Habitat use by waterbirds in wetlands during winter and spring – a study of five wetlands in Halmstad, Sweden

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Kristin Lundquist
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Kristin Lundquist
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Halmstad University
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Supervisor: Lars-Erik Widahl
External contact: John Strand
Examiner: Göran Sahlén

Abstract
During December-April in 2016/2017, five wetlands in near proximity to the city of Halmstad and four stretches along the stream Trönningeån were investigated regarding their use by birds during winter and spring. At one of the wetlands it was investigated whether non-entry rules are set accordingly to the breeding period. Furthermore, the recreational values of two of the wetlands were calculated. The five wetlands were used by a total of 37 species during the months December-April and they were occupied by mainly the same bird species with a few exceptions, showing some differences in numbers of individuals and species composition depending on wetland. The wetlands seemed to be of importance for a few wintering species as there were at least 12 species and 190 individuals at the near-coastal wetland Trönninge ängar during months December-February. The inland wetland Stjärnarps norra våtmark attracted 6 species and a surprising amount of 153 individuals during the same period. Especially the near-coastal wetlands also created for bird purposes (Trönninge ängar and Larssons våtmark) served as very important spots for migrating birds and were visited by a large number of species and attracted 1531 and 1314 individuals between months March-April. The no-entry rules regarding Trönninge ängar seemed to be up-to-date in terms of when the birds show signs of breeding. The recreational value was calculated to be almost three times higher for Trönninge ängar than for Larssons våtmark. The turnover rate for the birds in two of the wetlands showed some differences and/or patterns regarding how and when different bird species use the wetlands.
**Sammanfattning**

**Introduction**
Eutrophic wetlands are one of the world’s most productive environments. They provide biological diversity, water and productivity which the survival of many species relies upon (Millennium Ecosystem Assessment, 2005). The Ramsar Convention (articles 1.1) defines wetlands as:

“areas of marsh, fen, peatland or water, whether natural or artificial, permanent or temporary, with water that is static or flowing, fresh, brackish or salt, including areas of marine water the depth of which at low tide does not exceed six metres”.

(Ramsar Handbooks 5th edition, 2016)

Since the end of the 1980’s, globally threatened birds that are dependent on freshwater wetlands have deteriorated rapidly, more so than birds dependent on other (mainly terrestrial) ecosystems (Millennium Ecosystem Assessment, 2005). In Sweden, up to 19% of the red listed species are wetland dependent and during the last century, 25% of the wetlands in all of Sweden and approximately 90% of wetlands in southern Sweden’s agricultural areas have disappeared as a result of ditching and agricultural practises. The ones remaining are heavily affected by anthropogenic activities such as agriculture, foresting, peat mining and urbanization. (Göbrink & Hindborg, 2015; Naturvårdsverket, 2015). Despite the big loss of wetland areas, Sweden still has got one of the highest amount of wetlands in the world, approximately 20% of the land surface
consists of wetland areas (Naturvårdsverket, 2015; Naturvårdsverket, 2018). Conservation projects with the aim to increase the number of wetlands for different reasons create hope for the wetlands and their species (Ullman, 2008). LIFE-GoodStream is one such project, with the aim to create a better ecological status in the stream Trönningeån in Halmstad by lowering the concentration of phosphorus in the water, increase fish density and the biodiversity close to the stream (Feuerbach, 2016). Trönningeån runs from lake Knorrasjön in Jonstorp and on its way to the coast it runs adjacent to or through wetlands in the agricultural landscape south of Halmstad, further linking Trönningeån to this thesis (VISS, 2018; Hushållningssällskapet, 2018).

The majority of birds are most active during breeding season (April-July) and are during this period mainly present in their breeding habitats (Gejl, 2012; Aronsson & Stenvång-Lindqvist, 2013). During spring and fall, a large number of bird species are migrating along the coastlines (Gejl, 2012). Today there is a growing awareness about the importance of protecting not only the breeding habitats but also resting sites for migrating birds as well as wintering grounds. This is an important protective measure for birds in general and not least for species bound to wetland habitats (Ullman, 2008). Birds are attracted to wetlands for different reasons, but a major one is the access to food. All bird species have developed different morphological features as a result of evolution, such as the length and shape of their bills, length of neck or the overall body size, and are as a result of this adapted to different food sources and environments (Bolduc & Afton, 2008; Strand, 2008). If possible, during migration and/or breeding season, the wetland birds choose places with an abundance of the food they prefer and are adapted to. The wetlands in a varied agricultural landscape provide a larger amount of biomass in plants, small vertebrates and invertebrates than does large-scale farmlands or forests, which is one explanation for their popularity amongst many bird species (SOF, 2011).

The differences between natural and artificial wetlands might affect whether birds visit the wetland. Many studies have shown that artificial wetlands can provide a suitable habitat for waterbirds especially during wintering and migrating, and to some extent breeding periods as well. (Ma et al., 2004; Strand & Weisner, 2013). There are many factors that need to be considered regarding wetlands to be suitable for birds. Water depth and vegetation such as trees and bushes surrounding wetlands are important factors in how attractive a wetland is from the perspective of birds. In Sweden, natural wetlands often have a lower water level during summer and winter and a higher level during spring and autumn, depending on the wetlands construction. With these fluctuations in water level comes natural disturbances to plant species in the littoral zone of the wetlands, making wetlands even more attractive. (Feuerbach, 2016).

Additional ecosystem services following construction and protection of wetlands is the recreational value these offer, in terms of people visiting these with a purpose of enjoying the nature tied to this biotope. Not least is the interest of watching birds in wetlands a large contributor to why wetlands serve as important recreational places. (The Ramsar Bureau, 2017).
Every January, resting and wintering waterfowl along the Swedish coast, and some inland areas, are surveyed as part of an internationally coordinated project, with the aim of collecting data about trends and changes in the populations of the birds (Naturvårdsverket, 2012). Depending on ice cover, the amount of birds can vary a lot (Gejl, 2012). There is also an inventory of waterfowl in May and these are also repeated annually (Svensk fågeltaxering, 2016). But overall, there doesn’t seem to be a very high rate of surveys done during wintertime and early spring (especially regarding the use of wetlands by birds), which could lead to a potential shortage of information about species in different habitat types during different seasons. There is a value in knowing which species different habitats attract during winter and spring migration. There is also a value in obtaining knowledge about the recreational values of wetlands (that is, the assumed economical worth of a wetland) as it gives information about the direct and indirect benefits that people get from the wetlands. Perhaps artificial wetlands can be customized to suit these needs even better, creating more possibilities for birds during wintering and migration. The need for such surveys especially in wetland habitats has inspired this thesis.

Five wetlands in near proximity to the city of Halmstad and four stretches along the stream Trönningeån was chosen to be investigated regarding its use by birds during winter, migration and spring. The questions and hypotheses this study aim to answer are:

- What bird species are the most common during winter in the investigated wetlands?
- Are Trönninge ängar and Larssons våtmark used to a higher extent (in means of a higher concentration of birds and more species), because they were created with the purpose to serve as bird habitats, compared to the other three investigated wetlands in this study?
- Will the abundance of birds in the wetlands close to the coast be higher come spring migration, than in the wetlands further from the coast (inland)?
- Do the species common snipe (*Gallinago gallinago*), jack snipe (*Lymnocryptes minimus*) and eurasian woodcock (*Scolopax rusticola*) use parts of the stream Trönningeån during harsh winters?
- Is the starting date of the no-entry rules, set between April 1th and July 15th, regarding Trönninge ängar set accordingly to the time of breeding activity and is climate change a possible factor that can influence the accuracy of these dates?
- What is the recreational value of Trönninge ängar and Larssons våtmark?
- What is the turnover rate of the different bird species in Trönninge ängar and Larssons våtmark, by means of how and when the different species and individuals use the wetlands over the course of five hours?

The aim of this study was to get information regarding how, when and by what species the wetlands are used. The visited stretches of the stream Trönningeån could possibly provide information on whether the stream is of importance for wintering birds during the coldest time at year. Gathering information about recreational values of two of the wetlands was done to get an indication on how well these wetlands are doing in providing a functional place for people to
carry out their interest of bird watching. All of this knowledge will hopefully give further information about the importance of functional wetlands during wintering and spring migration and be of use in the administration of wetlands regarding bird benefits and recreational purposes.

**Materials and methods**
The visits to all of the investigated wetlands took place in the midmorning during months December-May 2016/2017 with a total of 13 visits. Four visits were made to the stretches of the stream Trönningeån in December-February. (Figure 1). Two additional longer visits were made only to wetlands Trönninge ängar and Larssons våtmark in May, to make a closer analysis of the bird activity. These two longer visits were carried out between 07:00 a.m. and 11:00 a.m. on the 20th and 21st of May.

When visiting the wetlands, methods in line with recommendations regarding waterbirds from Svensk Fågeltaxering (a bird counting organization part of The Swedish Environmental Protection Agency) was followed (Svensk fågeltaxering, 2016). Waterbirds in this study refer to waterfowl, shorebirds, seabirds and wading birds. At all wetlands, all birds in the water and in a range of 50 m from the water, were counted and identified. Depending on the amount of birds present, the length of the visits varied. No passing birds were counted, only birds in the wetland or in very close proximity (<50 m) were included. The reason for this was that only birds that actively used the wetlands either as a food resource or as a resting and/or breeding location were relevant to this study. At especially one wetland, many of the Greylag goose occupied themselves at farmlands right next to or surrounding the wetland. Since it was hard to establish whether they were there for the sake of the closeness of water, or mainly for the farmland, birds within 50 meters from the wetland were included since it could be assumed that the water had attracted the birds to the site in some way. At the two longer visits to the wetlands Trönninge ängar and Larssons våtmark, the birds were counted and observed regarding whereabouts in the wetland and their activities 5 times; one time per hour. Factors that were noted was whether the birds were active (e.g. feeding, flying around, mating) or passive (e.g. resting and/or nesting). It was also noted where in the wetlands they spent their time; on land, in the littoral zone or in the water zone (deeper water) and whether they arrived to or left the wetlands in the morning. All observed species can be found in Appendix 1.

A survey regarding the recreational value of Trönninge ängar and Larssons våtmark was created in Google Documents. It was then shared on the Facebook page of the local birding association, Halmstads ornitologiska förening (HOF), to invite bird watchers to answer survey questions, which would lay the foundation for the calculation of the recreational values. The method used to calculate the recreational value is called the travel cost method and, in this case, a simplified method was used to fit the available data. The calculation was based on the number of unique visits to the wetlands during the year of 2017. Data was collected from the site Artportalen by downloading excel files containing all reports from the concerned wetlands during the year of...
2017. The number of unique reports (visitors) was counted and multiplied with the mean value of visitors travel cost (collected from the survey) to visit these wetlands. The site Artportalen was also used to collect data about reported breeding activity at the wetland Trönninge ångar. The software Microsoft Excel was used to compile and analyse the data collected in this project.

A pair of binoculars of the brand Opticron, 8x32 magnification and a spotting scope of the brand Swarowski, 25x50 magnification, was used to help spotting and identifying the birds in the wetlands.

The surveyed wetlands and visited stretches of the stream Trönningeån

![Figure 1. Marked on the map is the location of the town Halmstad (red dot), the investigated wetlands (blue dots) and the visited stretches of the stream Trönningeån (yellow pins). (Google earth Pro Terra Metrics, 2018).](image)
**Larssons våtmark**
The wetland Larssons våtmark is a rather new wetland located south of Halmstad and it was finished in 2014. The wetland is ca 5 ha and the water depth is approximately 80 cm at its deepest parts (close to the outlet) but the rest of the area is rather shallow, to fit its aim as a bird-wetland. The recreational aspects of the wetland are heightened by a bird hide placed on a constructed hill and parking facilities, all created by the local bird association HOF (Halmstads ornitologiska förening). Its location (Figure 1) is rather close to Trönninge ängar and very close to Laholmsbukten (the bay in the south east of Kattegat), making it a very interesting bird locality, which is the reason it was included in this study. (HOF, 2013; Sveriges radio, 2014).

**Trönninge ängar**
The bird protection area Trönninge ängar is located north of the village Trönninge (Figure 1), between the highway E6 and the railway, approximately 10 km south of Halmstad (Länsstyrelsen Halland, 2017; Halmstad kommun, 2017). It was created as a bird wetland (parts of the wetland existed before this as retention wetlands) in 1993/94 (H Bjuringer 2017, personal communication, 22 November). On these fields there is a constructed wetland of around 7 ha. It consists of one bigger pond and east of it lies two older treatment ponds completed with a bird hide and a bird tower (HOF, 2013). The meadows around the waterbodies are moist grazing land with sections of bushes and by the bird hide is a smaller grove. (Halmstad kommun, 2017; HOF, 2013).

**Stjärnarps norra våtmark**
Stjärnarps norra våtmark (Figure 1) was constructed in 2006 as a LIP-wetland (local investment programs) with an original purpose of decreasing nutrient leakage from surrounding land and increasing biodiversity in the area (H Bjuringer 2017, personal communication, 22 November). It is approximately 8 ha in size and consists of four ponds surrounding the river Trönningeån that runs in the arable landscape north-east of the estate called Stjärnarp gods.

**Stjärnarpsdalen**
Stjärnarpsdalen (ca 3,5 ha) is a valley in the arable landscape in Stjärnarp south-east of Halmstad (Figure 1). The wetland is part of the EU-project Life GoodStream and was under reconstruction during this study. The wetland has been transformed from one large pond to five wetlands and six integrated buffer zones; the overall aim has been to decrease the nutrient leakage into the stream Trönningeån. Apart from the reconstruction of the wetland, creotopes (small-scale constructed biotopes with the aim of supporting specific species) and nest boxes for birds will be created in the area. (GoodStream, 2017). During this study, the wetlands were not yet finished, and they were therefore lacking certain elements such as vegetation that could be a key component in serving as an attractive spot for birds.

**Stjärnarppssägen**
The pond Stjärnarppssägen (ca 0,8 ha) is located by the road between Elsberga and Stjärnarp (Figure 1). It was created as a sawmill pond with a small water power plant in 1921 but was abandoned in 1961 and until the 1970’s it was used to soak timber. During the years, the pond
has been rebuilt for different purposes and the latest reconstruction (2013) was to improve its ecological status and open up for fish migration from the ocean to spawning grounds and all the way up to lake Knorrasjö, which had not been possible up until then. (Feuerbach, 2012; Hildingsson, 2015).

Results

What bird species are the most common during winter in the investigated wetlands and to what extent?

During the months December to February, only a small number of species and individuals were observed during the seven visits to the wetlands. At Trönninge ångar, 12 species and a total of 190 individuals were observed and the highest number of individuals observed at one visit was 116. The species with the highest number of individuals (mentioned in order highest-lowest) was the juvenile gull and european herring gull (Larus argentatus), followed by the greylag goose (Anser anser) and the mallard (Anas platyrhynchos). At Larssons våtmark 5 species and a total of 22 individuals were observed and the highest number of individuals at one visit was 13. The species with the highest number of individuals was the mallard followed by the mute swan (Cygnus olor). At Stjärnarps norra våtmark, 6 species and 153 individuals were observed in total and the highest number of individuals at one visit was 147. The species with the highest number of individuals was the greylag goose, followed by canada goose (Branta canadensis) and the common goldeneye (Bucephala clangula). At Stjärnarpsdalen, no species were observed. At Stjärnarpsågen, only one species, a grey heron (Ardea cinerea), was observed. (Figure 2).

![Figure 2](image_url)

**Figure 2.** Number of individuals (blue bars) and number of species (orange bars) in each wetland (a total of seven visits) during months December-February.
Are Trönninge ängar and Larssons våtmark used to a higher extent (in means of a higher concentration of birds and more species), because they were created with the purpose to serve as bird habitats, compared to the other three investigated wetlands in this study? Trönninge ängar ha total of 1721 individuals and 26 species from December-April. Larssons våtmark had 1336 individuals and 25 species during the same period. Stjärnarps norra våtmark had 884 individuals and 14 species, Stjärnarpsdalen had 80 individuals and 4 species. Last, Stjärnarpssågen had 41 individuals and 5 species. (Figures 3 & 4; Appendix 3, figures 12-13).

*Figures 3 and 4. Number of individuals (left figure, blue bars) and number of species (right figure, orange bars) in each wetland (a total of 13 visits) during months December-April.*

Will the abundance of birds in the wetlands close to the coast be higher come spring migration, than in the wetlands further from the coast (inland)? Trönninge ängar and Larssons våtmark, which are near coastal wetlands, had 1531 respective 1314 individuals using the wetlands during March-April. The remaining three wetlands are inland wetlands and results show that Stjärnarps norra våtmark had 731 individuals, Stjärnarpsdalen had 80 individuals and Stjärnarpssågen had 40 individuals during this period. (Figure 5).
Do the species common snipe (*Gallinago gallinago*), jack snipe (*Lymnocryptes minimus*) and eurasian woodcock (*Scolopax rusticola*) use parts of the stream Trönningeån during harsh winters?

No birds were found during the four visits to these parts of the stream.

Is the starting date of the no-entry rules, set between April 1\(^{\text{st}}\) and July 15\(^{\text{th}}\), regarding Trönninge ängar set accordingly to the time of breeding activity and is climate change a possible factor that can influence the accuracy of these dates?

No personal sightings during visits to the wetland Trönninge ängar indicated breeding activity before the date of April 1\(^{\text{th}}\). There are however seven reports on the site Artportalen (search period was set between the years 1990-2017 months December-March) reporting breeding activity before the date of April 1\(^{\text{th}}\). Between the dates of March 1\(^{\text{th}}\) to March 31\(^{\text{th}}\) during the years 2008-2014 seven reports confirm that such activities have been observed (Artportalen, 2018). These sightings of such early activity regard the greylag goose, the mute swan, the pied avocet (*Recurvirostra avosetta*) and the common goldeneye.

What is the recreational value of Trönninge ängar and Larssons våtmark?

Trönninge ängar had (according to the site Artportalen) a total of 960 visits during the year 2017 and the number of unique visitors was 296. The recreational value of the wetland was calculated to be 111 360 SEK for the year of 2017. Larssons våtmark had (according to the site Artportalen) a total of 736 visits during the year 2017 and had 264 unique visitors. The recreational value was calculated to be 33 856 SEK for the year of 2017. Relevant parts of the survey that the calculation is based on can be found in Appendix 2.
What is the turnover rate of the different bird species in Trönninge ängar and Larssons våtmark, by means of how and when the different species and individuals use the wetlands over the course of five hours?

At Larssons våtmark, there was a minimum number of 302 birds and a maximum of 333 from 07:00-11:00.

The most mobile and active birds, moving around actively (swimming or flying) at least 70% of the time, were waders such as the eurasian oystercatcher (*Haematopus ostralegus*), the little ringed plover (*Charadrius dubius*), the pied avocet and the common redshank (*Tringa totanus*).

The most passive birds who were occupied with resting and/or nesting at least 80% of the time were the mediterranean gull (*Ichthyaetus melanocephalus*), the black-headed gull (*Chroicocephalus ridibundus*) and the mute swan.

The species of wading birds, like the eurasian oystercatcher and the pied avocet, spent at least 70% of their time in the littoral zone (feeding) and 30% resting on land. Most species of ducks, such as the tufted duck and the northern shoveler (*Spatula clypeata*), spent approximately 80% of their time in the water zone and the rest of the 20% resting on land. The greylag goose spent 100% of its time on land and the mallard were present in all zones.

Species arriving in the morning were the greylag goose (figure 6) and the pied avocet (figure 7). Very stationary species in this wetland were the mediterranean gull and the black-headed gull (figure 8). Information involving the rest of the noted species and their fluctuations over time can be found in Appendix 4, figure 17.

![Figure 6. Fluctuations in individual numbers at Larssons våtmark from 07:00 am to 11:00 am.](image-url)
At Trönninge ängar, there was a minimum number of 70 birds and a maximum number of 113 from 07:00-11:00.

The most active and mobile species, moving around actively (swimming or flying) at least 60% of the time, were the eurasian oystercatcher, the common sandpiper (*Actitis hypoleucos*), the little
ringed plover, the common ringed plover (*Charadrius hiaticula*), the pied avocet and the common teal (*Anas crecca*).

The most passive bird species included the mute swan, the black-headed gull, the northern shoveler, the barnacle goose (*Branta leucopsis*), the greylag goose, the eurasian herring gull, the gadwall (*Mareca strepera*) and the northern lapwing who were all involved in resting/nesting activities at least 80% of the time.

The species of wading birds, like the little ringed plover and the common sandpiper, spent at least 80% of their time in the littoral zone (mainly feeding) and 20% on land (resting/nesting). The species of ducks, such as the common teal, spent at least 70% of their time in the water zone and the remaining 30% resting/nesting on land. The greylag goose, barnacle goose and the mallard were present in all zones.

Species that came to the wetland in the morning was the gadwall (figure 10) and species that left the wetland in the morning were the greylag goose (figure 9), the northern shoveler (figure 10), the black-headed gull and the eurasian herring gull (figure 11).

Information involving the rest of the noted species and their fluctuations over time can be found in Appendix 4 figure 18.

![Figure 9. Fluctuations in individual numbers at Trönninge ängar from 07:00 am to 11:00 am.](image-url)
Figure 10. Fluctuations in individual numbers at Trönninge ångar from 07:00 am to 11:00 am.

Figure 11. Fluctuations in individual numbers at Trönninge ångar from 07:00 am to 11:00 am.
Discussion

The investigated wetlands in this study do seem to have some importance for a few overwintering species. During spring, the wetlands (especially the near-coastal ones that are also created for bird purposes) served as very important places for migrating birds and were visited by a large number of species and individuals. As migratory birds are reluctant to fly over perilous or unknown areas, they follow the coastline for as long as possible and often accumulate on islands and headlands (Falsterbo Bird Show, 2012; Gejl, 2012). The Swedish west-coast therefore supplies a natural migration path for the birds on their journey to their wintering or breeding grounds. During mild winters, because of the access to open waters, wetlands can attract many species of waterfowl; the abundance of birds at this time can therefore be very high and large concentrations can occur in a few key areas, but ice cover can on the other hand be a cause for a very low abundance instead (Strand, 2008; Almaraz, 2012). The winter of 2016/2017 was quite mild with temperatures rarely dropping below zero during daytime (SMHI, 2018). Night temperatures were generally colder which resulted in the wetlands being fully or partly covered with ice during parts of January and February, despite warmer day temperatures. The amount of ice cover could have affected the wetlands usefulness to wintering birds as they might instead reside to nearby waters with no ice cover (Clipp, Peters & Anderson, 2017). Larssons våtmark, Stjärnarpsdalen and Stjärnarppssågen were the wetlands with the most ice cover in the end of February, which might explain further why Trönninge ängar was used to a higher extent than Larssons våtmark at this period event though they are both coastal wetlands and created for bird purposes. In the end of February/beginning of March, when spring migration began, all wetlands were used to some extent. It is clear though, that Trönninge ängar and Larssons våtmark were used to a higher extent and attracted more birds (both number of species and individuals) during spring than did the others. Although, Stjärnarps norra våtmark had a lot of visits especially in the beginning of March, with more individuals (mainly geese visiting surrounding farmland) but fewer species than Trönninge ängar and Larssons våtmark. It’s difficult to say whether the geese were there mainly for the sake of the wetland or for the surrounding farmland. If the geese were to be left out from the survey results, the number of individuals at Stjärnarps norra våtmark would be a lot less: 25 compared to 147 in the end of February and 41 compared to 253 in the beginning of March. On another note, the surrounding landscape is of very big importance since many wetland birds don’t breed in the specific wetland, but on surrounding areas (mainly large areas of grassland) and this factor is often overlooked (Strand, 2008). Stjärnarps norra våtmark seemed to serve as an important place for some wintering birds, which is somewhat surprising for an inland wetland not created for bird purposes. It might therefore be of relevance to further study this wetland during coming winters to verify the results, and to possibly get a better understanding as to why the wetland seem to be so popular during winter especially.

Stjärnarps norra våtmark also seemed to be a useful spot for migrating birds in the beginning of spring, but as spring advanced, the wetland seemed to become less attractive while Trönninge ängar and Larssons våtmark kept on increasing in number of species and individuals. It is likely
that there is more food available in these near-coastal wetlands created for bird purposes earlier in the season and that they have a higher food abundance later on as well, which might be why the birds preferred these wetlands instead. It might also have to do with the wetlands location in the landscape. A good bird wetland should be placed in an open landscape without adjacent forest or very large solitary trees (Strand, 2008). This might be a factor to why Stjärnarps norra våtmark seemed to be less attractive as spring advanced, it just might not be a suitable breeding spot because of its location next to a forest. Birds are also very social during the breeding period and many bird species form life-long monogamous relationships which they continue every year through courtship display at the breeding sites (Ullman, 2008). Some species who does not form life-long relationships or who has not yet established a such relationship needs to find a mate for breeding. The chances of doing so increases at sites with a high abundance of other birds belonging to the same species. Trönninge ängar and Larssons våtmark were created and are maintained solely to serve as bird habitats which makes it logical that these wetlands attracted more birds. The results from this study also indicates that the planning and maintenance of these two wetlands serves its purpose as they attracted the most birds. Although, wetlands created for other purposes (e.g. retention basins) can, with quite simple measures, be adapted to suit the needs of birds as well (Strand, 2008). Since Stjärnarpsdalen had just been rebuilt during the time of the visits for this study, there was a lack of some elements that birds appreciate around wetlands such as some small-scale vegetation and food abundance. Because of this, a lot of birds had probably not yet found the wetland to establish its use as a resting and breeding site.

Stjärnarpsdalen will hopefully be a well-visited site for birds in the future when the succession of this wetland has come further. It is important though, as with all wetlands, to properly maintain them, which can be a challenging and time-consuming commitment. Almost all constructed wetlands will only be temporary images in the landscape unless they are managed in some way (Strand, 2008). The vegetation must be kept short to prevent overgrowth, surrounding bushes and trees should be kept to a minimum to decrease risk of predation (that is, preventing predatory birds such as crows to use the bushes and trees as vantage-points) and by designing the wetland to be in a state of natural change (that is, following seasonal fluctuations in water levels) the birds will hopefully stay interested in the wetland and return (Feuerbach, 2014).

One of the most common bird species that visited Trönninge ängar during this study was the european herring gull (*Larus argentatus*). The european herring gull is considered vulnerable (even though it is quite common) according to the red list. The species has declined as a result of decreased small-scale fishing (leading to less by-catch available for gulls), covering of waste sites and lack of vitamin B1 in the population, leading to difficulties in reproduction and neurotoxic excess mortalities. (Artdatabanken, 2018). In light of this, it was uplifting to see that the european herring gull was the most common species at Trönninge ängar and it also shows the importance of wetlands for this species. The other species common in the wetlands in this study, the greylag goose, the common goldeneye, the mallard duck, the mute swan and the grey heron are all considered to be of least concern; meaning they have viable populations and no signs of declining
in numbers (Artdatabanken, 2018). All of the mentioned species are essentially migratory birds, but large parts of the populations winter in the south of Sweden as long as winters are mild. The mallard is one of the more widespread ducks in Europe, not only because it is good at exploiting man-made habitats, but also because millions of mallards are released into the wild for hunting purposes, further strengthening their numbers (Guillemain et al., 2013). 50 years ago, almost all geese moved south (leaving Sweden) but since the 1980’s the number of greylag geese that stay in Sweden during winter have been rising (Froster, 2018). The common goldeneye and mute swan seldom move further during winter than to the coast of Denmark, often staying in Sweden (Fageln, 2018). The mute swan is a very territorial bird (NOF, 2012). If the swan intends to breed in the South of Sweden and winter in the area, it might stick around in a wetland to defend the territory and to be sure to be the first one there when spring arrives, increasing its chances of breeding success. The grey heron often stays in Sweden during winter if there are open water bodies available but can move as far as to northern Africa if winters get cold (Fageln, 2018). It was not unexpected to find that these species dominated the wetlands during winter as they are all more or less common in wetland habitats. They are also opportunistic when it comes to migration during winter, leading to some birds taking their chances and staying in Sweden instead of moving south.

Birdwatching is a hobby that is expanding, and wetlands are a very important biotope in which birders can find a lot of both common and rare birds. When supporting wetlands for this purpose, positive ecological effects will follow in terms of providing possible habitats for both birds, amphibians, sometimes fish, and also mammals depending on wetland structure and maintenance (Feuerbach, 2014). The same goes the other way around: creating this kind of habitats for animals result in large possibilities for recreation and when putting some extra work into making it a good recreational spot (e.g. constructing functional bird towers and trails) it makes it more accessible to visitors. By calculating the recreational value for an area, one can find out how much people are willing to pay for different experiences, which can be of use when managing, developing and expanding wetlands. One way to calculate a recreational value is through the travel cost method. This method was developed in the 1950’s to put an economical value on national parks and it is built upon a correlation between a product that already has a price and a product that you wish to put a value on (Fredman, 2000). The recreational values for Trönninge ängar and Larssons våtmark are likely to be an underestimation of the reality, since it only takes consideration to visitors that report to the site Artportalen. The number of visits is therefore likely to be a lot higher. The calculated recreational values in this study are thus an estimation of the real values of these wetlands and one can assume that they are at least worth this much and probably more. One interesting note is that the mean value of the travel cost to Trönninge ängar was more than twice as much as the mean travel cost for Larssons våtmark (116 SEK versus 46 SEK). One theory is that there is a higher number of people living far away that visit Trönninge ängar since it is more widely known amongst birders. It has also been around for much longer (since ’93) compared to Larssons våtmark which was created in 2014. Larssons våtmark is probably visited more by
people living nearby and therefore the mean travel cost is lower. The cost of construction for Larssons våtmark was 1.13 million SEK and with a depreciation time of 20 years, the yearly cost of the wetland is 60 000 SEK (J.A Strand 2018, personal communication, 21 May). This means that the recreational value linked to bird watching covers approximately half of the yearly cost. The construction cost for Trönninge ängar was very low since it was created in connection with the construction of the adjacent freeway (J.A Strand 2018, personal communication, 21 May). The high recreational value is probably covering more than half of the yearly cost for the wetland Trönninge ängar, which is also more than 20 years old. The calculation for the travel cost method in this study is a bit simplified to fit the data that was collected. To get a more detailed picture of the recreational value, the mean travel time could have been included as well, to more thoroughly cover the question about how far people travel to visit the wetlands.

Climatic changes might lead to bird species becoming out of synchrony with their environment due to phenological mismatches and thus responding inappropriately or not responding at all to climate change (Crick, 2004; Santangeli, 2018). Following higher spring temperatures and earlier seasonal peaks in food abundance, many bird species lay their eggs earlier in the season to synchronize with the peak of food availability (Cresswell & Mc Cleery, 2003). Between the dates of April 1th – July 15th it is forbidden to reside within the wetland areas of Trönninge ängar and the reason is that birds can be disturbed during their most sensitive time: the time of breeding. According to the site Artportal en, there are seven reports regarding breeding activity before the date of April 1th between the years 2008-2014 (Artportal en, 2018). The criteria used for these reports are that the birds are showing signs of courtship and display (indicating probable breeding) and occupied nest (indicating confirmed breeding). It has been shown that passerine birds in general arrive 4-5 days earlier today than 40 years ago (Lindström, 2018). Some migrating birds are more optimistic than others; short-distance migratory birds can arrive to the South of Sweden already in January and February, but they are also prepared to turn around and fly south again if the weather gets too cold. These birds have mainly wintered in Western Europe and it is the weather and wind that are affecting their migration patterns rather than the length of day. (Ullman, 2008). Although, the impact of weather on bird populations have been well studied, the impact on long-term shifts in weather (that is climate change) has not been studied as much (Crick, 2004). There is a lack of research on waterbirds (with an exception for ducks) regarding their response to climate change. Instead, much effort has been put into researching specific bird groups such as cavity-nesting songbirds. Studies have shown examples of greylag geese migrating three weeks earlier than normal in the middle of 2000’s compared to the 1980’s. Earlier departure dates are not necessarily proof of effects of climate change, but since many bird species has been noted to arrive earlier in Finland in years that had positive North Atlantic Oscillation index values (that is, positive values characteristic of mild and rainy winters in the north of Europe), it can be assumed that climate change is partly responsible for changes in the migration schedule of birds. (Guillemain et al., 2013).
The ongoing climate change has been proved to influence wildlife through several factors and the potential consequences of global climate change for animal populations have recently become one of the greatest threats to biodiversity (Guillemain et al., 2013). The most vulnerable species are those that cannot adapt or respond to climatic changes and those who got poor dispersal abilities. The ones predicted to be most favoured by climatic changes are generalist species contra specialist species adapted to a small ecological niche. (Crick, 2004). Many bird species also have the ability to strategically control the hatching date after the first egg has been laid and might therefore be able to compensate for changes in temperature (Crisswell & McCleery, 2003). The processes underlying the patterns of spring migration is a complex field and arrival dates at breeding grounds do not seem to have changed despite the fact that areas in the north are warming relatively faster compared to areas further south. (Guillemain et al., 2013). The effects of climatic changes on the migration-and breeding patterns of birds need to be investigated further. The question is though, whether the date of hatching in general will be set to an earlier date for the main part of the bird population, as a result of climatic changes, leading to an earlier period in the spring where human disturbance should be minimized. Based on results of this study, no such indications can be seen clearly at Trönninge ängar. It is rather safe to say though, that climatic changes will most likely affect bird populations in different ways (some positive, some negative) and it’s important to keep up with their response and adaptations to this phenomenon.

The stream Trönningeån was visited to investigate whether the eurasian woodcock, the jacksnipe and the common snipe use the streams during winter, since they are dependent on areas with open water and unfrozen ground to forage on during the cold season (Gejl, 2012). All three species eat small invertebrates such as worms, snails, insects as well as small plant materials and they forage in mud and wet areas, such as shelves of small streams (Gejl, 2012; Jordbruksverket, 2017; Artdatabanken, 2018). Most individuals migrate to warmer sites during winter, but some stay in the south of Sweden. During the visits to the stream, no observations of these bird species were made, but small streams that run through the landscape (both forest and arable) are important for wildlife and should be maintained and taken care of in such matter that biological diversity is supported, and pollution is minimized. Studies of the stream Trönningeån should be repeated during several years to get data during a longer period of time and further explore its potential importance for wading birds during the cold time of year. As more birds stay in Sweden during winter (e.g. wetland users like the whooper swan, the common crane and stream users like the woodcock) because of climate change enabling more northerly wintering sites, providing habitats that supply shelter and food if winters get harsh is important (Kullberg et al., 2015; Lindström, 2018).

When investigating the turnover rate of the bird species at the wetlands Trönninge ängar and Larssons våtmark, very clear patterns were hard to notice, but there are some pointers on how the different species use the wetlands. To discover those patterns, it was easiest to divide the species into taxonomic groups. That way one can see that while there might not be a lot of differences in
how two diving duck species use the wetland, there are differences in how diving ducks use it versus wading birds or geese. Different species use wetlands for different reasons; some use wetlands as “bedrooms” as the open waters provide some security during sleep and some use the wetlands as “pantries” as the wetlands provide food for many species (Strand, 2008). One of the more clear differences between species in this study was whether they seemed to use the wetland for only some purposes mainly during a confined part of the day (either during daytime or during the night) or at all hours for all purposes.

Not all birds are attracted to wetlands only for the sake of the water. There are different groupings (with quite fluent boundaries) in which it can be seen that some birds are “water species” (ducks, geese, grebes, swans and gulls for example) while most wading birds are “land species” (Strand, 2008). A difference between the taxonomic groups was that wading birds in general were very active in their movements over the wetland area and there was a lot of social activity between them including chasing and flying after each other, either in terms of courtship or rivalry. Also, differences in feeding patterns could be noted as some birds kept more to the littoral zone (wading birds), some kept more to the open water (ducks) and some birds were more opportunistic and fed everywhere in the wetland (species like the greylag goose and the mallard). Studies have shown that water depth is something that have an influence on where different bird species forage in the wetland, and in general bigger birds (diving ducks) forage in deeper water compared to smaller birds (teals) and/or shorebirds (waders) who are more constricted by the depth of water (Isola et al., 2000; Colwell & Taft, 2000; Elphick & Oring, 1998). This is a logical pattern considering the birds morphology and ecology. Also, shallow wetlands seem to attract more species than deeper wetlands, but deeper wetlands can on the other hand attract specifically species of diving ducks (Colwell & Taft, 2000). This shows the importance of providing both shallow areas and areas with deeper water in a wetland to get a high biodiversity and support more bird species. If the investigation were to continue over the course of more hours or even days, more clear patterns showing more differences (also between species in the same taxonomic group) would probably be more easily discovered.

Overall, the wetlands surveyed in this study do seem to play important key roles in the ecology of wetland dependent birds, by supporting the birds during migration and winter. This confirms the importance of functional ice-free wetlands in Sweden during the non-breeding season. In northern Italy, rice fields (which are often flooded in the winter) have been proven to be important wintering sites for birds such as the ruff (Philomachus pugnax), the spotted redshank (Tringa erythropus) and also the black-crowned night heron (Nycticorax nycticorax) (Czech & Parsons, 2002). Wetlands and lakes in south-eastern China support the endangered species oriental white stork (Ciconia boyciana) and siberian crane (Leucogeranus leucogeranus) during migration stop overs and as wintering sites (Shimazaki,Tamura & Higuchi, 2004; Kanai et al., 2002). Most likely, birds experience wetlands as attractive patches in a more or less inhospitable landscape pattern and when food sources are scarce (e.g. during winter) they probably use several wetlands within a landscape to supplement their energy intake. It has been shown to be of
importance to maintain and preserve wetlands that are somewhat connected in the landscape and close to other favourable habitats, as opposed to isolated wetlands, in terms of supporting birds during all potential winter conditions and during migration as they often use a series of stopover sites. (Taft & Haig, 2006; Shimazaki, Tamura & Higuchi, 2004).

Depending on location in the world, different types of wetlands are used by birds during migration and winter; rice fields for example provide important wintering and stop over sites for many birds in the part of the world where they are present (Czech & Parsons, 2002). Coastal marshes provide important habitats for birds during winter and migration and estuaries have been proven to be an important biome for birds all year around during at least one or more stages of their life cycle (Bolduc & Afton, 2004; Ysebaert et al., 2000). Without functioning wetlands, a great loss of species could be expected, and the shift would probably turn towards a more homogenic mix of species instead of, as it is now, a great diversity at least during spring and summer. The abundance of birds in a wetland is frequently seen as an indicator of the health and biodiversity of a wetland and is often used to qualify wetlands as internationally important and to designate them as protected areas (Guilleman et al., 2013; Guareschi et al., 2015). By performing recurring investigations and studies regarding how and when bird species use different types of wetlands, more knowledge about the matter will be presented and also updated, which is important to maintain a good and up to date management of wetlands in the country.

Conclusions
The wetlands visited by the highest number of individuals and species was the wetlands close to the coast that were also created to function as bird wetlands. The species dominating in numbers in the five investigated wetlands were the gulls (juvenile gulls and the European herring gull), the greylag goose, the mallard, the mute swan, the common goldeneye and the Canada goose. The wetlands seemed to be of importance for some wintering species and during spring migration all wetlands played an important role in functioning as resting spots and especially the near-coastal wetlands (Trönninge ängar and Larssons våtmark) played a key role in supporting migrating birds and more stationary birds for breeding and resting purposes. The stream Trönningeån did not show any signs of being an important biotope for wading birds during winter. Repeated studies of the wetlands as well as the stream parts are desirable to further verify the results and contribute with new reports. The no-entry rules for Trönninge ängar seem to be correct at this time with no signs of birds breeding earlier than the starting date 1th of April but it should be monitored in the future to discover any changes in these patterns. The recreational value for the year 2017 of the wetland Trönninge ängar was calculated to be almost three times higher for Trönninge ängar than for Larssons våtmark, probably because Trönninge ängar is more widely known and visited by more far away visitors. The turnover rate for the wetlands showed some differences and/or patterns regarding how and when different bird species use the wetlands, more thorough
investigations regarding the turnover rate is desired to get more clear patterns between the taxonomic groups and species.

Acknowledgements
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References


SMHI: Sveriges meteorologiska och hydrologiska institut. (2018). A website for SMHI's compilations of the weather during different months, seasons or years. Available at: https://goo.gl/3BVtnX [2018-06-04]


Appendix 1

Table 1. All noted species and total amount of individuals from all 14 visits to Trönninge ängar and Larssons våtmark between December-May and all 13 visits to Stjärnarps norra våtmark, Stjärnarpsdalen and Stjärnarssågen between December-April.

<table>
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<tr>
<th>English/Swedish</th>
<th>Latin</th>
<th>Trönninge ängar</th>
<th>Larssons våtmark</th>
<th>Stjärnarps norra våtmark</th>
<th>Stjärnarpsdalen</th>
<th>Stjärnarps-sågen</th>
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<td>Mute swan / Knölsvan</td>
<td>Cygnus olor</td>
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<td><strong>884</strong></td>
<td><strong>80</strong></td>
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Appendix 2

Relevant figures from the survey regarding the recreational value of Trönninge ängar and Larssons våtmark that lay the foundation for the calculation of the recreational values.

3. What is your estimated fuel cost to travel to and return from Larssons våtmark? (If you do not travel by car, skip this question)

![Bar chart showing the distribution of travel costs for Larssons våtmark]

5. What is your estimated fuel cost to travel to and return from Trönninge ängar? (If you do not travel by car, skip this question)

![Bar chart showing the distribution of travel costs for Trönninge ängar]
Appendix 3
Figures showing the number of individuals and number of species on each wetland from all the 13 visits during months December-April.

**Figure 12.** Number of individuals (orange bars) and number of species (blue bars) on Trönninge ängar from all the 13 visits during months December-April.

**Figure 13.** Number of individuals (orange bars) and number of species (blue bars) on Larssons vätmark from all the 13 visits during months December-April.
Figure 14. Number of individuals (orange bars) and number of species (blue bars) on Stjärnarps norra våtmark from all the 13 visits during months December-April.

Figure 15. Number of individuals (orange bars) and number of species (blue bars) on Stjärnarpsdalen from all the 13 visits during months December-April.
Figure 16. Number of individuals (orange bars) and number of species (blue bars) on Stjärnarpssågen from all the 13 visits during months December-April.

Appendix 4
Figures showing fluctuations in number of individuals involving the species not mentioned in the results under question “What is the turnover rate of the different bird species in Trönninge ängar and Larssons våtmark, by means of how and when the different species and individuals use the wetlands over the course of five hours?”

Figure 17. Fluctuations in individual numbers at Larssons våtmark from 07:00 am to 11:00 am.
**Figure 18. Fluctuations in individual numbers at Trönninge ängar from 07:00 am to 11:00 am.**

<table>
<thead>
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<th>Animal Type</th>
<th>07:00</th>
<th>08:00</th>
<th>09:00</th>
<th>10:00</th>
<th>11:00</th>
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<tr>
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<td>1</td>
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<tr>
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<td>1</td>
<td>1</td>
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<tr>
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<td>5</td>
<td>6</td>
<td>3</td>
<td>13</td>
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<tr>
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<td>3</td>
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