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KATEDRA EKOLOGIE

Site trends of selected wintering duck species in the Czech Republic

Lokální trendy vybraných druhů kachen zimujících v České republice

Diplomová práce

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Prohlašuji, že jsem tuto diplomovou práci na téma „ Lokální trendy vybraných druhů kachen zimujících v České republice“ zpracovala samostatně a jen s využitím pramenů uvedených v seznamu literatury, které ve všech případech řádně cituji.

V Praze dne

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Eva Hrdličková

Abstract

V posledních letech můžeme pozorovat změny v distribuci zimních a hnízdních lokalit ptactva po celém světě, které jsou následkem globálních klimatických změn. Také populace vodních ptáků prochází distribučními změnami. Abychom byli schopni lépe porozumět problematice těchto změn na globální úrovni, potřebujeme se zaměřit na faktory ovlivňující populace vodních druhů ptactva na regionální úrovni. Použili jsme k tomu data z IWC monitoringu z let 1966 až 2013 a zhodnotili jsme dlouhodobé trendy na jednotlivých lokalitách, průměrnou početnost a frekvenci výskytu 10 druhů kachen v České republice. Následně jsme zhodnotili vliv environmentálních faktorů (zeměpisná poloha, lednová průměrná měsíční teplota, zastoupení urbánních biotopů v okolí, zastoupení mokřadních biotopů v okolí, ochrana lokality, průměrná početnost a frekvence výskytu jednotlivých druhů kachen) na tyto proměnné. Průměrnou početnost a frekvenci výskytu jednotlivých druhů ovlivňovalo více signifikantních environmentálních faktorů než tomu tak bylo v případě posouzení dlouhodobých trendů na lokalitách. Zatímco početnost a frekvenci výskytu ovlivňovali podobné environmentální faktory, faktory signifikantní pro trend početnosti se s početností a frekvencí nepřekrývali. Vliv jednotlivých environmentálních faktorů se lišil u jednotlivých druhů kachen. Obecně, byl pozorován pozitivní vliv vyšší průměrné lednové teploty a vyššího zastoupení mokřadních lokalit v okolí. Naopak, negativní vliv měl typ mokřadní lokality, konkrétně rybníky. Ochrana lokality, podobně i řeky a pískovny měly velmi malý vliv na průměrnou početnost, frekvenci a trendy jednotlivých druhů.

Klíčová slova: Mezinárodní sčítání vodních ptáků (IWC), lokální trendy, vodní ptáci, environmentální faktory, klimatické změny.

In last decades, we can observe distributional shifts of wintering and breeding bird areas worldwide as an effect of global climate changes. Also waterbirds are a subject of population and distributional changes. To understand better the problematics of such changes in a global scale, we need to focus on factors affecting waterbird populations in a regional scale. Using data from IWC monitoring between years 1966 and 2013, we assessed long-term site trends, mean numbers and frequencies of occurrence of 10 duck species wintering in the Czech Republic. Further, we evaluated effects of environmental factors (latitude, longitude, monthly mean January temperature, proportion of urban habitats in surroundings, proportion of wetland habitats in surroundings, site protection, mean numbers and frequency of occurrence of individual species) on those variables. Mean abundance and frequency of occurrence could be explained by more environmental variables than long-term changes in numbers. Similar environmental factors were found as significant in analysing mean numbers and occupation frequencies, whereas a set of variables significant for trends did not overlap with the mean numbers and frequencies. Effects of environmental variables varied according to individual species. Generally, positive effects were observed for mean January temperature and wetland proportion in the surroundings, and oppositely, negative effects were found in case of fishpond habitats. Protection of the site, as well as rivers and sandpits had a very little effect on species' trends, mean numbers or frequencies of occurrence.

Keywords: International Waterbird Census, site-trends in numbers, waterbirds, environmental factors, climate change.

Obsah

1. Introduction

Populations of waterfowl in Europe are undergoing extensive abundance and distribution changes. These changes are put in context with global climate change, as birds are easily-observed predictors of global climate change, directly reacting to changes in temperatures by changes in numbers and distribution. In this context we can find recently published studies on bird population changes on the large scale level (Ridgill & Fox, 1990; Lehikoinen et al., 2006; Rainio et al., 2006; MacLean et al. 2008; Lehikoinen et al. 2013). Yet, trends on the continental level are influenced by changes on specific sites, often lacking detailed research. Based on a large dataset, we investigate long-term site trends of 10 duck species occurring in the Czech Republic and compare them with trends on European level. Further, we analyse environmental site-specific variables with expected effect on waterbird populations. Understanding the importance of specific site variables influencing bird species trends, frequency of occurrence and abundance is essential for assessment and improvement of international and national policies in order to conserve and manage waterbird populations and key wetland sites in the changing world.

1.1. Waterfowl: significance for wetland indication

World's freshwater wetlands are habitats of a significant ecological value. Covering only 1 percent of the Earth's surface, they hold more than 40 percent of the world's species and 12 percent of all animal species; many of them are endangered or threatened (http://www.ducks.org/conservation/habitat/page2). Twenty four per cent (212) of all 871 waterbird species are categorised as globally threatened in the IUCN Red List 2012, including 28 that are Critically Endangered (Wetlands International 2012). Waterfowl species depend on wetlands for breeding, nesting, feeding, or shelter during their breeding cycles. Wetlands are important also for migratory birds that use them as flyway areas. About one third of birds in the North America are dependent on wetlands at least in some part of their life cycle (Kroodsma 1979). Hence, wetland's loss or degradation has a direct effect on the reduction of waterfowl populations worldwide (e.g. Tamisier & Grillas 1994; Duncan et al. 1999; Amezaga et al. 2002).

As wetlands are destroyed, some birds move to other less suitable habitats with less feeding opportunities or higher disturbance, where reproduction tends to be lower and mortality tends to be higher. The result over years is unsustainable population (Pulliam & Danielson 1991).

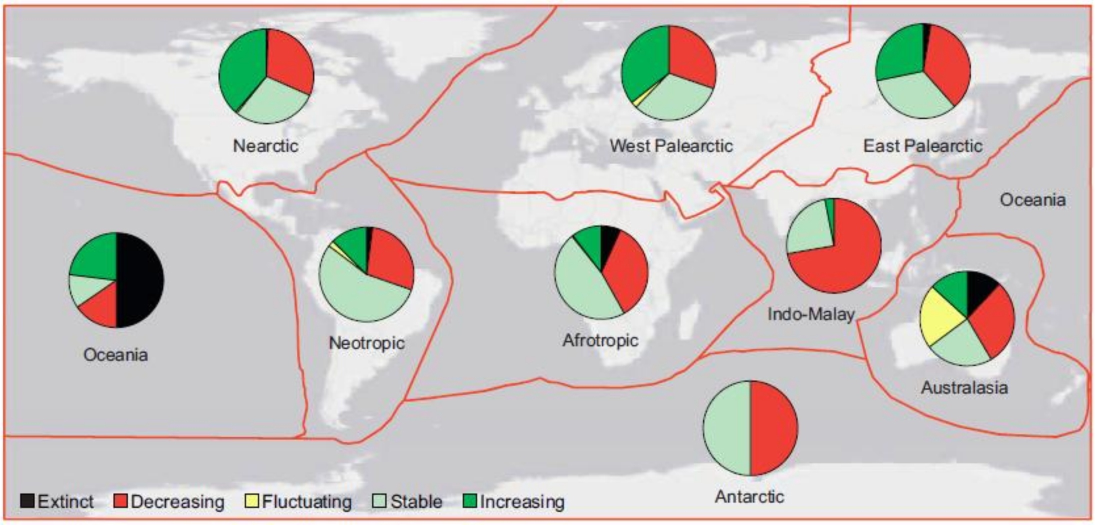
Wetlands are considered one of the most threatened ecosystems. In recognition of this, intergovernmental Ramsar Convention (or the Convention on Wetlands of International Importance, especially as Waterfowl Habitat) was established in 1971. Ramsar Convention works closely with five other organisations known as International Organization Partners (IOPs). These are Birdlife International, the International Union for Conservation of Nature (IUCN), the International Water Management Institute (IWMI), Wetlands International and WWF International. These support the work of the Convention by providing expert technical advice, helping implement field studies and providing financial support (Wetlands International 2006).

The Ramsar Convention determined specific criteria based on birds numbers for designation of wetlands of international importance (Ramsar sites).Those are Criteria 5 and 6. A wetland should be considered internationally important if it regularly supports 20.000 or more waterbirds (Criterion 5) and the 1% threshold criterion of the individuals in a population of one species or subspecies of waterbird (Criterion 6) (Wetlands International 2006).

In this context, knowledge of population size is fundamental to the application of conservation planning and action (Jackson et al. 2004; Sutherland et al. 2004), using the national threshold value (Wetlands International 2006).

Although there is no available trend information for a number of populations, the assessment of population trends through biogeographic realms gives us more detailed insights (Fig. 1) (Wetlands International 2006). As can be seen from the Figure 1, the status of waterbird population in West Palearctic is much more optimistic than in some other biogeographic realms, where legal and financial instruments to govern the conservation of waterbirds are lacking.

Fig.1: Waterbird population trends by biogeographic realm (%) (Wetlands International 2012).



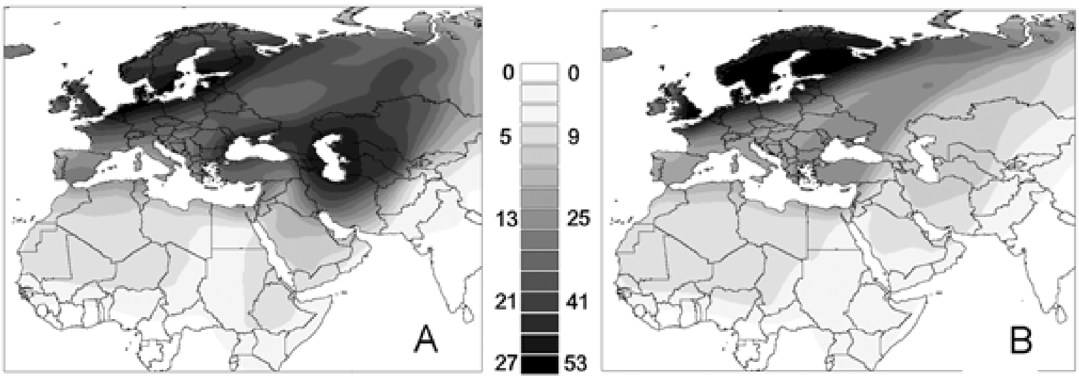
1.2. Migration of waterfowl

During over one hundred years of ringing tradition in Europe, more than 200 billion birds have been individually ringed worldwide, revealing movement patterns in bird populations. The main factor in timing the migration is apparently an endogenous rhythm within the bird, which is induced by seasonal changes in day length. Favourable weather conditions and sufficient extent of body reserves are other factors determining the timing of migration (Newton 2008).

In some species, individuals can migrate at almost any date in the nonbreeding season, if stimulated to do so by reduced food supplies, when they usually move further along the same migration axis, reaching the most distant parts of their wintering range only in extreme years (Newton 2008).

Duck species can be either residential or migratory. Generally, southerly distributed *Anatidae* in Europe do not suffer of harsh winters and poor feeding opportunities, hence they often winter in the same area as they breed and moult. Migratory waterfowl breeding in higher latitudes start migrating southwards in the end of summer to escape the frosts and profit of better feeding opportunities (Isakov 1967; Newton 2008). We recognise 3 main Western Palaearctic region flyways connecting breeding areas to wintering areas in Europe (Fig. 2). The North Sea flyway joins the wetlands of north-western Russia to Western Europe wintering sites and runs through Scandinavia, the Baltic basin, and the North Sea. The Black Sea and Caspian Sea flyways run from the west Siberian lowlands, leading to Mediterranean Europe and western Asia. When weighted according to the number of birds that use them (Fig. 2B), the North West Europe flyway stands out as the most important, followed by the Black Sea; the Caspian Sea flyway is of least consequence (Gilbert et al. 2006). However, migration systems have considerable between-species variations, which are often concealed in maps of generalised flyway system (Boere et al. 2006). The migration routes for each duck species are further described in *Atlas of Anatidae populations in Africa and Western Eurasia* of Rose & Scott (1966) or in Cepák's (2008) *Atlas migrace ptáků České republiky a Slovenska*.

Fig. 2. Distribution overlay of migratory flyways of *Anatidae* bird species in the western Palearctic: each pixel of gray shading indicates the number of species that include the area as part of their flyway. A) All species with an equal weight (indicative of species diversity by pixel). B) Flyways weighted according to their population (indicative of anatid populations) (Gilbert et al. 2006).



1.3. Wintering waterfowl

Almost all waterfowl have at least two alternative wintering areas- a roost and one or more feeding areas- and they regularly fly between them (Owen & Black 1990). One of the benefits of such a system is that the communal roost functions as an "information centre," where individuals benefit from a group experience and can effectively exploit food resources. Birds which had experienced poor feeding opportunities previously identified more successful feeders and followed them to their feeding areas (Ward & Zahavi 1973). Individuals also tend to be loyal to the wintering areas and staging areas on migration. Site fidelity is traditional for matured and paired geese, swans and sea-ducks, while freshwater diving ducks show lower return rates, and dabbling ducks still lower rates (Robertson & Cooke 1999). It is probably due to instability of occupied habitats (water level or ice cover) that diving and dabbling ducks show lower pattern of site fidelity (Newton 2008). Wide dispersal between wintering areas from one year to another (often more than 20 km) was well documented in Tufted Duck and Common Pochard (Kershaw & Hearn, in Wernham et al. 2002; Gurlay et al. 2012). Unpredictable movements within waterfowl are most common in response to food availability, drought or hard weather. Massive southerly movements occur, and inland waters are deserted as waterfowl move towards the coast during cold winters. Body size and wintering habitat are the factors that are responsible for immediacy of the movement, whereby smaller species depended on shallow waters are the most vulnerable (Owen & Black 1990). One of the most vulnerable species in this sense is Teal (Ogilvie 1981).

1.4. Waterbird monitoring in the Czech Republic

Monitoring of wintering waterbirds is carried out as part of International Waterfowl Census (IWC), coordinated by Wetlands International. IWC is one of the world's largest and longest-running monitoring programmes based on citizen science. It has been running since 1967 in more than 100 countries (Wetlands International 2002). The goal of monitoring scheme is to monitor status and trends of waterfowl species and to assess environmental and other factors that lead to changes in waterfowl population on both local and global scales. Waterbird population estimates are used to assess and improve international and national policies to conserve and manage waterbird populations and key wetland sites (Wetlands International 2002). Waterbird Population Estimates are used for designation of Wetlands of International Importance (Ramsar Sites), using 1% population threshold criterion.

1.4.1. History of monitoring in the Czech Republic

Wintering waterfowl monitoring has a long-term tradition in the Czech Republic. Coordinated monitoring takes place annually since 1965; Czechoslovakia was between first countries in Europe that joined the IWC monitoring programme in

January 1966 (Musilova & Musil 2004; Musilova et al. 2010). Until 1990/91, monitoring was being held every month during “winter” season (October- April). After that until now, monitoring has been reduced to October, January and April terms, with the term in January being the only one internationally recognised (Delany et al. 1999; Nilson 2008).

Data are collected in mid- January, when low temperatures cause concentration of bird individuals in groups (Musil & Musilova 2015). Since 2012, IWC monitoring in the Czech Republic has been coordinated by Department of Ecology, Faculty of Ennvironmental Sciences, Czech University of Life Sciences.

With help of many keen volunteers and collaborators of non-governmental organisations such as Czech Society for Ornithology and Czech Union for Nature Conservation (ČSOP), data from between 48 and 679 wetland sites were collected in January each year between 1966 and 2014, the record number of monitored localities was reached in January 2014 (Musilová et al. 2015, in litt.; Musil & Musilova 2015). With 194-200 monitored sites in 1978-1980, the intensity of monitoring in the following decade decreased. The numbers of sites increased again in 2004 when 478 sites were counted (Musil & Musilova 2010). The highest number of 680 monitored sites was reached in 2014. There are about 300 volunteers involved regularly in the last years (Musil & Musilova 2015).

1.5. Wintering waterbirds in Europe

Up to now, the majority of important European wintering sites for most waterbird species have been found in the coastal areas of north-west Europe, on the Baltic Sea and in the Mediterranean region (Gilissen et al. 2002, Kershaw & Cranswick 2003, Skov 2011, Van Roomen et al. 2012, Lehikoinen et al. 2013). We can observe shifts in the centre of the wintering range of waterbirds north-eastern direction. This north-eastward shift is correlated with temperature increase of 3.8°C in early winter temperature in north-eastern wintering areas in Europe (Lehikoinen et al. 2013). The importance of central Europe as a wintering region for waterbirds has been increasing in the recent decades (Fox et al. 2010, Musil et al. 2011, Pavol-Jordan et al. 2015). In particular, lakes, unfrozen reservoirs and running waters have attracted around 200.000 waterbirds every winter in central Europe (Gilissen et al. 2002, Keller 2011). The relatively mild climate can provide feeding opportunities throughout the wintering period especially when the Baltic coast becomes frozen in severe winters (Švažas et al. 2001, Nilsson 2008). On the contrary, many waterbird species have been declining in Western Europe (e.g. Wahl & Sudfeldt 2005; Crowe et al. 2008; MacLean et al. 2008). Concerning *Anatidae*, the decline doesn't apply for species such as Tufted Duck, Common Teal, Gadwall and Great Smew, which have been increasing in north-west Europe (Wetland International 2015).

1.6. Wintering trends in the Czech Republic

On the contrary to Western Europe, where we can find declining trends for most waterbird populations (e.g. Wahl & Sudfeldt 2005; Crowe et al. 2008; MacLean et al. 2008), the numbers of wintering waterfowl in Central Europe are mostly increasing or stable (Keller 2006; Darolová at al. 2007; Musil et al. 2011). Results of a long-term waterbird population study (1966–2008) showed that there has been an increase in numbers counted in 20 of the 26 most abundant wintering waterbird species in the Czech Republic and an expansion in range in 16 of these species that broadly correlates with the changes in numbers (Musil et al. 2011). More recent analysis also confirmed that that the majority of wintering waterfowl species in the Czech Republic were increasing (23 of 37 species), whereas decreasing were only 6 species (Musil & Musilova 2015).

Concerning total numbers, the 1st record of more than 200.000 waterbirds was in 2009 (Musil & Musilova 2010). The highest number of waterbirds was reported in 2012 with 260.010 individuals of 59 species (Musilova et al. 2014a). The most numerous species according to IWC data is Mallard, exceeding 100.000 individuals (population size estimates 162.000-194.000 individuals). The second most numerous species was White-fronted Goose (6.000-58.000), followed by Great Cormorant (10.600-14.100) and Common Coot (9.200-12.800) (Musilova et al. 2014b). Population size estimates of the most common *Anatidae* species in the Czech Republic are shown in Tab.1.

Tab. 1: Population size estimates of 10 common *Anatidae* according to IWC data between 2009 and 2013 (Musilova et al. 2014b).

Common name	Species	Population size	1% Threshold
Eurasian Wigeon	Anas penelope	100–160	1
Gadwall	Anas strepera	65–170	1
Common Teal	Anas crecca	460–690	6
Mallard	Anas platyrhynchos	162.000–194.000	1.800
Tufted Duck	Aythya fuligula	4.100–5.800	50
Greater Scaup	Aythya marila	20–100	0
Velvet Scoter	Melanitta fusca	15–115	0
Common Goldeneye	Bucephala clangula	850–1.300	10
Great Smew	Mergellus albellus	70–120	0
Goosander	Mergus merganser	2.800–4.000	35

The Czech Republic represents the edge of waterbird wintering area for most of species in Western Palearctic (Hudec 1994; Delany et al. 1999; Musil et al. 2001; Gilissen et al. 2002). Possibly due to relatively high diversity of smaller wetland areas providing feeding opportunities for waterbirds, and also likely with changing winter climate conditions in Europe, waterbird population in Czech Republic is increasing. Particularly, when there is freezing in Baltic regions and birds don't have feeding opportunities there, they search refuge in central and Eastern Europe (e.g. Svažas et al. 2001; Nilsson 2008).

In a previous study of Musilova et al. (2009), a total number of 15 regularly wintering duck species were recorded in the Czech Republic. Wintering population trends increased for 6 species: Eurasian Wigeon, Mallard, Pochard, Tufted Duck, Smew and Goosander. The only decreasing species was Common Teal. Stable trends were found in Pintail, Scaup, Velvet Scooter and Goldeneye. Those with uncertain trend were Gadwall, Shoveler, Red-crested Pochard and Ferruginous Duck.

In last 2 years, we can observe a high number of sea ducks in the Czech Republic, while declining in coastal areas. There were 110 individuals of Greater Scaup and 50 individuals of Velvet Scoter mostly present on big reservoirs during monitoring in 2014. This observation indicates their shift to the central European areas (Musil & Musilová 2015).

In general, the changes in numbers and distribution of waterbird species in the Czech Republic are consistent with species population trends in the Western

Palearctic (Wetlands International 2015). However, some differences were found (Musil et al. 2011). For example Common Teal which has decreasing status in the Czech Republic is increasing in other European countries (see for example, Wahl & Sudlfeldt 2005 Fouque et al. 2009; Calbrade et al. 2010). Oppositely, Mallard and Common Pochard that are decreasing in the North- Western Palaearctic flyway are increasing in the Czech Republic and other Eastern European countries (e.g. Slovakia, Slabeyová et al. 2008; Wetlands International 2015).

1.7. Wintering sites in the Czech Republic

Generally, wintering waterbirds prefer ice-free open freshwater for food resources and safety from predation (Ridgill and Fox 1990; Schummer et al. 2010). The highest numbers (i.e. more than 2000 individuals) of wintering waterbirds were recorded in the Czech Republic in the “Nové Mlýny“ Reservoir (VDNM), exceeding 20.894 individuals in 2013, including 18.000 individuals of the White-fronted Geese. For the site “Nové Mlýny“, the 1% threshold of flyway population (Ramsar Site) was reached in the same year for this species. The second and third most occupied sites were the dam reservoir “Nechranice” (11.228 ind.) and “Písečné rybníky“ (The Sand Ponds) by Hodonín (7.876 ind.). The most abundant river sites were “Vltava“ (Podolí- Mánesův most)- 3.841 ind. and “Labe” (Roudnice nad Labem- Litoměřice)- 2.943 ind. (Musilova et al. 2014a).

The highest number of waterbird species was found in reservoir “Želivka“ in the Central Bohemia-27 species and “ Nové Mlýny” reservoir)- 26 species (Musilova et al. 2014a).

“Nové mlýny VDNM” (Upper and Middle Part), “Lednické rybníky” and “Písečné rybníky” by Hodonín are the 3 recognized Ramsar Sites in the Czech Republic, holding important populations of The White-Fronted Goose and The Greylag Goose (Musilova et al. 2014a).

In last years we can observe expansion of waterbirds also to new, ornithologically little known sites. These sites are often located outside protected areas (Musil & Musilova 2015).

1.8 Environmental factors effecting migration and wintering of waterfowl

1.8.1. Global climate changes

Global climatic change is often put in a context with birds, influencing migration distance and phenology, potentially affecting patterns of mortality, as well as distribution and reproductive success (Guillemain et al. 2013). Web of Science database provides 1.399 articles related to climate change and birds. Although waterfowl are particularly responsive to climate change and are important for water habitat diversity (Svazas et al. 2001; Zipkin et al. 2010; Gunnarsson et al. 2012; Lehikoinen et al. 2013). Nevertheless, Web of Science database found only 121 studiess on this topic (Web of Science, 04-13-2015).

The effect of global warming on birds has been widely studied (e.g. Møller et al. 2008), particularly the phenological response to global warming, such as arrival dates of migratory birds (Møller et al. 2008, Lukas & Kery 2003, Both & Visser 2001, Kullberg et al. 2015).

Climatic conditions can be measured by the North Atlantic Oscillation index values (NAO). During a high index year (NAO+), westerly winds bring cool summers and mild and wet winters in Central Europe. In contrast, if the index is low (NAO-), northern European areas suffer cold dry winters and to southern Europe and North Africa suffer of increased storm activity and rainfall (Hurrell 1995; Hurrell et al. 2001). Earlier migration is correlated with higher NAO (milder winters) (Hüppop & Hüppop 2003; Vähätalo et al. 2004; Zalakevicius et al. 2006). Birds affected by advancement of spring migration also breed earlier, probably because their body condition is satisfactory for reproduction (Lehikoinen et al. 2006) or indirectly, because of benefits of early arrival to breeding grounds (Guillemain et al. 2008). They also showed to have better reproduction success. The earliest breeding Mallards, Common Teals and Common Eiders produced more offspring than later breeders (Dzus & Clark 1998; Elmberg et al. 2005; Öst et al 2008).

Different climate models show the rise in temperature in Europe. More specifically, over 25 years, the midwinter temperatures (December-February) are expected to increase by 1.7- 4.6°C in southern Europe and around the Mediterranean, and by 2.6- 8.2°C in northern Europe, depending on model projections (Solomon et al. 2007). Surprisingly, there were no significant long-term changes in December and

January monthly mean temperatures or NAO index values in the Czech Republic. In spite, significant linear correlation between the monthly mean temperature in the Czech Republic and the NAO index in December and January was recorded (Musilova et al. 2009). The effect of warmer winters has already been manifested by redistribution of bird wintering areas northerly. Birds find more favourable winter climate conditions there and better foraging opportunities, plus, a part of that they winter closer to breeding areas (Ridgill & Fox 1990).

With increasing temperatures we can expect advancement of spring migration. This effect was already observed in 1970 and published in many studies (e.g. Hughes 2000; Walther et al. 2002; Crick 2004; Gordo 2007; Ambrosini et al. 2011; Knudsen et al. 2011; Vähätalo et al. 2004). Birds are able to leave wintering areas earlier because they gain necessary body reserves earlier due to enhanced food availability (e.g. Bridge et al. 2010, Fox & Walsh 2012). The Greenland White-fronted geese *Anser albifrons flavirostris* departed 15 days earlier in 2007 than in 1973 from Ireland to Icelandic spring staging areas. During the study period, winter and spring temperatures on the wintering site rose by 1.0-1.3°C. However, in this study the correlation was found only for mean body mass and departure date and was not significant for temperature, suggesting that it was intrinsic factors enabling earlier departure of geese (Fox et al. 2012). In other study, earlier departure was related to intra-specific competition between birds (Miller-Rushing et al. 2008). Hence, the advancement of departure is not always the proof of effect of rise of temperature.

Less studied effect of climate change is delayed autumn migration. Lehikoinen et al. (2011) observed delayed migration of 6 waterbird species in Europe by more than a month over the past 31 years, suggesting waterfowl can be a good indicator group of global change. The largest change in its migration showed Tufted Duck.

Global warming will also cause increase in precipitation in some areas and droughts in others. More droughts are expected to appear in Mediterranean and more precipitation is expected with higher latitudes Spring and summer rains might cause clutch and duckling losses, whereas extreme droughts will lead to loss of wetland area, resulting in decreased reproductive success of waterbirds (Guillemain et al. 2013). Increase in rainfall will also cause nutrient flow from a catchment area that will have effect on waterbirds preferring nutrient-rich environment, as observed in Finland (Pöysä et al. 2013).

Coastal habitats are going to change due to sea level increase that is expected in following years. European coastal areas of Wash and North Norfolk coast, UK; Wadden Sea, the Netherlands, Germany and Denmark; Danube Delta, Romania are thus expected to change most significantly (Amezaga et al. 2002). According to Grinsted et al. (2010), the sea level will rise between 0.9 – 1.3 m in this century. The sea level rise will surely affect distribution and abundance of birds that are depended on coastal habitats. On the other hand, new interesting habitats may arise from abandoned flooded agricultural fields and other lowland areas (Guillemain et al. 2013).

1.8.2. Temperature

To understand global climate change, it is helpful to separate long-term trends from year-to-year fluctuations in temperatures. Temperature is a significant factor of seasonal variability. The winter distribution of most dabbling and diving duck species is largely driven by temperature, since access to water is critical for these aquatic species as they rely on ice-free open freshwater for food supply and/or safety from predation (Lebreton 1973; Schummer et al. 2010).

During mild winters we detect higher numbers of gulls, herons and some duck species (Gadwall, Northern Shoveler). On the contrary, in harsh winters, the numbers of Mute Swans, White-throated Dippers, northern ducks (Goosanders and Common Goldeneyes) increase. Some duck species showed intraspecific differences when females migrated more southerly during cold winters (Musil & Musilova 2015). Data from IWC monitoring in Vltava and Labe rivers (Central Bohemia, Czech Republic) showed that most of waterbird species (Mute Swan, Mallard, Tufted Duck, Pochard, Cormorant) moved to ice-free Prague's Vltava site during cold winter. On the contrary, higher temperatures, specifically in the second part of the winter, lead to leaving the sites earlier. Some species showed decrease in abundance in cold winters or showed decrease in population following year (Bergmann 1998). The temperature-dependent area's suitability for wintering was observed also in the study of Musilova et al. (2015); the sites that reduced the effect of a winter's harshness and served as 'cold-weather refuges' (i.e. running waters, warmer sites, urban and large wetland areas) could probably be assumed both in terms of species richness and numbers of individual waterbird species. However, some studies did not find the winter temperature to be an important factor and suggested factors such as feeding ecology to be more important (Dalby et al. 2012).

1.8.3. Geographical position

Due to climate-change-dependent wintering distributional shifts (Ridgill and Fox 1990; Rehfish et al. 2004; Austin and Rehfish 2005; Rainio et al. 2006; Lehikoinen et al. 2013) we consider the effect of a site's geographical position. Birds can show in general 2 different responses to climate changes. Either they adapt to changed conditions without shifting location or they move to a more favourable site. Changes in the centre of species distribution are closely related to increase of early winter temperature and favourable foraging opportunities (Austin & Rehfisch 2005), Species wintering distribution shifts north-eastward direction and declines at the south-western edge of the wintering ranges). This north-eastward shift was observed also in duck species (Great Smew, Tufted Duck, Goosander and Goldeneye) (Pavon-Jordan et al. 2015; Lehikoinen et al. 2013). Increase in wintering numbers north-easterly may not be linked with declines elsewhere within the study area but can represent a range expansion. Maclean et al. (2008) observed expansion of wintering area of waders in Western Europe up to 115 km, generally in the north-eastern direction.

Even though the margin range shifts have been observed for several bird species, there is lack of studies on distribution of the entire population at the migratory flyway level. It is challenging task but it is necessary to link the effect of climate change correctly to species distribution and to conserve populations in the changing world (Lehikoinen et al. 2013).

1.8.4. Wetland habitats

Running and standing waters are two main types of wetland habitats in the central European region. As a result of climate change, we can expect a change in numbers of waterbirds particularly on standing waters. With increasing winter temperatures, standing waters become ice-free and thus, more favourable for foraging opportunities. The study in Czech Republic showed that species with a significant (either decreasing or increasing) trend changed their numbers both on standing and running waters (Musil et al. 2011; Musilova et al. 2009). In detail, increase in running waters was observed in Gadwall, Pochard, Tufted Duck and Smew, whereas increase on standing waters was observed at Pintail. Numbers of Teal decreased on running waters but were stable on standing waters. The numbers of Goldeneye were stable in both types of wetland habitats (Musilova et al. 2009). On the contrary, another study of Musilova et al. (2015,~~ in itt.~~) presented increase in waterbirds on rivers and explained the observation as an effect of reducing winter harshness. She also indicated that other site variables with the warming effect, such as urban areas and sites with higher proportions of wetlands in their surroundings, might host higher number of wintering waterbirds. However, species' trends could be related to other causes than climate change, for example to habitat preferences of the species. For example, increase of diving ducks (Common Pochards, Tufted Ducks and Common Goldeneyes) on running waters and their decrease on standing waters is probably related to intensive fishpond management (see e.g. Musil et al. 2001; Musil 2006, Musil et al. 2011).

The proportion of waterbirds on standing and running waters varies in relation to the presence of ice layer on standing waters. During cold winters, when most of the standing waters are ice-freeze, birds prefer rivers as a habitat; otherwise they stay on standing waters. In cold months in winter 2004/2005, 80% of all monitored individuals in Central Bohemia were found on rivers (Bergmann et al. 2005). While numbers of individuals on rivers remained the same during freezing winter, abundance on standing waters decreased. The total abundance of wintering species during freezing periods was reduced as they migrated to sites outside of the Czech Republic. For example, the most abundant Mallard was lower in numbers during a freezing period on reservoirs but didn't increase on rivers (Bily et al. 2008). Nevertheless, we expect higher importance of standing waters as a wintering habitat in incoming years as a result of milder winters in Europe (Huntley et al. 2007; Musil et al. 2011).

1.8.5. Wetland area and connectivity

Wetland's proportion within the regions another factor influencing wintering distribution of waterfowl. Many studies have indicated that wetland size influences species richness and abundance of waterbirds (e.g. Froneman et al. 2001; Paracuellos & Telleria 2004; Sánchez-Zapata et al. 2005). Generally, larger wetlands have more likely higher habitat heterogeneity and support larger number of species than smaller wetlands (Colwell & Taft 2000; Paracuellos & Telleria 2004). Moreover, the importance of this variable is especially valuable for dabbling ducks (McKinstry & Anderson 2002).

Diving ducks move daily in short distances but they can also exploit several sites more than 100 km apart during one winter (Gourlay-Larour et al. 2012). Although several waterbirds are known to show winter site fidelity (Guillemain et al. 2009; Petersen et al. 2012), they move around landscape when deciding where to settle (Skagen & Knopf 1993; Plissner et al. 2000) or while foraging (Craig & Beal 1992). In winter, distance to the nearest pond is very important, due to an increase in waterbird movements between patches (Paracuellos & Telleria 2004). The connectivity and heterogeneity of wetlands nearby are therefore important factors of quality of wetland areas and should be of primary importance to wetland management and policies (Amezaga et al. 2002).

1.8.6. Urban habitats

Urban habitats represent alternative wintering sites for adaptive species, benefiting from reduced predation, better feeding opportunities, warmer temperature and shelter (Polakowski et al. 2010). Such a group of species are omnivorous birds that generally outnumber other bird species in urban area (Haila, 1981; Tilghman 1987) as a result of diverse food supply offered by humans. Generally, most of common duck species in Europe are omnivorous. Among duck species, Mallard is well adapted to urban conditions in Europe and thus being more abundant in urban areas (Emlen 1974, Cramp & Simmons 1977, Engel et al. 1988, Luniak 2006). The distributions of feeding sites as well as the feeding intensity were important factors affecting abundance and density of Mallards during winter periods (Jones & Reynolds 2008; Polakowski et al. 2010). In general, artificial feeding and food leftovers may improve the nutritional condition of wintering birds (Grubb & Cimprich 1990), decrease birds overwinter mortality (Jansson et al. 1981; Brittingham & Temple 1988) and consequently, increase the overall attractiveness of urban sites to birds (Erskine 1992; Yaukey 1996). Jokimaki & Suhonen (1998) explained variation in species abundance and stability in urbanized ecosystems is dependent on human food supply.

On the other hand, human activity in urban areas can negatively affect wintering waterfowl. Winter feeding may maintain already adapted populations of abundant species and consequently decrease other bird species (Jokimaki & Suhonen 1998). In Finland, the total density of waterbirds increased with the urbanisation level but the species richness remained unchanged (Jokimaki et al. 1996). Another negative effect of human disturbance is increased energy costs of wintering waterfowl, as they are forced to fly over to another site during disturbance (Pease et al. 2005). The cost of migration is high (Berthold 2001; Newton 2008) and individuals must consider the costs and benefits of staying or leaving a particular site (Ens et al. 2004).

1.8.7. Protection of the area

Site protection, i.e. position of site inside or outside the Special Protected Area (SPA) may affect distribution of waterbirds. SPAs ensure that bird species can find suitable breeding, wintering or stop-over sites and further show to benefit conservation status of some species (Donald et al. 2007). Such an example under Birds Directive is Important Bird and Biodiversity Area (IBA), a network of sites regularly holding significant populations of threatened, endemic or congregatory bird species, or highly representative bird assemblage (Birdlife International Contributors 2015). Member States are bound by the Directive to improve the conservation status of these species by protecting or enhancing their habitats, for example through the designation of Special Protection Areas (SPAs) (Tucker & Evans 1997). Important Bird Areas form one part of Natura 2000 network and maintain now more than 4.000 sites in Europe.

Moreover, there is lack of evidence-based assessment of the success of international policy instruments. One of few evidence-based studies was the assessment of the Bird Directive instrument, which provided a strong evidence of a positive impact of certain conservation measures through the Directive and the response of bird populations (Donald et al. 2007). In this study, a comparative analysis of population responses was assessed, including all breeding bird species in 15 European countries covering years 1970-2000. Evidence for a causal link between policy intervention and species response was found in the positive association across EU15 countries between mean species trend and the proportion of land designated as Special Protection Areas. In another study, trend of wintering

Smew in Europe was investigated according to climate changes and a protection level. Results showed that population of Smew was higher in SPAs than outside existing SPAs. However, due to climate-driven north-eastern distributional shift, newly colonised areas outside SPAs appeared. The author further suggested expanding current site-safeguard networks of this and other species in north-eastern regions (Pavon-Jordan et al. 2015).

However, not all waterbird species use protected areas as their optimal wintering habitat. Omnivorous duck species can be higher in wintering numbers in urban areas, profiting from better feeding opportunities, reduced predation and (or) higher temperatures (Polakowski et al. 2010) in comparison to SPAs .

1.8.8. Waterbird numbers

Waterbird numbers are often afffected by density-dependent regulation (Brown 1969; Fox 2005; Gunnarson et al. 2013). Abundance is a good predictor of the ability of a species to occupy sites in a given wetland complex. Generally, the less abundant the species are, the less colonising ability they have to occupy new wetland zones, appearing on few, mostly larger ponds, which are usually more heterogeneous ("sampling hypothesis") (Andrén 1994, Paracuellos & Tellería 2004). This hypothesis essentially states that the increase in species richness with increasing patch area is due simply to the larger population of individuals found in large patches (Helzer & Jelinski 1999). Oppositely, more abundant the species are on a specific site, the less new colonisers will appear. When the site reaches saturation, the total abundance and numbers of bird species will not increase. Habitats are considered saturated when some individuals are unable to secure or defend space there due to competition from conspecifics (Brown 1969). Once a favored site reaches saturation, less suitable habitats will show a greater rate of increase compared with those on a favored site ("buffer effect") (Jackson et al. 2004). Sequential habitat fill can be seen when birds are arriving at winter sites, filling the best sites first, and reversely, as populations decline, birds usually withdraw from the poorer habitats first, leaving an increasing proportion of individuals in the good habitats (Newton 2008). In the long-term study from the Czech Republic, the density-dependent regulation was one explaining factor of the shift of waterfowl to colder areas (most likely at higher latitudes) while using running waters to reduce winter harshness (Musilova et al. 2015).

Another factor influencing numbers and frequency of occurrence of waterfowl is undoubtedly site fidelity. Such site fidelity can be explained as a result of various selective pressures that favor individuals which have an intimate knowledge of their environment. Its consequence is that certain locations not only hold large concentrations of waterbirds year after year, but that these sites are repeatedly visited by the same birds (Owen & Black 1990; Blums et al. 2002; Boere et al. 2006; Phillips & Powell 2006; Iverson & Esler 2006).

2. Own study

2.1. Aims and hypotheses

The aim of this study was to analyse spatial variability in numbers, frequency of occurrence and long-term trends in numbers of 10 wintering duck species. The analysed data were used from sites counted by International Waterfowl Census (IWC) between years 1966 and 2013 in the Czech Republic. Furthermore, the study was aimed at identifying geographical and environmental variables that might explain patterns in species frequency of occurrence, mean numbers of wintering waterbirds, and their long-term trends, at the site level. There was used a set of geographical and environmental variables such as: wetland type (reservoirs, fishponds, sand and gravel pit lakes, rivers) latitude, longitude, monthly mean January temperature, proportion of urban habitats in surroundings, proportion of wetland habitats in surroundings, site protection, mean numbers and frequency of occurrence of analysed species.

In the study, we focused on 10 most common duck species in aim to answer following questions:

- Which of environmental variables (latitude, longitude, monthly mean January temperature, proportion of urban habitats in surroundings, proportion of wetland habitats in surroundings, site protection, mean numbers and frequency of occurrence) affect the numbers and frequency of occurrence on individual sites?

- Are the environmental variables affecting trends in numbers similarly as a set of variables affecting pattern in numbers and distribution (frequency of occurrence)?

We expect a higher importance of running waters and sites with a higher proportion of urban areas and other wetlands in their surroundings, and consider them as variables reducing the effect of winter harshness. Higher numbers on running waters can also be an effect of density-dependent regulation of expansion to colder areas, while still using rivers that remain ice-free (Musilova et al. 2015.). Conversely, as a result of milder winters and ice-free water enabling foraging (Ridgill and Fox 1990; Schummer et al. 2010), standing waters (reservoirs, fishponds, sandpits) might be also correlated with positive trends, higher numbers and frequency of occurrence of waterfowl. Our hypothesis concerning wetlands is that they would host more waterbirds as these sites provide a lower necessity to move long distances, enabling energy reserves savings and serving as cold refuge (Ens et al. 2004; Musilova et al. 2015. Further, we consider the effect of a site's geographical position as a result of distributional shifts related to the climate change (Ridgill and Fox 1990; Rehfish et al. 2004; Lehikoinen et al. 2013). We expect more ice-free wetlands at sites with higher January mean temperature, and thus higher number of wintering waterbirds there (Ridgill and Fox 1990; Bergmann et al. 2005; Schummer et al. 2010). However, higher numbers can be observed also at colder sites as an effect of density-dependent expansion to colder areas with running waters (Musilova et al. 2015). We don't make any assumption about the effect of long-term trend in temperature on long-term trends in numbers of studied species due to the fact that the January temperature remains the same (Musilova et al. 2009). Sites located within a protected area provide high-quality habitats with reduced human disturbance (Thomas et al. 2012). Hence, we expect their increasing significance in relation to waterbird populations. On the other hand, we also consider non-protected sites to host higher numbers of waterbirds (see e.g. Rodrigues et al. 2004; Pavón-Jordan et al. 2015), mainly as a result of density-dependent waterbird expansion to new wetland sites. With growing numbers of wintering waterfowl we expect density-dependent response in mean annual numbers and frequency of occurrence of the species (Brown 1969; Fox 2005; Gunnarson et al. 2013). We suppose similar effect of environmental variables on abundance and distribution as expected for trends.

3. Methodics

3.1. The IWC form

Numbers of wintering waterbirds in the Czech Republic were recorded by International Waterbird Census in mid-January (http://www.waterbirdmonitoring.cz/). The species included in monitoring scheme were divers, grebes, cormorants, herons, storks, bitterns, swans, geese, ducks, cranes, rallids, bustards, waders, gulls, terns and further sea eagles, kingfishers and dippers. The optimal day time for monitoring is between 10 a.m. and 2 p.m., when wintering birds are little active. An important factor is good visibility; during poor conditions (fog, heavy snow) monitoring must be postponed. The IWC census form is attached in Appendix in Fig.8.

3.2. Data collection

Data for this study were sampled from 1465 sites, which were monitored at least ten seasons and analysed duck species were present in at least two winters. We analysed data for 10 duck species: Eurasian Wigeon (*Anas penelope*), Gadwall (*Anas strepera*), Common Teal (*Anas crecca*), Common Pochard (*Aythya ferina*), Tufted Duck (*Aythya fuligula*), Greater Scaup (*Aythya marila*), Velvet Scoter (*Melanita fusca*), Common Goldeneye (*Bucephala clangula*), Great Smew (*Mergellus Albellus*), Goosander (*Mergus merganser*). In the analysis, we omitted Mallard, which was analysed in details in another study (Keilova 2015). Descriptive statistics is shown in Tab. 2.

The following variables were used for each site:

MEAN

- The value was calculated as a mean number of individuals of a individual duck species on individual wetland site.

FREQUENCY

- Represents how often each species was present on investigated wetland site. It was calculated as a ratio of seasons with occurrence of a species to the total number of winter seasons.

TREND

- Site trends were analysed using the TRIM 3.54 software. TRIM is a program developed for the analysis of count data obtained from monitoring wildlife populations. It analyses time series of counts, using Poisson regression and produces estimates of yearly indices and trends (Pannenkoek & van Strien 2003). TRIM's principal advantage is that it analyses time series with missing observations by implementing a variety of loglinear models. "Base Time" was the first year of presence of the species. Trends were characterized as "Uncertain (U)", "Strong Decline" (SD, >5%), "Moderate Decline" (MD<5%), "Stable (STA)", "Moderate Increase (<5%)" or "Strong Increase" (>5%). Results of the site trends represented long-term changes of each duck species.

The habitat of analysed wetland sites was classified using the following variables:

LONGITUDE AND LATITUDE

- The coordinates were obtained from Google Maps from the centre of each site.

JANUARY TEMPERATURE

Local climatic conditions were expressed as the monthly mean temperature measured at seven meteorological stations in the Czech Republic (Tolasz et al. 2007). There were found no significant long-term changes in the monthly day mean temperature in January and in February in the Czech Republic (Musilova et al. 2009).

URBAN AREA

- The proportion of urban area in a buffer zone within a 5 km radius from the centre of the IWC site- derived from CORINE Land Cover 2006 (EEA 2006).

WETLAND AREA

- The proportion of wetlands in a buffer zone within a 5 km radius from the centre of the IWC site- derived from CORINE Land Cover 2006 (EEA 2006).

PROTECTION OF AREA

- 0/1 variable one indicating the presence of legislative protection of any sort (Special Protected Areas, Landscape Protected Area, National Park, National Nature Reserve, Nature Reserve) or no protection. The majority of sites were without any protection level – 83%.

TYPE OF WATER

- categorical variable indicating: 1= dams (77 sites), 2= fishponds (123 sites), 3= sandpits and reservoirs (58 sites), 4= rivers (667 sites)
-

Tab.2: Descriptive statistics of waterbird, geographical and environmental variables of all 925 investigated wetland sites. Variable details are described in the text.

Variable	Range	Mean ± Sta. dev.
Mean abundance	0.04-678.24	8.67 ± 0.86
Frequency of occurrence	0.04-1	0.31 ± 0.11
Trend (changes in numbers)	-0.44-0.34	0.04 ± 0.08
Longitude (°) E	12.31-18.70	14.82 ± 3.55
Latitude (°) N	48.63-51.00	49.76 ± 0.47
January mean temperature (°C)	-3.5-0.5	-1.6 ± 0.6
Urban area as % of total land cover	0-76.37	15.9 ± 3.58
Wetland area as % of total land cover	0-40.75	3.25 ± 0.07

Multiple regression was used to assess the effect of site characteristics on trends in total numbers. In most cases, we used standard linear regression models with heteroskedasticity-robust standard errors. However, some species' site trends exhibited significant ($p < 0.05$) spatial autocorrelation, measured by the Moran's I and Geary's c statistics. In such cases, we resorted to a linear spatial-autoregressive model with spatial-autoregressive disturbances [sometimes referred to as SARAR(1,1)], estimated by the G2SLS method of Kelejian and Prucha (1998). The spatial-weighting matrix was based on inverse Euclidean distances obtained from the latitude and longitude variables; the matrix entered the regression in spectral-normalized form. It is worth noting, however, that the results of these spatial regressions were not qualitatively different from those obtained by ordinary least squares (not reported). All statistical analyses were carried out in Stata 13 (StataCorp LP, College Station, Texas); the user-written commands spmat and spreg were used for spatial regressions.

We employed regression analyses to study the effect of site characteristics on mean numbers and the frequency of appearances of individual species. For mean numbers, we estimated standard linear regression models with heteroskedasticity-robust standard errors. The frequencies, on the other hand, are bounded between 0 and 1 (so-called fractional outcomes), which calls for a different modelling approach. We applied the fractional logit model of Papke & Wooldridge (1996), whose quasi-ML estimator can be obtained through conventional generalized linear model (GLM) routines with a logit link function.

4. Results

4.1. Trend

Tab.3: Trends of 10 duck species represented in number of sites with the given trend.

	SD	MD	STA	UNC	MI	SI
Gadwall		1	4	12	6	4
Eurasian Wigeon			6	27	16	2
Common Teal	5	32	33	26	27	3
Common Pochard	2	8	29	67	18	4
Tufted Duck		9	28	76	36	16
Common Goldeneye	1	5	33	41	34	16
Goosander	2	20	40	20	73	46
Great Smew			8	17	12	3
Greater Scaup		2	5	12	7	
Velvet Scoter		2	2	2	3	4

Tab.4: Trends of 10 duck species represented as % of sites on which the species has the given trend. SD= strong decline, MD= moderate decline, STA= stable, UNC= uncertain, MI= moderate increase, SI= strong increase.

	SD	MD	STA	UNC	MI	SI
Gadwall		3,7	14,8	44,4	22,2	14,8
Eurasian Wigeon		0,0	11,8	52,9	31,4	3,9
Common Teal	4,0	25,4	26,2	20,6	21,4	2,4
Common Pochard	1,6	6,3	22,7	52,3	14,1	3,1
Tufted Duck		5,5	17,0	46,1	21,8	9,7
Common Goldeneye	0,8	3,8	25,4	31,5	26,2	12,3
Goosander	1,0	10,0	19,9	10,0	36,3	22,9
Great Smew		0,0	20,0	42,5	30,0	7,5
Greater Scaup		7,7	19,2	46,2	26,9	0,0
Velvet Scoter		15,4	15,4	15,4	23,1	30,8

From 1465 data on sites in total, we filtered 925 sites, which met the requirements (sites that were monitored at least ten seasons with presence of analysed duck species in at least two winters). Thus, 37 % of total numbers of sites were not used in the trend analysis. We found prevailing increasing trend on 350 sites (247 MI, 103 SI) and decreasing on 99 sites (88 MD, 11 SD). Trend was stable on 208 sites and on 264 sites the trend was uncertain. Tab. 3 and 4 show numbers and percentages of sites with given trend for individual species.

Long-term increase or stable trends in total numbers were more frequent in all duck species. An increasing trend was observed for Goosander (increasing on 119 sites, Fig. 3) Tufted Duck (52 sites, Fig. 4), Common Goldeneye (50 sites, Fig. 5) and Velvet Scoter, which was increasing on 7 of 13 sites in total (Fig. 6). Goosander had also decreasing trend (on 22 sites) but the most significant decrease was observed at Common Teal (37 sites, i.e. 29.4% of all sites with observation of the species, Fig. 7).

Fig.3: Site-trends for Goosander *(Mergus merganser).* Trend categories: Rostoucí = Increasing, Stabilní = Stable, Klesající = Decreasing, Nejasný = Uncertain. Map legend: Státní hranice = Boundary of the Czech Republic, Hranice krajů = County Boundary, Vodní toky = Rivers, streams, Vodní plochy = Water bodies.

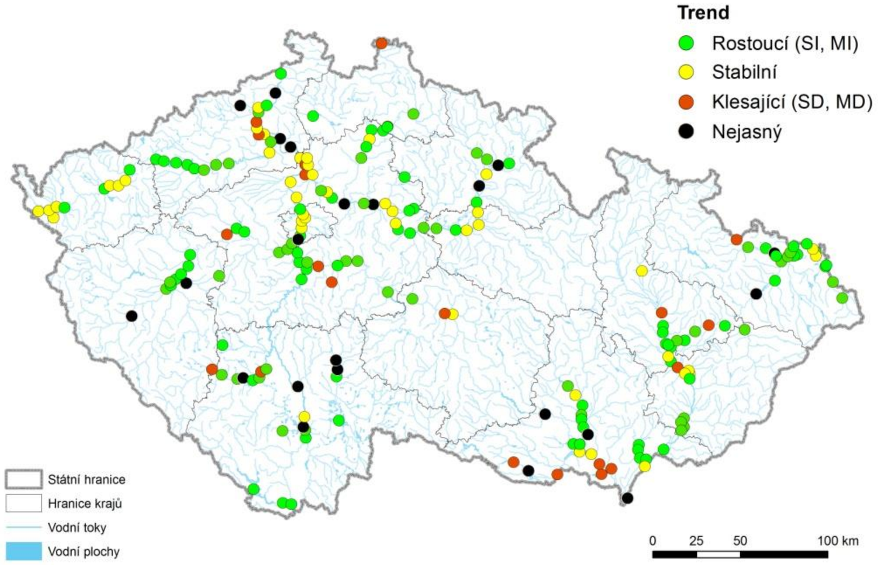


Fig.4: Site trend for Tufted Duck (*Aythya fuligula*). Trend categories: Rostoucí = Increasing, Stabilní = Stable, Klesající = Decreasing, Nejasný = Uncertain. Map legend: Státní hranice = Boundary of the Czech Republic, Hranice krajů = County Boundary, Vodní toky = Rivers, streams, Vodní plochy = Water bodies

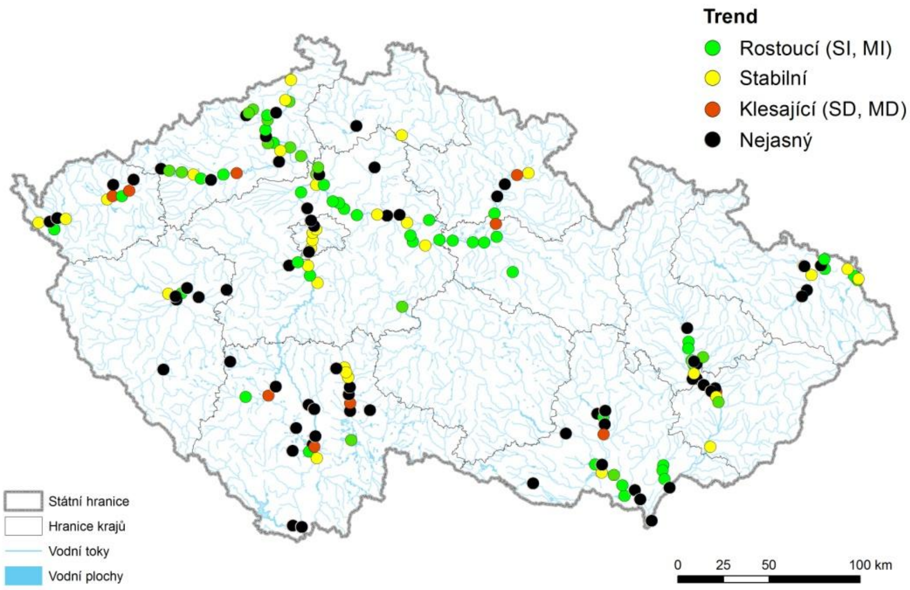


Fig.5: Site-trend for Common Goldeneye (*Bucephala clangula*). Trend categories: Rostoucí = Increasing, Stabilní = Stable, Klesající = Decreasing, Nejasný = Uncertain. Map legend: Státní hranice = Boundary of the Czech Republic, Hranice krajů = County Boundary, Vodní toky = Rivers, streams, Vodní plochy = Water bodies.

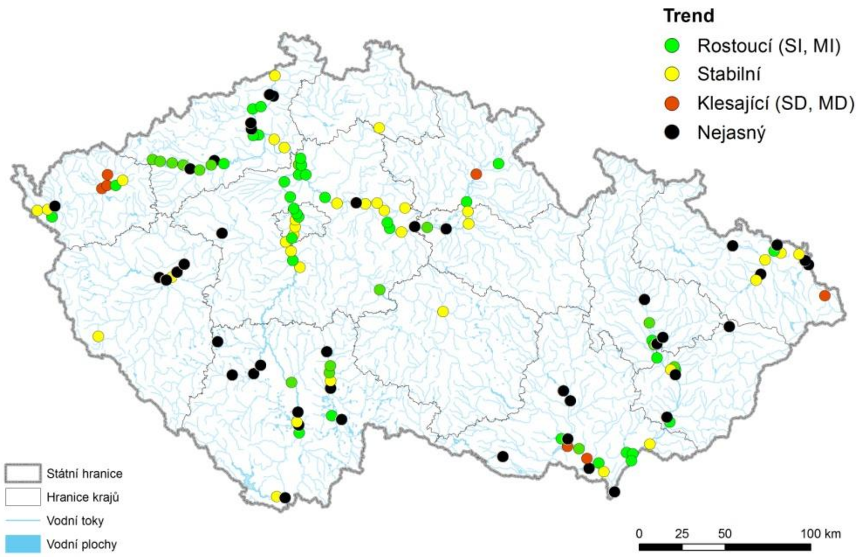


Fig.6: Site-trend for Velvet Scoter (*Melanitta fusca*). Trend categories: Rostoucí = Increasing, Stabilní = Stable, Klesající = Decreasing, Nejasný = Uncertain. Map legend: Státní hranice = Boundary of the Czech Republic, Hranice krajů = County Boundary, Vodní toky = Rivers, streams, Vodní plochy = Water bodies.

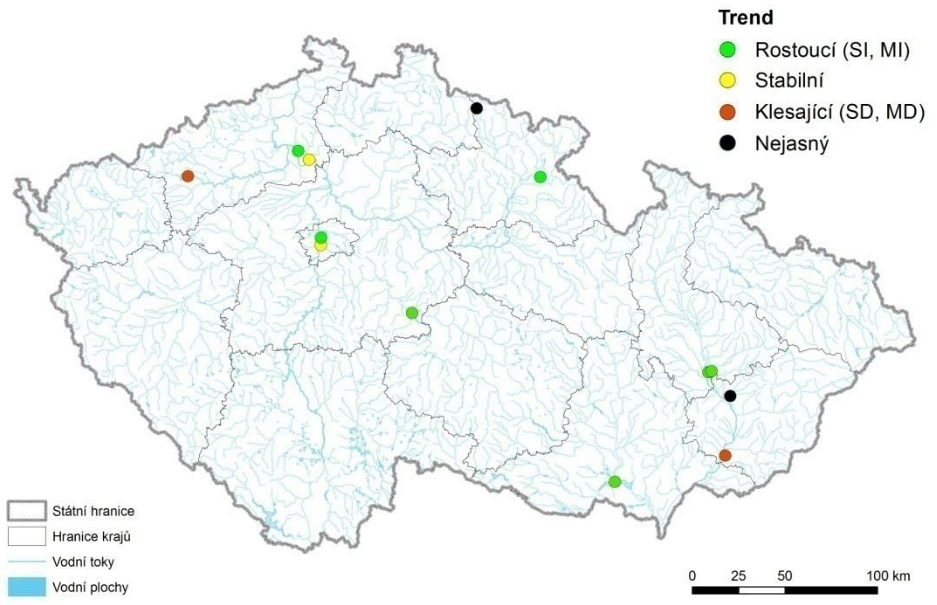
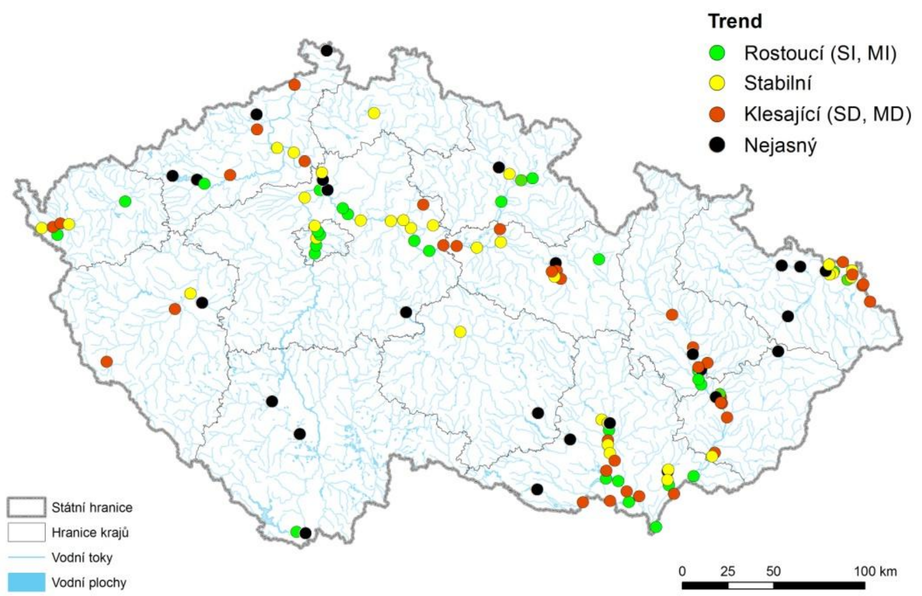


Fig.7: Site-trend for Common Teal (Anas crecca). Trend categories: Rostoucí = Increasing, Stabilní = Stable, Klesající = Decreasing, Nejasný = Uncertain. Map legend: Státní hranice = Boundary of the Czech Republic, Hranice krajů = County Boundary, Vodní toky = Rivers, streams, Vodní plochy = Water bodies.



Tab. 5a: Estimated effect of site characteristics on site trends of analysed species (1966- 2013).

X axis	Eurasian Wigeon OLS	Gadwall OLS	Common Teal OLS	Common Pochard OLS	Tufted Duck OLS
LATITUDE	-0.147***	0.100	0.0364	0.0101	0.0346
	(0.0194)	(0.142)	(0.0292)	(0.0121)	(0.0199)
LONGITUDE	-0.0214*	0.0278	0.00158	-0.00132	0.0000313
	(0.00968)	(0.0143)	(0.00572)	(0.00452)	(0.00461)
MEAN JAN.TEMP.	0.0220	0.0348	-0.0105	0.00289	0.00856
	(0.0138)	(0.113)	(0.0139)	(0.00950)	(0.0133)
URBAN AREA	-0.000595	-0.00354	0.000742	0.000115	-0.0000468
	(0.000498)	(0.00434)	(0.000544)	(0.000386)	(0.000456)
WETLANDS	-0.00174	0.0110	0.00235	0.00340*	0.00339
	(0.00458)	(0.0154)	(0.00189)	(0.00170)	(0.00252)
PROTECTION	-0.0105	-0.0499	0.0141	-0.00864	0.0112
	(0.0190)	(0.0971)	(0.0269)	(0.0142)	(0.0228)
FREQUENCY	0.351*	-0.0382	-0.00692	0.0239	-0.00676
	(0.161)	(0.221)	(0.0538)	(0.0437)	(0.0329)
MEAN	-0.0183	- 0.000524	0.0000786	-0.000900*	0.000161*
	(0.00952)	(0.0172)	(0.00124)	(0.000367)	(0.0000705)
Water type [%]					
Fishpond	-0.122***	0.0828	-0.0417	-0.0140	0.0228
	(0.0260)	(0.224)	(0.0340)	(0.0336)	(0.0416)
Sandpits	0	0	-0.0000311	0.0108	0.0374
	(.)	(.)	(0.0416)	(0.0325)	(0.0429)
Rivers	0.0183	0.103	-0.0183	-0.0236	-0.0281
	(0.0255)	(0.203)	(0.0264)	(0.0288)	(0.0376)
N	24	15	100	90	101
p(water type)	0.0006	0.8532	0.5556	0.2486	0.0154
p(Geary's c)	0.0781	0.1513	0.0916	0.4937	0.0846
p(Moran's I)	0.1880	0.0859	0.4037	0.4526	0.0875

Standard errors (in parentheses) are made robust to heteroskedasticity and autocorrelation. * p<0.05, ** p<0.01, *** p<0.001.

Tab. 5b: Estimated effect of site characteristics on site trends of analysed species (1966- 2013).

X axis	Common Goldeneye 2SLS	Goosander 2SLS	Smew 2SLS	Greater Scaup OLS	Velvet Scoter OLS
LATITUDE	-0.0137	0.00126	-0.0675	-0.210*	-0.319
	(0.0124)	(0.0154)	(0.0361)	(0.0453)	(.)
LONGITUDE	-0.000167	0.000343	-0.000659	-0.0608	0.0153
	(0.00447)	(0.00555)	(0.0117)	(0.0317)	(.)
MEAN JAN.TEMP.	-0.0181	-0.0372**	0.0150	-0.0397	-0.481
	(0.0126)	(0.0131)	(0.0177)	(0.0205)	(.)
URBAN AREA	-0.000505	0.000285	-0.00104*	0.000574	0.00477
	(0.000486)	(0.000623)	(0.000530)	(0.000650)	(.)
WETLANDS	0.00274	-0.000764	0.0156**	-0.00379	-0.0370
	(0.00218)	(0.00160)	(0.00559)	(0.00801)	(.)
PROTECTION	0.00519	-0.0280	0.0796***	0.0188	0.575
	(0.0189)	(0.0171)	(0.0228)	(0.0328)	(.)
FREQUENCY	0.00774	-0.0407	0.175*	-0.781	0.650
	(0.0394)	(0.0391)	(0.0823)	(0.337)	(.)
MEAN	-0.000539	0.000469	-0.0240**	0.133	-0.106
	(0.000588)	(0.000703)	(0.00794)	(0.0634)	(.)
Water type [%]					
Fishpond	-0.0682*	-0.00327	-0.144*	0	0
	(0.0336)	(0.0321)	(0.0590)	(.)	(.)
Sandpits	-0.0121	-0.0453	0.0793	0.0180	-0.459
	(0.0387)	(0.0374)	(0.0635)	(0.0980)	(.)
Rivers	-0.00956	-0.0112	0.127**	0.113	0.159
	(0.0316)	(0.0283)	(0.0402)	(0.147)	(.)
N	93	186	23	14	11
p(water type)	0.1493	0.5528	0.0001	0.6285	.
p(Geary's c)	0.0131	0.0000	0.0036	0.2575	0.1188
p(Moran's I)	0.0117	0.0000	0.0038	0.2730	0.2208

Standard errors (in parentheses) are made robust to heteroskedasticity and autocorrelation. * $p<0.05$, ** $p<0.01$, *** $p<0.001$

The environmental variables were significant for 7 of the 10 duck species. Smew's trend was significantly influenced by the most environmental variables- in total seven. Common Goldeneye was significantly decreasing on fishponds. Common Pochard was increasing on sites with high proportion of wetlands in the surroundings and decreasing on sites with high mean numbers, whereas Tufted Duck was increasing with higher mean numbers. Mean total numbers of individual species on a site was significant for 3 duck species; Common Pochard and Smew were decreasing on sites with high mean numbers, whereas Tufted Duck was increasing there. Latitude, wetland proportion, frequency of occurrence on a site and fishponds were significant for two duck species. Higher latitudes (northern sites) had negative effect on trends of Eurasian Wigeon and Greater Scaup. With higher proportion of wetlands in surroundings, Common Pochard and Smew were increasing. Wigeon and Smew had increasing trends on sites with high frequency of occurrence of individual species. Further, Common Goldeneye and Smew were decreasing on fishponds, whereas Smew was increasing on rivers. Eurasian Wigeon, as the only species, was increasing with lower longitudes (on the west of Czech Republic). Mean January temperature had effect only on Goosander- with lower temperatures, it had an increasing trend. Smew increased on less urban sites as well as on sites with a protection status. Only on sandpits and lakes we didn’t find a significant trend for any studied species at all. For Common Teal, Gadwall and Velvet Scoter we didn’t find any significant variables influencing their trends. Table with results of regression analysis for trends of individual species is shown in Tab. 5a and 5b.

4.2. Mean

Tab. 6a: Least-squares regression estimates for log (average numbers) of 10 species (1966-2013).

	Eurasian Wigeon	Gadwall	Common Teal	Common Pochard	Tufted Duck
LATITUDE	-0.0771*	-0.0124	-0.0721	0.281***	0.516***
	(0.0353)	(0.0209)	(0.0797)	(0.0809)	(0.0961)
LONGITUDE	0.00399	0.00518	0.151***	-0.0470	-0.0386
	(0.00658)	(0.00643)	(0.0336)	(0.0252)	(0.0283)
MEAN JAN.TEMP.	0.0889***	0.0428**	0.151*	0.439***	0.506***
	(0.0233)	(0.0155)	(0.0697)	(0.0841)	(0.0884)
PROTECTION	0.0523	0.0183	-0.0273	0.0225	-0.234
	(0.0373)	(0.0292)	(0.116)	(0.129)	(0.133)
Water type [%]					
Fishponds	-0.268**	-0.148	-0.169	-0.793**	-0.764***
	(0.103)	(0.0894)	(0.166)	(0.271)	(0.225)
Sandpits	-0.219*	-0.111	-0.113	-0.358	-0.364
	(0.100)	(0.0996)	(0.203)	(0.332)	(0.301)
Rivers	-0.162	-0.127	0.0513	-0.430	-0.181
	(0.0932)	(0.0854)	(0.173)	(0.267)	(0.233)
URBAN AREA	-0.00351**	-0.00151*	-0.00327	0.0107	0.0113
	(0.00115)	(0.000728)	(0.00388)	(0.00687)	(0.00623)
WETLANDS	0.00660	0.00962	0.0369*	0.0723**	0.0885**
	(0.00892)	(0.00666)	(0.0182)	(0.0273)	(0.0289)
N	384	384	384	384	384
p(Water type)	0.0017	0.3613	0.0740	0.0000	0.0000
p(Land cover)	0.0097	0.0773	0.0951	0.0127	0.0025

Standard errors (in parentheses) are made robust to heteroskedasticity and autocorrelation. * p<0.05, ** p<0.01, *** p<0.001

Tab. 6b: Least-squares regression estimates for log (average numbers) of 10 species (1966-2013).

	Eurasian Wigeon	Gadwall	Common Teal	Common Pochard	Tufted Duck
LATITUDE	-0.0771*	-0.0124	-0.0721	0.281***	0.516***
	(0.0353)	(0.0209)	(0.0797)	(0.0809)	(0.0961)
LONGITUDE	0.00399	0.00518	0.151***	-0.0470	-0.0386
	(0.00658)	(0.00643)	(0.0336)	(0.0252)	(0.0283)
MEAN JAN.TEMP.	0.0889***	0.0428**	0.151*	0.439***	0.506***
	(0.0233)	(0.0155)	(0.0697)	(0.0841)	(0.0884)
PROTECTION	0.0523	0.0183	-0.0273	0.0225	-0.234
	(0.0373)	(0.0292)	(0.116)	(0.129)	(0.133)
Water type [%]					
Fishponds	-0.268**	-0.148	-0.169	-0.793**	-0.764***
	(0.103)	(0.0894)	(0.166)	(0.271)	(0.225)
Sandpits	-0.219*	-0.111	-0.113	-0.358	-0.364
	(0.100)	(0.0996)	(0.203)	(0.332)	(0.301)
Rivers	-0.162	-0.127	0.0513	-0.430	-0.181
	(0.0932)	(0.0854)	(0.173)	(0.267)	(0.233)
URBAN AREA	-0.00351**	-0.00151*	-0.00327	0.0107	0.0113
	(0.00115)	(0.000728)	(0.00388)	(0.00687)	(0.00623)
WETLANDS	0.00660	0.00962	0.0369*	0.0723**	0.0885**
	(0.00892)	(0.00666)	(0.0182)	(0.0273)	(0.0289)
N	384	384	384	384	384
p(Water type)	0.0017	0.3613	0.0740	0.0000	0.0000
p(Land cover)	0.0097	0.0773	0.0951	0.0127	0.0025

Standard errors (in parentheses) are made robust to heteroskedasticity and autocorrelation. * p<0.05, ** p<0.01, *** p<0.001

The effect of environmental variables on mean annual numbers is presented in Tab. 6a and 6b. All environmental variables with an exception of site protection and rivers had a significant effect for at least one of the species. Only mean numbers of Velvet Scoter were not significantly influenced by any of the factors. Mean January temperature had significant positive effect on 8 of the 10 duck species in total. Only two northern species- Greater Scaup and Velvet Scoter were not more abundant on sites with higher mean January temperature. Four species (Common Pochard, Tufted Duck, Goosander, Greater Scaup) were more abundant with higher latitudes (i.e. on the northerly located sites), whereas Eurasian Wigeon was the only species negatively affected by higher latitudes. Mean numbers of Common Teal were higher on easterly located sites, whereas Common Goldeneye was lower there. Four species (Common Teal, Common Pochard, Tufted Duck, Common Goldeneye) were higher in mean numbers on sites with high proportion of wetlands. Decreasing mean numbers of individuals of 5 species (Wigeon, Pochard, Tufted Duck, Goldeneye, Goosander, Smew)were found at fishponds, Wigeon and Great Smew were also less abundant on sand-pits and reservoirs. Decreasing were also Wigeon, Gadwall and Goosander on urban sites.

4.3. Frequency

Tab. 7a: Quasi-ML proportional logit estimates for sites' occupation frequencies of 10 species (1966-2013).

	Eurasian Wigeon	Gadwall	Common Teal	Common Pochard	Tufted Duck
LATITUDE	-0.952**	-0.559	-0.328	0.326	0.417**
	(0.305)	(0.297)	(0.197)	(0.175)	(0.152)
LONGITUDE	-0.111	-0.0520	0.287***	-0.0808	-0.123*
	(0.0698)	(0.0925)	(0.0644)	(0.0485)	(0.0514)
MEAN JAN.TEMP.	1.045***	0.875***	0.631***	0.824***	0.793***
	(0.195)	(0.196)	(0.180)	(0.133)	(0.146)
PROTECTION	0.312	0.184	0.0184	0.0800	-0.263
	(0.292)	(0.324)	(0.245)	(0.246)	(0.235)
Water type [%]					
Fishponds	-2.924***	-1.795**	-0.881*	-0.969*	-0.989*
	(0.651)	(0.573)	(0.369)	(0.430)	(0.465)
Sandpits	-1.282	-1.421	-0.723	-0.0859	-0.0941
	(0.672)	(0.859)	(0.417)	(0.519)	(0.558)
Rivers	-0.733	-0.949	0.0709	0.302	0.608
	(0.494)	(0.564)	(0.366)	(0.423)	(0.447)
URBAN AREA	-0.0226*	-0.0231*	-0.00751	0.00421	0.00943
	(0.00997)	(0.0112)	(0.00788)	(0.00670)	(0.00592)
WETLANDS	0.0106	0.0198	0.0406*	0.0911***	0.104**
	(0.0238)	(0.0203)	(0.0197)	(0.0251)	(0.0319)
N	384	384	384	384	384
p(Water type)	0.0000	0.0083	0.0000	0.0000	0.0000
p(Land cover)	0.0733	0.0690	0.0812	0.0013	0.0023

Standard errors (in parentheses) are made robust to heteroskedasticity and autocorrelation. * p<0.05, ** p<0.01, *** p<0.001

Tab. 7b: Quasi-ML proportional logit estimates for sites' occupation frequencies of 10 species (1966-2013).

	Common Goldeneye	Goosander	Great Smew	Greater Scaup	Velvet Scoter
LATITUDE	-0.0309	0.378**	-0.220	0.689**	0.512
	(0.191)	(0.133)	(0.246)	(0.253)	(0.337)
LONGITUDE	-0.188***	-0.00918	-0.0873	-0.0488	0.119
	(0.0537)	(0.0506)	(0.0737)	(0.0824)	(0.0827)
MEAN JAN.TEMP.	0.654***	0.642***	1.008***	0.413*	0.102
	(0.170)	(0.131)	(0.212)	(0.203)	(0.219)
PROTECTION	0.271	0.198	0.638*	-0.648	-0.357
	(0.271)	(0.223)	(0.282)	(0.689)	(0.601)
Water type [%]					
Fishponds	-1.529**	-2.068***	-2.944***	-4.138***	-16.34***
	(0.510)	(0.340)	(0.547)	(1.029)	(0.754)
Sandpits	-0.0264	-0.479	-1.217	-2.017	-0.633
	(0.558)	(0.459)	(0.648)	(1.121)	(0.928)
Rivers	0.529	0.406	-0.759	-1.496	-1.993*
	(0.489)	(0.331)	(0.475)	(0.825)	(0.820)
URBAN area	-0.00575	-0.0283***	-0.0135	0.0231*	0.0252
	(0.00649)	(0.00578)	(0.00937)	(0.0117)	(0.0172)
WETLANDS	0.0926*	0.0623**	0.0731**	0.0630*	0.0709*
	(0.0380)	(0.0227)	(0.0253)	(0.0259)	(0.0308)
N	384	384	384	384	384
p(Water type)	0.0000	0.0000	0.0000	0.0004	0.0000
p(Land cover)	0.0264	0.0000	0.0052	0.0185	0.0556

Standard errors (in parentheses) are made robust to heteroskedasticity and autocorrelation. * p<0.05, ** p<0.01, *** p<0.001.

Results of regression analysis for sites' occupation frequencies are very similar to those investigating mean numbers, suggesting that specific environmental factors have similar effect on both the mean numbers of individual species on a site and frequency of occurrence. For all species' frequencies there was at least one significant environmental factor. Only sandpits did not affect frequency of occurrence of any of studied species. All duck species were returning less often to fishpond wintering sites; Velvet Scoter was also less frequently revisiting sites on rivers. The species that were decreasing in mean numbers on sites with higher proportion of urban sites were also decreasing in frequency of occurrence. Only Greater Scaup was more frequent on sites with higher urban proportion. Eight out of ten species were more frequent on to the same wintering sites if there were more wetlands in the surroundings. Protection of the site was significant only for Great

Smew, which was more frequent there. Increasing mean January temperature lead to higher frequency of occurrence of most of the species, with the exception of Velvet Scoter, which had no significant effect for this variable. Geographical position operated similarly in the case of mean numbers and frequency of occurrence, only Tufted Duck was observed more frequently on westerly sites. Tab. 7a and 7b show occupation frequencies for studied species.

5. Discussion

We found more explaining significant factors for mean numbers and frequency of occurrence than for trends. Though, our study shows that assessing long-term site trends is much less predictable than for mean numbers and frequency of occurrence of individual species. The significant factors affecting mean numbers and frequency of occurrence were very similar, whereas significant factors explaining long-term trends were often different.

The effect of geographical position of the sites differed within species. Declining trends in Eurasian Wigeon and Greater Scaup on northerly located sites and oppositely, their increasing trends in southern part of study area can be affected by availability of suitable wetlands in this region (e.g. Nove Mlýny water reservoir, Musilová et al. 2014a). On the contrary, prevailing increase in mean numbers and frequency of occurrence of some of the species northerly can be affected by increasing importance of some river s and artificial water bodies in northern part of country. On the other hand, increase on southerly located sites could indicate a preference of warmer, ice-free freshwaters. Notable was overall decrease on fishponds. We expect fishponds may be less favoured by wintering waterbirds due to worsen feeding opportunities there caused by intensive fish management (Musil et al. 2001, Musil 2006) and excessive eutrophication of waters. For instance, breeding waterbird populations occupying eutrophicated wetlands have recently shown a dramatic decline in numbers in Finland (Pöysä et al. 2013). Surprisingly, rivers had no effect on studied variables (with the exception of Smew's increasing trend there). Our finding is inconsistent with a study of Musilova et al. (2015) who found increasing total waterbird number on rivers or with another study, in which wintering waterbird trends were significantly increasing or decreasing on running and uncertain on standing waters (Musil et al. 2011). Similarly, sandpits had no effect, besides a weak negative response in mean numbers for Wigeon and Smew. Apart of one species, the effect of urbanisation was either neutral or negative. The most prone species were Goosander, Wigeon, Gadwall and Smew. For instance, Keilova (2015) found no effect of urbanisation for wintering Mallard numbers. Oppositely, Musilova et al. (2015) showed higher total mean numbers of individuals on sites with higher proportion of urban area, possibly because urban sites serve as cold weather refuges. Negative effect of urban sites is most likely due to human disturbing activity, similarly as Pease at al. (2005) presented in his study. Feeding intensity was another factor that played role in increased numbers of wintering Mallards on urban sites in Poland (Polakowski et al. 2010). In our study, these factors (improved feeding opportunities, reduced predation and cold-refuge nature of sites) possibly caused a continuous arrival of Greater Scaup on urban wintering sites and also could cause positive results on sites with higher proportion of wetlands in the surroundings (Hudec 1983, Hudec 1996, Hudec & Šťastný 2005; Keilova 2015; Musilova et al. 2015). Maybe surprising results were for protection of the site. Protection was significant only for Smew, which had declining trend but increasing frequency of occurrence on sites with protection. For instance, in the study of Musilova et al. (2015), protection of the site had no significant influence on trends and mean numbers of waterbirds. In contrast, wintering numbers of Smew and Mallard were found more increasing in SPA's on flyway (Pavon-Jordan et al. 2015) and in national level (Keilova 2015). Increasing wintering numbers on protected sites were also recorded for example Jackson et al. (2009) or Kleijn et al. (2014). Interestingly, January mean temperature was significant for trend of only one species (i.e. Goosander) naturally occurring in colder areas (Baltic and the North Sea) (Hudec & Šťastný 1994). Preference of warmer sites manifested by significant mean numbers and frequency of occurrence of most of the species is probably due to higher probability of ice-free freshwaters there, enabling better access to food resources. Negative trends of Common Pochard and Great Smew on sites with high mean numbers are possibly examples of density-dependent regulation (Gunnarsson et al. 2013). Decreasing trends can be expained by site saturation, forcing birds to find other suitable wintering habitats. Oppositely, if species' trends are still increasing on sites with high mean numbers or frequency of occupation, it means the site can still host more waterbirds.

As was shown in previous studies (Musil et al. 2011; Musilova et al. 2015), the prevailing effect explaining long-term waterfowl trends in the Czech Republic is Western-Palearctic; almost all studied waterbird species follow this macro-scale trend. However, interesting results of sites' variables on regional level are a good indication of state and condition of sites and preference of wintering waterfowl there. Based on the results, we can not only evaluate, for example, effectiveness of existing networks of protected areas but also determine newly colonised sites for wintering of waterfowl.

In general, in accordance with the global climate change forecasts which predict milder winters across Europe, including the Czech Republic (Huntley et al. 2007, IPCC 2007), we expect further increased importance of central Europe as a wintering habitat for waterfowl species. It is of highest importance to reconsider national and international protection policy (EU NATURA 2000) as an adaptation to distribution changes to waterbird species.

6. Conclusion

The aim of the study was to assess long-term wintering trends, mean numbers and occupation frequencies of 10 duck species in the Czech Republic. Further, we examined 10 geographical and environmental factors (latitude, longitude, monthly mean January temperature, proportion of urban habitats in surroundings, proportion of wetland habitats in surroundings, site protection, mean numbers and frequency of occurrence of individual species) in order to find their relation to the trends occurring. Further, we analysed similar set of factors in relation to mean numbers and frequency of the occurrence of individual species. Among other, we found that:

- Mean numbers and frequencies of occurrence had more explanatory variables than trend, which was though less predictable.
- January mean temperature had a positive effect on mean numbers and frequencies of occurrence of most of the species but is mostly insignificant for species' trends.
- Most species are declining in mean numbers and frequencies of occurrence on fishponds and 3 species had significant declining trends on fishponds.
- Wetland proportion in the surroundings had a positive effect on mean numbers and frequencies of occurrence of majority of the species, while the effect of urbanisation was mostly negative.
- Many species were increasing in mean numbers and frequency of occurrence northerly, except of Eurasian Wigeon, who was declining there.
- Protection of the site was significant only for Smew's site-trend, otherwise it had no effect at all.
- Similarly, rivers and sandpits were mostly insignificant for studied variables.

Here, we present results of an extensive data collection of last 49 years. These data were collected with help of many volunteers, who we are very grateful to. We think the obtained results are important investigation determining species mean numbers, trends and wintering site preferences in the Czech Republic. Even though we found some significant environmental factors affecting long-term trends of the species on the site level, we think they are insufficient for making general conclusions on the flyway level. Thus, in coherence with other studies, we consider Western Palearctic trend to be the prevailing factor determining wintering waterbird trends on a larger scale. Our findings can be used in further research on climate change effect on birds, which we still don't fully understand. It can also serve for evaluation of effectiveness of protected sites in need of their maintenance or as the indication of newly colonised wintering sites. Finally, we agree with Mawdsley (2011) that adaptive management of individual protected sites and maintenance of sites where distributional changes are occurring will play a key role enabling species to fight with climate change. However, studies on effect of climate change on animal distribution are still scarce and we hope with further research we will obtain more useful information.

7. Literature

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8. Appendix

Tab.8: Overview of studied duck species. Conservation status, Czech legislation: O= endangered, Ob= generally protected (all bird species), SO= strongly endangered, KO= critically endangered (Czech legislative 114/1992 § 5a). Conservation status, IUCN: LC= least concern, EN= endangered. Trends (2004-2008) by TRIM software: MD= moderate decline, S= stable, MI= moderate increase, SI= strong increase, U= uncertain. * (Musilova et al. 2009).

Latin name	English name	Weight (g)	Eco-taxonomic group	Habitat	Food	Trend in CZ*	Conserv.concern (Czech leg.)	Conserv. concern (IUCN)
Mergus Merganser	Goosander / Merganser	900-2160	surface diving	lake/pond	fish	MI	KO	LC
Melanita fusca	Velvet Scoter	1100-1250	surface diving	lake/ pond	insects	S	Ob	EN
Bucephala clangula	Common Goldeneye	600-1300	surface diving	lake/ pond	insects	S	SO	LC
Anas strepera	Gadwall	500-1250	dabbling	marsh	plants	U	Ob	LC
Anas penelope	Euroasian Wigeon	500-950	dabbling	lake/ pond	plants	MI	Ob	LC
Aythya fuligula	Tufted Duck	550-900	diving	lakes/rivers	mussels, seeds, insects	SI	Ob	LC
Aythya ferina	Common Pochard	770–970	diving	lake/ pond	seeds, plants, insects	MI	Ob	LC
Mergellus albellus	Great Smew	450-650	surface diving	lake/pond	fish, insects	MI	Ob	LC
Aythya marila	Greater Scaup	726–1360	diving	lake/ pond	insects	S	Ob	LC
Anas crecca	Common Teal	140-500	dabbling	marsh	seeds	MD	O	LC

Fig.8: IWC form of 2014.

Mezinárodní sčítání vodních ptáků *International Waterbird Census*

v České republice ***Wetlands International***

sčitatel			
jméno, příjmení:		**e-mail:**	
adresa:		**telefon:**	
lokalita (úsek):		**číslo:**	
datum a čas sčítání:			
podmínky sčítání:	**teplota:**	**stav vody:**	
počasí:	**viditelnost:**	**intenzita větru:**	
rušení:		**metoda sčítání:**	
zamrzlost vody:			

kód	**druh**	**staří**	**mladí**	**celkem**	**kód**	**druh**	**samci**	**samice**	**neurč.**	**celkem**
1	potáplice malá				**23**	kachna divoká				
2	potáplice severní				**24**	kopřivka obecná				
3	potápka roháč				**25**	hvízdák eurasijský				
5	potápka žlutorohá				**26**	čírka obecná				
6	potápka černokrká				**29**	lžičák pestrý				
7	potápka malá				**30**	zrzohl. rudozobá				
8	kormorán velký				**31**	polák velký				
9	volavka popelavá				**32**	polák chocholačka				
11	volavka bílá				**155**	polák kaholka				
162	labuť zpěvná				**33**	polák malý				
21	labuť velká				**34**	hohol severní				
22	husa velká				**35**	morčák velký				
101	husa polní				**36**	morčák prostřední				
153	husa běločelá				**37**	morčák bílý				
222	*neurčené husy*				**333**	*neurčené kachny*				
38	orel mořský									
47	slípka zelenonohá									
48	lyska černá									
57	vodouš kropenatý									
64	bekasina otavní									
67	racek bouřní									
68	racek stříbřitý									
69	racek chechtavý									
159	racek bělohlavý									
681	*neurč. velcí racci*									
74	ledňáček říční									
77	konipas horský									
78	konipas bílý									
79	skorec vodní									

poznámky:

Vyplněný formulář prosím zašlete na adresu: Zuzana Musilová, Katedra zoologie PřF UK, Viničná 7,
Praha 2, 128 44 nebo e-mail: **iwccz@post.c** *Mnohokrát děkujeme za spolupráci!*