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Master thesis

Goose response to hunting activities

Is there an optimal way of hunting?

Picture; Rein A. Riise Dalermoen, 2021

Master in applied ecology

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Preface

This master thesis is a part of the GULL project (*Gjess I Oslofjorden: Utfordringer, innovative Løsninger, verdiskapning og Lønnsomhet*), led by NINA (Norwegian Institute for Nature Research) and Fredrikstad municipality, financed by Viken Region Research Fund. The aim of this thesis is to increase knowledge and find solutions to the increasing goose-agriculture conflict in Fredrikstad municipality and identify success criteria for an optimal hunting organization that increases the number of harvested geese as a tool to reduce the conflicts between geese and agriculture.

For this thesis I will have Dr. Antonio Bjørn Stefan Poleo as my main supervisor. I will also have Dr. Ingunn Tombre from NINA as a supervisor. Also aiding the project is wildlife manager in Fredrikstad municipality, Jørgen Torp and project leader in the Norwegian Farmers' Union, Ove Martin Gundersen.

Fredrikstad 27. May 2022

Rein Riise

Summary

Most of the European goose (*Antidae*) populations are rapidly increasing. The Norwegian population of greylag goose (*Anser anser*) has increased from 7 000-10 000 individuals from the early 1990's to 20 000-25 000 in 2019 and is apparently still growing. The goose is described to be a climate winner; as climate is considered to be one of the main reasons for population increase in recent years. As the goose populations are increasing, the crop damages have also increased, causing a high conflict between the geese and agriculture. The Norwegian environmental authorities are aiming for a regulation of the population of greylag geese to reduce conflicts between geese and farmers. To reduce the population of geese, and hence reduce the conflicts with agriculture, hunting is considered as a useful contributor. However, the number of geese is continuing to increase although they are hunted. Previous studies have demonstrated a hunting practice, the GOOSEHUNT method, which may be implemented if the aim is to increase the harvest. This method has been shown to increase the hunting outcome in Mid-Norway and involves a practice with a combination of hunting fields and fields without hunting, always providing safe areas for the geese. The geese may hence stay longer in the area, giving more hunting opportunities for the hunters. As grazing damages in Fredrikstad municipality are increasing along with the goose abundance, the local farmer-goose conflict is escalating. In this study, I have attempted to evaluate the effect of implementing the GOOSEHUNT method in two areas in Fredrikstad municipality. As a further attempt to decrease grazing damages due to geese, a local management plan has been implemented opening for an earlier hunting start. Local geese behaviour may differ and therefor it is important to provide a deeper understanding of how local geese respond to different hunting behaviour, which again can suggest local hunting practice.

Results of this study demonstrate that geese quickly returned to the hunting site after hunting, allowing for more hunting opportunities. After hunting, the number of shots fired per hunt was significantly correlated (positively) to the distance geese flew away from the hunting site, and it also took significantly longer before the geese returned. However, hunting pressure, in terms of number of hunting incidents per day, had no significant impact on the distances the geese flew after hunting or on their return time to the hunting site. Furthermore, all geese registered in the early hunting period were observed foraging on standing cereal crops and pasture, crops where geese cause damage. However, in the ordinary hunting period, only 5,9% of the geese were causing damage to crops. This demonstrate that the early hunt can be a useful tool in terms of crop damage reduction.

As this thesis has relevant management perspectives, I suggest initiatives in goose management that will reduce the conflicts between geese and agriculture.

Sammendrag

De fleste populasjoner av gås er i sterk vekst. Den Norske populasjonen av grågås har siden tidlig 1990-tallet økt fra 7 000-10 000 individer til 20 000-25 000 i 2019 og er antatt å fortsatt være under sterk vekst. Gåsa er ansett som en klimavinner; dette er ansett til å være grunnen til den sterke populasjonsveksten de siste årene. Synonymt med en sterk populasjonsvekst av gås har det vært kraftige økninger i tilfeller av beiteskader forårsaket av gås. Dette skaper en økende konflikt mellom landbruk og gås. Norske myndigheter har som målsetning å regulere antallet grågås for å redusere konflikten mellom landbruk og gås. For å nå målsetningen om å redusere gåsepopulasjonen, og dermed konflikten er jakt ansett som et viktig verktøy. Gåsepopulasjonen øker til tross for at den blir jaktet på. Tidligere studier har demonstrert en jaktpraksis, kalt GOOSEHUNT metoden, som kan implementeres om formålet er å øke utbytte av jakt på gås. Denne metoden har ført til et høyere jaktuttak i Midt-Norge og innebærer en kombinasjon av jaktområder og jaktfrie områder, for å alltid ha trygge områder tilgjengelig for gåsa. Gåsa vil ved hjelp av denne metoden bli i området lengre, noe som fører til flere jaktmuligheter for jegere. I Fredrikstad kommune øker gåsepopulasjonene i takt med beiteskadene som medfører en eskalering av gås-landbruk konflikten. I denne studien har jeg forsøkt å implementere GOOSEHUNT metoden i to studieområder for å måle effekten av denne i Fredrikstad kommune. En lokal forvaltningsplan for gås har implementert en tidlig jaktstart. Gåseadferd kan avvike lokalt, det er derfor viktig å måle hvordan gåsa responderer på jaktpraksis, som igjen kan bidra til forslag om gjennomføring av lokal gåsejakt.

Resultatene demonstrerer at gåsa raskt kommer tilbake til området den har blitt jaktet i, som tillater flere jaktmuligheter. Etter jakt var antall skudd en signifikant (positiv) faktor for hvor langt gåsa flyktet fra jaktområde. Det tok også signifikant lengre tid før gåsa kom tilbake til jaktområdet. Imidlertid hadde jaktpress, som antall jakthendelser per dag en ikke-signifikant betydning for avstanden eller tiden gåsa brukte på å returnere til jaktområdet. Resultatene viser at all gås i tidlig jakten ble registrert på markslags kategorier som gress og korn hvor gås forårsaker beiteskader. I ordinær jakten ble bare 5,9% av gåsa registrert på markslag hvor den forårsaker beiteskader. Dette viser at tidlig jakt kan være et nyttig redskap for å redusere beiteskader på landbruksareal.

Da denne rapporten inneholder forvaltningsperspektiver, foreslår jeg initiativ i gåseforvaltning som vil redusere konflikter mellom gås og landbruk.

Contents

1. Introduction

The greylag goose (*Anser anser*) is one of the largest goose species in the waterfowl family (*Anatidae*). They are herbivorous and is adaptive to what they can eat, they are known to eat a variety of plants such as corn, carrots, grass, and water plants (Lorentsen. 2018). Along with the European goose populations, the greylag goose population is rapidly increasing, presumably due to the climate getting warmer and a high availability of food from agricultural fields (Fox et al. 2017). As goose populations drastically increase, the economic loss for farmers due to grazing geese does too (Beston et al. 2015). Geese in high numbers is typically creating a high conflict because of increasing crop damages (Fox et al. 2017), and as the goose population is rising, so is the conflict (Fox & Madsen 2017). Areas that previously didn't have a goose problem may have challenges today due to that the population is growing in number and the geese are expanding their range (Tulloch et al. 2017). To reduce the population of geese, and hence reduce the conflicts with agriculture, hunting is considered to be a significant contributor (Madsen & Williams 2012; Powolny et al. 2018). The Norwegian environmental authorities are aiming for a regulation of the population of greylag geese to reduce conflicts between geese and farmers. The Norwegian population of greylag goose has increased from 7 000-10 000 individuals from the early 1990's to 20 000-25 000 in 2019, and is apparently still growing (Bentsen et al. 2019).

However, the number of geese is continuing to increase although they are being hunted (Fox et al. 2017). Hence, if hunting is to reduce the population, the method of hunting needs to be more effective in order to reduce the greylag goose population (Jensen et al. 2016). The geese are smart and shy and considered difficult to hunt (Madsen et al. 2011). And itt has been shown that the geese may change their flight route when being hunted intensely (Béchet et al. 2003).

Previous studies have demonstrated a hunting practice, the GOOSEHUNT method, which may be implemented if the aim is to increase the harvest (Jensen et al. 2016, 2017; Tombre et al. 2022). There are many principles of the GOOSEHUNT method, but the main intention is to plan hunting in time and space to maximize outcome when hunting and minimizing the disturbance of geese (Jensen et al. 2016).

The main principles of the GOOSEHUNT method are as follows:

- The geese always need to have areas without hunting, always providing them with a safe area to forage and rest.
- Too intensive hunting may force the geese to leave the area.
- More geese in an area over time will result in a higher number of harvested geese per hunt and provide more hunting opportunities.
- It does not have to be the same hunting free area each time if they always have a free area from hunting.

To decrease the population of geese it may be necessary to apply this method of hunting to a larger extent. For my thesis I will be applying this method of hunting to two new areas in southern Norway. For the best outcome the hunting model needs to be adaptive to the area, as geese in the south might have different behaviour in a different landscape compared to what have been found in Mid-Norway.

The hunting season in Norway generally starts when most of the crops are harvested, this means the hunt generally don't decrease the damages on the crops the current year. However, it may reduce the number of geese the following year (Madsen et al. 2017). In municipalities with a local management plan and significant crop damages caused by geese, hunting may start the 26th of July rather than the ordinary hunt, starting the 10th of august (Fredrikstad commune, 2021) as an attempt to increase the number of shot geese and decrease the damages on crops. A lower number of geese is assumed to cause less crop damage. Therefore, hunters in the present study were hunting following the main principles in the GOOSEHUNT method, with the goal to make this model well adapted to the specific study areas as goose behaviour might differ.

The geese in Fredrikstad have a large, protected area where hunting is not allowed, hence functioning as a free area. Adapting this model for the area might be achieved by understanding dynamics in the local goose population, by measuring the goose response to hunting behaviour and different hunting practice. From daily counts I could evaluate the goose behaviour after each hunt, in terms of flight distances between the observed goose flocks and the hunting field. As there are increasing damages to crops in Fredrikstad

(Fredrikstad commune, 2021), the main objective for my thesis is accordingly; to provide an increased understanding of local goose behaviour dynamics by quantifying flight distances and evaluate and adapt the GOOSEHUNT method to my study area as this may further increase the harvest.

My research questions are:

- After hunting, how far do the geese fly and will they return to the hunting area?
- Is there a correlation between hunting intensity, in terms of number of shots and consecutive hunting days, and the time before the geese return to the hunting area?
- Will it be possible to conduct an earlier hunting start and still have high numbers of geese to hunt throughout the ordinary hunting period?

By collecting data, attempting to answer these questions, the aim is to suggest an optimal hunting practice in Fredrikstad as well as in general terms.

2. Material and methods

2.1 Study area

The study area was chosen based on agreements with landowners and a hunters' organization, consisting of the areas where these hunters already have a hunting permit, as well as extra nearby areas. In total, this gave us two hunting areas for the project: Kråkerøy and Torsnes, where Torsnes also includes adjacent areas (Figure 1).

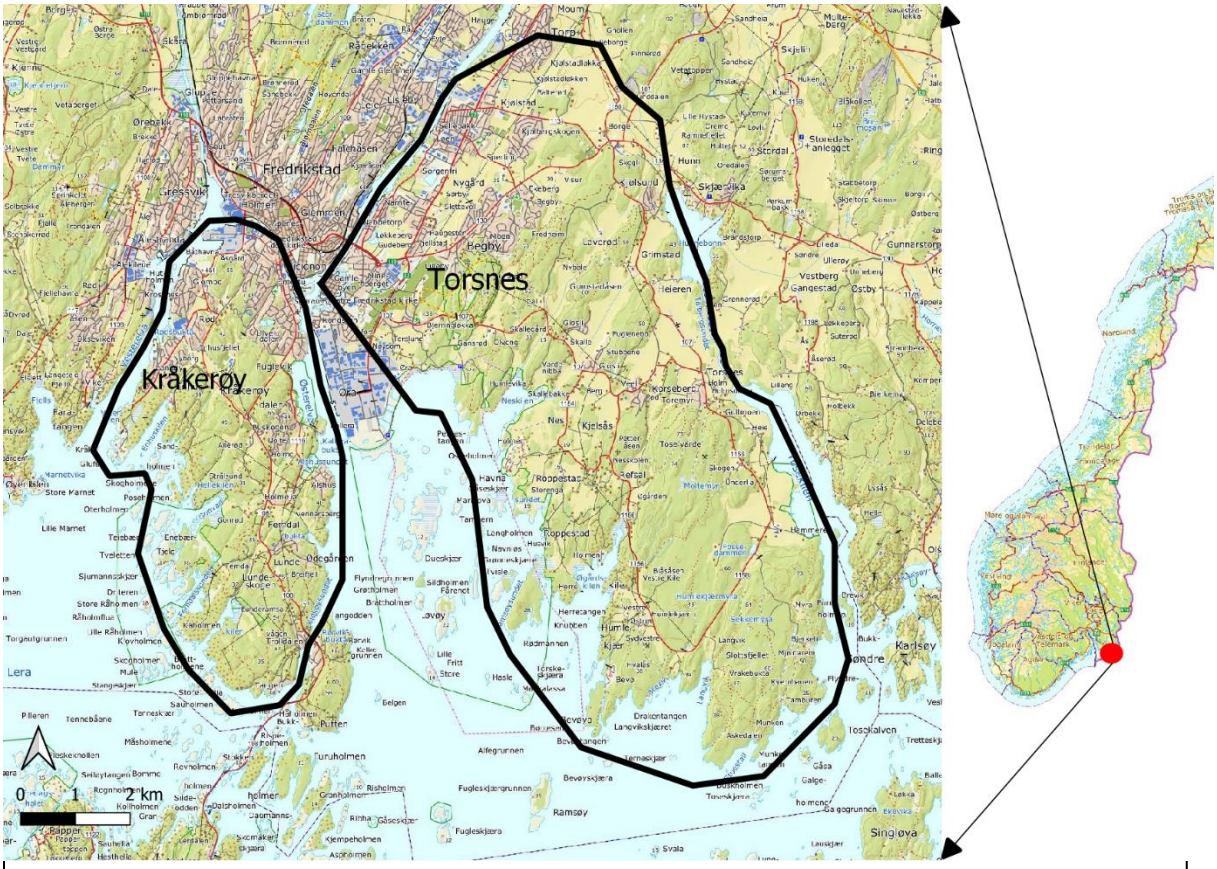


Figure 1: Study map displaying the two study areas, Kråkerøy to the west and Torsnes to the east. Map collected from Kartverket, GeoNorge.

2.2 Organizing

Before the data sampling began there had to be a chain of events (Figure 2) that made the study possible, like organizations of landowners, contacting and making agreements with skilled hunters and creating a continuous larger area where most, or preferably all of the hunting, where controlled.

The project started with landowners and hunters, informing about them about the hunting method and how they could benefit from implementing it. The wildlife manager of Fredrikstad municipality also communicated with the farmers in the municipality and informed about the project and asked for permission to hunt on their land.

Dedicated hunters and landowner associations are needed in other to conduct the hunting in the project. Hence, for a successful implementation of the project, well-organized network of landowners and hunters was needed. Together with NINA, the Norwegian Farmers' Union and Fredrikstad municipality we reached out to the local hunting and fishing organizations to form hunting teams for the goose hunt. From there we needed to gather skilled hunters that would be interested enough to spend a lot of time outside observing the geese and thereby finding the best time to hunt. All hunters were offered theoretical and practical goose hunting course (but all the hunters already had the mandatory hunting licence). Hunting leaders and scouts continuously went out to find where the geese were flocking up. I order to keep a certain degree of control of the goose behaviour and site-use. There were also hunters that already had much experience, who in the present project also had larger areas to hunt than before.

Before the data sampling could begin, I made study area maps that included the landowner association (Figure 1, 18 & 19), using the program QGIS (QGIS3, version 3.16.3). Study map was made by using background mapping from GeoNorge (Kartverket). The visualization was made, using the print layout function. Visualization was achieved using the print layout function. For all background mapping I used maps from GeoNorge (Kartverket).

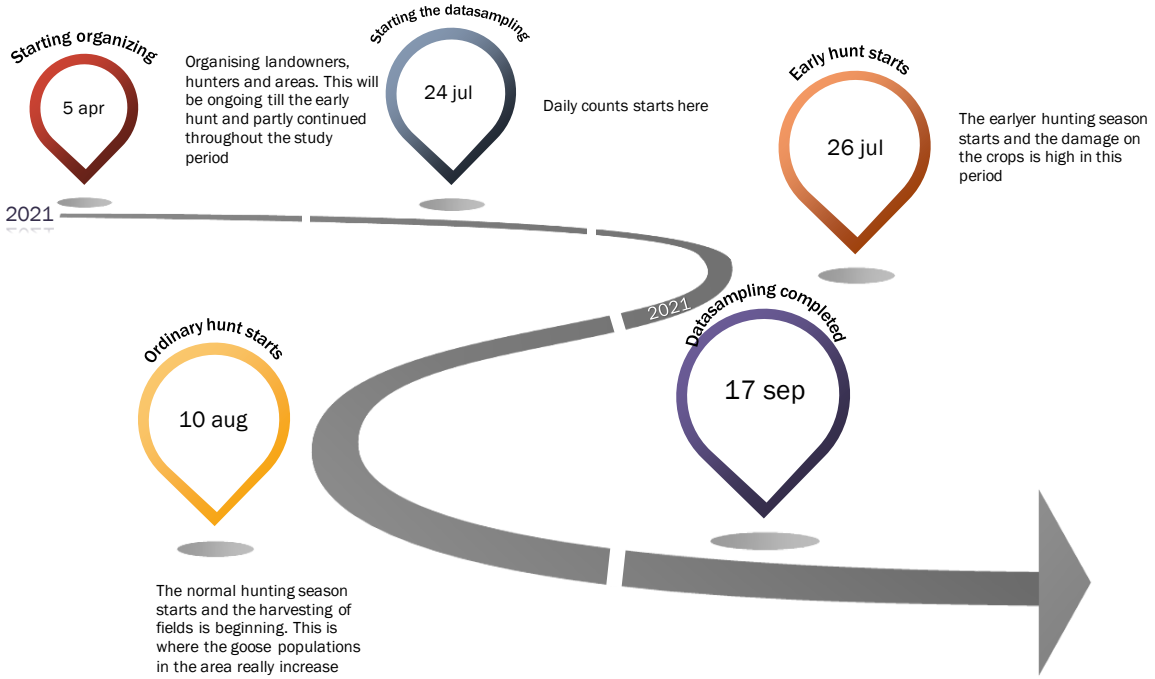


Figure 2: A timeline of the project, starting the 5th of April 2021, data sampling starting the 24th of July and data sampling completed the 17th of September.

2.3 Goose hunting

Goose hunting requires some equipment. On stubble fields (harvested cereal fields), the hunters hunt from so-called blinds camouflaged with straw (Picture 1). The hunters would lay inside a coffin and when the geese came in for landing the hunter rise, opening the lid and shoot the goose. Hunters in the project used such blinds, and also exercised on shooting clay pigeons from these.

Picture 1: Blinds with the lid open and harvested goose in front. Photo; Rein Riise Dalermoen, 2019

The hunters used decoys to attract the geese (Picture 2). The decoys had to be many, simulating a flock of geese sitting on the field. As geese are hard to lure, realistic decoys are necessary. Decoys were distributed in a realistic way, mimicking how a real goose flock would sit on the field. The decoys for the project were provided by the hunters.

Picture 2: Decoys in crops, these ones simulate pink-footed goose (anser brachyrhynchus). Photo; Åge Morten Veimo, Skogn Folkehøgskole, 2017

In total, 17 hunts were conducted during the study period (Figure 3).

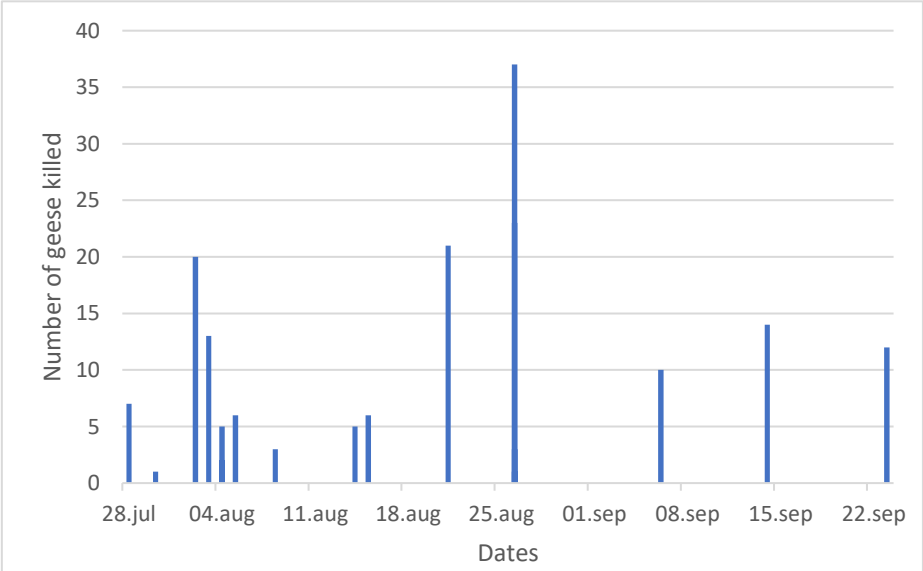


Figure 3: Hunts and hunting outcomes in the study area, the fall of 2021. When there was more than one hunt per day, number of geese shot are summarized for that day.

2.4 Data sampling

Geese were mainly counted by using telescope (Swarovzki ATX 25-60x, 85mm) and binoculars (Meade safari pro 8x, 42mm), in both study areas every day from 24th July to 17th September. The counts included three species, greylag geese, barnacle geese (*Branta leucopsis*) and canada geese (*Branta canadensis*).

As the early hunt starts the 26th of July, counts were also from days before the geese were disturbed from hunting activities. The data gave a total count of the goose populations in the two study areas (Figure 1). To evaluate goose behaviour, geese were registered from a specific site in the study areas (Appendix 2). I counted the entire goose abundance within my study area every day to be able to measure the site-use of the geese that is reflecting their behavioural response to hunting. For specific site-use, I made maps over the two study areas with zones that represented farmland and other areas where it is possible to find geese (Appendix 2).

Picture 3. The telescope used for counting, mounted on the car window. Photo; Rein Riise

2.5 Ring mapping

To provide a rough idea to how geese distributed in the landscape before and after hunting, ring maps were made for each site in QGIS (Figure 4). These maps illustrate repercussions around the hunting site. Ring 0 is the hunting area, Ring 1 is a 500-meters radius around the hunting site, Ring 2 is 1000 meters etc. (see Figure 4). From these maps, it can be counted how far geese are from the hunting site, before and after hunting. These maps where made in QGIS using the function “Buffer”.

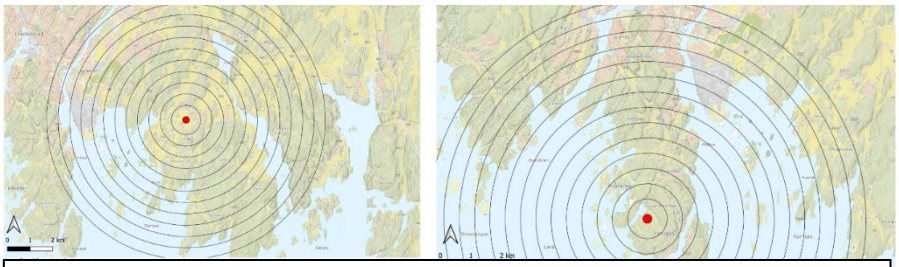


Figure 4: The two hunting sites illustrated with 500-meter rings. (Maps from Kartverket, GeoNorge. Visualized in QGIS.)

2.6 Statistical analyses

All data was organized in Microsoft Excel (Excel 2203). Statistical analyses were conducted in SAS (SAS 9.4) and R (R 1.4.1103). All the figures were made in Excel.

Relationships between number of shots fired and number of geese harvested were tested by a linear regression analysis. Also, the relationship between hunting pressure and distance to hunting site were tested. To test the differences between groups of geese observed within the same day (in relation to the hunting day), Analysis of Variances (ANOVAs) were used.

The number of shots fired per hunt was divided in two categories, high and low. Low meaning up to 10 shots fired and high being more than 10 shots fired per hunt. The number of shots were quantified by a combination of counting empty shells after a hunt and by information by the hunters themselves.

Hunting pressure was divided in high and low hunting pressure, categorized by the days where there were hunting multiple days in a row or more than one hunt at the same day. Correspondingly, low hunting pressure was defined by one singular hunt two days after the last hunt and two days prior to the next one. The two-day interval was chosen because because we anticipate that after two days the geese will be distributed in the landscape as before the hunts.

3. Results

3.1 Overview

The goose counts in the period with early hunt in Torsnes showed that the number of geese in the area increased to a peak of around 540 geese the 4th of August and then decreased (Figure 5). The greylag goose was the predominant species, closely followed by barnacle goose. Canada goose being the least numerous.

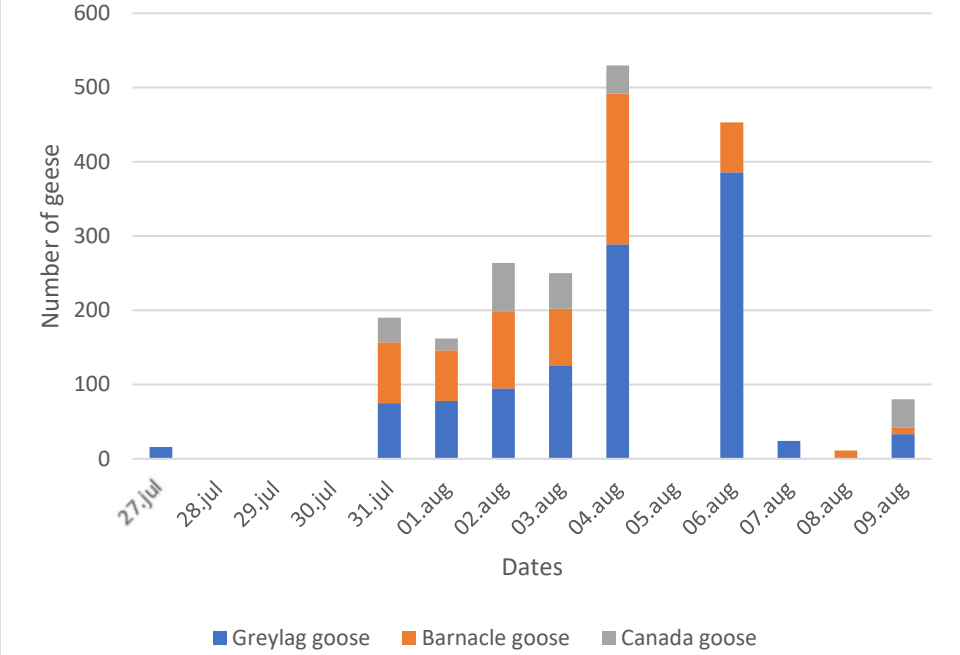


Figure 5: Total numbers of geese in Torsnes study area throughout the early hunting season. Species separated by blue = greylag geese. Orange = barnacle geese. Grey = Canada geese

The counts in the period with ordinary hunt showed an increasing number of geese in the Torsnes area (Figure 6). In the first half, the greylag goose appeared to be the dominant species. However, from 1st of September to 3rd of September the geese where almost absent in the study area, presumably explained by the high hunting pressure and many shots fired the previous days. After this, the number of geese increased again to an even higher number than the first period. Although the greylag goose numbers increased, the barnacle geese became the dominant species. Canada geese were almost absent most of the time, but there where periods

where they were seen in larger numbers of over 100 individuals. The largest flock of Canada goose being 541 the 15th of September. The largest number of geese in total at one day was almost 6000 geese (Figure 6).

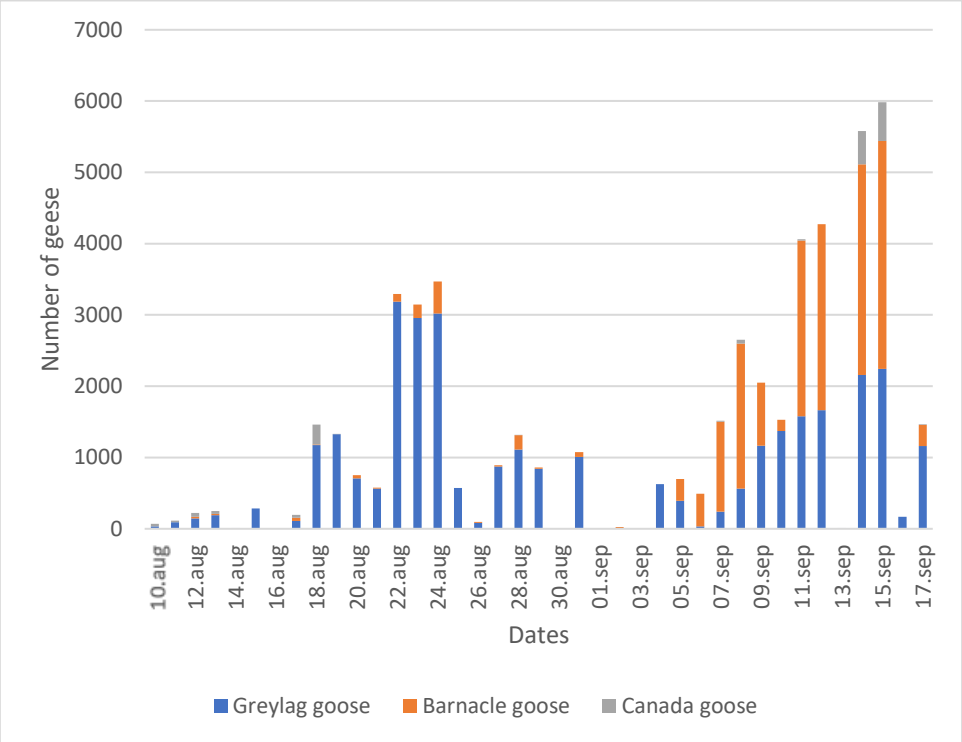


Figure 6: Total numbers of geese throughout the ordinary hunt in Torsnes. Species separated by blue = greylag geese. Orange = barnacle geese, Grey = Canada geese.

The counts at Kråkerøy started the 24th of July and showed smaller goose numbers than at Torsnes (Figure 7) The geese in this area abandoned after the 13th of August. The number of geese decreased from the peak on the 26th of July. After the 2nd of August the geese only occasionally occurred at Kråkerøy. There was only one hunt in this area, the 28th of July. The largest number of geese at one day was 68 geese.

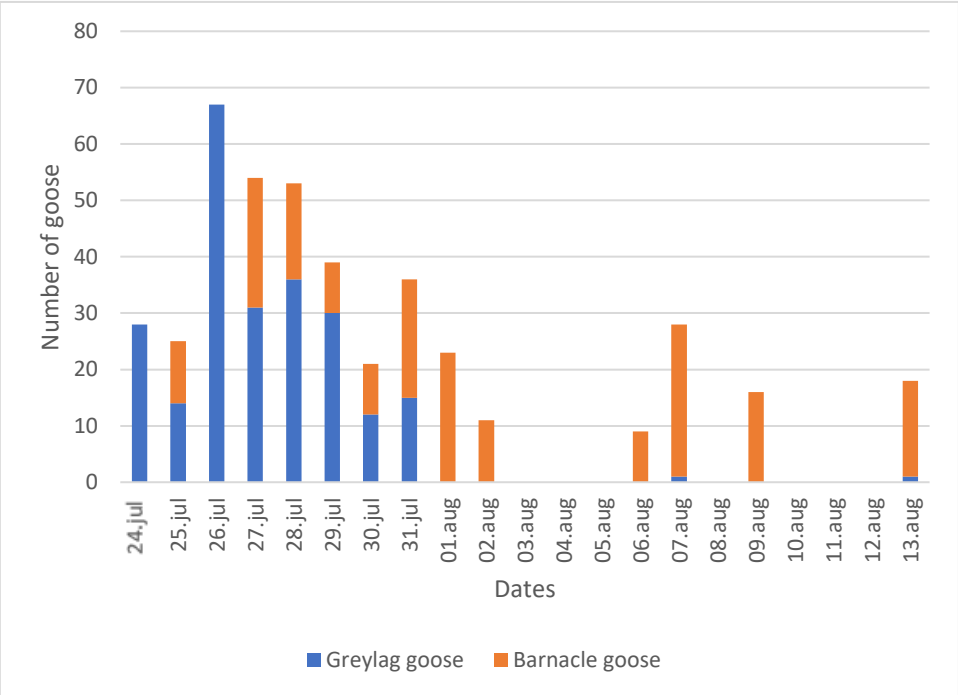


Figure 7: The numbers of geese throughout the study period in Kråkerøy. Species separated by blue = greylag geese. Orange = barnacle geese.

3.2 Hunting results

Skilled hunters are needed to maximize the hunting outcome, and the hunters in this study demonstrated a significant shooting accuracy (Figure 8), where the number of shots fired were significantly correlated with the numbers of geese killed (linear regression: r^2=0.996, n=14, p<0.0001).

Figure 8: The relationship between number of shots fired by the goose hunters and the number of harvested geese. The relationship is positive and significant (linear regression: Y=0.83X-0.12, r^2=0,99, n=14, p<0.0001).

The number of harvested geese is separated in the early and the ordinary hunting season. During the study, 27% of the geese were harvested in the early hunt (from six different hunts) and 73% in the ordinary hunting season (from ten different hunts, Figure 9). This represents 49 and 132 number of harvested geese respectively.

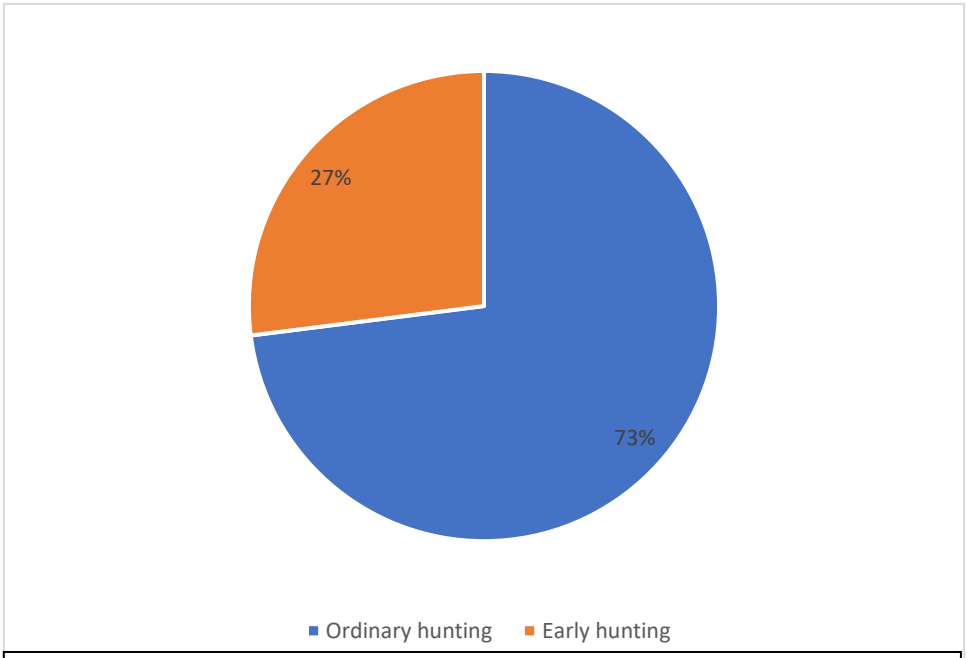


Figure 9: The percentage of harvested geese in the early hunt and the ordinary hunt. Blue represents ordinary hunt (73%). Orange represents early hunt (27%).

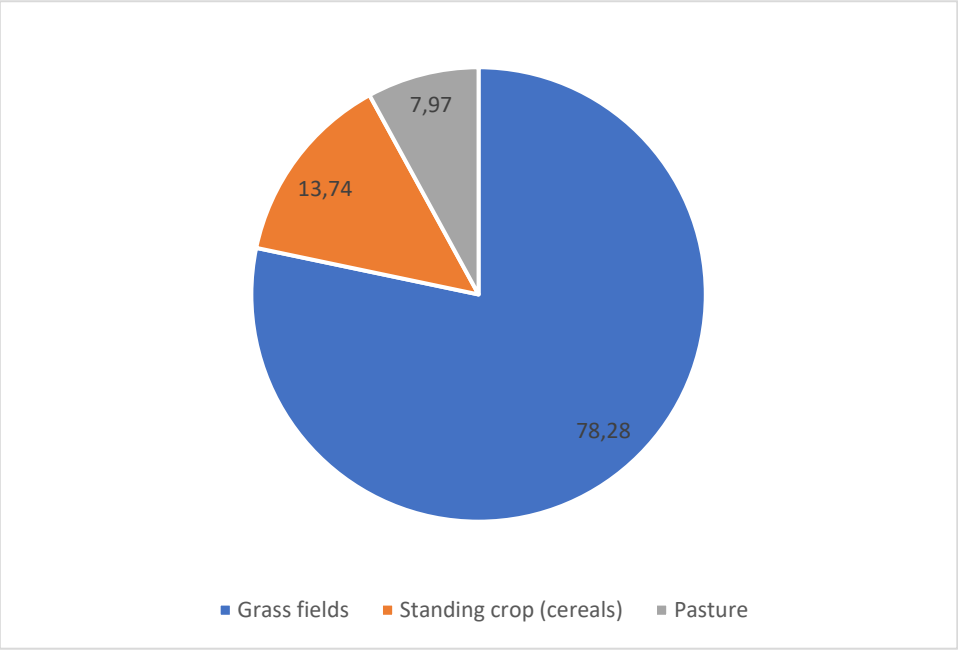
3.3 Crop distribution at various crops

The distribution of geese observed in the different crop types demonstrated a difference between early and ordinary hunt (Figure 10a & 10b).

In the early hunt (Figure 13a), geese where mainly found on grass fields (78,28%), while a smaller portion (13,74%) were found foraging on standing crops in cereal fields. Hence, only a minority were found on pasture fields (7,97%).

As the ordinary hunting season starts and crops were harvested, geese were found in more crop categories as they now also forage on peas, corn, rapeseed, and lettuce fields (Figure 10b). Most geese were now found on harvested stubble fields (93,52%). A minority was found on grass fields (5,52%), while only a fraction was found in standing cereal crops and in others (0,041% and 0,9% respectively).

A)



B)

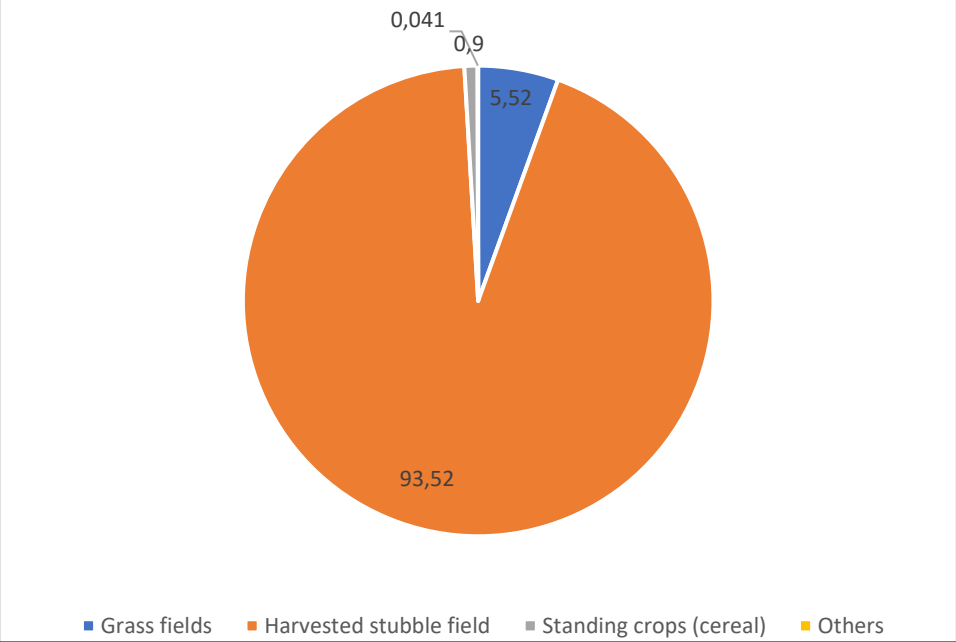


Figure 10a and b. The percentage distributions of geese observed in different by crop categories during the early (a) and ordinary (b) hunting period.

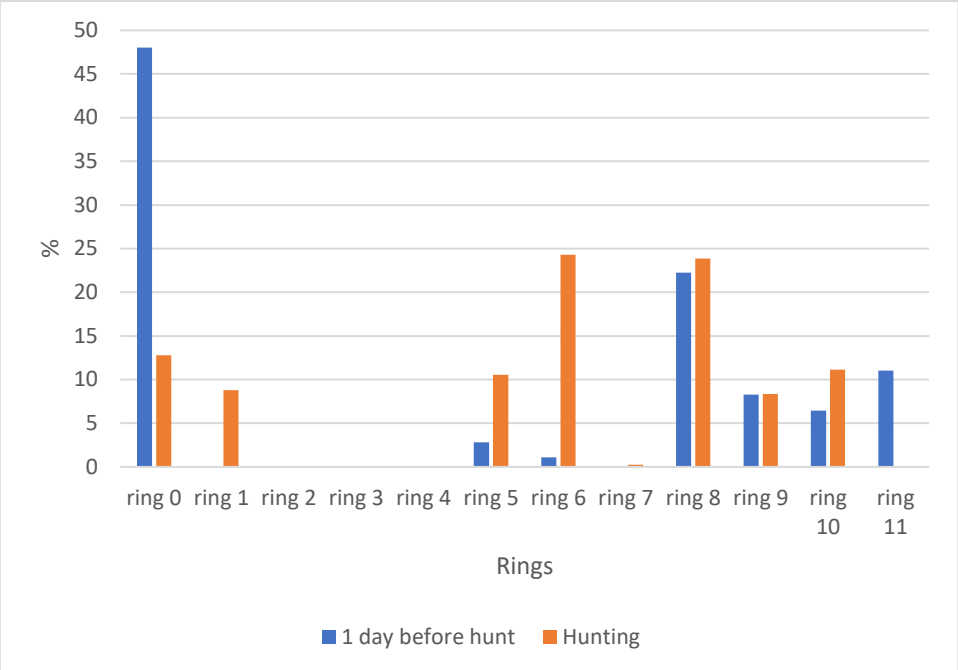
3.4 Initial results of goose behaviour

Figure 13 illustrates the percentage distribution of all geese observed in the study area in relation to the hunting areas, before the hunting day and after the hunt.

Nearly 50% of the geese were found in the hunting area the day before hunting, which is plausible since this is where the hunting is planned the current day. Later the same day, after hunting, the geese were distributed far away from the hunting site with most of the individuals registered from Ring 5 and further out (Figure 11a).

Percentage distribution for the geese in the following two days demonstrates that the birds gradually return to the hunting area (Figure 11b). Almost 30% of the geese were back in the hunting area already one day after hunting, and around 37% were back two days after hunting.

A)



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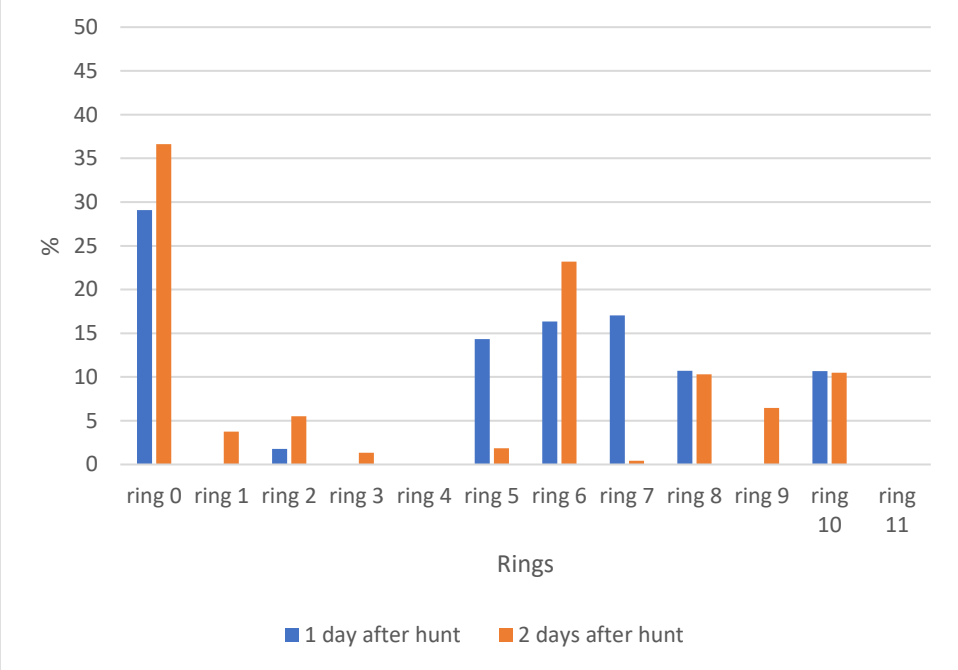

Figure 11 a) and b): The percentage distributions of geese quantified in circles around the hunting fields (see Methods for description). a) blue represent the day before hunting, while orange represents the same day as the hunt but later the same evening. b) Blue represents one day after a hunt, orange is two days after the hunt.

3.5 Goose behaviour in response to hunting practice

The distance between goose flocks and to the hunting area the days after hunting was related to the number of shots fired (Figure 12), where the average distance to the hunting area was on average higher when many shots were fired compared to when few shots were fired (regardless of day). The differences were, however, not significant (ANOVA: F= 1.96, df=5, 56, p=0,101) although when few shots were fired the geese were closest to the hunting field at day 2 after hunting (Figure 12).

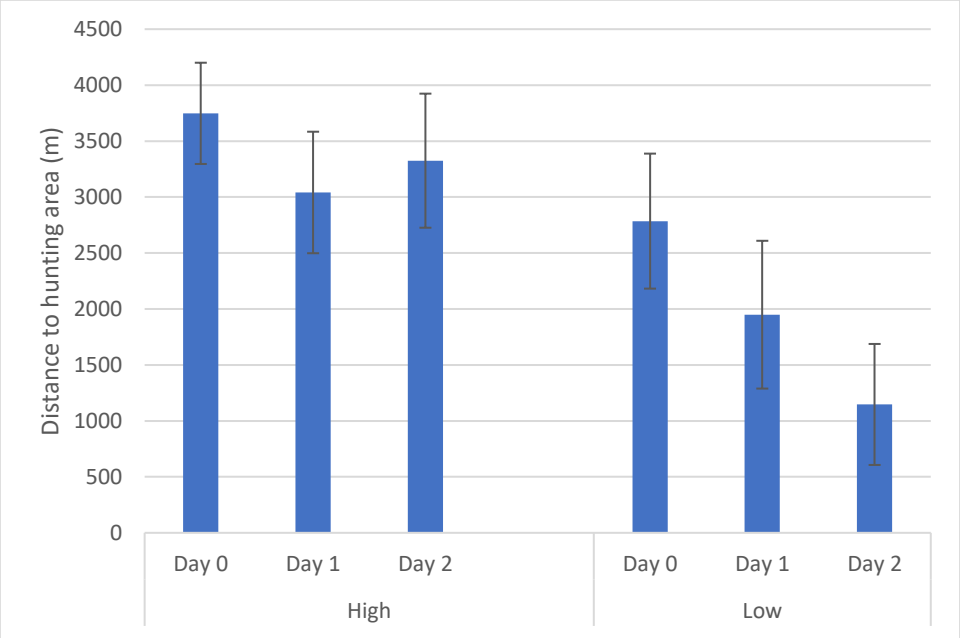

Figure 12: The average distance between goose flocks and the hunting field the same days as hunting and the two following days. Results are categorized in high (> 10) and low (<10) based on the number of shots fired each hunt. The vertical lines on columns represent standard error. Number of goose flocks in each column varies between six and 12.

Hunting pressure, expressed as number of hunting teams hunting each day and hunting on two consecutive days, did not have any significant different effect on goose distances than under low hunting pressure (ANOVA: F=0.32, df=5, 50, p=0.898) although geese were furthest away at the same day as hunting when the hunting pressure was high (Figure 13).

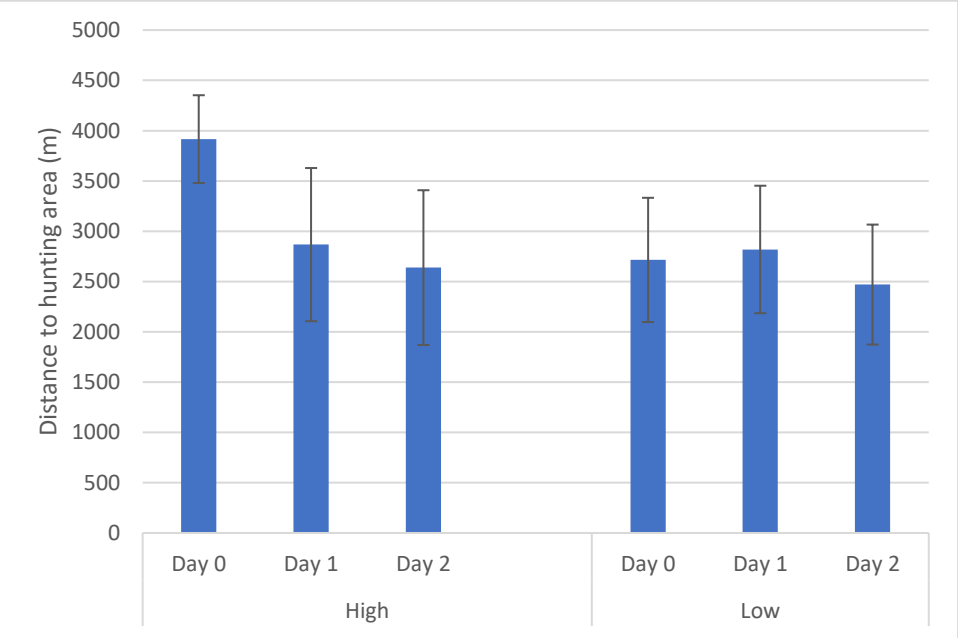

Figure 13: This is showing hunting pressure divided by high and low. Y axis representing meters away from hunting site and x axis representing days after hunting.

4. Discussion

After hunting, how far do the geese fly and will they return to the hunting area?

I wanted to see how far geese would fly after hunting and if they would return to the hunting site afterwards. Distances from the hunting area after a hunt varied from 0 meters to 4000 meters. However, the highest number of geese was always found within 500 meters (Ring 0) from the hunting site, except at the same day as hunting had occurred. Then, most geese were registered 3500 meters (Ring 6) away from the hunting site. This is significantly longer that similar studies have found (Jensen et al. 2016), which may be a consequence of the landscape and distances to the nearest roosting site or safe area without hunting. Expressed as the percentages of geese in the study area, 48% of the geese where registered in the hunting area before the hunt. Two days after the hunt, 37% of the total goose number had returned to the hunting site. In the study in Mid-Norway, it usually took longer for the geese to return to the hunting area (Jensen et al. 2016). A weakness of the present study is that I do not have individually ringed geese, and it is uncertain whether it is the same goose that is exposed to hunting and returns. Based, however, on the landscape, the nearby bird protection area and the observed flight patterns, we may anticipate that most of the geese are affected by the hunting. There were though 11% less geese in the hunting area two days after the hunt compared to one day before the hunt. Based on these findings I will suggest that hunters may hunt every second day as there will apparently be geese in the hunting area after two days.

Is there a correlation between hunting intensity, in terms of number of shots and consecutive hunting days, and the time before the geese return to the hunting area?

I wanted to find out if there was a correlation between hunting intensity, in terms of numbers of shots and consecutive hunting days, and the time before the geese would return to the hunting site. I found a correlation between numbers of shots fired and the time geese would use to return to the hunting site. The results from the present study demonstrate that a higher number of shots fired (10>) made the geese fly further away and took longer before they returned to the hunting area, while few shots fired (<10) made them fly shorter and they returned quicker. This indicates that the geese are more scared by a high number of shots fired than few. These results suggest that hunters should plan their hunting accordingly to the

number of shots fired to further maximize outcome. Other studies on this subject have also observed that 10 shots fired or less hardly affects the goose behaviour, while more than 10 shots fired is a higher disturbance to the geese (Jensen et al. 2016) indicating that geese will respond less to a lower number of shots fired which corresponds to the findings of this study. The data in the present study suggests that one can hunt more often if the number of shots are low, while the geese wait longer before they are back if they have been exposed to a high number of shots. The hunters in this study have, however, had a very high hunting accuracy. They apparently focus on the geese within shooting distance. Shooting at longer distances will not only increase the crippling probability but also increase the scaring effects causing longer time periods before the geese are back. Studies from the GOOSEHUNT method from Mid-Norway halved the number of wounded geese after implementing this method of hunting (Tombre & Gundersen 2016).

As the present study is providing a deeper understanding of local goose behaviour, some management guidelines can be implemented. More shots fired are causing a higher disturbance than more hunting parties as such. A better hunting practice could therefore be to hunt more often, but fire less shots per hunt to increase the total harvest. The result of another study demonstrated that too high hunting frequency would in total give less harvested geese (Tombre et al. 2022). In combination with the present study this illustrates the need for hunters to adjust to the local environment, testing how many days between each hunt would be optimal in terms of number of harvested geese over the season.

Concepts of the GOOSEHUNT method illuminates the importance of hunting-free areas and plan the hunting in time and space (Tombre et al. 2010; Jensen et al. 2016). In this study, fewer days were apparently needed between each hunt, as most of the geese were back in the hunting area after two days. Regardless of the geese are the same or not, this will still be a recommendation for hunters. As other studies have found that a reduced overlap between hunting teams is important to reduce disturbance to geese (Tombre et al. 2010), one might believe that disturbance by multiple hunting teams might cause a large disturbance to geese in this area as well. However, hunting pressure, in terms of number of hunting incidents per day, had no significant impact on the distances the geese flew after hunting or on their return time to the hunting site in this region. The total number of shots fired per hunt were of higher importance to how far geese would fly and how fast they return. The landscape in Fredrikstad may explain these findings, as different hunting teams may be far away from each other and

hence do not necessarily cause a higher disturbance. Within each team, however, when many shots are fired, the geese exposed to this hunting team will experience this disturbance directly.

A possible error is that the probability of all geese in the area being able to hear the shots fired from a hunt can be considered low, however, this is not accounted for in the analysis because it cannot be outruled. Another study found that geese would be disturbed by hunting up to 1,5-2 kilometres from the hunt (Jensen et al. 2016), indicating that all goose in the present study areas may not be disturbed by hunting. A local hunter participating in this study claims that they would hunt more than one team or multiple days in a row whenever there would be a strong wind, as the geese would not be able to hear all the shots fired and thereby causing less disturbance (R. Svendsen, Pers. Communication. 2021). Based on the results of this study, it seems to be a decent hunting practice. I have not been able to find any other study that describes a similar phenomenon, however the data in this study supports this claim. I would consider this an important find and suggest that hunters may draw advantage of stormy weather and increase hunting intensity to might achieve an elevated harvest on these days.

Geese can change their behaviour over time due to hunting activities, as have been suggested in a study by Gundersen (2013). High disturbance might make the geese fly to other areas (Béchet et al. 2003) and may cause damage to crops elsewhere. Whether the hunting practiced in this study will push the geese out of the area over time, is difficult to predict. But since the geese return to the hunting fields after a few days, I assume this is unlikely.

Will it be possible to conduct an earlier hunting start and still have high numbers of geese to hunt throughout the ordinary hunting period?

I wanted to find out whether an earlier hunting start (as is the case of the early hunt) will have an effect on the ordinary hunt and that there still would be high numbers of geese to hunt throughout this period. The present study demonstrated mixed results on this matter. The geese in Torsnes increased in numbers throughout the study period, regardless of the early hunt. Torsnes usually inhabited an average of 1 317 geese throughout the ordinary hunt, reaching a peak number of 5 982 geese off all goose species combined. In order to increase the hunting success, it will be an advantage to have a larger area controlled by few hunters. Kråkerøy is less than twice the size of Torsnes, and may hence be too small for this practice.

However, there was only one hunt that took place on this island, and the numbers of geese on Kråkerøy reached only a peak of nearly 70 geese which is far less than the goose numbers in the Torsnes area. In addition, there were numerous scaring tactics utilized to scare goose off the crops to avoid further damage on crops and this may well have been a significant contributor to the limited number of geese in this area. Similar practice was also done in Torsnes, although with apparent less effect since the geese still stayed in these areas. Moreover, the geese in Kråkerøy are notorious by the locals to leave early (A. Olsen, Pers. Communication. 2021) there was still a goal to be able to keep them in the area, when hunts where according to the GOOSEHUNT method. However, this was not the case in this study, the reasoning being uncertain.

The distribution of geese shot throughout the study period was divided by 27% in the early hunt and 73% in the ordinary hunting season. There were 16 hunts in total in this study, harvesting a total of 181 geese. In the early hunt, 49 geese where harvested. Whilst in the ordinary hunt there were harvested 132 geese. As these results demonstrate, the goose harvest continues to increase despite the early hunt taking place. This harvest is presumably dominated of geese on migration, using the region as a staging site where they forage on the cultivated fields providing important reserves (Tombre et al. 2022). Accordingly, these results demonstrate that the early hunt does not necessarily obstruct the possibility to hunt geese in the ordinary hunting season. In addition to may decrease damage on crops, the early hunt possibly also increased the total harvest. As most of the geese were foraging on crops in the early hunt, this can be a useful management tool to decrease grazing damages. In the ordinary hunt the predominant number of the geese were found in harvested stubble fields, where they won't cause damage to crops (Andersen et al. 2018). Therefor one can allow numbers of geese to increase in harvested stubble fields before hunting, further achieving an increased harvest of goose (Jensen et al. 2016). While in the early hunt, the predominant number of geese where registered in grass crops, but also standing cereal crops and pasture. In all these crop types, geese cause grazing damages (Bjerke et al. 2014; Fredrikstad commune, 2021).

A possible error when conducting the counts for the present study is considerable due to the low visibility geese will have in taller cereal crops. As this will probably result in a lower number of geese detected. Although it could be considered unlikely that there is a significant number of geese not found due to taller cereal fields, it cannot be outruled. There is also a high number of geese utilizing the ocean surrounding these areas (Fredrikstad commune, 2021) that will probably not be detected in my counts. Geese have been described to utilize a

nearby nature reserve called Øra, which is a brackish water area (Heggøy et al, 2017). However, it is probable that geese will utilize this nature reserve as a daytime retreat rather than a forage area, as similar incidents have been demonstrated in other studies (Kahlert et al. 1996). This is supported by a local study, describing the most extensive damages being close to the nature reserves (Fredrikstad commune., 2021).

5. Management implications

The present study focuses on the greylag goose and the canada goose. Both being the target species for hunting in this study. The reasoning for including barnacle goose in this study is to illuminate the elevated local numbers of them and highlight the difficulty many farmers experience with a high number of barnacle geese, as this being a protected species one is not allowed to hunt (Unsgård et al. 2021). Furthermore, measuring barnacle geese behaviour and response to hunting of other goose species, one might be able to further decrease damages to crops due to barnacle geese as well. Considering the results of the present study, it would appear that the barnacle geese may follow the behavioural patterns of other goose species to a certain extent, avoiding areas there has occurred a hunt for a shorter period of time. However, flocks consisting of only barnacle geese were observed in this study period, making it difficult to utilize hunting as a tool to decrease damages caused by this protected species.

The total income loss due to geese grazing damages in Fredrikstad is yet unknown. However, there is no doubt that annual loss for many farmers in this district is indeed high (Fredrikstad commune, 2021), further amplifying the need to hunt geese more efficiently. Although a subsidy scheme has been shown to reduce conflicts (Tombre et al. 2013), the problem with increasing goose populations and high grazing damages is still present and increasing (Fox et al. 2017). Physical scaring, warning shots, geese cannons, lethal scaring and more is ways to reduce crop damage, it is hard work and often has various effects in keeping geese out of the crops (Simonsen et al. 2016). However, local adaptions of the GOOSEHUNT method might be able to reduce the problems over time.

As shown in this study, local goose behaviour may vary slightly between different locations, indicating a need for an adaptive management approach also including local information about hunting practice and experiences with goose distribution. However, the main principles of the GOOSEHUNT method have been demonstrated to be a good approach. AEWA Action Plan 2009–2012 promotes an adaptive management approach for goose management, to

decrease the goose-agriculture conflict (AEWA, 2008). To optimize harvesting strategy, an adaptive approach has been promoted as a crucial step to manage migrating waterfowl (Madsen et al. 2017). To be able to regulate populations of geese there must be more landowner associations and organized hunting. This has been highlighted as a problem with goose management in Norway (Bentsen et al. 2019). If local goose behaviour is illuminated, hunters may increase the harvest.

6. Conclusions

The present study will hopefully aid optimizing local hunting practice. This study demonstrates that the early hunt can be an important management tool. Although this study has a limited data basis, it is providing a deeper insight in the local goose habits and response to hunting behaviour. In this study, geese would flee significantly further away from the hunting site if a high number of shots were fired. Also, the return to the hunting site will be significantly slower. However, with a lower number of shots fired the fleeing distance would be significantly shorter and the return significantly faster. Hunting pressure had a non-significant impact on distance to hunting site and how fast geese would return. For this study, one may consider Torsnes as a more prominent area applying the GOOSEHUNT method. Although the reasoning for geese on Kråkerøy to leave early is unknown. However, the study and sample are too small to be conclusive and should be considered functional as management guidance, rather than management rules. But also, a foundation for further research.

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7. Literature

AEWA. 2008. Action Plan 2009–2012, Annex III. Available: http://www.unep-aewa.org/documents/agreement_text/eng/pdf/aewa_agreement_text_2009_2012_annex3.pdf.

Andersen, G. E. B. & Tombre, I. M. 2018. Gjess i Vestfold; en oversikt over utbredelse, antall og preferanser i sentrale områder. NINA Rapport 1402. Norsk institutt for naturforskning. https://brage.nina.no/nina-xmlui/handle/11250/2501582

Andersen, G. E. B. & Tombre, I. M. 2018. Gjess i Vestfold; en oversikt over utbredelse, antall og preferanser i sentrale områder. NINA Rapport 1402. Norsk institutt for naturforskning. https://brage.nina.no/nina-xmlui/handle/11250/2501582

Andersen, G. E. B. & Tombre, I. M. 2018. Gjess i Vestfold; en oversikt over utbredelse, antall og preferanser i sentrale områder. NINA Rapport 1402. Norsk institutt for naturforskning. https://brage.nina.no/nina-xmlui/handle/11250/2501582

Andersen, G. E. B., & Tombre, I. (2018). Gjess i Vestfold; en oversikt over utbredelse, antall og preferanser i sentrale områder. https://brage.nina.no/nina-xmlui/handle/11250/2501582

Béchet, A., Giroux, J. F., Gauthier, G., Nichols, J. D., & Hines, J. E. (2003). Spring hunting changes the regional movements of migrating greater snow geese. Journal of applied ecology, 40(3), 553-564. https://www.jstor.org/stable/3506027?casa_token=b3BUlCcYlEYAAAAA%3AgJ3sQRRYawvi4n89_jg46NHyfZZRorcsPSeHfTfngIsMrwkvjjjtSjfHqPVuy_1UIJUdiRVhtvJb6zeOLsKoWAVQosvP7Lt2ZMjKfUHX_jWozCJOq1nAyQ&seq=1

Béchet, A., Giroux, J. F., Gauthier, G., Nichols, J. D., & Hines, J. E. (2003). Spring hunting changes the regional movements of migrating greater snow geese. Journal of applied ecology, 40(3), 553-564. https://www.jstor.org/stable/3506027?casa_token=okbrOyHouGQAAAAA%3AJfKVCZWPXS24UriQ3rT2PTQ5uQ6zm6GIcqk_nkIDgkTl4qeEqLQcz3OS6GDVuQBkP1hdyLZwJyq7GxfIWHLBGoTAXLkYRUX8XhC1GwnAqkhiYEzGgmUVAw&seq=1

Bentsen. V. J., Gundersen. O.M. 2019. Forvaltningsplan for gås i Nordland. Prosjekt Utmark. Samarbeidsforum for gås i Nordland og Norges Bondelag. https://www.birdlife.no/innhold/bilder/2019/03/28/5897/forvaltningsplan_gragas.pdf

Beston, J. A., Williams, C. K., Nichols, T. C., & Castelli, P. M. (2015). Survival and harvest of Atlantic Flyway resident population Canada Geese. Wildlife Society Bulletin, 39(3), 583-592 https://wildlife.onlinelibrary.wiley.com/doi/abs/10.1002/wsb.559

Bjerke, J. W., Bergjord, A. K., Tombre, I. M., & Madsen, J. (2014). Reduced dairy grassland yields in C entral N orway after a single springtime grazing event by pink-footed geese. *Grass and Forage Science*, *69*(1), 129-139. https://onlinelibrary.wiley.com/doi/full/10.1111/gfs.12045?casa_token=A3O5no7v2HIAAAAA%3AmbYTEdx7VX0UJvPZUuCvdRHgG2cNRYMJjSoFL1gOmWbB6yKwGbHXSqNpvQOxK4zuWnnWuj3OZN4TRkXRcQ

Chase, A. W. G., & NASH, C. Wild Goose Chase. https://static1.squarespace.com/static/53840dc9e4b037c978362f81/t/5670744f05f8e26b0fc06cd9/1450210383951/1972+wild+goose+chase+story.pdf

Chudzińska, M. E., van Beest, F. M., Madsen, J., & Nabe-Nielsen, J. (2015). Using habitat selection theories to predict the spatiotemporal distribution of migratory birds during stopover–a case study of pink-footed geese Anser brachyrhynchus. *Oikos*, *124*(7), 851-860. https://onlinelibrary.wiley.com/doi/full/10.1111/oik.01881

Fox, A. D., & Abraham, K. F. (2017). Why geese benefit from the transition from natural vegetation to agriculture. *Ambio*, *46*(2), 188-197. https://link.springer.com/article/10.1007/s13280-016-0879-1

Fox, A.D. & Madsen, J. 2017. Threatened species to super-abundance: The unexpected international implications of successful goose conservation. Ambio 46: S:179-S187. https://link.springer.com/article/10.1007%2Fs13280-016-0878-2

Fredrikstad kommune. (2021). Forvaltningsplan for gås 2021-2025. Collected from: https://www.fredrikstad.kommune.no/globalassets/dokumenter/kmb/miljo-og-landbruk/forvaltningsplan-for-gas-2021-2025.pdf

Fylkesmannen i Oslo og Viken, resultater fra sjøfugltellinger på Østfoldkysten (1993-2012). Non-published study.

Gundersen, O. M. (2013). *Jakt på kortnebbgås (Anser brachyrhynchus) under høsttrekket i Nord-Trøndelag: Jaktens utførelse, sammensetning av utbyttet og mulige konsekvenser for den Svalbard-hekkende bestanden* (Master's thesis, Institutt for biologi). https://ntnuopen.ntnu.no/ntnu-xmlui/bitstream/handle/11250/245217/637019_FULLTEXT01.pdf?sequence=1&isAllowed=y

Heggøy. O., & Eggen. M. (2017, 11.oct). Månedens IBA – Øra i Fredrikstad. Birdlife. https://www.birdlife.no/prosjekter/nyheter/?id=1935

Jensen, G. H., Madsen, J. & Tombre, I. 2016. Hunting migratory geese: Is there an optimal practice? Wildlife Biology 22: 194-203. http://www.bioone.org/doi/pdf/10.2981/wlb.00162

Jensen, G. H., Madsen, J., & Tombre, I. M. (2016). Hunting migratory geese: is there an optimal practice?.*Wildlife Biology*, *22*(5), 194-203. https://bioone.org/journals/wildlife-biology/volume-22/issue-5/wlb.00162/Hunting-migratory-geese-is-there-an-optimal-practice/10.2981/wlb.00162.full

Kahlert, J. O. H. N. N. Y., Fox, A. D., & Ettrup, H. E. N. N. I. N. G. (1996). Nocturnal feeding in moulting Greylag Geese Anser anser–an anti-predator response. Ardea, 84(1/2), 15-22. https://avibirds.com/wp-content/uploads/pdf/grauwe-gans6.pdf

Lorentsen, S. H., (2018) grågås. Artsdatabanken. NINA, Norskt institutt for naturforskning https://www.artsdatabanken.no/Pages/245076/Graagaas

Lorentsen. S. H., 2018. Grågås *Anser anser*. *Artsdatabanken. https://www.artsdatabanken.no/Pages/245076/Graagaas*

Madsen, J. and J. H. Williams (Compilers) 2012. International Species management Plan for the Svalbard Population of the Pink-footed Geese Anser brachyrhynchus. AEWA Technical Series No. 48. Bonn, Germany. https://www.unep-aewa.org/en/publication/internationalspecies-management-plan-svalbard-population-pink-footed-goose-ts-no-48

Madsen, J., & Williams, J. H. (2011). Draft International Species Management Plan for the Svalbard Population of the Pink-footed Goose. https://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.453.7351&rep=rep1&type=pdf

Madsen, J., Williams, J. H., Johnson, F. A., Tombre, I. M., Dereliev, S., & Kuijken, E. (2017). Implementation of the first adaptive management plan for a European migratory waterbird population: The case of the Svalbard pink-footed goose Anser brachyrhynchus. *Ambio*, *46*(2), 275-289. https://link.springer.com/article/10.1007/s13280-016-0888-0

Polowny, T., Jensen, G. H., Nagy, S., Czajkowski, A., Fox, A. D., Lewis, M., & Madsen, J. (2018). AEWA international single species management plan for the greylag goose (anser anser): Northwest/Southwest European population. (AEWA Technical Series; Vol. 2018, No. 64). https://www.google.com/url?sa=t&rct=j&q=&esrc=s&source=web&cd=2&cad=rja&uact=8&ved=2ahUKEwiYj-7suaTgAhURKywKHY_CABMQFjABegQICRAC&url=https%3A%2F%2Fwww.unep-aewa.org%2Fsites%2Fdefault%2Ffiles%2Fdocument%2Faewa_mop7_27_draft_gg_issmp_en.docx&usg=AOvVaw2EpT6rFRB3xv1M0838x-3Q

Polowny, T., Jensen, G. H., Nagy, S., Czajkowski, A., Fox, A. D., Lewis, M., & Madsen, J. (2018). AEWA international single species management plan for the greylag goose (anser anser): Northwest/Southwest European population. https://research.tilburguniversity.edu/en/publications/aewa-international-single-species-management-plan-for-the-greylag

Shimmings. P. & Øien. I. J (2015). Bestandsestimater for norske hekkefugler. NOF-rapport 2015-2. 268
s. https://www.birdlife.no/innhold/bilder/2015/11/17/3530/bestandsestimater_for_norske.pdf

Simonsen, C. E., Madsen, J., Tombre, I. M., & Nabe-Nielsen, J. (2016). Is it worthwhile scaring geese to alleviate damage to crops? – An experimental study. *Journal of Applied Ecology*, *53*(3), 916-924. https://besjournals.onlinelibrary.wiley.com/doi/full/10.1111/1365-2664.12604

Søreng, S. U., Eythórsson, E., Tombre, I. M., Jensen, G.H. & Madsen, J. 2013. Jakt på kortnebbgås i Nord-Trøndelag; jegererfaringer og jaktpraksis i to områder med organisert jakt. Norut Alta Rapport 2013:9, ISBN: 978-82-7571-234-7, 58 s. http://norut.no/sites/norut.no/files/static_files/content/download/4572172/9308668/NorutAltaRapport%202013_9.pdf

Tombre, I. M. Eythórsson, E. & Madsen J. 2013. Towards a solution to the goose-agriculture conflict in North Norway, 1988-2012: the interplay between policy, stakeholder influences and goose population dynamics. PLOS ONE August 8 (8), e71912, 1 – 7. http://www.plosone.org/article/info%3Adoi%2F10.1371%2Fjournal.pone.0071912 29

Tombre, I. M., Fredriksen, F., Jerpstad, O., Østnes, J. E., & Eythórsson, E. (2022). Population control by means of organised hunting effort: Experiences from a voluntary goose hunting arrangement. *Ambio*, *51*(3), 728-742. https://link.springer.com/content/pdf/10.1007/s13280-021-01590-2.pdf

Tombre, I. M., Fredriksen, F., Jerpstad, O., Østnes, J. E., Eythórsson, E. 2022. Population control by means of organised hunting effort; Experiences from a voluntary goose hunting arrangement. Ambio 51, 728–742. https://link.springer.com/article/10.1007/s13280-021-01590-2

Tombre, I. M., Jensen, G. H., Madsen, J., Eythórsson, E., & Gundersen, O. M. (2011). Gåsejakt i Nord-Trøndelag. *NINA Rapport 655: 32 pp. Norsk institutt for naturforskning, Tromsø*, *655*. https://www.nina.no/archive/nina/pppbasepdf/rapport/2011/655.pdf

Tombre, I.M., & Gundersen, O.M., 2016, Jegerene blir stadig mer treffsikre. Norges bondelag (red), Trøndelag Bondelag. 31. https://www.bondelaget.no/trondelag/nyheter/gasejegerne-blir-stadig-mer-treffsikre?offset4078=14

Tombre, I.M., Madsen, J., Eythórsson, E., Søreng, S. U., Tømmervik, H., Kristiansen, A. 2008. Jakt på kortnebbgås i Nord-Trøndelag; jegererfaringer og jaktpraksis i to områder med organisert jakt. https://www.nina.no/archive/nina/PppbasePdf/rapport/2009/431.pdf

Tulloch, A. I., Nicol, S., & Bunnefeld, N. (2017). Quantifying the expected value of uncertain management choices for over-abundant Greylag Geese. *Biological Conservation*, *214*, 147-155. https://doi.org/10.1016/j.biocon.2017.08.013

Unsgård. J. H., & Frøstrup. J. C. (2021). Gåsejakt, Norsk Jakt leksikon. SNL. https://snl.no/g%C3%A5sejakt

8. Appendix

8.1 Crop damages

Damage to crops is one of the largest problems with increasing goose populations and is one of the main drives to attempt to decrease the populations of geese in the municipality (Fredrikstad commune, 2021). The annual loss of income due to goose are considered to be significant. Local examples of loss due to geese grazing is plentiful (Picture 4).

Picture 4: Damages to grain (barley) crops in Torsnes, all the axis of the were eaten off by goose. Photo: Rein Riise Dalermoen

Geese often cause damage to crop types like cereals, carrots, potato, grass and more (Lorentsen. 2018). It is common for the goose to eat the axis of grain like illustrated (Picture 4) (Fredrikstad commune, 2021), also illustrating that the geese have damaged an entire field.

Damages might be reduced by scaring geese of the crops by lethal scaring or other types of scare techniques like laser, scarecrows, psychical scaring, warning shots and more (Fredrikstad commune, 2021). However, it would be very difficult to avoid the complete damages and some areas are more prone to damage than others (Fredrikstad commune, 2021). Moreover, as geese will land very early in the mornings and late in the evenings in it considered hard to keep them off the crops, and very time consuming (Fredrikstad commune, 2021). The crop illustrated (Picture 4) belongs to a farmer that used various scare-techniques, such as laser, warnings shots, physical scaring, hunting and more – many of these incidents taking place at 4 and 5 a.m. Moreover, this crop was harassed by geese despite numerous attempts of multiple types of scaring techniques.

Geese caused crop damage has been measured with boxes consisting of chicken net in the fields within my study area, in a former study. This showed that grass had up to 85,2% higher growth rate inside these boxes than outside the boxes (Fredrikstad commune, 2021). The previous mentioned study also displayed an income loss of 204 450 Norwegian kroners for a single farmer in Fredrikstad due to goose caused grazing damages (Fredrikstad commune, 2021). Due to the crop damage caused by geese are at its peak in spring (Fredrikstad commune, 2021), there might need to be an increased possibility to hunt geese in the spring in the future. Also, harvesting geese before they nest and hence, might increase effectiveness. Possibly harvesting more potential breeding geese before they produce offspring in the middle of march (Lorentsen. 2018).

8.2 Zones

Map for Torsnes with zones used to register geese to specific sites, allowing to analyse goose behavior in terms of habitat changes.

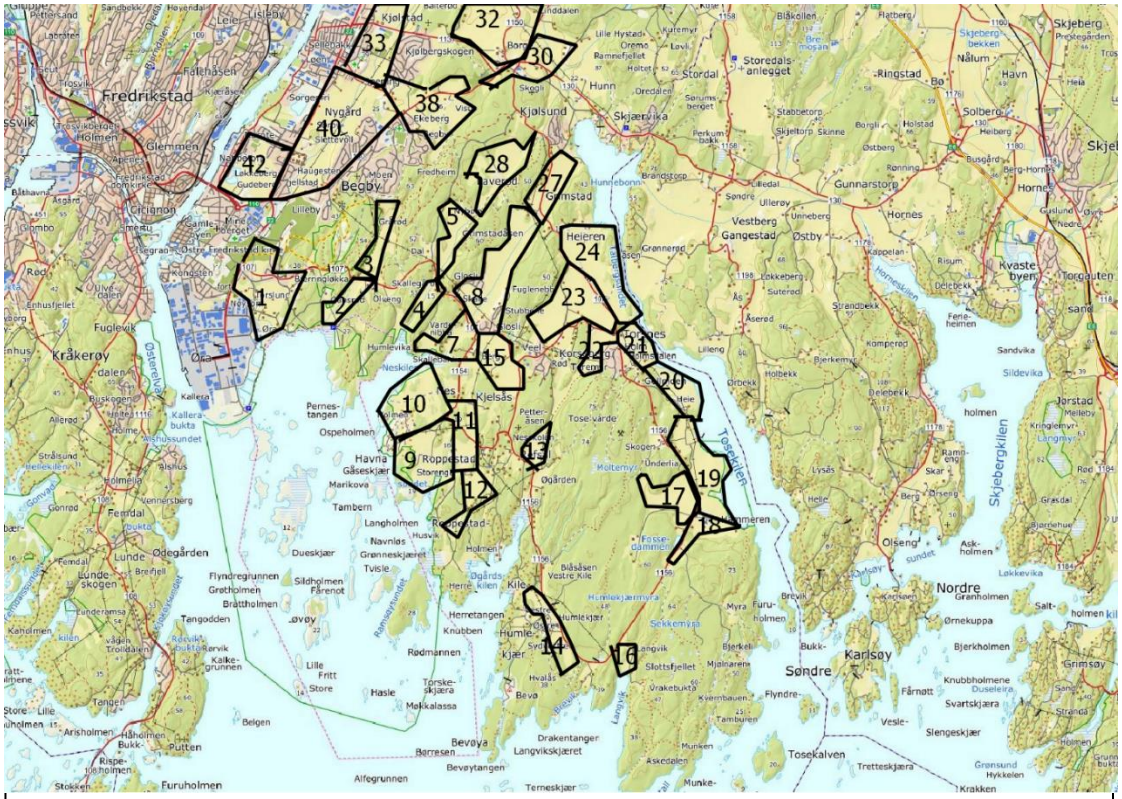

Figure 14: Zone map, Torsnes. Map collected from Kartverket, GeoNorge

Map for Kråkerøy used to register geese to specific sites.

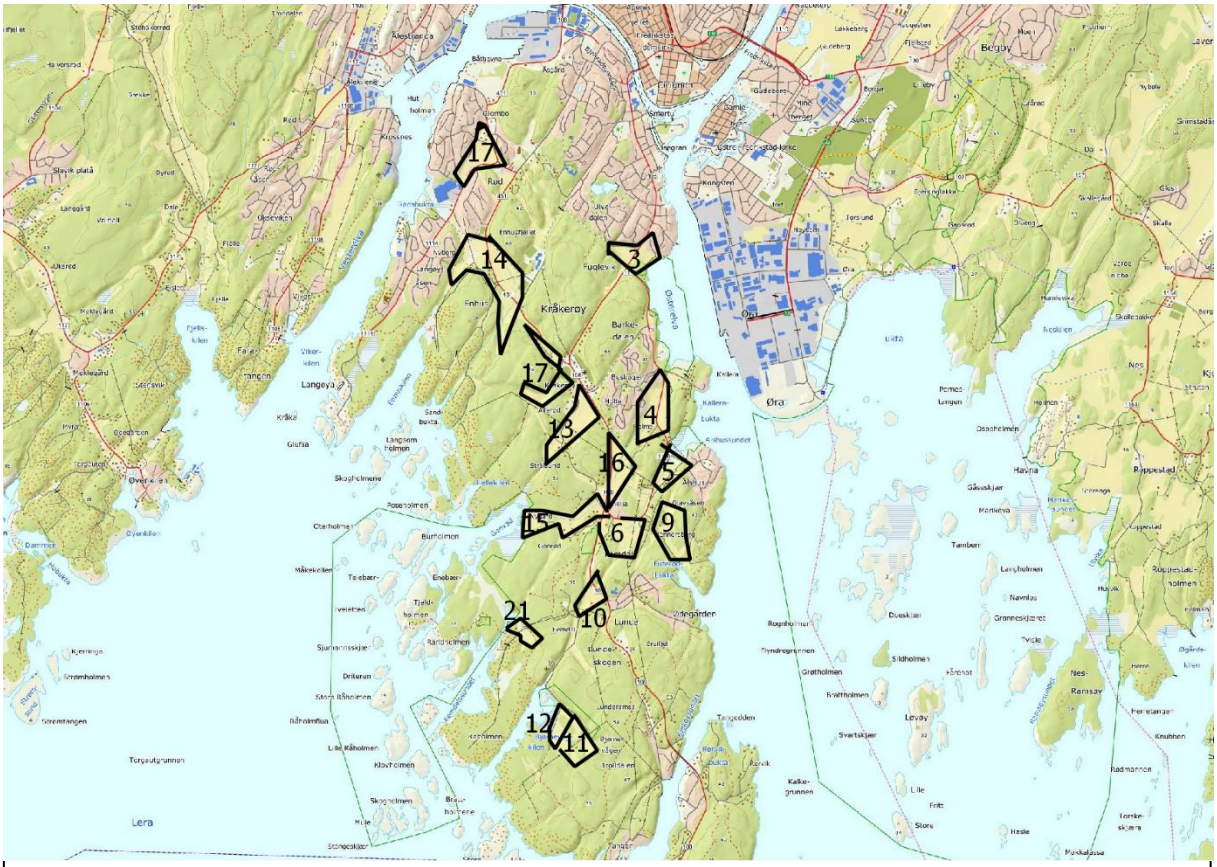

Figure 15: Zone map, Kråkerøy. Map collected from Kartverket, GeoNorge.

8.3 Timing of counting

Most of my geese registrations were done in the time span 9-11 a.m. It seemed to be a reasonable time due to most of the geese having landed and few-to-non had left the field, thereby giving the most representable geese numbers of the size of the local geese population.

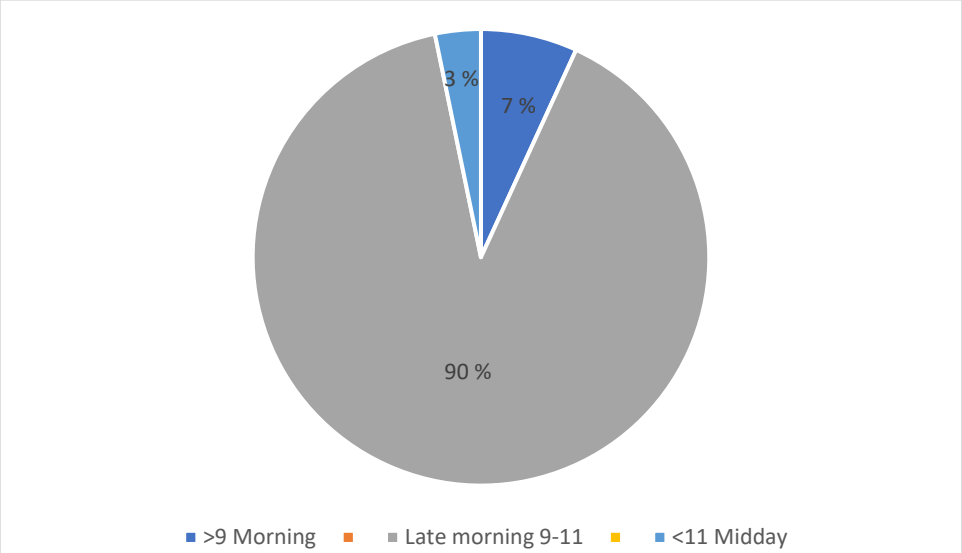

Figure 16: Showing total number of geese registered in the different time categories of the a.m.

8.4 Ring maps

Numerous maps were used to describe hunting pressure, this is because there needed to be a new map for each hunting site.

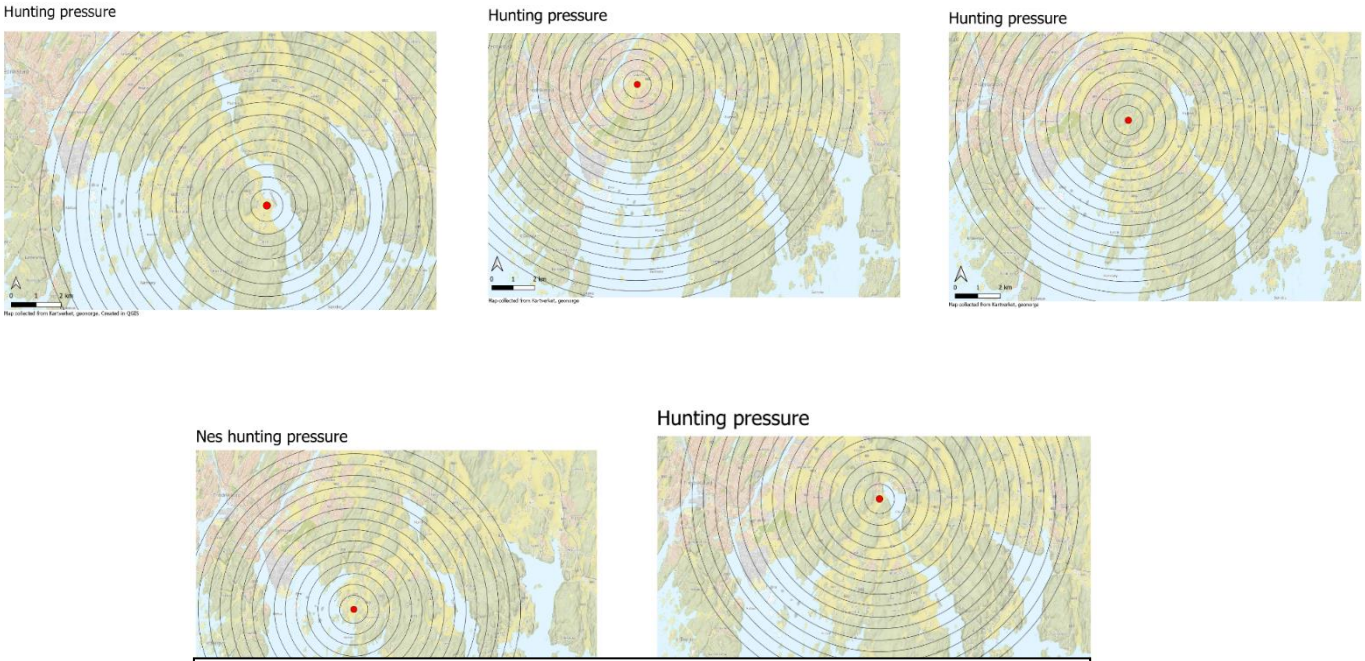

Figure 17: Ring maps. Background mapping collected from Kartverket, GeoNorge, visualized in QGIS:

8.5 Species distribution

The present study demonstrates that there is indeed an increasing number of geese throughout the fall in Torsnes. The greylag goose, being the dominant species, the first half of this study reaches a peak number of 3 188 the 22nd of August. However, barnacle geese numbers are seen to drastically increase and become highly abundant the second half of the study period. Furthermore, the dominating species in the study area is seen to change as barnacle geese being the dominating species in numbers, while reaching a number of 3 199 at its peak the 15th of September. This indicates that barnacle geese are causing lesser damage to crops within my study period, as they will appear in greater numbers later in the period, when most crops were harvested. However, this indeed illuminates the large amount of barnacle geese that could potentially cause damage to crops outside my study period. Other, local studies have found that damages to crops due to geese are at its peak in spring (Fredrikstad commune, 2021). Although the greylag geese where the most abundant in this study, this does not mean that crop damage due to barnacle geese and canada geese should be underestimated.