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BACHELOR´S THESIS

Population trends of waterbirds in Europe

Populačné trendy vodných vtákov v Európe

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Odovzdaním tejto bakalárskej práce na tému Populačné trendy vodných vtákov v Európe potvrdzujem, že som ju vypracovala pod vedením vedúceho práce samostatne za použitia v práci uvedených prameňov a literatúry. Ďalej potvrdzujem, že táto práca nebola využitá k získaniu iného alebo rovnakého titulu.

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ABSTRAKT

Vodné vtáctvo a jeho štúdium získalo v priebehu posledných desaťročí mnoho záujemcov z radov odborníkov, ale aj verejnosti. Historické záznamy o početnosti vodného vtáctva umožnili analýzu populačných trendov a identifikáciu potenciálnych aberácií. Európa je dôležitým regiónom pre mnohé hniezdiace a zimujúce druhy a poskytuje široké spektrum vhodných biotopov počas celého roka. Viaceré druhy kačíc, potáplice, ale aj brodivé, bahniaky, či kormorány vykazovali dlhodobo stabilné alebo rastúce populačné trendy. Najviac klesajúci trend bol zaznamenaný u niektorých potápavých kačíc, potápiek a bahniakov hniezdiacich na lúkach. Napriek správam o zjavnom poklese populácií vodného vtáctva je identifikácia ekologických príčin zložitá v dôsledku rôznorodých charakteristík širokého spektra druhov vodného vtáctva, a preto je štúdium tejto tematiky veľmi obšírne a komplikované. Z uvedených ekologických faktorov má strata vhodných biotopov najnegatívnejší vplyv na bahniaky, zatiaľ čo zmena klímy môže súvisieť s presunom hniezdisk a zimovísk. Úbytok početnosti vtákov hniezdiacich na vlhkých lúkach bol najviac ovplyvnený moderným poľnohospodárstvom a v súčasnosti sú ich populácie ohrozené.

KĽÚČOVÉ SLOVÁ

vodné vtáky, nespevavce, populačná dynamika, Európa, ochrana prírody, mokrade

ABSTRACT

Waterbird research has grown in importance over the decades, attracting both professional and public interest due to its fascinating nature. Historical records of waterbird abundance have allowed the analysis of population trends and the identification of potential aberrations. Europe is an important region for many breeding and wintering species, providing a wide range of suitable habitats throughout the year. Several wildfowl and diver species, but also common waders, wading birds or cormorants exhibited a long-term stable or increasing population trends. The most decreasing trends were reported for some diving ducks, grebes and grassland-nesting waders. Despite reports of apparent declines in waterbird populations, the identification of ecological causes is complex due to the diverse characteristics of different waterbird species, making this a broad and complex topic to investigate. From the mentioned ecological drivers, habitat loss has the most negative impact on waders, whilst climate change could be associated with the shifting of breeding and wintering ranges. The birds breeding on wet grasslands were mostly affected by modern agriculture, and nowadays, their populations are threatened.

KEYWORDS

wetland birds, non-passerines, population dynamics, Europe, conservation biology

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Introduction

The focus of this work is on population trends of waterbirds in Europe. The topic chosen will provide a review of available data and may serve as a comprehensive report of the current state of avian population trends.

The work is divided into two chapters. The first one is quite strictly focused on descriptions of population trends. For reasons explained later, the chapter is divided into breeding population trends and wintering population trends. Furthermore, geographically I will focus on northern, central, and southern Europe exclusively, as the geographic distribution of waterbird species differs respectively in both wintering and breeding counts. In the second part of this thesis, I will try to mention some of the possible ecological causes that have been studied about population trends and whether these are linked to specific taxa considering life histories, habitat preferences or feeding behaviours. The ecological causes mentioned are expected to affect different species in different ways as life histories and characteristic traits differ for the species presented.

A population is characterized as a group of interbreeding individuals found in the same space or area at the same time. Indeed, a local population is not the same as a species population, and it can be perceived as quite an arbitrary term (Rockwood, 2015). From the many attributes that describe population, in this work, the most important will be population growth and related population trends. Population trend is a result of long-term monitoring and data collection which presents the change in the mean as it is often described (Dixon et al., 1998). "Long-term" is a very vague concept, and it depends on the specific dynamics and relevant scale. However, it can also study spatial distribution changes in the region instead of changes in the amount (Dixon et al., 1998), which is very popular in studies focused on birds (Pavón-Jordán et al., 2015).

Waterbirds is an extensive term and to review various species in terms of life histories, habitat, or diet preferences. In this work, the species mentioned are all dependent upon aquatic habitat. Following families are included: geese, swans, and ducks (Anatidae), loons (Gaviidae), grebes (Podicipedidae), ibises and spoonbills (Threskiornithidae), herons (Ardeidae), storks (Ciconiidae), cormorants (Phalacrocoracidae), rails (Rallidae), waders (Charadriidae/Scolopacidae). Anatidae (wildfowl) is a group of medium to large waterbirds that spend most of their lives on water surfaces. Except for some species, they are well adapted to the aquatic environment. As many species are included in this group, their diet is as different as grass, fish, and plankton. They can be widespread but also bond to one island. They are usually nesting on the ground or on the water surface. Grebes are freshwater birds, preferring standing water or slow streams. They feed on fish, aquatic invertebrates, and small vertebrates (Fjeldså, 2004). In comparison to ducks, they are diving when catching prey and their feet are lobed. Nests made of aquatic vegetation are on the water surface. Loons are very similar to grebes, they tend to be smaller, and their feet are webbed which makes them excellent swimmers. There are only five species in total (Tekiela, 2021).

Wildfowl, loons and grebes are in this thesis discussed in one group as they spend most of the time on the water surface or underwater. (Owen & Black, 1990). The other group consists of wading birds (ibises, spoonbills, herons, storks, cormorants), shorebirds, and rails (coots, moorhens). These birds are mostly occupying shores and habitats surrounding the wetlands or they use wetlands as feeding grounds.

When it comes to wading birds, their diet mostly consists of aquatic insects, crustaceans, and other arthropods, which they prey on wading in shallow water (Taylor, 2020). Many species are colonial and migratory and need specific habitat quality for nesting and breeding (Hafner, 1997).

Shorebirds are a diverse group of birds that inhabit coastal areas, marshes, mudflats, and other wetland habitats. These birds have adapted to forage for food like invertebrates or insects along shorelines and in shallow waters. They are often migratory and gregarious (McCain, 2015).

Finally, coots (*Fulica spp*.) and moorhens (*Gallinula spp.)* are the only members of the family Rallidae included in some of the studies. They are relatively generalist, common, widespread, and medium-sized species, preferably inhabiting freshwater marshes with emergent vegetation.

In addition, I would like to address the specific role of waterbirds in ecosystems. One of the most important for future research is the role of bioindicators (Amat & Green, 2010). The population trends of certain species may suggest worsened quality of habitats and therefore make it possible to act sooner in terms of conservation adjustments. Furthermore, they can maintain the diversity of other organisms by controlling pest and invasive species populations or spreading seeds and other organic material (Green & Elmberg, 2014). In conclusion, the absence of waterbirds in the ecosystem could lead to the spreading of diseases, the introduction of more alien species and overall lower biodiversity.

Regarding the importance of studying population trends on waterbirds, I would like to introduce the role and state of European wetlands, which host a great proportion of waterbird species. Thanks to their usually high productivity, relatively small areas can support large concentrations of waterbirds (Mereta et al., 2021). Wetlands are often described as the most endangered habitat of all, resulting from the declining number of wetlands and the total area covered (Hu et al., 2017). This is usually linked to historical context, as in the past lack of knowledge caused an inadequate approach towards wetland management and their direct elimination (Čížková et al., 2013). Consequently, not only bird species have suffered from population declines and have become endangered or threatened. Recently, more and more countries are establishing wetlands as protected ecosystems and have started to promote conservation practices as well as restoration programmes. It is vital to keep the wetlands healthy and prospering as they provide several very important ecosystem services. A few of those worth mentioning would be climate regulation, water and air purification, and biodiversity conservation, but they also provide aesthetic and recreational value for local communities (Gardner & Finlayson, 2018; Mitsch et al., 2015).

The aim of this thesis is to assess trends in the total population abundances of waterbird species over time, focusing on their direction, magnitude, and timing of change. It is expected that trends will vary between species based on specific factors such as dietary preferences, habitat ranges, migratory distances, or colonial behaviour. It will also synthesise the ecological context of these trends based on existing research and assess their significance for individual species or families. This information is crucial for guiding future conservation efforts and preventing potential biodiversity loss.

1 Population Trends of Waterbirds

1.1 Breeding Season Population Trends

Breeding season and its success can have significant effects on population trends across various species. These effects can be observed in both short-term fluctuations and long-term population dynamics.

Monitoring breeding and wintering populations can have different results and for many species the long-term shifts in wintering ranges have not followed the same patterns as those in the breeding range (Potvin et al., 2016). The situation on breeding grounds can answer various questions about population fluctuations and is also crucial for further management and conservation. Breeding seasons play a vital role in shaping population trends through its effects on reproductive success, population growth, and migration.

1.1.1 Wildfowl, Grebes, and Divers of Northern Europe

Northern Europe, specifically the boreal zone is well known for its avian fauna and the region undeniably offers unique wetlands which host many common waterbird species. It is considered the key breeding area for several waterbird species, many of which breed exclusively in boreal and arctic regions (Järvinen & Väisänen, 1978). Even thought, the boreal region is home to lower number of wetland species, their richness is increasing (Keller et al., 2020).

When considering population trends, the most valuable data are observed in long-term or repeated studies. One of these compared two counts from the same locations in Finland (Pöysä et al., 2013). Finland is the main breeding site for six of the studied species as half of their European breeding population is located there. The results were quite disturbing, as the first change point (1986-97) showed declining trends for two out of sixteen species. These were common teal (*Anas crecca*) and northern pintail (*Anas acuta*) (Pöysä et al., 2013). However, the second change point (1997-2011) revealed negative trends for twelve species: northern shoveler (*Anas clypeata),* common teal, Eurasian wigeon (*Anas penelope),* northern pintail *(Anas acuta),* garganey *(Anas querquedula),* common pochard *(Aythya ferina),* tufted duck *(Aythya fuligula),* goldenye *(Bucephala clangula),* great crested grebe *(Podiceps cristatus),* Slavonian grebe *(Podiceps auratus),* red-necked grebe *(Podiceps grisegna),* red-breasted merganser *(Mergus serrator),* common merganser *(Mergus merganser)* (Pöysä et al., 2013). In 1984-95 Svensson (Svensson, 2007) surveyed a bird community in one plot located in Swedish

Lapland and observed ten Anatidae species in total. Significantly negative trend for common teal and scaup *(Aythya marila) (Svensson, 2007).*

Comparing the more recent studies from Fennoscandia, the differences in trends for similar species are not very common (Elmberg et al., 2020; Lehikoinen et al., 2016b; Pöysä et al., 2019). The species tend to have the same status amongst different breeding sites in different countries. Some of them show a consistent significant decline in longer periods, starting in 1986 (Pöysä et al., 2019) until the recent past. These include species like Slavonian grebe, common pochard, garganey, northern pintail, common merganser, great crested grebe, and coot *(Fulica atra).* Secondly, some species show inconsistent increase or decrease in three different long-term studies, which are northern pintail, northern shoveler, and red-breasted merganser (Elmberg et al., 2020; Lehikoinen, A. et al., 2016b; Pöysä et al., 2019).

On the other side of the Baltic Sea, in Latvia, the sharp decline in most of the waterbird species started to prevail in 1990 (Vīksne et al., 2005). Both nesting duck numbers and their nesting success have declined significantly, reaching as low as 11% in 2002. The declines

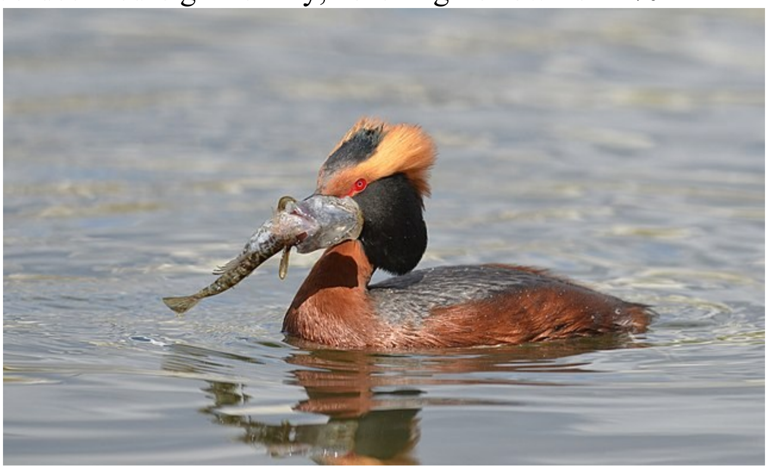

Figure 1 Slavonian grebe *(Podiceps auritus)*

observed in the nesting success of ducks were the most prevalent after the sites were abandoned by gulls. However, in this 45-year study, eighteen species of newcomers were reported as well, while 56% of them had southern origin (Vīksne et al., 2005). This was explained as an expansion of southern species that included gadwall or graylag goose, which are doing well in Fennoscandia (Elmberg et al., 2020). On the other hand, ten species ceased nesting. Amongst these were northern pintail and red-breasted merganser whose populations have declined in Fennoscandia too (Pöysä et al., 2013).

In terms of diet and habitat preferences, insectivorous species confined to luxurious wetlands did worse than herbivorous species with wider breeding ranges (Elmberg et al., 2020).

Researchers believe that this is a result of deteriorated foraging conditions for insectivores in boreal regions. Nearly all the species decreasing the most are large clutched, which makes clutch size a significantly associated variable. Another suggested hypothesis was that early nesting birds should be able to adjust their breeding phenology and therefore deal better with climate changes (Drever et al., 2012). While this was the case for local abundances, general population changes did include some contradictory cases such as common teal or common goldeneye which are considered early breeders but showed negative long-term trends in the study (Elmberg et al., 2020).

Taxonomically, trends of the family Podicipedidae are on decline for every member studied (great crested grebe, Slavonian grebe, red-necked grebe) (Elmberg et al., 2020). The family Anatidae is the most species abundant, amongst the declining populations of several ducks, some species have stable or positive trends, whooper swan (*Cygnus cygnus),* Canada goose *(Branta canadensis),* barnacle goose *(Branta leucopsis),* graylag goose *(Anser anser)* and gadwall *(Anas strepera)* (Elmberg et al., 2020). Only few species of family Gaviidae breed in Europe, therefore, the data are limited. However, there was reported an increase for red-throated diver (*Gavia stellata*) by 34% in Scotland from 1994 to 2006 (Dillon et al., 2009) and together with common diver (*Gavia arctica)* also in Fennoscandia (Elmberg et al., 2020).

1.1.2 Other Waterbirds of Northern Europe

Northern countries host the largest number of shorebird species in Europe due to several reasons. Firstly, the availability of temporary shallow waters ensures an abundant source of food for a short period (Järvinen & Väisänen, 1978). Secondly, habitats in northern countries are variable ranging from peatland to wet tundra (Järvinen & Väisänen, 1978). Importantly, many species are breeding exclusively in boreal and arctic regions, for instance Temminck's stint (*Calidris temminckii*), purple sandpiper (*Calidris maritima*), broad-billed sandpiper(*Limicola falcinellus*) and spotted redshank (*Tringa erythropus*) (Keller et al., 2020).

Long-term population trends of 24 wader species were studied in Fennoscandia (Lindström et al., 2015). The study took place between 2002-2013 and estimated population trends that were quite evenly distributed. Strong significant increases were almost as numerous as the decreases (Lindström et al., 2015). Specifically, the most positive trend could be found for common redshank *(Tringa tetanus*), followed by green sandpiper *(Tringa ochropus),* wood sandpiper *(Tringa glareola)* and common ringed plover (*Charadrius hiaticula),* whereas, negative trends were estimated for common snipe (*Gallinago gallinago)*, ruff (*Philomachus* *pugnax)* and spotted redshank (*Tringa erythropus)* (Lindström et al., 2015). In comparison to the older study from Sweden (Svensson, 2007), the trends were similar for studied wood sandpiper and common ringed plover in the years 1984-1995.

A more recent study (2006-2018) (Lindström et al., 2019)from boreal and arctic parts of Fennoscandia revealed positive trend for oystercatcher (*Haematopus ostralegus*), dunlin (*Calidris a. alpina*) and wood sandpiper while negative trend for red-necked phalarope (*Phalaropus lobatus*), broad-billed sandpiper (*Calidris falcinellus*), and whimbrel (*Numenius phaeopus*). Medium-distance migrants had more favourable trends than long-distance ones but as mentioned in the first study (Lindström et al., 2015), no general trends in waders numbers were observed (Lindström et al., 2019). Despite the global consensus that waders are rapidly declining (Delany et al. 2003; Zockler et al. 2003), the long-term population trends for waders in these studies (Lindström et al., 2015) seemed to be quite optimistic. The incoherence with the latitude-dependent predictions (Jiguet et al., 2010) might be explained by a small number of species and variation in the types of habitats utilised (Lindström et al., 2015).

In Denmark, one of the longest monitoring data collections enabled the researchers to evaluate long and short-term population trends (Meltofte & Clausen, 2016). Studies were conducted on an environmentally important Tipperne reserve between 1929-2014 where 25 wader species were nesting. None of the species had significantly decreasing trends throughout the study period, Eurasian golden plover and common greenshank have been increasing since the beginning (Meltofte & Clausen, 2016). Importantly, species that started to have significantly decreasing trend around the years 1990 were northern lapwing, black-tailed godwit, ruff, and common snipe. Many other species went from strongly increasing trend to stable or fluctuating.

Nonetheless, many wader species are becoming threatened, and their numbers are consistently declining. One example is the great snipe (*Gallinago media)*, which has been on decline since the second half of the 20th century (BirdLife International, 2024) and the decline is still noticeable in Sweden (Ekblom & Carlsson, 2007). Moreover, its range is shifting in Russia (Artemyev, 2022). Belarus where one of the largest populations occurs has noticed that lekking males decreased by 3- to 5-fold and the authors ascribed the trend to the lack of suitable nesting habitats (Mongin & Davidyonok, 2019). The same reason is also often connected with other two waders that are suffering from major declines all over the Europe.

Northern lapwing (*Vanellus vanellus*), Eurasian curlew*(Numenius arquata*), and great snipe raised concern in Northern Ireland as their populations declined by 66%, 58% and 30% respectively in twelve year period (Henderson et al., 2002). Additionally, another 26-yearlong

Figure 2 Eurasian curlew *(Numenius arquata)*

study revealed even more negative trends for the three mentioned species with addition of redshank (Colhoun et al., 2015b). Eurasian curlew is already classified as near threatened in Europe (BirdLife International, 2024) and there was also reported a great decline by 47% in Norway (Monthouel, 2018). Major contributor to this decline was supposedly progressive arterial and field drainage which led to wetland destruction (Colhoun et al., 2015a).

In Latvia, all wader species have declined significantly, most probably due to changes in habitat quality (Vīksne et al., 2005). The ruff *(Philomachus pugnax*) was reported to have ceased nesting completely, possibly due to overgrowth of reeds and shrubs in its breeding range (Vīksne et al., 2005).

1.1.3 Wildfowl, and Grebes of central Europe

When moving to the more southern parts of Europe, there has been observed a general decline in the number of breeding waterbird species (Bárcena et al., 2004). Food availability was the most relevant reason amongst others, especially for migrant birds. (Bárcena et al., 2004; Herrera, 1978). Nevertheless, in this part I am also including country from the Atlantic region which is an important area for many coastal species and species preferring inland wetlands as well (Keller et al., 2020). However, there are still a lot of suitable and ecologically important wetlands that host many waterbird species.

A considerably positive outcome revealed an older study from the Czech Republic, which recorded higher species richness in the 10-year period 1981-1991 (Musil & Fuchs, 1994). Species that were on decline involved Eurasian teal, garganey, northern shoveler, and moorhen which is again coherent with their status in northern Europe. In addition, two species started to decline in the second half of the study period, namely great crested grebe, and little grebe from the family Podicpedidae (Musil & Fuchs, 1994).

Red-necked grebe, coot, common pochard tufted duck and black-necked grebe (*Podiceps nigricollis*) showed declining trends between 1985-2014 in Poland (Nieoczym et al., 2021). Among species with positive population trends, there was also great crested grebe. Despite the regional microscale the study was based on, many results were convergent with national trends. The coot and moorhen (*Gallinula chloropus)* population trends whose European population trends are in positive numbers, were also increasing in France (Jiguet, Frédéric, Godet, & Devictor, 2012). In Germany (Kamp et al., 2021) a comprehensive study revealed that birds preferring wetland habitats were in general having positive population trends. However, species whose trends are decreasing in northern Europe continue to decrease in the lower latitude.

Despite the differences, some trends stay the same and considering avifauna generally, we can see that species with narrow niches are declining disproportionally (Kamp et al., 2021). It is also mentioned that long-distance migratory species are on decline and short-distance migrants as well as resident species are on incline, which agrees with the distribution pattern of breeding waterbirds (Bárcena et al., 2004). Climate-wise, low-temperature preferring species are on decline, which confirms the model for the future distribution of wetland species (Soultan et al., 2022).

1.1.4 Other Waterbirds of central Europe

Wader species composition breeding in central Europe is not that different from northern Europe. Mostly observed are common, widespread species like redshank, oystercatcher, red knot, or ruff.

In Polish nature reserve, breeding waterbirds were monitored between 1993-2013 and species raising concern all over the Europe like northern lapwing, black-tailed godwit, common redshank had a negative trend here as well (Marchowski & Ławicki, 2014). For these species the situation was similar in Slovakia and Czechia (Kubelka, Zámečník, Slabeyová, Škorpíková, & Šálek, 2018). In two studies from central Europe, coot was also reported as decreasing (Marchowski & Ławicki, 2014; Musil & Fuchs, 1994). Green sandpiper, common snipe, but also common crane (*Grus grus*), conversely, had positive trends (Marchowski & Ławicki, 2014).

Near threatened northern lapwing (BirdLife International, 2024) has been significantly declining in many European countries and the raising concerns led to careful monitoring . In 1976-2004 the ringing data revealed declines in every region studied (Zidkova et al., 2007). In addition, its habitat shifted towards fields and arable land. This was observed also for little ringed plover (*Charadrius dubius*) (Musil & Fuchs, 1994).

On the other hand, new species were observed in 1991 and the trend of the great cormorant (*Phalacorax carbo)* was indeed positive (Musil & Fuchs, 1994). Another species that currently seems to be on the rise is great egret (*Ardea alba)* (Ławicki, 2014). Its expansion was studied in Russia (Kouzov et al., 2022), where early onset of positive temperatures was strongly associated.

1.1.5 Waterbirds of Southern Europe

Southern states in comparison to other parts of Europe differ in the overall composition of breeding waterbird species. Even though we can still find some waterbird species with wide breeding ranges, the main proportion is made up of wading birds like herons, gulls or terns. Indeed, the life histories and most importantly diets of these birds are different. Generally speaking, more ichthyophagous species are present (de Arruda Almeida et al., 2019; Sorino et al., 2013).

Nevertheless, previously mentioned Eurasian wigeon, common pochard, tufted duck but also red-crested pochard *(Netta rufina)* showed a negative trend during the breeding season in 1984-2014, which was primarily driven by eutrophic nature of the lagoons (Martínez-Abraín et al., 2016a). However, the study reported an increase in 29 waterbird species, including northern shoveler, northern pintail, gadwall, Eurasian teal, common shelduck (*Tadorna tadorna)* but also great crested grebe, little grebe, black-necked grebe. The success is ascribed to the change in the protection policies (Martínez-Abraín et al., 2016b). Furthermore, species from families Phoenicopteridae, Ardeidae and Phalacrocoracidae that nest mainly or exclusively in southern Europe had also increasing or stable trends (Martínez-Abraín et al., 2016b).

Colonial wading birds showed positive trends in southern Europe and their numbers have been increasing since 1996 onwards (Ramo et al., 2013). These include night heron (*Nycticorax nycticorax),* grey heron *(Ardea cinerea),* white stork (*Ciconia ciconia)* or even purple heron (*Ardea purpurea)* that's trend was in the past decreasing (Prosper & Hafner, 1996). The same situation was described in northwestern Italy where the most noticeable increases in herons´ and egrets' numbers occurred between 1985-2000 (Fasola et al., 2023a). These were followed by decline of 50% in one of the studied sectors that stopped being permanently flooded, thus the availability of foraging habitats was reduced (Fasola et al., 2023b). The great egret´s (*Ardea alba*) populations remain stable or increasing, moreover, recently it was discovered to nest regularly in new regions (Valle et al., 2021).

When examining several potentially confounding factors that may be associated with population fluctuations, coloniality and habitat range were significantly related (Cuervo & Møller, 2017). The study was conducted on 231 European breeding birds, suggesting that size fluctuated more in colonial, less abundant species with larger breeding ranges. As colonial breeding waterbirds seem to suffer from the general loss of suitable habitats (Hanneman & Heckbert, 2001) positive research outcomes are even more valuable. On the other hand, it has been suggested that birds living in southern Europe had better future outlooks in terms of sustaining the populations than those which are northernly distributed (Jiguet et al., 2010) which may also contribute to some of the increasing trends in this region.

1.2 Wintering Season Population Trends

Migratory waterbirds annually undergo long-distance journeys to spend the inhospitable win conditions in a more productive, warmer, and ice-free environment. Wintering grounds are usually located southern to the breeding sites, on large waterbodies such as lakes, seas or even agricultural sites like fish ponds(Sebastián-González, Sánchez-Zapata, & Botella, 2010) or rice fields (Elphick & Oring, 1998). The main purpose of wintering sites is to rest and refuel, which also means spending as little energy as possible on thermoregulation (Musilová, Musil, Zouhar, & Adam, 2018). However, they often have limited wintering capacity (Goss-Custard & Charman, 1976; Goss-Custard, 1985).

Figure 3 Grey heron (*Ardea cinerea*)

When estimating population trends and counts on wintering sites, it is often difficult to foresee the breeding success or distinguish between breeding and non-breeding individuals.

Wintering sites and their quality may also affect the breeding success and population abundance in the following year. Their distribution is also expected to respond to the weather conditions more dynamically than breeding sites distribution (Ridgill & Fox, 1990).

1.2.1 Wintering Waterbirds in Northern Europe

Northern Europe hosts several wintering bird species, some of which are resident and present year-round. A long-term study in Scandinavia have reported increasing trends in many species (Nilsson & Haas, 2016). This could imply that milder winters allow more birds to spend the winter in higher latitudes. However, different outcome was observed when evaluating shorter 10-year period trends (Nilsson & Haas, 2016). Only six species remained with an increasing trend, specifically common eider (*Somateria mollissima).* greater scaup (*Aythya marila),* common scoter (*Melanitta nigra),* velvet scoter (*Melanitta fusca),* goldeneye and smew (*Mergellus albellus).* This was be explained by the sensitivity of short-term trends towards occasional years of either high or low numbers of birds (Nilsson & Hermansson, 2021).

Furthermore, 10-year monitoring from Ireland revealed negative trends for most of the species, with an exception for graylag goose, Icelandic whooper swan, great cormorant, common shelduck, brent goose and barnacle goose (Crowe et al., 2008). A possible explanation from a North American study suggests that wintering grounds are shifting not only towards northern areas but also further from coastal regions due to less severe inland winters (US Environmental Protection Agency).

The Great Britain is estimating wintering population trends regularly for many years. In the period 2012/13 to 2016/17 (Frost et al., 2019) goose species with a decreasing trend were snow goose (*Anser caerulescens*), tundra bean goose, white-fronted goose. Bewick´s swan (*Cygnus colombianus*), common shelduck, mallard, pintail, common pochard, common eider, smew, ruddy duck (*Oxyura jamaicensis*), little grebe, and moorhen also exhibited declines. Among waders, the biggest declines were estimated for red knot, common redshank, curlew, oystercatcher, but also for grey plover, Eurasian turnstone, dunlin, purple sandpiper, and spotted redshank. Britain totally reported a gain of 175 000 geese and loss of 142 000 waders (Frost et al. 2019). This is especially concerning when compared to older estimates, which reported mostly increases in 1987/88-1991/92 on estuaries and non-estuarine coasts (Cayford & Waters, 1996). The largest increase in estuaries (+118%) was seen in grey plover, while it decreased by

36% on non-estuarine coasts. Conversely, red knot showed the most significant increase (+130%) in non-estuarine coasts during this earlier period (Cayford & Waters, 1996). In addition, between 1948-1960, common pochard and tufted duck populations were also exhibiting positive trends (Eltringham & Atkinson-Willes, 1961).

In Lithuania, many wintering bird populations increased throughout the 20th century, with the number of species increasing from 17 to 42 (Švažas, Dagys, Žydelis, & Raudonikis, 2001). A shorter study from 1987 to 1999 focusing on coastal wetlands and winter visitors found that dominant species like goldeneye, long-tailed duck, velvet scoter, Steller's eider, goosander, and smew experienced significant declines after cold winters (Švažas et al., 2001). Therefore, climatic conditions were believed to be the primary determinant of their wintering population sizes (Švažas et al., 2001).

1.2.2 Wintering Waterbirds in central Europe

Several suitable areas in central Europe present well-known wintering areas, thus, the monitoring has been conducted regularly for many years. From previously mentioned species, there was reported incline in wintering populations in France evaluating the data from 88 wetlands from 1988/89 to 2008/09 annualy (Fouque, Guilleman, & Schricke, 2009). Graylag goose, mute swan (*Cygnus olor),* brent goose (*Branta bernicla),* common shelduck, gadwall, Eurasian wigeon, northern pintail, Eurasian teal, mallard, northern shoveler, common merganser, common pochard, red-crested pochard and coot had all moderately to strongly increasing trends. Tufted duck, goldeneye and tundra bean goose had moderately decreasing trends and a strong decrease was reported for greater scaup (*Aythya marila)* and red-breasted merganser (Fouque et al., 2009). Annual rate of change was -6.2% and -9.8% respectively, however, France holds only small proportion of European populations of these species. Comparing local and European population trends, French wintering population of common pochard was reported to have an increasing trend, whereas its European status is classified as decreasing. Its wintering numbers were also increasing in 2004-2013 in Czech republic, and it was reported that the habitat preference of this species is shifting from rivers to standing water bodies (Musil & Musilová, 2014).

In Poland, significant increase was reported for tufted duck, goldeneye, great crested grebe. Vice versa, common merganser had a negative trend over the 16-years-long study period (Marchowski, Ławicki, Guentzel, Kaliciuk, & Kajzer, 2018), which was explained by the wintering grounds shifting north (Lehikoinen et al., 2013). In Hungary the situation for merganser was similar and decreasing were also bean goose (*Anser fabalis*), tufted duck, goldeneye, and smew (Faragó & Gosztonyi, 2009). This, however, seems to be quite a recent shift, as in an older study (1966-2008) from Czechia (Musil, Musilová, Fuchs, & Poláková, 2011a), merganser had in contrary positive trend. So did tufted duck, common pochard, goldeneye, smew, and Eurasian wigeon. Similarly grey heron and great egret from waders (Musil et al., 2011b). Here, on the other hand, little grebe, great crested grebe, moorhen, Eurasian teal, and coot were on decline.

A different flyway population of mentioned whooper swan (Crowe et al., 2008) was also studied separately in 1995-2015, where distribution of the population amongst European countries was evaluated (Laubek et al., 2019). Its population size increased over the study period by 133%, but it was the most pronounced in Denmark and Germany. In addition, percentage of total annual count decreased in Norway, Sweden, Poland, and Netherlands (Laubek et al., 2019). The researchers ascribed this shift in wintering range to southern expansion of its breeding range based on the ringing recoveries of some individuals.

The shifting range of wintering grounds was specifically studied in Eurasian wigeon, which is declining in abundance in the west and south of the wintering range (Fox et al., 2016). Nevertheless, a major movement in the centre of gravity of the wintering distribution was not reported as 75% of the population winters in central Europe where the abundance is stable. The authors referred this to as the less pronounced winter severity (Fox et al., 2016) .

Similar phenomenon was observed for greylag goose, that was studied for 60 years on ringed individuals from Czechia with known breeding and wintering sites (Podhrázský et al., 2017). Throughout the years, less birds were migrating to southern Europe or northern Africa and observations of geese in central Europe became more frequent. The migration distance shortened significantly for the populations on North Africa and Atlantic flyway (Podhrázský et al., 2017).

1.2.3 Wintering Waterbirds in Southern Europe

Wintering Anatidae species, specifically common teal, Eurasian wigeon, common shelduck, and greylag goose were reported to be decreasing in Spain (Rendón, Green, Aguilera, & Almaraz, 2008). In Greece, the greatest declines (>5% per year) were observed for wintering common pochard and tufted duck (Liordos, Pergantis, Perganti, & Roussopoulos, 2014). Ducks and grebes had the highest proportion (53%) of species on decline during wintering counts in Valencia between 1984 and 2014 (Martínez-Abraín et al., 2016a).

Avocet, dunlin, and common ringed plover suffered from strong wintering populations decreases in Portugal (Belo et al., 2023). In a ten-year monitoring program, the overal numbers of waders declined in the whole estuary. The implied explanation was severe habitat loss, which is often detrimental for these birds and the same pattern could be observed in any geographic region.

Nevertheless, piscivores like flamingos, cormorants, herons, and small waders showed the strongest increases in numbers for most of the cases. Pied avocet (*Recurvirostra avosetta*), Kentish plover (*Anarhynchus alexandrius*), grey plover (*Pluvialis squatarola*), Eurasian golden plover (*Pluvialis apricaria*), and little stint (*Calidris minuta*) had the strongest increasing trend in Greece (Liordos et al., 2014) while pied avocet, white stork (*Ciconia Ciconia*), black-winged stilt (*Himantopus Himantopus*), greater flamingo (*Phoenicopterus roseus*), grey heron (*Ardea cinerea*), black-backed gull (*Larus marinus*), Eurasian spoonbill (*Platalea leucorodia)*, and great cormorant increased in Spain (Rendón et al., 2008). Red shank was the only increasing species in Portuguese estuary, while grey plover had stable population size throughout 10-year monitoring programme (Belo et al., 2023).

The phenomenon of shifting wintering ranges, especially for Anatidae gets more visible when looking at the trends from southern Europe winter refugees.

2 Possible Ecological Factors Explaining the Trends

In the past, longitudinal records have proven invaluable for analysing and assessing the impact of human activities on animal populations. Understanding the geographical distribution of populations and the timing of natural events can aid in predicting future trends. One example could be use of lead shots and its impact on birds of prey (Pain, Sears, & Newton, 1995). Long-term population studies are crucial in ecological research (Clutton-Brock & Sheldon, 2010), although they may not directly pinpoint the immediate causes of changes in species abundance, as it can be challenging to isolate the effects of individual environmental drivers, which often act simultaneously (Bowler, Heldbjerg, Fox, O'Hara, & Böhning-Gaese, 2018).

The preceding chapter provided clear evidence that several species have experienced changes in population size, density, or conservation status in recent years. Therefore, understanding the potential drivers behind these changes—whether they involve population increases, declines, or shifts in wintering ranges—is essential. It is important to note that long-term trends may differ from annual fluctuations (Newton, 1998).

The need to understand the trend from an ecological perspective has already resulted in several modelling and comparing studies that are exploring correlations between different factors and how they affect waterbird populations across the globe.

2.1 Climate Change

Very few things on planet Earth remain stable throughout time. Some things are changing constantly, others on a much larger time scale, however regarding climate, the impact of its change may be the most evident and broad (Hughes, 2000). Higher temperatures, shorter hydroperiods, winter severity or changes in seasonality may all have a dramatic effect on wetlands and, consequently, everything related. Bardecki (Bardecki, 1991) also proposed that wetlands could be one of the first responding ecosystems. Furthermore, waterbirds are more sensitive to climate change than other avian species (Jordán, 2017).

Apart from the direct impact that temperature changes have, climate also affects the habitat quality and sources availability. For instance, higher temperatures lead to more common utilising of habitats that were previously risky due to the high probability of freezing (Musilová et al., 2018). Rising sea levels may destroy seashores suitable for waders (Iwamura et al., 2013). These impacts will be discussed separately.

The Earth´s temperature has risen by an average of 0.06° Celsius per decade since 1850, and the largest increases in temperature occurred over the mid and high latitudes of northern continents (Lindsey & Dahlman, 2020)

2.1.1 Shifts in Ranges

Firstly, studies focusing on waterfowl presented an interesting shift in breeding and wintering ranges. In coherence with the researchers' hypothesis, three wintering ducks (tufted duck, goldeneye, goosander) increased at the northeastern edge of the flyway with a simultaneous decrease in the southwestern edge of their distributions in the last 30 years (Lehikoinen et al., 2013).

When looking at waders, the data from seven European countries showed a solid shift in wintering distributions ranging up to 115km (Maclean et al., 2008). From seven studied species (Eurasian oystercatcher, grey plover, dunlin, red knot, bar-tailed godwit, Eurasian curlew), six of them moved towards north-east, and only redshank moved towards north-west. The proposed explanation was temperature dependant climate change responses, as the correlation between changes in January temperatures and bird numbers was highly significant (Maclean et al., 2008). Moreover, the studies are also supported by reported poleward shifts in waterbird distribution (Amano et al., 2020). In a large-scale global study, temperature played an important role when assessing population increases in higher latitudes. The most affected were migratory species, larger-sized species, and those with a wider latitudinal range. Yet, precipitation changes did not show a significant correlation among or within species (Amano et al., 2020).

Breeding ranges are not excluded from this trend. In Britain, the northern margins of southerly freshwater breeding bird species have moved north by 18,9 km in 20 years and the suggested reason was higher spring and summer temperatures affecting the breeding distribution (Thomas & Lennon, 1999).

Nonetheless, as Lehikoinen (Lehikoinen et al., 2013) mentioned, widespread species are difficult to monitor over such large areas and thus, estimating their total population sizes and trends is rare.

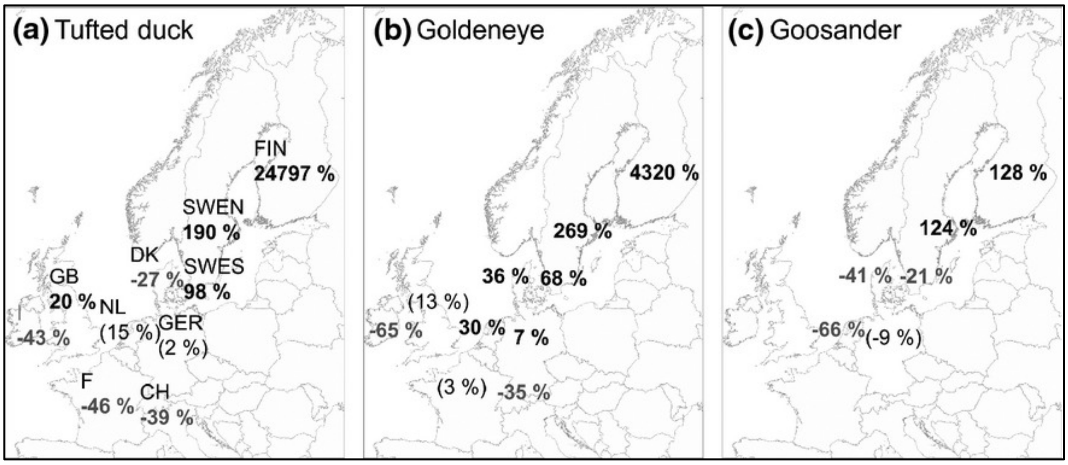

Figure 4 Distribution shifts in the wintering ranges of three common duck species. Incerases in the northeastern edges are accompanied with decreases in the southwestern edges. From „*Rapid climate driven shifts in wintering distributions of three common waterbird species*"(Lehikoinen et al., 2013)

2.1.2 Shifts in Timing

Another thing that has been studied quite vigorously in relation to climate change is avian breeding phenology and success. To begin with, a study on great tits (*Parus major*) showed that seasonal temperature variations served as a main timing schedule for females laying dates. However, mean annual temperature or daily variations did not have an impact (Schaper et al., 2012). For waterbirds, timing of nesting and migration is especially important because freezing waterbodies will not provide sufficient resources.

Breeding success as the percentage of eggs or nests within a population sample that effectively produces offspring (Rockwood, 2015) showed that for several waterbirds, breeding success was positively correlated with breeding population trend with a time lag corresponding to their recruitment age (Rönkä et al., 2011).

However, breeding phenology did not seem to have a significant impact on breeding success or population trends of ducks (Pöysä, 2019) or storks (Tobolka et al., 2018). Neither it was related to changes in the avian population sizes in a review studying 89 bird species (Dunn & Møller, 2014). Hence, it was suggested, that at least common teal, mallard and goldeneye, can withstand the changes in spring breeding phenology, while remaining horned grebe, Eurasian wigeon and tufted duck need to be studied more in the future (Pöysä, 2019).

When implementing NAO as a climate-connected variable, it has significantly influenced breeding numbers in populations of golden plover (*Pluvialis apicaria*) and common sandpiper

(*Actitis hypoleucos*) (Forchhammer, Post, & Stenseth, 1998). NAO was also significantly correlated with annual breeding success in Eurasian wigeon and it explained 27% of its variance (Fox et al., 2016). A significant impact had NAO accompanied by higher mean winter temperatures on migration distance in studied greylag goose. That resulted in earlier arrival date of these birds to their breeding sites in Czechia (Podhrázský et al., 2017). Earlier arrival was previously suggested to help two geese species occupy more suitable sites and therefore, optimize foraging and breeding success (Tombre et al., 2008).

2.1.3 Weather Impact

Nevertheless, the question remains, is the weather itself directly affecting population sizes? In China (Li, Anderson, Wang, & Lei, 2021), a comprehensive study revealed a positive association between mean temperature in spring and waterbird abundance as well as species richness. The correlation was the strongest for Charadiiformes, suggesting that the higher temperatures can drive invertebrate emergence and abundance, which is the primary source of waders´ diet (Tulp & Schekkerman, 2008). On the other hand, stronger precipitation occurring mostly in the autumn meant a lower abundance of Charadriiformes due to reduced mudflat habitat (Li et al., 2021). In contrary, families that prefer higher water levels, such as Podicipediformes, Pelecaniformes, and Anseriformes were likely to benefit from rising precipitation. Functional diversity was also affected by meteorological factors and while herbivorous birds, waders or ground-nesting birds were threatened by low temperatures, benthivores or omnivores suffered in the autumn when precipitation was high (Li, Zeng, Lei, & Sun, 2022). The authors predicted that in the future it may lead to poorer species-richness and overlapping niches, which would negatively affect overall ecosystem composition (Li et al., 2022).

Besides global warming, extreme climatic events (ECE) are becoming more and more prevalent. Even though there are still only a few studies regarding this topic, several events were reported where unexpected weather conditions led to abrupt population declines. In 1986, thousands of diving ducks died from starvation due to the birds´ inadequate reaction to food shortage (Suter & van Eerden, 1992). Apparently, the birds were not ready for a surprisingly long winter spell. There was also an occurrence of a 19.7-75.5% decline in bird species after the flood in China (Wang, Wang, Hou, & Ouyang, 2019). However, after one year, the abundance was back to the original level, which indicates that birds outlasted unfavourable conditions in different refugees. A study based on citizen observations described various shifts and responses among waterfowl species when comparing ECE years and non-ECE years. One of the interesting observed shifts was wetland species shifted southwards during ECEs (Masto et al., 2022).

Unexpected frost in the spring, draughts or floods are severely deteriorating birds' survival rates (Suter & van Eerden, 1992) but for example, the effects of hurricanes on colonial waterbirds in Louisiana have not yet been explained (Leberg et al., 2007). Indeed, the topic is multifaceted and there is still a lot to uncover.

2.2 Disturbance and Human Activities

Recent studies are often trying to measure the impact of human disturbances on animal populations and how seriously the degradation and overexploitation of natural sites can affect biodiversity (Prakash & Verma, 2022). For instance, in Portugal, three wader species (dunlin, grey plover, redshank) showed long-term significant decrease over the past 30 years. As the declines were detected only locally, it was suggested that the main cause was the loss of roosting sites due to increased human activity (Catry et al., 2011). The most densely occupied parts of the estuary varied seasonally and whereas the northern part was preferred during the migratory period, the southern area was favoured in winter (Catry et al., 2011). This brings the focus to a well-balanced habitat network based on the proximity of roosting and foraging areas.

2.2.1 Hunting

Possibly the most straightforward type of human disturbance in waterbird communities is hunting. Madsen (Madsen & Fox, 1995) very comprehensively discussed the possible impacts of hunting pressure and stressed the bias in available studies. It was also concluded that hunting can reduce the capacity of a site, modify avian behaviour and cause species redistribution. The study evaluating experimental waterfowl refuge in Denmark concluded that before the 4-year experimental hunting-free period, hunting caused a redistribution of quarry species, resulting in a species-poor waterfowl community (Madsen, 1998). Jiguet (2012) stated that species' breeding populations in France were negatively affected if they were hunted.

In contrast, the study from Finland did not reveal the significant association between hunting pressure and population trends of the species in Finland and Europe (Pöysä et al., 2013). Altogether, the controversial nature of this factor has resulted in various research outcomes ranging from none to serious impact.

2.3 Habitat Quality, its Loss and Degradation

The global decline in wetland areas was calculated around 50-80% (Davidson, 2014). This resulted in an overall shortage of available habitats not only for avian species. Other important water bodies like ponds, rivers, estuaries, and remaining wetlands are facing changes in hydroperiods, salinity or water levels. In Czechia, areas with higher proportion of wetlands have been proven to be significantly richer in species and sustain higher numbers of wintering waterbirds (Musilová, Musil, Zouhar, & Romportl, 2015). In the study, habitat quality and its ability to minimize the impacts of severe winter conditions or unpredicted extreme weather conditions were positively associated with species richness and total numbers. For instance, wetlands featuring running water accommodated more waterbirds, as the winter harshness was attenuated (Musilová et al., 2015).

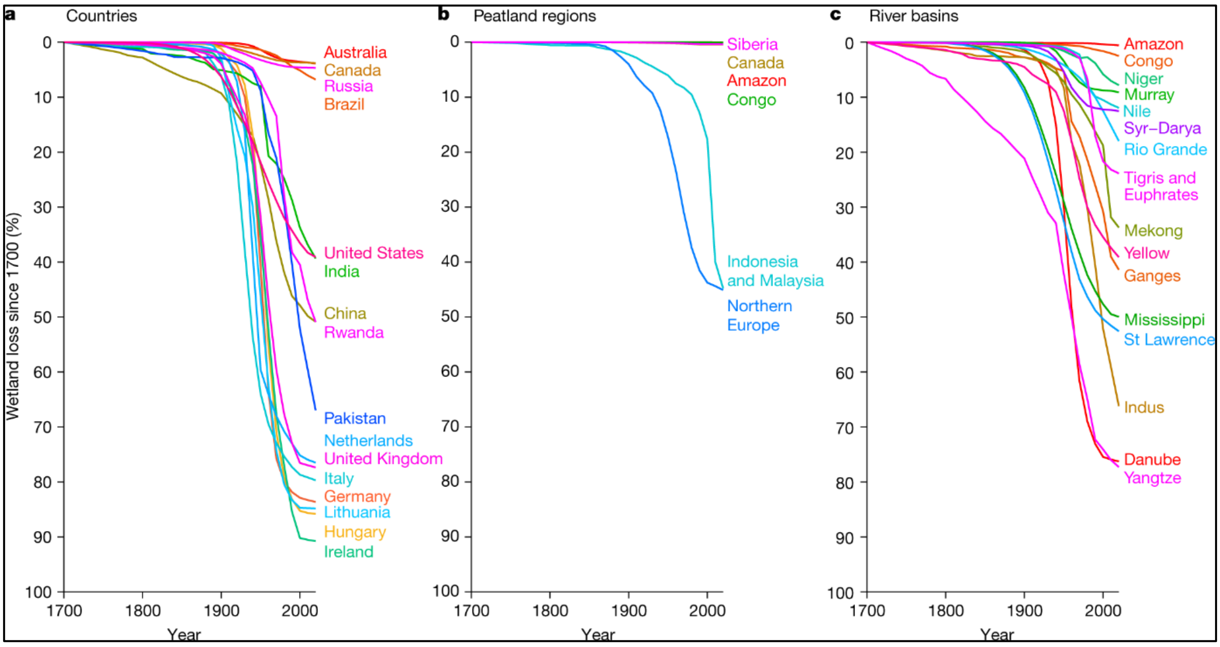

Figure 5 Habitats that provide refugees for waterbirds are globally threatened and their area is declining in many regions. From "*Extensive global wetland loss over the past three centuries*" (Fluet-Chouinard et al., 2023).

2.3.1 Eutrophication and Water Chemistry

Eutrophication is a process of continual accumulation of nutrients leading to consequences such as increased primary productivity which can have an impact on local flora and fauna composition (Sánchez-Carrillo et al., 2011). Alongside other changes in water chemistry, it was studied as a possible driver of waterbirds´ population declines in Finland. The results suggested that pH, phosphorus levels and water colour affected waterbirds differently depending on the trophic status of the wetlands (Holopainen et al., 2024). For instance, piscivorous birds, common coot or goldeneye were negatively affected by water browning, but generalist dabbling ducks could cope much better. Lower pH, on the other hand, was negatively associated with all waterbirds´ trends. Hence, the mentioned variables have led to altered waterbird composition.

The population trend of tufted duck was significantly more positive in oligotrophic wetlands compared with populations in eutrophic wetlands, and two other species (teal, wigeon) had similar but weaker effects (Lehikoinen, Rintala, Lammi, & Pöysä, 2016a). The explored habitat-specific population trends in addition to over-eutrophication of this ecosystem are according to researchers´ conclusion a serious threat to waterbird populations of the eutrophic wetlands.

Another study on wintering birds located on the mediterranean lagoon showed that total waterbird biomass increased more than 4-fold over the study period. However, 50% of the biomass is represented by the great cormorant, while the contribution of red-breasted merganser decreased from more than 90% to less than 15% (Robledano, Esteve, Martínez-Fernández, & Farinós, 2011). In the boreal lake complex in Finland, increased water turbidity was accompanied by declining numbers of waterbirds, especially ducks like Eurasian wigeon, Eurasian teal, goldeneye, and red-breasted merganser (Virkkala, 2016). The major declines were observed between 2004-2012 and the authors explain the trend by the ducks´ prey-catching strategy which is dependent on vision (Virkkala, 2016). With that in mind, ecosystem composition may become more fragile and species richness could be compromised.

Figure 6 Increased water turbidity as a result of eutrophication.

2.3.2 Water Management Practices

In Australia, artificial water management has led to a 90% drop in overall waterbird numbers in 19 years (Kingsford & Thomas, 2004). Despite Australia being a lot more arid and climate-wise different continent, human impact does not end with direct degradation or interaction. In contrast, even habitats that may look natural and pristine, like river floodplains are often modified by dams or diversions and it can alter the ecosystem conclusively.

When sticking closer to Europe, a major problem presents the current fishpond management. Musil (2006) in his work has ascribed declining populations of several waterbirds to the current fishpond management, especially to the increasing fish stocks. Unsuitable fishpond management characterized by severe increase in fish production over the last 30 years has led to the overgrowth of phytoplankton and respectively lowered transparency, which might be the reason behind the decreasing population trends of grebes, ducks, coots, and Black-headed gulls in Czechia.

Sea shores are often very important wintering areas or migratory stopovers for many waders. Especially tidal flats in estuaries are great foraging sites, but also one of the most threatened by human activities (Day Jr et al., 2012) and rising sea levels (Iwamura et al., 2013). The consequences were monitored in the Portuguese estuary where roosting area declined by 21% over the ten-year study period (Belo et al., 2023). Common ringed plover, black-tailed godwit, dunlin, and avocet were the most negatively affected. The observed declines in wader populations were therefore ascribed to the loss of available habitats mainly due to expanding fish farms and the vegetation growth inside the ponds (Belo et al., 2023).

2.3.3 Agriculture intensification

Agricultural practices have undergone significant changes over the last century, with factors such as drainage, pesticide use, mechanized cutting, and fertilizers cited as key contributors to population declines. Although not all locations have been directly converted into arable lands, the far-reaching impact of agriculture remains extensive and enduring.

Wading birds that nest in wet grasslands or meadows have experienced severe population declines due to agricultural intensification in many countries. Species like the Northern lapwing, redshank, and great snipe are increasingly threatened, with various factors affecting the safety of their nests. Despite high adult survival rates, the primary cause of declining populations is believed to be low nesting success.

Several bird species have adapted by shifting their breeding habitats from drained ponds to fields. However, the lack of sites with sufficient water and food resources has hindered successful nesting (Musil & Šálek, 1994). Studies in Czechia have highlighted the impact of flooding and increased water levels on wader populations, leading to the cessation of nesting among species like the spoonbill, night heron, and little egret (Rajchard et al., 2007).

Conclusion

To conduct a population trend analysis of avian species, long-term monitoring and data analysis are essential. Ideally, the study area should be extensive, and consistent methodology should be applied during each count. Wintering and breeding numbers should be monitored separately and annually. Such research is often time-consuming and economically demanding, making citizen science and studies based on volunteer observations more frequently used data sources. However, the information and evidence provided can be summarised according to geographical regions and bird characteristics.

Certain patterns appear to be more characteristic of specific geographical regions. Northern countries are experiencing warmer temperatures due to climate change, resulting in observed shifts in bird ranges and potential reductions in migratory distances to find ice-free wintering grounds, particularly evident in southern or central Europe. Significant increases in wintering populations of common anatids like greylag geese, tufted ducks, goldeneyes, and Eurasian wigeons are observed in the northern parts of their wintering ranges, while southern countries that historically hosted larger proportions of these birds are reporting declines. Additionally, storks, egrets, and spoonbills, which traditionally wintered in Africa or Asia, are increasingly observed in southern Europe, where their numbers are rising.

While the avian world has definitely not remained unaffected by climate change, it does not necessarily and directly result in population declines or rising concerns for threatened species. In some cases, the birds themselves have adapted quite well to the situation. Predicting the future relating to the climate and its impact on wetlands is still a challenging task. Addressing the observed phenomena of shifting ranges and integrating the data into future conservation efforts is crucial. Providing suitable wintering and roosting areas for waterbird populations is key to sustaining their sizes and preventing overexploitation of existing wintering grounds. Local monitoring may also help to manage the adverse effects of extreme climate conditions such as droughts.

A more pressing issue for waterbirds appears to be the lack of suitable habitats and declining habitat quality. Breeding population trends are closely associated with dietary preferences, current habitat quality, and breeding ground conditions. Species like grebes, pochards, mergansers, and scaups exhibit consistent population declines across European regions. Eutrophication, whether natural or human-induced, can have a diminishing effect on specialist waterbirds. Increased water turbidity can significantly reduce prey-catching success for species that rely on vision. Additionally, increasing demands on fisheries can lead to competition for food between waterbirds and fish.

Current farming practices are often cited as a primary driver of severe population declines, including wetland conversion to arable land, grassland drainage, and inappropriate fertilizer use. Birds nesting in wet grasslands or meadows are among the most threatened waterbird species mentioned in this thesis, with significant declines observed following agricultural intensification. Disturbances during the nesting period, affecting nesting success, appear to be the main reason for their setbacks, as adult survival rates remain unaffected (Pakanen & Kylmänen, 2023). Overall, habitat loss has the most negative impact on waders, which are particularly sensitive to disturbances during nesting periods. Importantly, many of these challenges can be addressed through appropriate policies and support for natural restoration processes. The rapid pace of modern agriculture has inevitably altered many ecosystems and led to several population decreases not only within the avian world.

Despite all the obstacles waterbirds must overcome, some species are doing very well in the long term. Anatids like whooper swan, *Branta* species, graylag goose and gadwall, followed by divers but also common waders like common snipe, wood sandpiper, and green sandpiper, have so far exhibited stable or increasing population trends. Following are species that are almost evenly rigorously studied as near-threatened ones. Quickly expanding great cormorants, or great egrets are observed more and more frequently in various regions and habitats, often concerning fishermen´s profits. The reasons for the success of these populations cannot be simply ascribed to one life trait or characteristic as they differ quite marginally. However, the truth is that for the time being, these birds seemed to have found the right place and time to be.

Finally, I would like to note that none of the perceptions could be made without consistent and long-term monitoring, which is the key feature for processing, analysing, and evaluating population trends. Nevertheless, many questions remain open and further research is needed to confirm the suggested hypotheses. Conversely, acquired knowledge is necessary to be implemented into conservation efforts so there are still plentiful waterbirds to be observed and monitored for future generations.

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