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Birds and Biodiversity in Germany

2010

Target



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„Birds and Biodiversity in Germany - 2010 Target“ gives a comprehensive overview about the current status of bird life in Germany – also of the common starling. Photo: T. Krüger



Dear readers,

Germany will host the 9th UN nature conservation conference (“ninth meeting of the Conference of the Parties to the UN Convention on Biodiversity”) in Bonn from 19th to 30th May 2008, to which more than 5.000 representatives from all over the world are expected. The basis of the conference of the parties is the “Convention on Biological Diversity (CBD)”, which was agreed at the world summit in Rio de Janeiro in 1992 and is celebrated as a milestone for nature conservation. Here, it is expressly acknowledged that the conservation of biological diversity is in the interest of all mankind. So far, 189 countries, as well as the European Union have signed the convention.

In Johannesburg, South Africa, in 2002, the so-called “2010 target” was adopted within the framework of the CBD, in order to reduce significantly by 2010 the rate of biological diversity loss at a global, regional and national level. At Gothenburg in 2001, the EU had already decided to halt the loss of biodiversity in Europe by 2010.

On the occasion of the 9th meeting of the Conference of the Parties to CBD, the report “Birds and Biodiversity in Germany – 2010 target” represents a comprehensive overview of the conservation status of national bird life – representing all biological diversity. The report aims to inform decision makers in politics and administration as well as the public who are interested in the successes achieved in species conservation in recent years, and also to reveal the continuing or even increasing need for action, in particular in the unprotected “wider countryside”.

The analysis is based on several million records, gathered by more than 5.000 bird watchers. The evaluation allows concrete conclusions about the application of nature conservation concepts, so we could achieve a sustainable contribution to the protection of species diversity. On the other hand, they also act as early-warning systems by pointing out current undesirable developments, which need to be stopped if the aim of preventing continuous losses of species diversity is to be achieved.

Stefan Fischer, chairman of the DDA

Key points

Overall situation

- ➔ Many common bird species are in decline: numbers of 23 of the 64 commonest German birds have fallen over the last 15 years. Even species such as **house sparrow**, **common house martin** and **northern lapwing** continue to deteriorate in status.
- ➔ Ground-nesting birds of farmland such as **Eurasian skylark** and **Eurasian curlew** are particularly threatened: causes are intensification of agriculture, loss of semi-natural wet grasslands and the recent use of fallow land for the cultivation of energy crops. Favourable trends are found only where there are high levels of organic farming and in large protected areas. If biodiversity loss is to be halted on agricultural land, support measures must be targeted more strongly at the conservation of species and habitats. An important current issue is the need for a fallow land programme to compensate for the loss of EU set-aside.
- ➔ Forest birds have shown a slight recovery: semi-natural forest management has led to better living conditions for typical species such as **Eurasian nuthatch** and **great spotted woodpecker**. Nearly half of the 52 commonest woodland species have increased since 1990, but this increase has taken place almost exclusively outside forests, in parks, gardens and green spaces. Sharp rises in the price of timber and increased use of wood for fuel are currently causing severe intensification of forest management. Therefore, declines in forest birds should be expected in the future.
- ➔ Species breeding on the coasts are particularly seriously threatened: **Kentish plover** and **little tern** need targeted protection measures if they are to survive in Germany. Numbers of shellfish-eating visitors to the Wadden Sea, such as **red knot** and **common eider**, have shown alarming declines over the last 10 years.
- ➔ Long-running protection schemes have helped spectacular larger birds: continuing population increases for **black stork**, **white-tailed eagle**, **peregrine falcon** and **common crane** show that voluntary- and state-sector conservation measures can enable the long-term survival of these species.

Sustainability

- ➔ Birds are policy indicators of the sustainability of land-use in Germany. The Federal Government's sustainability strategy sets a target of stabilising the status of all species in the species diversity indicator and those selected to represent high value habitats.
- ➔ The indicator has stagnated over the last ten years and in 2005 only 74% of the target had been met. Significant extra effort will be needed if the sustainability target is to be achieved.

Climate change

- ➔ Climate change also affects bird life: numbers of ducks wintering in Germany have increased, because the winter range of some species has moved in response to milder winter conditions in central Europe.
- ➔ Long-distance migrants such as **tree pipit**, **wood warbler** and **European pied flycatcher** suffer from dramatic changes in landscape, on migration and on their African wintering grounds. Causes are drought, overgrazing, deforestation and expansion of desert.
- ➔ Long-distance migrants are particularly strongly affected by population declines, regardless of habitat preference, ecological guild, or genetic kinship. Therefore, rapidly changing conditions on the African continent should be brought more strongly within the focus of nature conservation.

Bird monitoring

In order to be able to make statements about the world of birds, we need to map and count as precisely as possible the breeding and resting birds which occur regularly in Germany.

We benefit from the presence of several thousand skilled and experienced, deeply committed bird-watchers, who willingly give their knowledge to non-profit service. Through this mostly voluntary collaboration, they all contribute to the permanent observation of our avifauna in the framework of so-called monitoring programmes, with which it is possible to describe

very accurately changes in distribution and numbers of bird species. Evaluation of habitats and their links with information on landuse allows analysis of causes of population change. This is used to develop recommendations for nature conservation policy.

Monitoring of common breeding birds by the Dachverband Deutscher Avifaunisten (DDA) – the Federation of German Avifaunists – has provided reliable information on the widespread common bird species of Germany since 1990. Further important modules of bird ob-

servation are the “rare breeding birds monitoring” and the monitoring programmes for resting waterbirds (e.g. International Waterbird Census, Trilateral Monitoring and Assessment Programm of the Wadden Sea, Seabirds at Sea), as well as monitoring of birds of prey and owls and the “Integrated Monitoring of Songbird populations”.

Further information on bird monitoring can be found on the homepage of the DDA under www.dda-web.de, in particular in the online information system “Vögel in Deutschland” [“Birds in Germany”]



The population of common wood pigeon in Germany is stable. Photo: T. Krüger

Population trends of 64 common breeding birds in Germany between 1990-2005.			
Species	Trend 1990-2005	Species	Trend 1990-2005
Common pheasant	↘	Common chiffchaff	→
Northern lapwing	↓↓	Willow warbler	↓
Stock dove	↑↑	Goldcrest	↘
Common wood pigeon	→	Firecrest	↑
European turtle dove	↓	Spotted flycatcher	→
Common swift	↘	European pied flycatcher	↓
European green woodpecker	↑↑	Long-tailed bushtit	→
Black woodpecker	↑	Marsh tit	→
Great spotted woodpecker	↗	European crested tit	↑
Eurasian skylark	↘	Coal tit	↑
Barn swallow	↓	Blue tit	→
Common house martin	↓	Great tit	→
Tree pipit	↓↓	Eurasian nuthatch	↗
White wagtail	↓	Eurasian treecreeper	↘
Winter wren	↑	Short-toed treecreeper	→
Dunnock	→	Eurasian golden oriole	↓
European robin	→	Red-backed shrike	→
Common nightingale	↑	Eurasian jay	↗
Common redstart	↑	Eurasian magpie	↘
Black redstart	→	Carrion / Hooded crow	→
Common blackbird	↗	Northern raven	↑
Mistle thrush	→	Common starling	→
Song thrush	→	House sparrow	↘
Common grasshopper warbler	↓	Eurasian tree sparrow	→
Marsh warbler	↑ ↓	Common chaffinch	→
Eurasian reed warbler	→	European serin	↓
Icterine warbler	→	European greenfinch	↑ ↓
Lesser whitethroat	→	European goldfinch	↘
Common whitethroat	↗	Common linnet	↓
Garden warbler	→	Eurasian bullfinch	→
Eurasian blackcap	↑↑	Yellowhammer	→
Wood warbler	↓↓	Common reed bunting	→

Legend: ↓↓ = strong decline (> 50 %), ↓ = decline (20-50 %), ↘ = moderate decline (< 20 %), → = Population fluctuating and/or without trend, ↗ = moderate increase (< 20 %), ↑ = increase (20-50 %), ↑↑ = strong increase (> 50 %), ↑ | ↓ = increase in the first, decline in the second part of the period

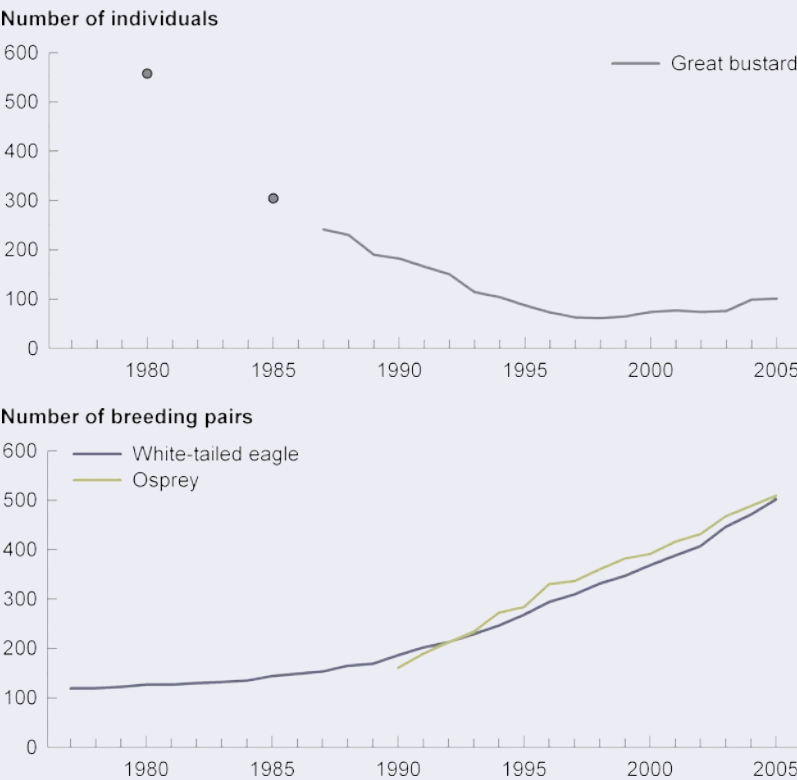


Little owl benefits from nest boxes, but needs further optimal habitat conditions. Photo: H. Glader

In various ways, several thousand volunteers, nature protection organisations and foundations as well as public authorities are involved in species conservation. The activities range from installing nest boxes, to the purchase of ecologically valuable areas and their ecologically-friendly cultivation, to payment of compensation for profits lost by farmers and forest owners. Has the conservation situation improved for species for which particular protection measures have been in place for several years? Experience shows that those species that are in the public eye may have been helped through specific supporting measures.

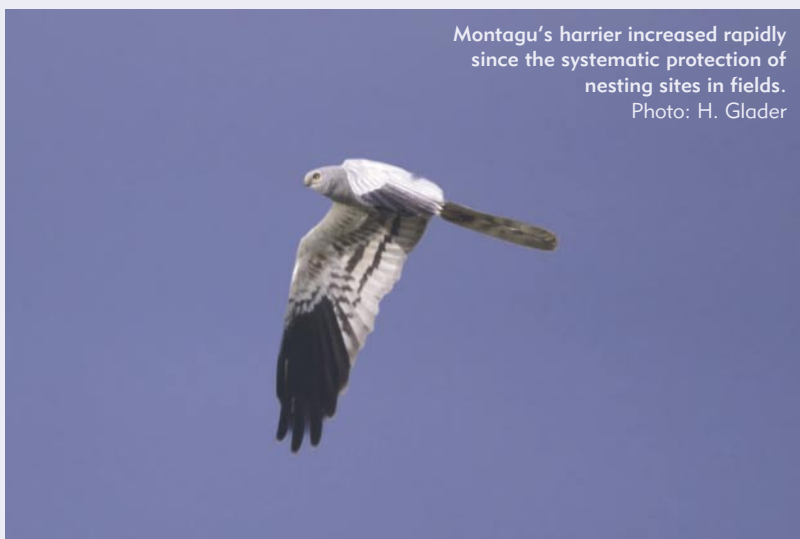
The installation of artificial nests and nesting assistance are easy measures to support breeding populations of endangered species: **osprey** and **peregrine falcon** have both benefited. For species that are particularly sensitive to disturbance, such as **white-tailed eagle** and **common crane**, securing breeding sites and introducing nest protection zones have been proved to work.

The growing breeding population of **Montagu's harrier** proves that successful protection of nest sites can also be practised on land used for agricultural crops. Since the start of state-aided species recovery programmes, the population increased nationally to between 430 and 460 pairs. In the mid 1990s the species was still „critically endangered“ on the Red-List.



Thanks to intensive efforts, in 1998 the population of **great bustard** increased at the three remaining breeding sites in Brandenburg and Saxony-Anhalt for the first time in decades of decline. In 2005, more than 100 birds were recorded. The population of **Eurasian eagle-owl** reached a low point of 70 pairs at the end of 1950s, but by 2005, large areas of Germany had been repopulated and more than 1,000 pairs were registered. While the population continues to increase in northern and western Germany, numbers are stable or even locally decreasing in South Germany. This species is supported through reintroduction in Schleswig-Holstein.

Due to enormous voluntary engagement, which has been given to species recovery programs for decades and is funded by donations as well as by public authorities, species such as **barn owl** and **little owl** also profit from the construction of nest boxes and nest holes, as do



Montagu's harrier increased rapidly since the systematic protection of nesting sites in fields. Photo: H. Glader

European golden plover from clutch protection, and **black tern** and **common tern** from the installation of breeding rafts.

For the permanent protection of many endangered bird species, species action plans are indispensable. However, these plans can only proceed in the long term if the preservation of natural habitats is given the highest priority. With the designation of Special Protection Areas (SPAs) under the EU Birds

Directive, Germany is on the right track to secure for future generations a comprehensive species diversity as a national contribution to the European NATURA 2000 site network. By April 2008, Germany had designated 734 SPAs (11.1% of the land area). In addition, almost 1.9 million hectares of sea, bays, intertidal areas and parts of Lake Constance are also included in the network. Further proposals for bird protection areas will be made in 2008.

Population trends for selected species between 1996 and 2005, which benefited by special protection activities at the nesting sites. All numbers represent breeding pairs. (except individuals = ind.)					
Species	Trend 1996-2005	Population 2005	Species	Trend 1996-2005	Population 2005
Black stork	↑	500-530	Common crane	↑↑	5200-5400
White stork	→	4200-4300	Great bustard	↑↑	101 ind.
Osprey	↑↑	500	European golden plover	→	8
Golden eagle	→	46	Black tern	→	760-790
Montagu's harrier	↑↑	430-460	Common tern	↑	11000
White-tailed eagle	↑↑	501	Eurasian eagle-owl	↑↑	1400-1500
Peregrine falcon	↑↑	800-830	Little owl	↑	8200-8400

Legend: ↓↓ = strong decline (> 50 %), ↓ = decline (20-50 %), → = stable (-20 % bis +20 %), ↑ increase (20-50 %), ↑↑ = strong increase (> 50 %)

Critically endangered birds



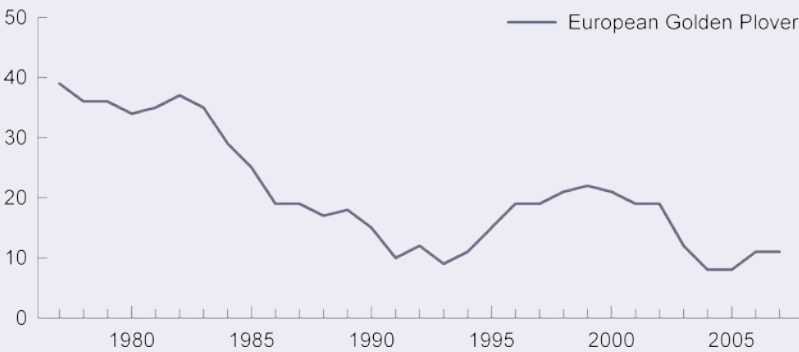
The black grouse is still threatened with extinction. Photo: H. Weindorf

At the beginning of this millennium, 26 species of breeding birds were critically endangered in Germany – as shown by the 2002 Red List. Has the ringing of alarm bells led to increased conservation effort? The balance is ambivalent: 4 species recovered slightly, for 12 species, the negative population trend has been stopped and for another 4 species the rate of decline could at least be slowed. However, for 5 species the conservation effort needs to be intensified considerably if they are to be prevented from becoming extinct...

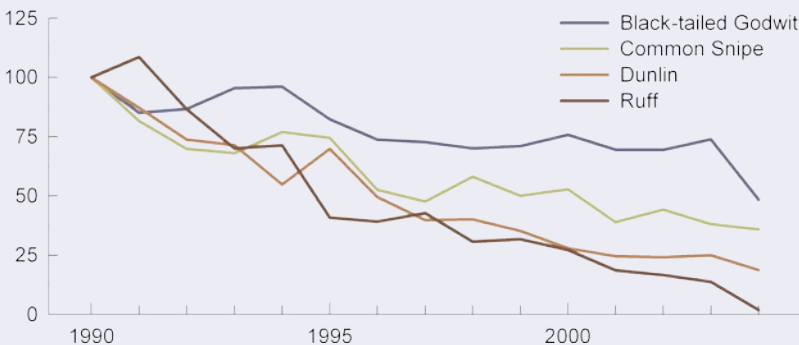
...a fate, which has already befallen the **European roller**, which bred for the last time in Baden-Württemberg in 1994. Populations of **ruff**, **dunlin**, **woodchat shrike** and **aquatic warbler** are threatened with immediate extinction in Germany. **Kentish plover** breeding on the North Sea coast show an unremittingly strong downward trend. Away from the Alps, **black grouse** are

severely threatened, and have been lost from most of the moors and heaths in north Germany where they previously occurred. An exception is the increasing population in the Lüneburg Heath. Inland breeding numbers of **black-tailed godwit**, a target species of the wet meadow protection programmes of several federal states, have continued to decline, in spite of the wide-

Number of possible breeding pairs



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spread purchase of ecologically valuable meadow areas. After nearly two decades of intensive efforts, the first signs of success can be detected in protection areas. This gives rise to hope that the federal and state government conservation programmes for protecting wet meadows and bogs are slowly beginning to succeed.

European golden plover have also benefited from extensive nature protection measures, which have allowed the small remnant population in Lower Saxony to be maintained with increasing breeding success.

The breeding populations of **black tern**, **short-eared owl** and **Eurasian hoopoe**, which showed heavy losses between 1975 and



The decline of black-tailed godwit has not been stopped, but slowed in protected areas. Photo: H. Glader

1990, have stabilised since the middle of the 1990s.

The population of **Eurasian bittern**, a widespread inhabitant of reedbeds, has recovered from

heavy losses due to two cold winters in the middle of the 1990s. **Ferruginous duck** breeds – after an absence of more than 20 years – since 1997 again regularly in Germany.

Population trends of „critically endangered“ species contained in the Red Data Book (2002), between 1996 and 2005. All numbers represent breeding pairs (exceptional individuals = ind.)					
Species	Trend 1996-2005	Population 2005	Species	Trend 1996-2005	Population 2005
Ferruginous duck	↑↑	2-9	Common sandpiper	→	260-330
Black grouse	↓	1000-1400	Ruff	↓↓	19-39
Western capercaillie	↓	580-780	Dunlin	↓↓	8-13
Eurasian bittern	↑↑	580-640	Caspian tern	→	0-2
Least bittern	↑	97-150	Black tern	→	760-790
Northern harrier	→	52-62	Short-eared owl	→	70-170
Great bustard	↑↑	101 ind.	European roller	ex	0
Spotted crane	→	570-810	Eurasian hoopoe	→	380-450
Little crane	→	33-49	Woodchat shrike	↓↓	1-2
European golden plover	→	8	Great grey shrike	→	1900-2400
Kentish plover	↓↓	181-183	aquatic warbler	↓↓	6
Black-tailed godwit	↓	4700	Collared flycatcher	→	4100-5600
Common snipe	↓	5700-6600	Rock bunting	→	360-440

Legend: ↓↓ = strong decline (> 50 %), ↓ = decline (20-50 %), → = stable (-20 % bis +20 %), ↑ increase (20-50 %), ↑↑ = strong increase (> 50 %)

Birds as indicators



The red-backed shrike is one of ten indicator species for the habitat „farmlands“. Photo: H. Glader

As a signatory to the “Convention on Biodiversity”, Germany has committed itself to stopping the decline of species diversity. In order to assess whether this aim can be achieved, performance indicators have been developed which react sensitively to changes in the use of our natural resources. Indicators are important aids to display complex connections in a clear and simple way. They also clarify to the public and politicians, where nature conservation action needs to be taken.

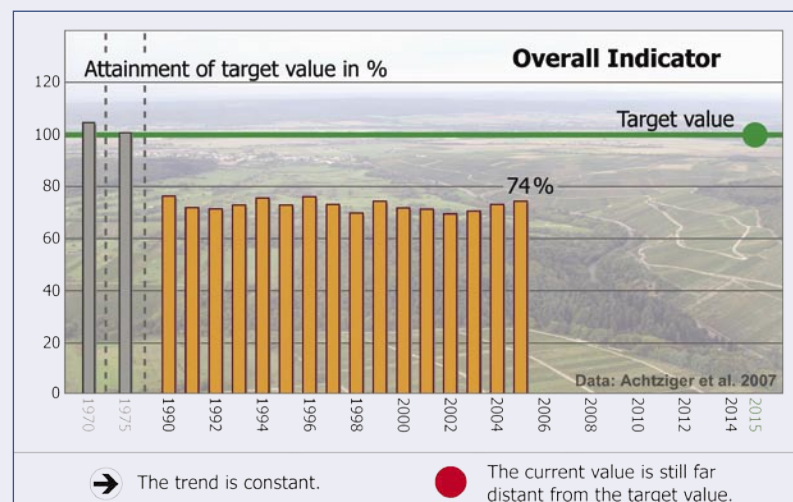
Sustainability indicator for species diversity

The sustainability indicator for species diversity is one of 21 indicators, against which the proposed aim of sustainable development in Germany shall be assessed. This indicator displays the quality of nature and landscape and is based on the population trends of 59 selected bird species that represent the most important landscape, habitat and landuse types in Germany (farmland, forests, settlements, inland waters, coasts and seas and the Alps). The size of the populations directly reflects the suitability of the landscape as

habitat for the bird species concerned. As many species besides birds are also bonded to a rich and diverse landscape with intact, sustainably used habitats, the indicator also indirectly measures species diversity and sustainability of landuse, when considered on a large scale.

An expert panel has determined target population levels for 2015 for each bird species; these are achievable if legal requirements for nature conservation and guidelines for sustainable development are put into practice.

The indicator shows that current landuse in Germany is not



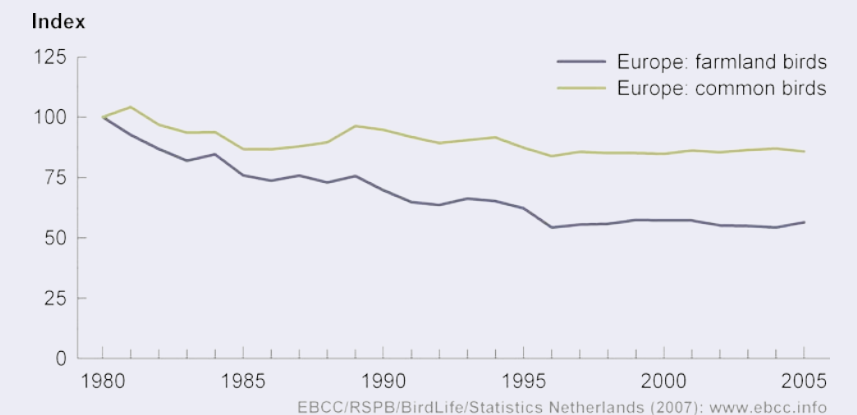
sustainable and no trend is recognisable regarding the target values for 2015. Therefore additional efforts are necessary in order to hit the target and to secure the conservation of species diversity.

‘Wild Bird’ indicators for Europe

The view over the border of Germany shows that the European “Wild Bird Indicator”, which summarises the population trends of 124 common bird species of all habitats, showed a moderate decrease in the 1980s, but stabilised since the mid-1990s. The “Farmland Bird Indicator”, which belongs to the EU-guideline indicators for the “management of natural resources” shows that the situation for farmland birds has clearly developed negatively.



High responsibility: almost 60 % of all red kites worldwide are breeding in Germany. Photo: K. Budweiser



The population trend of great crested grebe is included in the indicator for the habitat of inland waters. Photo: T. Krüger

Farmland birds



The population of meadow pipit halved within the last 15 years.
Photo: H. Glader

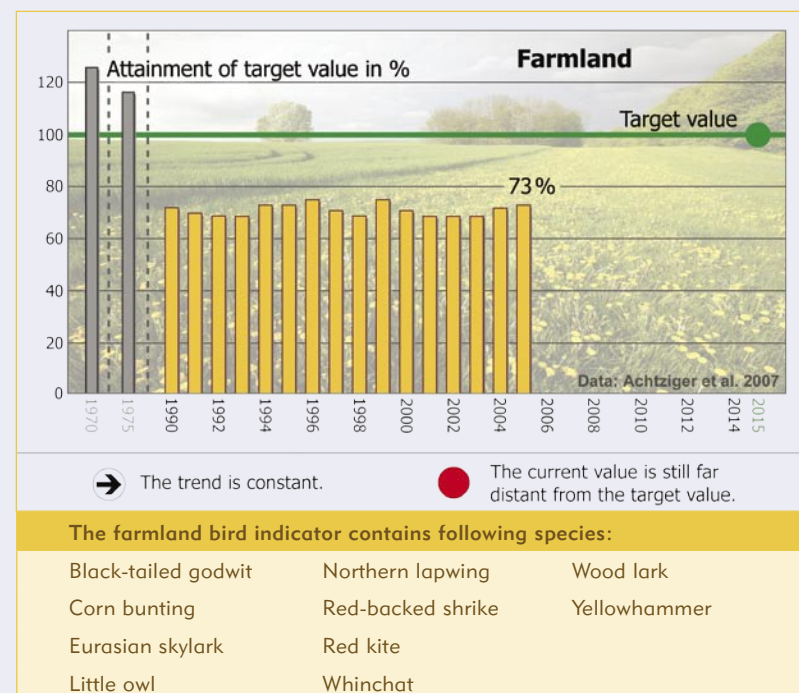
As in other European countries, a particular sharp decline of bird populations in agricultural landscapes was observed in Germany between 1960 and 1990. West and East Germany experienced a dramatic intensification of agricultural production through mechanisation, pesticide and fertiliser application, as well as measures to improve the land, e.g. through dewatering, drainage, installation of flood defences, as well as consolidation of farmland and reclamation of waste land. Intensification of use and productivity, and loss of species diversity on agricultural land were disproportionately greater in West Germany than in East Germany. The causes for these declines are now well understood: particular problems are rapid and dense growth of crops, lack of food, habitat destruction, lack of crop diversity, drainage of wet grassland and high levels of predation by mammals.

Current trends

Populations of birds breeding on arable land developed differently following German reunification: declines continued in the west, while a recovery of many species (e.g. **yellowhammer** and **corn bunting**) was observed in the east after reorganisation of

agriculture and an increase of set-aside areas to 15-20 % of the arable land. However, here too the data mainly show declines since the late 1990s.

The population trends of **northern lapwing**, **Eurasian skylark**, **whinchat** and **meadow pipit** represent many ground-

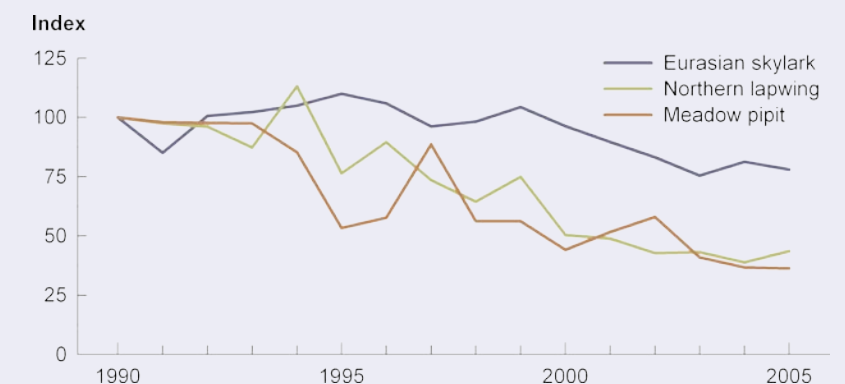


nesting birds, which were also affected by continuing declines over the last 15 years. Even more threatened are species of marshland areas: **dunlin** and **ruff** have become almost extinct in Germany; the breeding population of **black-tailed godwit** has shrunk to less than half its former level, and the **Eurasian curlew** population is in sharp decline. When considering birds breeding in arable landscapes, no clear winners can be found: only **western yellow wagtail** is able to use intensively cultivated field areas as breeding habitat.

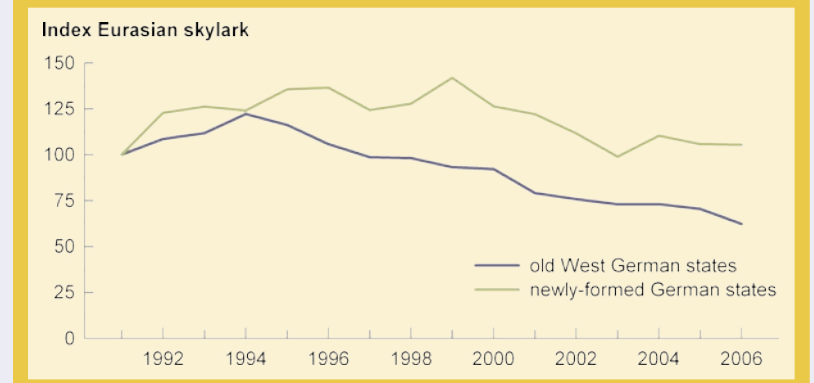
Due to current farming conditions, many species are no longer able to breed, or to rear their young successfully. Drainage measures cause reductions in food supply and encourage the spread of predatory mammals, for which nests or not-fully fledged young are easy prey. Climate change and over-fertilisation add to the wider negative trend in breeding conditions: cultivated plants grow earlier, faster and more densely than a few decades ago. This is a problem for ground-nesting birds.

Bird species nesting in hedges and shrubs show less distinct population trends: while **common nightingale** and **common whitethroat** now show positive trends following population collapse in the 1970s, the numbers of **willow warbler** and **common linnet** have declined continuously.

In western and southern Germany almost a rarity: a singing Eurasian skylark.
Photo: M. Schäf



Example Eurasian skylark: The already high densities of this typical farmland bird in East Germany increased even more following German Reunification, while in West Germany – after a short population recovery – declines clearly continued. Since 1999, this species has decreased at the same rate in both parts of Germany.

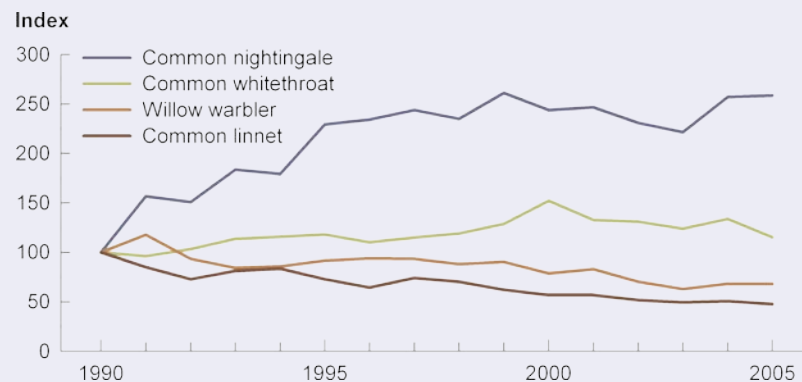




New threats

Rapid changes in ecological and political determining factors over the next few years could cause further wide-ranging and immediate population losses for birds of agricultural landscapes.

As a consequence of increased crop prices and concurrent increased demand for land used to produce so-called energy crops (in particular maize for bio-gas) at explosive rates, the pressure on farmland has risen considerably in Germany, as well as in other European countries, over a relatively short time. A first consequence of this development at a European level is the suspension of compulsory set-aside. As a result, the proportion of fallow land in the landscape will be noticeably less from 2008. This will have a massive



impact on the population levels of many bird species.

A second consequence is the further spread of monocultures (above all, maize), with expected negative impacts on biodiversity in agricultural regions. Already noticeable is loss of grassland, which is less profitable than arable, even more so today than several years ago. Many of the most endangered bird species are grassland specialists. Compensation payments within the framework of agri-environment programmes are likely to be uncompetitive compared with potential future earnings, with the result that either farmers will lose interest in those programmes in the near future, or – if average

payment rates are increased and if the budget remains the same – a smaller total area is included in the programme. In either case, the significance of the contract based nature protection scheme might be weakened.

New and largely unexplored regarding their impacts, are the first releases of genetically modified crops, with the connected push to intensify agricultural land. Regardless of possibly unwanted impacts, the wanted impacts of genetically modified crops (GM crops) currently pose a potential threat to nature protection targets: GM crops allow intensive landuse on an unprecedented scale so far, resulting in sterile, homogeneous blocks

of economic plants. If GM crops are cultivated increasingly in the future, it must be feared that populations of many farmland birds would decline further.

The consequences of climate change for farmland birds are currently not predictable. As climate change affects bird habitats not only directly, but also indirectly, due to changed forms of farmland cultivation, complex correlations are unfolded which allow only a few concrete prognoses. Birds of grassland are likely to be particularly affected, as their conservation status is already recorded as critical.

Farmland birds

Organic farming assists the biodiversity and the species frequency of agrolandscapes.
Photo: M. Herrmann



Taking into account continuing negative population trends, and the massive new threats, the aim of halting biodiversity loss on farmland by 2010 is likely by-and-large to be missed.

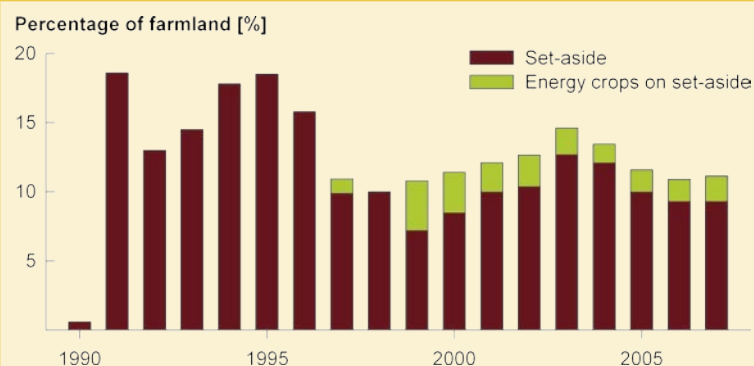
To save farmland birds is possible

The knowledge of how to help farmland birds is largely available. A number of small measures

(e.g. laying out strips of fallow land, skylark patches, or hedges) are some of the improvements that can be achieved at a local scale. Effective, wider-ranging solutions have also been tried out. Compared with conventional agriculture, organic farming significantly increases the likelihood of higher bird densities.

Large scale protected areas, e.g. biosphere reserves, can also make a significant contribution. For example, the population of farmland birds developed better on large reserves in East Germany than in the wider countryside. The population trends for **corn bunting**, **yellowhammer** and **Eurasian skylark** indicate successes: while popu-

Factor of set-aside of agricultural land: In eastern Germany between 1991 and 1996, the proportion of set-aside was temporarily very high (15-20%), but then declined to 10% (example shown here is the state of Brandenburg; data: ZALF Müncheberg). This factor proved to be significant for population trends of many farmland birds.

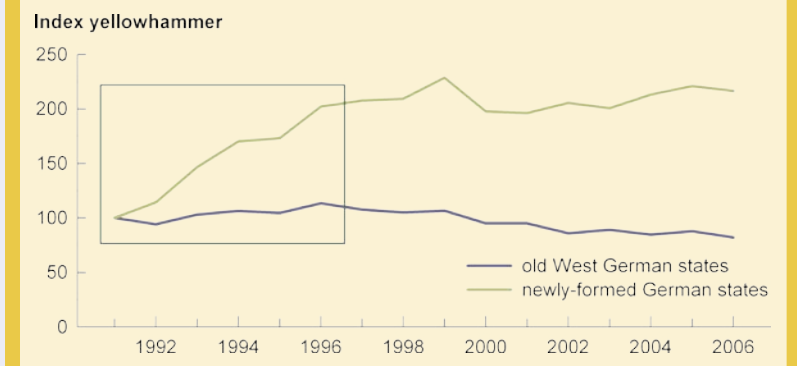


lations remain stable in the wider countryside of East Germany outside reserves following declines in set-aside since the mid-1990s, numbers on large scale protected areas clearly increased, even in recent years. By contrast, **corn bunting** has almost completely disappeared from farmland in most regions of West Germany.

The management of wet grassland has also shown some progress. Through direct rewetting, reversion of arable fields to meadows and pasture often in close collaboration with farmers – at least some populations could be supported at some localities.

Thus, tested action strategies exist to halt the decline of bio-

Example yellowhammer: Numbers of yellowhammer remained constant in West Germany until 1996, but then decreased, while in the east, particularly during the establishment of agricultural set-aside, this species increased enormously and the population doubled! Since the reduction in set-aside to around 10% of farmland, the population has levelled off in the east.



logical diversity on agricultural land. These include the promotion of organic farming and extensive pastoral agriculture, as well as maintaining at least 10% of the agricultural landscape as

fallow land, as indicated by the conclusions of several research projects. However, implementation of these measures is still a problem.

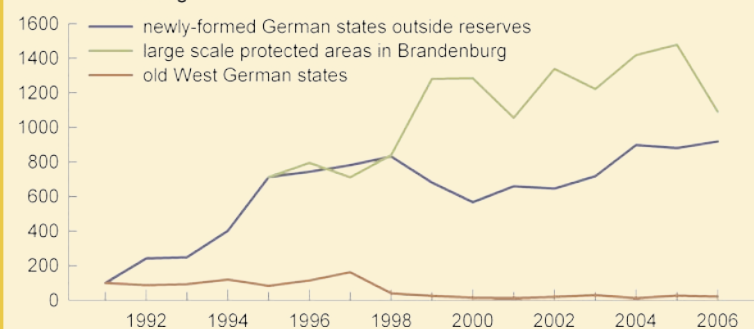
Yellowhammer show different population trends between eastern and western Germany. Photo: M. Schäf



Farmland birds

Example corn bunting: The steep rise in eastern Germany during 1991 and 1996 is linked to the phase of increasing levels of set-aside. However, further increases after 1998 only occurred on large scale protected areas and not in the wider countryside.

Index corn bunting



Overview of trends in agricultural landscape

- Most typical bird species of agricultural land are decreasing; declines have accelerated since the late 1990s.

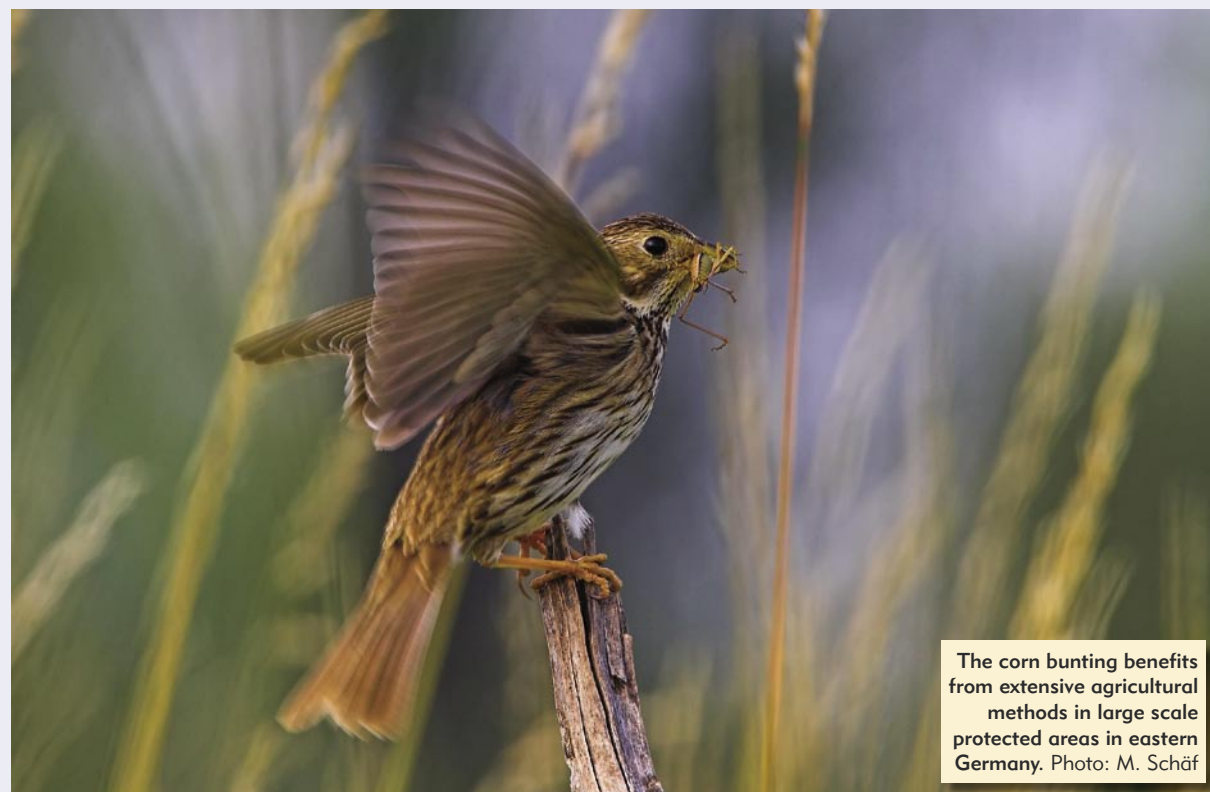
- Reasons for these declines are well researched for many species. Fallow land and set-aside are key factors; the cancellation of compulsory set-aside and the boom in “energy crops” (e.g. maize)

Conclusion and recommended courses of action

Because of current increases in agricultural prices and the competition for land used for energy or food production, it is essential to provide the second pillar

indicate dramatic population collapses within the next few years. The policy target of halting the loss of biodiversity by 2010, cannot be reached in this way.

- The mainly positive developments on organic farmland and large reserves show one way to save the biodiversity of our agricultural landscape.



The corn bunting benefits from extensive agricultural methods in large scale protected areas in eastern Germany. Photo: M. Schäf



The loss of fallows due to the production of energy crops threatens seed-eating birds like the grey partridge. Photo: M. Schäf

of EU agriculture policy (rural development) with efficient and well-resourced development programmes and to define sophisticated environmental standards for cross-compliance. In order to avoid a new wave of intensification, with increasing declines of species on agricultural land, the following measures are required over the next few years:

- ➔ Clear **expansion of rural development** through re-deployment of EU agricultural payments by 20% into the second pillar in the framework of the forthcoming mid-term assessment of the Common Agricultural Policy in 2008,
- ➔ Creation of uniform, **performance-related financial**

- instrument** for sustainable development of agricultural regions within the EU from 2014,
- ➔ Improvement of environmental standards of **cross-compliance** by compulsory establishment of ecologically important areas (e.g. farm woodland, strips of flowers, managed fallow land, extensive grassland) over at least 10% of farmed areas, tightening the ban on ploughing grassland in sensitive areas, and maintaining at least three-year crop-rotation systems,
- ➔ Focussing financially and in content on **agri-environment programs** for particular ecological efficient measures

- (e.g. nature conservation of fallow land, preservation of species-rich grasslands, promotion orientated on success, enhancement of farmland, business development programmes),
- ➔ Further development of the promotion of **energy crops** in harmony with environment-friendly farming, by complementing existing promotional instruments on ecological minimum-criteria (e.g. regarding biogas plants, the maize proportion needs to be restricted to no more than 50% as well as the maintenance of three-year crop-rotation).



Germany is located in the middle of the European natural range of beech forests, whose area increased in the last 15 years. Photo: S.Ellermann

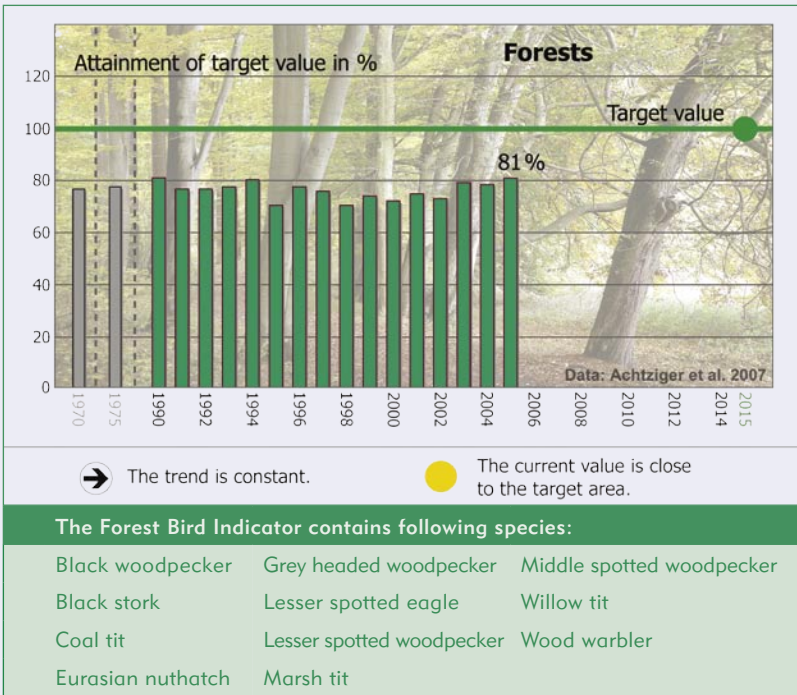
Forest bird populations have developed inconsistently. The forest bird indicator stagnates, but a slightly positive trend is noticeable since the millennium. For some species, this could be due to increasing abandonment of rotational clear-cutting and the trend to continuous forest use (selective cutting). However, there are signs that improvements in forest management are currently being negated by intensified felling. It is also notable that overall numbers of many common forest bird species increase, but that these increases actually occur outside forests, namely in settlements, gardens and parks.

Actual trends

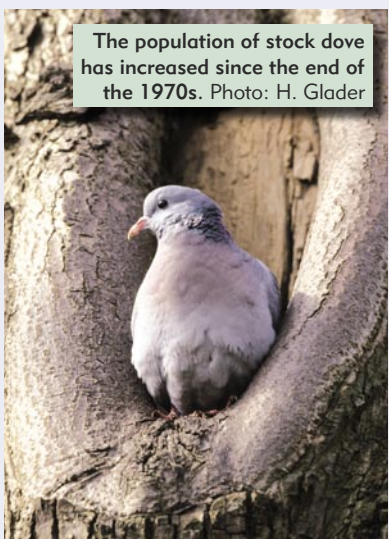
Better protection of mature forest stands and the increasing average age of our forests (increased stock of wood) have encouraged populations of many species breeding in holes, such as **stock dove**, **black woodpecker**, **great spotted woodpecker**, Tit species and **Eurasian nuthatch**. Common birds of coniferous forest, such as **European crested tit**, **fire-crest**, **coal tit**, **Eurasian pygmy**

owl and **boreal owl**, are also among the winners.

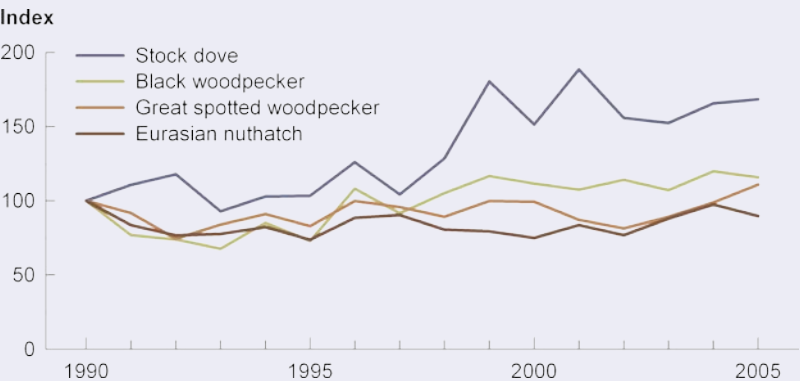
Populations of nearly half of 52 common forest species have increased since 1990. However, these increases did not occur predominately or exclusively in forests, but rather in settlements. The growth of green space and the increasing age of trees in cities, villages and gardens enables more and more forest birds to settle in urban habitats.



The Eurasian nuthatch and several hole-nesting birds are the winners of forest birds. Photo: H. Glader



The population of stock dove has increased since the end of the 1970s. Photo: H. Glader

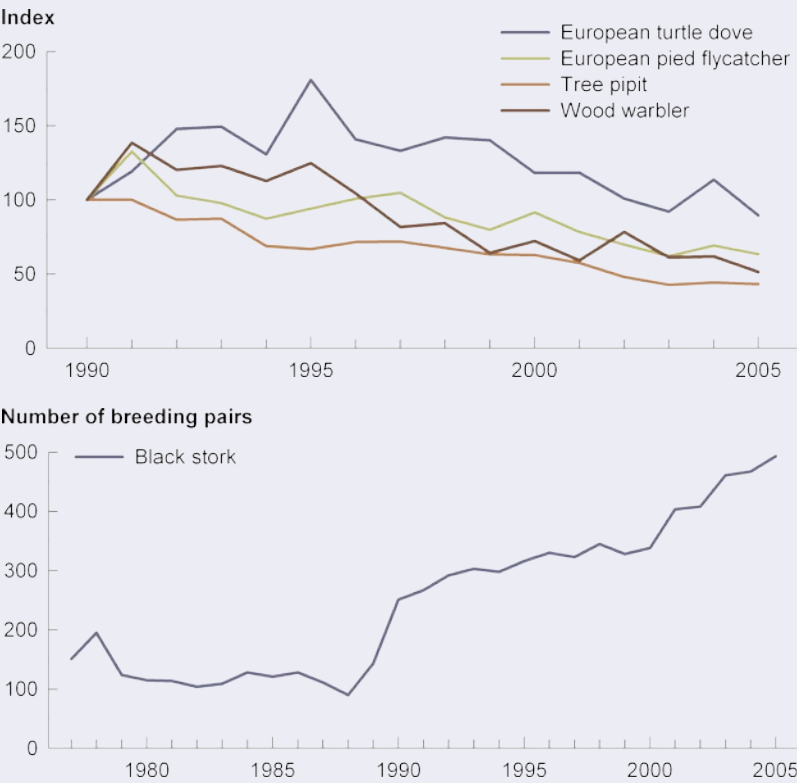


The tree pipit and other long-distance migrants are the losers of forest birds. Photo: J. Ruddek

Particular losers among forest birds are long-distance migrants, such as **European turtle dove**, **European pied flycatcher**, **tree pipit** and **wood warbler** – species which annually cover distances of several thousand kilometres between their local breeding areas and wintering grounds in Africa. It seems that the reasons for these declines are found not so much in Germany, but rather along migration routes, or on the wintering grounds.

Losers and winners can also be found among large birds living in forests. Combined with the resettlement of the German low mountain range, numbers of **black stork** have increased since the late 1980s – also a result of intensive species protection measures. In contrast, the population of **lesser spotted eagle** decreased continuously in spite of species conservation efforts since the mid-1990s.

Forest birds



The breeding population of **red kite** – of which nearly 60% of the entire world population occurs in Germany and for the conservation of which we therefore carry a particular responsibility – has declined by more than 25% since the end of the 1980s; this decrease is significantly caused by a collapse of the population in the core red kite area in Saxony-Anhalt. The population of the secretive **European honey buzzard** shows a similar trend over the same time period. The declines are connected to the decline of cultivation of fodder crops (leys) and summer cereals, as well as the loss of insect-rich, extensively used cultivated landscapes. This leads to a reduction



The lesser spotted eagle – a rare and declining breeding bird in northeastern Germany – inhabits a mixture of near-natural woodlands and extensive grasslands. Photo: H. Glader



in food supply (for example common hamster, wasps), and, in addition, prey species are also difficult to catch due to dense and high vegetation even in early spring. The changes in vegetation cover and phenology are a result of the use of agricultural fertilisers and the nutrient effect of atmospheric inputs.

Our woodland grouses, **western capercaillie** and **hazel grouse**, are also decreasing. While the **western capercaillie** suffers losses of berry-rich, well-structured coniferous and mixed mountain forest habitats, and in the 1990s the last lowland populations were lost from the berry-rich, pine-sessile oak woods of Lusatia, the **hazel grouse** has





The population trend of great spotted woodpecker is decisive affected by crops of mast.
Photo: H. Glader

disappeared from many areas following the abandonment of traditional coppice management of woodland. Woodland grouse are particularly disadvantaged by the control of deciduous softwoods, as well as the wide-spread suppression of natural woodland regeneration due to afforestation.

New threats

For several years strong growth in demand for timber and an increase in timber prices have been noticeable. Not even the large quantities of fallen timber, caused by storm Kyrill in January 2007, could affect the price of timber. Pulp production, as well as wood chip and wood pellet fired heating systems are becoming more common. This means that increasingly not only good-quality timber, i.e. premium trunkwood and veneers, but also wood previously considered as low quality (broken branches, dead wood, soft woods and young trees, brush) can be used profitably. Accordingly, the felling rate has increased strongly in recent years. Likewise, there is a current increase in the use of domestic firewood.

These developments might be a cause for concern, as the so far stable to positive trends for bird species that depend on old and dead wood, such as woodpeckers, treecreepers, **Eurasian nuthatch** and other hole-nesting



The increase of forest birds has occurred in settlements, but not in the forests itself, where several species – as the European robin – decline. Photo: T. Krüger

birds, might decline. Frequent heavy use, increased numbers of wood collectors and higher levels of use and work during the breeding season causes more disturbances in old woodlands and causes the displacement of

disturbance-sensitive species, such as birds of prey, **black stork** and **common crane**.

It seems that so far, climate change has had no direct impact on forest birds. Some species

Population development of a number of typically forest birds, which show different trends inside and outside of woods. Trend numbers specify the average population change (in %) per year since 1991.			
Species	Trend inside of forests	Trend outside of forests	Difference
European green woodpecker	-1,6	+7,2 **	*
Great spotted woodpecker	+1,4 *	+5,1 **	*
Winter wren	+0,4	+3,6 **	**
Common blackbird	-0,2	+1,3 **	*
Eurasian blackcap	+3,2 **	+7,5 **	**
Garden warbler	-0,4	+5,6 **	**
Common chiffchaff	-0,6 *	+2,3 **	**
Goldcrest	-2,5 **	+8,7 *	*
European robin	-0,6 *	+1,3 **	*
Great tit	-0,5	+1,0 **	*
Eurasian jay	-1,8 *	+7,4 **	**
Song thrush	-0,6	-3,1 **	*
Hawfinch	-1,2	-6,8 **	*
Legend: Black = different trends inside and outside of forests, red = significant decreasing trends, * = significant, ** = high significant.			



Seed-eating birds, such as the European crested tit, benefit from heavy mast crops, which could become more frequent due to climate change. Photo: H. Glader

(great spotted woodpecker, Eurasian nuthatch, tits and finches), which eat seeds in winter, even benefit from frequent and strong crops of mast, which are encouraged through mild winters and dry-sunny springs. Again, here the potential effect of warmer and drier summers might also overlap with changes in forest management (reduction of clear-cutting, increase of permanent forests)

which lead to darker and denser forest stands.

The increasing interest in cultivation of alien tree species, often fast growing conifers, caused by the fear of climate change, could also have a negative effect on long-term population trends of many species, which are tied to local forest types and their associated invertebrate species.



Protection and preservation of dead wood could benefit the willow tit. Photo: H. Glader

Overview of trends in forests

- Among the most common forest birds, more species have increased since 1990 than decreased, but these increases occurred mainly outside forests, in urban areas and parks.
- Long-distance migrants are particularly affected by population decreases.
- Hole-nesters and some large bird species profit from the occasional increase in old woods and the trend towards permanent forests-like types of landuse.
- Populations of some birds of prey, notably **lesser spotted eagle**, as well as grouses still decrease and need specific conservation programmes.
- Potential threats are current and possible future intensification of timber use, also the profitable use of low-quality timber, the increasing cultivation of alien tree species, as well as potential indirect impacts of climate change.

Conclusion and recommended courses of action

Top priority must be given to the protection of old trees, the promotion of varied woodland structure and of the co-existence of different forest development phases side-by-side, the preser-



Protection and preservation of old forests and dead wood will be essential to maintain population increases for grey-headed woodpecker and other species. Photo: H. Glader

vation of the highest possible numbers of ancient trees, as well as a sufficient stock of dead wood. For this, several instruments are suitable:

- ➔ Precise formulation of prescriptions for “good technical practise”;
- ➔ designation of an adequately dense network of wide-ranging protected areas (total reserves) and old forest islands;
- ➔ “Methusalem” projects for marking and preservation of old trees within a wider area, allowing them to become old naturally (for example, in the Brandenburg state forest 5 living old trees/ha are chosen,

marked with badges and excluded from use).

- ➔ The cultivation of alien tree species should totally be avoided in conservation areas and limited to a specific maximum (for example in public forests not more than 10%) outside conservation areas.
- ➔ Impacts due to activities (felling, moving trees) in potential breeding areas of species sensitive to disturbance should be limited to time periods outside the breeding season (October to February, or mid-January at **white-tailed eagle** breeding sites).

- ➔ At actual or potential breeding areas of **lesser spotted eagle**, **western capercaillie** and **hazel grouse**, specific conservation programs need to be drafted and put into action.
- ➔ The trend to promote local deciduous trees and local forest companies, as well as management to encourage mosaics of age classes and forest development phases (for example permanent forest, individual trunk selection, thinning, continuous cover forestry on small areas, and to an extent also forest meadows) should become stronger.



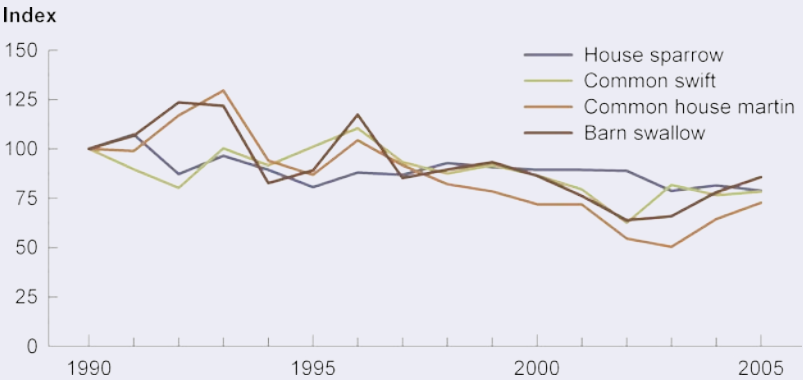
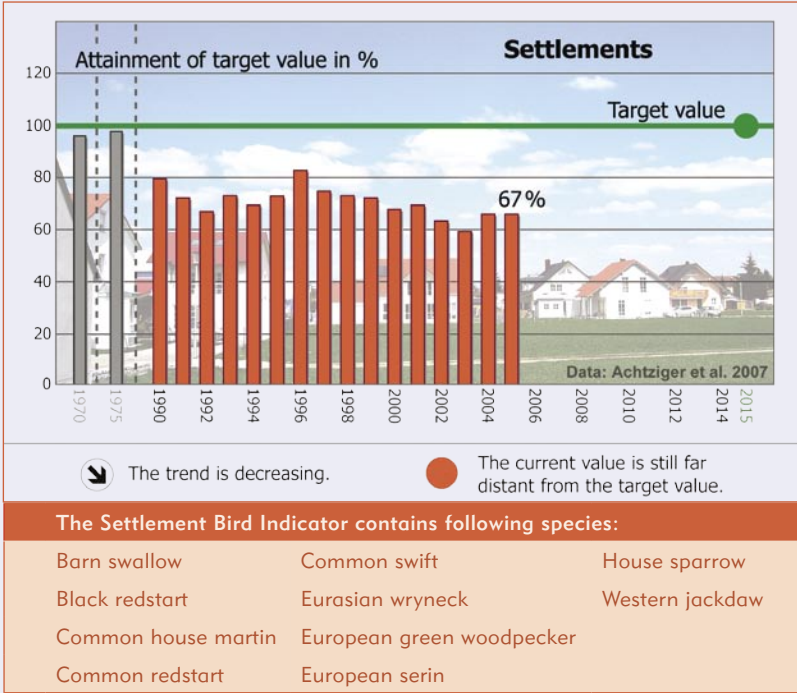
Populations of common swift and other birds of urban areas are decreasing. Photo: H. Glader

Overall, birds of urban areas show a negative trend over the last decade. Birds breeding at buildings and birds that almost exclusively occur in built-up areas or depend on farm buildings on the outskirts of towns and villages, have clearly decreased. Negative trends are caused by the loss of orchards, rural gardens and small domestic animals. In towns, redevelopment of buildings and building on fallow land has made it more difficult for many birds to find nest sites.

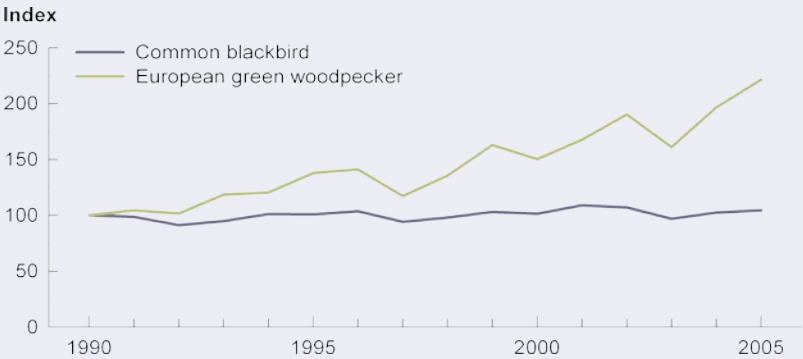
Birds that need breeding sites on buildings have shown an alarming, nationwide decline. The four most common building nesters in Germany – **house sparrow**, **common swift**, **common house martin** and **barn swallow** – show largely parallel population declines since the 1990s. **Eurasian collared dove** and **European serin** are also among the losers. **Crested lark** is now almost entirely absent; up to the 1960s, it was a common breeding bird on open, sparsely

vegetated industrial fallow land and gap sites.

Among the winners in towns and villages are birds that occur in green spaces, parks and gardens in residential areas. Birds that used to be forest species, such as **European robin**, **Eurasian blackcap**, **winter wren**, **European green woodpecker** and **great spotted woodpecker**, belong to this group. **Common blackbird** – next to **house sparrow** the most common



The house sparrow is one of the most common birds in Germany, but the population is declining. Photo: H. Glader

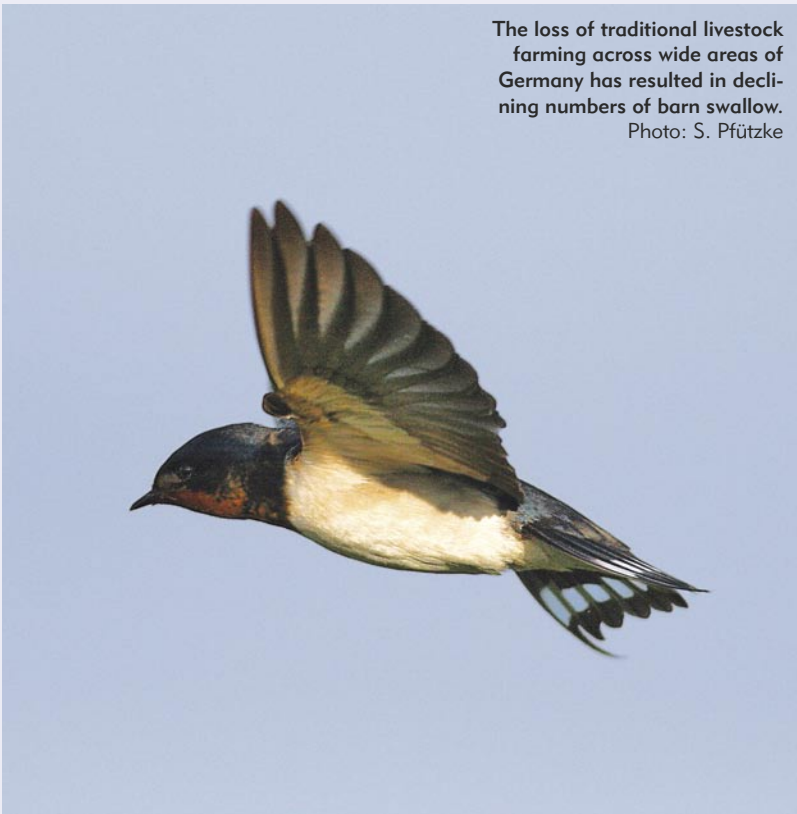


species of built-up areas – still show slightly growing populations.

Even though numbers of breeding **Eurasian magpies** have increased in towns and villages, it is increasingly disappearing from farmland, so that altogether the population trend tends to decline.

Breeding populations of **common kestrel** and **barn owl** have been protected for a long time through specific recovery programmes and by installing nesting boxes. **Peregrine falcons** have also profited from such measures, and successfully rear young in several cities: feral **domestic dove** are the main prey.

The loss of traditional livestock farming across wide areas of Germany has resulted in declining numbers of barn swallow. Photo: S. Pfützke





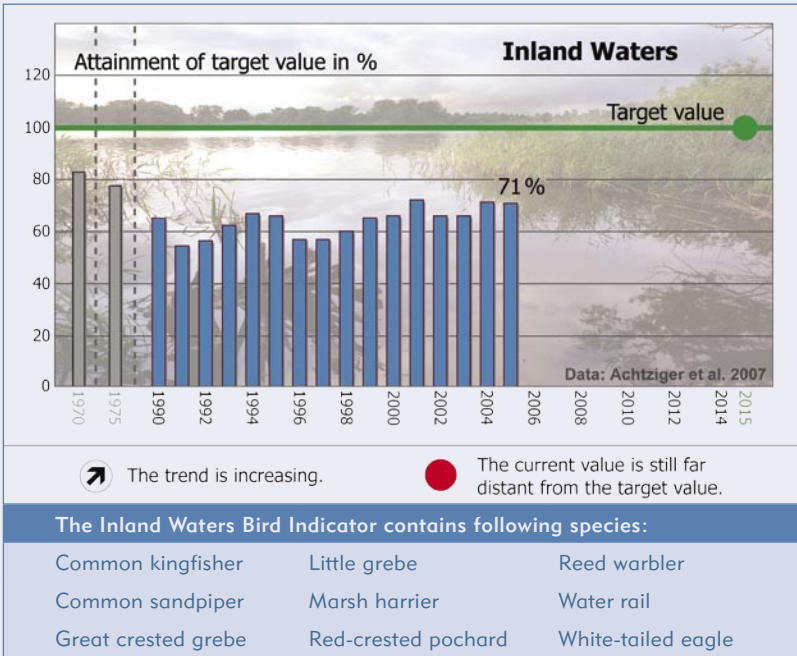
The population decline of black tern – caused by pollution and loss of natural breeding sites – can be halted with artificial nesting rafts.
Photo: C. Grüneberg

The populations of most wetland bird species show positive trends over the last 10 years. These increases often began during the second half of the 1980s, when programmes to improve the water quality of local rivers and lakes came into force. After high losses due to the development of water bodies during the 1960s and 1970s, the populations of many species have not recovered to their former size. After the water quality has further been improved, particularly for standing water bodies, measures must be taken with the aim of restoring wetlands to their natural state and allowing a natural dynamic of water bodies.

Despite enhanced wastewater treatments, the quality of most lakes has not or scarcely improved since 1990. High nutrient inputs from arable farmland (over-use of nitrate fertilisers) and slow rates of water exchange cause often very high nutrient contents of standing water bodies (eutrophic). As a result, populations of whitefish, insignificant for fishery, have increased steadily, which could benefit opportu-

nistic fish eaters, such as **great cormorant**, **white-tailed eagle** and **osprey**. Increasing population trends are also displayed by birds breeding in reeds at the edge of water bodies, such as **Eurasian bittern**, **bearded reedling** and **bluethroat**.

The water quality of rivers and streams has clearly improved. Due to better visibility in water bodies, fish are easier to catch, which might be also the reason



for population increases of **common merganser**.

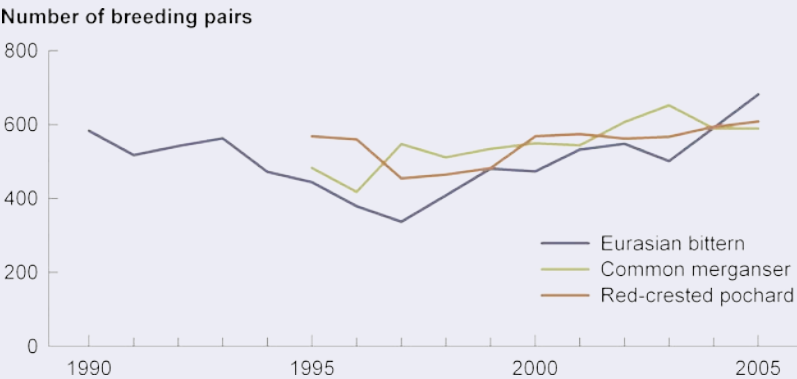
Red-crested pochard has also benefited from improved water quality: in Lake Constance, the German stronghold for this species, stoneworts have spread since the late 1980s. This is the main food source of **red-crested pochard** and so their population has increased steadily, currently in the southern federal states and in north-east Germany.

Over the last 20 years or so, it has been observed that a high number of introduced and escaped bird species are increasingly expanding their range in Germany. By now, almost a dozen non-native waterbird species are breeding regularly in Germany and species such as **Egyptian goose**, **ruddy shelduck**, **Canada goose** and **mandarin duck** are in some cases spreading quite quickly.

Recently, colonisation of waterbirds has also occurred without human assistance, for example, breeding populations of **whooper swan** and **barnacle goose** increase quickly in Northern Germany. If the increase of the globally endangered **ferruginous duck** was also “un-influenced” is not known. However, its numbers increase in Germany slightly, even still on a very low level, while in nearly all neighbouring countries the negative trend continues.



High nutrient contents of standing waters conducted a optimal food basis for white-tailed eagle. Photo: H. Glader



The red-crested pochard benefits from improved water quality. Photo: O. Nüssen

Coastal and sea birds



Northern gannet, common murre and other sea birds breed only on Helgoland, Germany's only off-shore island. Photo: J. O. Kriegs

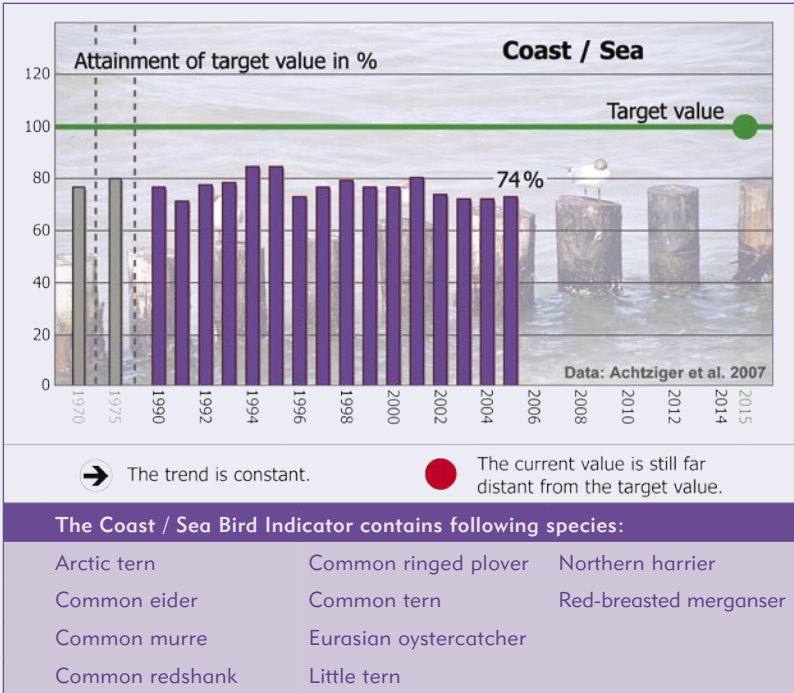
The “coasts and seas” indicator has remained stable over the last 10 years. Most coastal bird species are still increasing at the North Sea coast, but show decreasing trends at the Baltic Sea coast during the 1990s.

On the North Sea, increases of some species were the result of increased food resources due to nutrient accumulation and discards (un-used fishery waste). Conservation measures in the national parks were also a positive factor.

The status of **Kentish plover** is worrying, as the breeding population decreases in spite of intensive conservation measures. New concepts are necessary to improve the status of shore birds, including **little terns**: areas of the German Wadden Sea National Park with high natural beach and dune dynamic are not only

endangered by coastal protection measures; but must also be protected from recreation activities. This is particularly so if one takes into account rising sea levels, which threaten habitats of species that breed close to the high tide line.

Sea level rise will have a negative effect on bird life in the German Wadden Sea in the middle- and long-term. Increased energy input already means that smaller quantities of fine sediments, particularly mud, are deposited in front of the seawall. Birds that forage on muddy tidal flats, such as **avocets**, will increa-

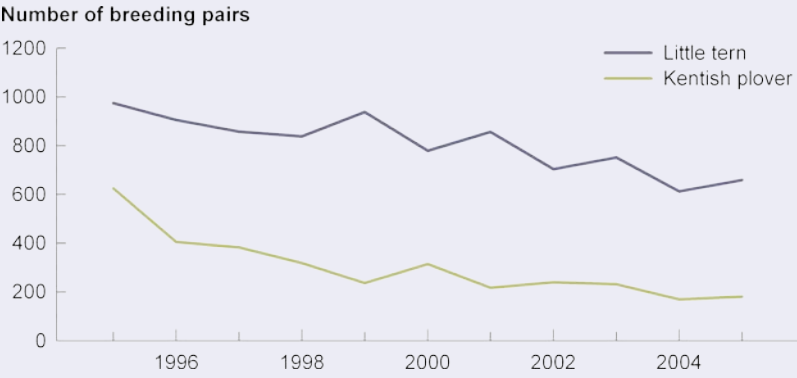


singly lose areas of foraging habitat. For energetic reasons, they need food-rich mud to rear their young, and so their breeding areas will increasingly deteriorate in quality. In addition, populations of these coastal breeding birds, whose conservation status is generally declining, suffer increasing pressure from predation, with many predators introduced or promoted by man.

The population dynamics of a typical bird species of the transition areas between the open sea and the Wadden Sea can be shown by the example of the **sandwich tern**. Here, multiple factors – including human persecution, marine pollution (pesticides), the designation of conservation zones (breeding sites), natural succession of breeding habitats and the natural



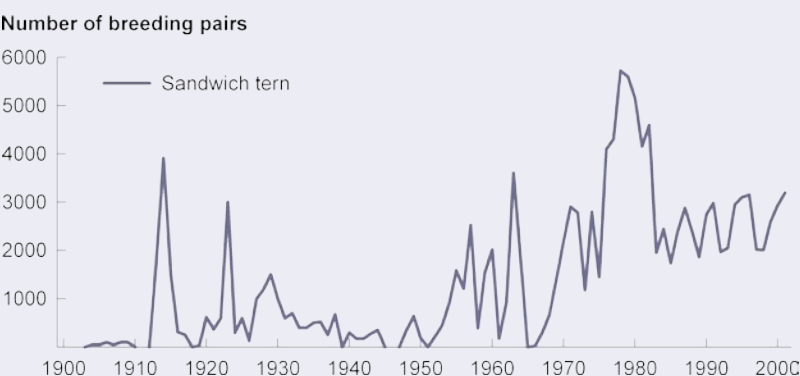
Decreasing: little tern.
Photo: J. Ruddek



Breeding birds of sands and coastlines – such as the common ringed plover – are threatened by tourism as well as rising sea levels. Photo: T. Krüger

Coastal and sea birds

Birds that forage on muddy tidal flats – such as avocets – will increasingly lose areas of foraging habitat. Photo: H. Glader



Multiple factors influence the breeding populations of sandwich tern. Photo: H. Glader

dynamics of the coastal sea – influence breeding populations. Short-term observations often present a different picture from population trends than a hundred year period.

In the Baltic, the situation of many coastal bird species has deteriorated: eleven ground-breeders are nearly extinct in Mecklenburg-Western Pomerania. For many coastal birds the protection and conservation of salt marsh as well as the continuation of extensive pasturage and hay cropping on coastal wet grasslands are all important for survival.

On Helgoland, breeding populations of seabirds continued to increase and **northern fulmar**, **northern gannet** and **razorbill** have reached new maximum values. Populations of **black-legged kittiwake** (ca. 7,500 breeding pairs) and **common murre** (ca. 2,500 breeding pairs) have now stabilised. For both species, the carrying capacity at Helgoland seems to have been reached. Numbers of **northern gannets** are still increasing, but there are signs that they will reach a plateau very soon.

For North Sea seabirds as a whole, it is generally the case that following strong population increases over the last decades, different trends are now detectable: **black-legged kittiwake** numbers are strongly declining, those of **northern fulmar** to a

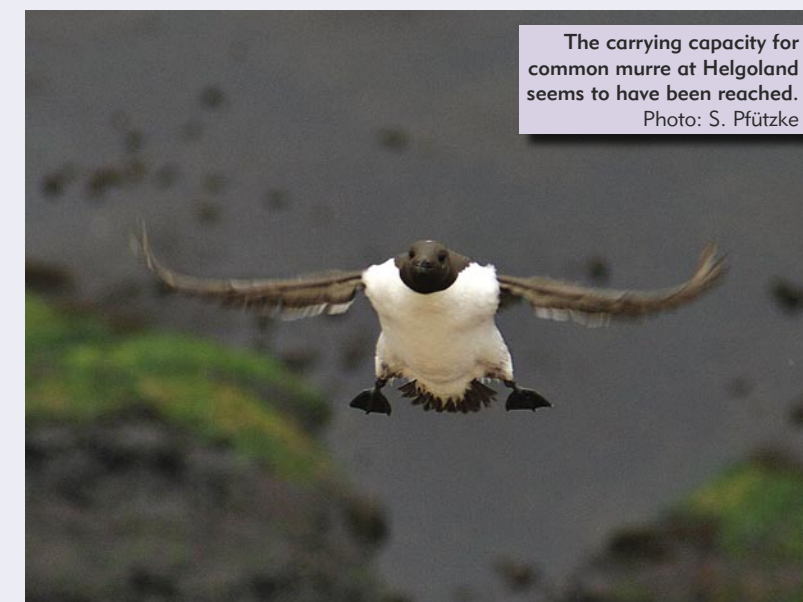
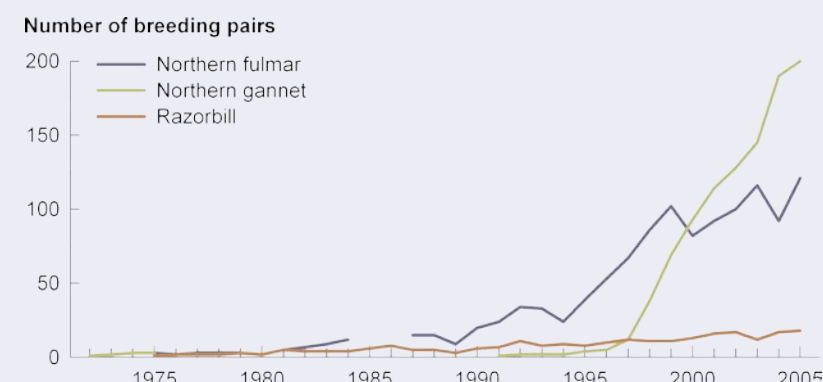
lesser extent. In contrast, **common murre** numbers increase only slightly, while **northern gannets** show a clear increase. Causes include different feeding strategies between species, as well as changes in the ecosystem of the North Sea, mainly due to climate change and fishing activities.

Conclusion and recommended courses of action

- ➔ Climate change and sea level rise will have adverse impacts on coastal breeding birds: therefore large protected areas are becoming more important, as birds can adapt more easily to changing conditions there than elsewhere. The protection of large areas, where natural processes are allowed to continue unimpeded are of vital importance. This is particularly the case for low-lying beach, dune and salt marsh areas, as they are greatly important for coastal breeding birds.
- ➔ In order to safeguard future natural sedimentation processes in the Wadden Sea, measures are needed to increase retention areas of the Wadden Sea, so that enough fine sediment can continue to be deposited.



The population of northern gannet is still increasing. Photo: S. Pfützke



The carrying capacity for common murre at Helgoland seems to have been reached. Photo: S. Pfützke



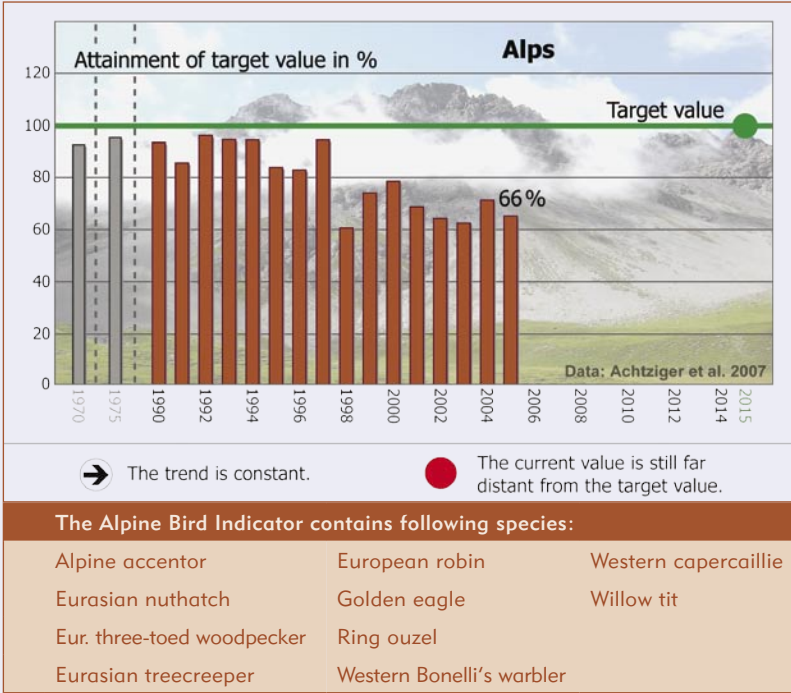
The Bavarian Alps are habitat for a number of bird species, which breed only there in Germany.
Photo: N. Anthes

Bird populations in the Alps have generally stagnated over the last 10 years, but this follows earlier declines. Reasons for this generally unfavourable situation are: increasing human settlement and tourist development; intensification of agriculture; widespread eutrophication; and the abandonment of traditional types of agriculture. Urban sprawl, the development of easily accessible valley sites and the expansion of tourist centres all combine to open up previously remote areas.

Intensive use and fragmentation of alpine habitats affect sensitive species, especially **western capercaillie**, **hazel grouse** and **rufous-tailed rock thrush**, as well as mammals. The habitat of **citril finch**, an endemic species in Europe, which in Germany breeds only in the Alps and the Black Forest, is altered more and more by increasing tourist development and by intensification or abandonment of alpine pastoral farming. Increased nutrient contents and earlier growing seasons

for plants are unfavourable for an alpine insectivore.

Population declines of alpine bird species occur regularly, often due to poor weather conditions at the start of the breeding season, for example between 1997 and 1998 for **Eurasian three-toed woodpecker** and to a lesser extent for **western capercaillie**, **European robin** and **Eurasian treecreeper**. For long-lived species, complete breeding failure in some years



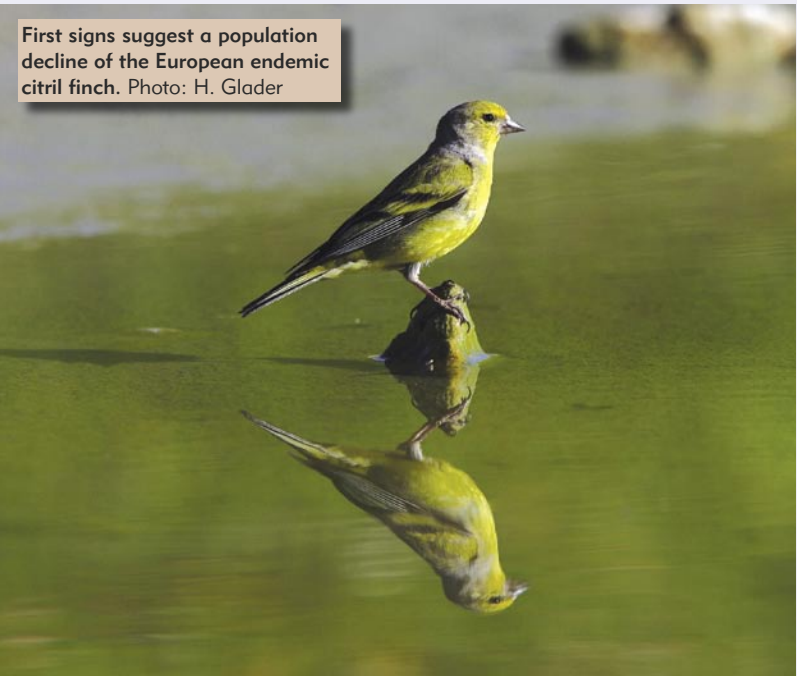
Population trends and numbers of several montane breeding birds between 1996 and 2005, which occur only or predominantly in the Alps.					
Species	Trend 1996-2005	Population 2005	Species	Trend 1996-2005	Population 2005
Rock ptarmigan	↗	300-600	Eurasian crag martin	↗	30-50
Western capercaillie	↘	580-780	Wallcreeper	↗	100-200
Golden eagle	↗	46	Alpine accentor	↗	700-1200
Eurasian three-toed woodpecker	↘	730-1000	White-winged snowfinch	↗	200-400
White-backed woodpecker	↗	250-410	Water pipit	↗	2000-6000
Alpine chough	↗	2000-4000	Citril finch	↗	3400-5500

Legend: ↘↘ = strong decrease (> 50 %), ↘ = decrease (20-50 %), ↗ = stable (-20 % bis +20 %), ↗ = increase (20-50 %), ↗↗ = strong increase (> 50 %)

can generally be balanced out, but climate change could have very adverse effects in alpine regions. A warmer climate not only affects melting of glaciers, it also causes altitudinal displacement in birds which are bound to specific altitude zones. At present, for example, we notice the loss of **water pipit** and **citril finch** from montane regions.



The rufous-tailed rock thrush breeds again in the German Alps since the beginning of the century.
Photo: B. Fischer



First signs suggest a population decline of the European endemic citril finch. Photo: H. Glader

Golden eagle occurs in Germany only in the Bavarian Alps, where they have been monitored since 1998 within a species conservation programme. The population is stable. However, only 25-50% of territory-holding birds actually breed, and these with very low success, with the result that the population depends on immigration. Other species with the potential for immigration from neighbouring European regions are **griffon vulture** and **bearded vulture**. Observations of both species have recently strongly increased due to protection measures and reintroductions in other parts of Europe.

Alpine birds

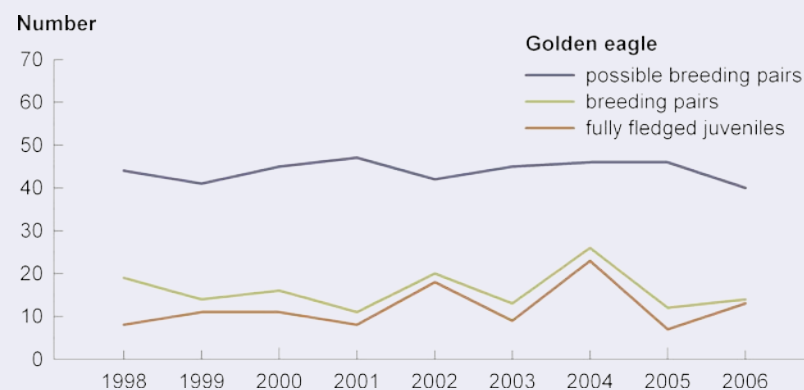
Breeding birds of the alpine mountains such as the rock ptarmigan are particularly threatened by climate change. Photo: T. Krüger



A number of species, such as **rock ptarmigan** and **white-winged snowfinch**, breed only in the Alps and their numbers can only be estimated due to the difficulty of accessing their mountain breeding sites. Since the beginning of the 21st century, **rufous-tailed rock thrush** has bred regularly again in the western Bavarian Alps (Allgaeu), having previously been recorded for the last time in 1983.

Conclusion and recommended courses of action

➔ In order to conserve alpine biodiversity, birds within the Alps have to be protected from general tourist activity, as well as urban sprawl and habitat fragmentation. Unexploited mountain regions



must be protected more strictly from human impacts than before.

➔ Traditional landuse of old cultivated landscapes (e.g. mountain pastures and Alps) must be safeguarded. The separation of forest and meadow has not only to consider forestry criteria but also species protection interests.

➔ On the other hand, there is a need to safeguard semi-natural forests, rich in old

and dead wood, in order to conserve mountain forest specialists, such as **white-backed woodpecker**, **Eurasian three-toed woodpecker**, and **western capercaillie**.

➔ Adverse consequences of climate change can only be solved through international collaboration, but in the long-term are likely to have the largest impacts on the species diversity of the Alps.

In spite of low breeding success, the golden eagle population is stabile. Foto: H. Glader



Migrating waterbirds



Waterbird numbers – as of barnacle goose – overall increased since the 1970s, but recent trends for some populations are worrying. Photo: H. Glader

Many millions of waterbirds rest in Germany on their annual migration and 130 different waterbird species occur regularly. Here, they depend on a network of areas where they can replenish their energy reserves for the onward migration, or moult undisturbed, or spend the cold winter season. For resting, they use very different habitats, such as the Wadden Sea; sea coasts with their shallow sandbanks; lakes in the lowlands of north Germany and in the foothills of the Alps; rivers and their barrages; reservoirs; or sewage ponds. Due to its geographical location, Germany is very important for moulting, migrating and overwintering waterbirds – and therefore has a high responsibility for the conservation of their populations.

Germany – at the crossroads of European waterbird migration

Germany bears a very high responsibility for the protection and conservation of at least 15 waterbird species, and a high responsibility for another 23 species.

The Wadden Sea

Unique habitat of global importance

The Wadden Sea is a unique habitat, supporting 10-12 million waterbirds annually, especially during migration. Due to its rich food supplies, many populations depend on the Wadden Sea, leading to a high to very high responsibility for 13 waterbird species, mainly waders.

Nearly the entire northwest European population of **common shelduck** moult their wings in the Wadden Sea. Estimated 250,000 birds concentrate only at a few sites during this crucial period in their annual life cycle, unable

to fly for several weeks. More than half of the northwest European population of **avocet** also moult in the German Wadden Sea. **Brant goose, common eider, Eurasian oystercatcher, red knot, dunlin** and **bar-tailed godwit** rest here in very high numbers. **Barnacle goose, grey plover, sanderling, spotted redshank** and **Eurasian curlew** also occur in high numbers.

Long-term negative trends of shellfish-eaters

After generally positive population trends for all waterbirds until the end of the 1980s, which can be considered as a success due to the designation of national parks with large, disturbance-free protected zones and hunting bans, recent trends of some bird guilds are worrying: since the 1990s, the populations of species that predominately feed on shellfish have declined over the whole Wadden Sea, including species such as **common eider, Eurasian oystercatcher** and **red knot**, for which Germany holds a very high responsibility. There

seems to be a connection with industrial fishing of cockles, identified as major cause of the decline of **red knot** in the Dutch Wadden Sea and has subsequently been significantly reduced. However, it is still unclear, what impacts on local shellfish species are caused by the introduced Pacific oyster, which is spreading due to climate change and is generally not suitable as food for shellfish-eating birds.

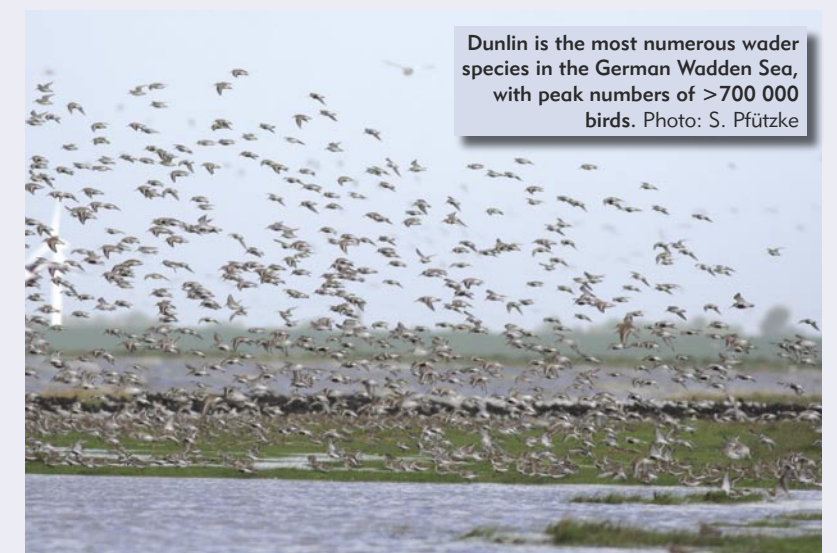
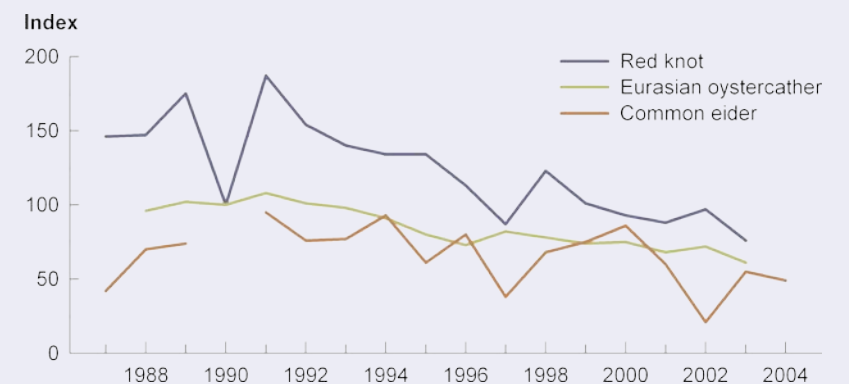
Some bird species react sensitively to changing ecological conditions and the **avocet**, for which population declines have been observed over years, is a good example. One possible reason is habitat loss due to climate change: even slight increases in water levels mean that mudflats are exposed for shorter periods, resulting in a decline of mud areas. **Avocets** forage in precisely these areas.

Clear declines in some other species, such as **brant goose** since the mid 1990s, seem to be the result of changes on the Arctic breeding areas: over several years, **brant geese** returned to the Wadden Sea with only small numbers of young, even though they had left the Wadden Sea in good body condition.

These examples show that favourable foraging conditions and disturbance-free core zones are necessary for many waterbird and wader populations.



Bar-tailed godwits occur in large numbers especially in spring before flying non-stop to their arctic breeding grounds. Photo: H. Glader



Dunlin is the most numerous wader species in the German Wadden Sea, with peak numbers of >700 000 birds. Photo: S. Pfütze

Migrating waterbirds

Baltic Sea

International importance for diving ducks

The combination of extensive mussel beds, important fish spawning grounds and relatively short periods of sea ice, compared to the northern and

northeastern Baltic, ensure the survival of more than 1 million waterbirds during the non-breeding season. In particular, the German Baltic Sea coast is of international importance as an overwintering area for diving ducks.

Overview of the waterbird species for the conservation of which Germany bears a high or very high responsibility. A main habitat was assigned to each waterbird species. Where several biogeographical populations occur, that for which Germany has a specific responsibility is shown (in brackets).

Wadden Sea and Baltic Sea	
Very high responsibility	High responsibility
Brant goose (bernicla)	Barnacle goose
Common shelduck	Greater scaup
Common eider	Smew
Eurasian oystercatcher	Grey plover
Avocet	Sanderling
Red knot	Eurasian curlew
Dunlin	Spotted redshank
Bar-tailed godwit	
Agricultural land	
Bewick's swan	Mute swan
Tundra bean goose	Whooper swan
Taiga bean goose	Greater white-fronted goose
Common crane	Greylag goose
	European Golden plover
	Northern lapwing
Inland water bodies	
Northern shoveler	Great crested grebe
Red-crested pochard	Grey heron
Common merganser	Gadwall (NW Europe)
(alpine population)	Northern pintail
Eurasian oystercatcher	Common pochard (NW Europe)
	Tufted duck (NW Europe)
	Coot
	Black-headed gull
Offshore waters	
	Red-necked grebe
	Black scoter

Nearly all of the **greater scaup** that occur in Germany are concentrated on a few water bodies close to the Baltic Sea coast. In particular, sheltered bays of the Baltic Sea water bodies called Haff (similar to a lagoon) and Bodden (shallow coastal waters of the Baltic Sea) are of crucial importance for **mute swan**, **tufted duck** and **smew** in Germany. Many overwintering species at the Baltic Sea show complex movements between daytime roost sites (bays, small lagoons, or lower river courses) and night-time feeding areas (on the Baltic Sea).

Positive trends and shifts due to milder winters?

Populations of resting waterbird species, of which large concentrations occur at the Baltic coast, show positive or stable long-term trends. A significant cause is the tendency for mild winters since the end of the 1980s. Wide-ranging freezing events occur less often and make movements to more westerly areas unnecessary. At the same time, the wintering distribution of species that are not sensitive to the cold have shifted further east, to the coasts of Poland and the Baltic states. This might be one of the reasons why overwintering numbers of some diving duck species have declined in the German Baltic. Such regional shifts of wintering distribution are not problematic for waterbird populations, as long as sites along the species' flyway are protected sufficiently.

Here, the effects of international agreements for the protection of wetlands (Ramsar convention, Helsinki convention) or more generally for migrating water-bird species (African-Eurasian Migratory Waterbird Agreement) become important.

The extent to which increased shipping traffic and increased use by tourism have an impact on resting and moulting populations, in particular of coastal areas in Mecklenburg-Western Pomerania, can currently not be quantified. Several water bodies, previously important for moulting birds, have held none in recent years.

Agricultural land

Favourable conditions for foraging geese, swans and cranes

During the day, geese, swans, cranes and some waders forage

Trends of resting populations of ducks and mergansers between 1980 and 2005. Species that rest and winter regularly in significant numbers in Germany.

Gadwall	↑↑
Eurasian wigeon	↑↑ ↓
Eurasian teal	→
Mallard	↓
Northern shoveler	↑↑
Red-crested pochard	↑↑
Common pochard	↓
Tufted duck	→
Greater scaup	↑ ↓
Common eider	↑ ↓
Common goldeneye	↑
Smew	↑↑
Common merganser	→ ↑
Red-breasted merganser	↑

Legend: ↓↓ = strong decrease (> 50 %), ↓ = decrease (20-50 %), → = stable (-20 % bis +20 %), ↑ = increase (20-50 %), ↑↑ = strong increase (>50 %), ↑ | ↓ = increase in the first, decline in the second part of the period

on agricultural land away from wetlands. Two to three million birds use the available favourable conditions for foraging and overwintering in Germany. In conjunction with disturbance-free night-time roosts, this habi-

tat is of critical importance for the conservation of a total of 10 species, for which Germany bears a high to very high responsibility.



Migrating waterbirds



High numbers of northern lapwings are resting in agricultural land.
Photo: H. Glader

Resting populations of swans and geese have increased in northwest Europe since the 1970s. They have benefited particularly from favourable conditions in overwintering areas, with low hunting pressure in many regions, mainly mild winters and energy-rich food (e.g. oilseed rape, winter cereals). Population increases in northwest Europe, particularly of **greater white-fronted goose**, are possibly

related to declines in southeast Europe, suggesting in part that a wide-ranging shift of overwintering areas has occurred. In northwest Europe hunting pressure is much lower than in most south-east European countries.

Bewick's swan and **taiga bean goose**, however, have shown (clear) negative trends over the same period. Both species have very high proportions of their

population resting in Germany, with more than half of the world population of **taiga bean goose** in northeast Germany. As for **brant goose**, the reasons for the observed negative trends might originate in breeding areas or on migration routes. Despite unchanged favourable conditions in overwintering areas, the birds return from their breeding grounds with fewer young than in previous years. The causes of the population decline in taiga bean goose are not yet well understood.

Model protection concept for common cranes

Nearly the whole northwestern European population of **common crane** rests in autumn in the northeast of Germany, before onward migration to their winter quarters. The Darss-Rügen region is known internationally for its large gatherings of **common cranes**. Since the 1980s, areas used for resting have spread in-

land, and since the end of the 1990s large roosts can also be found in the western federal states. Germany bears a very high international responsibility for the conservation of **common cranes** in the western part of their range. Due to extensive protection measures along the entire migration route, breeding and resting numbers have increased continuously since the 1980s. This shows that success can happen quickly if sustainable approaches and concepts in nature and species conservation are applied.

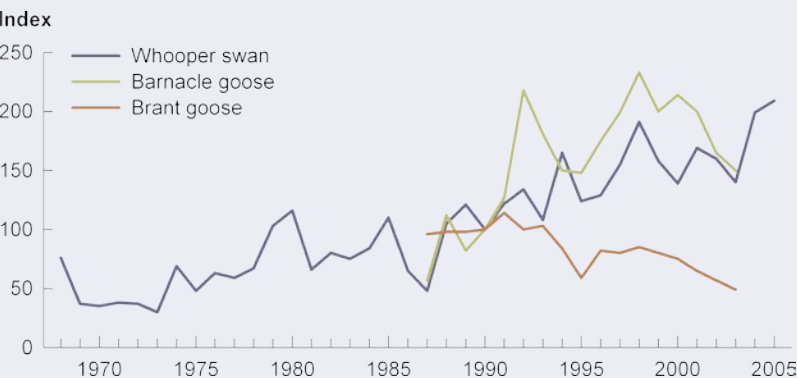
Inland water bodies

Large accumulations of resting birds in northern Germany and in the foothills of the Alps

Grebes, ducks and mergansers are the main overwintering waterbirds on inland water bodies. Germany is of high to very high importance as a moulting, res-

Trends of resting populations of geese and swans between 1980 and 2005. Species that rest and winter regularly in significant numbers in Germany	
Mute swan	↑
Whooper swan	↑↑
Bewick's swan	↑ →
Brant goose	↑ ↓
Barnacle goose	↑↑
Tundra bean goose (A. f. rossicus)	↑↑ →
Taiga bean goose (A. f. fabalis)	↓
Greater white-fronted goose	↑ →
Greylag goose	↑↑

Legend: ↓↓ = strong decrease (> 50 %), ↓ = decrease (20-50 %), → = stable (-20 % bis +20 %), ↑ = increase (20-50 %), ↑↑ = strong increase (>50 %), ↑ | ↓ = increase in the first, decline in the second part of the period



Intelligent and long-term sustainable solutions need to be found regarding the conflict surrounding geese, swans and cranes that forage on agricultural land.
Photo: S. R. Sudmann



Whooper swans benefit from milder winters and better food supply. Photo: H. Glader

Migrating waterbirds

ting or overwintering area for a total of 11 waterbird species that occur in considerable numbers in these habitats. The populations of many of these species are very large and are spread over a wide geographical area. Therefore, to a large extent we are jointly responsible for the long-term conservation of species which, compared to others, have small biogeographical populations. One third of the entire Alpine population of **common merganser**, which comprises only approximately 4000 individuals, breeds in Germany. They mostly overwinter in

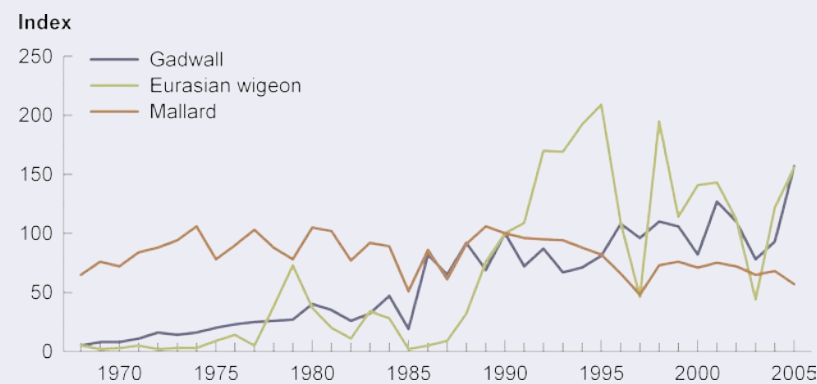
areas immediately surrounding their breeding grounds in south Germany and neighbouring Switzerland and, according to recent genetic analyses, have been classified as a separate conservation unit. Thus, appropriate protection measures are necessary for this population.

Positive trends – with some exceptions

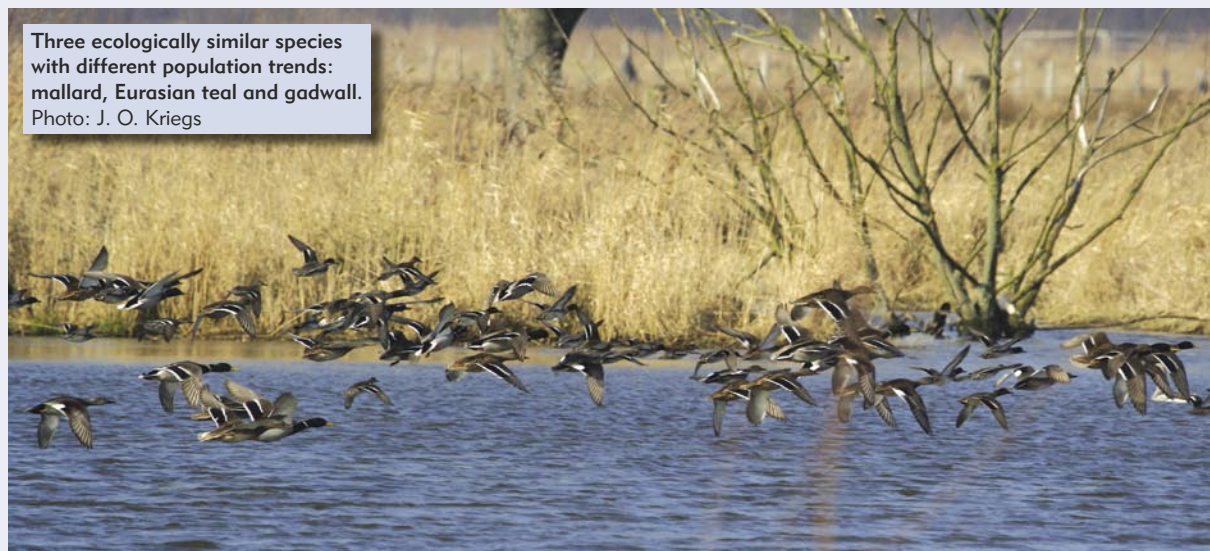
Population trends for resting and overwintering ducks and grebes that occur mainly inland are predominately positive. Due to milder winters, several species have gradually shifted their

overwintering areas from west or southwest Europe to central Europe. Here they are exposed to lower hunting pressure and, in addition, the migration routes to their breeding areas in north or northeastern Europe become shorter. The area of open water in Germany is also continuously increasing (for example due to excavation, flooding of coal-mining areas, permanent flooding of polders), which means that more resting areas are available. At the same time, the mild winters since the end of 1980s make it possible that cold-tolerant species, which decades ago still overwintered in central Europe, have been able to expand their overwintering areas to the north and east. This is one of the reasons for the decline of wintering **mallard** in Germany and other west European countries.

Among others, **red-crested pochard** has benefited from the improved water quality of



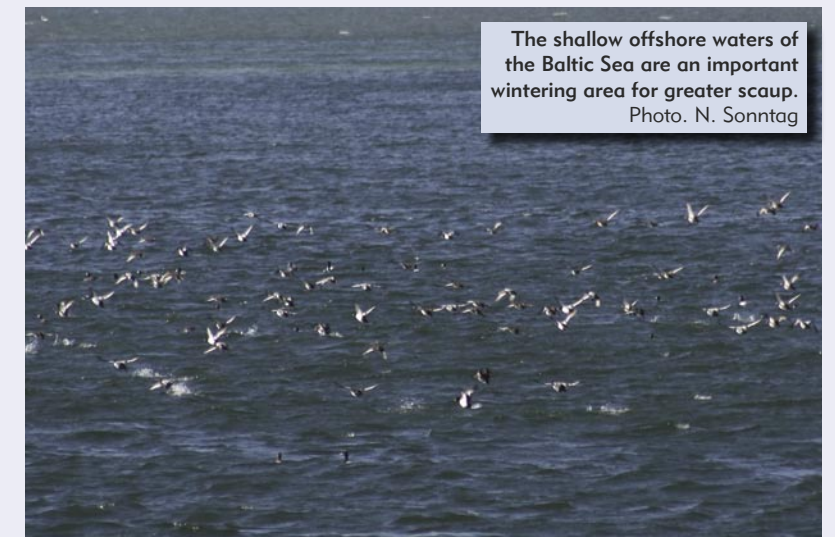
Three ecologically similar species with different population trends: mallard, Eurasian teal and gadwall. Photo: J. O. Kriegs



many lakes, especially in the foothills of the Alps. Its resting populations have increased continuously since the 1980s, and particularly rapidly on Lake Constance and in neighbouring Switzerland since the 1990s. During the same period, numbers of wintering **red-crested pochard** declined strongly in Spain. It seems that wide-ranging displacements have occurred, which could be connected to above-average dry years on the Iberian peninsula. Improved water quality at lakes in the foothills of the Alps has enabled the spread of stonewort, providing **red-crested pochard** with food. At the same time, a large proportion of the population shifted to areas north of the Alps for moulting. Forty percent of the southwest European population now moult their wings in south and over the last few years also in northeast Germany.

Offshore areas

Several hundred thousand birds are present in offshore waters of the North and Baltic Sea at all seasons – during the course of the year the number of individuals totals several million. Population sizes and the importance of these concentrations have only been systematically analysed in recent years. Due both to the nomadic lifestyle especially of true seabirds and to difficult survey conditions, many questions remain open and com-



The shallow offshore waters of the Baltic Sea are an important wintering area for greater scaup. Photo: N. Sonntag

pared with terrestrial habitats it is more difficult to identify long-term trends and causal relationships.

North Sea

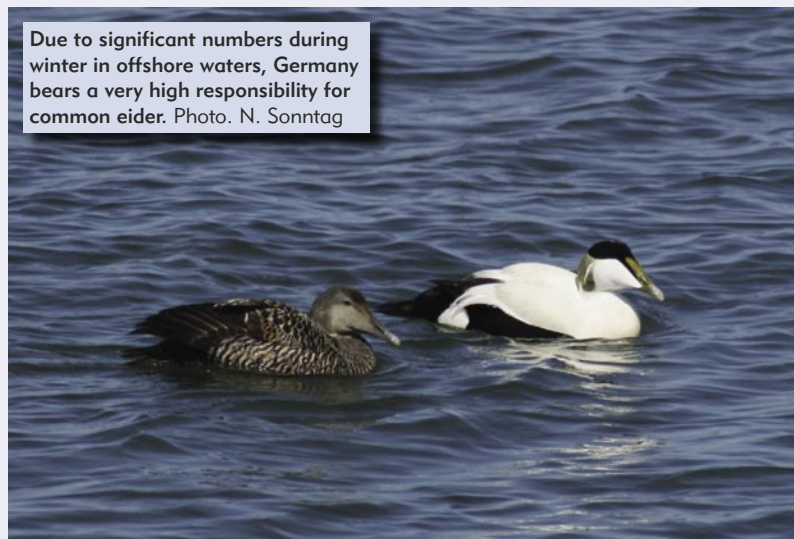
Offshore areas of the North Sea are most important during the summer when terns and gulls from the large breeding colonies along the coast of the Wadden Sea forage intensively in coastal waters, as well as around the island of Helgoland. During winter, **black scoter** and **common eider** are present in particularly large numbers, for which Germany bears a high to very high responsibility. During spring migration, concentrations of **red-throated diver** and to a lesser extent **black-throated diver** occur close to the coast, two species which are very sensitive to disturbance.

In the North Sea, the decades-long increase in numbers of most seabird species has now stopped.

The North Sea breeding population of **black-legged kittiwake** is reduced by nearly half. Declines in **northern fulmar** have also been recorded in north Scotland. These population changes are also reflected in resting, wintering and non-breeding populations at sea – also in areas, for which Germany is responsible. The reasons for these population declines, which do not affect all seabird species to the same extent, are severe changes in food supply especially during recent years in the northern part of the North Sea: climate change and intensive industrial fishing have caused a dramatic decrease in the numbers of sandeels, which are an important food source for seabirds. By contrast, snake pipefish have increased explosively in recent years, having benefited from rising sea temperatures. However, they are particularly unsuitable for seabird chicks, so that young in the nest starve, despite the provision of plenty of

Migrating waterbirds

Due to significant numbers during winter in offshore waters, Germany bears a very high responsibility for common eider. Photo. N. Sonntag



prey by their parents. Long-term consequences of these serious changes to the ecosystem in the North Sea are unpredictable.

Numbers of **European herring gull** and **great black-backed gull** have also decreased in recent years, especially in winter. One important reason – actually beneficial from an ecosystem point of view – could be a clear reduction in the amount of unused commercial fisheries by-catch (“discard”). Declines in **European herring gull** are also noticeable in the Wadden Sea. The closure of inland rubbish tips – sensible from a wider environmental view – is likely to amplify this trend. The gulls found easily available and plentiful food at such sites in winter. Since then, inland numbers have decreased by more than half. These examples show how immediate human action or impacts can markedly affect ecosystems.

Baltic Sea

The species composition of the Baltic differs from that of the North Sea. Of the waterbird species, for which Germany bears a high or very high responsibility, only **common eider** and **black scoter** overwinter in large numbers in both the North Sea and the Baltic. Other diving ducks, such as **long-tailed duck** and **velvet scoter**, are restricted to more distant offshore waters of the Baltic and reach their maximum resting populations in winter. Accordingly and in contrast to the North Sea, the Baltic Sea is of greater importance at this time of the year. These species are concentrated mainly in shallow offshore waters off the coast of Schleswig-Holstein, north of the Darss and in the Pomeranian Bight. Because birds accumulate especially over food-rich shoals, the gillnet fishery in the Baltic Sea endangers diving birds foraging there and thousands of water-

birds are killed that way each year. The effects on population trends of these losses, as well as those of increasing shipping traffic and sand and gravel extraction activities at important offshore areas used for foraging cannot currently be quantified.

Conclusion and recommended courses of action

Considered overall, resting populations of waterbirds have increased in Germany as well as in other European countries. The reasons for this among others are: (1) increased conservation effort since the 1970s, which made disturbance-free areas available; (2) the introduction of closed seasons, and shorter hunting seasons for many species; (3) the improvement of overwintering conditions due to milder winters since the end of the 1980s; and (4) the wide-ranging availability of energy-rich food sources and the emergence of new ones.

However, recent trends for some populations are worrying, and protection measures are necessary. In order to stop negative developments with regard to the 2010 target, the following measures are required – in particular for species for which Germany bears a high (to very high) responsibility:

- ➔ At all important sites, refuge areas undisturbed by human activity should be created and maintained. In the Wadden Sea, these are in particular high-tide roosts, and in the Baltic Sea food-rich shallow offshore waters. In these areas, nature conservation should permanently take priority over commercial interests or tourist use.
- ➔ Sites that are important for wing-moulting waterbirds need to be granted a particularly high level of protection – regardless whether these water bodies are located inland, at the coast or offshore. During the moulting season, which occurs for most birds during summer, birds have a particular need of food-rich areas that are free of disturbance. During this time, many waterbird species are unable to fly for several weeks.
- ➔ Interdisciplinary research must be intensified in the Wadden Sea, where long-term negative population trends have been observed for shellfish-eaters, and at sea, where clear changes in the ecosystem have occurred during recent years, in order to identify adverse changes as soon as possible and so be able to take remedial action. In particular, studies on food supply and quality are urgently required.
- ➔ The gillnet fishery in the Baltic must be stopped as a significant cause of losses that endangers foraging waterbirds. Disturbance by shipping traffic must be minimised in protected sites and should be banned from areas with peak concentrations of waterbirds.
- ➔ There should be a ban on hunting on EU Special Protection Areas all year around.
- ➔ Intelligent and long-term sustainable solutions need to be found regarding the conflict surrounding geese, swans and cranes that forage on agricultural land. The same applies to the conflict between commercial fisheries and foraging **great cormorants**. In both cases, solutions to solve these conflicts exist, which take into account both the responsibility for conservation as well as the interest of the affected parties.
- ➔ Long-term strategies need to be developed in reaction to climate change and associated sea level rise, to guarantee the availability of mud-rich tidal flats. Removing embankments to enlarge intertidal areas are promising measures, and at the same time useful for flood control.



Many waterbird species – such as barnacle goose – rely on a network of protected sites, comprising high-quality foraging sites and sheltered roosts. Photo. H. Glader

Trans-Saharan migrants



Next to threats in the wintering region the Ortolan Bunting is endangered by hunting in the Mediterranean region. Photo: M. Schäf

In Germany, disproportionate reductions in populations of trans-Saharan migrants can be observed. This trend is evident for species of various habitats, e.g. in woodland birds or birds of agricultural landscapes. According to a study by BirdLife International, a particularly high number of trans-Saharan migrant species are affected by population declines all over Europe. These connections suggest that the cause of population decline in migrating birds is not only to be found in breeding areas. This problem has been known since the end of the 1960s, when some songbird populations that winter south of the Sahara declined considerably. This was attributed to the extreme drought in the Sahel at the time and led to further research into the relationship between variations in populations and the conditions during migration or in the wintering areas.

Problems on migration routes and in wintering areas

Most studies on this subject relate to the size of breeding bird populations, or the individual probability of survival in relation to rainfall in wintering areas. Behind this is an assumption that high and low amounts of rainfall respectively result in relatively poor or good food supply. This has an affect not only on the probability of survival of migrating birds, but also influences subsequent breeding success. Birds arriving in the breeding area in a good condition are more successful breeders than those that winter under less favourable conditions.

Examples of the ways in which bird populations are influenced by conditions in wintering areas include studies which show that populations of **purple heron** and **little egret** in the

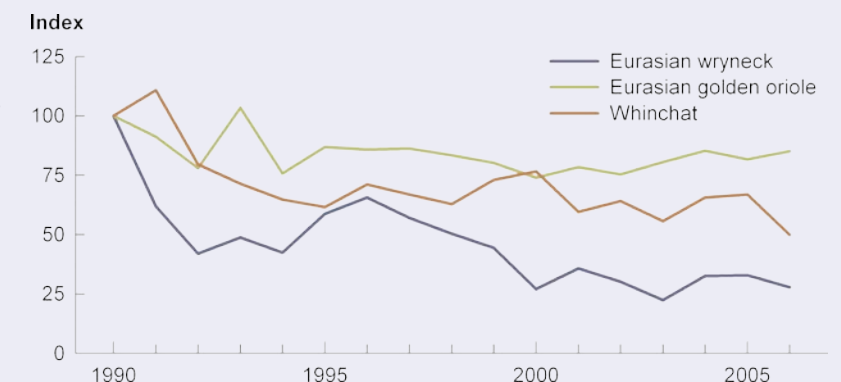
Netherlands and in France can be correlated with the outflow of the rivers Niger and Senegal in West Africa. The current interpretation is that high outflows show high amounts of rainfall and thus a more favourable food supply, which means a better rate of survival for birds in the wintering area. The probability of survival in the wintering area of for example **white stork**, **sand martin**, **common nightingale**, **common redstart** and **sedge warbler** depends on local rainfall. If the preceding wintering period had a high amount of rainfall the probability for **barn swallows** to raise a second brood increases.

Unlike many other factors, climatic influences such as rainfall or temperatures (cold snaps can lead to mass mortality) are not influenced directly by anthropogenic activity (but indirectly through the climate change influenced by man).

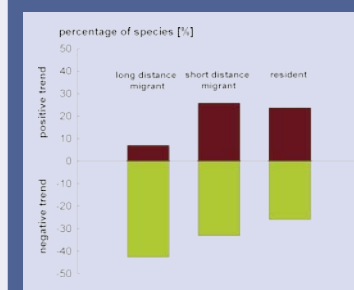
Some migrant species are already under high hunting pressure in Europe. It is estimated that up to 50 000 **ortolan buntings** are killed every year in France – a species which to some extent shows large declines in population numbers. In north Africa, **common quail** and **corn crane** are hunted extensively, but their negative population trends are due to changed agricultural practices in the European breeding areas. **Garganey** and **northern shoveler** are hunted extensively, not only during their migration in southern Europe but also by Europeans in West Africa, and terns are caught for food there. However, direct hunting in wintering areas probably has only a minor influence on population trends. The uncontrolled use of insecticides could be more important,



The Eurasian Golden Oriole is one of a number of long distance migrants with decreasing populations. Photo: M. Schäf



Number of significantly increasing or decreasing bird species according to different migration strategies. The 97 commonest breeding bird species in Germany were analysed. Forty six of these showed no significant population changes. In contrast to short-distance migrants and non-migrating birds, disproportionately more long distance migrants show population declines and disproportionately fewer have increasing populations.



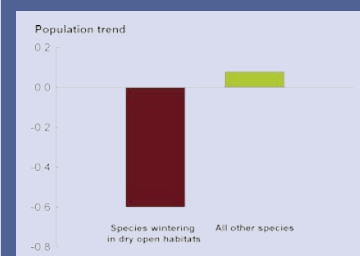
Within Germany the decline of willow warbler is stronger in the west than the east – a possible indication of climatic factors as one explanation. Photo: S. Achtermann

Trans-Saharan migrants

Species wintering in the Sahel – such as the wryneck – show stronger declines than other species. Photo: M. Schäf



Population trends of long distance migrants between 1990 and 2000 by wintering habitats. Population trends for 108 European migrating birds that winter in Africa (excluding sea birds and waders) were studied. On average, species that winter in dry African habitats show significantly negative population trends, in contrast to other long-distance migrants. This can be considered as a clue that problems for long-distance migrants occur mainly in the African Sahel and Sudan areas (according to Sanderson et al. [2006]: Long-term population declines in Afro-Palearctic migrant birds. Biological Conservation 131: 93-105).



especially if applied on a large scale. Observed large decreases in bird densities following the application of insecticides is largely attributed to displacement due to the subsequent lack of food. However, according to some reports mass mortality of **white storks** has occurred in connection with measures to combat red-billed queleas.

As with breeding areas, the biggest threat to migrant birds in wintering areas is probably the large-scale destruction of habitats. This particularly applies to the Sahel, south of the Sahara. In Senegal, the area of some riverine acacia forests decreased by 90% between 1954 and 1986. In north east Nigeria, the area of wooded savannah was reduced

by 14% between 1976 and 1995 and in study areas in northern Nigeria, the tree population decreased by 80% in only 8 years (1993/94-2001/02). These drastic negative changes are attributed solely to anthropogenic activities, such as consumption of wood for fuel, overgrazing and conversion of natural habitats to agricultural land. Studies in Nigeria have also shown that fewer migrating birds winter in study areas with a decreasing tree population. Because of the large-scale habitat loss, many birds could be forced to divert into less suitable habitats. The likely result would be a lower chance of survival, but also reduced breeding success later, if the birds arrive in the breeding areas in worse condition.

Open questions indicate need for research

Even though there are some hints as to how populations of migrating birds can be influenced by the conditions in the wintering area or on migration, there is often no detailed knowledge that can be transferred into conservation measures. For some species the exact wintering areas are still unknown. Examples of this are **wood warbler** and **ortolan bunting**, which show strongly negative population trends. The main wintering area, the Senegal delta, for the globally threatened aquatic warbler had not been discovered until February 2007. Moreover, it is often not known where different populations of a species overwinter. This applies

to **willow warbler** which has decreased in many parts of Europe. Studies from the Netherlands and the south of Great Britain show that mortality rates during the non-breeding season rather than reduced breeding success is the cause of declines in numbers. However, in the north of Great Britain hardly any negative trend in **willow warbler** numbers is detectable. This raises the question whether northern populations winter in different parts of Africa and whether they have a better probability of survival there than their conspecifics breeding further south.

Also little is known of the ecology of long distance migrants in their African wintering areas. Even simple questions cannot be answered for many species: What habitats are used by migrant birds? Where do migrating birds build up the necessary fat reserves for spring migration? How do changes of habitat affect migrant birds? How flexibly can migrant birds react to changes? Do birds of open habitats benefit from the destruction of the rain-forest? What habitats do migrant birds use during the course of a wintering season and where? The common factor to all of the points mentioned above is that populations of migrant birds seem to depend on conditions during migration or in the wintering area, but that the detailed knowledge of the main connections is rudimentary.



The population of whinchat in Germany is still declining. Photo: M. Schäf

Conclusion and recommended courses of action

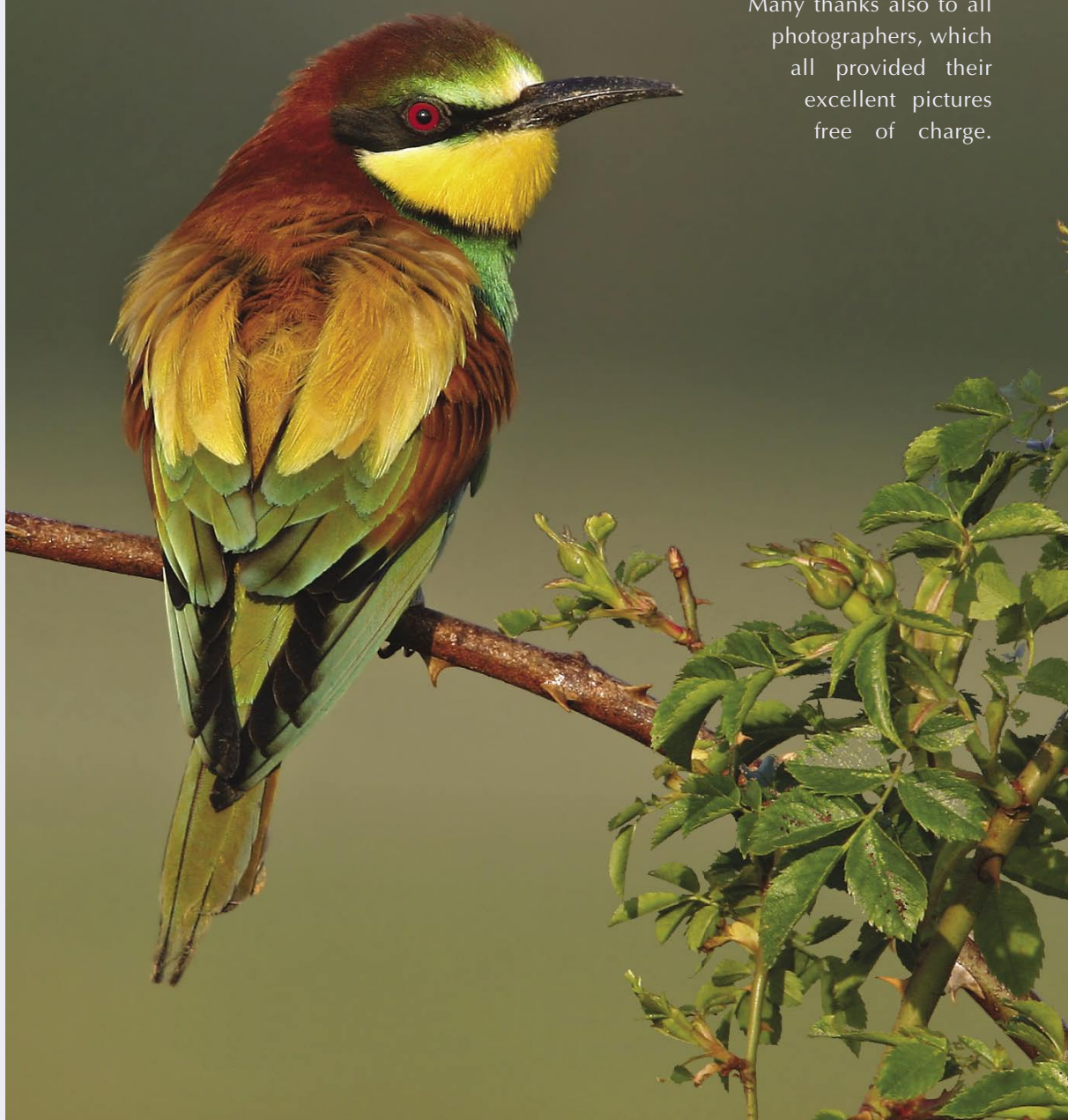
- ➔ Long distance migrants are disproportionately affected by decreasing population trends all over Europe, regardless of systematic kinship, membership of an ecological guild, or habitat preference.
- ➔ Demographic factors relevant to population trends (probability of survival in the wintering area, breeding success) can be influenced by the conditions during migration or in the wintering area.
- ➔ Specific conservation measures that take into account the wintering areas of European long distance migrants

can often not be suggested, since little is known about where individual populations or species spend more than half of the year, which habitats in the wintering area are used, how populations and species react to changes of habitat and climate and how the conditions in the wintering and breeding areas influence each other.

- ➔ The elimination of this huge knowledge deficit would be a first step towards the understanding of population variation and urgently required protection of long distance migrants.
- ➔ Essentially is the assistance of African States to implement a sustainable land use.

Acknowledgements

Such extensive duties and responsibilities can only be met thanks to the energetic and voluntary help of large numbers of bird watchers. More than 5000 keen amateur ornithologists have helped to carry out bird counts, with great pleasure and scientific ambition. We particularly wish to express our gratitude to them. Many thanks also to all photographers, which all provided their excellent pictures free of charge.



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Since more than 100 years the **Naturschutzbund Deutschland** (NABU, Nature and Biodiversity Conservation Union) is involved in practical and political bird and nature conservation. The NABU is the German partner of BirdLife International, it is member of the DNR (German League for Nature and Environment), and since 1971 the NABU chooses the Bird of the Year in Germany (2008: common cuckoo).



The **Deutsche Rat für Vogelschutz** (DRV, German Council for Bird Protection) is a forum, which enables the co-operation and an intensive exchange of experiences between representatives of governmental bird conservation agencies, scientific institutions and NGOs. The aim is to give scientifically well-founded advice to decision takers and to promote scientific knowledge and conservation strategies.



The **Deutsche Ornithologen-Gesellschaft** (DO-G, German Ornithologists' Society) is one of the oldest scientific associations in the world. Since its formation in 1850, it has promoted ornithology as a pure science as well as in applied research.



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