Food preferences by spring migrating Pink-footed geese (*Anser brachyryhnchus*) in Central Norway

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Abstract

The spring migrating Svalbard population of Pink-footed geese (Anser brachyrhynchus) stages in Central-Norway from mid-April to mid-May. They feed on agriculture fields mainly on a menu of grain and grass. These nutrients do they find in fields with stubble, sown barley and on grassland.
In the present study it is hypothesized that Pink-footed geese adapt to the available food resources depending on the availability. It is predicted that there may be yearly variances in the availability and that the preferences will depend on the time in the season, the location and seasonal climatic development.

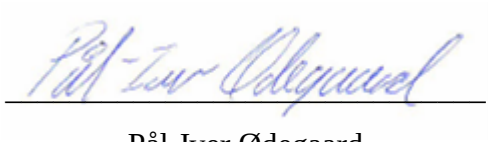
The results from goose registrations in 2008 and 2009 show a difference between the years in preferences for food. This was basically caused by the harvest success of the previous year, which depends on the current climate condition. The results of the present study also indicate differences in climate within the study area, determining the choices of food source by the Pink-footed geese

It is concluded in this study that Pink-footed geese have different food-preferences determined by the climatic situations. A more detailed study is recommended in order to fully understand the dynamics of spring staging Pink-footed geese staging in the cultivated landscape of Central-Norway.

Acknowledgments

I am very grateful for the support and guidance I have received from my supervisors Hans Christian Pedersen and Ingunn Tombre. They have helped me through this challenging task. Great honour to my good friend Per Ivar Nicolaisen, who carried out the fieldwork in the municipality of Steinkjer. He made it possible to include the whole Pink-footed geese staging area in the analyses.

Finally, I am very privileged to have a very understanding and patient family who allows me to spend hours (years) on watching geese and doing my writings. This support from my family of several years, have made it possible for me to complete this study. Most of all I am thankful to my beloved ones.



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Introduction

The species Pink-footed goose (*Anser brachyrhynchus*) is separated in two populations. One population with breeding area in Greenland, and the other with breeding area in Svalbard. The Greenland population consists of approximately 250 000 individuals and they spend the winter on the British island (Mitchell *et al*. 2004). During seasonal migration they go via Iceland. The Svalbard population is estimated to hold 80 000 individuals and they winters in the Netherland and Belgium (Madsen & Williams 2012). Their seasonal migration goes via Denmark and Norway. In Norway they have mainly two staging areas, one in Central Norway and the other in north of Norway. There is very little migration between the wintering areas of the Svalbard and Greenland populations, it is estimated to be 0,1 – 0,7% (Madsen *et al*. 1999). One collared Pink-footed goose tagged in England has been registered in Central Norway (own observation). There is a very little portion within the populations that are collared with neckbands.

The Svalbard population less than 1% and the Greenland population even fewer. The ringing project of the Svalbard population is organised by Danish scientists. Ringing is a useful tool when conducting studies at the single bird level (Bakken *et al.* 2003).

This study will focus on the Svalbard population at their staging site in Central Norway in the spring of 2008 and 2009.

The study area is in Nord-Trøndelag County and involves the municipalities of Levanger, Verdal, Inderøy and Steinkjer (Figure 1). The whole area used by geese in spring is roughly 750km^2, and normally below 75meter in altitude. The birds are roosting in inter-tidal areas and lakes nearby feeding sites. They feed mainly on cultivated land, and the birds have a strong preference for fields with grass, stubble and newly sowed barely (Madsen *et al*. 1999).

Figure 1. Map showing the municipalities involved in the study of spring-staging Pink-footed geese in Central Norway

There are slightly small differences in annual use of the area by geese depending on external influences like human activity, the presence of predators and the availability of fields offering various food sources (Madsen- *et al*. 1999). Disturbance by humans are mainly spring farming on the fields and/or scaring activity where farmers chase geese off their cultivated fields to protect their crop. Spring farming is a seasonal activity, but the start-up date slightly differs by current climate conditions. The presence of Pink-footed geese in spring and the possibility of crop damage caused by these birds seem to give many farmers a negative attitude towards the geese.

A natural disturbance by predator activity often results in increasing flock size and use of foraging areas of higher altitude (own observation). The predators that represent a serious threat towards the geese in the study area are Goshawk (*Accipiter gentilis*), Golden eagle (*Aquila chrysaetos*) and Sea eagle (*Haliaeetus albicilla*).

The geese are present in the Nord-Trøndelag County from early April to mid-May, with peak numbers in late April and early May. The Pink-footed geese population has increased significantly over the last decades (Madsen *et al*. 1999; Fox et al.2010). Until early 1980's the geese passed Central Norway, and flew directly from Denmark to north of Norway, and the population size at that time was between 10 000 25 000 birds (Madsen *et al*. 1999; Madsen 2001). In early 1980's they started staging in Central Norway and foraging on cultivated fields (Madsen *et al*. 1999). In combination with a favourable change in climate (earlier spring; see Tombre *et al*. 2008), the population has grown to around 80 000 individuals (Madsen & Williams 2012). Increasing numbers of geese in the areas increase the impact on agriculture interests, although an overall quantification of the crop damage is still lacking (but see Bjerke *et al*. 2013).

The availability of food in spring changes annually. This may be caused by the harvest and the season of the previous year (autumn) which again depends on the current climate situation. It will be good harvests (of cereals) if the autumn is dry with little precipitation enhancing the manoeuvring of farming machines and harvest processing. An autumn with much precipitation makes it difficult to enter the fields with heavy harvesting equipment thereby reducing the harvest success, leaving a lot of unharvest fields.

In this study a comparison between climate and harvest success was conducted for 2007 and 2008, with the corresponding preferences for food source of Pink-foot geese in the following spring of 2008 and 2009. The study area was divided in four smaller units in order to evaluate whether there were any differences in climate and corresponding agriculture activities. The main question for these analyses was: What did the geese eat during the

spring season, and was it determined by climate, the area and/or the agricultural activity the previous season? It is hypothesized that Pink-footed geese adapt to the food resources depending on the availability and it is predicted that there may be yearly variations in the availability and that the preferences will depend on the time in the season, the location and seasonal climatic development.

Methods

Fieldwork

The fieldwork registration methods have been improved over several years, combined with learning species behavior ecology (Gilbert *et al.*1998). The area is quite large and a trade-off between having few people doing the registrations and keeping a certain standard of accuracy was experienced. However, the disadvantage of registrations over a large area over several days were considered to have minor consequences, based on analyses of neckband registrations that gave approximately movement of birds within a radius of 3-7 km. This is also corresponding to other studies (Madsen *et al.*1999). The area was divided in six registration routes with two observers covering three routes each. Roughly route length was 100 km and the duration was six to eight hours to complete. Each of the three southern municipalities had one route, and Steinkjer municipality had three routes (Figure 2), as a consequence of the distribution of the geese. In 2008 the routes was driven twice a week, in 2009 the routes were covered once a week. The site-specific registrations followed a map and the amount of geese using the various types of the habitats stubble fields, new-sown barley and grass (mainly dominated by timothy) was recorded. The specific sites were identified by ether marking on a map or by using GPS sat navigation and laser range measurement.

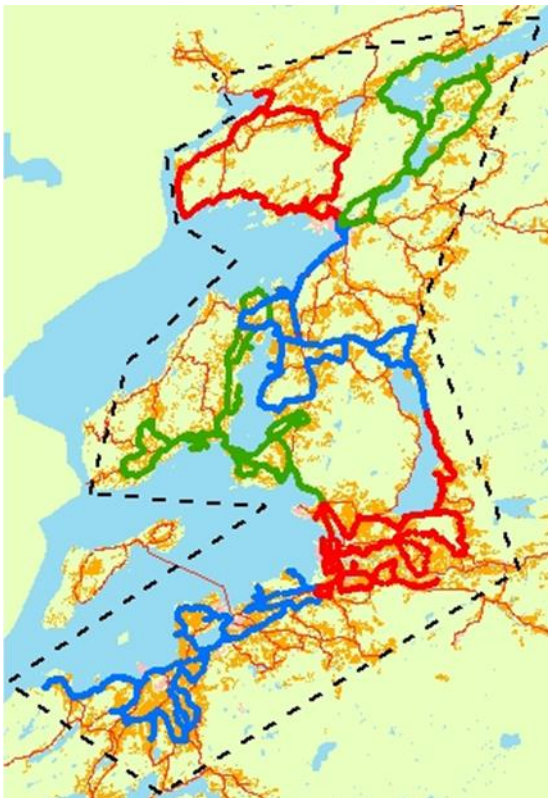

Figure 2. Map over study area with colored registration routs. Registration routs with same color are done at same time.

Human made constructions in the terrain improved the accuracy of the map indications, and the GPS operated within a precision of ± 5-10 meters. The laser guided range finder had a capacity of measuring distances within 1400 meter and a precision of ± 1meter.

Analyses

The study area was divided in four smaller units (Figure 3) as it is assumed that the growth may be different for the different areas. This division was used for both 2008 and 2009. The basic registration data were: date, location (UTM geo reference), field type and number of geese. The date format was changed to week number. The location was on a UTM geo reference and these were transformed to km^2 giving goose numbers per square. The registrations were sorted in the four sub-areas. In the habitat analyses only the registrations from the most essential food sources were included: grassland, stubble and sowed barley. After summarizing the geese by week and habitat in each area, separately for each year, the amount of geese was expressed as ratios using each habitat giving one value per habitat per week. Hence, it was possible to compare between weeks, areas and years giving relative values independent of the amount of geese present in the area. The results were presented in diagram as plots with trend lines of each food source for each area (Figure 3) and year with statistical coefficients, made by linear models with the "R" software.

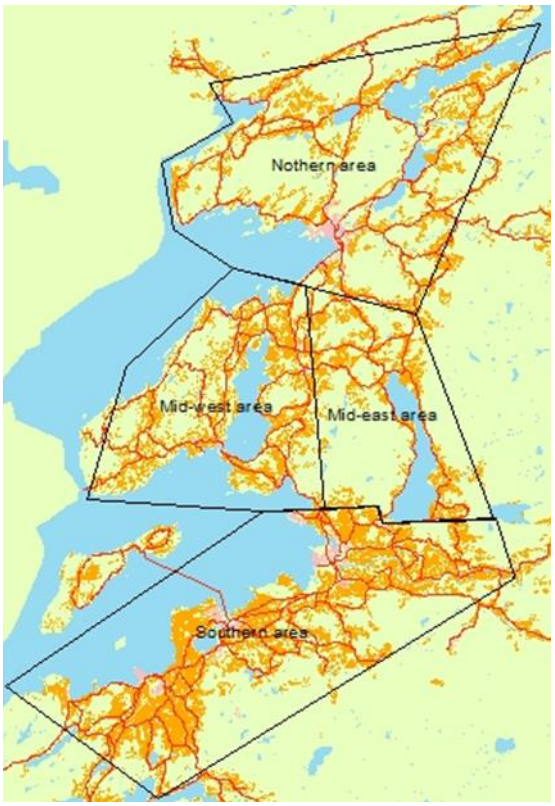

Figure 3. Map over study area where spring-staging Pink-footed goose were observed in four sub-areas based on the geographical distribution.

Additionally, agricultural statistics in 2007 and 2008 were included (Statistics Norway), as well as meteorological statistics with temperature and precipitations of 2007, 2008 and 2009 (Norwegian Meteorological Institute). Comparison between habitats, areas, years and weather statistics were done by welch two sample t-tests, where the alternative hypothesis was: true difference in means is not equal to zero.

Results

The northern area

Figure 4 and 5 show the ratio of geese on different food sources in the northern area. The diagrams on stubble indicate decreasing ratio of geese through the period. This is due to decrease in suitable fields with stubble caused by spring work. There is low variance along the trend line in 2008 and that put high significance level to the trend. In 2009 the variance is larger and the geese seem to have more fluctuating preference. The trend line holds a low significance level, but it is instructive. Comparison of stubble preference between the years gives low significance level (t=0.8223, df=7.958, p=0.4348, mean: 2008 ratio=0.54, 2009 ratio=0.37) and there is no difference between the years.

Sowed barley as food source show an increasing trend trough period in both years. This is also affected of spring work by processed stubble fields, changed to new sown fields.

Grass as food source has an increasing trend in both years. Comparison of grass preference between the years gives low significance level (t=0.8808, df=7.999, p=0.4041, mean: 2008 ratio=0.42, 2009 ratio=0.58) and there is no difference between the years.

Overall the variances towards the trend are low in 2008 in opposite to the relative higher variance in 2009. This may stand on differences between the years consider quality or availability of the food sources. Considering the higher conflict level towards crop related food sources (grass), this may explain some of the variance in 2009.

Another factor that decreases the significance level in 2009 is lack of registrations in week 20, and this may strengthen the effect of the existing variance. In figure 5 the trend lines are instructive, but not significant. Comparing figure 4 and 5, the trend lines show differences in feeding ratio on certain habitats, but there are little statistical differences between the years.

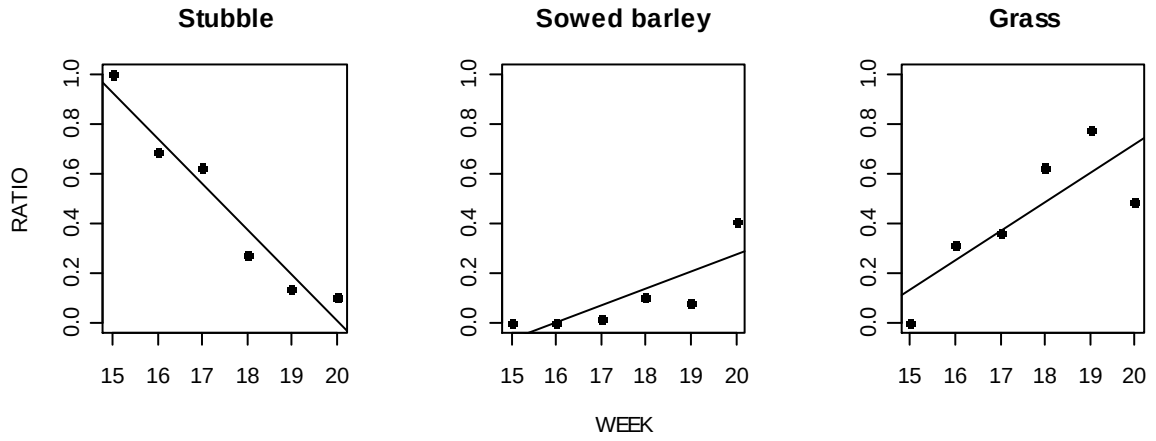

Figure 4. The distribution of Pink-footed geese in the northern study area in Trøndelag, Central Norway, at different feeding habitats in 2008. Each value represents the ratio of the specific food source in the current week. Stubble as food source decrease by week (slope ± SE: -0.186 ± 0.023; $F_{1,4} = 67.89$, $p = 0.0012$). Sown barley as food source increase by week (slope ± SE: 0.068 ± 0.024; $F_{1,4} = 7.76$, $p = 0.0496$). Grass as food source increase by week (slope ± SE: 0.118 ± 0.042; $F_{1,4} = 7.77$, $p = 0.04949$).

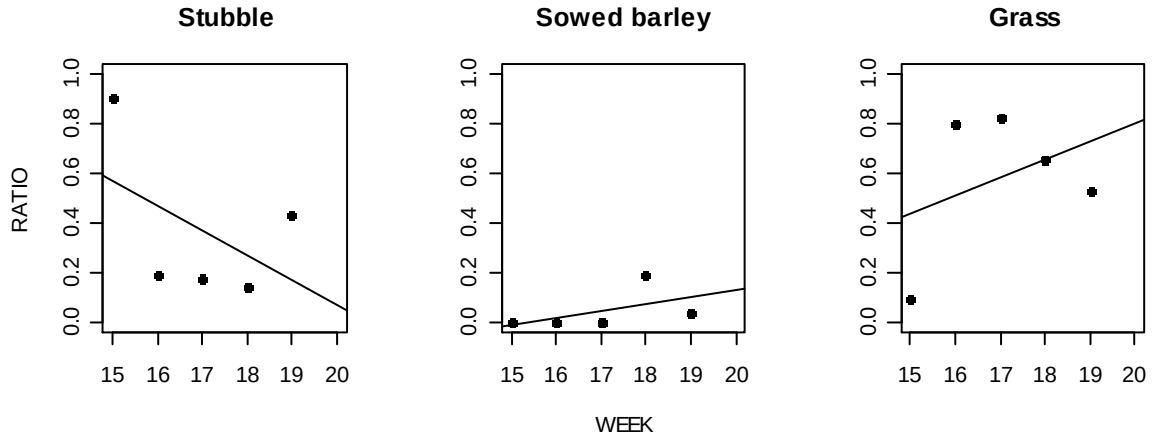

Figure 5. The distribution of Pink-footed geese in the northern study area in Trøndelag, Central Norway, at different feeding habitats in 2009. Each value represents the ratio of the specific food source in the current week. Stubble as food source decrease by week (slope ± SE: -0.100 ± 0.102; $F_{1,3} = 0.97$, $p = 0.3979$). Sown barley as food source increase by week (slope ± SE: 0.027 ± 0.027; $F_{1,3} = 1.04$, $p = 0.3835$). Grass as food source increase by week (slope ± SE: 0.073 ± 0.100; $F_{1,3} = 0.53$, $p = 0.5192$).

The mid-east area

In 2008 the Pink-footed geese had a large preference towards stubble fields in the mid-east area. There was a decreasing ratio on stubble through the period, due to increasing spring work. Sowed barley and grass receive an evenly increasing ratio of geese feeding on these food sources through the period this year.

In figure 6 there are no registrations in week 15 and this is caused by the absence of birds in the area. In the mid-east area there are normally lower numbers of birds, and there was late arrival of birds this year. Lack of registrations affects the significance level of the trend lines in figure 6.

In 2009 is there similar tendencies as in 2008, but the ratios on each food source differs significantly. In this area the stubble fields were most preferred as food source in 2008, and there was some fields with unharvests barley from 2007 available. In 2009 there was an opposite situation with regards to availability of food sources, and grass became the most preferred food source.

There is a short distance between the locations for roosting and feeding on grassland in the mid-east area. This may put the grassland area under stress considering the longer distance to stubble fields.

The trend lines in the figures 6 and 7 are not at high significant level, but they are although instructive and show a clear difference between the years 2008 and 2009 considering stubble and grass as feeding source.

Comparison of grass preference between years gives a high significance level ($t=6.2454$, $df=9.371$, $p=0.0001$, mean: 2008 ratio=0.17, 2009 ratio=0.84) and comparison of stubble preference between years gives a high significance level ($t=3.5693$, $df=7.148$, $p=0.0088$, mean: 2008 ratio=0.69, 2009 ratio=0.14), thereby indication of statistical differences between the years.

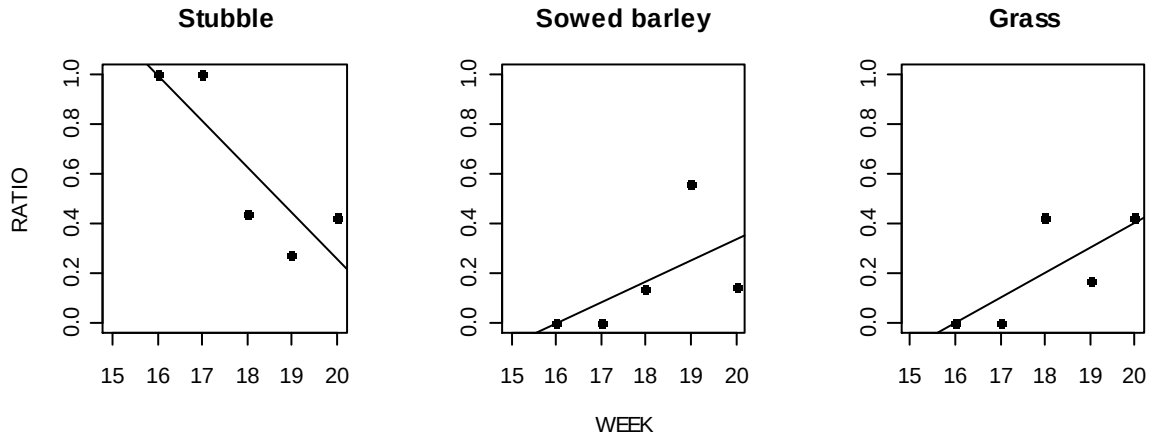

Figure 6. The distribution of Pink-footed geese in the mid-east study area in Trøndelag, Central Norway, at different feeding habitats in 2008. Each value represents the ratio of the specific food source in the current week. Stubble as food source decrease by week (slope ± SE: -0.187 ± 0.065; $F_{1,3} = 8.16$, $p = 0.0648$). Sown barley as food source increase by week (slope ± SE: 0.085 ± 0.069; $F_{1,3} = 1.52$, $p = 0.3056$). Grass as food source increase by week (slope ± SE: 0.102 ± 0.051; $F_{1,3} = 3.98$, $p = 0.1400$).

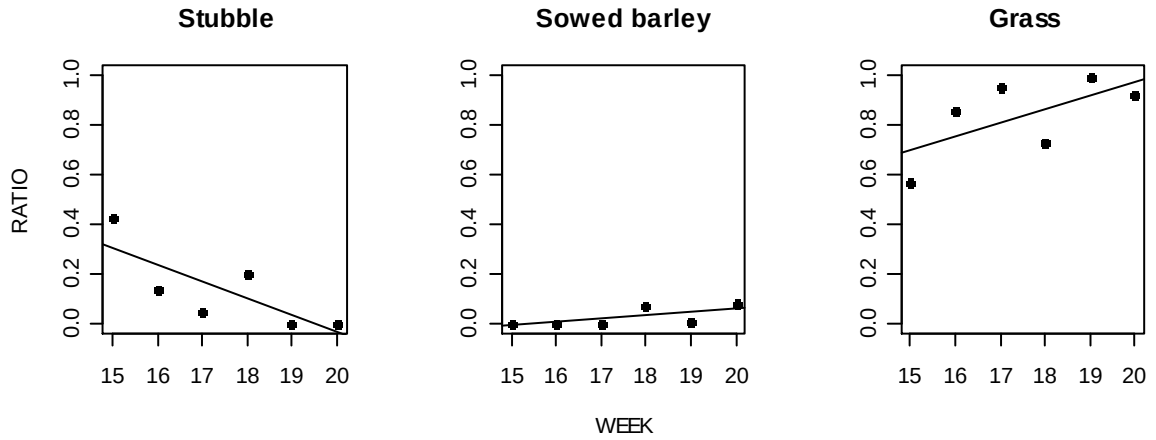

Figure 7. The distribution of Pink-footed geese in the mid-east study area in Trøndelag, Central Norway, at different feeding habitats in 2009. Each value represents the ratio of the specific food source in the current week. Stubble as food source decrease by week (slope ± SE: -0.069 ± 0.027; $F_{1,4} = 6.38$, $p = 0.0650$). Sown barley as food source increase by week (slope ± SE: 0.014 ± 0.008; $F_{1,4} = 3.17$, $p = 0.1495$). Grass as food source increase by week (slope ± SE: 0.055 ± 0.033; $F_{1,4} = 2.83$, $p = 0.1678$).

The mid-west area

The mid-west area holds a smaller part of the population and early in the season, it happens that birds in this area disperse to nearby areas in shorter periods. This happened in week 16 in 2008, and that might have affected the significance level of the trend lines in figure 8. The significance level of trend line on stubble as food source is high and the diagram show a decreasing ratio of birds on this habitat through the season. Sowed barley show an increasing trend as food source through the season of Pink-footed geese is registered in both years.

In 2008 is there an increasing trend of geese feeding on grass through the season. Grass as food source is affected by too large variance to be significant. Comparing the food sources in week 19 and 20 there is only geese found on sowed barley and grass, but there is a clear change in choice of food source at this time. It is difficult to determine the causes of these changes, but it can be disturbance like scaring actions since this is crop related food sources.

There is clearly less feeding on stubble fields in 2009 in opposite the previous year. The trend is decreasing and show good significant level on stubble. The grass fields seem to be a compensating food source considering the lower preference on this food source previous year. The trend on grass is decreasing in the period, and seems to be affected by limited availability of fields with stubble, considering the ratios of birds on this habitat in both years.

The trend of both years show an equal ratio birds on grass in the end of the season, and grass may be a compensating food source in the beginning of the season of 2009. When considering the trend lines as instructive, the figures 8-9 show a difference in preference on stubble and grass between the years.

Comparison of stubble preference between years gives a high significance level ($t=2.2935$, $df=5.837$, $p=0.0629$, mean: 2008 ratio=0.57, 2009 ratio=0.11) and comparison of grass preference between years gives a high significance level ($t=2.5259$, $df=8.25$, $p=0.0346$, mean: 2008 ratio=0.21, 2009 ratio=0.56), thereby indication of statistical differences between the years.

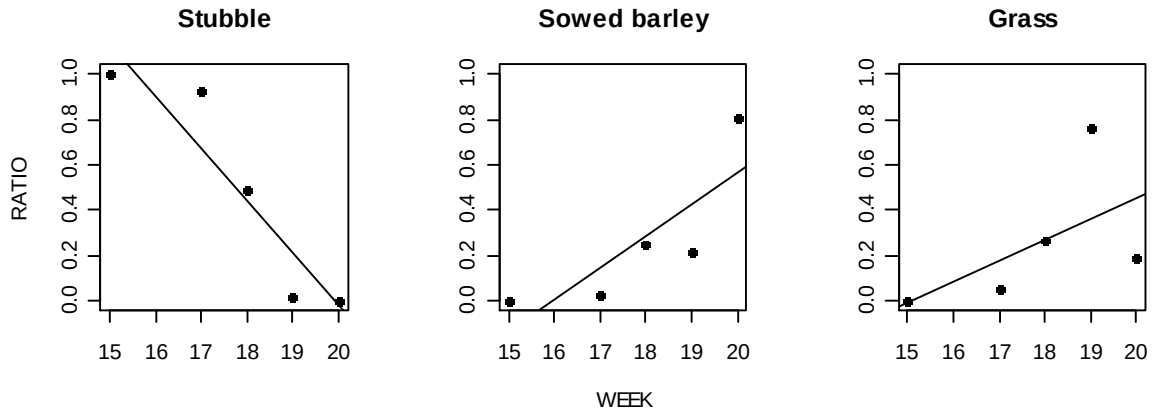

Figure 8. The distribution of Pink-footed geese in the mid-west study area in Trøndelag, Central Norway, at different feeding habitats in 2008. Each value represents the ratio of the specific food source in the current week. Stubble as food source decrease by week (slope ± SE: -0.231 ± 0.052; $F_{1,3} = 19.79$, $p = 0.0211$). Sown barley as food source increase by week (slope ± SE: 0.140 ± 0.055; $F_{1,3} = 6.42$, $p = 0.0851$). Grass as food source increase by week (slope ± SE: 0.092 ± 0.074; $F_{1,3} = 1.52$, $p = 0.3060$).

Figure 9. The distribution of Pink-footed geese in the mid-west study area in Trøndelag, Central Norway, at different feeding habitats in 2009. Each value represents the ratio of the specific food source in the current week. Stubble as food source decrease by week (slope ± SE: -0.062 ± 0.020; $F_{1,4} = 9.2$, $p = 0.0387$). Sown barley as food source increase by week (slope ± SE: 0.112 ± 0.049; $F_{1,4} = 5.27$, $p = 0.0833$). Grass as food source decrease by week (slope ± SE: -0.050 ± 0.040; $F_{1,4} = 1.57$, $p = 0.2782$).

The southern area

In the southern area are there decreasing ratios of geese on stubble as food source through the season. This is mainly due to farmers spring work, and the availability of fields with stubble decrease as the fields gets processed. The diagram of sowed barley show increasingly ratios of geese on this food source through the season as a consequence of farmers spring work, changing stubble fields into new sown fields. The Pink-footed geese show a clearly preference towards stubble fields and fields with sowed barley in 2008. Grassland as food source is in minor use this year. The trend line on grass has very low significance level, but it is instructive showing a mean through the period.
The diagram on grass in figure 10, show higher feeding ratio in week 17 and this is corresponding to the time when the trend lines of stubble and sowed barley are crossing. Grass may be a supplementary food source at this time when geese change from stubble to sowed barley as main feeding source.

In 2009 is it a lower preference towards stubble fields, compared with the same habitat in 2008. This reduction in ratio indicates a reduction of availability of stubble fields as food source in figure 11. The new sown fields with barley have lower preference of the geese in 2009 compared with previous year. On this habitat in week 18 is there lager ratio on this food source, and there is a corresponding lower ratio on grass as food source in the same week (figure 11). This may be caused by human activity like e.g. scaring actions.
Grass seems to be a more preferred food source in 2009, and it can be a compensating source due to limited availability of fields with grain early in the staging period.

Comparison of grass preference between years gives a high significance level ($t=7.1771$, $df=9.837$, $p<0.05$, mean: 2008 ratio=0.06, 2009 ratio=0.48), thereby indication of statistical differences between the years. Comparison of stubble preference between years gives a low significance level ($t=1.0724$, $df=7.901$, $p=0.3152$, mean: 2008 ratio= 0.47, 2009 ratio=0.24), thereby no indication of statistical differences between the years.

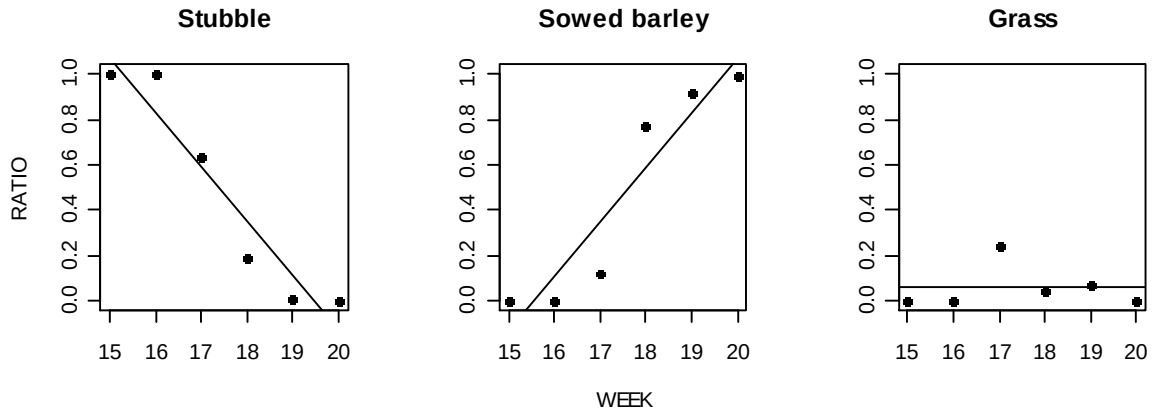

Figure 10. The distribution of Pink-footed geese in the southern study area in Trøndelag, Central Norway, at different feeding habitats in 2008. Each value represents the ratio of the specific food source in the current week. Stubble as food source decrease by week (slope ± SE: -0.240 ± 0.036; $F_{1,4} = 45.25$, p = 0.0025). Sown barley as food source increase by week (slope ± SE: 0.240 ± 0.043; $F_{1,4} = 31.30$, p = 0.0050). Grass as food source approximately unaltered by week (slope ± SE: 0.001 ± 0.025; $F_{1,4} = 0.001$, p = 0.977).

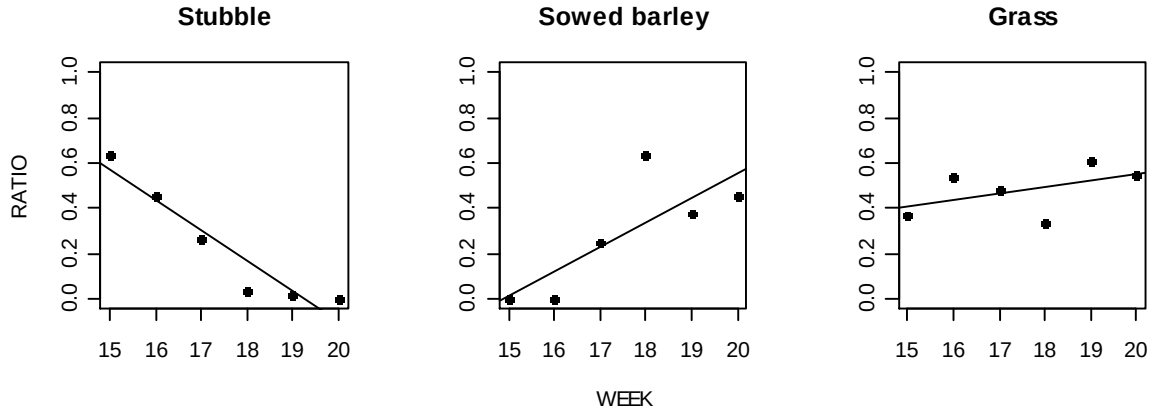

Figure 11. The distribution of Pink-footed geese in the southern study area in Trøndelag, Central Norway, at different feeding habitats in 2009. Each value represents the ratio of the specific food source in the current week.Stubble as food source decrease by week (slope ± SE: -0.135 ± 0.022; $F_{1,4} = 36.79$, p = 0.0037). Sown barley as food source increase by week (slope ± SE: 0.108 ± 0.041; $F_{1,4} = 6.98$, p = 0.0575). Grass as food source increase by week (slope ± SE: 0.027 ± 0.025; $F_{1,4} = 1.13$, p = 0.3469).

Farmers harvest success

The main difference in geese choice of food source between the year 2008 and 2009, are more nutrients available in stubble fields in 2008 than in 2009, and there was more feeding on grassland in 2009 than in 2008 as a compensating food source.

The explanation of these phenomena might stand on the harvest of previous years.

The waste of grain connected to harvest in the autumn seems to form the basis for geese feeding on the stubble fields in the spring time. The harvest of grain was very poor in 2007 compared with the harvest of 2008 (Figure 12). From 2007 to 2008 is there an increase of approximately 50% of grain harvest in Nord-Trøndelag County. In the same period is there a reduction of growing area of approximately 3% from 2007 to 2008 (Figure 13). The statistics of grain harvest of 2007 and 2008 do only refer the harvest success and do not say anything about the production in the fields. The expectations of production in the fields are of minor variations and the production is far more stable than Figure 12 may indicate. To ensure a high success rate of harvest the farmers depend on good and dry climate conditions short before and during the harvesting, to be able to use their machineries on the fields. The optimal conditions during the growing season are relative wet climate in the first half (April – June) and relative dry climate in the second half (July – September) and with high temperature through the period. There are no studies done in this area on grain production in the fields in the actual years, only the results of the harvest are registered. There was

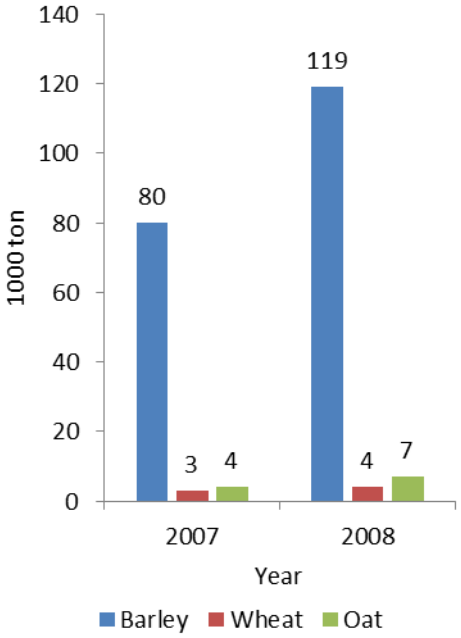

Figure 12. Grain harvest in N-Trøndelag County in 2007 and 2008. (Statistics Norway. 2008,2009)

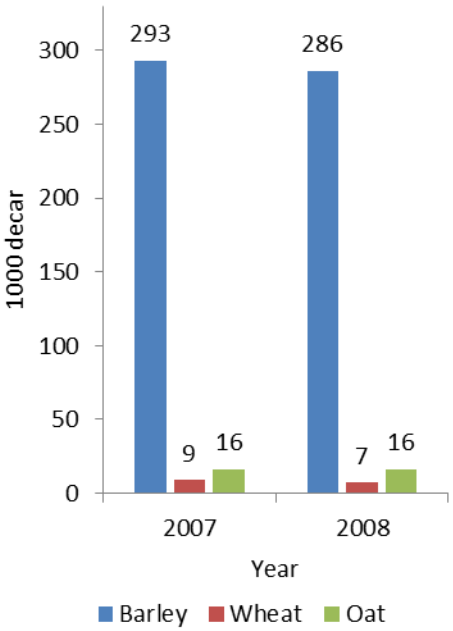

Figure 13. Growing area in N-Trøndelag County in 2007 and 2008. (Statistics Norway. 2008,2009)

a huge loss of grain crop during the harvest season of 2007 due to the climate conditions. It was very wet climate and a lot of grain fields were not harvested at all. This was observed, but the amount of area that wasn't harvested was not registered.

The climate situation in 2007 differs from 2008. When observing farmer's struggle to harvest the barley in 2007 and the geese on abounded food source of stubble and fields with unharvest barley the following spring, was it a quite radical contrast to the easy and very good harvest in 2008 with poorer food source for the geese the following spring in 2009. The weather conditions during the harvest season have a great impact towards geese food preference the following spring. Some analyses done of metrological registrations from the growing season of 2007 and 2008, gives the results shown in figures 14.

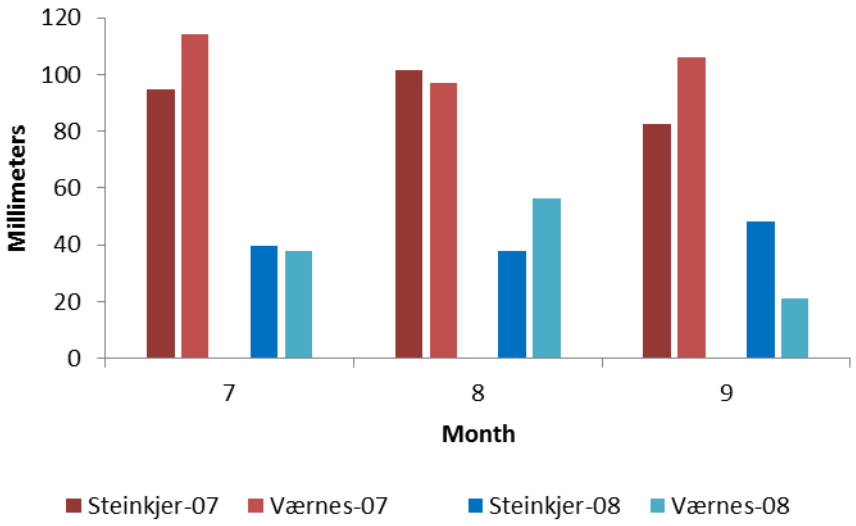

Figure 14. Registrations of monthly precipitation in Steinkjer and Værnes in 2007-2008 (Norwegian Meteorological Institute. 2013)

The precipitation is measured in the northernmost registration site, Steinkjer, and the southernmost registration site, Værnes.

Comparison of precipitation in Steinkjer in 2007 and 2008 gives a high significance level ($t=2.8581$, $df=157.282$, $p=0.0048$, mean: 2007 =3.03, 2008 =1.37), and comparison of precipitation in Værnes in 2007 and 2008 gives a high significance level ($t=3.1479$, $df=134.76$, $p=0.0020$, mean: 2007 =3.42, 2008 =1.23), thereby indication of statistical differences between the years.

Climate differences within the study area

The increase of farmer's spring work affects Pink-foot geese feeding behaviour, and the farmers begin their spring work when the climatic conditions are ready for this. The trend lines on sowed barley (Figure 4-11) indicate differences between the north eastern areas and the south western areas with regards to starting point in time of spring work and amount of geese with preference towards this food source. This corresponds with observations done in the area on the farming activities and the climate situation. It is not unusual to observe farmers doing spring work in the southernmost parts of the study area and at the same time some fields in the northernmost parts of the area are still cowered with snow. This is extreme points of climate differences, but between these points is there a climate gradient that exists through the geese staging period in the area. To test this observation statistically a comparison of Pink-foot geese preference towards sowed barley between analyses units were done.

Comparison of northern and eastern area gives a low significance level (t=0.3646, df=7.27, p=0.7258, mean: north 2009 ratio=0.04, east 2009 ratio=0.03) and thereby no indication of statistical differences between the areas. Comparison of southern and western area gives a low significance level (t=0.2943, df=9.914, p=0.7746, mean: south 2009 ratio=0.28, west 2009 ratio=0.33) and thereby no indication of statistical differences between the areas. Comparison of eastern and western area gives a high significance level (t=2.6543, df=5.187, p=0.04357, mean: east 2009 ratio=0.03, west 2009 ratio=0. 33) and thereby high indication of statistical differences between the areas. A further support of the climatic theory of a north – south gradient is done by comparisons of temperature in the study area within the geese staging period, measured in the northernmost registration site, Snåsa, and the southernmost registration site, Værnes. Comparison of temperature in 2009 gives a high significance level (t=3.7598, df=249.681, p=0.0002, mean: Snåsa =6.92, Værnes =9.03) and thereby indication of statistical differences between the areas. To confirm this not to be a single incident, a comparison of temperature in 2008 was done, and that gave a high significance level (t=3.7657, df=248.622, p=0.0002, mean: Snåsa =5.86, Værnes =8.00) and thereby indication of statistical differences between the areas.

Discussion

This thesis is based on registrations of geese feeding on a various food sources in different geographical areas. The cultivated landscape in Central Norway is a very dynamic environment in spring time, and contains several aspects not included in the present study. E.g., the human activities may be unpredictable and will influence habitat availability for the geese; which fields have been ploughed, when do the farmers start spring work, and are the farmers chasing geese off their properties? The farmer's attitudes towards Pink-footed geese do vary, from seeing them as a normal natural element with minor impact on crop, to more extreme negative attitude that look at geese as a pest and irregular phenomena with large negative impact on quantity of crop (own observation, see also Søreng 2008 for some perspectives). This may affect the habitat preferences for the geese. The annual variations in climate conditions are another factor with a major impact on both farmers and geese, as it determine the timing of ploughing and sowing and, hence, food availability for the geese.

All the observations were conducted in the afternoon. The geese normally have two daily foraging periods; early in the morning and in the afternoon, probably due to the advantage of less human disturbance. It is assumed that there are insignificant difference in habitat preferences between morning and afternoon.

In all the diagrams in Figure 4-11, the preference for stubble fields decreased throughout the study period. This is correlated with the farmer's increasing spring work in the fields where fields are ploughed giving no nutrients available for geese. The dynamics of stubble fields as food source for geese throughout the spring has previously not been studied in details, and no information exists on how the availability of stubble fields affects the geese and their food preferences in the area, with a corresponding conflict with the agricultural activity. The data in the present study, however, suggest that as after utilising the available stubble fields the geese shift to grass and new-sown barley (the main cereal crop in Nord-Trøndelag region).

The northern area are in the borderland of growth of barley and grassland is commonly more used as food source by the geese compared with the other parts of the study areas (Moen 1998). Comparing the trend lines on stubble fields for the northern study site (Figure 4-5), the data suggest that more fields were available in 2008 than in 2009 (starting with a high fraction-value in 2008). When available, the geese usually shift towards feeding on fields with new-sown barley. In general the geese apparently to abandon the fields as

soon the seed start sprouting and rather choose newly sown fields (own observation). The grassland areas seem to be more preferred food source in 2009 than 2008. The northern area have too little difference between the registered ratios on stubble and grass, to determine a statistically difference between the years. The trend lines on these habitats may indicate that the area is affected of the harvest success in 2007 and 2008.

In the mid-east area the climate conditions are similar to the northern area. Here, there is a high preference for stubble fields in 2008, as in opposite to 2009, where grasslands were most preferred throughout the study period. Apparently, the availability of stubble fields was large in 2008. From a farmer's point of view the geese were causing more crop damage in 2009 than in 2008, as the grass fields are more vulnerable and there are no damages caused by geese when feeding on stubble fields.

In the mid-west area, the spring farming activity are earlier than in the mid-eastern and northern area, as the geese start feeding on new-sown barley fields much earlier (switch from stubble) compared to the other sites (Figure 4-11).

In the southern area the geese have a high preference towards grain especially in 2008. The diagrams for both years indicate a decreasing feeding on stubble throughout the study period and an increasing feeding on new-sown barley (Figure 10-11). The difference between these two years indicates that the geese have different preference towards grassland. This may be caused by limited availability of preferred feeding source, grain, and a change in mean feeding ratio on grassland from 0.06 (2008) to 0.48 (2009) may be seen as a compensating feeding choice.

The diagrams (Figure 4-11) indicate an increasing trend in ratio of birds on new-sown barley through the study period. There is some debate within the agriculture discipline about quantity of crop reduction and decrease in yield of grain crop in fields with new-sown barley, but there is no study done on crop reductions caused by Pink-footed geese in Nord-Trøndelag, Central Norway. There are scaring actions towards geese caused by differences in farmer's attitude considering possible reduction of grain crop, which are affecting geese behaviour.

Grassland as feeding source creates more conflicts between farmers and geese. This is related to crop damage either as early food source for livestock, or as general grass harvest. In some sites, there is a high stress towards fields with grassland located next to the roosting location caused by local farmer's tolerance towards geese and crop damage, or relative long distance to sites with stubble fields. The geese seem to settle for grassland as food source in some areas and it can be difficult to determinate a preference based on a free

choice of food source. The nutrients geese needs to continue their migration are both carbohydrates (grain) and proteins (grass), but the consumed distribution between these differs annually (Madsen *et al.* 1999, 2006).

Management Implications

The goal for this study was to show some phenomena that occur when climate conditions shifts in the agriculture area in Central Norway and the adaptation the Pink footed geese do to the present food sources. This study show that Pink-footed geese adapt to the available food source and the accessibility of different food sources are affected by the climate situation. The study show that the agriculture area used by the geese hold a climate gradient that vary, based on observations of geese feeding ratio on different food sources in different parts of the study area, and differences in temperature in some registration points.

The motivation for doing this study is supported by different interests. The Pink-footed geese have an intrinsic value as observation object. They are easy to observe due to their large physical size and they reveal their biology and behaviour in a relative easily observable way. In the perspective of ecology the geese become useful as a key-species. The human dimension with the interaction between human and geese increase the complexity of the study. This also gives importance to the results of this study to be a part of a wider perspective. The human economic interests and conflict with spring migrating Pink-footed geese in Central Norway is essential to conduct this type of study to get a better understanding of "cause and effect" in an ecological perspective.

The on-going large scale climate change with warmer climate conditions, give benefit to both farmers and geese (Hoffgaard 2004, Nicolaisen *et al.*2007). The population of Pink-footed geese has increased from 25 000 since early 1980's (Madsen *et al*. 1999), to 80 000 in the latest estimates of 2012 (Madsen & Williams 2012). In the same period the growing conditions in farming fields in Central Norway have improved. Farmers can now harvest their grassland two or three times per season, in contrast to the past when it was common to do the harvest only one or two times per season. The improvement in growing conditions may be overshadowed by the increase in Pink-foot geese population. Large flocks with geese make a dominating view in the landscape due to the bird's physical size, and some people can feel the view overwhelming. Spring migrating Pink-footed geese in Central-Norway is not a problem-free visit, and there have to be done some crop damage

studies and further studies on geese use of the cultivated landscape with regard to variations in climate, to level out the understanding among people, and create a more balanced attitude in general. The results of this study show that the staging area for spring migrating Pink-footed geese is not a homogeneous surface with equally distribution of food resources and climate conditions. It will be recommended to establish a system to give public compensation to farmers with real over-browsing by geese. This is a very challenging part of the local agricultural and wildlife management.

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Appendix

Summary of registrations

Week	:	**15**	**16**	**17**	**18**	**19**	**20**	**Total**
North-area	:	6917	37400	57418	18942	26792	15752	
East-area	:	0	4000	18500	11835	3655	583	
West-area	:	552	0	18289	27769	26591	2584	
South-area	:	2500	19152	33005	33491	31392	31980	
Weekly number	:	9969	60552	127212	92037	84549	34909	409228
Number of flocks	:	6	30	63	113	174	105	491
Min.	:	52	2	5	2	2	2	
Mean	:	1662	2018	2019	815	486	333	
Max.	:	6000	10000	6000	10000	7000	3000	

Table 1. The number of pink-footed geese registered in Nord-Trøndelag, Central Norway, in 2008. Shown are the total numbers of birds registered per week and number of flocks the registrations are based on. Also shown are the average flock size (mean), and the smallest (min) and largest (max) flock observed.

Week	:	**15**	**16**	**17**	**18**	**19**	**20**	**Total**
North-area	:	11382	3080	7923	9638	11590	0	
East-area	:	2410	4060	3470	13468	4875	455	
West-area	:	2788	5712	3880	7257	6969	1986	
South-area	:	10525	17225	15625	41981	16100	16782	
Weekly number	:	27105	30077	30898	72344	39570	19223	219217
Number of flocks	:	34	37	62	238	125	113	609
Min.	:	5	50	10	4	2	2	
Mean	:	797	813	498	304	317	170	
Max.	:	3000	3500	3000	3000	3000	1750	

Table 2. The number of pink-footed geese registered in Nord-Trøndelag, Central Norway, in 2009. Shown are the total numbers of birds registered per week and number of flocks the registrations are based on. Also shown are the average flock size (mean), and the smallest (min) and largest (max) flock observed.

Localizations of meteorological registrations

Grid system:	UTM
Datum:	WGS84
Snåsa	33W 376940 7117145
Steinkjer	32W 619755 7101824
Værnes	32V 596469 7038211