild Animals (CMS), often known as the Bonn Convention (after the city in Germany where the convention text was concluded in 1979), that focuses conservation attention on migratory species. This convention aims to stimulate international conservation of all migratory species and to provide a framework to facilitate cooperation. Further details on the CMS are provided in section 10.1.

Some migratory species are also subject to activities under other international legal treaties; whales and dolphins for instance are subject to management decisions by the International Whaling Commission, whilst migratory commercial fish species are managed under the UN Fish Stock Agreement (UNFSA).

Further reading:
- *The Palearctic-African Bird Migration System (Moreau 1972).*
- *Conserving migratory birds (Salathé 1991).*
- *An Atlas of Wader Populations in Africa and Western Eurasia (Delany et al. 20009): http://www.wetlands.org/WatchRead/tabid/56/mod/1570/articleType/ArticleView/articleId/2132/Wader-Atlas-draft-for-consultation.aspx.*
- *Wings Over Wetlands: www.wingsoverwetlands.org.*
- *AEWA: http://www.unep-aewa.org/home*
- *CMS: http://www.cms.int/index.html.*
- *Global Register of Migratory Species (GROMS): www.groms.de.*

1.2 Definitions of migratory species, migration and flyway

1.2.1 Definitions under the CMS

Key message
Bird migration is the regular movement of birds between separate areas; a flyway is the entire range of a migratory bird species or population.

To grasp all aspects of migration by a wide range of species of very different distribution patterns and life cycles, the CMS or Bonn Convention defines migratory species in the following way for the purposes of the convention as an intergovernmental treaty:

> ***"Migratory species" means 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."***

This formulation remains open for different interpretations of 'cyclically' and 'predictably', which were later defined in resolutions adopted by the Parties. The word '*cyclically*' relates to a cycle of any nature, such as astronomical (circadian, annual etc.), life or climatic, and of any frequency; the word '*predictably*' implies that a phenomenon can be anticipated to recur in a given set of circumstances, though not necessarily regularly in time.

This definition of migratory is based on the assumption that the Bonn Convention as a formal intergovernmental instrument is being used to stimulate cooperation between countries, and it thus mentions 'crossing borders' as an important criterion. Clearly this definition of migration and thus its legal jurisdiction does not apply to migratory patterns within a country's boundaries, such as movements within countries with a large surface area, or movements restricted along extensive coastlines of countries such as South Africa. The disintegration of the former USSR resulted in a few new species falling under the Bonn Convention definition; i.e. species whose range has changed from one nation to more than one nation. The CMS also provides a more general statement on migration (www.cms.int/about/faqs_en.htm):

> ***"Migration is a natural phenomenon by which individuals of given species move between areas which they inhabit at different times of the year. Migratory movements tend to be regular and largely predictable. They may take place over large fronts or along thin, traditional routes; in one single, continuous journey or as a series of legs interspersed with rests. In this latter case, many species use regular staging areas as stop-over sites where they recover from the previous leg and gather fuel before they continue their trip."***

1.2.2 Other definitions

Overall, it is preferable to have a definition of migration that refers to ecological terminology and not to national boundaries. A suitable definition of 'migration' applied to birds is provided by Newton (2008):

> ***"Migration is a regular seasonal movement between separate breeding and non-breeding areas."***

Using this definition, a migratory species is therefore ***any species that performs regular seasonal movements between separate breeding and non-breeding areas***. However, for the purposes of flyway conservation, we need to broaden the terminology in order to include those birds that move often, but not necessarily regularly. This applies to many birds that move in response to rain, but where rainfall is rather unpredictable. Therefore, for the purposes of this publication, the following rather broader definitions are proposed for migratory birds and migration:

Migratory birds:	***Birds that, during their lifecycles, perform regular movements between separate areas, usually linked to seasonal changes.***
Migration:	***The regular movement of birds between separate areas.***

In both cases the term 'regular' does not imply a fixed period in time, whilst 'seasonal' can refer to different kinds of seasons, such as rainy season, dry season, winter and summer. In **Palearctic-African migration** the northern winter is a major incentive for movement, and most movements are in a north-south direction (or vice-versa). For birds breeding in the far north, notably the Arctic, the need to escape the harsh winter forces most birds to leave. However, for many Palearctic-African migrants, the original incentives to move were born in Africa, with birds venturing out of Africa during prolonged dry periods when competition for food was high.

Intra-African migration is generally accepted to refer to movements within Africa. Dodman & Diagana (2006) define it as ***"the movement of birds within Africa and around its coastline according to local triggers and continental weather patterns, especially rainfall"***.

The term '**flyway**' also needs to be defined and used in combination with the definition of migratory birds. In understanding the flyway approach a generalised definition is useful, such as that formulated by Boere & Stroud (2006):

"A flyway is 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."

This definition fits well for migratory birds, though not so well for nomadic and semi-nomadic birds, though they also form a focus of these modules, as the flyway approach to conservation is also important to them, as they too invariably depend on networks of key sites.

Further reading:
- *The Palearctic-African Bird Migration System (Moreau 1972).*
- *CMS definitions: http://www.cms.int/documents/index.htm and http://www.cms.int/bodies/COP/cop2/English/Res2.2_E.pdf.*
- *The Migration Ecology of Birds (Newton 2008).*
- *Conservation dilemmas for intra-African migratory waterbirds (Dodman & Diagana 2006): http://www.jncc.gov.uk/PDF/pub07_waterbirds_part3.4.1.pdf.*
- *The flyway concept: what it is and what it isn't (Boere & Stroud 2006): http://www.jncc.gov.uk/PDF/pub07_waterbirds_part1_flywayconcept.pdf.*

1.3 Historical aspects of migration

Key message

Although there are strong historical reasons for migration, migration patterns are constantly changing, especially due to climatic change.

Migration routes are not static, and there is much evidence from recent geological eras (e.g. ice-ages during Pleistocene) that climate zones were in geographically different locations than they are now. As a result migratory routes have evolved and constantly evolve, and must have been quite different in past periods than in the present. The current phase of climate change presents a modern trigger for further evolution of migration strategies.

Migratory routes have in fact changed considerably during recent geological times, and the many glaciations, especially in the Northern Hemisphere, have influenced the structure of migration routes and the extinction or survival of many species. The effect of glaciations is visible in the present distribution, migratory routes and sub-species of many arctic breeding waders, ducks and geese. During some past periods there were extensive breeding areas for these birds north of the present extended ice-cap (Ploeger 1968) or on large ice-free areas, also known as '*nunataks*'. [Nunataks were often on mountain plateaus, some in areas north of the ice cap extension. They have acted as refuges for arctic fauna and flora and influenced particular sub-species formation through isolation of populations of the same species].

Some of the very long migration routes we know probably developed through the re-colonisation of suitable habitats following the shifting of breeding areas towards other geographical latitudes and longitudes after glaciations. Examples of birds with long distance migrations that have developed in this manner are the Northern Wheatear *Oenanthe oenanthe* and the Ruff *Philomachus pugnax* (Figures 1.4 and 1.5).

This process of re-colonisation of suitable habitats after glaciations may also explain an interesting case of breeding Curlew Sandpipers *Calidris ferruginea* on the Taimyr of northern Siberia. Birds ringed within the same sampling plot and breeding just a few hundred metres from each other were controlled in distant non-breeding areas: one in South Africa and one in Australia. Birds from separate non-breeding destination areas have completely different migration routes to reach the same small breeding area. Such movements present interesting challenges for researchers.

In northern Africa climatic changes have had a significant impact on the landscape, and there have been several periods when the Sahara was much moister than it is today. The most recent 'Green Sahara' (or Neolithic Subpluvial) period from about 7,000–3,000 BC must have had a substantial effect on the length of migration routes and the numbers of birds utilising that region. Presently the Sahara is a serious barrier for many species, but this has not always been the case, and still some birds opt to cross this challenging obstacle.

Migration routes are continuously changing, and research has shown this for many species in all parts of the world. Some changes are as a result

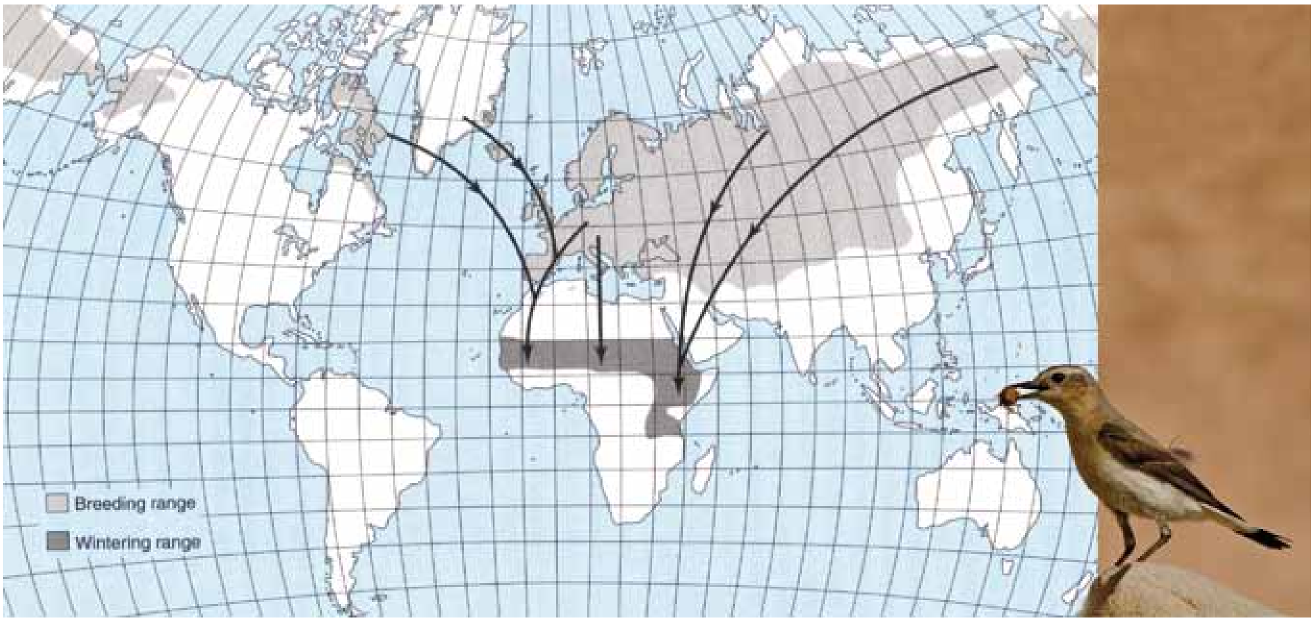


Figure 1.4. Breeding and wintering range of Northern Wheatear *Oenanthe oenanthe* showing migration from breeding areas into Africa (arrows do not indicate precise routes); (source: Newton 2008); Northern Wheatear (photo: İnanç Sevim).

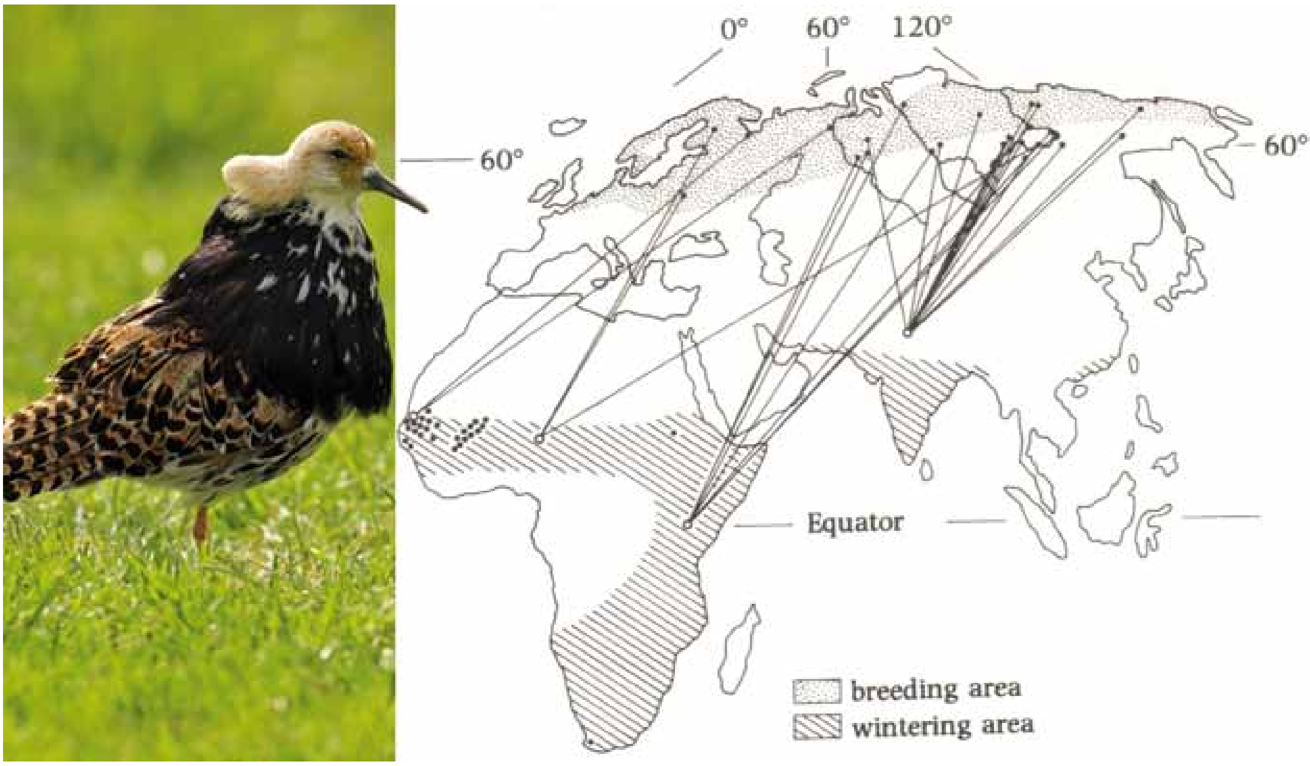


Figure 1.5. Breeding and wintering area of the Ruff *Philomachus pugnax*, with lines connecting ringing and recovery places (not necessarily the migration routes!) (source: Alerstam 1990); Male Ruff in breeding plumage (photo: Nicky Petkov/www.wildlifephotos.eu).

of changes in habitats. The drainage of the Iraq marshes for instance has most likely contributed to higher numbers of Palearctic-breeding ducks spending the northern winter in north-eastern Africa since the 1990s. Common Cranes *Grus grus* in Europe are expanding their wintering quarters from traditional key areas in Spain (which are still in use) hundreds of kilometres to the north to various areas in south, central and even north France. This changes the relative importance of the key sites in Spain.

Effects of the current period of climate change on influencing the movements of birds are becoming obvious in many species. In Europe a number of waterbird species are wintering in more northern regions than before, and climate change is already having an impact on long-established traditional migration routes of some passerine species in relation to their breeding seasons and preferred food sources. See section 11 for further information.

Further reading:
- *The Palearctic-African Bird Migration System (Moreau 1972).*
- *The Migration Ecology of Birds (Newton 2008).*
- *Bird Migration (Alerstam 1990).*

1.4 Ecology and survival – the driving forces behind migration

Key messages

Migration is driven by ecology and survival, with factors such as winter, rainfall and drought all playing important roles, especially in the availability of seasonal resources. Rainfall is a major driving force for movement in Africa, and erratic rainfall patterns result in nomadic and semi-nomadic movement strategies.

1.4.1 Making use of seasonal resources

Migration, in all its forms, has important ecological advantages for individual birds and populations. It is a way, for instance, of making optimal use of the availability along the flyway of shelter for breeding and moulting, and of food supplies (at breeding, moulting, resting and stopover sites). It also affords protection against bad weather conditions, drought, predators, parasites and other constraints over a larger geographical area, and in some situations serves to reduce competition for resources such as food and breeding sites, e.g. with non-migratory birds. Overall, migration is a strategy to make use of the usually seasonal variations in climatic conditions and the resulting availability of natural resources. And it is a very successful strategy, which has enabled birds to develop and thrive and make the best use of seasonal bouts of productivity.

Clearly the millions of waterbirds, including waders, geese, ducks, gulls and swans breeding in the Arctic, sub-Arctic and large parts of the Boreal region have to leave when snowfall and low temperatures make food resources inaccessible or unavailable. Similarly in other parts of the AEWA region, notably Africa, the Middle East and parts of Central Asia, irregular rainfall is an important driving factor for waterbirds to migrate and move around, as food supplies in dry seasons can become very scarce. Such movements are not always very specific or predictable, nor directed towards particular areas as with most north-south migrations, which, from an evolutionary perspective, probably have a long history and are largely predictable concerning the species involved, the timing of migration and the sites visited.

1.4.2 Movements of Arctic breeding birds

Birds have to migrate out of arctic and sub-arctic breeding areas due to snow and ice coverage for about five to six months a year and to long-term changes in water levels of marshes and lakes. However, birds breeding here and in Arctic regions originally came from elsewhere to breed during the region's relatively short but productive northern summer, making use of the optimal food resources. It is clearly worthwhile for some birds to breed in these northern latitudes during the summer, when there is an abundance of food, but winter conditions dictate that they cannot stay here all-year round.

Birds come to these northern latitudes to breed from different directions, and disperse after breeding back south, again in different directions. When birds of the same species migrate back to different regions, these are generally considered as discrete populations, although the distinctions are not always clear. Often there is great variation between individuals of the same species and their migratory behaviours. This variation is visible in the timing of their migrations: sometimes there is a difference of two months between the start of the migration of the first birds of a species and the last ones from the same region.

The final non-breeding destination areas may be separated by thousands of kilometres, providing individual birds of the same species a large geographical area to spend the non-breeding period. This variation is important for survival at the species level and provides an adaptive mechanism to changes which may occur along the migration route. These changes are a reality in a rapidly-changing world. Sometimes substantial changes in suitable habitat availability occur and force birds to utilise alternative areas or to exploit a slightly different food resource.

1.4.3 East-west migrations in Eurasia

Ringing recoveries of waterbirds have shown that besides north-south migration, there is also a substantial east-west migration through the Eurasian continent. Results of waterbird ringing by the Biological Institute of the Russian Academy of Sciences in the Western Siberian lowland show frequent movements between Western Siberia and Western Europe across the continent in addition to the more regular, and expected north-south movements of the same species (Veen *et al.* 2005). One species that shows such movements is the Northern Lapwing *Vanellus vanellus*; these east-west movements are compared with ringing results of the same species from Finland (Figure 1.6).

These movements indicate possible differences in the way areas have been colonized by the Northern Lapwing. Breeding in Finland is a result of the Western European population expanding northwards substantially in past decades and colonising Finland (Kalela 1955) with these birds maintaining a migration route in a south-westerly direction. A tendency towards east-west movements is also shown strikingly by results of ringing recoveries of Common Pochard *Aythya ferina* (Figure 1.7).

1.4.4 Movements within Africa

<u>Rainfall</u>
The main driving force for migratory birds in Africa is rainfall. Rainfall patterns in Africa are largely dictated by the Inter-Tropical Convergence Zone (ITCZ, Figure 1.8). Over Africa

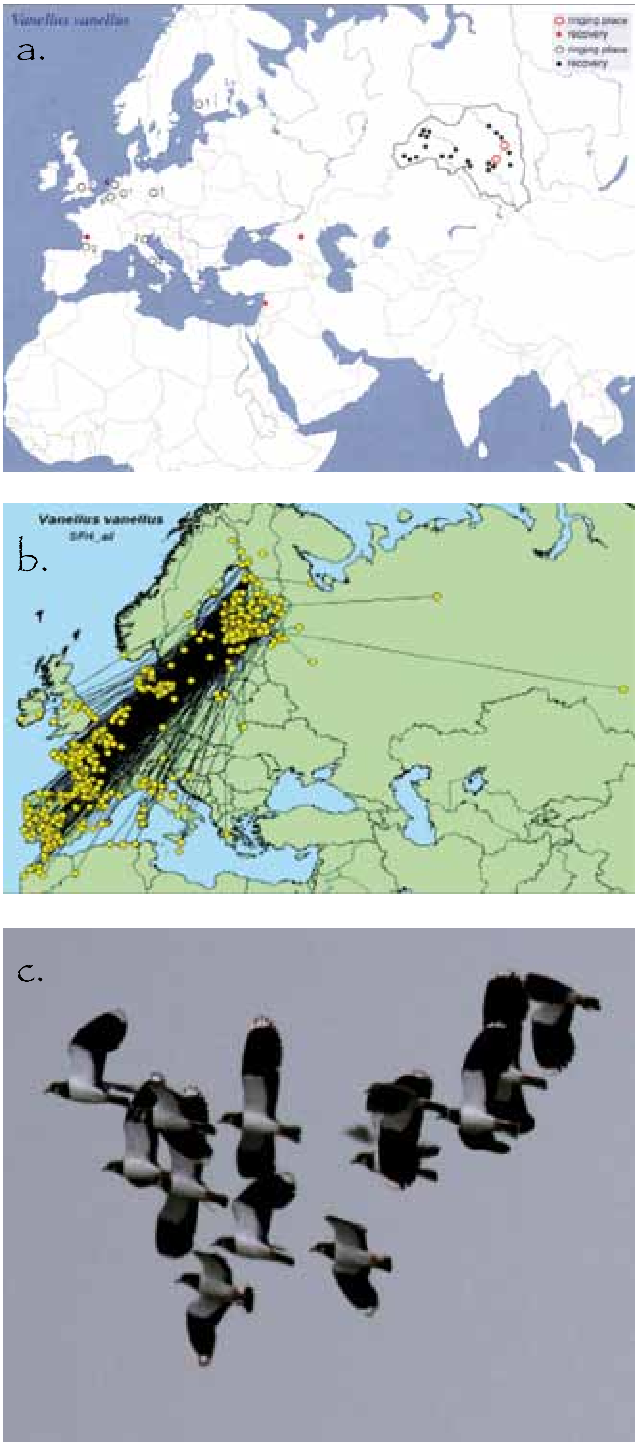


Figure 1.6. a. Ringing recoveries of Northern Lapwings *Vanellus vanellus* ringed or recovered in Central Siberia, mainly Lake Chany and wider surroundings, showing a relatively frequent east-west exchange and migration; (source: Veen *et al.* 2005). Many other waterbird species show similar movements. b. Ringing results from Finland for Northern Lapwing *Vanellus vanellus*; most movements are between Finland and areas to the south-west, but there is also an indication of some east-west migration; (source: Finnish Ringing Centre). c. Flock of Northern Lapwing at Nemunas Delta, Lithuania (photo: Nicky Petkov/www.wildlifephotos.eu).

Figure 1.7. Ringing recoveries of Common Pochard *Aythya ferina* showing predominantly east-west movements across Eurasia; (source: Wernham *et al.* 2002).

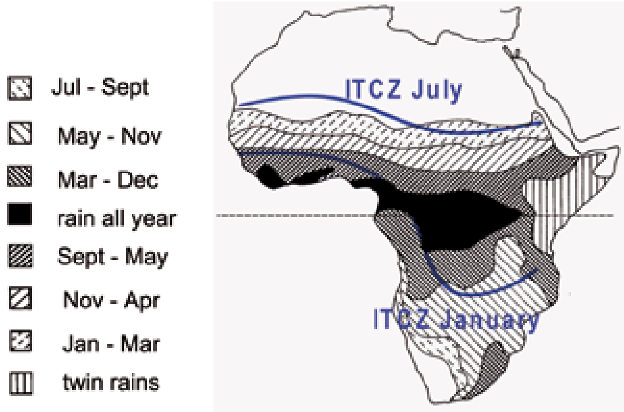


Figure 1.8. The timing and duration of rainfall in sub-Saharan Africa; The thick lines show the July (northern midsummer) and January (northern midwinter) positions of the Inter-Tropical Convergence Zone (ITCZ) (source: Jones 1995).

the ITCZ can be interpreted as a band that moves back and forth across the equator according to the earth's orbit around the sun. The ITCZ is thus a seasonal climatic phenomenon, and its leading fronts carry moist equatorial air north of the equator approximately between May and November, and south of equator approximately between November and April. Whilst there are other factors influencing climate in Africa (including effects of the sea), these movements of the ITCZ are the main factors influencing rainfall in sub-Saharan Africa.

Figure 1.8 is therefore a very useful guide in understanding expected seasonal rainfall patterns in Africa … and a map that all conservation managers in Africa with responsibility for migratory birds should stick up on their wall! These patterns clearly have widespread significant impacts, for instance on crop production, but they are also important for migratory birds, both African-Palearctic migrants and birds that live year-round in Africa. Indeed for many African-Palearctic migrants, drought conditions and competition in Africa was most likely the key original driving force that encouraged birds to move north to seek alternative areas for breeding.

Trans-equatorial migrants
Some waterbirds have regular seasonal trans-equatorial movements that relate directly to these rainfall patterns. One of the best examples is Abdim's Stork *Ciconia abdimii*, a trans-equatorial migrant that breeds in the West African Sahel zone during the rains after which it migrates to Eastern Africa. Their movement patterns were researched by Jensen *et al.* (2006), whose results show visually the migration of eight birds from Niger (Figure 1.9). The main non-breeding destination for these birds is north-western Tanzania, where they arrive as the rains begin in November, exploiting the fresh production of hoppers (immature locusts) and army worms. Some storks then move further south to Zambia and Zimbabwe, depending on the rains. When the early rains in the Rift Valley are good, the storks can be found further east in Tanzania in large numbers. All move northwards eventually through the Rift before moving back to West Africa in time for the onset of rains there.

A comparison of the migration of Abdim's Stork with another African stork, the African Openbill *Anastomus lamelligerus*, is given in the Exercises. This stork breeds mainly in Southern and Eastern Africa, usually late in the rainy season and into the dry season, after which it moves north especially to the Sahel zone and in West Africa, where it is mainly a dry season visitor. The key to their converse strategies is diet. Whilst Abdim's Stork exploits hoppers and other prey that appear just as the rains begin (Figure 1.10), the African Openbill is a specialist of snails that become available later on when wetlands are full, being most readily available as wetlands start to recede.

Nomadic and semi-nomadic movements
As rains in Africa are not always reliable, many waterbirds in Africa do not have such regular movements as the Abdim's Stork. They have adopted more flexible migratory strategies to make sure that they can find the conditions they need to complete their annual life cycles. Some have become partial migrants, moving when conditions dictate; others have become

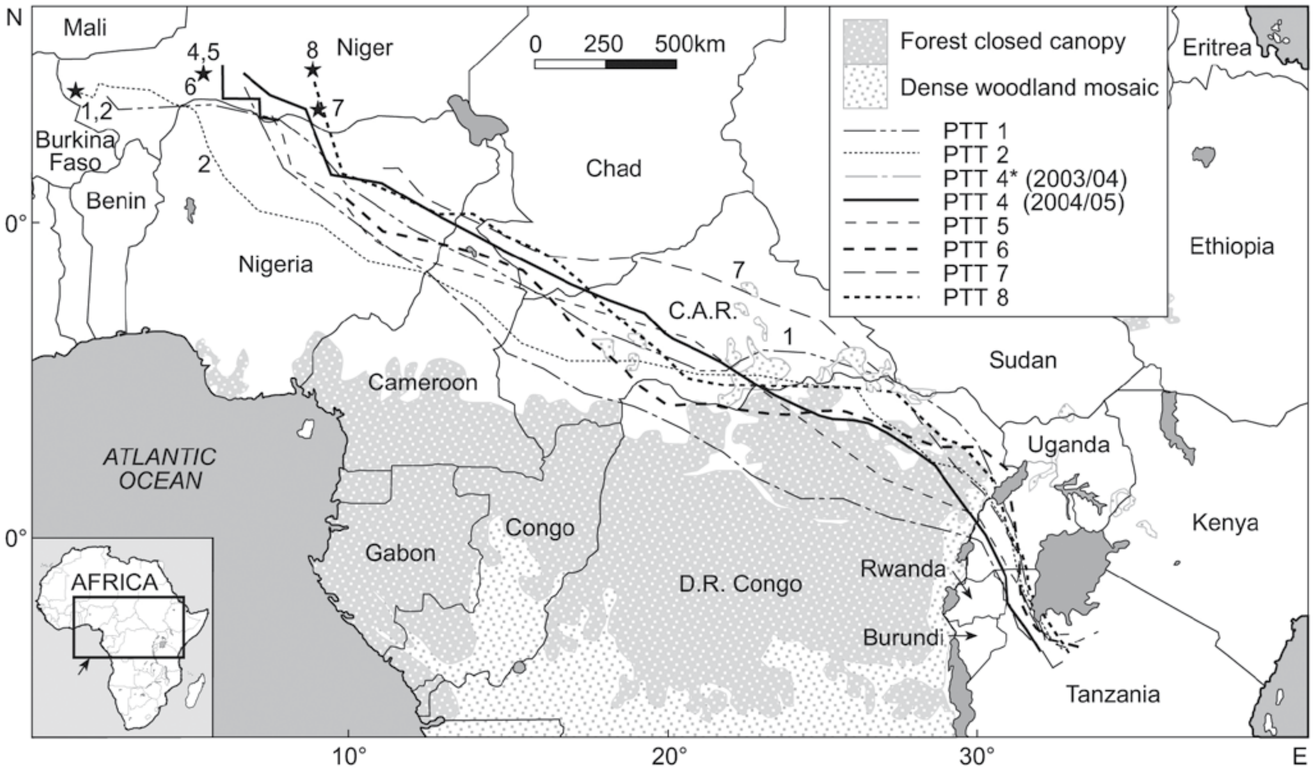


Figure 1.9. Migration routes of Abdim's Storks *Ciconia abdimii* carrying satellite transmitters (PTT1–8) from Niger, West Africa to Tanzania in 2003/04 (broken lines), and that of one bird in 2004–2005 (PTT04, solid line); nesting sites are marked with stars; (source: Jensen *et al.* 2006).

Figure 1.10. Abdim's Stork *Ciconia abdimii* feeding on prey in the grasslands of Ngorongoro Crater, Tanzania (photo: Dorthe Ingemann Larsen).

wanderers or nomads. A nomadic lifestyle particularly favours areas of water scarcity, a strategy adopted not only by waterbirds but by other animals, as well as people. It may also favour birds that depend on a chain of wetlands that they can move between with relative ease.

An example of a nomadic bird is the Lesser Flamingo *Phoeniconaias minor* in Eastern Africa, which moves frequently and unpredictably between a chain of lakes in the Rift Valley. Childress *et al.* (2006) found the movements of satellite-tagged birds to be truly itinerant, with no clear pattern between the very frequent movements of the birds. One bird made 70 inter-lake flights between November 2002 and January 2004, visiting 11 different wetlands and covering a distance of nearly 8,000 km. The only current breeding site for the population is Lake Natron, though none of the three birds came here during the study period, visiting instead other lakes, such as Bogoria, Manyara and Nakuru (Figure 1.11).

The different driving forces for migration associated with rainfall

Movements associated with rainfall are not always 'clear-cut'; Dodman & Diagana (2006) describe several different triggers for movement in Africa associated with rainfall:

- *Sudden availability of productive wetlands*
  The sudden availability of productive wetlands is particularly apparent in arid and semi-arid areas, as ephemeral (or temporary) wetlands are formed. Birds arrive in waves, some moving directly with the rain fronts and thunder clouds (see section 3.6).

- *Rising water levels/flooding*
  Many waterbirds are attracted to floodplains, and move into these areas as water levels rise and flood conditions take over. Such birds include some herons, cranes and rails. Often birds might breed in colonies in thickets within the wetlands, such as the huge egret colonies in the flooded forests of the Inner Niger Delta. Conversely, the same rising water levels push some birds out of wetlands, especially waders that feed at the water's edge. For instance most of Zambia's Kittlitz's Plovers *Charadrius pecuarius* move out during the rainy season, as wetlands become 'too wet'.

- *Falling water levels/edge effects*
  Receding water levels provide the best feeding opportunities for birds that feed at the water's edge, including most waders. In the Inner Niger Delta, water levels fall mainly between January and April, providing optimal feeding conditions for waders and other waterbirds. The Marabou Stork *Leptoptilos crumeniferus* exploits dwindling pools as the dry season sets in, feasting on the high concentrations of prey like catfish.

- *Lack of water*
  Some birds will exploit these dwindling pools until all water has gone, then the lack of water itself is the driving force for movement.

Figure 1.11. Lesser Flamingos *Phoeniconaias minor* at Lake Nakuru, Rift Valley, Kenya. Numbers of flamingos at this lake vary considerably throughout the year (photo: Tim Dodman).

It is important to appreciate the time lag between rainfall and optimal conditions for waterbirds, especially in river basins. Some of the most important sites for waterbirds in Africa are found on wetlands of the major rivers such as the Nile, Niger and Zambezi. The Niger depends most on rainfall in the highlands of Guinea, not on rainfall patterns in the Sahel zone. Flooding in the Sudd is dependent on rainfall upriver Uganda and other countries. In such areas the rainy thus does not equate with periods of peak productivity.

Madagascar-Africa migrations

Some birds have a regular migration between Madagascar and continental Africa. Two of these, the Madagascar Pond-Heron *Ardeola idae* and the Madagascar Pratincole *Glareola ocularis* are threatened, and urgent measures are needed for their conservation, in both their breeding areas in Madagascar and their non-breeding areas in Africa. The original triggers for their migration are not clear, but may have originated in Africa, perhaps due to competition with other birds.

Coastal movements

Some African birds move along Africa's long coastlines. The key driving forces for migration are a combination of food resources and the

Figure 1.12. Royal Terns *Sterna maxima* breeding on a Senegalese island (photo: Jan Veen/VEDA).

Figure 1.13. Flock of geese at a lake adjacent to extensive hayfields in Kazakhstan (photo: Albert Salemgareyev).

availability of suitable breeding areas. Food richness is linked closely to the different marine upwellings. The various islands between Mauritania and Guinea provide good breeding sites for Royal Tern *Sterna maxima*, which come here to breed around May. After breeding, many terns move south and east along the coastline of the Gulf of Guinea as far south as Angola, spreading themselves along the coastline to feed over a wide area. Strong upwellings off the Ghana coast bring spawning fish inshore, with a peak in September, providing a strong incentive for terns to migrate. However, east of Guinea there are no suitable breeding islands, so most terns will return annually to the islands further west for breeding (Figure 1.12).

The Damara Tern *Sterna balaenarum* moves in the opposite direction; it breeds particularly in the coastal zone of Namibia. After breeding birds group into non-breeding flocks then move north along the coastline, also reaching Ghana and other Gulf of Guinea countries to exploit spawning fish.

1.4.5 Movements in a changing world

Climatic conditions around the world are not static, and to keep up with changing conditions, birds too need to adapt themselves in order to survive and prosper. An example of birds changing their habitat preferences is provided by geese in Europe. Some geese have gradually changed from using natural vegetation/ grasslands such as coastal marshes towards intensively managed grasslands for a part of the non-breeding period. As natural habitats have declined in area and quality, geese have learned to exploit alternative habitats in landscapes that are extensively managed, which often include good quality pasture (Figure 1.13). For this reason, geese and other congregatory waterbirds often come into conflict with farmers.

In semi-arid areas of Southern Africa, a number of waterbird species now make use of the many artificial wetlands scattered throughout the region, such as farm ponds and dams created for purposes of agricultural irrigation, which in many cases provide year-round habitat, compared to the many seasonal ponds that are only available for a short period after the rains.

Many migratory waterbirds are thus adaptable, and are quick to exploit new wetlands or find alternative sites if their usual ones disappear or are no longer productive, or perhaps may be subject to land use change that render them unsuitable (such as disturbance). Birds with well-defined narrow-front migrations (see section 3.1) may be less adaptable. Some cranes for instance have high site fidelity.

Evolutionary changes

New migration routes and non-breeding areas may also result from evolutionary change, as has occurred with some Blackcaps *Sylvia atricapilla* breeding in central Europe; a portion of the population has shifted their migration from a south-westerly to a north-westerly direction, establishing new non-breeding areas in Britain within a period of 30 years (Helbig 1996). This shows that new ‘inbuilt’ migration routes can develop quite rapidly, giving the potential at least for rapid adaptation to changing conditions.

Further reading:
- *The Migration Ecology of Birds (Newton 2008).*
- *An Atlas of movements of Southwest Siberian waterbirds (Veen et al. 2005): http://global.wetlands.org/LinkClick.aspx?fileticket=fjmT2I7Hn14%3d&tabid=56.*
- *Migration strategies of Palearctic passerines in Africa (Jones 1995).*
- *Conservation dilemmas for intra-African migratory waterbirds (Dodman & Diagana 2006): http://www.jncc.gov.uk/PDF/pub07_waterbirds_part3.4.1.pdf.*
- *Migration routes and staging areas of Abdim's Storks Ciconia abdimi identified by satellite telemetry (Jensen et al. 2006).*
- *Satellite tracking documents the East African flyway and key site network of the Lesser Flamingo Phoenicopterus minor (Childress et al. 2006): http://www.jncc.gov.uk/pdf/pub07_waterbirds_part3.4.6.pdf.*

1.5 Migratory energy storage

Key message

Migration over long distances presents a high physical strain on birds; efficient energy storage mechanisms and undisturbed feeding sites are essential.

To be able to migrate birds must have a 'feeling and ability' for orientation (where to go and when) and to be in a physical condition to actually fly sometimes long distances without being able to feed. To maintain their physical condition requires a system of energy storage by means of fat and an efficient way to use it for migration. Continuous disturbance at important feeding areas can negatively influence the fat storage process with the result that birds cannot build up to the condition required for successful migration (see section 8.2.6). Recent research has provided insight in this mechanism of fat storage and has even shown that birds are able to use other parts of their body (such as muscles and stomach tissue) as an energy source if the amount of fat is not sufficient to meet the energy requirements to cover a long distance flight. This strategy enables long-distance migrants to reach their destinations, although it puts them at risk, especially if conditions along their migration are not good (Figure 1.14).

Figure 1.14. A dead Red Knot *Calidris canutus*, one of a number freshly found on the beach near Iwik, Banc d'Arguin, Mauritania in December 1982. This bird used its flight muscles to reach the area, but even that was not enough to reach the area in a good condition. What happened 'en route' is not clear (photo: Gerard Boere).

Birds can also make use of external energy sources such as certain wind/air stream patterns, which will help them cover longer distances between 'refuelling stops'. The availability of suitable habitat and food resources along the migration route is vital, although the location and distance between refuelling sites varies according to the different migratory strategies employed.

Further reading:
- *The Migration Ecology of Birds (Newton 2008).*
- *Shorebirds: An illustrated behavioural ecology (van de Kam et al. 2004).*

1.6 Navigation and orientation

Key message

Birds use a range of navigation and orientation techniques and clues to find their way. Some birds learn migration methods by travelling in flocks. Weather can influence migration.

1.6.1 Definitions and overview

In terms of bird migration, Newton (2008) provides these definitions:

- ***Navigation*** is following a specific course to a distant goal.
- ***Orientation*** is the direction in which a migrant bird heads to a non-specific goal.
- ***Compass orientation*** is keeping a constant angle towards an external reference system to give a straight migration direction.

Navigation is basically the 'art of getting there', whilst orientation refers to the direction taken. How birds actually determine the direction they have to take during migration has been subject to much research and speculation, with a range of theories and explanatory models. However, there is no 'one answer' as to how birds find their way; rather, birds use a range of techniques and clues, with different strategies for different species. The way orientation and navigation work is difficult to explain, and a number of systems are probably in place that birds have learned to understand, one way or another, including:

a. a celestial compass based on the sun, light patterns and star patterns;
b. a magnetic compass based on the earth's magnetic field;
c. an internal clock; and
d. an inherited mean migratory direction and time programme.

In addition some birds have an internal, endocrine mechanism that sets the bird off for migration, whilst there may also be genetically controlled differences between age groups (as shown in Figure 3.23, section 3.8.2). Many birds have good spatial memory and/or can learn from others.

1.6.2 Compass orientation

Relocation studies (i.e. when a bird is moved or displaced somewhere else) have shown that some birds are able to rapidly return to their original breeding place, even if they have to migrate in the opposite direction to usual. Manx Shearwaters *Puffinus puffinus* displaced from their breeding colony in Wales (UK) to eastern North America managed the return distance of nearly 5,000 km in 12 days (Matthews 1968). This type of orientation is known as compass orientation; i.e. the birds assume a knowledge about the direction in which they must travel. Most birds find their way using one or more of three compasses:

a. Sun (or sun-azimuth) compass
Birds find their way based on the position of the sun in the sky, whilst sunset, sunrise and hours of sunshine (day length) also provide clues. The use of the sun in orientation was shown by Kramer (1951) who experimented with Common Starlings *Sturnus vulgaris* (Figure 1.15).

Clear nights are also important for many migratory species; Common Cranes *Grus grus* are essentially daylight migrants, but they can also migrate in large numbers at night if there is a clear sky and moon.

b. Star compass
Similar experiments to those with Common Starlings have shown that some birds also

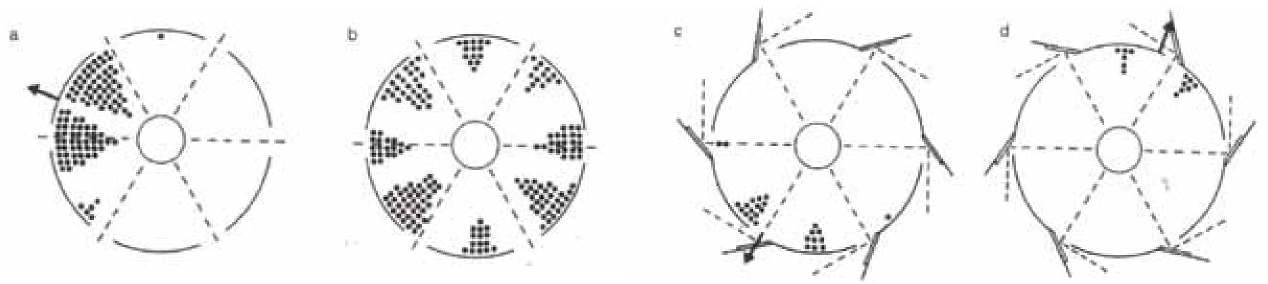


Figure 1.15. Orientation in Kramer cages by Common Starlings *Sturnus vulgaris*; each dot represents 10 seconds of fluttering activity, and arrows show mean direction of activity: a. behaviour under clear skies; b. behaviour under totally overcast conditions; c and d. orientation when the sun was experimentally deflected using mirrors (source: Newton 2008; based on Kramer 1951).

navigate by the stars. This is mainly achieved through learning star patterns.

c. Magnetic compass
Experiments have also shown that some birds use a magnetic compass to navigate, with an ability to detect lines of magnetic force. Navigation using the magnetic compass is less dependent on weather conditions, but it is only really useable for moving in north-south (or south-north) directions.

Birds also use landscape features to navigate, especially when 'homing' in on an exact location, such as the exact same breeding site they have used before. This can only be achieved through learning, whilst compass orientation requires innate (or inbuilt) abilities.

1.6.3 Social factors

Social influences are important particularly in waterbirds, as many of them migrate in flocks or in family units. Young birds can learn migration routes from experienced adults, whilst birds moving in flocks can also benefit from experienced individuals and from 'collective' flock decisions. Birds migrating in flocks often call; this may be especially helpful when moving together at night or in poor visibility (e.g. mist or fog). The ability of young birds to learn migration routes is important in conservation of threatened migratory birds, when there is a need to build migratory behaviour into captive-bred birds destined for release. This has led to endangered cranes being 'shown the way' by the use of microlight aircraft. In Europe reintroduced Northern Bald Ibises *Geronticus eremita* have been taught a migration tradition by the Waldrappteam.at team from the breeding area to an appropriate non-breeding destination area guided by flying motor trikes (Figure 1.16).

Figure 1.16. Northern Bald Ibises *Geronticus eremita* guided on migration by microlights (photo: Markus Unsöld).

1.6.4 Orthodromes and Loxodromes

The type of route migratory birds take on their journey is not yet very clear. When a bird moves between due North and due South, the shortest route is a 'straight line' between its origin and destination. However, if the journey has an easterly or westerly component, then it has two choices:

a. Great circle or orthodrome route
The great circle route is the shortest distance between two places but requires a constant change of direction compared flying in a direct or compass line.

b. Rhumbline or loxodrome route
A route maintaining the same heading (or compass direction) throughout the journey.

These different choices are illustrated in Figure 1.17. The advantage of an orthodrome route only becomes clear when looking at a map using an *equal-area* or *gnomonic projection*. So moving across longitudes (east-west travel) presents extra navigational complexity, whilst there are also time shifts to consider (i.e. birds move between time zones).

Figure 1.17. Illustration of great circle and loxodrome routes of Ruff *Philomachus pugnax* migrating between the Lena Delta in Eastern Siberia and Senegal. After breeding in Siberia, Ruffs fly mainly according to the great circle route, a distance of 10,060 km, continuously changing their direction to stay on the right track. In the northern spring the return route from Senegal is closer to the loxodrome, a distance of 11,850 km, i.e. about 18% longer. Ruffs probably choose the longer loxodrome route in spring due to the unpredictability of the habitat of the great circle route then (frost, snow cover etc.). Also, there is probably more food available in the main staging areas around the Mediterranean due to the winter rains (source: Alerstam 1990).

1.6.5 Migration and weather

Birds are able to adapt their migratory strategies and change their routes if necessary. Weather in particular can have a substantial influence on bird migration through strong winds, fog, intense heat, snow and ice cover and other conditions (Elkins 1988). Birds have mechanisms to correct towards the right direction if strong winds have moved them off course. However, this is not always possible and can result in vagrancy (see section 3.8.1). Particularly bad weather conditions can cause the death of thousands of birds.

Further reading:
- *The Migration Ecology of Bird (Newton 2008).*
- *Atlas of Bird Migration (Natural History Museum 2007).*
- *Waldrappteam.at: www.waldrapp.eu/eng/start_eng.html.*
- *Weather and bird behaviour (Elkins 1988).*
- *Bird Migration, physiology and ecophysiology (Gwinner 1990).*
- *Cartography – Visualisation of Spatial Data (Kraak & Ormeling 1996).*
- *Gnomonic projection: http://en.wikipedia.org/wiki/Gnomonic_projection.*

1.7 The complexity of migration

Key message

Bird migration is complex, with many different strategies. International cooperation is vital in unravelling these strategies in order to improve conservation actions.

The complexity of bird migration makes it a fascinating subject for scientific discovery, and modern research techniques present new opportunities for us to find out more about the many strategies and driving forces of migration. The diversity of migration, which involves hundreds (globally even thousands) of species, each with its specific way of ‘ handling’ the need for migration, and the range of approaches: short, medium and long distance migrants, north-south migration, east-west migration and intra-African migration etc. are covered in greater detail in the next two sections. However we do not go into further detail on the techniques of migration, such as orientation, fat storage, the use of body parts as an energy supply and the use of external energy sources. These are all interesting subjects, and the whole question of how birds find their way is one that has fascinated mankind for centuries. Interested readers are advised to turn to Newton’s ‘*The Migration Ecology of Birds’* (2008), which has information on all aspects of migration. The Migration Atlas of Britain and Ireland (Wernham *et al.* 2002) also has much useful general information on migration in its introductory chapters.

However, this diversity of migratory strategies also makes it a complex issue for conservation actions which can only be effective through intensive international cooperation over a large geographical area: in other words by using the flyway approach in its full!

Further reading:
- *The Palearctic-African Bird Migration System (Moreau 1972).*
- *The Migration Ecology of Birds (Newton 2008).*
- *Atlas of Bird Migration (Natural History Museum 2007).*
- *The Migration Atlas: movements of the birds of Britain and Ireland (Wernham et al. 2002): http://www.bto.org/research/projects/atlas.htm.*

2. Flight techniques, travel schedules and their conservation implications

Migration strategies may be described at three levels or categories:

- The technique/behaviour waterbirds use to move forwards
- The way waterbirds cover the distance between the beginning and the end of the migration route
- How migration takes place within the wider geographical context.

The complexity of migration routes of so many different waterbird species of all sizes is mirrored by a great variation in migration strategies; in this respect waterbirds do not differ much from other bird species groups such as passerines and birds of prey.

Figure 2.1. Flock of Greater White-fronted Geese *Anser albifrons* in The Netherlands (photo: Wouter Boere).

2.1 The behaviour and flight techniques of waterbirds

Key message

Birds mostly migrate using active flight or soaring. Soaring birds may experience bottlenecks, where conservation action may need to be prioritised.

Birds have adapted different techniques for flying long distances. Some birds use active flight techniques, others soar, and some use a combination of the two. A few waterbirds migrate by walking or swimming, particularly juveniles and attendant adults. Some birds also fly at high altitudes, where the wind is generally stronger. Birds flying against the wind will thus tend to fly at low altitudes, and fly higher when they are moving with the wind. Some waterbirds have been recorded migrating at heights of up to 9,000 m above sea level.

Figure 2.2. V-formation of geese, with a hot air balloon in the background (photo: Wouter Boere).

2.1.1 Active flight

Many waterbirds use active flight when covering a large distance during migration, including most waders, ducks and geese, as well as some larger species such as cranes. There are different

Figure 2.3. Hundreds of migrating storks exploit a thermal column over Haifa's Carmel ridge (photo: David King).

behaviours of active flight. Some birds fly in large groups without a particular structure, but others, notably several goose and crane species, adopt characteristic V-formations, which enable birds to work together as a flock to conserve individual energy (Figures 2.1 and 2.2). Flying in a V-formation enables each bird (apart from the leader) to see the one in front whilst also benefiting from its slipstream, helping the bird behind to gain lift and reduce drag, with an energy saving of some 10–20%. Leaders, usually adult birds, tire quicker, so change position. Birds that fly in less structured flocks also experience some energy-saving benefits.

There are different kinds of active flight, such as continuous flapping, flapping and gliding and bounding (used mainly by smaller birds).

2.1.2 Soaring

Soaring is the technique birds use to move forwards by exploiting thermal currents to gain height and then glide over longer distances. As the ground warms up in the morning sun, it absorbs energy, but some surface features, such as open spaces, absorb more than others, causing air to heat up above them. This warm air rises, and as it does so, draws in more air that also heats up and rises. This action results in thermal currents that can literally lift birds up. Soaring is frequently used by migratory birds of prey and some larger waterbirds, including cranes, storks and pelicans (Figure 2.3). Birds migrating through the rift valleys of the Middle East and Africa depend a lot on thermal currents, as do birds of extensive plains.

Many seabirds such as albatrosses, petrels and fulmars, practice 'dynamic soaring', making use of the friction created by wind over water. Birds climb into the wind to gain height then turn and glide with the wide on long thin outstretched wings.

2.1.3 Walking and swimming

Some birds cannot fly and may migrate by walking or swimming. Examples include ostriches and penguins. However, most waterbirds have good flight capabilities, but some species do migrate relatively short distances with their flightless young. Flightless moulting birds may also have to walk or swim some distance, for instance if their chosen moult site is disturbed.

2.1.4 Conservation implications

The different techniques used for migrating have some conservation implications, though not as many as for the different travel schedules (see below). Soaring tends to be a more efficient mechanism than active flight, so soaring birds do not need to feed so much while they are migrating. This means that they are generally less dependent on key fuelling sites during their migration than birds that are actively flying. They also do not need to build up such extensive energy stores, so their dependence on key staging areas is not so high. However, soaring birds are often forced by their flight needs into ***bottlenecks***, where they may be exposed to specific threats, such as persecution and wind farms. (For more information on bottlenecks see section 4.8).

Active fliers need to be in good physical condition before and during their migration, especially those that adopt long non-stop flights. The V-formations described above help birds to save energy, as the birds at the front of the V have to work harder than those at the back.

Walking and swimming juvenile migrating birds may be rather vulnerable to predation and other threats along their journeys, similar to the threats facing moult migrants (see section 3).

For many migratory waterbirds their tendency to form large flocks is a good defence strategy, but it does make them vulnerable to hunting and such environmental incidents like oil spills.

Further reading:
- *Bird Migration (Alerstam 1990).*
- *The Migration Ecology of Birds (Newton 2008).*
- *Shorebirds: An illustrated behavioural ecology (van de Kam et al. 2004).*
- *Atlas of Bird Migration (Natural History Museum 2007).*
- *Soaring birds: http://www.birdlife.org/flyways/africa_eurasia/soaringbirds.*

2.2 Travel schedules: covering the distance of the migration route

Key messages

The different travel schemes adopted by birds have important conservation implications; 'hopping' birds require suitable sites at regular distances, whilst 'skipping' birds need larger sites where they can reliably feed. The Arctic Tern has the longest regular migration.

2.2.1 Travel Schedules

The various strategies used by waterbirds to migrate over long distances are only recently becoming known and understood, and are mostly described in section 3. However, birds following these different strategies may have rather different travel schedules. When an observer sees a flock of birds migrating overhead, it is almost impossible to tell if they are flying a long distance in just one flight or if they instead are moving locally from wetland to wetland and taking their time.

Through years of careful study it has become clear that many migratory waterbirds use three basic travel schemes for covering the distance between their breeding areas and their non-breeding destination areas, as outlined by Piersma (1987) and illustrated in Figure 2.4 for waders moving along the East Atlantic Flyway on their spring migration from West Africa to northern breeding sites. These different travel schemes are:

- ***Short-distance or hopping***
  This is a strategy in which waterbirds migrate over relatively short distances, perhaps of only a few hundred up to a thousand kilometres in between resting and feeding places. Such a strategy requires the availability of suitable habitat at regular intervals in the migration route and of food over longer periods. Hopping does not require much fat accumulation in the birds' bodies, and keeps their weight low.

- ***Medium-distance or skipping***
  Birds using this travel scheme cover longer distances between resting places, often up to 1,500–2,000 km at any one time. Compared to 'hopping' birds, they have a greater dependence on a relatively small number of favoured sites, where they must refuel and rest.

- ***Long-distance or jumping, and non-stop***
  Birds using this travel scheme cover large distances in individual flights, sometimes of 3,000–5,000 km or even more. These birds have a high dependence on a very limited number of key sites for replenishing fat stores and resting. Some birds following this scheme make non-stop journeys between their breeding areas and non-breeding areas.

The kinds of distances actually travelled by birds following the East Atlantic Flyway are illustrated in Figure 2.5 using a different map projection. It can

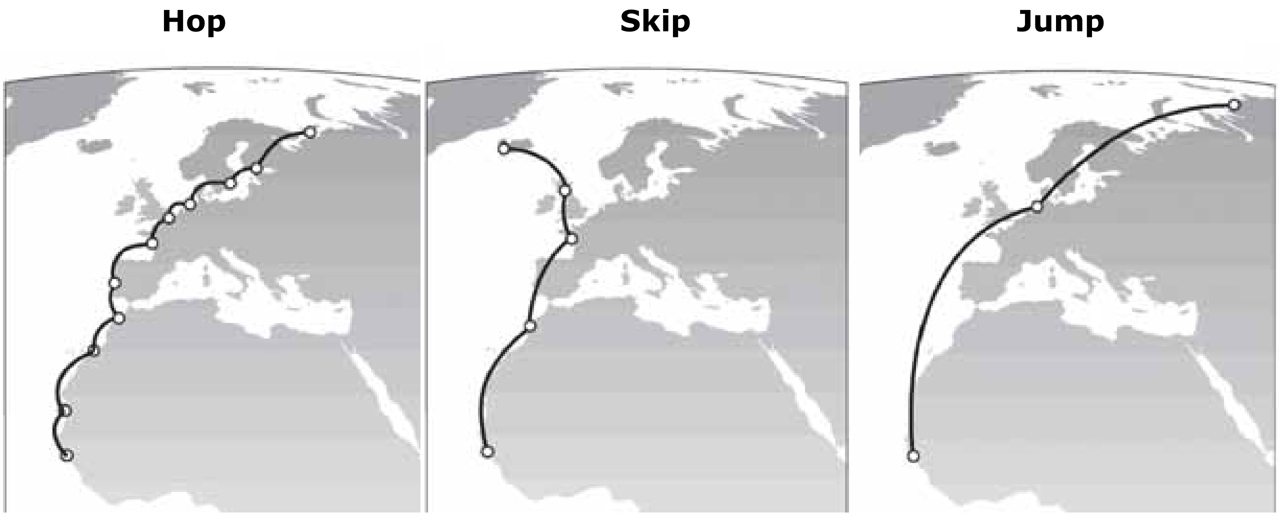


Figure 2.4. Different travel schemes shown by waders moving from coastal West Africa to sub-arctic breeding grounds. From left to right: Ruddy Turnstone *Arenaria interpres* ('hop'); Dunlin *Calidris alpina* and Common Redshank *Tringa totanus* ('skip'); Red Knot *Calidris canutus* and Bar-tailed Godwit *Limosa lapponica* ('jump') (source: Piersma 1987).

be seen that the Wadden Sea in northern Europe is about halfway between important breeding areas for many waders in the Arctic Circle and the main non-breeding destination areas in West Africa.

2.2.2 Conservation implications

These three different travel schemes have different implications for the conservation of the species. A 'hopper' requires a number of suitable sites at regular distances but may be flexible to move to another area if a site disappears. It is probably not strictly bound to larger sites, depending instead on the availability of a network of sites at suitable intervals.

By comparison, 'skippers' do require a number of larger sites and, as they have been flying relatively long distances, may be less able to adapt if suitable sites disappear, forcing them to fly on longer distances, potentially compromising their ability to complete the flight.

This requirement for large 'dependable' sites is even more accentuated for waterbirds, mainly waders, which use a 'jumping' strategy. These long distance migrants often operate their migration at the very limit of their physical abilities. They adapt for their migrations by maximising their fat load, whilst at the same time reducing their weight by minimising body parts not useful for flight, such as the stomach. They even may use up parts of their muscles as an energy source for flight. These birds rely heavily on the existence of larger areas with sufficient food resources and limited disturbance, where they can quickly and safely restore their body conditions and put on weight again.

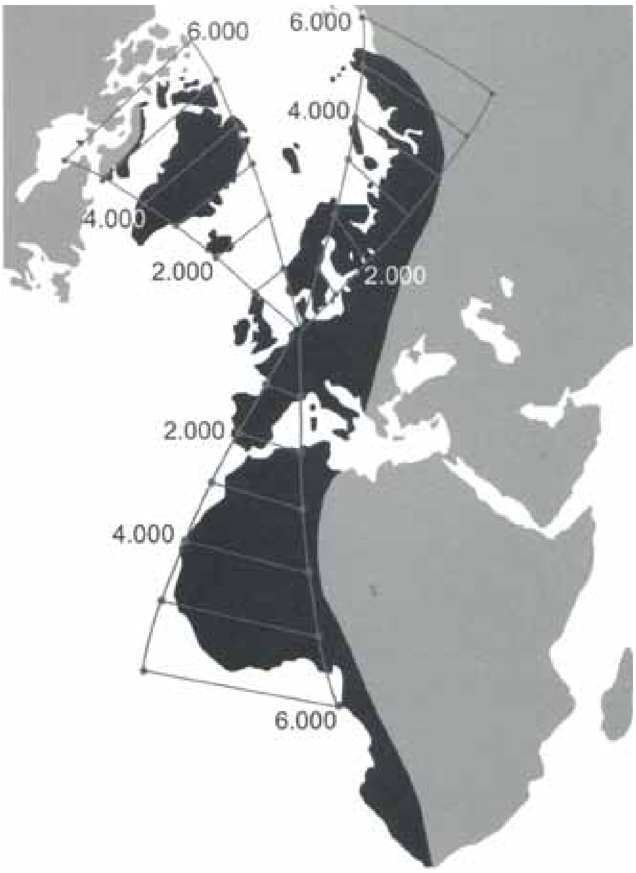
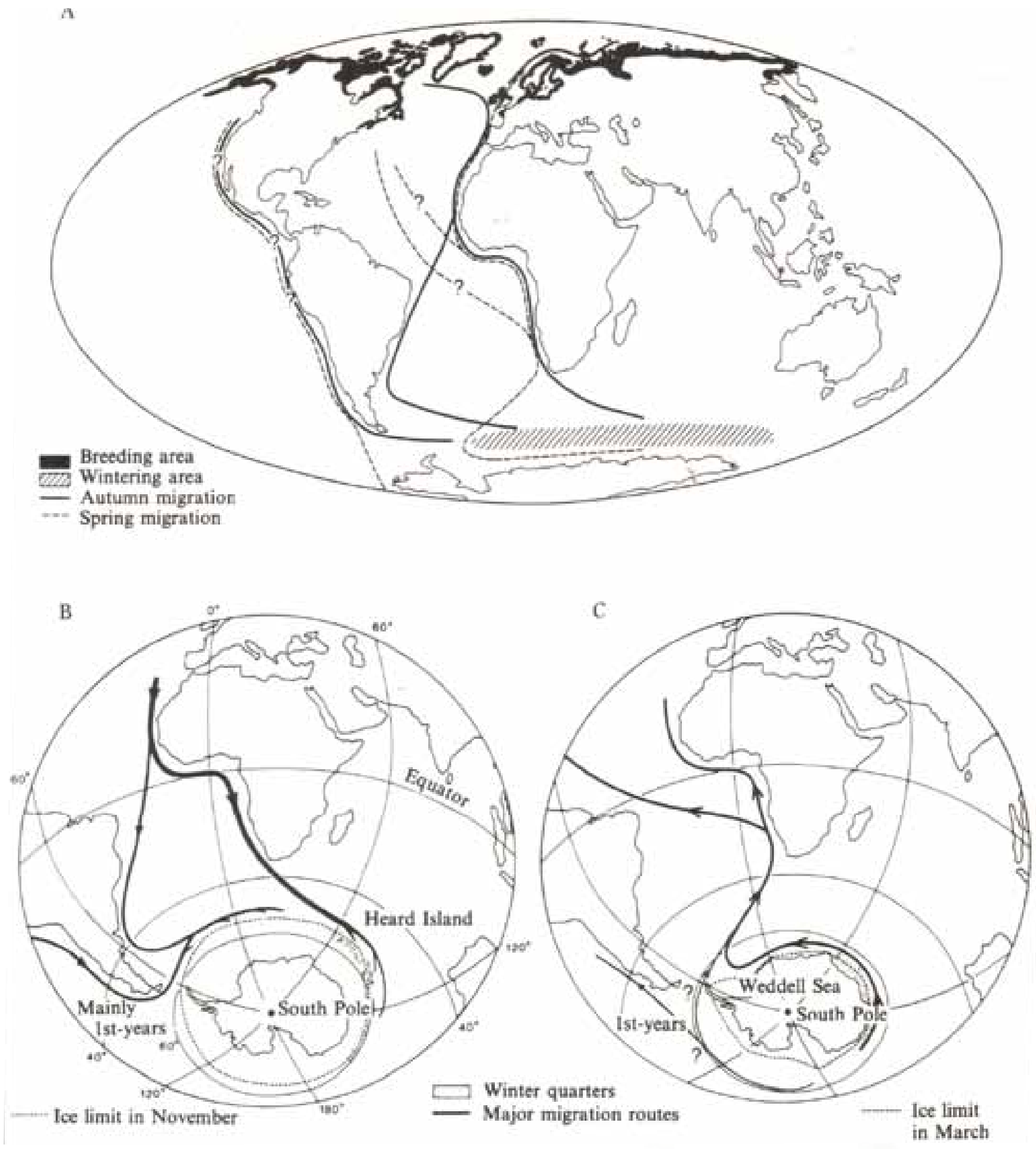


Figure 2.5. Diagram of the East Atlantic Flyway showing some migration distances (in kilometres) based on the Great Circle Route (see section 1.6.4) in relation to the Wadden Sea (source: Engelmoer 2008).

The champion of long distance migration is probably the Arctic Tern *Sterna paradisaea*. Birds breeding in northern Europe migrate to the open oceans around Antarctica, most travelling along



the west coast of Africa; some return via the coast of South America, thus performing a loop migration (Figure 2.6). However, unlike the Bar-tailed Godwit, which carries out 'long-haul' flights, the Arctic Tern feeds constantly on its migration, so these two long-distance migrants both have very different travel schedules. There are thus very different conservation implications for them. The Arctic Tern depends on a good food supply and feeding conditions all along its long route, whilst the Bar-tailed Godwit depends on just one or two key sites in order to perform its migration successfully.

Figure 2.6. Migration patterns of the Arctic Tern *Sterna paradisaea* (source: Alerstam 1990)*;* Arctic Tern (photo: Christophe Mueller).

Further reading:
- *The Migration Ecology of Birds (Newton 2008).*
- *Hop, skip or jump? Constraints in migration of arctic waders by feeding, fattening and flight speed (Piersma 1987).*
- *Bird Migration (Alerstam 1990).*
- *Shorebirds: An illustrated behavioural ecology (van de Kam et al. 2004).*

3. Migration strategies within the wider geographical context

[Note: *'Further reading'* for all migration strategies is given at the end of section 3].

Migration has evolved in different species at different times and for different reasons, so it is not surprising that a wide range of migration strategies or patterns have developed. Migration routes do not always cover the same geographical areas in both directions. Some species have geographically narrow migratory ranges, whilst for others the range may be very broad. Different migration strategies have also been adopted by different populations of certain species; indeed this behaviour has often led to the splitting of species into separate discrete populations. Some species have populations that are migratory and others that are not. An example is the Eurasian Spoonbill *Platalea leucorodia,* which has two migratory populations breeding in Europe (*leucorodia*), a resident breeding population in Mauritania (*balsaci*) and a largely resident population of the Red Sea (*archeri*).

The main migration strategies adopted by waterbirds are the following:

- Narrow-front migration
- Broad-front migration and parallel migration
- Loop migration
- Leapfrog migration
- Moult migration

There are also other less common migration strategies, such as chain migration, crossover migration and altitudinal migration.

Modern research techniques in particular are helping us to unravel these different strategies, and have revealed some astonishing migration feats. Various colour marking techniques and detailed regular observations of migrations have significantly improved our knowledge of migration strategies, but the recent use of satellite technology in particular has enabled us to gain information to a new level of detail. Satellite telemetry, for instance, revealed the incredible migration strategy of a Bar-tailed Godwit *Limosa lapponica*, which performed a loop migration around the west Pacific Rim from New Zealand north to Alaska, returning across the Pacific Ocean (Figure 3.8).

3.1 Narrow-front migration

Key messages

Birds migrating along a narrow front are channelled into corridors, where there may also be bottlenecks. Conservation of key sites along corridors is important.

This occurs when migrants from a wide area are concentrated by topographic situations that channel them, such as when they pass along coastlines, peninsulas or through narrow valleys (Newton 2008). Many waterbirds use a restricted geographical range through which they migrate between areas, usually between the breeding area and the main non-breeding area. The Common Crane *Grus grus* restricts itself to very narrow ranges or ***corridors*** when on migration through Europe (Figure 3.1). Several species of goose also have narrow front migrations in Europe, often applied by different populations of the same species, migrating via a narrow corridor to separate wintering areas. In Eastern Africa, the Nile and Rift Valleys can serve as corridors, favoured areas through which migrants move on a narrow-front.

Many wader species are restricted to coastal/marine habitats away from their breeding areas, and only small numbers of these species are observed inland outside the breeding season (often first year birds). This means that they have a relatively narrow geographical band through which they move. Several wader populations migrate along the East Atlantic Flyway, which presents a narrow band along the western coastline of Africa. This coastline is relatively rich in potential feeding areas, with several coastal wetlands of high productivity and limited disturbance. It presents therefore many more feeding opportunities than, for instance, inland crossings over the Sahara Desert. The Red Knot *Calidris canutus* shows a very clear narrow front migration along this route (Figure 3.2). Other birds using this narrow-front migration route include the Whimbrel *Numenius phaeopus* and the Black Tern *Chlidonias niger*.

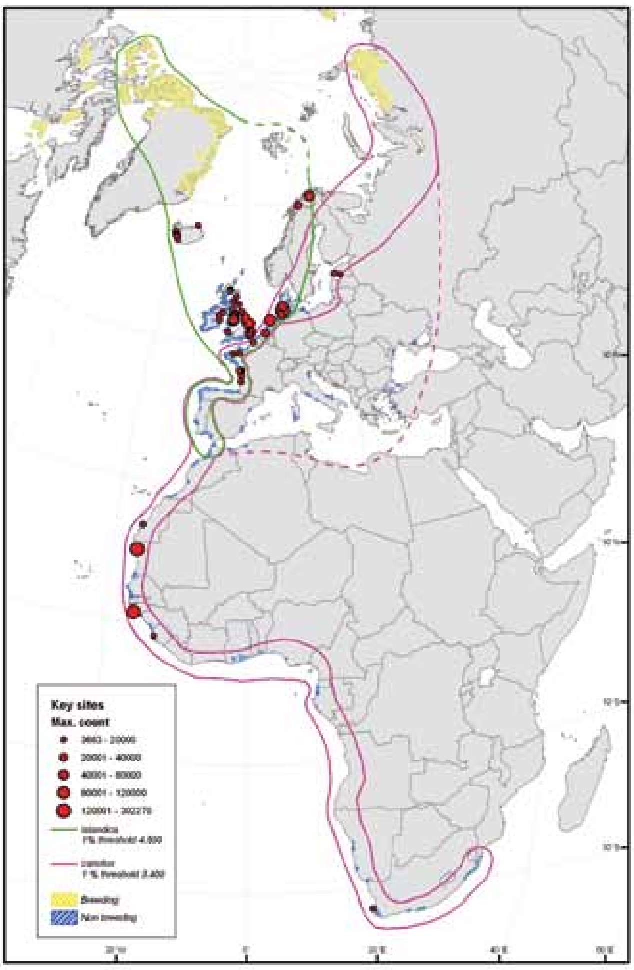


Figure 3.2. Narrow-front migration of the Red Knot *Calidris canutus* along coastal West Africa (Delany *et al.* 2009); Red Knots in Turkey (photo: Soner Bekir).

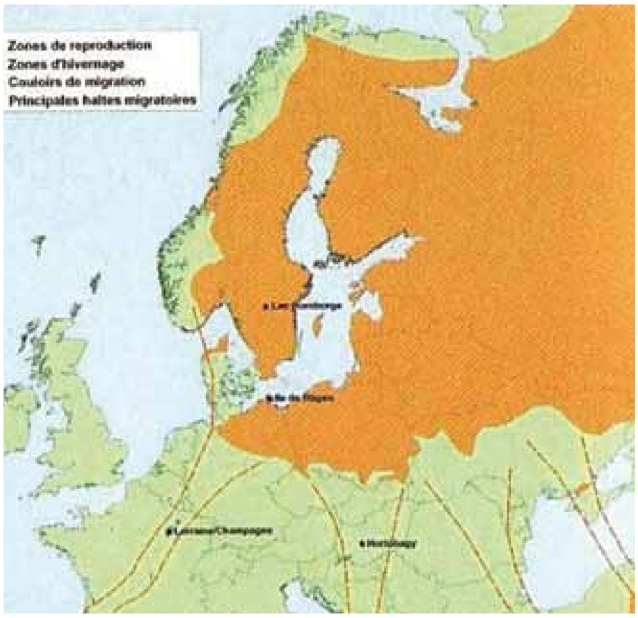


Figure 3.1. Example of the very restricted migration routes of the Common Crane *Grus grus* in Europe and North Africa. These cranes have a large breeding range in Northwest Europe, but concentrate after the breeding season at a few preferred sites. They then continue their migration via narrow bands through Europe; locations of these narrow bands are strongly determined by cross-Mediterranean bottlenecks. The migration route in France is the best known, and the narrow band shown is based on hundreds of observations made year after year (source: LPO Champagne-Ardenne, France, 2006).

3.2 Broad-front migration and parallel migration

> ***Key messages***
>
> *Birds migrating along a broad front use many suitable sites over a large area. Some birds adopt parallel migration routes, which may result in parallel corridors, resulting in discrete migratory populations. Conservation is needed at the population or flyway level.*

3.2.1 Broad-front migration

Broad-front migration describes migration across a region with no apparent streaming or concentration by topographic or other features (Newton 2008). In contrast to the Red Knot *Calidris canutus*, several other wader species have a broad-front migration and use all suitable inland habitats along their migration route. One such species is the Common Sandpiper *Actitis (Tringa) hypoleucos* which has a broad-front migratory route between breeding areas in

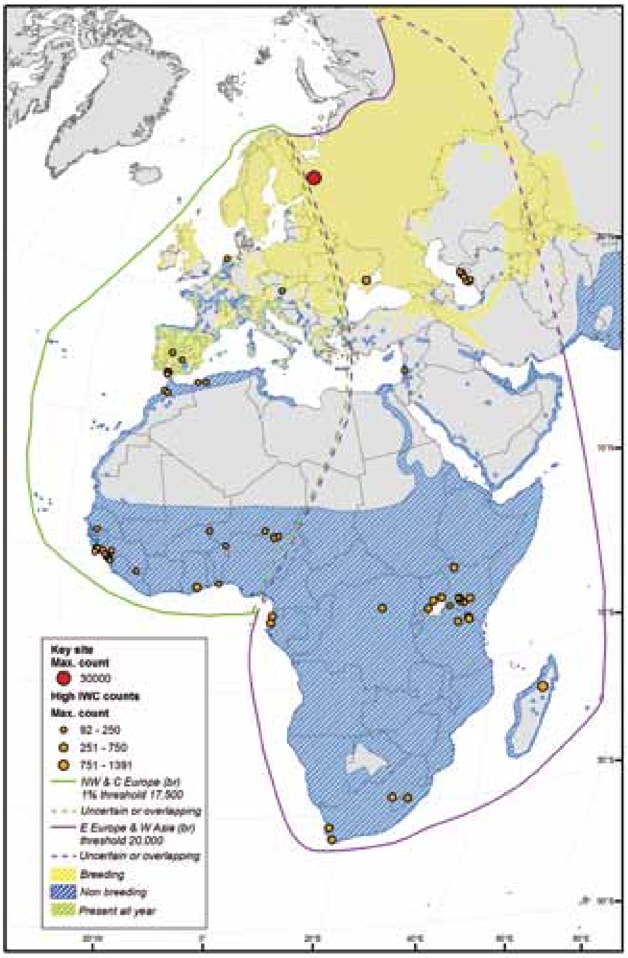


Figure 3.3. Common Sandpiper *Actitis (Tringa) hypoleucos* is a clear example of a waterbird with a broad-front migration (map: Delany *et al.* 2009; photo: Albert Winkelman).

Eurasia and non-breeding areas in Africa, often not concentrating at any particular sites, unlike many coastal species (Figure 3.3). Most wader species of freshwater habitats belong to this group and can be observed at even the most isolated and small, and usually freshwater, wetlands in Eurasia and Africa.

3.2.2 Parallel migration

Broad-front migration does not imply that individual birds from year to year may use a different route within the overall broad-front area. Recent research with satellite tagged birds and analyses of ringing recoveries have shown that birds from different geographical regions of Europe have ***parallel migration*** routes to their non-breeding areas, almost akin to parallel flyways within a broad-front migration. Such a pattern in illustrated well by a passerine bird, the Chaffinch *Fringilla coelebs* (Figure 3.4). Montagu's Harrier *Circus pygargus* shows parallel migrations between Europe and Africa.

Like the Common Sandpiper, the Common Redshank *Tringa totanus* also has a generally broad-front migration between breeding areas in Europe and non-breeding areas in Africa. However, when we look at the Common

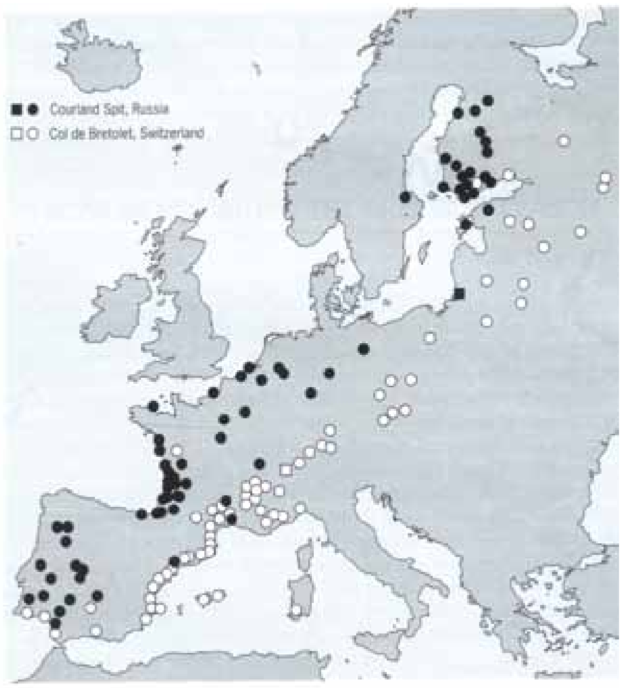


Figure 3.4. Ringing recoveries of Chaffinches *Fringilla coelebs*, ringed at Courland Spot (Russian coast Baltic Sea) and Col de Bretolet (Swiss Alps) clearly show different parallel migrations within Europe (source: Newton 2008).

Redshank at the population level, there are clearly different strategies in place. The population that breeds in Scandinavia and winters in coastal West Africa in fact has a narrow front migration (Figure 3.5).

3.2.3 Migration corridors

In some species, parallel migration routes are, or have become, separate, such that there is little or no overlap between birds from the discrete parallel 'flyways'. Migration does not occur on a broad-front, as the routes are essentially ***parallel corridors***, and the birds within these separate migration units may be treated as discrete populations. A good example is provided by the Barnacle Goose *Branta leucopsis* (Figure 3.6).

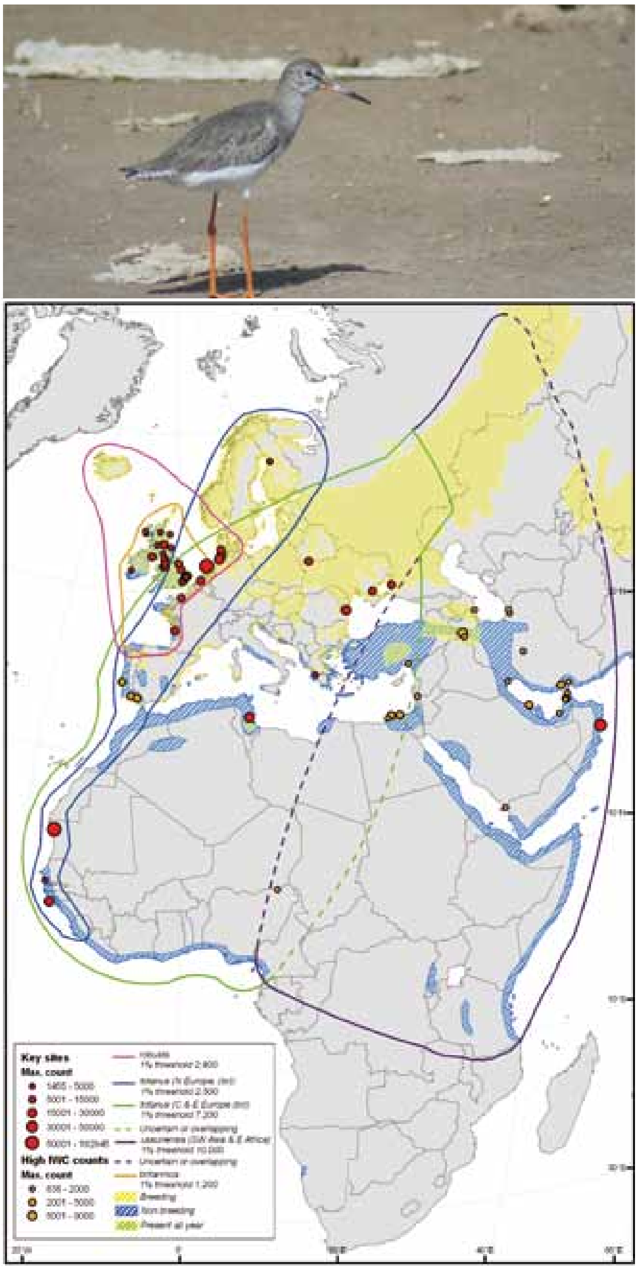


Figure 3.5. Most populations of Common Redshank *Tringa totanus* show a broad-front migration, but note the narrow-front migration along coastal West Africa (map: Delany *et al.* 2009). Common Redshank in Tunisia (photo: Hichem Azafzaf).

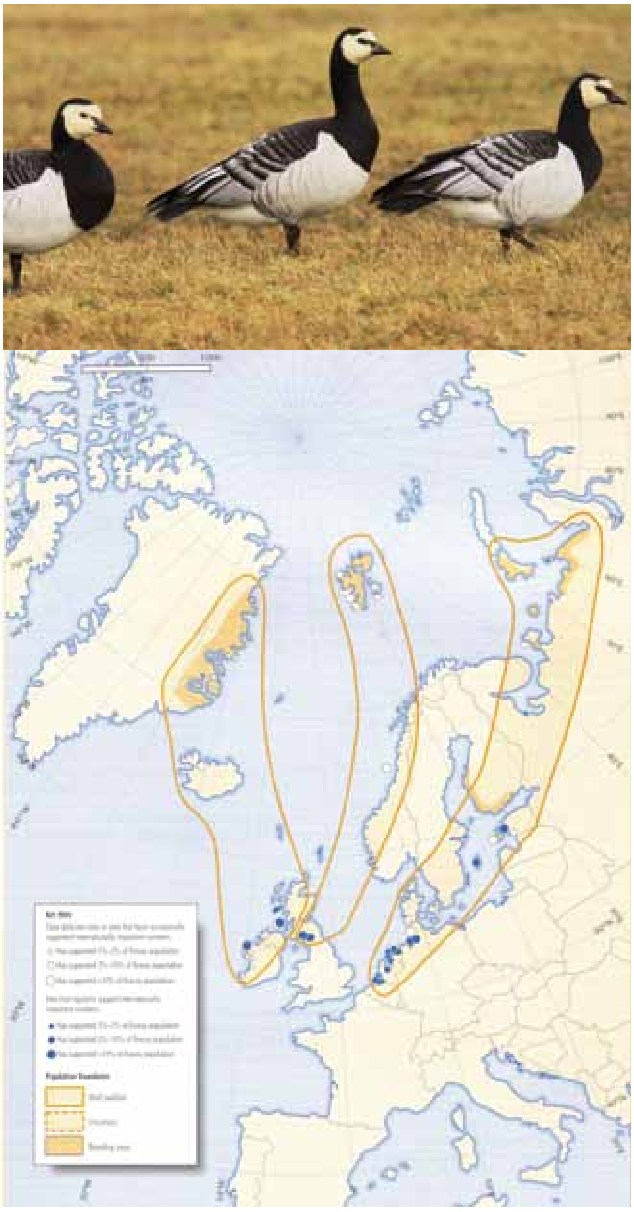


Figure 3.6. Breeding and wintering distribution of the Barnacle Goose *Branta leucopsis*. This is a classical example of a species with separate breeding populations having separate flyways and separate non-breeding (wintering) areas (Scott & Rose 1996). Barnacle Geese at Lauwersmeer, The Netherlands. (photo: Nicky Petkov/ www.wildlifephotos.eu).

3.3 Loop migration

> ***Key message***
> *Loop migration is when birds take different routes on their outward and return journeys.*

Loop migration, also known as elliptical migration, is when birds take markedly different routes on their outward and return journeys (Newton 2008). Under this migration strategy waterbirds take different routes during their migrations from and to their breeding areas. It is particularly visible in long distance migrants that breed in northern latitudes and choose different routes for their autumn and spring migration. An example occurs in the Curlew Sandpiper *Calidris ferruginea,* of which a good number of birds migrate from high Arctic breeding areas to coastal West and Southern Africa via coastal Europe, where the Wadden Sea is particularly important, whilst some birds also migrate through the Great Rift Valley (Figure 3.7). However spring migration of the Eastern and Southern African non-breeding population is mainly through inland Africa via the Sahara route and the Great Rift Valley towards Eastern Europe and the Arctic breeding areas. Birds from West Africa generally also migrate across Africa rather than returning via coastal sites in Western Europe.

A spectacular loop migration route around the Pacific was recently illustrated by a Bar-tailed Godwit *Limosa limosa* fitted with a satellite telemetry platform in New Zealand (Figure 3.8).

Loop migration is also adopted by several passerine migrant species, such as the European Pied Flycatcher *Ficedula hypoleuca* and the Garden Warbler *Sylvia borin.* Migratory waterbirds with loop migrations in North America include the Brent Goose *Branta bernicla* and the Western Sandpiper *Calidris mauri.*

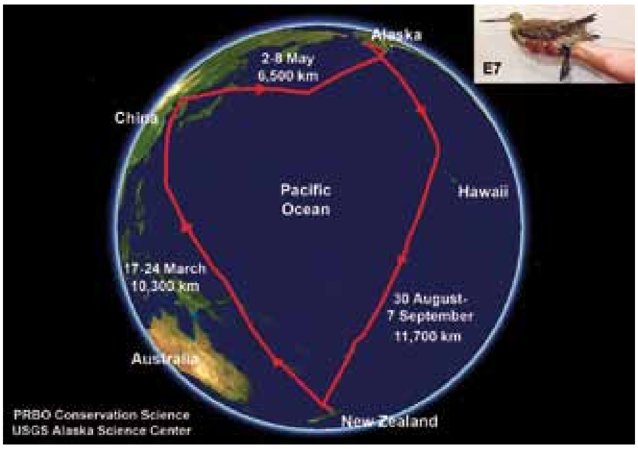


Figure 3.8. Migration pattern of a Bar-tailed Godwit *Limosa lapponica* in the Pacific region in 2007 (source: USGS, Alaska Science Center 2007 and PRBO Conservation Science).

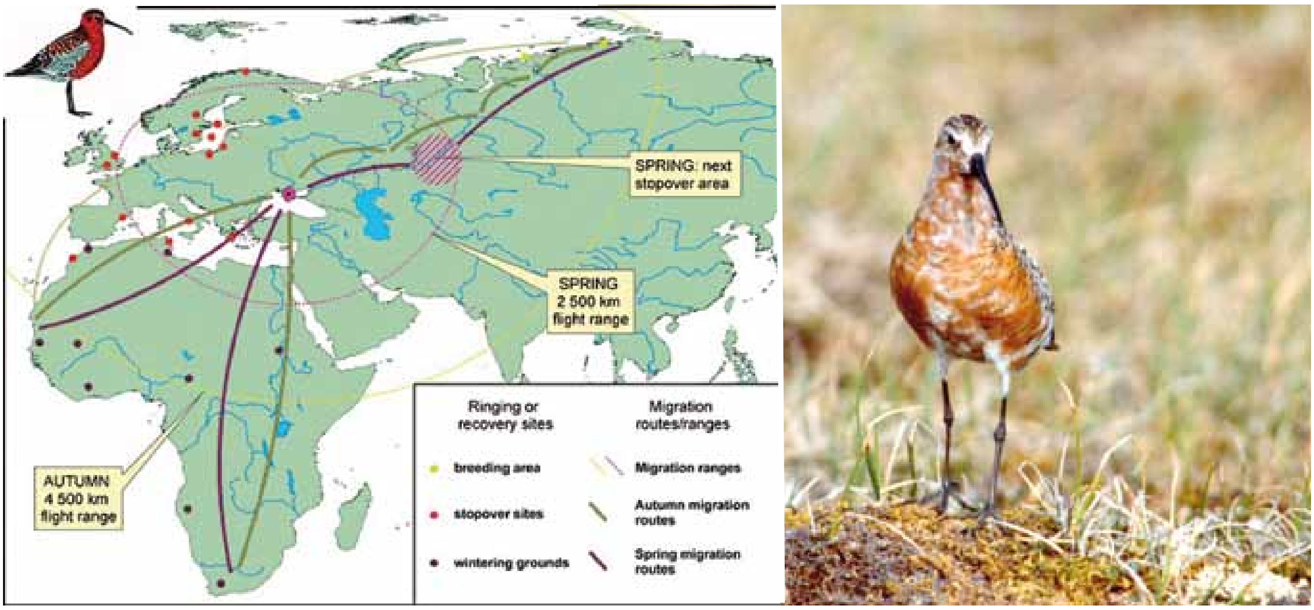


Figure 3.7. Migration routes of Curlew Sandpiper *Calidris ferruginea* showing the differences between routes taken in autumn and spring (Khomenko 2006); Curlew Sandpiper, Taimyr, Russia (photo: Gerard Boere).

3.4 Leapfrog migration

Key message

Leapfrog migration is when birds from one population overfly another.

This is a migration strategy in which birds from a migratory population of one species over-fly less migratory birds of the same species. It usually applies to species with at least one breeding population in the far north, when the northern breeding population migrates and passes over populations of the same species breeding in more temperate or southern areas that are not migratory (or much less migratory). A documented example is the Common Ringed Plover *Charadrius hiaticula*, whose *tundrae* population is strongly migratory, moving from extensive breeding areas in northern latitudes on a broad-front migration to Africa, leapfrogging over the much less migratory *hiaticula* population of Northwest Europe (Figure 3.9). Leapfrog migration is also practiced by Eurasian Oystercatcher *Haematopus ostralegus* and Bar-tailed Godwit *Limosa lapponica*, with northern-breeding populations leapfrogging over more sedentary populations in Europe.

Some geese also show leapfrog migration, a good example being the Greenland White-fronted Goose *Anser albifrons flavirostris.* Birds spending the northern winter at Wexford in Ireland tend to breed in northwest Greenland, whilst birds from more northerly wintering areas in Scotland tend to breed in central/southwest Greenland (Kampp *et al.* 1988).

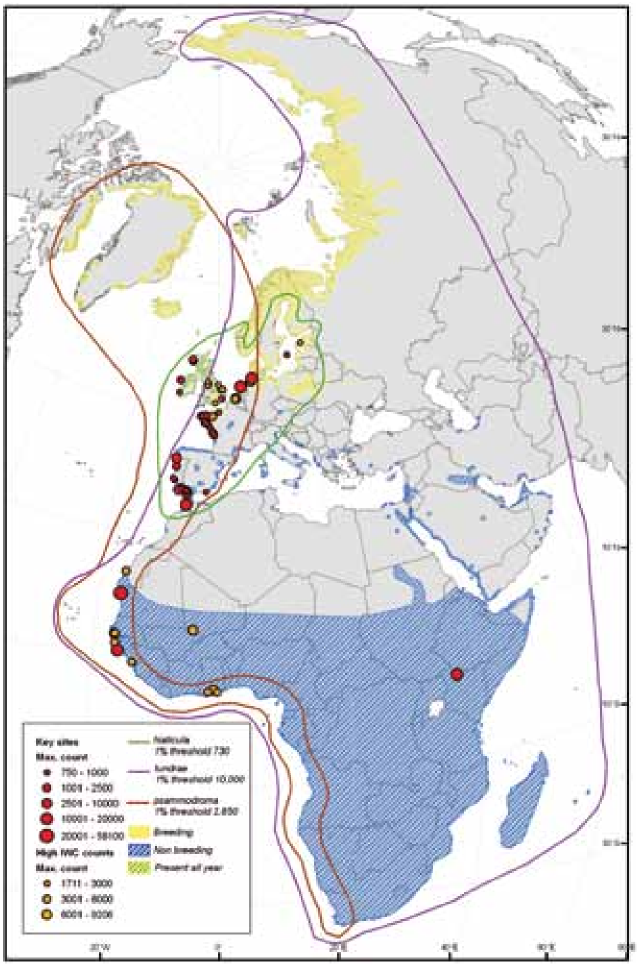


Figure 3.9. Geographical ranges of different populations of Common Ringed Plover *Charadrius hiaticula*, showing leapfrog migration; (source: Delany *et al.* 2009); Common Ringed Plover, Djibouti (photo: Werner Suter).

3.5 Moult migration

Key messages

Moult migration is when birds, especially ducks and geese, move to special areas to moult, where they lose their main flight feathers and become temporarily flightless. Moulting sites are priority areas for conservation. Some birds divide their moult between areas (split moult) or moult different sets of feathers in turn (suspended moult).

Figure 3.11. Wing of a Brent Goose *Branta bernicla*, showing that all primaries and secondaries are in growth simultaneously; the bird shown is from the flock in Figure 3.10, Taimyr, Russia (photo: Gerard Boere).

Moult migration occurs when birds move to a special area for moult, which is a scheduled renewal, or partial renewal, of plumage (Salomonsen 1968; Newton 2008). During a moult specific feathers, often flight feathers, are shed simultaneously and renewed.

3.5.1 Moult migration of Anatidae

All Anatidae (ducks, geese and swans) moult their wing feathers (the post-nuptial moult of primaries and secondaries) at the same time. This renders them flightless for a few weeks and thus very vulnerable to disturbance and predation (Figures 3.10 and 3.11).

Not surprisingly the moulting birds seek undisturbed areas with plenty of food within swimming or walking distance at this life cycle stage. Such areas are available in the more remote parts of the AEWA region, for instance the Arctic breeding areas where most of the adult geese go through their moult on the tundra lakes before their west and south migration to wintering areas. Many species specifically migrate to favoured moult sites where they often congregate in large numbers; in the Arctic such areas often lie north of the breeding areas for migratory geese (Figure 3.12).

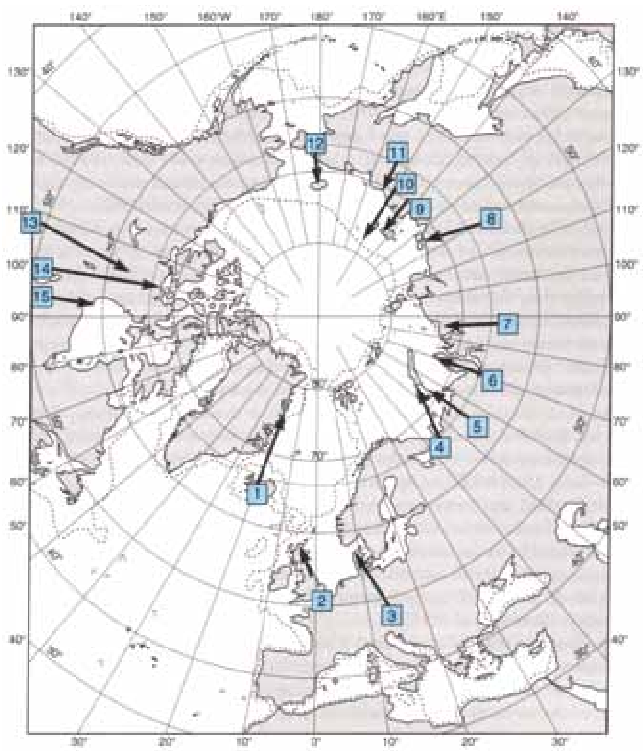


Figure 3.12. Moult migration routes and areas in the circumpolar Arctic for geese: 1: Pink-footed Goose *Anser brachyrhynchus*; 2, 13–15: Canada Goose *Branta canadensis;* 3: Greylag Goose *Anser anser;* 5–9, 11: Bean Goose *Anser fabalis;* 4, 9, 10, 12: Brent Goose *Branta bernicla* (source: Newton 2008, after Salomonsen 1968).

Figure 3.10. A group of moulting and flightless Brent Geese *Branta bernicla* (300 in total) caught near a Taimyr tundra lake (North Siberia) during a joint Russian-Dutch-German expedition (photo: Gerard Boere).

Ducks may also concentrate during their moult, including on large lake systems in Western Siberia, smaller sites in Western Europe, the Mediterranean and parts of Africa. In Europe mass concentration of moulting Mute Swan *Cygnus olor* are known from the Dutch IJsselmeer Lake, where tens of thousands of Great Crested Grebe *Podiceps cristatus* also concentrate to moult.

Moulting ducks in Africa
Egyptian Geese *Alopochen aegyptiacus* in Africa normally concentrate in larger wetlands during moult, where birds can dive capably to escape if pursued. The post-nuptial moult can occur throughout the year, related to the timing of breeding and local wet seasons, both of which vary across Africa. A number of duck species concentrate on the Kafue Flats in Zambia to moult in the early dry season, after breeding during the rainy season at rain-fed marshes. The favoured moult period recorded by Douthwaite (1975) for most ducks at the Kafue Flats between 1971 and 1973 was between April and July/August, largely coinciding with the period just after maximum flood, when a large variety of food items was available.

Moulting birds included the Fulvous Whistling Duck *Dendrocygna bicolor*, White-faced Whistling Duck *D. viduata*, White-backed Duck *Thalassornis leuconotus*, African Pochard *Netta erythropthalma*, Red-billed Teal *Anas erythrorhyncha*, Yellow-billed Duck *A. undulata*, Hottentot Teal *A. hottentota* and Comb Duck *Sarkidiornis melanotos* (Figure 3.13). However, there was much variation between years; for instance no moulting White-faced Whistling Ducks were seen in 1972, whilst there were several hundred in 1973. Since the early 1970s the artificial control of water flow across the Kafue Flats by dams has brought significant changes to flooding patterns, which most likely has reduced the importance of this area as a dependable moult site for some ducks.

Figure 3.13. Comb Ducks *Sarkidiornis melanotos* on the Kafue Flats, Zambia, a regular moult site (source: www.kafueflats.org/).

Overall, the moult strategies of ducks in Africa may vary considerably according to the extent and duration of the rains and subsequent conditions of favoured sites. Most Afro-tropical ducks are partial migrants or nomads, a result of the changing patterns of rainfall and subsequent availability of food. They are thus able to adapt their moult migrations to some extent, and probably depend on a network of sites for this.

3.5.2 Moult migration of species other than Anatidae

Besides the special case of moulting rapidly by losing flight feathers all at once, as in ducks and geese, many other waterbird species also have distinct moult migrations, when they move to suitable areas for moult. These migrations to moult sites can take place over large distances. Black Terns *Chlidonias niger,* for instance, migrate from Western Siberian lowlands to Lake Ijsselmeer in The Netherlands and the Asov Sea/Sivash in the Ukraine. Here they moult and prepare (by fattening) for migration further south to their wintering areas along the western seaboard of Africa, especially in the Gulf of Guinea and further south (Figure 3.14). Figure 3.15 illustrates the wing of a moulting Black Tern.

Waders have various strategies to go through their wing moult. Some start to moult in the breeding areas and others during migration, whilst others do not moult until they reach their non-breeding destinations. Still others divide their

Figure 3.14. Map showing the breeding range of the Black Tern *Chlidonias niger* and the two main moulting and fattening areas in Lake IJsselmeer, The Netherlands and Asov Sea/Sivash, Ukraine. From these two sites migration takes place along the West African coast and south to the coasts of Namibia and South Africa. The whole coastline, indicated in yellow, acts as a wintering area, with concentrations at certain places, especially where there are upwellings near the coast. (Map courtesy of Jan van der Winden 2008; van der Winden 2002).

moult between different areas, including on migration. The various strategies whereby moult is divided between different areas are types of ***split moult***. For a number of wader species the Wadden Sea and other areas around the North Sea form an important moulting area after the breeding season (Boere 1976). With these types of moult migration, where primary feathers are not all lost at once, birds retain their flight capacity, although they may loose sometimes up to 50% of their primaries at the same time (Figure 3.16).

When observing flocks of waders in areas like the Wadden Sea the big gaps in the wings, where primaries are missing and others have just started to grow, are reasonably well visible, and from detailed photos even the stage of primary moult can be determined and the process of moult over time elucidated. This technique, together with collecting moulted primaries from roosts, is used to study the moult process, and is especially useful in situations where there is no possibility to actually catch waterbirds at regular intervals, either due to a lack of equipment, resources or trained people available (e.g. Blanken *et al.* 1981).

Another strategy for moult migration is to carry out complete moults of different sets of feathers in succession through a ***suspended moult***. In other words, birds complete a moult of a certain number of feathers in one place and resume full flying capacity thereafter. They then migrate further and complete a moult of remaining feathers (e.g. some of the primaries and secondaries) at a completely different site. The second moult site may be thousands of kilometres away from where the original moult first started. Some waders show this type of moulting behaviour, of migration with suspended moult, such as the Common Greenshank *Tringa nebularia* (Figure 3.17).

Often, different stages of moult can be observed in several waterbird species, as illustrated by the flock of White-winged (Black) Terns *Chlidonias leucopterus* in Figure 3.18. The resulting changing plumage patterns of birds can render identification difficult at times, especially for marsh terns (*Chlidonias* species) and waders in their various stages of moult and non-breeding plumages.

Other birds, including many seabirds, carry out a more continuous moult, or waves of moult, over a successive period but without developing gaps in their wings, in which growing feathers are interspersed among complete ones. This strategy is known as a ***serial moult***.

Figure 3.15. Wing of a moulting Black Tern *Chlidonias niger* in the Dutch Lake Ijsselmeer, showing old primaries (the outer five) and others growing or new; note also the difference in colour (photo: Jan van der Winden).

Figure 3.16. Moult pattern in Dunlin *Calidris alpina*: Primary number ten is old, primaries 8 and 9 are missing and the other primaries are new in various stages of growth. A few secondaries are new but still growing and the other secondaries are not present or in very early stages of growth. In spite of the big gaps, flight capacity remains intact (photo: Gerard Boere).

Figure 3.17. Common Greenshank *Tringa nebularia* in the Dutch Wadden Sea in August before migration to the non-breeding areas in Southern Europe and Africa; wing showing suspended moult which is almost ready. Three outer primaries remain old, the other primaries are new (note the differences in colour and wear). Of the secondaries six are new and the rest remain old (photo: Gerard Boere).

Figure 3.18. A flock of White-winged (Black) Terns *Chlidonias leucopterus* at a wetland in the coastal belt of Angola showing various stages of moult. The lower middle bird shows a clear gap in the wing, whilst the upper bird on the right has two old primaries (the longer outer feathers) on its left wing, which is midway through a suspended moult. Note also the variation between all the birds in the amount of black on their wings (photo: Ronnie Gallagher).

3.5.3 Moult sites, conservation and research

From a conservation point of view it is important to know the moult migration strategies of waterbirds, and to take this into consideration for species and site management. Birds that have just one or two moult sites are clearly highly dependent on those sites, which are therefore critical for their survival. Birds with suspended moults also require large areas of good quality in terms of food resources and with minimum disturbance at different places along their migration route. Birds in Africa also require 'safe havens' for moulting, most likely a network of sites.

In terms of improving our understanding about migration, the flightless period when birds lose their flight feathers presents a unique chance to catch large numbers of waterbirds relatively easily for ringing, colour ringing and collecting data on condition, moult progress and other parameters. However, this flightless condition of groups of birds has also been exploited to catch large numbers for food and sale in markets. Although not very well documented, it is generally accepted that this practice has substantially influenced populations of certain species moulting in the Arctic and larger lake systems of Russia and Central Asia. Conservation efforts need to be particularly strong at moulting sites. Even in the remote Arctic moult sites are not free from disturbance due to a strong increase in exploration and exploitation of oil, gas and minerals.

3.6 Nomadism and semi-nomadism

Key messages

Truly nomadic birds have no fixed migration routes or directions, so their conservation is challenging, as the dependence of birds on particular sites is not predictable. In semi-arid areas it may be necessary to protect sites that are only used occasionally.

3.6.1 Definitions

Nomadism refers to movements that result in irregular changes in distribution, such that truly nomadic birds have no fixed spatial migration pattern and no fixed directional preferences (Newton 2008). Nomadism occurs particularly within waterbirds living in an environment where physical conditions can change rapidly, especially as a result of weather conditions. Rainfall in arid and semi-arid areas is a clear case and can trigger mass movements from one place to another. True nomads have no fixed migration routes or directions in which they move, and their distribution within a certain large geographical area is not stable. Some birds are essentially nomadic, but may have generally predictable movements, for instance movements in response to first rainfall of the season. Such movements may be considered as ***semi-nomadic***. Neither type of movement is migratory in the stricter definitions of migration, as the movements are generally neither cyclical nor regular, but from a conservation perspective it is more practical to consider such movements as extreme forms of migration.

3.6.2 African nomads

Within the AEWA region, nomadic and semi-nomadic movements patterns are probably most numerous in Africa, especially in arid and semi-arid areas where rainfall and water availability are often unreliable. Clearly in such environments a strict seasonal migration pattern would be very unsuccessful. Instead of finding their way to specific sites, as for many birds with clear migration routes, nomadic birds must instead find their way to a specific commodity, invariably water. These birds need different abilities, most remarkably, their ability to appear at sites just as the rains are beginning. In this sense, local people view some nomadic birds as harbingers of rain, and consider them to be a good omen, as rainfall of course is so important to people in semi-arid regions.

In Bushmanland in north-eastern Namibia, a semi-arid region, Simmons *et al.* (1998) showed that many waterbirds follow the rain fronts, descending onto isolated pans as they start to fill during the first rains (Figure 3.19). Birds of different species arrived the same day as pans began to fill, and many others arrived within the next few days. Birds arriving early benefit from the rapid emergence of large numbers of termites, dragonflies and other invertebrates that have lain dormant in and around the pans since the last rains, as well as vertebrates such as frogs. These animals breed almost immediately, ensuring a rich source of food for birds often until the pools dry out. After the first rainfall, some birds stay to breed opportunistically if conditions are favourable, whilst others wander locally thereafter, perhaps visiting a network of temporary wetlands. One of the first birds to arrive at pans in reasonable numbers was the Red-billed Teal *Anas erythrorhyncha*, which was also quick to breed here.

Figure 3.19. Heavy rain clouds build up in Namibia over the semi-arid landscape (photo: Rob Simmons).

Nomadic and semi-nomadic waterbirds also arrive with the first rains in other areas, so this phenomenon is not restricted to semi-arid regions. The first rains in Zambia, for instance, are accompanied by waves of arrivals of birds, depending on the habitat. Small ponds and marshes suddenly become 'alive' with the noises of insects, frogs, and birds such as flufftails and crakes also arrive to exploit these rich but short-lived food resources.

Truly nomadic birds include the Lesser Flamingo *Phoeniconaias minor*, which wanders between networks of sites, with populations in Western Africa, Eastern Africa and Southern Africa. However, these flamingos do have specific preferred breeding sites which they return to, although timing of breeding is rather unpredictable.

3.6.3 Nomadism in other regions

Outside the AEWA region, the Banded Stilt *Cladorhynchus leucocephalus* and the Oriental Pratincole *Glareola maldivarum* provide good examples of nomads from Australia. The Banded Stilt can suddenly appear in very large numbers if rainfall creates good opportunities for food and breeding on salt lakes that may be dry for decades. Suddenly 'out of the blue' the birds are there to take advantage of the situation and breed in huge colonies. The world population of Oriental Pratincole was formerly estimated at 70,000 birds, then in February 2004 huge flocks were discovered by chance on the west coast of Australia; counts were quickly organised, yielding at least 2.88 million birds (Figure 3.20, Wetlands

International 2006). The species was known to winter in inland areas of Australia that are seldom surveyed due to logistical constraints. For some reasons poor conditions must have forced them to go to coastal areas to feed instead.

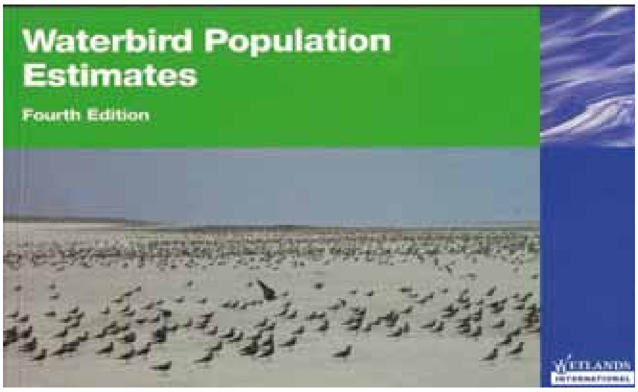


Figure 3.20. The cover of the fourth edition of Waterbird Population Estimates shows huge flocks of Oriental Pratincoles *Glareola maldivarum* on a beach in northwest Australia, February 2004 (photo of pratincoles: Chris Hassell).

3.6.4 Conservation of nomadic birds

From a flyway conservation approach, nomadism falls within our understanding of migration, but this behaviour is not fully predictable in terms of direction or month of the year, although for some species behaviour is reasonably predictable in the sense that movements are usually linked to specific conditions in a certain area. From a conservation and management point of view nomadic waterbirds present particular difficulties, as the sites they use may vary between years and seasons. For many nomadic waterbirds in Africa the potential of certain sites for breeding when rain conditions are good should be recognised, and measures taken to conserve periodically important breeding sites. These could include some of the ephemeral (temporary) wetlands of Namibia that are known to support high numbers of breeding waterbirds during years of exceptionally good rainfall.

Taking the flyway approach to conservation for nomadic waterbirds also infers application of the ***precautionary principle*** (see Glossary) in full and arranging for conservation and management of selected sites, even if the species that use them are absent for many years or even decades. These sites may have a long-term role in boosting populations in 'times of plenty', for instance in years of good rainfall in arid areas, and may thus be vital for long-term maintenance of populations.

Figure 3.21. This photograph from Australia shows that semi-arid areas may suddenly develop into extensive wetlands through intensive rainfall. Such areas may only have rain irregularly, but when it does rain they may attract large numbers of waterbirds, some of which may breed (photo: Gerard Boere).

3.7 Other migration strategies

> ***Key message***
> *There are various migration strategies adopted by birds; these need to be known and taken into account for effective conservation actions.*

3.7.1 Chain migration

An example of chain migration is when the southernmost breeding birds of a species or population occupy the southernmost non-breeding grounds. Although this strategy almost seems the most obvious, it is not widely practised by waterbirds. On the East Atlantic flyway, the only shorebirds that follow this strategy are some Dunlins *Calidris alpina*.

3.7.2 Crossover migration

This occurs when populations from different breeding areas cross over each others' flyways en route to the non-breeding destination areas. This happens on the East Atlantic flyway with some Dunlins *Calidris alpina* and Red Knot *Calidris canutus*.

3.7.3 Altitudinal migration

Some birds breed in highland areas and migrate down to lower levels after breeding. One bird that practices this in the AEWA region is the population of African Snipe *Gallinago nigripennis aequatorialis* in Eastern Africa, which breeds in

Figure 3.22. African Snipe *Gallinago nigripennis* in Zimbabwe (photo: Ian Nason).

highland bogs up to 4,000 m above sea level, from where it migrates down to lower-lying and warmer areas during the non-breeding season (Gichuki *et al.* 2000).

Greenland White-fronted Geese *Anser albifrons flavirostris* show a different sort of altitudinal migration by moving uphill during the course of the northern summer - progressively exploiting newly emerging plants that are freshly growing.

3.7.4 Deferred migration

This is when younger birds travel to the non-breeding destination areas, but then opt to stay there for one or more years before returning to the breeding range. This occurs especially in birds that do not reach sexual maturity until they are two or more years old. It is common to find juvenile waders from northern latitudes spending the northern summer in Africa, at a time when all adults will have returned to the breeding range. A similar situation is when younger birds do not remain in the main non-breeding destination area, but move progressively nearer to the breeding range until they reach breeding age. This is known as ***graded migration***.

3.7.5 Partial migration and differential migration

Partial migration occurs when some birds from a particular breeding area migrate away for the non-breeding season, while others remain in the breeding area year-round. This is fairly common in Africa, where movements are generally much more 'flexible' than for birds breeding in northern latitudes. Often, this may be due to ***differential migration***, which is when the migrations of some classes of waterbirds, such as different age groups or sex groups, differ.

3.8 Vagrancy, dispersal and colonisation

Key messages

Vagrancy is when birds appear outside their normal range or migratory route. Dispersal is when (young) birds move widely in different directions. Colonisation occurs when birds fined their way to new areas where they take up residence.

Some birds may disperse widely or show vagrant movements. Although such movements could be seen as a type of migratory behaviour they do not really fall within the definition of the flyway approach.

3.8.1 Vagrancy

Vagrancy is the result of a bird being taken away from its original migration route, due to a number of factors, such as storm depressions or strong winds over a longer period in the same direction, and appearing far outside its normal distribution range. Reasonable numbers of vagrant migratory birds from both Africa-Eurasia and North America appear on many of the Atlantic Ocean islands groups like the Azores, usually blown off-course and by chance finding land in the hostile ocean environment. Vagrancy may affect almost all migratory species at one time or another, but appearance of a vagrant does not create a situation whereby specific conservation measures need to be taken.

Alerstam (1990) illustrated examples of vagrancy with a North American wader and an East

Siberian passerine (Figure 3.23), showing how birds may end up in Western Europe far outside their very different breeding areas and regular migration routes.

Some vagrancy patterns derive from ***reversed migration***, when birds (usually young birds) migrate in essentially the opposite direction. For birds breeding in northern latitudes, this would mean that they take in error their 'spring direction' (northwards) in autumn, and so end up in unexpected localities.

In Africa, vagrants are more likely in birds with nomadic movements, which are regularly seeking temporary or ephemeral wetlands. Some African waterbirds have pitched up on sub-Antarctic islands as vagrants, presumably blown off-course whilst searching for suitable feeding sites. Blacksmith Lapwings *Vanellus armatus* have been found as vagrants on the island of Europa in the Mozambique Channel and much further south in the sub-Antarctic island groups of Prince Edward and Crozet (Cooper & Underhill 2002).

3.8.2 Dispersal

Dispersal occurs particularly in first-year birds after fledging, which move widely in various directions before showing a real targeted migration, which is largely determined by a genetic component. This effect is demonstrated in the famous displacement experiments with Common Starlings *Sturnus vulgaris* by Perdeck (1958) in which about 15,000 Common Starlings were caught and ringed in The Netherlands, then moved to Switzerland and released. Figure 3.24 shows the recoveries in the years thereafter, with young birds maintaining their directional orientation (fixed direction and distance), whereas adult birds used goal orientation towards their original migration route and wintering areas. Thus adults were able to correct for the displacements, whereas juvenile birds were not.

From a conservation perspective, it is important that suitable habitats are available for young dispersing birds. The locations of such sites may be quite different to locations of key sites along migratory routes.

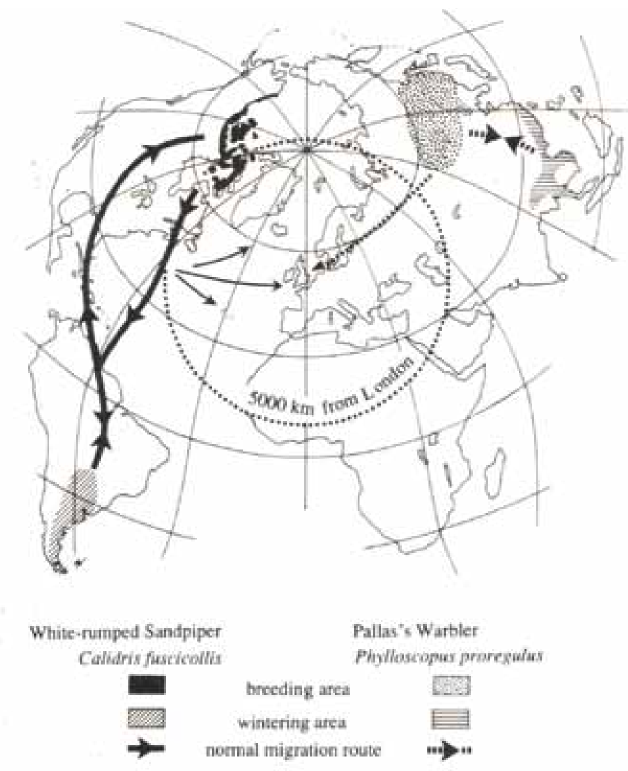


Figure 3.23. Vagrant movements of a wader and a warbler into Western Europe (source: Alerstam 1990).

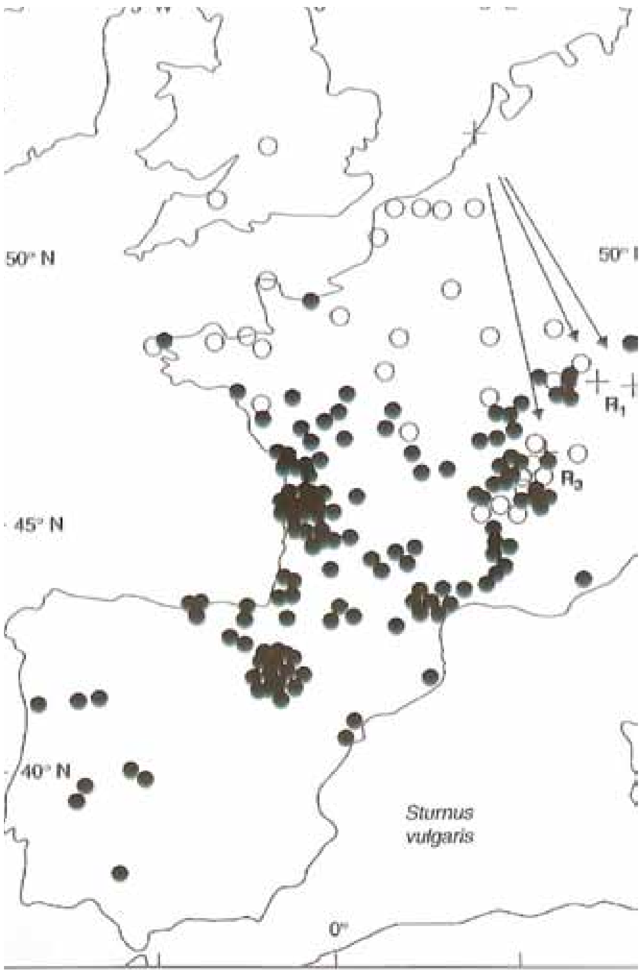


Figure 3.24. Replacement experiments with Common Starlings *Sturnus vulgaris*: black dots show recoveries of juvenile birds; open dots recoveries of adult birds (source: Newton 2008; after Perdeck 1958).

3.8.3 Colonisation by migratory birds

Vagrancy or other irregular movements may in some cases lead to permanent colonisation of new areas. A classic example is shown by the African subspecies of the Cattle Egret *Bubulcus ibis*, which managed to cross the Atlantic Ocean in some numbers (Figure 3.25 and 3.26). It was already a regular migrant between continental West Africa and Cape Verde (islands west of Senegal), but in the 1930s the bird appeared in South America. Since arriving, it rapidly colonised parts of North and South America, where it is now a common bird in many areas and has even established a migratory pattern. The Southeast Asian subspecies of Cattle Egret colonised Australia and New Zealand in a similar manner.

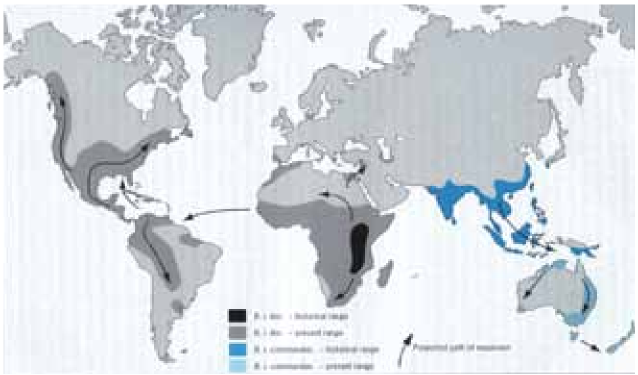


Figure 3.25. Colonisation of the Americas by the African subspecies of Cattle Egret *Bubulcus ibis* (source: Newton 2008).

Figure 3.26. Cattle Egret *Bubulcus ibis*, Robben Island, South Africa at the very south-west of its range in Africa (photo: Dieter Oschadleus).

3.9 Cold weather movements

Key messages

Cold weather movements can result in many thousands of birds being forced to move, especially out of areas with heavy frost; it is important to afford such birds with protection.

A more specific form of incidental movements not exactly falling within the definitions of nomadic migration, vagrancy or dispersal are cold weather movements (Ridgill & Fox 1990). These can occur in the whole of Europe and Central Asia and other areas where cold weather forces birds to move. Most Eurasian waterbirds are capable of surviving prolonged cold periods so long as food is still available (Figure 3.27). However, mass migration of waterbirds to warmer climes may become a necessity under the influence of frost and/or snowfall. Prolonged severe frost periods render larger water bodies frozen for longer than usual, forcing ducks and other waterbirds to leave affected areas and head for warmer climes. Within the AEWA region, most cold weather movements result in birds moving from northern Eurasia or Central Asia to regions further south and west that are not so severely affected by frost. Frost and snowfall can render food sources such as marsh and grassland vegetation no longer available. Cold weather movements are typical for the European situation, when frost in particular can make large feeding areas inaccessible, often leading to massive migration from continental Europe to the British Isles and to Southern Europe.

As these movements or 'migrations' result from severe weather conditions, they can involve tens of thousands of birds, all moving to find frost- and snow-free areas. The movements may be more than a thousand kilometres. Some waders, including the Eurasian Golden Plover *Pluvialis apricaria*, can cross the North Sea from Scandinavia to the UK and Ireland in large numbers, where generally a milder climate persists. The Northern Shoveler *Anas clypeata*

Figure 3.27. The partially-frozen Dutch Wadden Sea in winter; still various wader species like Eurasian Oystercatcher *Haematopus ostralegus*, Dunlin *Calidris alpina*, Grey Plover *Pluvialis squatarola* and Bar-tailed Godwit *Limosa lapponica* can find enough food (photo: Gerard Boere).

has been recorded in cold years in much higher concentrations in south-western parts of its range in winter (Figure 3.28).

Cold weather movements can have conservation implications; it is important in particular to look at conservation regulations in the countries that birds move into during such movements. For instance if recipient countries have a long hunting season, then there is a danger of mass shooting taking place, because birds are much more concentrated in flocks at fewer sites, and a much larger proportion of the population may be harvested. However with present regulations in European countries and a generally more conservative attitude of hunters, such events do not take place so widely. Some countries formally suspend shooting during periods of prolonged cold weather (e.g. Stroud *et al.* 2006b).

3.10 Conservation implications of migration strategies

Key messages

Conservation of migratory birds must take their diverse migration strategies into account; a 'no net loss of wetlands policy' is useful for broad-front migrants, whilst identifying and conserving key sites for moult migration and nomadic migration are priorities.

Implementing the right conservation measures towards such a variety of migration strategies and patterns on a geographical scale is not easy. In the first place, the range of strategies underlines the need to protect the habitats of migratory waterbirds, especially wetlands, but not only the sites meeting the Ramsar waterbird criteria for identifying sites of international importance, as many migratory species depend on networks of smaller sites, for instance.

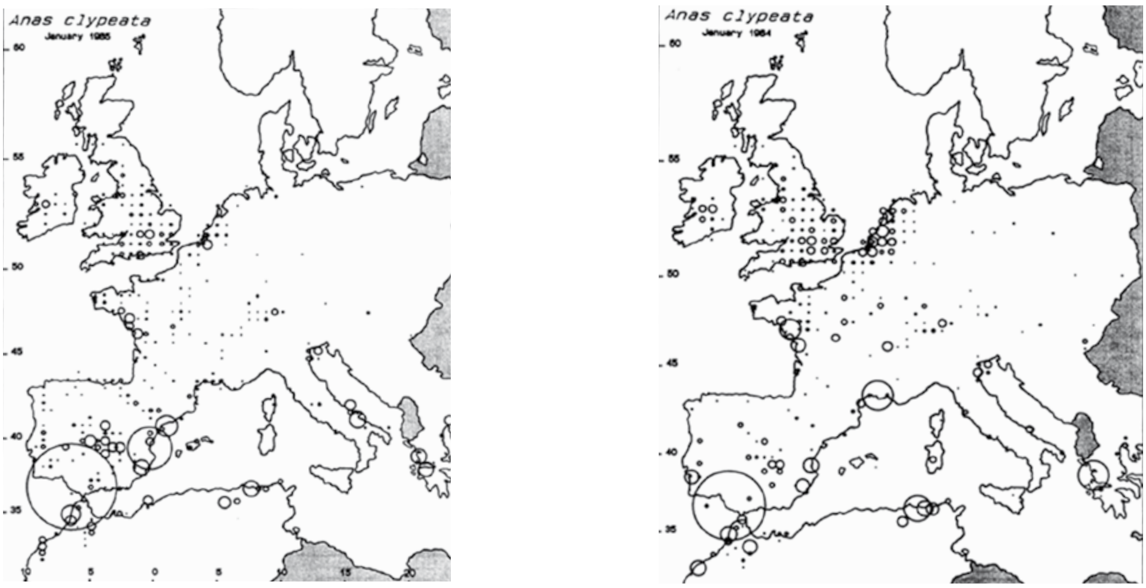


Figure 3.28. Example of cold weather movements based on the International Waterbird Census: distribution of Northern Shoveler *Anas clypeata* in the mild winter of 1964 (top) and in the cold winter of 1965 (bottom); (source: Ridgill & Fox 1990).

Birds using a narrow front strategy are more vulnerable to the disappearance of important stop-over sites within their range than species using a combination of hopping and broad-front migration, which are probably more flexible and able to use smaller wetland sites of various types.

3.10.1 Importance of site networks

A ***'no net loss of wetlands policy'*** is needed to maintain the minimum requirements for migratory waterbirds, noting that wetland loss has already occurred extensively over the last hundreds of years. Maintaining viable networks of wetlands is essential to maintain the present complex patterns of migration behaviour, which are so interlinked and mingled. This policy implies that if wetlands are to be lost as a result of economic or other reasons, adequate compensation must be provided by developing replacement habitats of the same type and of at least the equivalent ecological function and extent nearby. Clearly maintaining existing wetlands is much less expensive than destroying them and creating new ones in their place. The almost instant use of new wetlands by birds demonstrates the need for more wetland habitats, especially in Europe, where wetland degradation has been most severe.

Landscape-scale networks of many, often small, wetlands of all habitats types across the AEWA region are needed to meet the requirements of waterbird species with a broad-front migration, especially for freshwater species like Green Sandpiper *Tringa ochropus* and Common Snipe *Gallinago gallinago* (Figure 3.30). Temminck's Stint *Calidris temminckii* and Little Stint *Calidris minuta* frequently use river borders, so protecting stretches of rivers is important for these and other species.

Figure 3.30. Common Snipe *Gallinago gallinago* (photo: Stuart Elsom).

3.10.2 Moult migration and nomadic species

For some migration patterns, notably moult migration, conservation measures for migration routes and key sites need to be much stricter. Birds rely heavily on moulting areas, and as many waterbird species undergo a full primary and secondary wing moult at once, they are highly vulnerable to disturbance. Important moulting sites require strict protection, and no human activities should be allowed until the moment birds can fly again.

Conservation measures for nomadic species are more difficult to apply, generally requiring a certain number of 'reserve' areas, which may not always act as waterbird habitats, but which are important when physical conditions, notably rainfall, are right. Dry salt pans, wadis (river beds) in arid regions and tidal flats that are only wet during extreme high tides are good examples of such habitats. Throughout the AEWA range, important sites for nomadic waterbirds need to be identified and form part of the critical site network for migratory waterbirds, even if their use is only irregular.

3.10.3 The need for information and gap filling surveys

The spectacular discovery of huge non-breeding flocks of Oriental Pratincole *Glareola maldivarum* in 2004 in Australia (see section 3.6.3) underlines that there are still significant gaps in our knowledge of migratory birds, and undoubtedly there is still much to learn about waterbird movements, especially in large areas of Africa, the Middle East, Central Asia and the Arctic. The recent discovery in early spring 2007 of staging and non-breeding areas of several thousand Sociable Lapwing *Vanellus gregarius* in Syria and Turkey, with probably also a link towards Ethiopia and Sudan, is an indication that even in better known regions there is much to find out (Figure 3.31). At the same it showed the need for urgent and strict conservation measures as intensive hunting on the species has been observed.

Figure 3.31. Flock of Sociable Lapwings *Vanellus gregarius* in a steppe area of Syria (photo: Guido Keijl).

Sound comprehensive information on the migration strategies of individual populations of waterbirds is the key to apply the right conservation measures for individual species and populations. Comparisons between the strategies of different species should then be made to identify common flyways and key sites for a range of species. Such information is reasonably well known for a number of birds, but there are still important information gaps, especially in Africa and Central Asia. In this regard, furthering gap filling wetland inventories remains an important aspect for future activities, in particular to document smaller inland sites and ascertain their importance. Further waterbird surveys are also essential, particularly at times outside of the usual count periods organised under the IWC.

Arguably, identifying and conserving key sites for moult migration and nomadic migration are priorities due to their conservation relevance and a lack of information from many areas.

Further reading:

Migration strategies:

- *The Migration Ecology of Birds (Newton 2008).*
- *An Atlas of Wader Populations in Africa and Western Eurasia (Delany et al. 2009): http://www.wetlands.org/WatchRead/tabid/56/mod/1570/articleType/ArticleView/articleId/2132/Wader-Atlas-draft-for-consultation.aspx.*
- *Atlas of Anatidae Populations in Africa and Western Eurasia (Scott & Rose 1996).*
- The Sivash Bay as a migratory stopover site for Curlew Sandpiper *Calidris ferruginea (Khomenko 2006): http://www.jncc.gov.uk/pdf/pub07_waterbirds_part4.4.17.pdf.*
- *Bird Migration (Alerstam 1990).*
- *Bar-tailed Godwit migration loop migration: http://alaska.usgs.gov/science/biology/shorebirds/barg_updates.html.*
- *Mortality and movements of the Greenland White-fronted Goose Anser albifrons flavirostris (Kampp et al. 1988): http://www2.dmu.dk/1_Viden/2_Publikationer/3_ovrige/rapporter/TFO_Doctors_27art_web/6_161_174.pdf.*

Moult migration:

- *The moult migration (Salomonson 1968).*
- *Filter-feeding ducks of the Kafue Flats, Zambia, 1971–1973 (Douthwaite 1975).*
- *The odyssey of the Black Tern Chlidonias niger: migration ecology in Europe and Africa (van der Winden 2002): http://nou.natuurinfo.nl/website/ardea/ardea_show_article.php?nr=163.*
- *Primary moult of the Redshank Tringa totanus, in the Dutch Waddensea studied by collecting shed-feathers; a test (den Blanken et al. 1981): http://nou.natuurinfo.nl/website/ardea/ardea_show_article.php?nr=986.*

Nomadic movements:

- *What precipitates influxes of birds to ephemeral wetlands in arid landscapes? Observations from Namibia (Simmons et al. 1998).*

Dispersal:

- *Two types of orientation in migrating Starlings, Sturnus vulgaris, and Chaffinches, Fringilla coelebs, as revealed by displacement experiments (Perdeck 1958): http://nou.natuurinfo.nl/website/ardea/ardea_show_article.php?nr=1562.*

Cold weather movements:

- *Cold weather movements of waterfowl in Western Europe (Ridgill & Fox 1990).*
- *Reducing waterbird mortality in severe cold weather: 25 years of statutory shooting suspensions in Britain (Stroud et al. 2006b): http://www.jncc.gov.uk/PDF/pub07_waterbirds_part6.1.1.pdf.*

4. The concept of sites: the functional role of sites in supporting bird migration and implications for conservation

[Note: *'Further reading'* for all site functions is given at the end of section 4].

Within a migration system, a range of sites are used, each carrying out a distinctive function in the annual life cycle or daily pattern of birds. The most important functions of sites are as:

- Pre-breeding areas
- Breeding areas
- Post-breeding areas
- Moulting areas
- Staging or passage areas
- Roosts
- Non-breeding destination areas
- Bottleneck areas.

4.1 Pre-breeding areas

Key message

Pre-breeding areas can play a critical role in helping migratory birds prepare for breeding.

Pre-breeding areas are types of staging areas (see below), but refer to those sites that birds visit specifically to prepare themselves for breeding. A good example is provided by the Barnacle Goose *Branta leucopsis* (Figure 3.6). After migrating from Scotland to staging areas on the Norway coast, many birds then visit Vårsolbukta on the west coast of Spitsbergen, Svalbard, where they feed and put on fat on south-facing slopes where snow melts relatively early (Hübner 2006, Figure 4.1). These pre-breeding areas may act as a buffer where individuals can compensate for their lower initial weight at arrival in the Arctic. Such sites can play a critical role in helping migratory birds improve their body condition and fat stores and prepare themselves for breeding.

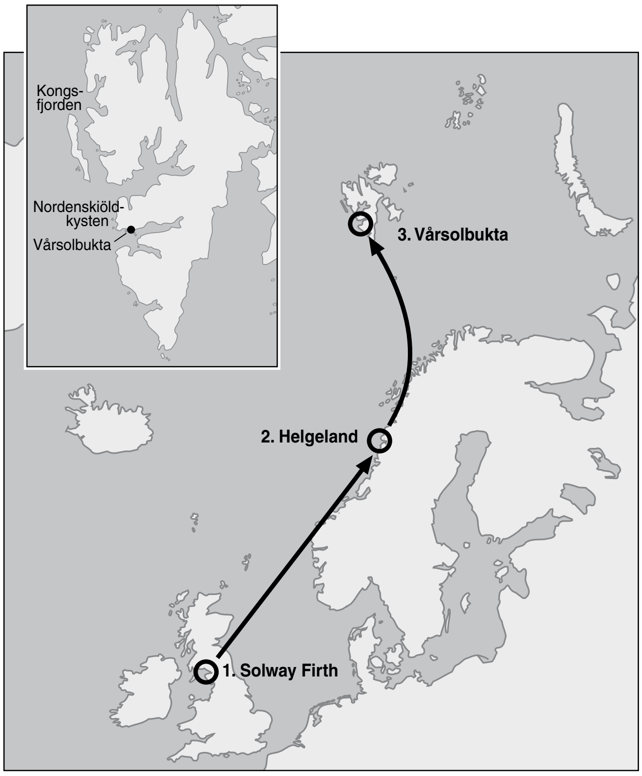


Figure 4.1. Flyway of the Barnacle Goose *Branta leucopsis* population breeding on western Spitsbergen, Svalbard: 1. Solway Firth, UK: the main wintering area; 2. Helgeland, Norway: the main staging area during spring migration; 3. Vårsolbukta, Svalbard (area in photograph): a pre-breeding area. Inset: Spitsbergen with Kongsfjorden and Nordenskiöldkysten, two of the breeding sites on the west coast (source & photo: Christiaane Hübner 2006).

4.2 Breeding areas

Key messages

Many waterbirds are colonial breeders, often in mixed-species colonies; colonies are susceptible to disturbance and catastrophes, and their conservation is vital. Waterbirds breeding as single pairs often group together after breeding.

4.2.1 Colonial breeding

Breeding strategies differ greatly among waterbirds. Some species breed in colonies of sometimes substantial size, especially flamingos and terns. Lake Natron in Tanzania is the most important breeding site for flamingos in the AEWA region and the only regular breeding site for all of Eastern Africa's Lesser Flamingos *Phoeniconaias minor*, which may number some 1.5–2.5 million birds. Terns are particularly numerous on tropical islands; one of the largest colonies in the AEWA region is the colony of Sooty Terns *Sterna fuscata* on Bird Island in Seychelles, which supports some 700,000 breeding pairs. Many gull species also breed in large colonies, including some in Northern Europe. Some species breed in mixed colonies, and there are several large mixed colonies of gulls and terns in the AEWA region. Examples include the mixed colonies of:

- Caspian Tern *Sterna caspia* and Pallas's (or Great Black-headed) Gull *Larus ichthyaetus* such as the colony on an island in Lake Chany, Western Siberia (Figure 4.2);
- Royal Tern *Sterna maxima*, Caspian Tern, Slender-billed Gull *Larus genei*, Grey-headed Gull *Larus cirrocephalus* and others on islands off Western Africa, notably at Ile aux Oiseaux in Senegal's Sine Saloum Delta (Figure 4.3);
- Aride Island, Seychelles, which supports about 1 million pairs of seabirds of 10 species, including Sooty Tern, Fairy Tern *Gygis alba* and Lesser Noddy *Anous tenuirostris*.

Many other species breed in smaller colonies, including several species of herons, ibises, spoonbills and cormorants, which may all breed alongside each other. When some herons are present, such mixed colonies are usually referred to as heronries. In Africa, mixed waterbird colonies are quite common along the coast, sometimes in mangrove trees, which provide a relatively safe breeding habitat, or on isolated islands (Figure 4.4).

Figure 4.2. Mixed breeding colony of Caspian Terns *Sterna caspia* and Pallas's Gull *Larus ichthyaetus*, Lake Chany, Western Siberia (photo: Sasha Yurlov).

Figure 4.3. Royal Tern *Sterna maxima* breeding colony at Ile aux Oiseaux, Saloum, Senegal; the terns breed in close proximity to other species of terns and gulls (photo: Hanneke Dallmeijer/VEDA).

Figure 4.4. Mixed colony of Eurasian Spoonbill *Platalea leucorodia balsaci* and Reed Cormorants *Phalacrocorax africana* at Ile Marguerite in the Parc National du Banc d'Arguin, Mauritania (photo: Hanneke Dallmeijer/VEDA).

Figure 4.5. Breeding colony of Great White Pelican *Pelecanus onocrotalus* at Djoudj National Park, Senegal (photo: Abdoulaye Ndiaye).

Figure 4.6. Destroyed Cattle Egret *Bubulcus ibis* colony and displaced chick, Nile Delta, Egypt (photos: Wed Ibrahim).

Great Cormorants *Phalacrocorax carbo* and Great White Pelicans *Pelecanus onocrotalus* breed in adjacent colonies in Senegal's Djoudj National Park in large numbers, where the pelicans breed on islands within the wetlands, and cormorants in surrounding bushes. The pelicans are relatively safe so long as the islands remain, though are vulnerable to predation when lake water levels drop (Figure 4.5).

The Wembere Steppe in Tanzania has a heronry that has supported many thousands of breeding waterbirds, including Reed Cormorant *Phalacrocorax africana*, African Darter *Anhinga rufa*, at least five species of herons and egrets, Yellow-billed Stork *Mycteria ibis*, African Openbill *Anastomus lamelligerus*, Sacred Ibis *Threskiornis aethiopicus* and African Spoonbill *Platalea alba*. Such birds are drawn together primarily by their shared requirements to find safe breeding areas. In the rainy season, when most waterbirds breed in Tanzania, much of Wembere is flooded and its trees (many standing in water) provide safe breeding habitat that attracts many different species. Many such colonies disappear when the habitat is impacted, and the current status of Wembere is not well known, although habitat destruction by pastoralists has been relentless (Baker & Baker 2002).

Such breeding colonies are thus critical for the survival of many migratory waterbirds, and a high priority for conservation action. Local communities destroyed several Cattle Egrets *Bubulcus ibis* heronries in 2007 in the Nile Delta of Egypt, as this bird was considered as a threat to health, especially for fear of the spread of avian influenza (W. Abdou *in litt*. 2009; Figure 4.6). There is wide international consensus that attempting to control avian influenza through responses such as culling or disturbing wild birds, or destroying wetland habitats, is not feasible and should not be attempted, not least since it may exacerbate the problem by causing further dispersion of infected birds (Ramsar Resolution X.21).

4.2.2 Non-colonial breeding

However many waterbirds, including most ducks, geese, swans and waders, breed as single pairs. In some areas these individual pairs may be widespread across a large area, such as in the Arctic tundra or the steppe lands of Central Asia. Such areas present a large expanse of relatively uniform habitat suitable for breeding in. During the migration period birds breeding in these areas concentrate into large flocks, often for reasons of protection against predators. For Arctic breeding species such 'concentrations' are

Figure 4.7. Single breeding Greater White-fronted Goose *Anser albifrons*, Taimyr; flocks of wintering Greater White-fronted Goose, The Netherlands (photos: Gerard Boere).

estimated at a factor of at least 100–130; i.e. their density per square unit in the stopover and non-breeding sites is 100–130 times greater than the density in breeding areas (Hulscher, pers. comm. to GB). This is illustrated photographically for the Greater White-fronted Goose *Anser albifrons* (Figure 4.7).

At the species level, birds that breed as single pairs are less susceptible than colonial-breeding birds to large-scale threats or catastrophes that may, for instance, destroy a whole colony, although colonies have 'safety in numbers' and can benefit by building up a collective defence system. Single pair breeders are thus individually more vulnerable, and often depend on camouflage or hiding their nests. Birds breeding on the ground in open areas tend to be especially well camouflaged, such as breeding Red Knots *Calidris canutus* on the Taimyr in Russia (Figure 4.8).

Figure 4.8. Well camouflaged breeding Red Knot *Calidris canutus*, Taimyr, Russia (photo: Gerard Boere).

Many single pairs waterbirds hide their nests in dense vegetation at or close to wetlands. Female Eider Ducks *Somateria mollissima* nest singly, though often in close proximity to each other, and blend in extremely well in maritime grassland, moorland or among weeds along the shoreline (Figure 4.9). When they leave the nest, females move their young to the water, where they share in looking after each others' young, which are grouped into crèches, thus benefiting from safety in numbers. In Africa, Comb Ducks *Sarkidiornis melanotos* often breed in tree cavities close to water. Although they are monogamous in marginal habitats, interestingly they are often polygamous in optimal habitats, when each breeding male may reside over a harem of two or more breeding females. Males meanwhile head off to form moulting flocks.

Figure 4.9. This female Common Eider *Somateria mollissima* on the Holm of Papay, Orkney, Scotland, is well camouflaged at her nest in rank grassland; she will only leave the nest as a last resort (photo: Tim Dodman).

4.3 Post-breeding areas

Key message

Some birds move short distances after breeding with their flightless, vulnerable young.

Most waterbirds breed at sites where they remain directly after breeding to raise and feed their young. However, several waterbird species move with their young (by foot, swimming or active flight) outside their original breeding areas into optimal feeding areas, which are usually nearby, so movements to them are not really considered as migration patterns. Lesser Flamingo *Phoeniconaias minor* chicks form a crèche and walk some tens of kilometres away from their isolated breeding sites to feeding areas, essentially a long-distance trek to water. This behaviour occurs at Lake Natron (Tanzania), the Makgadikgadi Pans (Botswana) and Etosha (Namibia). At Etosha, treks to water of up to 80 km have been recorded (Figure 4.11).

Some birds with young that can swim may move them quite far distances, usually to better feeding areas or for safety reasons. Some cliff-nesting species like guillemots move young this way from their crowded cliff ledge breeding sites out to the open sea. Some geese also need to move their young usually short distances away from rather inaccessible breeding sites, especially as young geese are not fed by their parents but feed directly themselves. The Barnacle Goose *Branta leucopsis* moves its chicks away from its breeding cliffs to grazing areas nearby where they can feed.

Figure 4.10. A small family unit of Black Crowned Cranes *Balearica pavonina* during the breeding season on the Plaine de Monchon in Guinea (photo: Menno Hornman); a large non-breeding flock of Black Crowned Cranes at Lac Fitri, Chad (photo: Bertrand Trolliet).

Black Crowned Cranes *Balearica pavonina* separate off into pairs during the breeding season, and defend their quite large breeding territories against each other. They make their nest on the ground within long grassland or reeds, and stay within their family units until the chicks have fledged. Once breeding is over they congregate once more into flocks with other cranes, in most cases after a relatively short migration from their breeding sites (Figure 4.10).

Figure 4.11. A crèche or kindergarten of Lesser Flamingo *Phoeniconaias minor* chicks making a long trek across Etosha, Namibia in 1971; note the small number of paler adult birds amongst the chicks (photo: Hu Berry).

4.4 Moulting areas

Key message
Moulting areas are critical sites for waterbirds, and priority areas for conservation.

Waterbirds that moult all their flight feathers at once and become temporarily flightless are particularly vulnerable to predation both by animal predators (e.g. birds of prey, foxes) and man. It is no accident therefore that key moulting sites are in remote places such as the Arctic tundra, with its many lakes and rivers, or at large water bodies and wetlands/marshes that are difficult to access and which have easily accessible food sources. Birds with suspended moults and birds that moult without losing primaries and secondaries at once also need large quiet areas with enough food of good quality within easy reach. Within the flyway approach to conservation, such areas are of crucial importance as they have a direct relation to the flight capacity of birds and their capability to migrate. [Refer to section 3.5: Moult migration].

4.5 Staging and/or passage areas

Key messages
Staging areas are of key importance to migratory waterbirds, especially for food and rest; birds must put on weight in order to complete their journeys successfully. The cumulative importance of staging areas should be recognised (turnover). Many staging areas are IBAs.

Staging areas or passage areas are general terms for any place where waterbirds stay when on migration between the breeding and non-breeding destination areas. Stops at such sites may be short or long, depending on a range of factors. These terms are often used when the movements concern larger groups of birds. Many of the larger staging areas attract high numbers of migratory birds and are well-known as important sites. The East Atlantic Flyway has a number of important staging areas, including the Wadden Sea in Western Europe (Figure 4.12), the Banc d'Arguin and the Bijagós in coastal West Africa and coastal wetlands of the Gulf of Guinea, such as those in Ghana (Figure 4.13).

Many migratory waders and terns from breeding areas in northern Eurasia are concentrated in large numbers at such sites, often alongside African birds.

Some birds using the flyway exploit a wide range of sites as their staging areas, including the Whimbrel *Numenius phaeopus* (Figure 4.14), which may be found in almost any coastal habitat of West Africa from mudflats to mangrove creeks and rocky shorelines, including Africa's offshore islands such as Cape Verde. However, it is not easy to differentiate for individual Whimbrels if a site is a staging area or a non-breeding destination area, i.e. if they are moving on or there to stay for some months.

Figure 4.12. The international Wadden Sea is an important staging and moulting area for millions of waterbirds (photo: Wouter Boere).

Figure 4.13. Songor Lagoon on the Ghana coast provides excellent habitat and feeding for waders and terns coming from northern destinations, as well as for resident birds and intra-African migrants, including waders, egrets and cormorants (photo: Tim Dodman).

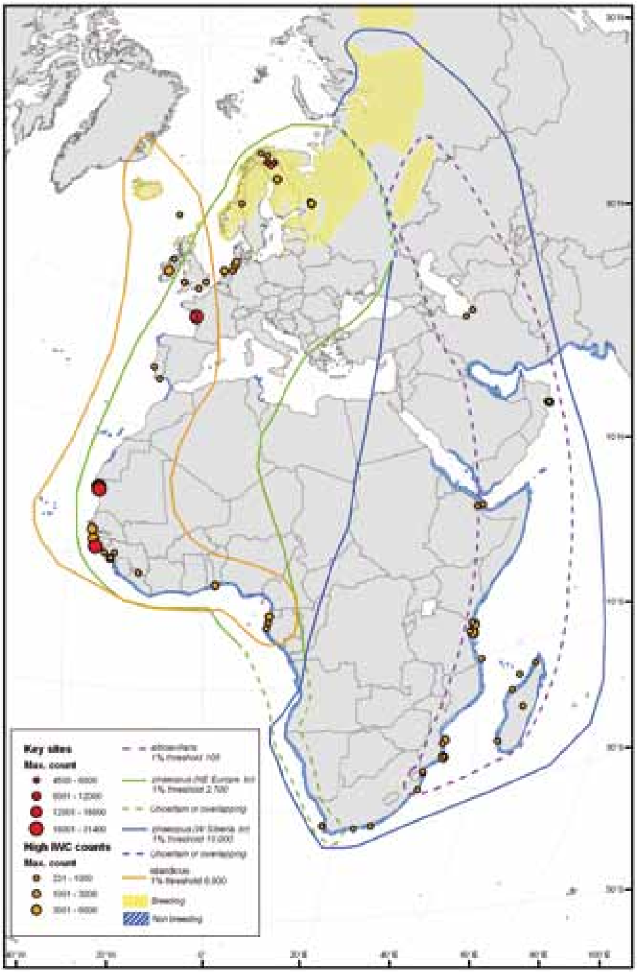


Figure 4.14. Distribution of Whimbrel *Numenius phaeopus* in AEWA region (Delany *et al.* 2009); Whimbrel (photo: Martin Hale).

Figure 4.15. A lone Common Sandpiper *Actitis (Tringa) hypoleucos* at a small wetland in Kazakhstan (photo: Marek Szczepanek).

Figure 4.16. A lone Wood Sandpiper *Tringa glareola* at a small wetland in South Africa (photo: Mark Anderson).

The same terms (staging or passage areas) also apply to sites where individually migrating birds stay on migration, like several species of *Tringa* sandpiper and Temminck's Stint *Calidris temminckii,* often migrating through inland areas. Green Sandpiper *Tringa ochropus*, Wood Sandpiper *T. glareola* and Common Sandpiper *Actitis* (*Tringa) hypoleucos* (Figure 4.15 & 4.16) occur at small pools and streams all across much of Europe, Asia and Africa throughout their entire migration (and non-breeding) range, and for them such sites may be considered as staging sites.

Staging areas and energetics

A fundamental role of a staging area for migratory birds is to provide them with a plentiful food

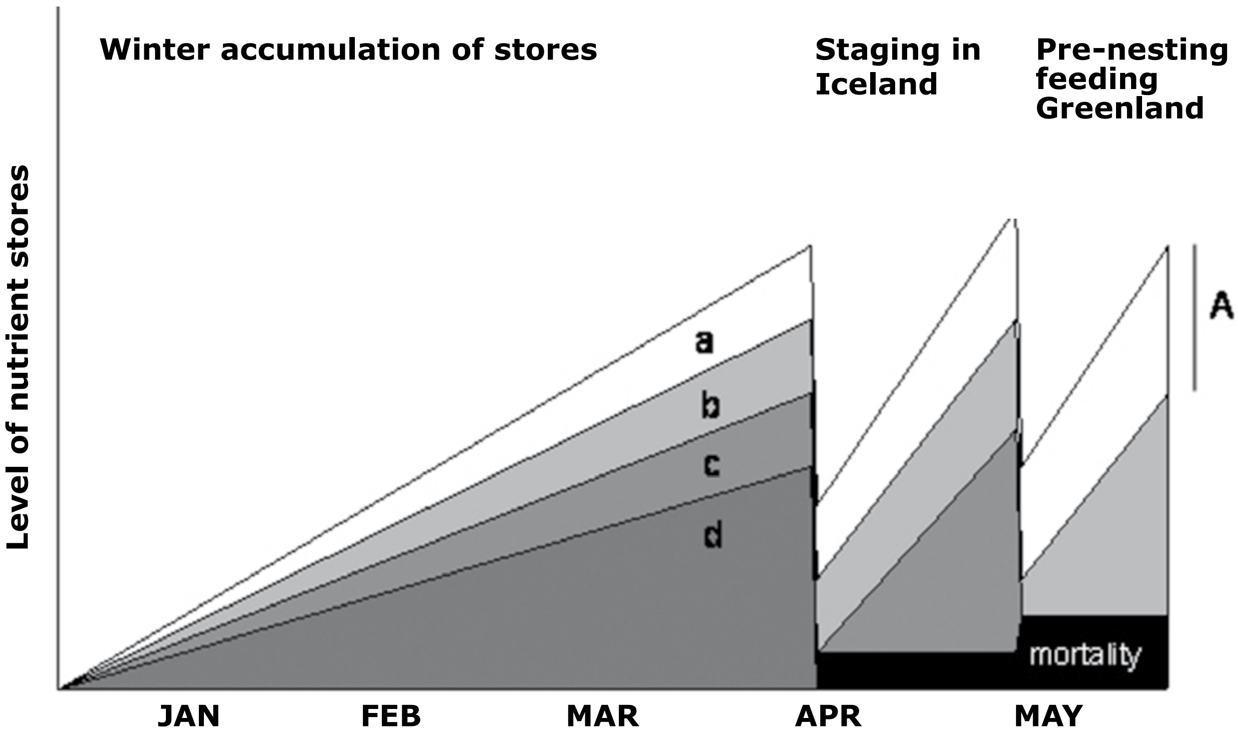


Figure 4.17. Patterns of theoretical accumulation of fat stores by adult female Greenland White-fronted Geese *Anser albifrons flavirostris* during the first five months of the year. The three sets of graphs show accumulation of fat stores at the non-breeding (wintering) grounds in Britain and Ireland (January to March), at the staging areas in Iceland (April) and at the pre-breeding areas in Greenland (May). The graphs a to d represent four different individuals that differ in their rate of accumulation of stores in these areas (due to feeding efficiency, behavioural dominance, parasite load, etc.), with 'a' accumulating the most fat and 'd' the least. Bird 'd' fails to accumulate sufficient reserves to reach a particular threshold at winter departure, and may fail to reach Iceland. Bird 'c' only builds up insufficient stores over winter and has too little time to accumulate stores to complete the journey to the west coast of Greenland; it therefore fails at the staging area. Even if accumulated stores are sufficient to support the flight successfully to the breeding areas, bird 'b' still cannot accumulate stores rapidly enough post-arrival to the level required to initiate a clutch (shown by 'A'), hence she incurs a fitness cost in terms of failed breeding (source: Fox 2003).

supply so that they can fairly quickly fatten up for the next stage of their journey. In order for them to achieve this, important staging areas should also be 'safe havens'; if birds are disturbed regularly then they will not be able to store up energy for their onward journey. This can affect timing or it can force them to leave the site in a sub-optimal condition.

Figure 4.17 illustrates patterns of theoretical accumulation of fat stores by adult female Greenland White-fronted Geese *Anser albifrons flavirostris* at the wintering, staging and pre-breeding areas (Fox 2003). Small differences in feeding efficiency, and hence accumulation of stores, can be seen to have a cumulative effect during the five or so months before first egg date. The critical periods of store acquisition are those in Iceland and Greenland (staging and pre-breeding areas), where rates of accumulation are most rapid and therefore where small perturbations are likely to have most effect.

However, even during the slow accumulation of stores on the wintering grounds, failure to accumulate stores bears a future cost, and the short episodes of rapid store accumulation in Iceland and Greenland do not permit individuals to 'catch up lost ground' at these later stages in the spring period.

Conservation of staging areas
As well as providing a reliable food source, staging areas are also important resting sites for migratory birds. Migration is a highly demanding activity, and rest is essential en route for birds that do not follow a non-stop strategy. For birds to feed efficiently and rest, staging areas must be largely free of disturbance and threats. Therefore, conservation measures at important staging areas are essential in order to safeguard the functional role of these sites.

Direct targeted conservation measures for staging sites to protect a certain species are difficult, but it is essential to maintain within the flyway a dense network of suitable smaller sites for birds that do not flock together. Removing too many of them just for reasons that they are small and do not appear important, could in the end break the migration route system and have a substantial impact. With these smaller sites it is important to apply the ***precautionary principle*** (refer to Glossary). In the case of small wetlands, for instance, it may be necessary to set up a physical planning mechanism to compensate for the previous loss of smaller wetlands by establishing new ones at a different place. There is enough ecological and technological know-how among countries in the AEWA region to provide advice and to implement this in a satisfactory way. However, protection of existing wetlands is far more effective and less costly than creating new ones, and site protection should therefore be the key policy in this respect. [More information on site conservation is provided in various sections of Module 2, as well as in the Ramsar guidelines, especially Handbook 2 (CD 3)].

<u>Turnover</u>
An important concept for staging areas is that of ***population turnover***. When birds migrate they usually do so in a staggered fashion rather than all at the same time. This is due to several reasons; some may start their journey much further away than others, whilst issues relating to energetics are also important. So a staging wetland will be important for a 'wave' of birds, arriving and leaving on staggered and variable time schedules. This means that the peak count at any one moment will not represent the actual importance of the site in terms of numbers. Rather, the site will have a cumulative importance for different individual birds using the site at different times. It is important to take account of this fact especially for smaller wetlands, which may not seem as important as they really are!

<u>*Staging areas and site inventories*</u>
Many of the larger sites important as staging areas are well known and mapped, and are listed or described in various wetland inventory publications and resources. Flyway atlases provide lists of important sites for waterbirds (e.g. Scott & Rose 1996, Delany *et al.* 2009). There are many published wetland inventories, e.g. A Directory of Wetlands of the Middle East (Scott 1995), and A Directory of African Wetlands (Hughes & Hughes 1992). Many key staging areas are Ramsar sites (Sites of International Importance under the Ramsar Convention), and described on the Ramsar site list (see *Further reading* below). Indeed, the fourth site selection criterion of the Ramsar Convention was framed especially in the context of such areas (sites important for animals "at a critical stage in their life cycles").

Many staging areas have also been identified as Important Bird Areas (IBAs), and are described in various IBA directories. There are regional IBA directories, such as for Africa and associated islands (Fishpool & Evans 2001) and the Middle East (Evans 1994), and national inventories, such as for Kazakhstan and Uzbekistan (Kashkarov *et al.* 2008; Sklyarenko *et al.* 2008). For some regions inventories of IBAs that are also potential Ramsar Sites have been published (e.g. BirdLife International 2002).

4.6 Roosts

> ***Key message***
> *Roosts are congregations of resting birds, especially at staging areas or night-time 'dormitories'; birds need to feel secure at their roosts.*

Similar to staging areas, roosts are places where groups of birds gather and stay for a certain period. Roosts are often associated with staging areas, but they have a particular function. In tidal staging areas roosts are occupied when high tide makes the feeding areas inaccessible. Waders like Dunlin *Calidris alpina,* Bar-tailed Godwit *Limosa lapponica* and others may congregate while on migration in large flocks, or roosts, of sometimes 100,000 birds or more, waiting until the tide goes out again. At the roost birds sleep, preen and rest for a couple of hours. The term roost is also used to describe a sleeping place or safe area (such as a water body or island) where birds spend the night. This may happen during migration and at non-breeding destination areas, as well as in breeding areas. Some birds use trees, bushes and mangroves as roosts, especially colonial birds, which may nest in the same or similar habitats (Figure 4.18). Swallows and harriers in particular roost in reed beds, and some roosts of Barn Swallows *Hirundo rustica* in Africa may number hundreds of thousands of birds.

Roosting in large flocks provides security to birds, and this strategy has been adopted by many types of birds. Forming roosts may reduce the risk to waders, for instance, of predation by migratory raptors such as Peregrine Falcon *Falco peregrinus.* This fast and efficient bird of prey is an important predator in tidal areas like the Banc d'Arguin. This critically important non-breeding and staging area supports high concentrations of waders and other waterbirds, many of which will need to rest at times, especially when high tide reduces availability of mudflats and feeding opportunities (Figure 4.19).

Figure 4.18. Roost of African Spoonbills *Platalea alba* in the coastal zone of Guinea-Bissau (photo: Leo Zwarts).

Figure 4.19. A high tide roost in the Banc d'Arguin, Mauritania, a critical site for many species of wader and other waterbirds (photo: © Hellio – Van Ingen).

4.7 Non-breeding destination areas (wintering areas)

Key messages

Some waterbirds may spend several months in their non-breeding destination areas. Conditions in these areas can influence breeding success.

Within a migration system these are the areas where birds stay at the end of their migration. They are, in essence, the final destination of the birds, from where they will depart once more to return to the breeding areas. The term 'non-breeding area' applies to any area used outside the breeding range. Adding the word 'destination' specifies the areas used after migration. This term replaces to some extent the widely-used term of 'wintering area', which refers directly to destination areas of birds that have migrated generally to warmer climes from summer breeding areas in temperate zones. These areas are thus used when it is winter in their breeding areas. The vast majority of birds that have clear wintering areas breed in northern latitudes, which they leave on north-south migrations when temperatures become much lower after summer along with a reduction in food availability. In breeding areas far to the north frost and snow set in soon after the end of summer, forcing birds to migrate. [The terms 'wintering' and 'wintering area' are used in this Training Kit only in relation to the non-breeding destination areas of birds that breed in temperate zones and have a north-south migration].

Birds may stay for quite a while, perhaps several months at their non-breeding destination areas. Preferred sites should be relatively productive and capable of supporting large numbers of birds for some time. Poor conditions in these areas can directly impact breeding success the following breeding season (see section 7.4.8).

Migratory birds in Africa also use non-breeding destination areas, though in general such areas are not clearly defined. The grasslands of the Mwanza-Shinyanga region in north-western Tanzania form an important non-breeding destination area for Abdim's Stork *Ciconia abdimi*, but the level of importance will vary according to rainfall patterns, and in some years this area may be best considered as a staging area for the storks.

It is not easy to define non-breeding destination areas for nomadic and semi-nomadic waterbirds, which depend on a network of sites that may vary regularly according to climatic and other reasons.

4.8 Bottleneck areas

> ***Key messages***
> *In migration studies, bottlenecks are places where birds are concentrated on migration, especially narrow-front migrants. Birds are especially vulnerable at bottlenecks; policies need to ensure that physical barriers are not constructed at bottleneck areas.*

Population ecology
In population ecology, a ***bottleneck*** may be considered as an important population-limiting factor. For migratory waterbirds, bottlenecks (or bottleneck areas) are not distinctive areas or sites at a fixed moment in the annual cycle. Rather, this is a collective term used for all those sites and areas that are crucial for a migratory species and that if no longer available, would substantially affect their migration. A bottleneck can occur during the breeding season (e.g. availability of nesting places), or it can be the disappearance of suitable moulting areas.

Migration studies
However, in migration studies, the term ***bottleneck*** usually refers to an area where birds are concentrated due to their migratory behaviour, and where they are thus especially vulnerable, e.g. to external threats. Typically, bottlenecks are narrow corridors through which birds must pass, such as the Rift Valley, where strong thermal currents are generated, mountain passes or land bridges. Bottlenecks are particularly relevant in narrow-front migration (section 3.1), as illustrated for migrating Common Cranes *Grus grus* in Figure 3.1. The best-known bottlenecks are those where soaring birds cross large water bodies, such as Gibraltar and the Bosporus (Figure 4.20), both Mediterranean Sea crossings. These and the crossings into Africa both at the north and south of the Red Sea are all shown in Figure 4.21. Falsterbo in Southern Sweden is also a famous bottleneck, where many migratory birds pass, crossing the sea between continental Europe and Scandinavia.

Figure 4.20. Soaring birds over the Bosporos, Istanbul, Turkey (photo: Ümit Yardım).

Figure 4.21. A simplified flyway map illustrating what a 'real' bottleneck area can be, such as the Jordan valley, especially near Eilat, Israel. Large numbers of soaring birds, including many birds of prey, White Storks *Ciconia ciconia* and Black Storks *Ciconia nigra*, pass through this bottleneck area, sometimes in tens of thousands every day (source: Leshem *et al.* 1998).

Due to the large passage of birds through relatively narrow bottlenecks, birds are particularly at risk, for instance from high densities of physical barriers like power lines or wind farms, the latter an issue which is becoming increasingly important as renewable sources of energy are exploited in the face of soaring oil costs and the desire to reduce carbon inputs to the atmosphere.

In all cases, the loss of functionality of bottleneck areas may cause a serious threat to the populations involved.

4.9 Implications for conservation

Key message

Conservation managers must take account of the different life cycles and uses of sites by migratory waterbirds; where knowledge is lacking, follow the precautionary principle.

Different uses of sites

Although the above list describes the types of sites used by waterbirds in their annual life cycle, the way different species use the sites can be quite different. Clearly all waterbirds have a breeding area, though not all breeding areas are 'fixed'. There are great differences in habitat needs and use between colonial breeding species and those breeding on an individual basis, sometimes with a certain distance between nests. Some species moult at sites within the breeding area, such as Arctic breeding geese (sometimes after a short moult migration (see section 3.5), whilst others have a shorter or longer moult migration to specific areas outside the breeding area. Once on migration many migratory waterbirds need staging and resting areas and roost sites within these areas. They may also need such sites within the non-breeding destination areas.

Importance of annual cycles

In order to be effective, conservation actions for a migratory waterbird population cannot be restricted to the obvious areas where it breeds and where it stays during the main non-breeding period. It is also necessary to understand how its annual cycle takes place and which sites are really needed to complete this cycle in the most appropriate way. Such detailed knowledge is available for some species and their different populations, but for many others it is not. For instance, very little is known concerning the long-term effect of the removal of so many smaller lakes, ditches and other wetlands in Europe and Africa (through periods of extended drought) on the migration and survival of waterbirds such as freshwater-dependant sandpipers. Where declines in such migratory waterbirds and their habitats continue, it may be necessary to recreate such habitats in order to enable birds to successfully complete their annual cycles.

Such actions require information about waterbirds and their life cycles, at least to the species level, but also for different populations. Many waterbird species have several different populations, all with different migratory strategies and ranges, and different actions will be needed for these at the population level. Waterbird populations are all given in Wetlands International's Waterbird Population Estimates series, which also provide basic information, where available, on the numbers, status and trends of each population (e.g. Wetlands International 2006).

Where knowledge is lacking, it is also important to adhere to the ***precautionary principle*** (see Glossary) in the conservation of migratory routes, as laid down in all international treaties, and apply this principle as widely as possible.

Further reading:

- *The Migration Ecology of Birds (Newton 2008).*
- *Bird Migration (Alerstam 1990)*

Pre-breeding areas:

- *The importance of pre-breeding areas for the arctic Barnacle Goose Branta leucopsis (Hübner 2006): http://nou.natuurinfo.nl/website/ardea/ardea_show_article.php?nr=630.*

Staging areas and annual cycles:

- *The Greenland White-fronted Goose Anser albifrons flavirostris: The annual cycle of a migratory herbivore on the European continental fringe (Fox 2003): http://www2.dmu.dk/1_Viden/2_Publikationer/3_o vrige/rapporter/TFO_Doctors_27art_web/TFO_Doc tors_web.pdf.*

Migration atlases:

- *Atlas of Anatidae Populations in Africa and Western Eurasia (Scott & Rose 1996).*
- *An Atlas of Wader Populations in Africa and Western Eurasia (Delany et al. 2009): http://www.wetlands.org/WatchRead/tabid/56/mod/1570/articleType/ArticleView/articleId/2132/Wader-Atlas-draft-for-consultation.aspx.*

Wetland and IBA Directories (examples):

- *A Directory of Wetlands in the Middle East (Scott 1995).*
- *A Directory of African Wetlands (Hughes & Hughes 1992).*
- *Ramsar sites: http://ramsar.wetlands.org/Database/Searchforsites/tabid/765/Default.aspx.*
- *Important Bird Areas in Africa and associated islands (Fishpool & Evans 2001).*
- *Important Bird Areas in the Middle East (Evans 1994).*
- *Important Bird Areas in Uzbekistan (Kashkarov et al. 2008).*
- *Important Bird Areas in Kazakhstan (Sklyarenko et al. 2008).*
- *Important Bird Areas and potential Ramsar Site in Africa (BirdLife International 2002).*

5. Understanding the flyway approach and flyway terminology

5.1 The definitions of a flyway

Key message

A flyway is the entire range of a migratory bird species or groups of related species or distinct populations of a species. There are different scales of flyways: single species migration systems, multi-species flyways and 'political flyways.'

5.1.1 Origins of the term 'flyway' in North America

The word flyway originated in America meaning simply 'the road taken by birds when flying'. However it has always been used in its understanding of indicating a migration route in a geographical sense. The term has been used since at least the early 1950s in publications on the migrations of ducks and geese in North America, as it was recognised that many species use relative small geographical corridors to move during migration: a road between the breeding and non-breeding areas. Four major flyways were recognised through the North American continent (Figure 5.1):

- Pacific Flyway
- Central Flyway
- Mississippi Flyway
- Atlantic Flyway

These flyways are well defined and described in their historical development and implementation, by Hawkins *et al.* (1984), who emphasises that the identification of the four major flyways within Northern America could only take place after analyses of the results of large scale waterbird ringing programmes and much detailed census work in the field. It is important to bear this emphasis on research in mind when discussing flyway boundaries within the AEWA region.

After the four major flyways in North America were identified, they were used as administrative units for the management of the flyways and their waterbird populations. For each flyway, Flyway Councils were established which are, *inter alia,* responsible for the management in the broadest sense of waterbird populations within their flyway. This management and related research is important given the fact that waterbird hunting is common practice in North America, and a sustainable harvest requires good insight into the populations, their ecology and fluctuations, as well as their migratory behaviour.

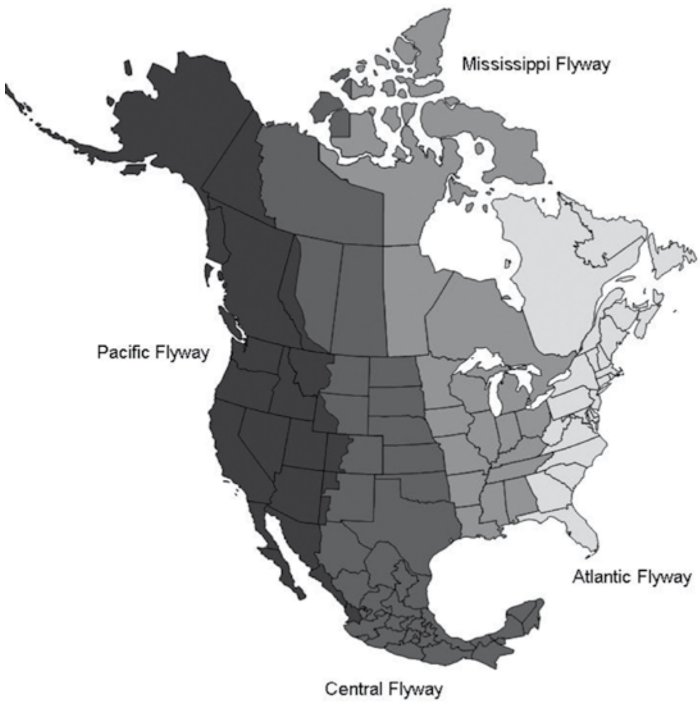


Figure 5.1. Flyways in North America (Blohm *et al.* 2006) (source: Blohm *et al.* 2006)

5.1.2 Identification of flyways in the AEWA region

Some of the early work on establishing flyway boundaries in the AEWA region was carried out by Isakov (1967), who described four main geographical population zones for Anatidae (Figure 5.2). More recent atlasing work has further progressed the identification of flyways, notably through the Anatidae Atlas (Scott & Rose 1996, Figure 5.3) and the Wader Atlas (Delany *et al.* 2009), both of which provide a wealth of information on flyways for different populations of each species covered.

Figure 5.2. The 'start of African-Eurasian flyway mapping': Isakov's (1967) main geographical populations of Anatidae in western Eurasia. Flyway coding:

1. Northern White Sea/North Sea population
2. European Siberia/Black Sea-Mediterranean population
3. West Siberian/Caspian/Nile population
4. Siberian-Kazakhstan/Pakistan-India population.

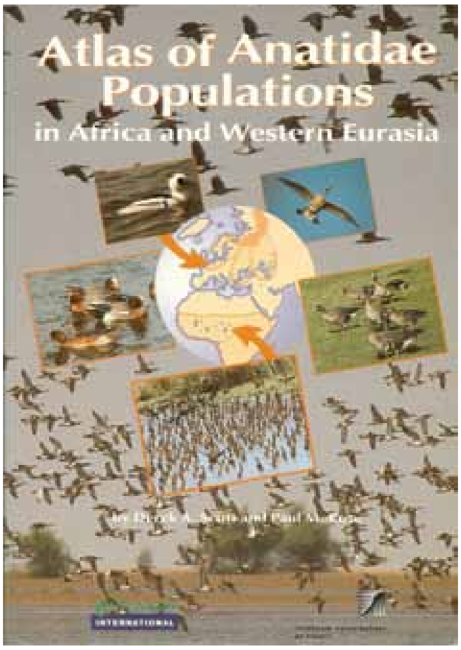


Figure 5.3. Anatidae Flyway Atlas (Scott & Rose 1996).

5.1.3 Later definitions and applications of the term 'flyway'

Subsequently the term flyway has been more widely adopted to indicate the entire migration route of a migratory bird, though it is also used in both its geographical and political/ administrative meaning. In understanding the flyway approach to conservation, the use of a generalised definition of a flyway is helpful, such as that provided by Boere & Stroud (2006):

> ***"A flyway is 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."***

A flyway in this meaning can be geographically restricted to a narrow band, as previously shown for the Common Crane (Figure 3.1) or with the Barnacle Goose *Branta leucopsis*, or it can include a much wider geographical area as for the Black-tailed Godwit *Limosa lapponica* (Figure 5.4).

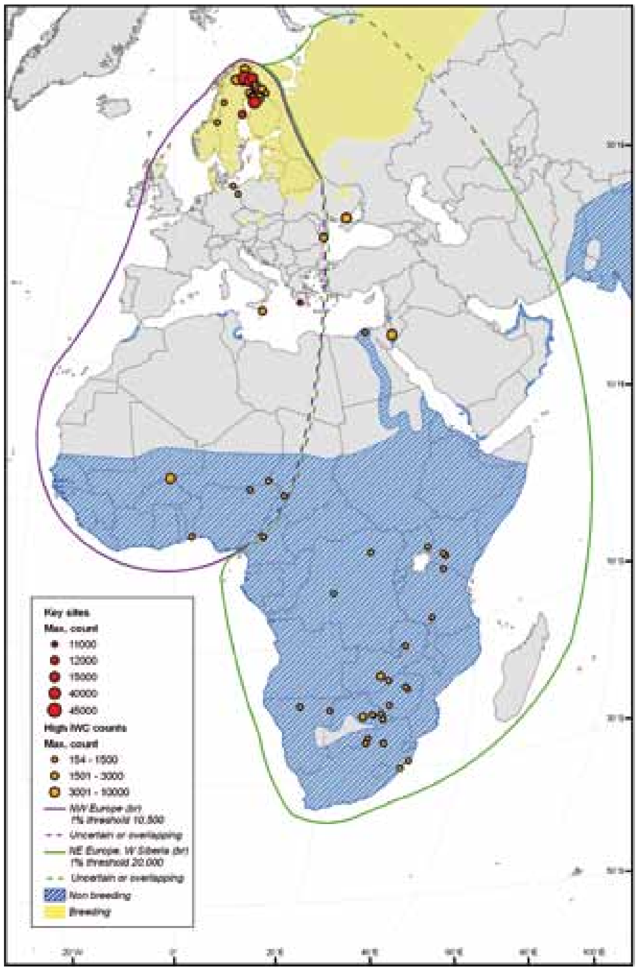


Figure 5.4. Narrow and broad flyways:
a. Geographically restricted (or narrow) flyway of one population of Barnacle Goose *Branta leucopsis* (after Madsen et al. 1999)
b. Geographically broad flyway for Wood Sandpiper *Tringa glareola* (Delany *et al*. 2009).

The term flyway can also be applied to groups of species that use the same approximate route. At the global level generalised flyways have been described for the wader or shorebird group (Figure 5.5). A flyway may further prescribe a migratory route for birds of different species groups. For instance, not only waders use the East Atlantic Flyway, one of the wader flyways shown in Figure 5.5; this flyway is also used by many other birds, including terns, gulls and some birds of prey.

Thus the word flyway can have different meanings from a geographical point of view. The term flyway is also used to identify a geographical range included in a political or strategic arrangement on migratory birds. At the global level, four main potential political flyways as administrative units have been identified (Figure 5.6). However recent discussions within the Bonn Convention also indicate a possible need for a fifth flyway instrument covering the Central Pacific Ocean area (Bonn Convention CoP; December 2008, Rome).

The Agreement on the Conservation of African-Eurasian Migratory Waterbirds (AEWA) geographical area is often indicated as the African Eurasian Flyway. In this context the word flyway is used as a geopolitical term indicating a range of countries working together in the conservation and management of migratory birds and facilitating that cooperation (Figure 1, in the Training Kit Introduction). From a scientific point of view the AEWA Flyway Agreement contains many different flyways of groups of birds, individual species and populations, all with their own ecological requirements.

<u>*Different flyway scales*</u>
To summarise the information above, flyways can therefore be considered at different scales (Boere & Stroud 2006):

- ***Single species migration systems***: The distributional extent of the annual migration of a species or population, encompassing breeding, staging and non-breeding areas.
- ***Multi-species flyway***: Grouping of

migration routes used by waterbirds into broad flyways, each of which is used by many species, often in a similar way, e.g. broad grouping of migration of waders into eight flyways (Figure 5.5).
- ***Global regions for waterbird conservation management*** ('political flyways', Figure 5.6).

5.1.4 Further considerations

For flyway conservation, it is necessary to have sufficient knowledge of the migration strategies of individual populations. This enables us to determine how a population's migration route is built upon the availability of sites, timing and other parameters, and to identify the consequences for sound management and conservation.

The flyway maps illustrated throughout this manual show the various ways in which the word flyway is being used and slowly developed for the African-Eurasian region. They also underline the need to be clear what is actually meant when using the word flyway, due to the different (geographical and political) meanings. The term flyway has been used most widely to indicate north-south migrations, due largely to a bias in

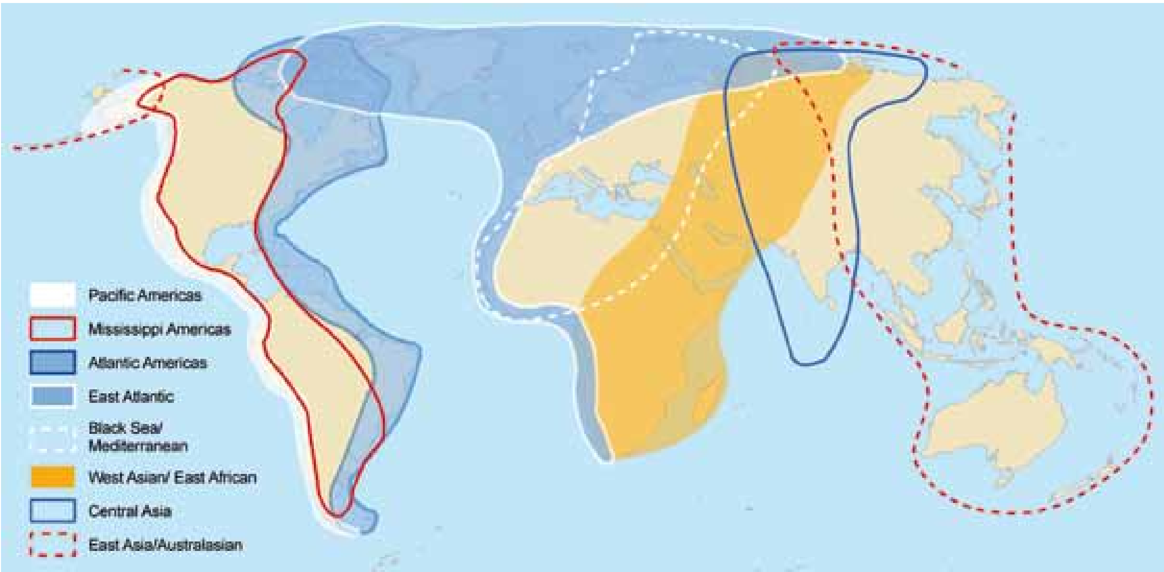


Figure 5.5. Wader flyways of the world (source: International Wader Study Group).

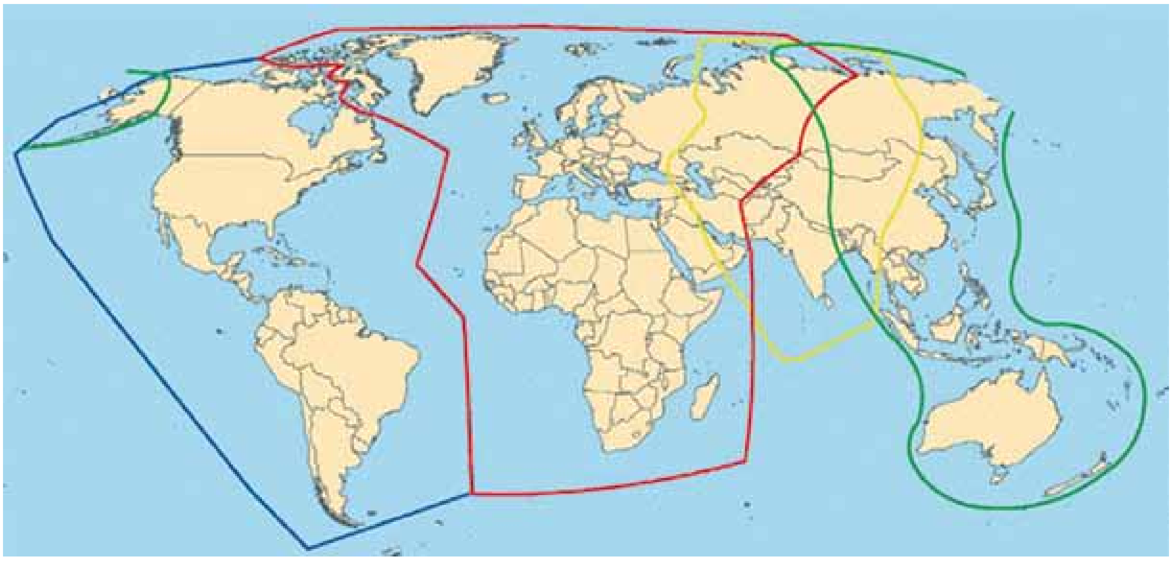


Figure 5.6. 'Political flyways' as a way to arrange for international cooperation; the possible global scope of multilateral agreements for the conservation of migratory waterbirds (source: Stroud *et al.* 2006a).

knowledge, as much more research has been and still is carried out on birds breeding in Europe and Northern America, both by professionals and volunteers, than elsewhere. East-west movements of birds on the Eurasian continent have been little studied; indeed it is not even clear if the ranges covered by such movements may be considered as flyways or not, in the sense of commonly used migration routes.

Flyways are poorly identified for Africa, in particular, especially in relation to intra-African migration, which is often characterised by irregular and nomadic movements, although these are in some cases at least partially predictable. Most waterbird movements within Africa relate closely to rainfall and the resulting availability of suitable areas for feeding and other life cycle stages (Dodman & Diagana 2006). However, it is hard to describe accurate flyways for such movements, which may be very variable.

Further reading:

- *Atlas of Anatidae Populations in Africa and Western Eurasia (Scott & Rose 1996).*
- *The flyway concept: what it is and what it isn't (Boere & Stroud 2006): http://www.jncc.gov.uk/PDF/pub07_waterbirds_part1_flywayconcept.pdf.*
- *Goose populations of the Western Palearctic. A review of status and distribution (Madsen et al. 1999).*
- *An Atlas of Wader Populations in Africa and Western Eurasia (Delany et al. 20009): http://www.wetlands.org/WatchRead/tabid/56/mod/1570/articleType/ArticleView/articleId/2132/Wader-Atlas-draft-for-consultation.aspx.*
- *Conservation dilemmas for intra-African migratory waterbirds (Dodman & Diagana 2006): http://www.jncc.gov.uk/PDF/pub07_waterbirds_part3.4.1.pdf.*
- *Integrated waterfowl management in North America (Blohm et al. 2006): http://www.jncc.gov.uk/pdf/pub07_waterbirds_part3.3.3.1.pdf.*

5.2 Migration, ecological networks and the ecosystem approach

Key message

Conservation strategies for migratory waterbirds need to be built into ecological networks, whereby the functionality of key sites for waterbirds is recognised.

In order to implement effective conservation strategies for migratory waterbirds, it is important to consider the relation of migration routes, flyways and staging sites within the context of international discussions on the development of global ecological networks and the application of the ecosystem approach. Ecological networks form an important leading policy concept for many governments and international treaties to stimulate the cessation and reversal of the fragmentation of nature.

5.2.1 Ecological networks concept

<u>Elements of an ecological network</u>

The main function of an ecological network is to maintain the broad integrity of environmental processes. One means of achieving this is to ensure ***connectivity*** between sites that play (or can play) an important function (see Module 2 section 3.1). The proximity of sites to each other varies between species, but the common element is the ***functionality*** of sites. Ecological networks contain four main elements (Figure 5.7, Biró *et al.* 2006):

- core area(s)
- corridor(s)
- buffer zone(s)
- restoration area(s), where and if necessary.

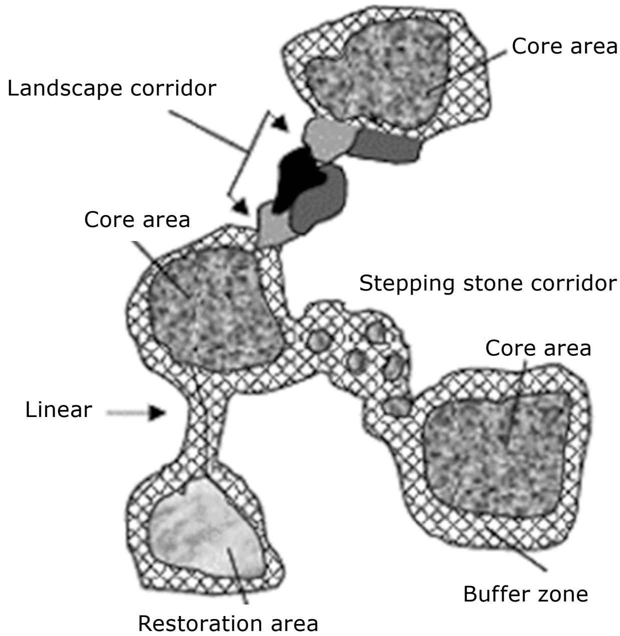


Figure 5.7. Schematic diagram of an ecological network (source: Biró *et al.* 2006/ECNC).

For migratory waterbirds the corridors may be termed 'migration corridors', whilst the core areas may be supporting different stages of the annual cycle. A 'stepping stone corridor' is important for migratory birds that use the 'hopping' strategy (see section 2.2.1).

European Ecological Network (EECONET)
A discussion on the concept of ecological networks was launched and stimulated at the international level in 1991 by The Netherlands when facilitating the publication 'Towards a European Ecological Network' produced by the Institute for European Environmental Policy (Bennett 1991). It was brought to the political and policy level through the international conference 'Conserving Europe's natural heritage; towards a European Ecological Network' held in Maastricht, The Netherlands, November 1993. The conference adopted the 'EECONET Declaration' outlining the basic elements of this conservation concept.

Ecological networks and the CBD
Ecological networks have been on the agenda of many organisations and international treaties, notably the Convention on Biological Diversity, in one form or another for some time, with examples provided in Bennett & de Wit (2001), Hindmarch & Kirby (2002) and Bennett (2004). Further information is also provided in the CBD (2003) document on ecological networks (CBD/SBSTTA 2003).

5.2.2 Ecological networks and flyways

From the beginning the concept included migration routes or flyways as a form of ecological network where migratory species, in particular birds, were recognised as using a chain of areas and sites for different purposes during their annual cycle (Figure 5.8, Bennett 1991).

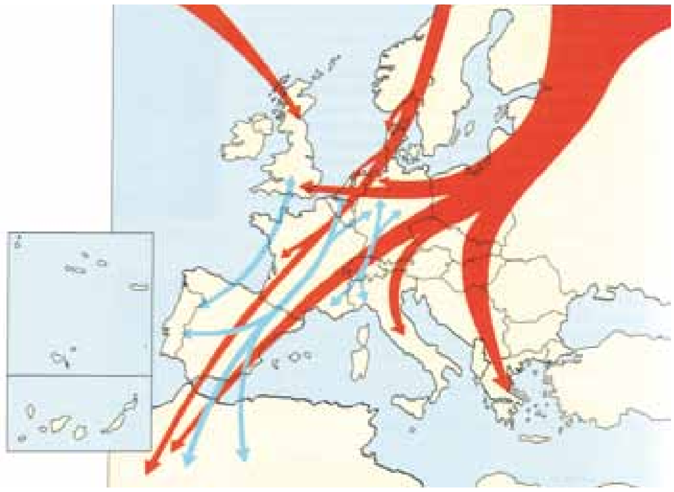


Figure 5.8. Map showing example migration routes of birds within Europe to illustrate migration routes as ecological networks (source: Bennett 1991).

The flyway approach is often seen as an example of an ecological network given the specific needs of migratory birds for breeding, staging and non-breeding areas that are available throughout the year. One practical implication is that funding agencies (of governments and international organisations) tend to stimulate the development of ecological networks, and of course for good reasons. The flyway approach, as an example of ecological network development, may thus be included as a strategy applicable for funding under ecological network funding programmes, especially if carried out in combination with local communities' sustainable use of birds as a protein resource and of the ecosystem services of the wetlands used by waterbirds.

5.2.3 The ecosystem approach

Related to this but more difficult to use as a concept is the 'ecosystem approach' - a concept developed specifically in relation to development aid activities and strongly promoted in the framework of the CBD towards larger scale conservation programmes. The ecosystem approach requires the whole ecosystem to be taken into account, for instance through a river basin approach. The World Wide Fund for Nature

(WWF) has identified a series of ecoregions, which further aid conservation planning using the ecosystem approach. These include Freshwater Ecoregions identified for all regions, and now available as a searchable information tool (http://www.feow.org/index.php). Figure 5.9 shows the freshwater ecoregions for Africa.

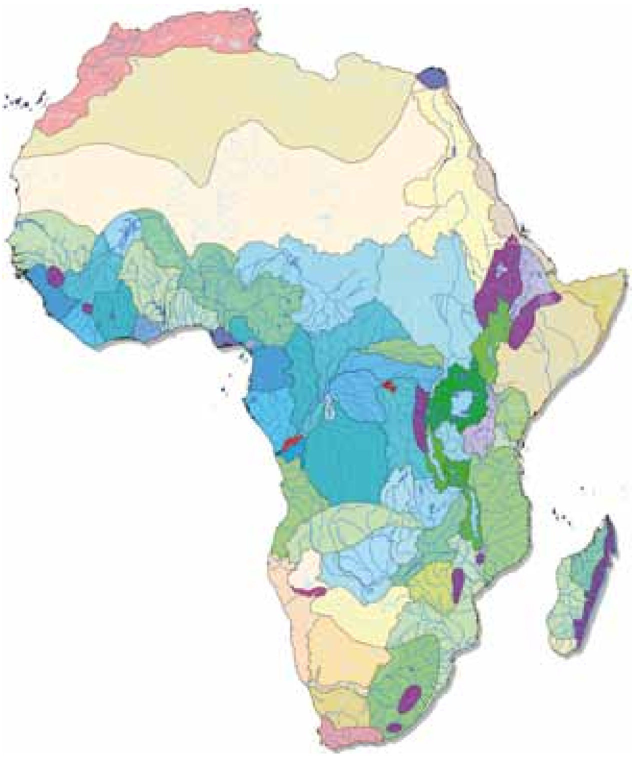


Figure 5.9. Freshwater ecosystems for Africa (source: Freshwater Ecoregions of the World).

The flyway approach has some parallels with the ecosystem approach. The flyway for a bird population is the ecosystem it needs to survive, though in reality this is a rather specific interpretation of the concept of the ecosystem approach and not often used in this sense.

Further reading:

Ecological networks:

- *Ecological network references: http://www.eeconet.org/eeconet/peen/factsheet10.pdf.*
- *Indicative map of the Pan-European Ecological Network in South-Eastern Europe. Technical background document (Biró et al. 2006): http://www.ecnc.org/file_handler/documents/original/view/68/2006--indicative-map-of-the-peen-see-backgroundpdf.pdf?PHPSESSID=c27cf2a9a378c6ecda912da2c32f516c.*
- *The development and application of ecological networks; a review of proposals, plans and programmes (Bennett & de Wit 2001).*

The ecosystem approach:

- *CBD SBSTTA Recommendation IX/6: Ecosystem approach (CBD/SBSTTA 2003): http://www.cbd.int/recommendations/sbstta/view.shtml?id=7462.*
- *Freshwater Ecoregions of the World: http://www.feow.org/index.php.*

6. Understanding the principles of the flyway approach and considerations in different parts of the world

6.1 Principles of the flyway approach

Key message

All stakeholders along a flyway should work together towards the wise use of migratory waterbird populations across their entire range.

6.1.1 Cooperation and negotiation

The fundamental principle of the flyway approach is that all stakeholders in the entire flyway work together towards the conservation and/or sustainable management of migratory species across their entire range. As such it is a form of international co-operation. For example, to effectively conserve the Garganey *Anas querquedula*, coordinated and agreed actions for managing the species in a sustainable manner across all range states are needed; (see Exercises). Garganeys that breed in Russia may pass through Europe and North Africa to spend the northern winter in Sahelian wetlands, such as the Inner Niger Delta in Mali. There are pressures on Garganeys in Russia and in parts of Europe by hunters, whereas some European countries prefer to conserve them. In Mali, Garganey has long been considered as an important seasonal food source for local people living in and around the Inner Niger Delta. The principle of the flyway approach to conservation in this example is to ensure that joint and coordinated actions are taken to ensure that the population of Garganey remains in a healthy conservation status. This requires cooperation and negotiation between range states.

The Convention on Wetlands recognises the importance of international cooperation in the management of shared wetland resources, including migratory waterbirds. An example of this recognition at the international level is Ramsar's Joint Work Plan with CMS and AEWA (2004), which focused on areas of mutual interest. Guidelines to international cooperation are provided in Ramsar Handbook 17 (available on CD3).

6.1.2 Defining the principles for cooperation

To achieve flyway conservation, some basic elements must be in place:

- Define the geographical region and which migratory species are involved.
- There must be understanding by all parties involved which migratory species (and populations) need specific actions.
- Agreement on what actions should be put in place.
- Arrangements on the implementation of the actions. This concerns issues such as: by whom, who pays, within what time frame should the actions be finalised, how should the public at large be involved and how should general awareness be raised?
- Establish a system of monitoring and evaluation to measure the effects of the actions and redirect actions if needed.

In practice this means that all stakeholders should be involved in the development of a document that lays down these elements in more detail. Such an arrangement can be developed at various political levels and thus with various degrees of a binding nature for either just one population or species, a group of closely related species or indeed for all species within a defined geographical area.

Further reading:

- *Ramsar handbook 17: International cooperation: http://www.ramsar.org/pdf/lib/lib_handbooks2006_e17.pdf*
- *Ramsar/CMS/AEWA Joint Work Plan 2004: http://www.ramsar.org/cda/ramsar/display/main/main.jsp?zn=ramsar&cp=1-31-115©2096_4000_0__*

6.2 Converting principles into political instruments

Key message

Various types of instruments are available to facilitate cooperation and to formalise it if necessary. These can be powerful tools for conservation.

6.2.1 Different types of instruments

On the political/policy level various kinds of arrangements/instruments have been developed and are generally accepted procedures for cooperation. These include:

1. Exchange of letters
2. Statement of Co-operation (SoC)
3. Memorandum of Understanding (MoU)
4. Strategy
5. Agreement (for instance in line with the Bonn Convention)
6. Convention
7. Directive

Exchanges of letters, SoCs, MoUs and Strategies are international arrangements or instruments that, strictly speaking, do not have a legally binding nature but which provide, essentially, a voluntary framework for international cooperation. We emphasise the term 'legally not binding', as letters exchanged between directors of conservation authorities of Governmental or Non-Governmental Organisations are not to be ignored of course. However their status is different to intergovernmental instruments like international conventions. Letters are relatively easy to develop and agree upon. Agreements and Conventions have typically the status of international law, and as such are legal instruments. However in the field of nature conservation they rarely have enforcement or compliance mechanisms, which renders them harder to enforce through international law. The process to develop, conclude and then ratify them can be a complex one and may take several years. The process of development of the AEWA took almost ten years from the start of the discussions to the formal signing in 1995, and a further four years was needed to achieve the ratifications to bring it legally 'into force' in November 1999. [See Annex 10, CD 1 for examples of such instruments].

6.2.2 The European Union's Birds Directive

Within the European Union there are two legal instruments: Directives and Regulations. Regulations enter into force directly, whilst Directives establish legally binding objectives, but leave the means by which these are to be achieved to the Member States. In this respect the EC Directive on the conservation of wild birds (Birds Directive) of 1979 has been a successful instrument that has contributed to reducing the speed of decline of some birds, to reversing declines to render some populations stable, and in other cases to improving the conservation status of bird species (Donald *et. al.* 2007). The designation of Special Protection Areas (SPAs) under the Birds Directive (as part of the Natura 2000 network contributes further to the conservation status of birds. Migratory birds form an essential element in the EC Birds Directive, which has had notable success in many respects, such as a reduction in hunting pressure, protection of important sites and prevention of some cases of loss or degradation through development of other impacts.

6.2.3 Some history in the development of international instruments

Worldwide there are great differences in the way states have, or wish to have, their cooperation arranged and formalised. These differences are also visible in the way cooperation on migratory species has been arranged, often long before the Bonn Convention appeared on the platform of worldwide environmental treaties. Regional arrangements include the Paris Convention in Europe (1902 and 1950) and the Migratory Birds Act between Canada and the USA (as early as 1916, later amended in 1936). The latter was a relatively straightforward act to conclude, with only two states involved within which many flyways are located in full. Both states had comparable governance and legal systems and used largely the same language. Mexico later joined this formal treaty, and the USA developed a separate act, the Neotropical Migratory Birds Conservation Act (NMBCA). This provided a facility to finance conservation projects in Central and South America aiming at the protection of North American migratory breeding birds spending the non-breeding season in South America, where threats to tropical forests in particular influenced their survival. Within North America it is very much a bottom-up process towards establishing Joint Ventures (articles formed between two or more parties to undertake identified and agreed activities together).

6.2.4 Africa-Eurasia and Asia-Pacific instruments

In Africa-Eurasia, the large number of states, great differences in governance structures between states and great linguistic diversity required a more top-down process aiming at a binding instrument such as was the case with the development of the AEWA. In the Asia-Pacific region the development of a flyway instrument for migratory waterbirds covering many states was largely a bottom-up process of a voluntary nature. Its result was the Asia-Pacific Migratory Waterbird Conservation Strategy 1996–2001, recently updated and still in place. The implementation of the strategy is overseen by a Board with representatives of the region, stakeholders and international conventions.

The situation in the Asia-Pacific Region is interesting because as well as the present joint strategy for the whole flyway there are a number of bilateral instruments between states on the conservation of migratory birds. Such bilateral arrangements exist between, for example the Russian Federation and Japan, the Russian Federation and Australia, Japan and Australia, and the Russian Federation and India. These formal bilateral arrangements are still intact, but in almost all cases implementation takes place within the framework of the agreed joint strategy.

Further reading:
- *Annex 10 on CD1.*
- *CMS instruments: http://www.cms.int/species/index.htm.*
- *EU Birds Directive: http://ec.europa.eu/environment/nature/legislation/birdsdirective/index_en.htm.*

6.3 Towards implementation of flyway instruments

Key message
Action plans are practical means to implement flyway instruments.

Once an arrangement has been made on how the cooperation could be organised, technical documents should be prepared to describe the species involved, their biology and other relevant issues. This may take the format of a Flyway Management Plan or an Action Plan. It could involve just one species, or closely related waterbird groups, or it could involve all species occurring in a flyway. Under the auspices of AEWA a number of Flyway and Action Plans have been developed and are in place for implementation (examples in Figure 6.1). [Further information on Species Action Plans (SAPs) is provided in Module 2 section 2.2 and in the presentations, whilst all AEWA SAPs are available on CD 4].

Figure 6.1. Examples of AEWA Single Species Action Plans: Northern Bald Ibis *Geronticus eremita*, White-headed Duck *Oxyura leucocephala* and Sociable Lapwing *Vanellus gregarius*.

Required actions may already be formulated in the text of an international SoC, MoU or other instrument, especially if the instruments are concerned with single species. Alternatively they may need to be developed as a separate plan, which is often a time and resource consuming exercise. The resulting plan may then be added to the over-arching instrument as an Annex. This is the case with Single Species Action Plans and other plans developed under AEWA - they need to be formally adopted as Annexes by the Parties to the Agreement.

The Siberian Crane *Grus leucogeranus* is a good example of a rare species for which a successful Memorandum of Understanding under the Bonn Convention functions and brings all stakeholders together on a regular basis (UNEP/CMS 2008). The work has benefited greatly from a GEF programme grant focussing on the conservation of a number of sites (Figure 6.2). The actions taken at key sites are at the same time beneficial for many other species of waterbirds that share these sites.

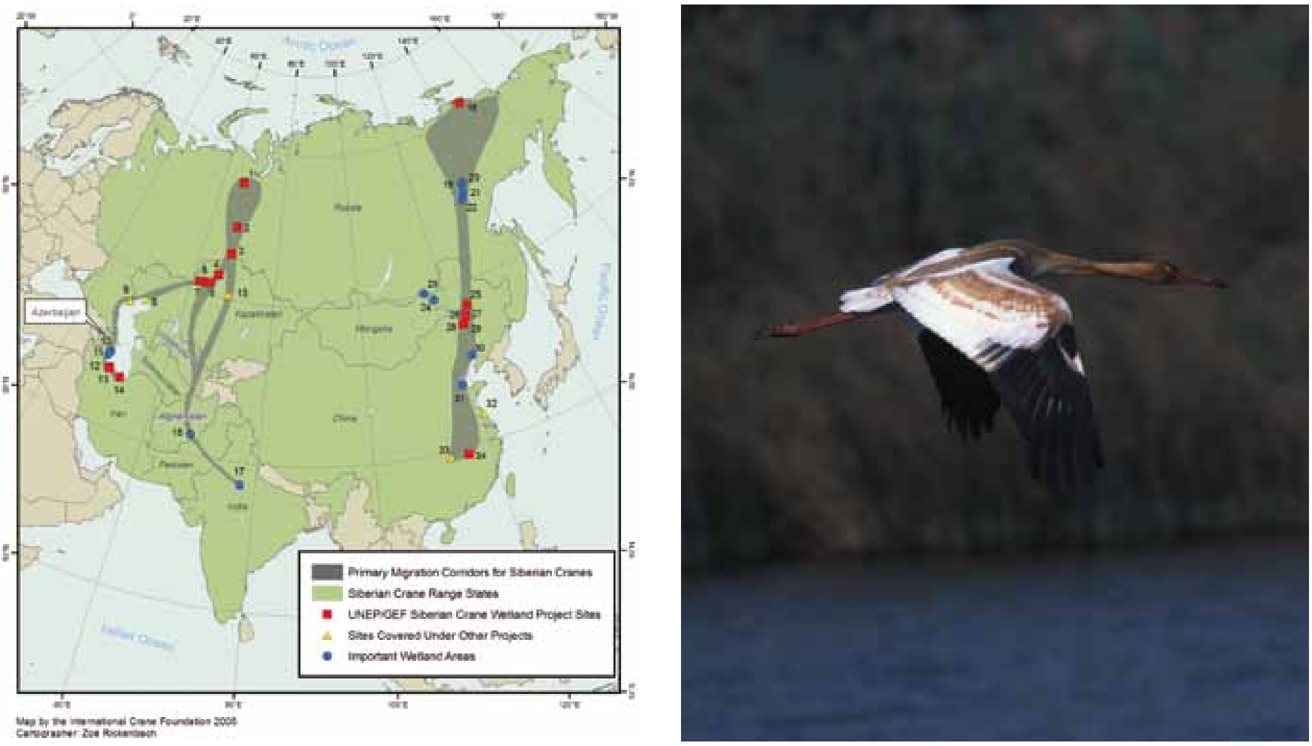


Figure 6.2. Breeding, staging and non-breeding sites of Siberian Crane *Grus leucogeranus* plus migration routes/ corridors; actions based on a formal Bonn Convention MoU (source: UNEP/GEF/ICF Siberian Crane Wetland Project); Siberian Crane in flight (photo: Martin Hale).

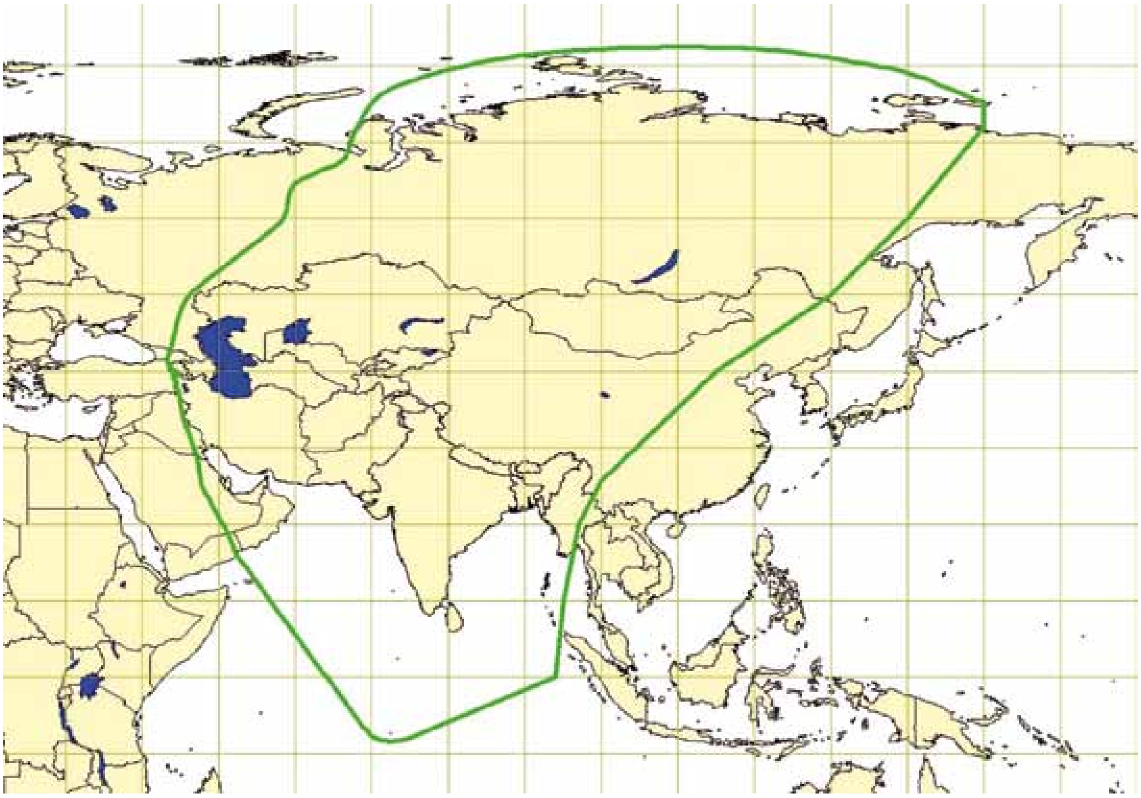


Figure 6.3. Indicative map of the Central Asian Flyway region (source: UNEP/CMS).

Other examples of Bonn Convention MoUs for birds are for Great Bustard *Otis tarda*, Slender-billed Curlew *Numenius tenuirostris* and Aquatic Warbler *Acrocephalus paludicola*. Another Agreement for birds is the Agreement on the Conservation of Albatrosses and Petrels (ACAP) that geographically partly overlaps with the AEWA region but does not include any species of the AEWA list. There is also an Action Plan in place for the Central Asian Flyway (CAF) which is closely related to AEWA in terms of actions and species, whilst a number of countries are involved in both instruments (Figures 6.3 and 6.4).

Further reading:
- *AEWA Single Species Action Plans.*
- *Siberian Crane Wetland Project: http://www.scwp.info/.*
- *Conservation measures for the Siberian Crane (UNEP/CMS 2008): http://www.cms.int/publications/TechSeries/SibCrane16/siberian_crane_TC16.htm.*
- *CMS Agreements and MoUs: http://www.cms.int/species/index.htm.*
- *Central Asian Flyway Action Plan: http://www.cms.int/species/CAF/CAF_ap_English.pdf.*
- *Atlas of Key Sites for Anatidae in the East Asian Flyway (Miyabayashi & Mundkur 1999): www.jawgp.org/anet/aaa1999/aaaendx.htm.*

6.4 Other instruments

Key message

Conservation of a migratory bird is only possible if a good framework is available between parties involved to inform each other and to agree on actions to be taken.

There are many more Agreements and MoUs on other species, including Agreements on Wadden Sea Seals, European Bats, Gorillas and various small cetacean populations, whilst there are MoUs for marine turtle populations and West African Elephants. Various Action Plans are in place, including for Sahelo-Saharan Antelopes, West African Manatee and small cetaceans, all under the CMS.

In conclusion, there is a great variety of instruments in place to promote the conservation and sustainable management of migratory species. Which instrument is chosen depends on a number of considerations, such as the urgency, geographical range, potential political problems if a binding instrument may be developed, and practical problems to be solved. However, from all ongoing activities the signal is clear in relation to migratory birds: *Conservation of a migratory bird is only possible if all aspects of the annual cycle are included and if a good framework is available between parties involved to inform each other and to agree on actions to be taken*. These actions may influence the status and occurrence of birds elsewhere along the migration route.

Further reading:
- *CMS instruments: http://www.cms.int/species/index.htm.*

7. Understanding the key factors influencing the population dynamics of migratory waterbirds

This section discusses the importance of population dynamics, in particular the roles of density dependence and carrying capacity. The information provided here is largely based on overview publications by Newton (2003, 2004 and 2008).

7.1 Density dependence

Key message

Density-dependent factors influence population density through changes in mortality and reproduction, immigration and emigration.

Density dependence refers to a population-regulating, or population-limiting, factor that allows numbers in a population to increase when they are low, and causes numbers to decrease when they are high. Such factors result in density-related changes in reproduction or mortality, immigration or emigration. Density dependent factors are related very closely to carrying capacity (see section 7.5), which is the maximum number of animals that a site can support. When the density of birds at a site has reached the site's carrying capacity, density-dependent factors will cause the population to stabilise. Typical density dependent factors include:

- Competition for food and other resources
- Competition for breeding or nest sites
- Parasitism and infectious diseases
- Predation.

All of these factors can affect a greater number of individuals as the population rises. They influence the population density by changing the numbers in the population, typically by:

- ***Changes in mortality:*** If competition for food is too great and there are no alternative sites, then some birds may die through a lack of food, either directly by starvation, or indirectly by weak birds succumbing to disease or parasite loads.

- ***Changes in reproduction****:* If density at breeding sites is too high, competition for food may also be high, resulting in low reproduction success. This may be through lower clutch sizes or higher chick mortality. Conversely low density at breeding areas may promote higher reproductive success.

- ***Immigration:*** This refers to arrival of new individuals from elsewhere and their recruitment into a population. It may occur when birds leave a population of high density to move to a different population with a lower density.

- ***Emigration:*** This is dispersal or migration away from an area or population. If density is too high, some birds may opt to leave a population altogether and seek alternative areas.

Further information on population dynamics and its relation to species conservation management are given in Module 2 section 2, where more detail is provided on some of these issues, including the main population parameters. Also refer to the presentations and the Exercises.

Further reading:
- *The Migration Ecology of Birds (Newton 2008).*
- *Density dependence: http://www.bgu.ac.il/desert_agriculture/Popecology/PEtexts/PE-F.htm.*
- *Limiting factors: http://www.gov.mb.ca/conservation/sustain/limfac.pdf.*

7.2 Density independence

> ***Key message***
> *Density-independent factors such as catastrophes can result in population fluctuations.*

Density independent factors are those that affect proportions of individuals, regardless of population size. Examples include severe weather or other natural disasters or catastrophes, which may be one-off or irregular events. Such factors tend to cause fluctuations in populations, rather than regulate them within their normal restricted limits. A population that crashes one year due to severe weather may take a few years to recover, when density dependent factors may once again come into play.

Further reading:
- *The Migration Ecology of Birds (Newton 2008).*
- *Limiting factors: http://www.gov.mb.ca/conservation/sustain/limfac.pdf.*

7.3 Annual life cycle of birds

> ***Key messages***
> *Migratory behaviour is a key feature of a migratory bird's annual cycle; it is influenced by proximate and ultimate factors. Factors influencing a migratory bird population can operate at different stages of the annual cycle and in different geographical areas.*

Effective conservation of species and populations of species should in the first instance focus on some key elements in their life cycle. Understanding the factors influencing the population dynamics of a species such as the total size of a population and its fluctuations over time is such a key element. Understanding such factors also means that one is able to know where conservation measures might be most effective and where they do not have much or any effect. In relation to this it is important to differentiate between factors influencing the survival of an individual bird (e.g. disease) compared to factors working on a population level (overall food supplies) and then influencing the survival of an individual. Clearly the annual life cycle of birds varies considerably depending on their migratory status and patterns. The more complex the migratory behaviour during the annual life cycle, the more factors there are that will influence dynamics of the overall population.

The influences on the annual life cycle and migration of birds can be divided into proximate factors and ultimate factors. ***Proximate factors*** are external stimuli (such as daylength) used as cues to trigger preparation for breeding, migration or other events. ***Ultimate factors*** are those that determine the value of a behaviour in an evolutionary sense, i.e. factors that lead birds to migrate and adapt different migratory strategies, such as moulting and when to breed. Ultimate factors include environmental aspects, such as seasonal fluctuations of food supply, which can influence timing of annual cycle events by effecting survival and reproductive success (Newton 2008).

Understanding the key factors influencing population dynamics requires a different approach between resident and migratory species. In resident birds factors influencing population dynamics and population size are present in the breeding area only, though different factors may operate during different periods of the year. In migratory birds, factors influencing the population also operate in the non-breeding areas and during migration at staging and stop-over sites. This makes it difficult to interpret fluctuations in a population of a migratory species.

In migratory birds that breed in temperate zones, there are two general scenarios at the population level: winter-limited and summer-limited, as illustrated in Figure 7.1.

a. Winter-limited scenario
In winter-limited birds, numbers at the end of the non-breeding season and returning are lower than the carrying capacity of the breeding habitat.

b. Summer-limited scenario
In summer-limited birds, numbers at the end of the non-breeding season are too high for the available breeding habitat and part of the population does not breed and is non-territorial.

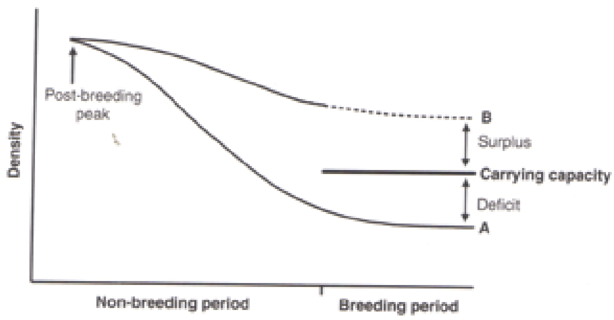


Figure 7.1. Model showing seasonal changes in bird numbers in relation to the carrying capacity of the breeding area (shown as a thick line). In scenario A, which is 'winter-limited', too few birds are left at the end of the non-breeding season to occupy all available nesting habitat. Breeding numbers are therefore limited by conditions in the non-breeding areas. In scenario B, which is 'summer-limited', more birds are left at the end of the non-breeding season than available nesting habitat can support, resulting in a surplus of non-breeding birds. Breeding numbers are limited by conditions in the breeding season (source: Newton 2008).

Similar scenarios may also be formulated for migratory birds in Africa, with rains-limited and dry season-limited birds, e.g. for birds breeding during the seasonal rains.

Further reading:
- *The Migration Ecology of Birds (Newton 2008).*

7.4 Factors impacting migratory populations

Key messages
Various factors/threats impact migratory birds including habitat and food availability, parasites and disease, predation, hunting, poisoning and trade. Conditions in non-breeding areas, such as rainfall in Africa, can directly influence the overall population.

All birds are subject to a number of factors that may limit their populations, such as food availability, disease and hunting. However these issues are all particularly relevant for migratory birds because their population sizes may be influenced by conditions in different parts of the world. Breeding conditions may be excellent, for instance, and result in a good number of young birds recruited into the population, but if conditions are bad along the flyway or at non-breeding destination areas, then this may result in high mortality. In the case of a declining population, it is often a challenge for conservationists to find out first *where* the main factor limiting the population is, before they are able to determine *what* it is. It is also important to differentiate long-term population trends from short-term trends. Some of the main impacts on migratory populations are provided below.

7.4.1 Habitat and food availability

Changes in habitat availability, such as habitat loss or creation, cause changes in bird numbers. New forests attract passerine birds, whilst the loss of wet meadows impacts the populations of waders such as Common Redshank *Tringa totanus*, Northern Lapwing *Vanellus vanellus* and Black-tailed Godwit *Limosa limosa*. For resident populations the effect may be simple: if half of the favoured area disappears, then half of the population also disappears; this assumes an even distribution and no other density dependent factors. In the case of migrant birds the situation at staging and non-breeding areas may also limit populations, unless food supplies etc. are still sufficient to support the population.

Density dependent factors come into play when resources are impacted, especially food availability. The decline of Red Knot *Calidris canutus* populations in various flyways is partly attributable to over-harvesting of their food resources (bivalves in Western Europe, horseshoe crab eggs in North America). In this case, availability of productive stop-over sites seems to clearly limit the size of the population, rather than the situation in the breeding or non-breeding destination areas.

7.4.2 Parasites and disease

Parasites and disease are natural phenomena, but they are particularly relevant for migratory birds for three main reasons:

a. Firstly, migratory birds are more likely to pick up parasites and disease organisms than resident birds because they visit many different sites in different parts of the world, so naturally come into contact with a wider range of such organisms than resident birds. Accordingly, migratory birds have developed life history strategies to reduce the potential for infection (Piersma 2003).
b. Secondly, migratory birds tend to form large, often mixed, flocks at key stop-over and other sites. Such dense concentrations of birds favour transmission of parasites and disease.
c. Thirdly, the migratory performance of birds can be negatively affected by parasites and disease. Carrying out a successful migration requires a bird to be in good physical condition, and the debilitating effects of parasites or disease may prevent a migratory bird from completing its journey.

In addition, migratory birds may contribute in transmitting parasites or disease between different regions. Migratory birds have been implicated in the spread of Highly Pathogenic Avian Influenza (HPAI) H5N1, Lyme disease and West Nile virus, amongst other vectors, though their potential role in the dispersal of diseases is not well understood (see section 8.2.5 concerning avian influenza). Diseases are continually evolving, and the number of diseases and magnitude of losses are such that disease emergence and resurgence are posing an unprecedented challenge for the conservation of wildlife, including some waterbird populations (Friend 2006).

Botulism is one disease that may cause the mass mortality of migratory waterbirds, as it is a water-borne disease that proliferates in anaerobic conditions such as those found in stagnant waters or mud in warm weather. On a world-wide basis, avian botulism is the most significant disease of waterbirds (Rocke 2006). It may particularly strike birds in drought conditions, when they are forced to concentrate at dwindling wetlands. In the AEWA region, botulism is thus a particular threat to both resident and migratory waterbirds in Africa.

7.4.3 Predation

Migratory birds are particularly vulnerable to predation at stop-over sites, as predators, particularly falcons, also concentrate themselves at such sites, at times in ratios that are high enough to exert an abnormally high level of predator pressure. The Peregrine *Falco peregrinus* is a particularly efficient hunter. Further, migratory birds arriving at a key stopover site must spend as much time as possible feeding, so that they can regain their strength in preparation for the next leg of their journey. By throwing themselves fully into this task they are thus not so vigilant; carelessness may cost them their lives. Birds on large open estuaries or tidal flats are at less risk than birds at smaller sites. The presence of predators at some sites may even cause birds to change their migratory pattern, either seeking alternative sites or causing them to move on more quickly than they normally might. Falcons in particular can also take birds while they are on migration; migrating birds that fly by night are generally at a lower risk of predation.

Predators are also a threat at breeding areas, both for resident and migratory birds. However, birds breeding in colonies or in close proximity to each other are particularly vulnerable, as predators may flourish to such an extent that they seriously affect their breeding success. The presence of alien predators on bird-breeding islands in particular can be disastrous. Indeed, rats and cats have been directly implicated in the extinction of breeding colonies and in some cases even species extinction. As many migratory waterbirds do breed in colonies they are among those birds at risk from predation. Removing predators has been a preoccupation for many conservation managers at important bird-breeding islands. Rats, mice and feral cats have impacted breeding migratory waterbirds, for instance, at some of South Africa's offshore islands, including Dyer Island and Dassen Island.

7.4.4 Hunting

Hunting directly results in bird mortalities, reducing the overall population. Low hunting levels usually have little impact on the overall population size, but care needs to be taken in determining 'low levels' for migratory birds, as hunting across the whole flyway is cumulative. If hunting levels are high enough to cause a reduction in population numbers, then density dependant factors such as a higher survival rate or better reproduction rate may come into play and improve the situation (i.e. numbers may pick up again through lower competition etc). However, if density dependent factors (such as good breeding success and survival) do not lead to recovery, perhaps due to additional impacts, then populations will continue to decline, and hunting should be discontinued. In the case of population growth, density dependence creates what is called the 'buffer effect'. This means that the best habitats are first occupied until they reach their capacity, when birds then move to areas of less quality. For recovering populations, hunting should clearly be restricted, especially in the best habitats.

Fluctuations in populations of geese have been greatly influenced by **hunting**, particularly within Western Europe. With stricter regulations on hunting the populations have grown substantially since the 1960s. However that growth then slowed down due to limitations and density dependant factors in the breeding areas with a result that the number of juveniles subsequently reduced, as illustrated in Figure 7.2 for populations of Greylag Goose *Anser anser* and Barnacle Goose *Branta leucopsis*.

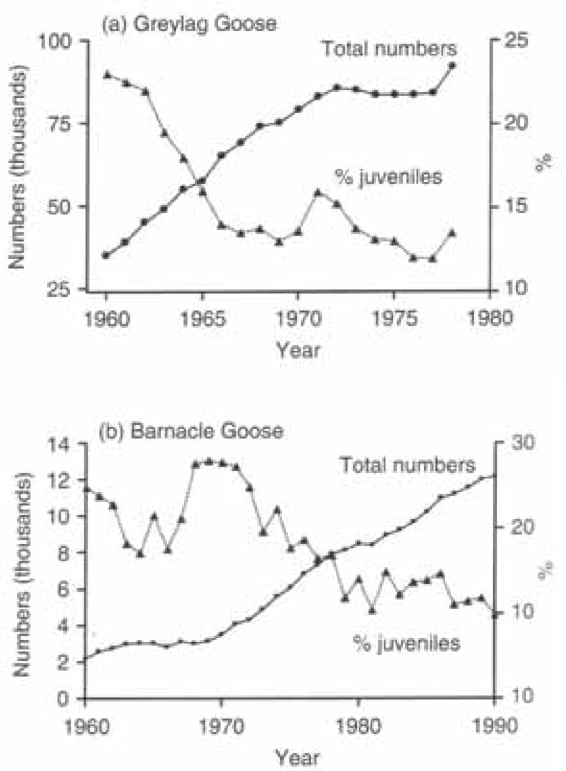


Figure 7.2. Relation between population growth and the reduction of reproductive success in two goose species. Showing density dependent factors influencing population dynamics and size. As the populations increase, the proportion of juveniles decrease, due to increased competition on the breeding grounds (from Newton 2004, adapted from Owen *et al.* 1986).

Hunting pressure is most likely a controlling factor of Greater White-fronted Goose *Anser albifrons* populations of Russia's Taimyr region: the breeding population that migrates to Western Europe is stable or even increasing, whereas the more easterly breeding population that migrates to South-east Asia is in decline. This is considered to be a result of a reduced and better controlled hunting policy in Western Europe compared to a high and probably still increasing hunting pressure in the non-breeding areas of Asia (Syroechkovskiy 2006**;** Dr. Rogacheva, pers. comm. to GB).

7.4.5 Lead shot

Lead shot is widely used by hunters, but lead is a poisonous substance and its presence in wetlands poses a threat to waterbirds, as well as to the health of the wetlands themselves and other wildlife and people that use these wetlands (Pain 1992, Beintema 2001). Lead shotgun shells used for hunting ducks and geese each contain about 200–300 lead pellets, weighing around 30 grams in all (Figure 7.3). A hunter fires an average of three to six shells for every bird that is hit, but only a few pellets actually hit the bird; the rest fall to the ground or into the water, thus thousands of tonnes of lead are deposited in wetlands each year (UNEP/AEWA 2004). Waterbirds regularly ingest grit to facilitate the grinding of food in their gizzards. Shot pellets look just like grit, so birds sometimes inadvertently pick them up from the bottom and

Figure 7.3. Gun cartridge showing the small lead pellets that are inside it (source: UNEP/AEWA).

ingest them, whence the grinding action of the gizzard, combined with the acidic stomach juices, causes the retained pellets to dissolve easily. The dissolved lead then enters the bloodstream and soon starts to poison the bird. Lead impedes the production of haemoglobin, the blood protein responsible for oxygen transportation, causing severe anaemia. It can also affect the nervous and circulatory systems, liver and kidneys.

Birds that ingest even a few lead pellets can die of acute lead poisoning within a few days (depending on the size of the bird). Some birds that ingest small numbers of pellets may survive but others will gradually start to show signs of chronic lead poisoning, such as drooping wings, green and watery faeces, weight loss and atypical behaviour which in turn will enhance susceptibility to predation and other causes of mortality. Even low levels of lead impede energy storage, which is particularly problematic in migratory birds.

7.4.6 Poisoning

Poisoning has the potential to seriously impact migratory bird populations in certain instances, especially when poisons become concentrated in dwindling water bodies. Botulism, mentioned under section 7.4.2, is in fact a type of poisoning caused by toxic bacteria. Some birds have suffered from poisoning due to the widespread use of chemicals in agricultural pest control. The pesticide DDT has caused particular problems, and it is now banned in most of the world, though it is still used in some African countries. Organochloride poisons such as DDT have had particular impacts on birds of prey, which are top of the food chain, and contributed to widespread declines in many parts of the world, especially due to eggshell-thinning. As well as birds of prey, fish-eating waterbirds are also at risk, such as cormorants and darters. Populations of vultures and other scavenging birds have been severely impacted in India due to the widespread use of diclofenac, which has been used widely as a drug in cattle (Green *et al.* 2004).

One example of a waterbird whose population has been impacted by poisoning is the Blue Crane *Grus paradisea* in South Africa (Figure 7.4). This crane favours open grasslands and dwarf shrublands but is also frequently found in agricultural fields; in the Western Cape it is even restricted to cereal crop fields and dryland pastures. The crane's habit of feeding in agricultural land has brought it into conflict with farmers, and the crane and other birds have suffered from both targeted and unintentional poisoning.

Figure 7.4. Blue Crane *Grus paradisea* (photo: Mark Anderson).

Figure 7.5. Snails baited with the poison Furadan to catch storks (photo: Martin Odino).

Figure 7.6. Live decoy African Openbills *Anastomus lamelligerus* being carried by the wings at Bunyala rice scheme in Western Kenya; the decoys are used to attract other storks to the fields where poison is set (photo: Martin Odino).

The case of Furadan: impacting wild bird populations in Eastern Africa

One poison that has had significant impacts on mammals and birds in Eastern Africa is Furadan (or carbofuran), an agricultural pesticide which is powerful enough to kill birds and even large mammals. The misuse of Furadan in Kenya was first documented by ornithologists in the mid-1990s when the chemical was being used to kill large numbers of ducks and other waterfowl near Ahero (Western Kenya) and Mwea (Central Kenya) rice schemes. Poisoned waterfowl were then sold for human consumption (Odino & Ogada 2008). In Kenya, its use in killing lions has also recently been documented, and publicity and campaigning led to its withdrawal from sale in 2009. However, the poison was still being used to catch birds in the Bunyala rice scheme in Western Kenya. Here, a range of birds are targeted for capture and sale in local markets, including African Openbills (or African Open-billed Storks) *Anastomus lamelligerus* and other waterbirds. Decoy Openbills are used to attract wild storks into the fields, which are baited with snails laced in deadly Furadan granules (Figures 7.5 and 7.6).

7.4.7 Trade

Some migratory bird populations have been impacted by trade. Historically, birds such as egrets suffered severely due to collection of their feather plumes for the fashion industry. Some wetland birds in Africa are still impacted by trade, especially cranes and the Shoebill *Balaeniceps rex*. Populations of Black Crowned Cranes *Balearica pavonina* have crashed completely in some areas largely as a direct result of trade, especially in parts of Sahelian Africa, such as in northern Nigeria and Mali. Cranes are caught for international trade, traditional medicine and local trade, with birds kept as pets on account of their beauty (Figure 7.7).

Figure 7.7. A captive Black Crowned Crane *Balearica pavonina* in a suburb of Bissau, Guinea-Bissau (photo: Tim Dodman).

7.4.8 Conditions in non-breeding and staging areas

Many of the threats listed above have particular significance for migratory birds in non-breeding and staging areas.

With arctic breeding geese and some waders, conditions in spring just before migration to breeding areas have a strong influence on populations. Birds with high weights on spring departure are more likely to return after breeding with young birds. It assumes good feeding conditions in the non-breeding and stop-over places, which for many waders breeding in the north will reflect conditions in Africa. Food availability at stop-over sites determines the intake rate and how long an individual has to stay to reach its preferred weight for migration.

Rainfall in Western Africa
Rainfall plays an important role for many migratory bird populations spending the non-breeding season in Africa, for passerine birds as well as for larger waterbirds, as illustrated in Figure 7.8. Low rainfall in the non-breeding areas can lead to increased mortality and therefore subsequent low density on the breeding grounds in the following breeding season; this will result in a high recruitment. If conditions in the non-breeding grounds improve when the birds return it will result in a larger breeding population the following year. Thus annual fluctuations in such species can to a large extent be explained by conditions in the non-breeding area and not the breeding area. High rainfall in Western Africa results in higher survival rates during the northern winter and consequently high numbers of breeding pairs the following year.

The survival of Purple Herons *Ardea purpurea* is also linked to the area of floating grasses (*bourgou*) in the Inner Niger Delta of Mali (Wymenga *et al.* 2002). More information is being generated on the Purple Heron through the Follow the Bird project, in which the movements of Purple Herons are being tracked between The Netherlands and West Africa using satellite telemetry (Figure 7.9).

Figure 7.9. A Purple Heron *Ardea purpurea* fitted with a transmitter (photo: Jan van der Winden).

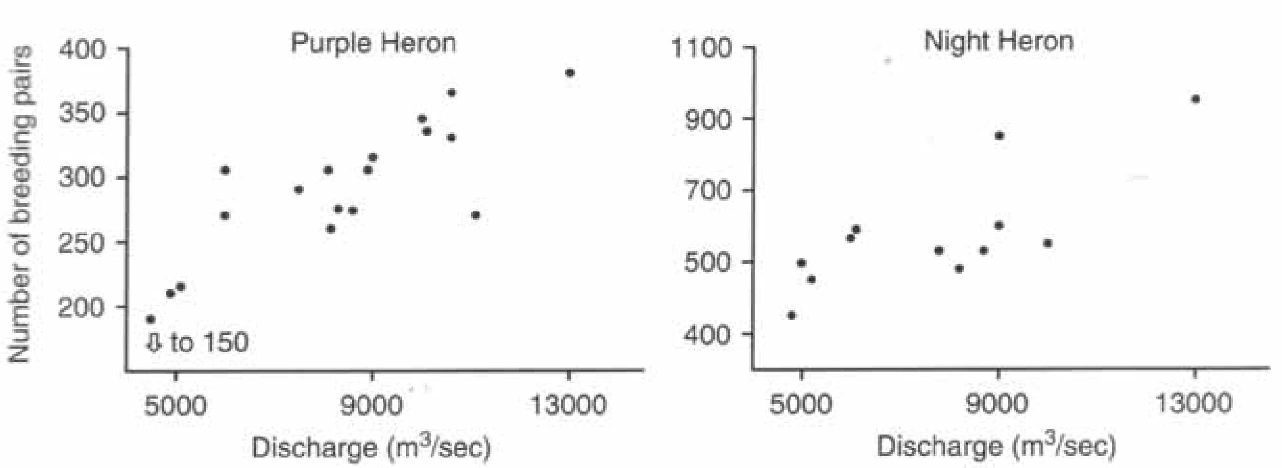


Figure 7.8. Relation between wetland conditions in Sahelian West Africa, represented by water discharge (maximum monthly discharges through the Senegal and Niger rivers) and the number of breeding pairs of Purple Heron *Ardea purpurea* and Black-crowned Night Heron *Nycticorax nycticorax* in the year thereafter in Western Europe (source: Newton 2008 based on various studies).

Newton (2003) formulates this relationship as a causal chain:

Low rainfall → low winter food supplies → lower winter survival → lower breeding population

This chain even holds true for some species that do not directly depend on the presence of water, such as the White Stork *Ciconia ciconia*. Figure 7.10 shows the relationship between the breeding success of White Storks in northwest Germany and rainfall during the previous year in the Sahel.

Winter conditions in Eurasia
Comparable population dynamics are also visible with resident species in Europe. Their populations decline after severe winters, whereas species returning from Africa have not suffered such conditions and may remain more stable, assuming that conditions related to low rainfall in Africa have not led to high bird mortality there. Thus, after harsh winters in Europe, birds returning from Africa can take a larger part of the available habitat in their northern breeding areas as a result of reduced competition from the resident species. In passerines, a good example is the competition for nesting holes between the non-migratory Great Tit *Parus major* and the migratory Pied Flycatcher *Ficedula hypoleuca.*

Habitat destruction
Besides the importance of rainfall in Africa, habitat destruction in Africa also contributes to population fluctuations, though these most likely occur in a more definitive or lasting way. Whereas an increase in annual rainfall in Africa has a direct positive effect on the population of many species, it is more difficult to restore habitats that have been lost or degraded.

Impacts of hunting in non-breeding areas
Reduction in numbers of a population returning to their breeding areas can affect breeding density, thus influencing density dependence factors, as there is a lower breeding population. Spring hunting, for instance, directly reduces the number of breeding birds and thus to some extent the number of offspring, and is strictly illegal in EU Member States and AEWA Contracting Parties. Although reduced breeding density can result in larger broods, higher fledging rates and breeding success due to density dependence influences, populations may not necessarily recover, as other factors also influence the final breeding success and the overall population size.

Pre-breeding conditions
There is also evidence that feeding conditions just before and/or during pre-breeding (or spring) migration influence the breeding conditions and thus breeding success, as has

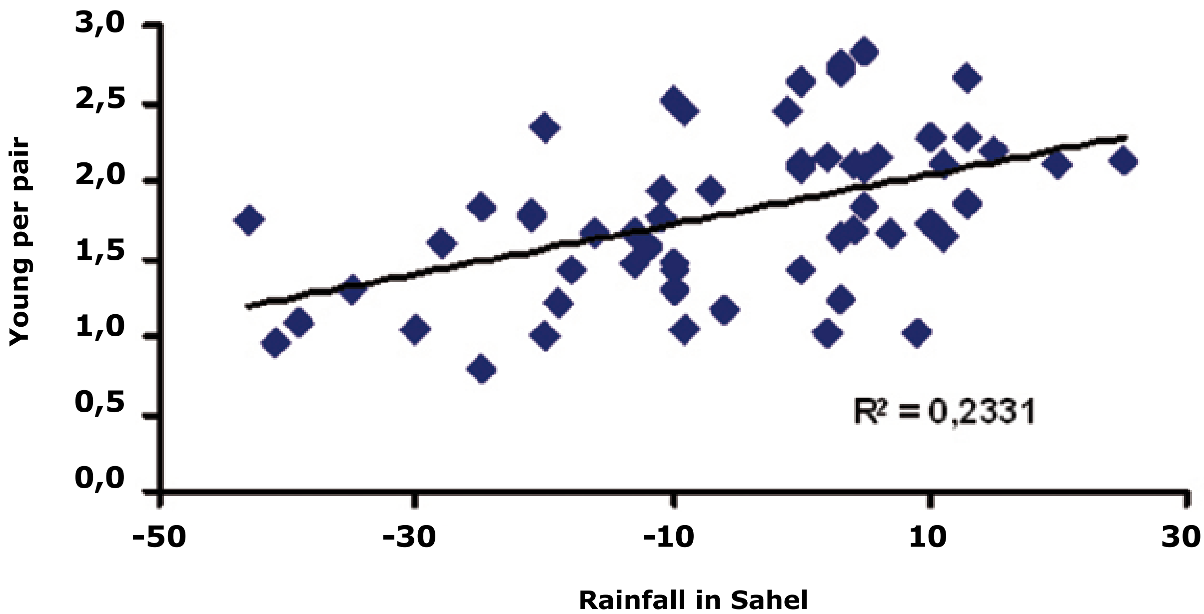


Figure 7.10. Relation between rainfall in the Sahel and breeding success of the White Stork *Ciconia ciconia* in northwest Germany. Each symbol represents the average number of young per breeding pair for each year between 1928 and 1984, and the corresponding rainfall index which is the % deviation from the long-term average. The R^2 (explained variance) value indicates that the relationship is highly significant (source: Bairlein & Henneberg 2000).

been shown by studies on Arctic geese such as Brent Goose *Branta bernicla*. Food resources at stopover sites during this goose's spring migration may vary from year to year, variations which affect survival and breeding. Nolet & Drent (1998) showed that available food at stopover sites for Bewick Swans *Cygnus columbianus bewickii* can also be depleted by the birds that arrive first. One such site is at the White Sea, were the swans feed on tubers of Fennel Pondweed *Potamogeton pectinatus.* Later arriving swans have less food, and resulting competition for food may result in a situation whereby fewer birds are prepared to breed and produce offspring. In this way a single stopover site can influence population size if there are no alternatives available, or if such possible alternatives have been taken away. This importance is illustrated in Figure 7.11.

These examples illustrate that from a conservation point of view great care is needed to maintain sufficient good quality feeding sites during pre-breeding or spring migration. For many species these stopover sites are the same sites as used during autumn migration, though this is not the case for birds performing loop migrations.

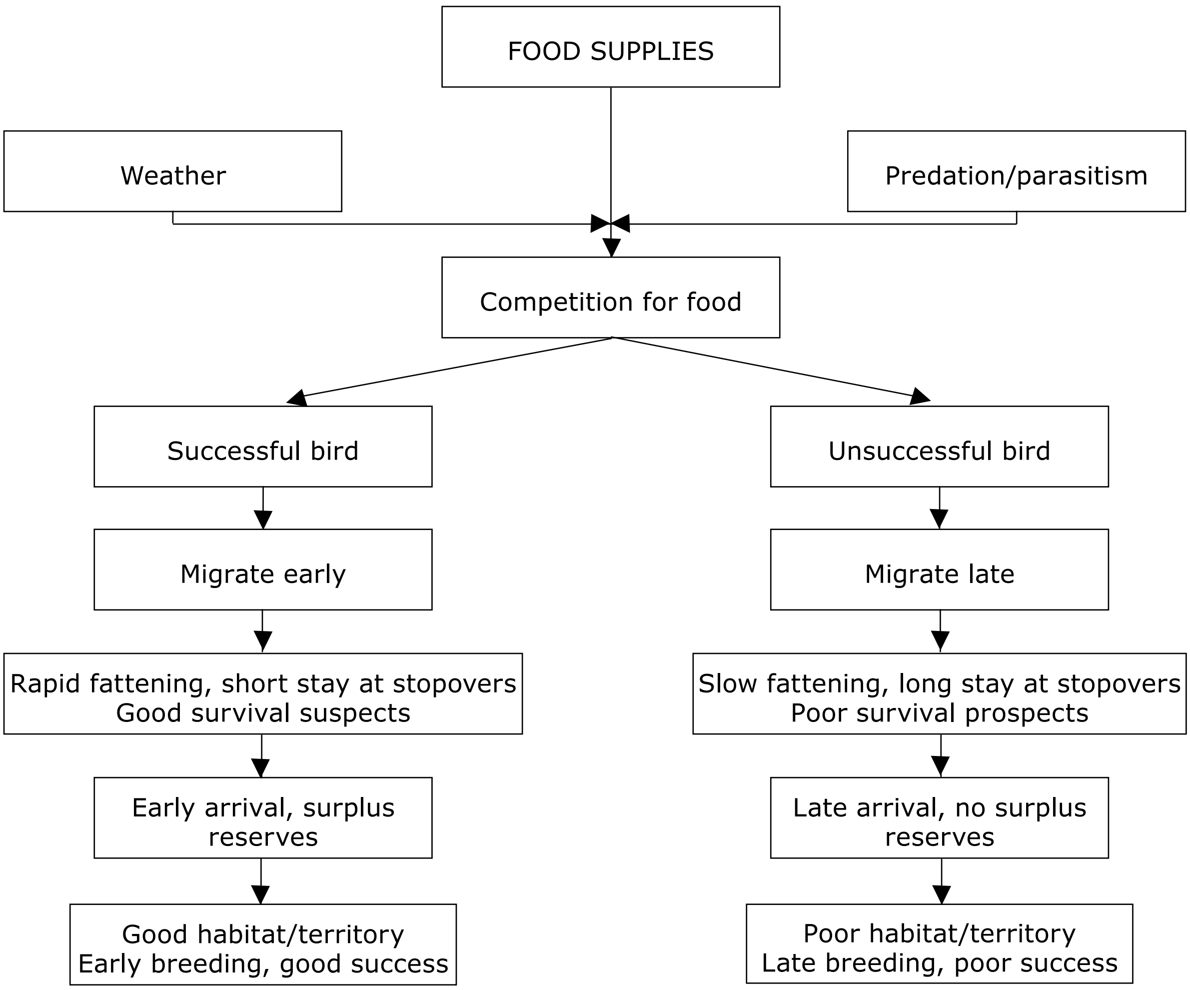


Figure 7.11. Summary of the various scenarios for a migratory bird on spring migration and the effect it may have on the total population (source: Newton 2008).

7.5 Carrying capacity

Key messages

Carrying capacity reflects the ability of a site to support populations of animals. Different sites have different carrying capacities, largely depending on their productivity. However, the carrying capacity also depends on the availability of food.

The term carrying capacity is used to indicate the maximum number of animals per unit at a site that can be present and forage successfully. It is an essential aspect of site management for many species of wildlife, and directly relates to the ability of a particular site to support populations of animals. Carrying capacity of a particular site is influenced by many ecological and behavioural factors. Key factors to consider for waterbirds in relation to sites outside the breeding range are:

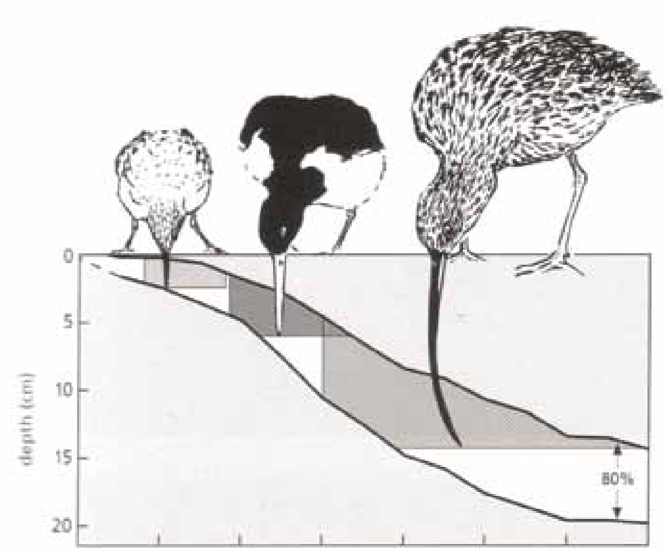


Figure 7.12. This figure shows the importance of prey availability for three different species of wader (Red Knot *Calidris canutus*, Eurasian Oystercatcher *Haematopus ostralegus* and Eurasian Curlew *Numenius arquata*) on an intertidal flat. Their prey choice does not overlap when they eat Sand Gapers *Mya arenaria*; larger Sand Gapers burrow deeper and are inaccessible as well as ingestible (too large to eat) to smaller waders, whilst prey that is too small is not profitable for the larger birds. An intertidal area can have a large biomass based on available invertebrates but if these are deep burrowing bivalves, a Red Knot (on left) cannot reach them. Conversely, if predator pressure is high (e.g. due to a decline in area of the flats), too few shellfish may mature, resulting in a low number of older larger prey items, when the site may no longer be able to support larger birds such as curlews. Thus a 'rich' or productive area may not be rich in food for all species, even if they have certain similarities, such as shorebirds (source: van de Kam *et al.* 2004).

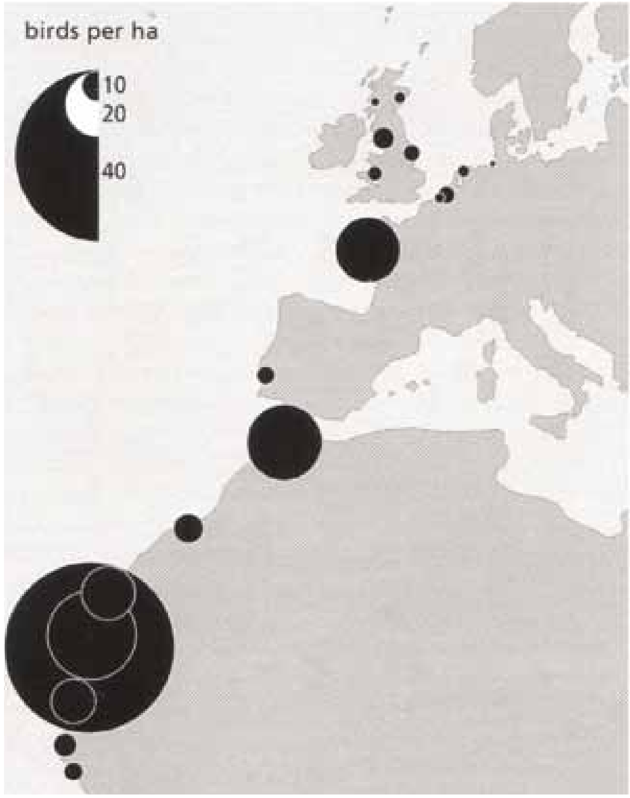


Figure 7.13. Shorebird densities per ha along the East Atlantic flyway (source: van de Kam *et al.* 2004).

- Density of prey items
- Distribution of prey items
- Accessibility of prey
- Production circumstances for prey items
- Amount of food needed (can vary during the year)
- Size of the bird
- Behaviour of the bird (social interactions within the species)
- Social interactions between species
- Competition between species.

This large number of variables makes it difficult to predict what happens if a site is no longer available and if birds have to go elsewhere. Are alternative sites and food available elsewhere or are all places already occupied? Even if some sites are available, food availability is not the same at all sites, as illustrated for three different waders in Figure 7.12.

Carrying capacity of a site, and thus densities of birds at that site, differ along the flyway, as shown in Figure 7.13. Highest densities of birds in this example are present at the Banc d'Arguin in Mauritania, an extensive and productive site, capable of supporting high densities of waders.

Figure 7.14. A flock of Sanderling *Calidris alba* on a beach in the Bijagós Archipelago, Guinea-Bissau. Densities of Sanderling vary considerably along the flyway (photo: © Hellio – Van Ingen).

Availability of places is also influenced by annual fluctuations in the populations themselves. In years when few or no young birds are produced, as can be the case with high Arctic breeding species, pressure on sites may be much less and alternative sites more readily available, thus providing a better survival rate of the remaining birds. The reverse is also true: a high reproduction rate and increasing population increases pressure on sites and may lead to a lower survival rate of both young and adult birds.

Further reading:

- *The Migration Ecology of Birds (Newton 2008).*
- *Shorebirds: an illustrated behavioural ecology (van de Kam et al. 2004).*
- *Follow the Bird project: http://followthebird.wetlands.org/Default.aspx.*
- *Long-term declines in Arctic goose populations in eastern Asia (Syroechkovskiy 2006): http://www.jncc.gov.uk/PDF/pub07_waterbirds_part5.2.2.pdf.*

Disease:

- *Evolving changes in diseases of waterbirds (Friend 2006): http://www.jncc.gov.uk/PDF/pub07_waterbirds_part4.2.1.pdf.*
- *The global importance of avian botulism (Rocke 2006): http://www.jncc.gov.uk/PDF/pub07_waterbirds_part4.2.3.pdf.*
- *The Wildlife Disease Information Node: http://wildlifedisease.nbii.gov/.*
- *Vulture Rescue: http://www.vulturerescue.org/index.html.*

Non-toxic shot & lead poisoning:

- *Non-toxic shot (AEWA 2004, technical series no.3): http://www.unep-aewa.org/publications/technical_series/ts3_non-toxic_shot_english.pdf.*
- *Lead Poisoning in Waterbirds: International update report (Beintema 2001): http://global.wetlands.org/LinkClick.aspx?fileticket=HuGL1Qe0%2bBE%3d&tabid=56*
- *Lead poisoning in waterfowl. Proceedings of an IWRB Workshop, Brussels, Belgium, 13–15 June 1991 (Pain 1992).*

Poisoning:

- *Furadan in Kenya (Odino & Ogada 2008): http://stopwildlifepoisoning.wildlifedirect.org/furadan-in-kenya/.*
- *Furadan use at Bunyala, Kenya: http://stopwildlifepoisoning.wildlifedirect.org/.*

8. An overview of key threats and their relations to the ecology of migratory waterbirds

There are two key levels at which serious threats occur to migratory waterbirds: at the habitat level and at the species/individual bird level.

8.1 Habitat threats

Key message

Habitat threats, resulting notably in wetland loss, can have significant impacts on migratory waterbirds, which may depend on a range of different habitats along the flyway. Mitigating measures include protection of key sites and adoption of a 'no net loss of wetlands policy.'

Habitat loss may take place along the whole flyway, and can affect survival chances of individual birds, especially when it occurs in more than one part of the flyway. There are many reasons for habitat loss, which varies in type and severity across the AEWA region. With sites having different functions, such as breeding and moulting (see section 4), the levels of impact on birds and populations can be quite different, depending on where (and at what migratory stage) the habitat loss occurs. The loss of breeding habitat directly affects the total population and annual recruitment, the level depending on the extent of habitat loss and the relative importance (i.e. quality) of the breeding habitat lost. The loss of a small amount of habitat rarely has a significant effect on the total population, but there may be cumulative impacts if many small areas are lost at the same time. Losses may also be cumulative over time, and the continuous removal of small areas of habitat will eventually result in a substantial amount of habitat loss. This can be a serious problem along the whole flyway and for different types of habitat. It is important to carry out proper Environmental Impact Assessments (EIAs) in all cases which involve habitat change or loss (see Module 2 section 7.4).

A ***'no net loss of wetlands policy'*** should be adopted for rare or declining birds. This means in practice that if overriding social and economic interests requires a wetland to be changed, then compensation must be provided elsewhere.

However, this policy does not apply to species with a restricted breeding area, or to those breeding in just a few large colonies. Lake Natron in Tanzania, for instance, a site that is regularly threatened by developments, is irreplaceable, being the only regular breeding site for Lesser Flamingo *Phoeniconaias minor* in Eastern Africa. Loss of the breeding habitat at this site could directly lead to the extinction of the Lesser Flamingo in Eastern Africa.

There are various reasons for habitat loss, both from natural and anthropogenic threats. Natural threats include drought and other climatic changes, though some of these effects are due to man's activities. Some natural fires cause habitat loss, e.g. in reed beds or floodplains. Invasive species also threaten the functioning of sites, though the proliferation of such species is usually due to man-made impacts. Anthropogenic threats include:

- wetland drainage for agriculture or forestry
- destruction of wetlands for alternative land use
- pollution
- fire (Figure 8.1)
- wetland or river basin developments impacting hydrology
- water abstraction (from wetland or from aquifer)
- coastal developments
- over-harvesting of wetland plants
- introduction of invasive species.

Many of these threats can cause significant change to or loss of wetlands, which will naturally affect the integrity of sites for migratory waterbirds.

[Refer to the Exercises *'The Migration Challenge'* and *'Flyway Threats'* when covering habitat threats during a workshop].

Further reading:
- *Threatened wetlands: http://www.wetlands.org/Aboutwetlandareas/Threatened wetlandsites/tabid/1125/Default.aspx.*
- *Specific habitat threats are given in AEWA single species action plans and conservation guidelines (CD4): http://www.unep-aewa.org/publications/technical_series.htm*

Figure 8.1. Fires rage across floodplains of the Sudd, Southern Sudan. Some fires may be natural, others may be set to improve grazing. Fires in floodplains or wetlands are not always destructive and can encourage new growth; however, intense fires can destroy or permanently change wetlands, and may also destroy birds' nests (photo: Niels Gilissen - MIRATIO).

8.2 Species threats

Key messages

- *Hunting and harvesting of migratory birds are carried out widely and can have significant impacts at the population level. Coordinated actions are essential to ensure that bird taking levels are sustainable, and that rare birds are not taken.*
- *Physical structures such as power-lines and wind turbines can be significant sources of mortality if located across migratory or other flight-lines. However, their impact can be reduced by undertaking a full assessment of data on bird movements prior to construction through EIAs as well as through other means.*
- *Oil pollution can result in high levels of bird mortality; prevention is the best option.*
- *Disease: Botulism is one of the most significant diseases of waterbirds, whilst the implication of wild birds in the potential spread of HPAI H5N1 in the 2000s presented a significant management issue for migratory waterbird populations.*
- *Disturbance needs to be minimised especially at breeding and staging areas.*

At the species and individual level there are a number of direct and indirect threats that can reduce populations below sustainable conservation levels. These include:

8.2.1 Taking birds (hunting/harvesting)

Bird taking

Taking birds refers to the removal of birds from a population, either by hunting or trapping them or by other means. Hunting and trapping are the methods most used, and mass hunting and/or capturing can have adverse effects on population survival. However, taking of a low percentage of a population may not be harmful, especially if hunting is well regulated and coordinated at the flyway level. Coordination is essential for sustainable hunting of migratory waterbirds, as the level of taking must account for all birds removed along the whole flyway. In many areas of the flyway it is impossible to obtain accurate data of taking, especially of subsistence hunting and trapping in remote areas. The application of the precautionary principle should therefore take precedent when such thresholds are developed. It is much wiser, however, to avoid any taking of populations that are in decline. Taking of rare species and populations is prohibited under AEWA.

Subsistence use and marketing

Besides regular hunting there is widespread activity to trap waterbirds with nets and snares. This is largely carried out in countries where firearms are either not available or restricted. In many areas where waterbirds concentrate (including large numbers of non-breeding birds) such as the Inner Niger Delta in Mali and coastal areas of the Caspian Sea, netting waterbirds is a common practice to provide a sometimes essential source of protein and income through marketing of the birds. However, numbers taken are not usually monitored, so the effect of these activities on the whole flyway populations is difficult to assess and understand. In addition, improving infrastructures and the growth of urban centres in many areas causes additional pressure. This is certainly the case in the Inner Niger Delta. Whilst migratory waterbirds such as Garganey *Anas querquedula* and Ruff *Philomachus pugnax* are traditionally hunted for local consumption and sale within a limited area, they are now also packed in ice and transported much further afield to urban centres, such as Bamako (Figure 8.2). Demand can be high, especially in cases where local people have moved to cities and made some money, and can afford to buy these birds, which they may still value as a traditional food item.

Figure 8.2. Freshly caught and plucked Ruff *Philomachus pugnax* on sale in Mopti, Mali (photo: Leo Zwarts).

Another issue is the trapping of terns in countries along West African beaches, largely carried out by children using a small baited snare system. Hundreds of terns may be caught in a relatively short period. This may have caused declines in West Africa of the Roseate Tern *Sterna dougallii.* Education and awareness is the key conservation action in this respect, as tern trapping is not an important activity for collecting food, and is partly recreational (Meininger 1988).

Non-selective methods of hunting and trapping and subsequent marketing are prohibited under AEWA. [For further details on bird taking in relation to sustainable use, refer to Module 2 section 2.3].

8.2.2 Physical barriers

[For information on the impacts and mitigating measures in relation to physical barriers, go to Module 2 section 7.4].

Power lines
Power lines in open areas are a widespread cause of death to larger waterbirds, especially soaring birds like storks and cranes, as well as other species such as herons. Power lines have long been a problem for larger species, and certain mitigation measures like extra lines without power help against electrocution, although the collision problem still remains. White Storks *Ciconia ciconia* seem to be particularly collision-prone, as illustrated in Figures 8.3. A White Stork fitted with a satellite transmitter in South Africa migrated north to Burundi, where it collided with power lines. The bird was actually 'arrested' and transferred to a local police station, where the suspicious-looking satellite transmitter was removed!

One threatened bird that has suffered from the impact of power lines is the Blue Crane *Grus paradisea* (Figure 7.4). The birds regularly collide with power lines, especially in the Overberg region of South Africa's Western Cape Province; they apparently fail to see the lines especially when obscured by a dark background. Research is underway to identify mitigation measures that may minimise collisions of cranes and other large birds with power lines in South Africa.

Figure 8.3. The corpses of White Storks *Ciconia ciconia* litter the ground under two sets of power lines near Ash Shuaibah, some 100 km from Jeddah in Saudi Arabia at the end of August 2008. The larger photo shows well the huge size of the pylons, whilst the smaller photos show dead storks and a dead Purple Heron *Ardea purpurea* close-up. Altogether 252 White Storks were found in three areas (236, 3 & 9 birds) along the same power line (photos: Mohammed Shobrak).

Wind turbines (Figure 8.4)
The increase of wind turbines, particularly when placed together in wind farms or wind parks, is also becoming a serious threat to migratory birds, and this threat will substantially increase when more wind farms are constructed under pressure of increasing prices for fossil fuels. As more of these developments take place at different sites along the flyway, so they create a cumulative threat to migratory birds. Whilst the development of wind energy is a welcome and necessary contribution to reduce reliance on fossil fuels, it is nevertheless important to ensure that they are not sited close to key migratory stopover sites or other sensitive areas. In all cases, adequate EIAs should always be undertaken prior to any development; (see Module 2 section 7.4, where links to EIA guidance are also provided, including the Ramsar handbook on Impact Assessment).

International measures
The Bern Convention has published useful overviews describing these problems and suggesting mitigation measures (Langston & Pullan 2004; Haas *et al.* 2005). The Bonn Convention has also paid attention to these problems and has adopted resolutions on both power lines and wind farms (CMS/COP Res. 7.12 and 7.13, September 2002). The German NGO NABU also presented a technical document to CMS/COP7 on practices to protect birds from collision with power lines (NABU 2002, CMS/COP7 Inf. 7.21).

8.2.3 Oil pollution

Oil pollution, mainly caused by wrecked oil tankers, has over the years been a cause of death for literally millions of waterbirds and seabirds. There have been very large scale incidents along many coastal areas in the whole

Figure 8.4. A wind farm close to wetlands in Sardinia, Italy (photo: Tim Dodman).

AEWA region, and accidents have also taken place on rivers and larger lakes, as well as small-scale events in harbours, on rivers, and in lakes etc. The large-scale incidents with oil tankers have in particular caused bird casualties numbering several hundred thousand, including large numbers of sea ducks, grebes and other waterbirds. There is little one can do if an accident happens. Views differ considerably on the effect of cleaning oiled birds in bird hospitals (that are present in several European countries). Preventative measures against an oil spill are difficult to take, and in the case of an accident, large-scale assistance is needed, which certainly would be difficult to mobilise in many areas, such as along the entire African coastline. [See Module 2 section 7.4.5 for pollution mitigation measures].

8.2.4 Diseases

Disease has always played a role in natural mortality of waterbirds, but in present days the effects appear to have been more intense as a result of human interventions. For instance the general increase in water temperature has in many countries of Western Europe caused more outbreaks of ***botulism*** (a paralytic disease caused by ingestion of a toxin produced by the bacteria *Clostridium botulinum*) which can kill hundreds of waterbirds at the same time in a restricted area. It can be a threat to humans as well depending on the type of the botulism bacteria. Monitoring water temperatures and collecting and burning dead birds as soon as possible are basic measures that are relatively easy to put in place which can prevent an outbreak from spreading or even stop it.

A wide range of bacteria, viruses and fungi are known to affect the health of birds. One of the most notorious diseases relevant to migratory bird conservation is HPAI H5N1 (see below).

8.2.5 Avian influenza

Avian influenza (AI) is an infectious disease caused by type A influenza viruses which commonly occurs in many waterbird species with little or no effect. The AI viruses are classified as low pathogenic (LPAI) or highly pathogenic (HPAI) depending on their virulence in domestic chickens. The HPAI virus subtype H5N1 of Asian lineage has been of great concern over the last decade as it spread rapidly across Asia, Africa and Europe and because of its unique pathogenicity. Although HPAI H5N1 is a less serious direct threat to waterbirds than other threats in this section, the disease caused significant international alarm in the 2000s. Migratory birds were widely blamed as key vectors of the disease, and some countries began or at least considered programmes of wild bird control and wetland drainage. It is these reactions to and high media interest in HPAI H5N1 that justify specific attention to this issue within this module.

History of the HPAI H5N1 virus of Asian lineage
The Asian lineage HPAI H5N1 virus was first identified in 1996 in a domestic goose in southern China and was detected in humans and domestic poultry in Hong Kong in 1997. It has since spread across Asia, Africa and Europe to at least 60 countries and has resulted in the deaths of some wild birds, the death and culling of several million domestic poultry and death of over 250 people. Its spread since late 2003 has been particularly alarming because of:

a. its high virulence in domestic poultry (particularly domestic chickens, ducks, turkey and pigeons),
b. its ability to infect a variety of hosts, and
c. its potential to spread quickly over large geographic areas, presumably via commercial poultry and the wild bird trade, and possibly migratory waterbird routes.

The emergence of the zoonotic virus (i.e. a virus that can be transmitted between animals and man) has caused considerable concern among medical and veterinary experts, public health officials, wildlife biologists, wildlife conservationists and, after considerable media attention, the general public. The recent HPAI H5N1 outbreak appears as a rare and exceptional epidemiological event in wild birds. The only previously known mass mortality of wild birds due to infection by an AI virus was in Common Terns *Sterna hirundo* in South Africa in 1961.

Virus transmission
AI viruses are transmitted via direct contact with an infected bird or indirectly via close exposure to materials contaminated with infected faeces or possibly respiratory secretions. However, AI viruses have limited ability to survive outside the host where persistence in the environment is highly dependent on moisture, temperature and salinity. AI viruses can, however, persist for years in ice in high latitude lakes and have been shown to persist for over one month in other cool, moist habitats. In fact, the viruses are most often encountered in wetland habitats frequented by waterbird species, including Anatidae (ducks, geese and swans) and

Charadriidae (shorebirds), which are the most common wild avian hosts of AI viruses.

LPAI, HPAI and virulence
In wild birds, a ***Low Pathogenic Avian Influenza (LPAI)*** infection can affect foraging and migratory performance (van Gils *et al*. 2007), but most infected birds show no obvious clinical signs of disease. Common AI strains and their wild host populations have developed an evolutionary equilibrium over time whereby the virus does not cause serious disease or mortality. Periodically, wild birds, particularly ducks and geese, have been identified as the source of low pathogenic virus introductions to poultry. ***Reassortment*** (the mixing of genetic material of two similar viruses infecting the same cell) or recombination between LPAI viruses in a common host can, but does not necessarily, lead to increased ***virulence***; (virulence is the degree of ***pathogenicity***, i.e. the relative ability of a pathogen to cause disease).

In addition, during viral replication while circulating in domestic flocks, AI viruses also undergo frequent mutations which can give rise to new biological characteristics. This can cause development of an LPAI virus to a more virulent or ***Highly Pathogenic Avian Influenza (HPAI)*** virus. Emergent HPAI strains are often more contagious (depending on the density of susceptible hosts) and typically virulent in gallinaceous species (such as chickens), resulting in disease outbreaks with up to 100% mortality in unprotected poultry flocks; these are popularly known as "bird flu" or "fowl plague" outbreaks.

Wild birds and H5N1 HPAI
Wild birds were not known to be implicated in the initial H5N1 HPAI outbreaks as the disease emerged in Asian poultry in 2003/04, although there was limited surveillance of wild birds being undertaken at that time. However, in May 2005, an H5N1 virus mortality event killed over 6,000 waterbirds, mainly Bar-headed Geese *Anser indicus* (Figure 8.5), Great Cormorants *Phalacrocorax carbo*, Pallas's Gulls *Larus ichthyaetus*, Brown-headed Gulls *L. brunnicephalus* and Ruddy Shelducks *Tadorna ferruginea* at the Qinghai Lake National Nature Reserve in northwest China. Estimates indicate that between 5–10% of the world population of Bar-headed Geese were killed during this event. Following the mortality events in China and Mongolia, the virus greatly increased its geographic range into west Asia, Europe and Africa. [Further information is available in Appendix I of the Ramsar COP10 Resolution X.21 on CD 3, and in AEWA Resolution 4.15 on CD 4].

Figure 8.5. Bar-headed Goose *Anser indicus* carcass found during an H5N1 AI mortality event in Mongolia in August 2005 (source: FAO 2007; photo: Martin Gilbert).

Discovery, detection and spread of H5N1 HPAI in wild birds from May 2005 -September 2008
The Qinghai event and further mortality events in China, Siberia, Kazakhstan and Mongolia in July and August 2005 signalled a significant geographic expansion of the disease, but the means of transmission were unclear. The virus continued its westward expansion during the northern autumn of 2005 and by October it was detected in poultry in Turkey, then in Croatia and Romania, the first occurrences in Europe. Its arrival in Turkey and Eastern Europe heralded its swift spread throughout Europe and into the Persian Gulf region by December 2005, and the Middle East and Africa by February/March 2006. In January 2006, human H5N1 AI infections occurred in Turkey, and within a few months were also reported in Iraq, Azerbaijan, Egypt and Djibouti, raising to 10 the number of countries reporting H5N1 virus infections in humans (258 cases, 154 fatal as of 29 November 2006). As in Asia, human cases were associated with handling infected domestic poultry. However, the first fatality in Azerbaijan in March 2006 was linked to plucking a dead infected swan: the first, and only, known case of H5N1 virus transmission from a wild bird to a human.

Over a two-month period during the northern summer of 2007, H5N1 was detected in over 200 dead wild birds from three countries (Czech Republic, France and Germany) with two of them (Czech Republic and Germany) experiencing a concurrent outbreak in domestic birds. These mortalities in wild birds involved primarily non-migratory species, and took place at a time of year (June-July) when birds may have been flightless due to moult, and were not migrating into or away from Europe. In 2008, infected wild birds were reported in four countries: Mute Swans *Cygnus olor* and a Canada Goose *Branta canadensis* in the United Kingdom in January and February; sick and dead swans in three areas of Japan in April and May; a Common Pochard *Aythya ferina* in Switzerland in March; and one dead House Crow *Corvus splendens* in Hong Kong, PR China in October.

<u>*Global situation of H5N1 HPAI by October 2008*</u>
As of October 2008, the H5N1 HPAI virus had been confirmed in poultry or wild birds in 59 different countries on three continents (Figure 8.6). In Europe, the virus has been detected in both wild birds and poultry in 12 countries, only in wild birds in 12 countries, and only in poultry in one country. By contrast, outbreaks in 10 African countries have been limited almost entirely to poultry. Only three H5N1 AI cases have been recorded in wild birds in Africa: a sparrowhawk in Côte d'Ivoire (identification not confirmed), a possibly wild duck in Cameroon and unspecified vulture species in Nigeria. Unspecified reports highlight the difficulty in identification of wild birds and the need for veterinarians and ornithologists to work together.

Further information is available in the FAO publication '*Wild birds and avian influenza: an introduction to applied field research and disease sampling techniques'* (FAO 2007), whilst issues relating to surveillance for AI and links to guidelines are given in Module 2 section 2.5.8.

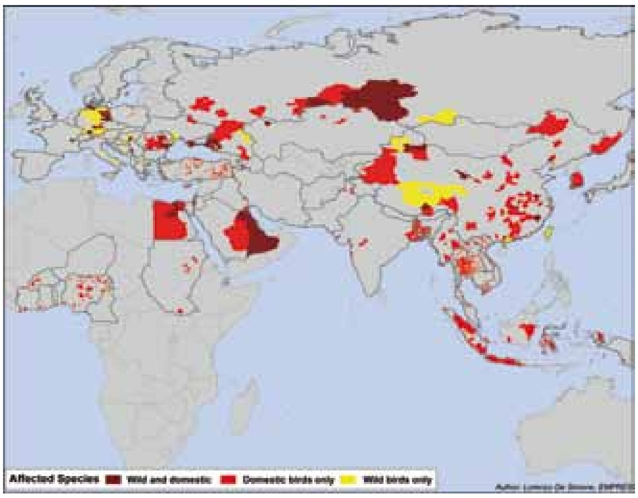


Figure 8.6. Countries in which the H5N1 HPAI virus has been detected in poultry and/or wild birds by October 2008 (source: FAO; map prepared by Lorenzo De Simone, EMPRES, FAO). [Find map updates at http://www.fao.org/avianflu/en/maps.html].

8.2.6 External influences

These refer to activities that impact waterbirds and their habitats indirectly, notably in areas surrounding an important site. Such activities may influence the site itself through ecological relations. For instance large-scale fishing activities near a key site like the Banc d'Arguin in Mauritania can influence the ecosystem and food chain. Many important wetlands in river basins are now subject to artificial flooding regimes due to the construction of major barrages. Large dams in the Zambezi Basin, for instance, have completely altered the natural flooding cycles at wetlands such as Zambia's Kafue Flats and Mozambique's Zambezi Delta. Non-seasonal releases of water can flood the nests of ground-nesting birds, such as Kittlitz's Plover *Charadrius pecuarius* and Red-winged Pratincole *Glareola pratincola*. In Mozambique such flooding has also had serious humanitarian implications.

8.2.7 Disturbance

<u>*Disturbance at breeding areas*</u>
Disturbance can significantly influence the behaviour of waterbirds, and contribute to preventing them feeding or breeding. Some waterbirds will abandon favoured breeding sites if they become disturbed by too much activity nearby. Great White Pelicans *Pelecanus onocrotalus* are very shy of humans at most breeding colonies, and disturbance may cause them to suddenly abandon the whole colony. The large colony in Senegal's Djoudj National Park is on islands, and the birds have learned to tolerate visiting boats (an important form of revenue for the park), but people walking nearby or amongst the colony are not tolerated.

<u>*Disturbance at staging areas*</u>
At key staging areas in the Delta and Wadden Sea regions of The Netherlands, larger waterbirds are more easily disturbed than smaller waterbirds (Figure 8.7, graph A). There is also evidence that waterbirds can tolerate disturbance better over time. Graph B of Figure 8.7 shows how disturbance distances have decreased over time, with birds adapting their behaviour to become less sensitive to disturbance, after previous exposure or an increase in frequency of disturbance.
<u>*Disturbance and conservation*</u>
Although birds may be able to adapt to disturbance to some extent, this is still a relevant conservation problem, and one that

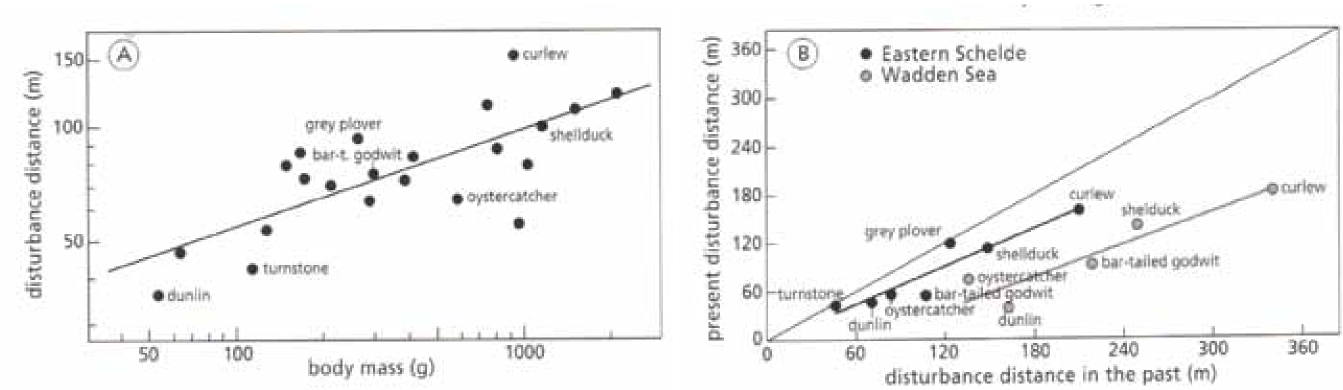


Figure 8.7. Effects of disturbance on waterbirds in the Wadden Sea and their adaptation to disturbance. Graph A: Larger species take flight at greater disturbance distances than smaller species. Graph B: Disturbance distances are shorter in the Eastern Schelde (which is frequently visited by people) than in the Wadden Sea which is less visited). Disturbance distances in both areas have decreased over time, especially in the Wadden Sea, as birds have become more used to more frequent visiting by people (source: van de Kam *et al.* 2004).

needs addressing through site management, particularly at sensitive areas such as colonial breeding sites, roosts and important staging areas. When birds are continuously being forced away from their search for food or from their necessary resting periods (e.g. at high tide roosts), their ability to migrate can be compromised. It is also important to minimise the frequency of disturbance; it is better for instance to disturb birds once with 100 people that ten times with one or two people!

Further reading:
- *The Migration Ecology of Birds (Newton 2008).*
- *Shorebirds: an illustrated behavioural ecology (van de Kam et al. 2004).*

Waterbird taking:
- *Sustainable harvest of waterbirds: a global review (Kanstrup 2006): http://www.jncc.gov.uk/PDF/pub07_waterbirds_part2.2.7.pdf.*

Power-lines and Wind Turbines:
- *Protecting birds from powerlines (Haas et al. 2005): http://book.coe.int/EN/ficheouvrage.php?PAGEID=36&lang=EN&produit_aliasid=1827.*
- *Suggested practices for bird protection on power lines (NABU 2002): http://www.cms.int/bodies/COP/cop7/list_of_docs/pdf/en/caution_electrocution.pdf.*
- *CMS COP7 Resolution on Electrocution: http://www.cms.int/bodies/COP/cop7/list_of_docs/pdf/en/CP7RES7_12_Electrocution.pdf.*
- *Effects of wind farms on birds (Langston & Pullen 2004): http://book.coe.int/EN/ficheouvrage.php?PAGEID=36&lang=EN&produit_aliasid=1837.*
- *CMS COP7 Resolution on Offshore Wind Turbines: http://www.cms.int/bodies/COP/cop7/list_of_docs/pdf/en/CP7RES7_13_Offshore_wind_turbines.pdf.*

Pollution and emergency situations:
- *CMS COP 7 Resolution on Offshore Oil Pollution: http://www.cms.int/bodies/COP/cop7/list_of_docs/pdf/en/CP7RES7_11_Offshore_Oil_Pollution.pdf.*
- *Guidelines on identifying and tackling emergency situations for migratory waterbirds (UNEP/AEWA 2005): http://www.unep-aewa.org/publications/conservation_guidelines/pdf/cg_2new.pdf.*

Avian Influenza:
- *Wild Birds and Avian Influenza: FAO (2007). Provides practical up-to-date techniques on wild bird capture, bird handling and ringing, disease sampling, monitoring and radio telemetry. Available for downloading either as whole book or by chapter: www.fao.org/avianflu; http://www.fao.org/docrep/010/a1521e/a1521e00.htm.*
- *The Avian Influenza, Wildlife and the Environment Web (AIWeb): http://www.aiweb.info/.*
- *FAO pages on avian influenza: http://www.fao.org/avianflu/en/index.html.*
- *Wild Bird Global Avian Influenza Network for Surveillance (GAINS): http://www.gains.org/.*
- *Ramsar Resolution X.21: Guidance on responding to the continued spread of highly pathogenic avian influenza: http://www.ramsar.org/pdf/res/key_res_x_21_e.pdf.*
- *Responding to the spread of Highly Pathogenic Avian Influenza H5N1 (AEWA Resolution 4.15): http://www.unep-aewa.org/meetings/en/mop/mop4_docs/final_res_pdf/res4_15_responding_threat_ai_final.pdf.*

9. Site-based conservation in a flyway context

[Note: *'Further reading'* for sub-sections 9.1–9.3 is given at the end of section 9].

9.1 Site-based conservation

Key messages

Site-based conservation is a first line of action in the conservation of migratory waterbirds. Wetland creation and restoration are important aspects for (partially) degraded sites.

In previous chapters the various important areas which play a role in flyways, such as breeding, moulting, staging and non-breeding destination areas, have been described and their general functions defined. Conservation of these areas and sites is one of the most important steps in the wise use and conservation of migratory waterbirds. Module 2 provides in-depth information on applying the flyway approach to conservation at these important areas, and many of the important aspects of site-based conservation are covered there. Clearly site-based conservation is of primary importance for many migratory waterbirds, which depend often on a network of specific sites. These sites are key areas for conserving migratory populations.

However, site-based conservation does not work well for all migratory waterbirds, especially broad-front migrants that do not depend on particular sites, but rely instead on the availability of a large number of wetlands scattered over a large area. Further, some waterbirds do not depend on wetlands for all their life cycle stages. Some storks use woodlands and savannas more frequently, perhaps again over a wide area. The conservation of nomadic waterbirds is also difficult through a site-based approach, as birds do not necessarily depend on particular sites, at least not on a regular basis.

9.1.1 Wetland creation and restoration

If applying a 'no net loss of wetlands policy' (as mentioned in section 8.1), it may be necessary to compensate for lost habitat by creating or restoring waterbird habitat, usually wetlands, particularly in non-breeding areas. It is relatively easy to create a wetland at a grassland site, certainly in comparison with restoring other habitat types. There is significant experience in wetland (and river) creation and restoration in many European countries, for which case studies are described in Eiseltová & Biggs (1995). Some countries have created large wetland areas where sufficient space has been available. A classic example is the creation of the Oostvaardersplassen Nature Reserve, one of the largest and richest wetland sites of The Netherlands, in an area originally planned to be developed for industry (Figure 9.1). Many waterbird species have colonised the site, demonstrating their ability to adapt and explore new areas for fulfilling important annual life cycle functions such as moulting.

Figure 9.1. The Dutch Oostvaardersplassen, originally planned to become an industrial area (photo: Gerard Boere).

What effect this has on total population size and whether or not a new area creates a real increase of habitat with a positive effect on population size, or just compensates for losses elsewhere, is hard to measure. As this happens along the whole flyway it is important to monitor such cases through international cooperation and to maintain monitoring under the International Waterbird Census (IWC) to the highest standard possible, so that at least some hard data on population trends are available. However, even with good time-series IWC data, it is still difficult to give root causes for changes in population, which requires more in-depth research and monitoring.

There is great potential for wetland creation in areas such as quarry sites, after mineral extraction (e.g. sand or gravel) has taken place. These sites have potential to become productive wetlands supporting good numbers of birds if the right management takes place. [Further details and examples of wetland creation and restoration are provided in Module 2 section 5.5]. The importance of wetland restoration is increased by climate change impacts as an essential part of national mitigation strategies.

9.2 The need to take life cycle stages into account

Key message

Site-based conservation actions must take account of the roles that each site plays in the annual or life cycles of migratory waterbird populations.

Where site-based conservation is a useful conservation objective, then it is most important that it takes into account the relevant life cycle stages of waterbirds. Conservation managers need to define sites in terms of the life cycle stages that they support. They also need to know which attributes are important for different migratory birds at different stages, and should be able to use this information for contributing to site management decisions.

At the flyway level, the roles of key sites in supporting specific annual (or life) cycle stages should be known, and conservation actions set at each site that favour these roles and enable them to be fulfilled. It is especially important to build the roles that a site plays for migratory waterbird conservation into a site management plan. At the same time it will be necessary to identify and clearly define those roles so that good management actions are planned that favour maintaining or enhancing the role of the site for waterbirds.

Zambia's Bangweulu Swamps, for instance, support an important breeding population of Shoebills *Balaeniceps rex*, an endangered species (Figure 9.2). Clearly the management plan for Bangweulu must describe and define the breeding areas for Shoebills (as far as is known) and build appropriate conservation actions into the site management plan. Where there are information gaps, then filling such gaps can become part of the plan, through actions such as surveys and applied research. A key management objective will be to conserve the breeding habitat and minimise threats to breeding birds.

Figure 9.2. An adult Shoebill *Balaeniceps rex* at Lake Yirol, Southern Sudan (photo: Niels Gilissen – MIRATIO).

9.3 Multiple functions of sites

Key message

The multiple functions of sites for different migratory waterbird populations should all be catered for in the site's management plan.

Many key sites for migratory waterbirds are important not just for one or two species but for several, and may also be important for other fauna or various attributes (see Module 2 section 3.3.1). Some of these species may depend on the same habitat and attributes of a site, such as intertidal mudflats or flooded forests providing safe roost areas. However, other sites may carry out multiple functions in supporting different migratory waterbirds.

The Parc National du Banc d'Arguin of Mauritania has been mentioned already in terms of its high importance as a staging and non-breeding destination area for many waders that breed in northern Europe east to Siberia. The key attributes of the Banc d'Arguin for these waders are the extensive productive coastal flats. These areas must be maintained in a good state and relatively free of disturbance if the Banc d'Arguin is to serve these wader populations effectively. However, the same site supports a breeding population of Greater Flamingos *Phoenicopterus roseus*, for which the undisturbed offshore islands are of greatest importance. The Banc d'Arguin also supports two populations of Eurasian Spoonbill *Platalea leucorodia,* migratory birds from Northwest European breeding colonies and a resident population that has local movements along the West African coast. Thus, the site supports different life cycle stages for different species and populations, and conservation of the site needs to take account of the habitat and other needs of all these birds.

Many sites along flyways similarly have important multiple functions for migratory waterbirds, and these need to be described and catered for by the site management. The multiple functions of a site favour management that retains a diversity of habitats, though it can be difficult to recreate damaged habitats, as changes made elsewhere, for instance in favour of waders, may negatively impact a different species.

Further reading:

- *Restoration of Stream Ecosystems - an integrated catchment approach (Eiseltová & Biggs 1995).*
- *Wetlands and global climate change: the role of wetland restoration in a changing world (Erwin 2009): http://www.environment.com/wp-content/uploads/2009/01/fulltext.pdf.*
- *The Migration Ecology of Birds (Newton 2008).*
- *Shorebirds: an illustrated behavioural ecology (van de Kam et al. 2004).*

Further references relating to wetland restoration are provided in Module 2.

10. Flyway-scale conservation initiatives

[Note: For ease of reference, *'Further reading'* links are provided under each initiative (10.1.1–10.1.10 and 10.2.1–10.2.7) instead of at the end of each sub-section (10.1 & 10.2)].

Conservation initiatives on a flyway scale are numerous, and differ in the number of species included and the size of the geographical area covered, as well as in their legal and administrative format. Initiatives range from international conventions to flyway projects, some of which are described below:

10.1 Multilateral and large-scale flyway initiatives

Key message

A range of large-scale flyway initiatives are in place at different political levels that, between them, play major roles in wetland and waterbird conservation. The Ramsar Convention, CMS and AEWA are key multilateral arrangements, with far-reaching influence.

These represent a mixture of legally binding and non-binding arrangements. Governments initiated some, whilst others have their origin in science or in the activities of NGOs. Further details are provided by Boere & Rubec (2002) and Boere (2003).

10.1.1 Convention on the Conservation of Migratory Species of Wild Animals (UNEP/CMS; Bonn 1979)

The development of the CMS or Bonn Convention arose from recommendations from the first world environment conference held in Stockholm in 1972. The German Government (then the Federal Republic of Germany or West Germany) took the lead to develop the international legal instrument and the text was concluded at a diplomatic conference in Bonn, Germany in 1979. The Bonn Convention came into force in 1983 after ratification by sufficient Parties. It requires the conservation and sustainable use of all migratory species, and so is an important instrument for bird conservation.

Annex 1 of the Convention requires strict protection of a number of highly endangered bird species such as the Slender-billed Curlew *Numenius tenuirostris* and Siberian Crane *Grus leucogeranus*; for which separate 'soft legal instruments', such as Memoranda of Understanding, have been concluded. Annex 2 of the Bonn Convention lists a large group of species and families for which coordinated action is important to maintain populations. This is mainly achieved through agreements between the states in which species occur. Migratory bird agreements covering geographical flyway systems are the *African Eurasian Migratory Waterbird Agreement* (AEWA, The Hague, 1995) and the *Agreement on the Conservation of Albatross and Petrel* (ACAP, Cape Town, 2001). The CMS has high potential as a bird conservation treaty and there are many new initiatives underway to develop agreements for flyways and threatened groups.

The CMS is supported by two key information systems:

a. ***Global Register of Migratory Species (GROMS)***, an information system holding scientific information on migratory species and their populations. GROMS has useful information on migratory species, including a number of interactive maps.
b. ***CMS Information Management System (CMS IMS)*** managed by the World Conservation Monitoring Centre (WCMC), which brings together data from various expert organisations, knowledge generated within CMS and other MEAs, and the information provided by the CMS Parties through their National Reports.

Further reading:
- *The Convention on Migratory Species: www.cms.int.*
- *The Global Register on Migratory Species*

(GROMS) provides maps and information on migratory species in general: http://www.groms.de.

- *WCMC: http://www.unep-wcmc.org/.*
- *CMS IMS: http://www.unep-wcmc.org/isdb/cms/Taxonomy/index.cfm.*

10.1.2 Convention on Wetlands (Ramsar, Iran, 1971) or Ramsar Convention

One of the first international conservation treaties, the Ramsar Convention is very important for waterbird conservation. It is a successful convention because of its relatively simple obligations, and many countries have signed up as Contracting Parties (159 in May 2009). It also has partnerships with a number of NGOs. Countries may become a Contracting Party by subscribing to the general terms of the convention, which are to conserve and use in a sustainable way resources associated with all wetlands (not only those of international importance), as well as to designate at least one wetland of international importance (as a Ramsar site). Under the ***'three pillars'*** of the Convention, the Parties have committed themselves to:

- work towards the ***wise use of all their wetlands*** through national land-use planning, appropriate policies and legislation, management actions, and public education;
- designate suitable wetlands for the ***List of Wetlands of International Importance*** ('Ramsar List') and ensure their effective management; and
- ***cooperate internationally*** concerning transboundary wetlands, shared wetland systems, shared species, and development projects that may affect wetlands.

There are specific criteria that aid in the identification and selection of Ramsar sites (see Module 2 section 3.5). These include the waterbird criteria, which rely on waterbird data, largely provided through the International Waterbird Census. Article 5 of the convention specifically asks for international cooperation, and a new specific resolution on flyways has been agreed (see Module 2 section 7.1.2). The Ramsar Convention deals with all aspects of wetlands, including integrated conservation, management, wise use, fresh water resources and catchment areas. Further information is provided elsewhere in these modules, e.g. Module 2 section 7.1.2 and on CD 3).

Further reading:

- *The Ramsar Convention: www.ramsar.org.*
- *The Ramsar Sites Information Service: http://ramsar.wetlands.org/.*
- *The Ramsar Handbook series: http://www.ramsar.org/cda/ramsar/display/main/main.jsp?zn=ramsar&cp=1-30©1323_4000_0__.*

10.1.3 African Eurasian Migratory Waterbird Agreement (UNEP/AEWA)

This is the largest Agreement under the Bonn Convention both in geographical coverage and species, and the largest flyway Agreement in the world. The AEWA came into force in November 1999, and the Secretariat is based at the UNEP/CMS offices in Bonn, Germany. An Action Plan is in place, which guides activities of the Convention.

AEWA focuses on 255 migratory waterbird (and seabird) species ecologically dependent on wetlands for at least part of their annual cycle including many species of pelicans, storks, flamingos, ducks, waders, terns, gulls and geese. The AEWA Agreement area covers 118 Range States in Africa, Europe including parts of Canada, Central Asia and the Middle East. The geographic area stretches from the northern reaches of Canada and the Russian Federation to the southernmost tip of Africa (Figure 1). Parties to the Agreement are called upon to engage in a wide range of conservation actions which are described in a comprehensive Action Plan (2003–2005). This detailed plan addresses key issues such as: species and habitat conservation, management of human activities, research and monitoring, education and information, and implementation.

Further information on AEWA is provided widely throughout these modules, including on many of the AEWA Species Action Plans and guidelines, whilst CD4 is dedicated to AEWA materials. Specific information on the Agreement and its implementation are given in Module 2 section 7.1.3.

Further reading:

- *AEWA: http://www.unep-aewa.org/home/index.htm.*

10.1.4 Central Asian Flyway (CAF)

This is a recent initiative by UNEP/CMS, the Russian and Dutch Governments, the AEWA Secretariat and Wetlands International, which has led to a coordinated effort to develop an action plan and which, in the long term, may become a more formal instrument like a MoU. The priority is to address the lack of data concerning many species and habitats. The political situation in the region complicates data collection and reduces the possibilities for international cooperation.

Further reading:

- *CAF: http://www.cms.int/species/CAF/caf_ap.htm.*

10.1.5 Partnership for the East-Asian Australasian Flyway (EAAF): Implementation Strategy for the period 2007–2011

The original strategy for the region, the **Asia-Pacific Migratory Waterbird Conservation Strategy (APMWCS) 2001–2005** included a large geographical area involving three major flyways: Central Asian Flyway, East Asian-Australasian Flyway and the West Pacific Flyway. Separate initiatives are underway for the Central Asian Flyway, whilst the West Pacific Flyway is not yet recognised. The region covered by the implementation strategy is shown in Figure 10.1. The work is coordinated by Wetlands International with support from the Governments of Japan and Australia. Site-based networks for cranes, Anatidae and shorebirds have been developed, stimulating many bilateral conservation actions on habitat and the wider countryside.

Figure 10.1. Area covered by the EAAF

Further reading:

- *Partnership for the East-Asian Australasian Flyway: www.eaaflyway.net.*
- *Implementation Strategy: www.eaaflyway.net/documents/Partnership-Implementation-Strategy-MoP2revision.pdf.*
- *Asia-Pacific Shorebird Network: http://www.shorebirdnetwork.org.*

10.1.6 Migratory Birds Commission (MBC) of the International Council for Game and Wildlife Conservation (CIC)

For the sustainable use of wildlife

CIC – International Council for Game and Wildlife Conservation

FACE

This commission provides the framework for cooperation among a number of national and international hunting organisations like CIC in consulation with the Federation of Associations for Hunting and Conservation in the EU (FACE). Activities include the study of harvesting waterbirds, coordinating applied research and monitoring on migratory waterbirds, and habitat conservation in both the breeding and non-breeding ranges from Russia to Africa.

Further reading:

- *Migratory Birds Commission: www.cic-wildlife.org/?id=76.*
- *CIC: www.cic-wildlife.org.*
- *FACE: www.face-europe.org.*

10.1.7 Wings Over Wetlands

wings over wetlands

The UNEP-GEF African-Eurasian Flyways Project

The Wings Over Wetlands (WOW) is a large flyway initiative based on policies outlined in the AEWA Agreement, and a joint effort between UNEP/GEF (UNEP/Global Environment Facility), Wetlands International, BirdLife International, UNOPS, UNEP/AEWA, The Ramsar Convention Secretariat, and many donors and local partners. The partners work closely together guided by a Project Coordination Unit. WOW is developing various instruments on the flyway level such as the Critical Site Network Tool, gap-filling initiatives and outputs such as this manual. It also supports 11 demonstration projects on the ground in 12 countries. The project is highly facilitated through substantial financial support from GEF and larger donors like the Government of Germany.

Further reading:
- *WOW: www.wingsoverwetlands.org.*
- *WOW information at AEWA: www.unep-aewa.org/activities/wow/index.htm.*

10.1.8 Ramsar Evian Initiative (1997–2002)

This initiative focused on implementing an action programme for water resource and water quality conservation and management in wetland ecosystems of international importance mainly through awareness-raising, training and communication. These included a training network for the East Atlantic, which addressed the importance of water quality and quantity for waterbirds, ecotourism and integration of local communities and exploitation of natural resources in coastal wetlands by humans and uses by birds. As such it was a good example of cooperation along a flyway.

Further reading:
- *Ramsar Evian Initiative: http://www.ramsar.org/cda/ramsar/display/main/main.jsp?zn=ramsar&cp=1-63-98-398©3923_4000_0__*

10.1.9 Working Group on the Conservation of Arctic Flora and Fauna (CAFF)

Conservation of Arctic Flora and Fauna

CAFF is a working group of the Arctic Council, which is the high level coordination body of the eight Arctic countries (Canada, USA, Iceland, Norway, Sweden, Finland, Denmark (including Greenland) and the Russian Federation). Other working groups include the Arctic Contaminants Action Programme (ACAP), Arctic Assessment and Monitoring Programme (AMAP) and the Protection of the Arctic Marine Environment (PAME). The CAFF Working Group is very active on issues relevant to flyway conservation, and has expert groups on Circumpolar Biodiversity Monitoring, Seabird Sustainable Management, Arctic Flora and Arctic Protected Areas. The Arctic is the main breeding area of millions of waterbirds; CAFF's efforts to increase the number and size of protected areas in the Arctic are important for the AEWA region.

The CAFF overview '*Global Review of the Conservation of Migratory Arctic Breeding Birds outside the Arctic*' (Scott 1998) illustrates well the importance of the Arctic region for global biodiversity (Figure 10.2). *'Arctic Flora and Fauna: Status and conservation'* (CAFF 2001) provides an excellent overview of Arctic biodiversity, its conservation and challenges.

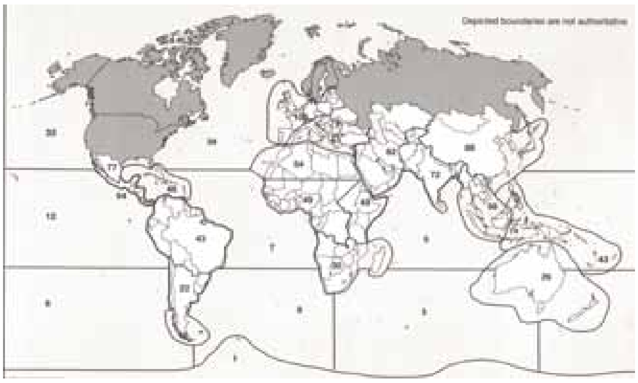


Figure 10.2. The number of Arctic breeding bird species migrating to different parts of the world (e.g. 49 Arctic-breeding species winter in Western Africa); (source: Scott 1998).

Further reading:
- *CAFF: http://arctic-council.org/working_group/caff.*
- *CAFF publications: http://arcticportal.org/en/caff/.*
- *Arctic Flora and Fauna: Status and Conservation: http://arcticportal.org/en/caff/arctic-flora-and-fauna2.*

10.1.10 MoU on the Conservation of Migratory Birds of Prey in Africa and Eurasia

This is a new instrument under the Bonn Convention, which was concluded at an international diplomatic conference in Abu Dhabi, United Arab Emirates, in October 2008, following a first preparatory conference in Scotland in October 2007. The MoU Signatories aim to '*take co-ordinated measures to achieve and maintain the favourable conservation status* *of birds of prey throughout their range and to reverse their decline when and where appropriate'*. This is particularly relevant for the migration period when many birds of prey (or raptors) form large flocks and often follow a narrow front migration. Many of the proposed actions are similar to those agreed under AEWA, though there are specific issues such as the taking of raptors for the traditional falconry in the Middle East.

The area includes more Asian countries than AEWA, but does not include any marine areas (Figure 10.3). A secretariat will be based at a CMS secretarial unit in Abu Dhabi with support by the United Arab Emirates; this unit also serves other CMS instruments in the region, e.g. MoUs for Dugongs and Marine Turtles.

Figure 10.3. Map of the area included in the MoU on the Conservation of Migratory Birds of Prey in Africa and Eurasia.

Further reading:
- *http://www.cms.int/species/raptors/*

10.2 Regional and bilateral initiatives important for flyways

Key message

Regional and bilateral initiatives can be effective platforms for cooperation in the shared management of nature, including migratory waterbirds. The EU Birds and Habitats Directives together require EU Member States to take specific conservation actions.

Many other arrangements are in place for migratory birds focussing on smaller areas or which service bilateral cooperation between countries (Boere & Rubec 2001), including the following:

10.2.1 EU Birds and Habitats Directives

The EU Directive on the Conservation of Wild Birds, more commonly known as the **Birds Directive** was adopted in 1979 and provides legal protection for all European bird species, including migrants, and their habitats in all European Union Member States, together with a framework for the sustainable hunting of some specified species. New Member States have to comply with the EU Directive at the time of their accession. This creates a large geographical area with potentially good legal protection for migratory birds throughout.

The **EU Habitats Directive** was adopted in 1992 as a legislative instrument in the field of nature conservation that establishes a common framework for the conservation of wild animal and plant species and natural habitats of Community importance. One of the main implementation arrangements for the Directive is **Natura 2000**, which is an EU-wide network of nature protection areas. The aim of the network is to assure the long-term survival of Europe's most valuable and threatened species and habitats. It is comprised of Special Areas of Conservation (SAC) designated by Member States under the Habitats Directive, and Special Protection Areas (SPAs) classified under the Birds Directive.

Together, the Birds and Habitats Directives require all EU Member States to take a number of measures in order to protect all bird species, their sites and their habitats, including:

- Take measures to conserve all naturally occurring bird species across the EU
- Classify as **Special Protection Areas** (SPAs) the most suitable territories for birds listed on Annex I of the Directive and migratory species
- Maintain SPAs in Favourable Conservation Status
- Prepare and implement management plans, setting clear conservation objectives for all SPAs in the EU
- Provide co-financing for the management of these protected sites (SPAs)
- Regulate the hunting of certain species of birds listed in Annex II of the Birds Directive
- Follow the procedure outlined in Article 6 of the Habitats Directive for carrying out appropriate assessments of environmental impacts on SPAs.

Further reading:

- *EU Birds Directive: http://ec.europa.eu/environment/nature/legislation/birdsdirective/index_en.htm*
- *EU Habitats Directive: http://ec.europa.eu/environment/nature/legislation/habitatsdirective/index_en.htm*
- *Natura 2000: http://ec.europa.eu/environment/nature/natura2000/index_en.htm*

10.2.2 Bern Convention/Convention on the Conservation of European Wildlife and Natural Habitats, 1979

Administered by the Council of Europe this convention has a specific annex for the protection of migratory species, which forms the rationale for a few African countries ratifying the convention, as clearly Africa is important for many migratory waterbirds that breed in Europe. The Bonn Convention has taken on the migratory bird conservation aspects, e.g. via the AEWA.

Further reading:

- *Bern Convention: http://www.coe.int/t/dg4/cultureheritage/conventions/bern.*

10.2.3 Siberian Crane Memorandum of Understanding (UNEP/CMS Bonn Convention)

This MoU aims to conserve the various small populations of this globally endangered crane, each with its distinctive flyway and staging and non-breeding destination areas. The MoU provides the basis for active cooperation between the governments involved, NGOs (e.g. the International Crane Foundation) and UNEP/CMS. The MoU is substantially supported by funds from the Global Environment Facility (GEF).

Further reading:

- *CMS Siberian Crane MoU: http://www.cms.int/species/siberian_crane/sib_bkrd.htm.*
- *Siberian Crane Flyway Coordination: http://www.sibeflyway.org.*

10.2.4 Slender-billed Curlew Memorandum of Understanding (UNEP/CMS Bonn Convention)

This is another flyway agreement for a single species - one of the world's rarest birds. It facilitates a number of conservation activities in wetlands in the former non-breeding areas and surveys of supposed last strongholds in the Middle East. Activities are somewhat limited as no birds have been observed for several years. [For further information see Module 2 section 9.3.3].

Further reading:

- *CMS Slender-billed Curlew MoU: http://www.cms.int/species/sb_curlew/sbc_bkrd.htm.*

10.2.5 Bilateral agreements on migratory birds

There are several bilateral agreements, such as: China–Australia (CAMBA), Russia–India, Australia–Japan (JAMBA), Russia–Japan, USA–Russia, Korea D.P.R–Russia and Japan–USA. Canada has agreements on migratory species with Ireland, Russia and the UK. Some of these bilateral agreements are quite effective but not really functioning on the flyway level. However if a multilateral agreement is not possible, e.g. for policy or political reasons, theoretically you need a couple of hundred bilateral ones to secure the interest of migratory birds on a flyway level.

<ins>*Global Flyway Network*</ins>

Within the scientific community there is much cooperation on the flyway level, often within one of the above mentioned instruments. A more organised and recent initiative is the **Global Flyway Network** (GFN), which brings together a number of wader researchers from around the world, working to unravel the migration patterns and background of a few wader species, notably the Red Knot *Calidris canutus* and the Bar-tailed Godwit *Limosa lapponica*. Using satellite tracking they have already achieved amazing results with their work (e.g. Gill *et al.* 2008). Shorebird populations worldwide are declining and their habitats are under stress from human factors including global climate change. Thus, to underpin the conservation of the migratory shorebirds that connect us all, the Global Flyway Network aims to foster and conduct global cooperative ecological and demographic research.

Further reading:
- *Global Flyway Network: www.globalflywaynetwork.com.au.*
- *Extreme endurance flights by landbirds crossing the Pacific Ocean: http://alaska.usgs.gov/science/biology/avian_influenza/pdfs/Gill_et_al_2008_Godwit_Migration.pdf.*

10.2.6 Migrating Soaring Birds in the Middle East and North Africa

This is a new initiative led by BirdLife International which sets out to achieve improved conservation status of a number of key sites that support high numbers of globally threatened soaring birds. These sites have been selected using BirdLife's 'bottleneck' criteria. The overall objective of the project is that "*globally threatened and significant populations of migrating soaring birds are effectively protected at a network of key bottleneck IBAs along the eastern sector of the Africa-Eurasia flyway (Rift Valley and Red Sea Flyway), thereby ensuring their safe passage between breeding and non-breeding grounds*." Project components will address policy, planning and legislation; awareness and constituency building; sustainable management and socio-economic development; co-ordination, co-operation and communication; and capacity development.

Further reading:
- *Soaring Birds initiative: www.birdlife.org/action/ground/soaring_birds/index.html.*

10.2.7 Initiatives in the Americas

The North American Waterfowl Management Plan (NAWMP) has been in place for many years, and acted to stimulate coordinated activities in Europe, Asia and Africa. There is a strong participatory approach with all partners and stakeholders and much attention for awareness and education. A recent development is the Western Hemisphere Migratory Species Initiative (WHMSI) with the United States Fish and Wildlife Service (USFWS) playing the leading role. Annex 5 provides a brief overview of the most important American initiatives in relation to flyway conservation.

Further reading:
- *NAWMP: http://www.nawmp.ca/.*
- *WHMSI: http://www.fws.gov/international/DIC/WHMSI/whmsi_eng.html.*

11. Potential impacts of climate change on flyway-scale conservation

11.1 Climate change research

Key message

Research that explores potential future scenarios is required to underpin the wide-scale planning needed to mitigate climate change impacts on waterbirds and their habitats.

The Edinburgh Declaration (Annex 4), as endorsed by the international flyway conference 'Waterbirds around the world' (April 2004 in Edinburgh, Scotland) highlights the effect of climate change on waterbirds as follows:

> **'***Climate changes are already affecting waterbirds. The consequences of climate change for waterbirds will be multiple, and will greatly exacerbate current negative impacts such as habitat loss and degradation. There is a need for wide-scale planning, at landscape and flyway scales, to reduce or mitigate the impacts on waterbird populations and their habitats. Research that explores a range of potential future scenarios will be required to underpin this planning and will need data from long-term monitoring and surveillance***.'**

The amount of research ongoing today to study and model the effects of climate change on all aspects of society is enormous, not least because of possible economic and social consequences, for instance for low-lying countries like the Pacific Ocean Island States, or low-lying coastal plains, where in most countries the economic activities and larger industries are based. Impacts on flyways however have been little studied. An atlas has been published focused on climate change in relation to European breeding birds, showing for instance how the location of breeding areas would change as a result of climate changes (Huntley *et. al.* 2007). Some other works have also been published, but, overall, there are still many unknowns about the future impacts of climate change.

Further reading:

- *Climate variability and change and other pressures on wetlands and waterbirds: impacts and adaptation (Finlayson et al. 2006): http://www.jncc.gov.uk/PDF/pub07_waterbirds_part2.2.6.pdf.*
- *Climate change, waterbird conservation and international treaties (Boere & Taylor 2004).*
- *The effects of climate change on migratory waterbirds within the African-Eurasian flyways (Maclean et al. 2008): http://www.unep-aewa.org/publications/technical_series.htm*.
- *The migration ecology of birds (Newton 2008).*

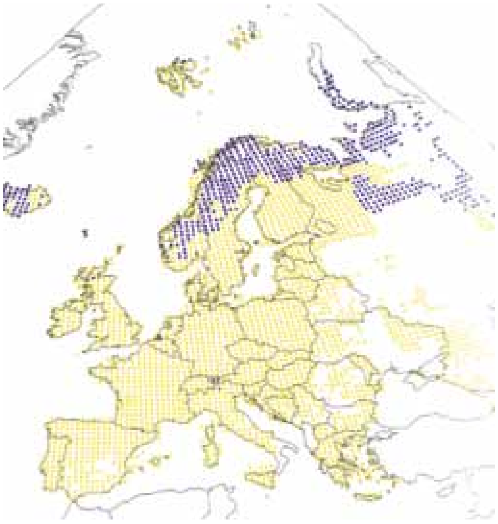
11.2 Some expected climate change impacts on birds in Europe

Key message

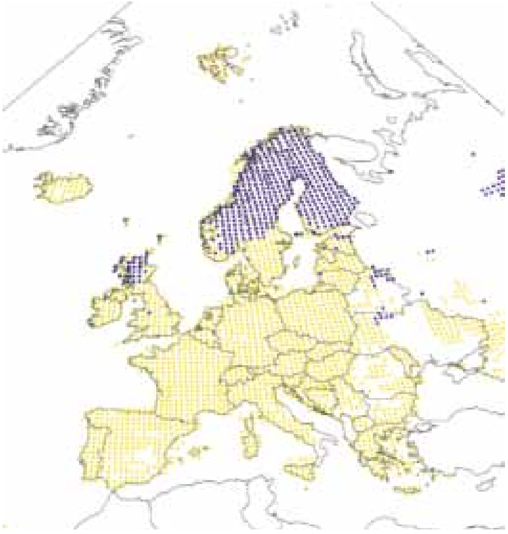
Climate change effects on migratory birds are already noticeable in Europe, with distributional shifts and earlier arrival dates for example; some sites may lose their 'importance status' in favour of others. Regular monitoring is essential.

The following information is taken from the Climate Atlas on birds in Europe (Huntley *et al.* 2007), which shows how some birds might be affected by climate change. Figures 11.1 and 11.2 illustrate how the breeding distributions of Black Tern *Chlidonias niger* and Common Greenshank *Tringa nebularia* would change if climate models as predicted for Europe are applied. One could conclude that in such situations the distance between breeding area and non-breeding area could remain the same. Clearly many uncertainties remain about what actually will happen.

Some long distance passerine African migrants breeding in Europe like Pied Flycatcher *Ficedula*



A: present distribution



B. Predicted distribution

Figure 11.1. Distribution of the present and predicted breeding area of the Common Greenshank *Tringa nebularia*; purple = breeding areas, yellow = non-breeding areas (source: Huntley *et al.* 2007).

A. Present distribution

B. Predicted distribution

Figure 11.2. Distribution of the present and predicted breeding area of the Black Tern *Chlidonias niger*; purple = breeding areas, yellow = non-breeding areas (source: Huntley *et al.* 2007).

hypoleuca already have problems to adapt their migration to the changing food availability in their breeding areas in Northwest Europe, where climate change effects negatively influence the availability of food resources at a time when they are most needed. This may in the long run lead to a change of the timing and route of their migration; such changes are likely to be more rapidly visible in passerine species, which have a more rapid turn-over of generations than waterbirds.

The general trend is that breeding areas are expected to move north/north east. In principle this could lead to a longer migration route for some birds. However at the same time it is already visible (e.g. from IWC data) that the main non-breeding, or wintering, areas for some species are also moving north and north east. These movements may lead to birds 'leaving' existing important areas. There may even be cases where some sites designated as Ramsar sites or IBAs on the strength of waterbird criteria may fail in the future to meet these criteria. Conversely, birds may move to alternative sites with no international designations that may merit future designation by meeting the relevant criteria (see Boere and Taylor 2004). Such scenarios illustrate the importance of the regular continuation and expansion of IWC and IBA monitoring, both useful tools in site and species monitoring and in contributing to the site designation process.

In countries with long term bird monitoring programmes, climate change effects are already visible, for instance in the continuous forward arrival date observed for Barn Swallows *Hirundo rustica* in Great Britain (Figure 11.3). This

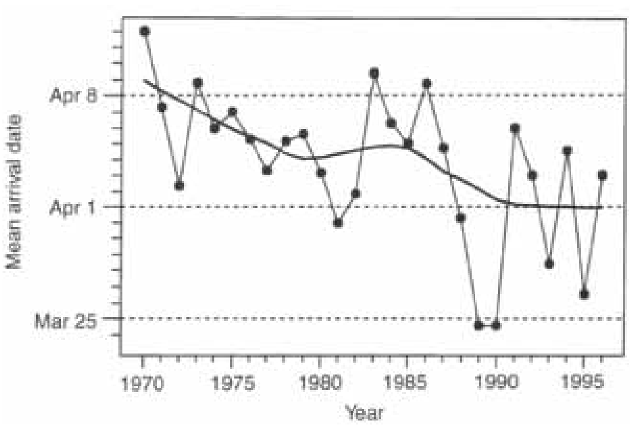


Figure 11.3. Changes in the mean arrival dates of Barn Swallows *Hirundo rustica* in Great Britain (source: Newton 2008).

species is also breeding further north in Britain than it used to in the past.

Distributional shifts of waders have also been observed in recent years in the UK. As wader distributions in Britain change with climate change, the numbers of some species at some British Special Protection Areas are dropping below the thresholds upon which the designations are based, such as declines of Dunlin *Calidris alpina* wintering on the Severn Estuary (Rehfish & Austin 2006).

Further reading:

- *A climatic atlas of European breeding birds (Huntley et al. 2007).*
- *The effect of climate change on birds (Leech 2007): http://www.bto.org/research/advice/ecc/index.htm.*
- *Climate change and coastal waterbirds: the United Kingdom experience reviewed (Rehfish & Austin 2006): http://www.jncc.gov.uk/PDF/pub07_waterbirds_part4.1.2.pdf.*
- *Impacts of a Warming Arctic (ACIA 2004): http://amap.no/acia/.*
- *Impacts of Climate Change on Wildlife (Green et al. 1991): http://www.unep-wcmc.org/climate/climatebook/introduction.aspx.*

11.3 Expected climate change impacts in the Arctic

Key message

Changes in the Arctic climate are already noticeable; as many migratory waterbirds breed in the Arctic, impacts on them, such as loss of breeding habitat, are inevitable.

It is widely accepted that the Arctic region will be influenced substantially by climate change, and changes in this region, which are already measurable, are bound to have significant influence on Arctic-breeding migratory waterbirds, especially waders, geese, ducks and swans, amongst many other impacts.

The Arctic Climate Impact Assessment (ACIA) is an international project of the Arctic Council and the International Arctic Science Committee (IASC), to evaluate and synthesize knowledge on climate variability, climate change, and increased ultraviolet radiation and their consequences. The ACIA produced a comprehensive report *'Impacts of a Warming Arctic'* in 2004, in which key expected impacts are listed and detailed. For example, it is expected that over time the treeline will move northwards, with forests replacing much of the tundra. Clearly this would have impacts on tundra-breeding waterbirds. Some of the wider expected changes in the Arctic due to melting ice etc. will have significant global impacts.

Specific information relating to waterbirds is included in the publication *'Impacts of Climate Change on Wildlife'* (Green *et al.* 1999), which has a chapter titled *'Waterbirds on the edge: climate change impact on Arctic breeding waterbirds'.* The authors predict significant loss of breeding habitat for several species, with the Red-breasted Goose *Branta ruficollis*, for instance, losing some 67% of its breeding habitat to forest. Expected impacts on shorebirds are given by Meltofte *et al.* (2007), who predict that High Arctic species and populations appear particularly at risk. The environmental consequences of global climate change are predicted to have their greatest effect at high latitudes and have great potential to impact fragile tundra ecosystems; O'Connell *et al.* (2006) describe an integrated approach to understanding climate change impacts at the flyway level, especially in relation to changing conditions in the Arctic.

Further reading:

- *Effects of climate variation on the breeding ecology of arctic shorebirds (Meltofte et al. 2007): http://www.dpc.dk/graphics/Design/Danish/Videnscenter/DPC_publikationer/MoGpdf/MoG%20Bio/Bioscience%2059.pdf.*
- *Developing an integrated approach to understanding the effects of climate change and other environmental alterations at a flyway level (O'Connell et al. 2006): http://www.jncc.gov.uk/pdf/pub07_waterbirds_part4.1.1.pdf.*

11.4 Expected climate change impacts in Africa

Key message

Changes in rainfall patterns in Africa will directly influence intra-African migrants.

A key expected impact is a change in rainfall patterns, which will result in less rainfall in much of Southern, Eastern and Sahelian Africa, but higher rainfall in the tropical forest zone of equatorial Africa. Seasonal patterns of rainfall in Africa are largely dictated by the Inter-Tropical Convergence Zone (ITCZ). Future changes in patterns of the ITCZ will lead to changes in seasonality and a redistribution of rainfall. Some of Africa's waterbirds already have nomadic and semi-nomadic tendencies, so they may be able to adapt themselves fairly readily to such changes. Nevertheless distributions and concentrations of birds, and the migration strategies of intra-African migrants, will certainly be affected.

It is likely that climate change will increase the pace of desertification in much of Africa, especially in the Sahel belt and in the semi-arid regions of Southern Africa. This may have long-term impacts on the migratory patterns of some waterbirds, and may lead to the drying up of oases.

Compared to Europe, the current and potential future impacts of climate change on African ecosystems and biodiversity are poorly known; the tropical and subtropical regions of Africa are distinct in many ways, and research on how they may respond to climate change has been surprising and insightful. Focused questions are needed about what climate change will mean for Africa's varied environments, and which kinds of human responses can minimise adverse impacts. Within this framework, birds can act as sentinels of change, thanks to their wide distribution in different habitats, their visibility and some relatively long-term data sets (de Villiers 2009). It has been shown, for instance, that there is a direct correlation between rainfall levels and the survival and reproduction of the Blue Crane *Grus virgo* in South Africa (Altwegg & Anderson 2009).

Further reading:
- *The Atlas of Climate Change (Dow & Downing 2006).*
- *Climate Change and Africa (Low 2006): http://www.cambridge.org/uk/catalogue/catalogue.asp?isbn=9780511113895.*
- *de Villiers, M.S. (ed.). 2009. Birds and environmental change: building an early warning system in South Africa. SANBI, Pretoria: http://www.adu.org.za/docs/climate_change_booklet.pdf.*

11.5 AEWA study on climate change

Key message

The AEWA study highlights climate change impacts on migratory waterbirds; species with a restricted distribution and specialised habitat and food requirements are most vulnerable.

A recent AEWA study on waterbirds and climate change makes clear that waterbirds are already affected by climate change, for instance with many birds in Europe moving their breeding and wintering areas towards the north and north-east (Maclean *et al.* 2008). The report indicates a number of issues where changes are inevitable, such as the disappearance of some coastal wetlands due to sea-level rise. However it also indicates that climate change could potentially create wetlands in other places, although at the coast this is unlikely to be widespread as few stretches of the coastline will be set aside for wetlands.

Rainfall changes are influencing the presence and size of wetlands and such changes can have influence on breeding success in migratory birds. They also influence the habitats for species breeding and staging in drier areas like steppe. Changes in seasons will likely create a mismatch between the needs for food during the breeding season and the availability of that food, which may be earlier or later. This situation already appears to be occurring in the North Sea, resulting in widespread failures of breeding colonies of Arctic Terns *Sterna paradisaea*, Black-legged Kittiwakes *Rissa tridactyla* and other seabirds.

The AEWA study also indicates the differences between species in their sensitivity to climate change effects. Species with a restricted distribution, highly specialised habitat and food requirements are more vulnerable, for example Damara Tern *Sterna balaenarum*, which breeds in the coastal zone of south-western Africa, Northern Bald Ibis *Geronticus eremita*, whose main breeding colony is in Morocco and Cape Gannet *Morus capensis* of coastal Southern Africa. Some populations with restricted ranges that may also be affected include the Southern Africa population of the White Stork *Ciconia ciconia,* the North African population of the White-headed Duck, *Oxyura leucocephala* and the Ukrainian and North-east African breeding population of the Demoiselle Crane *Grus virgo.*

Effects will be visible in changes in the locations of suitable sites, especially in relation to the disappearance of sites and the need to compensate for them. This will have important conservation consequences in terms of land use planning, as alternative sites should be available or made available; this may then have consequences for other forms of land use. Thus within a flyway a certain amount of habitat or potential habitat should be available as a kind of reserve. This relates again to the widely accepted precautionary principle.

Further reading:
- *The effects of climate change on migratory waterbirds within the African-Eurasian flyways (Maclean et al. 2008): http://www.unep-aewa.org/publications/technical_series.htm.*

12. Key knowledge gaps and research needs

Key message

Significant gaps remain in our understanding of migratory waterbirds and their flyways. Regular monitoring of sites and species is essential in helping to improve our understanding, whilst full use should be made of new techniques. Priorities include improving understanding of climate change impacts, intra-African migration and impacts of waterbird taking.

There are still many gaps in our understanding about flyways and migratory waterbirds, despite fairly intensive research and advancing technologies. Gap-filling surveys are particularly useful, though it is often necessary to prioritise areas for survey, due to limited resources. The type and extent of knowledge gaps varies considerably throughout the AEWA region. A number of knowledge gaps are given in the presentation, some of which are discussed in more detail below. An important message is that the tools being made available under the WOW project, such as the Critical Site Network Tool (see Module 2 section 3.6) can be used in identifying knowledge gaps and prioritising gaps to fill.

Figure 12.1. Red Knot *Calidris canutus* feeding on mudflats in Turkey (photo: Riyat Gül).

12.1 Compensation for lost wetlands

Modern techniques of studying bird movements and migrations have, in a relatively short period, added much to our understanding of the function of sites and site networks within the migration routes or flyways of individual species. The key question still is: what happens if a site is taken out of the flyway, are alternatives available and at what distance? This question is difficult to answer as the availability of alternative sites depends on a large number of factors that influence each other. It is difficult to separate specific factors out and adjust management of a site to them. This is illustrated by the simple scenario below:

12.1.1 Red Knot Scenario

Site A is important for the Red Knot *Calidris canutus* due to good availability of small molluscs (Figure 12.1). However, it is destroyed. Nearby is a large productive wetland, site B, with many waterbirds and abundant food for them, and many small molluscs, more than are eaten by the species present. A regional land use manager decides that the loss of Site A is not very important, because the birds using it can easily move to site B instead. However, the molluscs at this site are not the right species for the Red Knot; their ecology is that of a deep-buried species - too deep to be reached by the short bill of the Red Knot. So the large nearby wetland with plenty of biomass in the substrate, not exploited fully by the other species, is not an alternative because the Red Knot cannot reach that available biomass.

It is often this more specific kind of information that is lacking when faced with making decisions, and where there is a large knowledge gap, for instance in our understanding of providing alternative sites for lost wetlands, even by creating new ones.

Further reading:

- *Shorebirds: An illustrated behavioural ecology (van de Kam et al. 2004).*

12.2 East-west movements in Eurasia

There is growing understanding about the existence of an important east-west migration in Eurasia, but little is known about its origin and how 'stable' this migration is. More research is also needed in light of concerns over the potential transport of diseases. Information on these movements and on other migratory routes was highly needed in 2005, after the outbreak of avian influenza in the Ural region, and authorities in Western Europe became concerned about the growing proximity of HPAI H5N1. As migratory wild birds were considered as a possible factor in the distribution of the virus, information was urgently needed on the migration of waterbirds from that part of Russia to Europe. It became clear that little was known, and the Wetlands International publication *'An atlas of movements of Southwest Siberian waterbirds'* (Veen *et al.* 2005) was a key source of information.

Further reading:
- *An Atlas of movements of Southwest Siberian waterbirds (Veen et al. 2005): http://global.wetlands.org/LinkClick.aspx?fileticket=fjmT2I7Hn14%3d&tabid=56.*

12.3 Intra-African migration

Another important gap is our understanding and knowledge of intra-African migration. Compared to migratory birds in Europe or birds visiting Africa from Europe, very little research has been carried out on intra-African migrants, and some of the diverse movement patterns are only now coming to light. We have illustrated some of these movements already in this module, for instance through the migration of the Abdim's Stork *Ciconia abdimi*, but for many birds in Africa there are still unanswered questions about their migratory or nomadic strategies. However, the main triggers for movement are largely known, especially the importance of rain cycles.

Intra-African migration is a key area for research, and one that could be adopted by African research institutes and universities.

Further reading:
- *Conservation dilemmas for intra-African migratory waterbirds (Dodman & Diagana 2006): http://www.jncc.gov.uk/PDF/pub07_waterbirds_part3.4.1.pdf.*

12.4 Impacts of waterbird taking

As many species throughout the flyway are hunted and harvested in various ways, there is an absolute need for more research into the effects of this taking. The increased commercial taking in key sites in Africa should form part of a more intensive monitoring and research programme to determine the overall effects of waterbird harvesting and hunting on populations across the flyways. Good information about the levels of taking would help in putting an early warning system in place, especially in cases where there is a strong population decline. As in other aspects of flyway conservation, it is best, as far as possible, to base decisions and actions, such as implementing hunting bans, on sound information. Where information is lacking, the precautionary principle should take precedent (see section 8.2.1).

Further reading:
- *Sustainable harvest of waterbirds: a global review (Kanstrup 2006): http://www.jncc.gov.uk/PDF/pub07_waterbirds_part2.2.7.pdf.*

12.5 Site coverage

Although waterbird monitoring is, worldwide, one of the most effective monitoring programmes for any group of species, there are still significant gaps in coverage. Many major wetlands remain only poorly known, including in the AEWA region. The Sudd of Southern Sudan, for instance, is one of the most important wetlands in Africa, but data on waterbirds and on site attributes for waterbirds from this site are very limited. Further, the IWC tends to yield data only from January and in some cases July, which limits its useful as a tool for monitoring waterbird movements. Across the AEWA region many sites are not visited regularly for site or species monitoring, usually due to limited resources. As long as such significant gaps remain in the knowledge about the importance of sites year-round, then there will still be difficulties in applying the flyway approach to conservation successfully.

Further reading:
- *International Waterbird Census: http://www.wetlands.org/Whatwedo/Wetlandbiodiversity/MonitoringWaterbirds/tabid/773/Default.aspx.*
- *WOW gap-filling surveys: http://wow.wetlands.org/INFORMATIONFLYWAY/CRITICALSITESNETWORKTOOL/WOWGapFillingSurveys/tabid/1371/language/en-US/Default.aspx.*

12.6 Climate change

The changing climate will have significant implications for the future conservation of waterbirds and wetlands. However, the actual impacts for migratory species and the influences on flyways, sites, breeding and non-breeding area are certainly not well understood. Newton (2008) provides examples in which changes in the timing of migration, length of migratory routes and the location of non-breeding areas can be noticed (see section 11). The changes noticed to date have been on a 'micro-scale', concerning a change in distance of a few hundred kilometres. Climate change impacts are likely to require the need for alternative habitats or the possibility to create new habitats for migratory birds. Much further research is needed, especially to consider impacts at the flyway level and for entire flyways.

Climate change effects also have consequences for the way international conventions and treaties need to deal with legal aspects of site designations, which may need to become more flexible (Boere & Taylor 2004).

Further reading:
- *See 'Further reading' lists under section 11.*
- *Climate change, waterbird conservation and international treaties (Boere & Taylor 2004).*

12.7 Priority data and information needs identified by the Wader Study Group

Overall data and information needs
The International Wader Study Group (IWSG) identified the following main priority data and information needs for waders in Africa and Western Eurasia (Stroud *et al.* 2004):

- Population sizes of waders breeding in the former Soviet Union and Mediterranean countries
- Changes in the population sizes of waders breeding in Europe
- Geographical variations in productivity per pair, and per unit area, over breeding ranges in Europe
- Autumn migration patterns of inland waders
- The relative importance of different coastal moulting sites along the East Atlantic flyway
- The winter distribution over Europe of open-habitat inland waders
- Numbers of waders wintering inland in Africa
- Numbers of wintering waders along the Gulf of Guinea (from Guinea to Angola)
- Numbers of waders wintering along the non-estuarine coasts of Europe (and Africa)
- Population fluctuations of waders wintering in coastal west Africa
- Size and composition of the over-summering wader populations along the East Atlantic flyway
- Spring migration patterns of inland waders
- Migratory pathways of the waders wintering in coastal West Africa
- Connections involving migrating waders between East Atlantic and Mediterranean flyways

Overall, the top priority identified was to ensure there is adequate monitoring provision for all wader populations.

Specific needs identified for the period 2005–2014

- Better population sizes and trends for Black Sea/Mediterranean and West Asian/East African Flyways
- Understanding the importance of staging areas and the implications of their loss or degradation
- More frequent surveys of Banc d’Arguin, Arquipélago dos Bijagós (and other ‘megasites’)
- Waders using the Caspian Sea region, Iran and Iraq
- Intra-African migrants
- Identification and monitoring populations at greatest potential risk of climate change effects
- Methodological development and standardisation of survey and census techniques
- Establishing functional links between important sites
- Use of new technologies
- Turnover
- Future data handling and accessibility
- Monitoring demographic patterns.

Further reading:

- *Status of migratory wader populations in Africa and Western Eurasia in the 1990s (Stroud et al. 2004): http://www.waderstudygroup.org/pubs/pdf/iws15_discussion.pdf.*