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The effect of hunting bans on population development in the willow grouse (*Lagopus lagopus*) in Norway

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This thesis is worth 60 credits

Foreword

First and foremost, I would like to thank my supervisor, Øyvind Steifetten at USN. Without him, I would not have been able to write a thesis about something I feel very strongly about. I also thank him for being patient and kind during the many discussions we have had surrounding this thesis. I would also like to thank Erlend B. Nilsen for steering me in the right direction concerning DISTANCE and providing me with an R-script. Furthermore, I would like to thank all the people I have spoken to and that have so willingly helped me collect data on hunting bans and regulations.

Eg vil også gjerne sei takk til familien min for all støtte, spesielt til Ruben som har vore mitt alt gjennom ein vanskeleg periode.

“Faithless is he that says farewell when the road darkens”
-J.R.R Tolkien

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Abstract

The willow grouse (*Lagopus lagopus*) is by far the most popular small game species in Norway, and it is hunted annually throughout the country. However, during the last 20 years it has experienced a continuous decline, and this has raised serious conservation concerns among wildlife managers. Several management actions have been implemented to mitigate this decline (e.g. geographical zoning, daily bag limits, reduced hunting periods), but more recently the use of complete hunting bans has been applied by a number of hunting districts. However, little is still known about the effects on population development of such bans. Here, I investigate the immediate (one year after the ban) and short-term (two years after the ban) density effects of hunting bans to see if such a management strategy would be effective in mitigating population declines. In calculating population development, I used two density measures: population growth rate (λ) and true density (i.e. a yearly change in the number of individuals), which were based on line-transect data from 96 hunting districts in Norway. I found an immediate positive effect on population development after a hunting ban, both when comparing the preceding five years and the last year before a ban to the first year after a ban. This effect was stronger for banned areas compared to both regulated and hunted areas. I also found a stronger positive effect for longer bans (1-year vs. 2-year), but this was only significant for measures of density. It is therefore to be concluded that future management should aim to prolong bans in areas when needed in order to see a true positive effect of hunting bans.

Introduction

Recent studies have shown that a number of bird species inhabiting montane areas in Scandinavia are declining (Lehikoinen et al. 2014; Lehikoinen et al. 2018), and among those species is the willow grouse (*Lagopus lagopus*), which during the last 20 years has experienced a serious decline. In 2015 it was classified as near threatened (NT) on the Norwegian Red List (Henriksen and Hilmo 2015), and the current situation has raised concern among wildlife managers, researchers, ornithologists, and the public (Breisjøberget et al. 2018; Kaltenborn et al. 2012). Several reasons have been suggested to explain the current decline. This includes, for instance, the reduction of suitable habitat, which have been significantly reduced during the last 30-50 years (Pedersen 2004). These changes are mainly the result of human land-use changes, such as increased agricultural, logging and grazing activities. Furthermore, the development of hydropower stations that cause damming over large areas is likely to add to the loss of suitable habitat. The development of large cabin communities in montane areas can increase tourism and recreational activities, subsequently leading to higher rates of disturbance (Pedersen 2004), and global warming is likely to drive grouse populations northwards and to higher altitudes due to elevated treelines (Virkkala and Lehikoinen 2014).

One characteristic of the willow grouse, separating it from most other species with a similar population trend, is the species' status as a game bird. In Norway, the willow grouse is by far the most popular small game species, and it is hunted annually throughout the country. However, since the late 1990's there has been a drastic decrease in the number of shot birds, and during the last 10 years the grouse population in Norway has decreased by almost 50% (SSB 2019). For the 2019/20 hunting season a 90% decrease of the number of shot birds has been predicted for southern Norway

(Veberg 2019). Thus, it is likely that hunting could be one of the driving forces governing the decline, and negative effects for harvest rates of 15% or more have also been documented (Andersen et al. 2014). Similarly, a number of well-known examples show that excessive hunting has the potential to seriously decimate species to the brink of extinction, including the overexploitation of forest species in Asia, Africa and South America due to commerce and subsistence (Whytock et al. 2018) or species related to the bush meat industry (Milner-Gulland and Bennett 2003).

There are several possible strategies for regulating hunting pressure in grouse populations, and which one to use is a question that continues to be discussed. One strategy could be to use source-sink models that involves a limit for the upper threshold of total hunter effort in management areas, which has been applied in several parts of Fennoscandia (Kastdalen, 1992; Hörnell-Willebrand, 2005). Other strategies can include the use of daily bag limits, a reduced hunting period, discrimination between local and outside hunters, or prohibiting the use of hunting dogs. Some stakeholders might also differentiate the use of hunting dogs between local and outside hunters.

An alternative strategy, which has become more common in recent years, is to partially or completely ban hunting in specific areas, and there are several examples of previously exploited and endangered species where a hunting ban has led to an increase in population size (e.g. arctic fox (*Vulpes lagopus)* (WWF Norge 2020), polar bear (*Ursus maritimus)* (Norwegian Polar Institute 2020) and white-tailed eagle (*Haliaeetus albicilla)* (RSPB 2020)). A study in Sweden also showed that the overall mortality was higher in a hunted area compared to a non-hunted area (Smith and Willebrand 1999), indicating that hunting bans could prove valuable in reducing mortality rates. However, another study found that areas with and without hunting showed no difference in population density the following spring (Willebrand et al. 2014). Although these studies show no clear pattern on the effects of hunting bans, the knowledge is still poor, and considering the dire state of the Norwegian willow grouse population the subject requires more attention.

In this study I investigated how immediate (1 year) and short-term (2 year) hunting bans would affect the population development of the willow grouse. Because hunting bans will remove one source of mortality, I expected to find a positive population development after 1 year, and even a stronger population development after 2 years of hunting ban.

Methods

Data collection

Density estimates used to calculate population development was collected from a public resource site (gbif.org), which contain large datasets compiled by the Norwegian Mountain Association (i.e. Fjellstyrene), the Finnmark Estate (FeFo) and the Norwegian State-Owned Land and Forest Enterprise (Statskog). These organisations provide hunting licenses for a number of species, including the willow grouse, and perform annual line-transect surveys following a specific protocol. All surveys were performed in August preceding the hunting season, which opens the 10th of September. Each dataset consists of several hunting districts, and to extract data on grouse density from each district I used a distance analysis using the package DISTANCE in R (R Core Team 2017). The hunting districts were geographically well represented for mainland Norway (Figure 1), and the surveys spanned the time period 1999-2018.

Figure 1. Map showing the location of the hunting districts in Norway were annual grouse surveys are conducted, and which for this study were used for calculating population development. Points represent areas for the Finnmark Estate (FeFo), the Norwegian State-Owned Land and Forest Enterprise (Statskog). and the Norwegian Mountain Association.

Data on which hunting districts that had implemented hunting bans and the duration of the bans, was collected by approaching the organizations predominantly by email. In addition to records of hunting bans, I also gathered information on other regulatory management strategies, such as a reduced hunting period, a reduced bag limit, and a ban using hunting dogs.

Calculation of population development

I used both population growth (λ) and density (i.e. a yearly change in the number of individuals) as measures to calculate population development. Although population growth in general is the better option of measuring population development, at low initial population size a small increase by just a few individuals can result in overly large values, and hence, could bias the results. Therefore, I also decided to include a measure of density, and although it only shows an increase or decrease in population size, and not population growth per se, it will generate unbiased results.

Because most hunting bans in Norway only recently have been implemented, the majority of the hunting districts had only banned hunting for a short period of time (1 year = 12; 2 year = 4; 3 year = 3; 12 year = 1). Although I had four categories of hunting ban periods I only analysed the effect after 1 and 2 years, because 1) I was unable to calculate the effect after three years, as I did not have density estimates for 2019, and 2) the sample size was too low to get any meaningful results from the 12-year ban category. However, the first two years from these two categories were still included in the analyses. To calculate a change in population development I used density estimates from the first year a hunting ban was active and compared it with density estimates one or two years after the initial ban. In addition, I also used the mean density values from the five years (2014-2018) preceding a hunting ban to include a more general picture of the long-term population trends, and any natural variation in the dataset.

Statistical analysis

I used a Kruskal-Wallis test to see if there was a difference in population development between banned, regulated and hunted areas. For banned areas a change in density and population growth was calculated using density estimates from the first year of ban and the first year after the ban, while for regulated and hunted areas I used the five-year time series of population estimates. For the banned areas only, I used a t-test to see if there was a difference in population development between the five years preceding the ban and the estimates one year after the ban. This was in order to see if implementing a ban would have an effect on the existing trend. I also wanted to see if 2-year bans would show a stronger positive effect than 1-year bans. I therefore tested the change in population development from first year of ban against the change in second year of ban. All data were checked for normality using the Shapiro-Wilks test, and all analyses were performed in R (RStudio 2015).

Results

In total, I calculated density estimates from 112 hunting districts, but because some areas were insufficient regarding the number of counts (i.e. only a few counts each year) and years (i.e. enough counts but only over one or two years), I only used 96 areas for analyses. Of these, 20 had implemented hunting bans, 21 had other regulatory measures, and for 55 areas hunting was still allowed.

For both measures of population development (i.e. density and population growth rate) I found a significant difference between banned, regulated and hunted areas (Kruskal-Wallis test: $\chi 2$= 0.9, P<0,001 and $\chi 2$=16.2, P<0,001, respectively) (Figure 2).

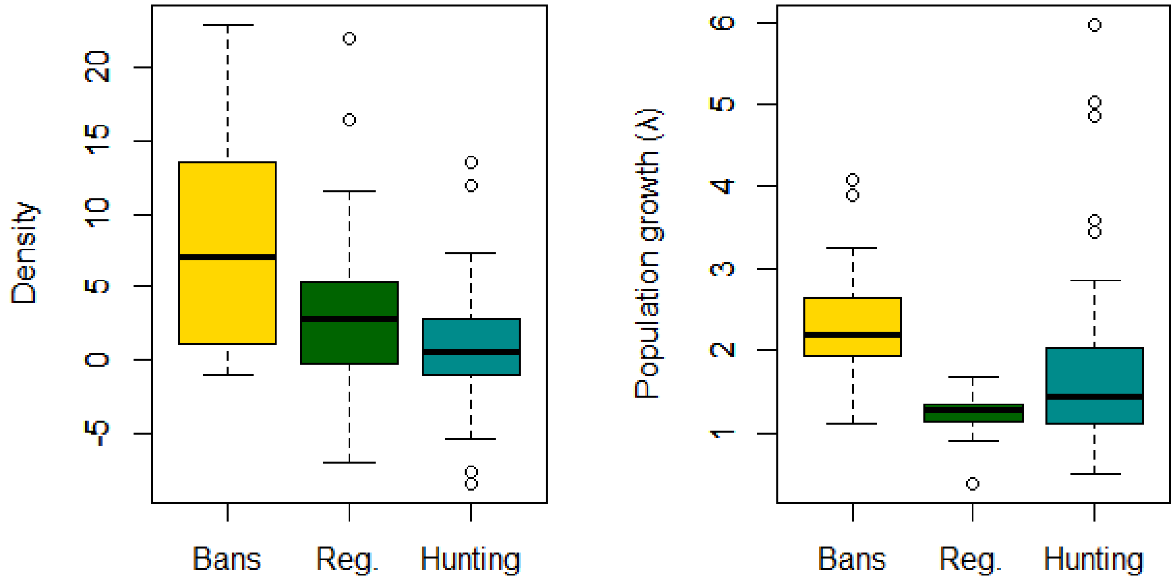

Figure 2. Population development in banned (n=20), regulated (n=21) and hunted (n=55) districts for measures of density (left), and population growth rate (right).

There was a significant difference for both measures of population development (i.e. density and population growth rate) when comparing the 5-year population trend before a ban with the population estimates one year after the ban (T-test: t= -5.14, N=16 (20), P<0.001 and t= -4.3, N=16 (20), P<0.001) (Figure 3).

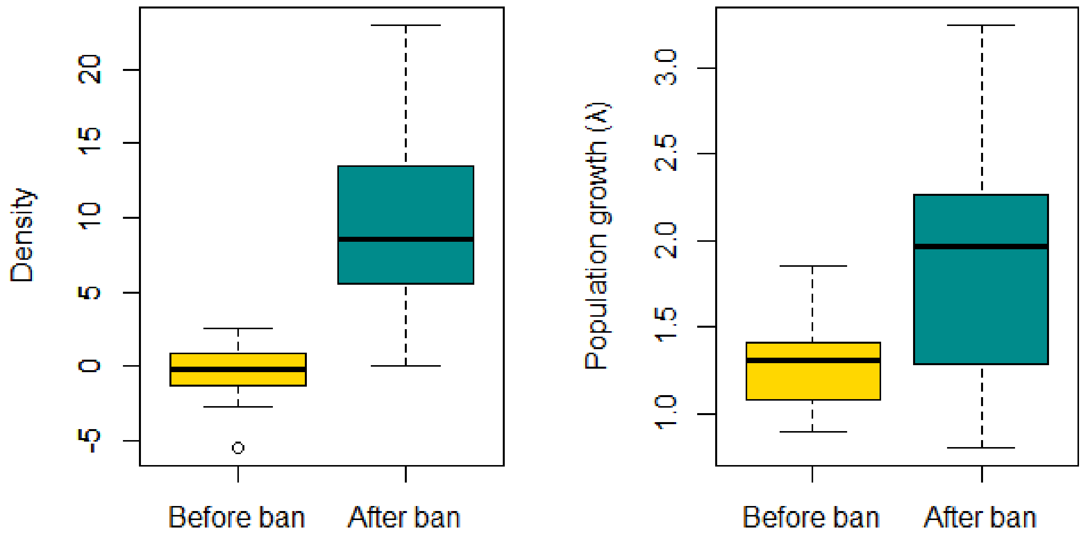

Figure 3. Population development five years before a ban and one year after the ban for measures of density (left) and population growth rate (right).

When doing a pairwise comparison between a 1-year and a 2-year ban for the same area, I found that extending the hunting ban period with an additional year had a positive effect on population development, but only significantly so for measures of density (T-test: t=-2.4, N=8, P=0.03) but not for population growth rate (t=-1.9, N=8, P=0.09) (Figure 4).

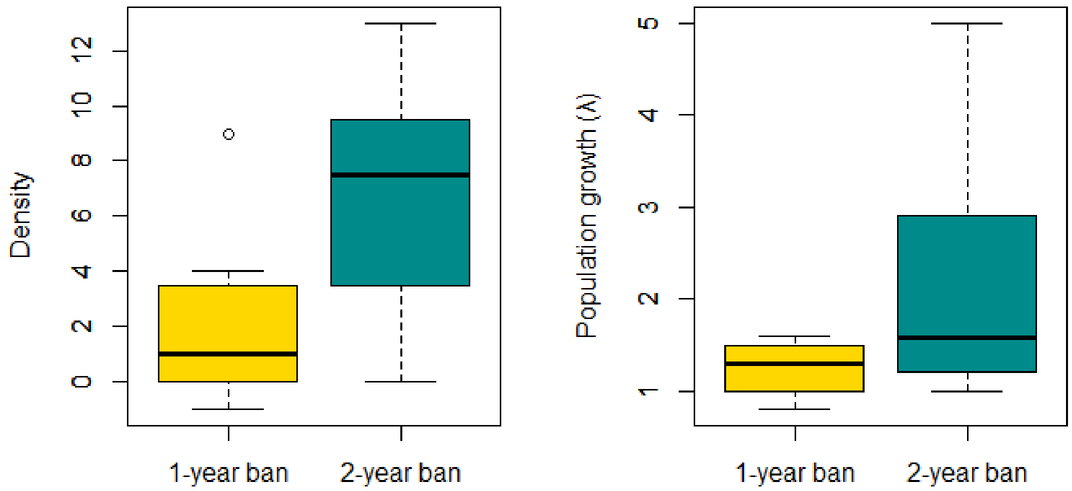

Figure 4. Population development after a 1-year and a 2-year hunting ban period within the same area for measures of density (left) and population growth rate (right). The lower sample size in this analysis is due to the sample being the number of districts that had a two-year ban in place (n=8).

Discussion

This study show that hunting bans has an immediate and short-term positive effect on population development in the willow grouse, and that a complete hunting ban is a more effective management strategy than other regulatory measures. It also shows that areas where hunting is prohibited has a notably stronger effect on population development than areas where hunting is still allowed. My study is based on data with few districts with hunting bans and with few hunting ban years. This is because of the data available and that implementation of hunting bans is a more recent management strategy. Therefore, one needs to be careful when drawing conclusions, but my results indicate that hunting bans do have a positive effect. There are other variables that can affect the results, such as normal variations caused by rodent cycles. The close connection between the ptarmigan and small rodent populations also has a role in determining ptarmigan dynamics (Henden et al. 2011). Therefore, these cycles may have affected my results, however, it is unlikely since the areas I have used varies geographically and temporally, so my data is not defined by a peak year or a bottom year. The connection between rodent cycles and ptarmigan cycles is a confounding variable that makes studying ptarmigan dynamics difficult.

Most areas that implemented hunting bans had the bans in place for one year. The reason for this could be several, like for instance, the population has increased enough to be sustainable for hunting the following year or there is no significant change in density during the banned season and therefore hunting resumed the following season. The most important reason for this, however, is that most bans were implemented in recent years and data for 2019 was not available for the analysis, thus making one-year bans the majority.

In this study it showed that there was a significant difference between the three categories of management. Adding regulations also showed to have a positive effect, although not as positive as for implementing bans. 21 of the 96 areas had regulations in place. Examples of such regulations were geographical zoning, daily bag limits, reduction of hunting time and banning use of hunting dogs (Breisjøberget et al. 2018). These regulations have a positive effect on density due it being an upper limit on how many birds that can be harvested, however, there is still an outtake of birds due to hunting. This is the reason for the regulations not having the same size positive effect as hunting bans.

All the analyses showed little difference in pattern between density and population growth. However, it is important to note that these two parameters estimate population development differently. If one were to consider figure 3 and the estimates before the ban was implemented one can see that the median change in density is zero, but the population growth rate can be estimated to approximately 1.3, i.e. a 30 % increase. This occurs due to the low population sizes. When the original density is one individual, an increase of one more individual will result in a lambda value of 2.0. Furthermore, the density estimates only tell us if there is a positive or negative trend, but not the magnitude of decrease or decline. To see that you need population growth. If one considers figure 2 and look at the areas with regulations and hunting and their population growth, you see that growth rates are lower for these areas. These areas also had a higher overall density of birds.

A positive effect of hunting bans was also prominent due to the difference between the five-year trend before a ban was set in place and the change that occurred during the first year of ban, indicating that even though the ban duration is quite short, there is an effect. Figure 3 shows that there is a large increase in both density and population growth from the five years preceding to the end of the first ban.

Another aim of this study was to investigate the effect of the duration of the ban and if a longer ban showed a larger positive effect. When I tested for this within the districts that had a two-year ban in place, I found a significant effect for the change density but not for population growth. Figure 4 tells us that there is an increase in change in density from the first year of ban to the end of second year of ban. You can see a similar positive pattern for population growth, however, the range of growth rates during the second year of ban is quite broad which makes it difficult to determine a significant difference in growth rate from first year of ban to the second year of ban. Nonetheless, the sample size for this analysis was very small (n=8) so if this were to increase, we might also see that there is a significant difference in growth rate as well.

The choice of continuing a ban can be affected by many things, one being that the stakeholders do not see a significant difference from year to year. Therefore, one must consider the dynamics of the species in question. The ptarmigan is an r-selected species with a logistic growth curve and the species can take a long time to recover when population levels are low, depending on where you are on the logistic curve and the slope of the curve. If the slope is flat, it indicates slow growth and the population needs time to come back. One will also expect that many populations are well below ½ K. Thus, the timing of the ban is crucial. If the ban is set early on, a change might not be detected year to year straight away due to the slow growth or if there has been a longer period of decline. If one does not detect a change from year to year during this period of slow growth, one can mistake it for the ban not working and therefore end the ban early. Consequently, it is favourable to determine the temporal dimensions concerning the population dynamics. A solution could be to add another year to the hunting ban to see then if the density changes.

An interesting observation of the selected hunting districts was that the overall densities were notably higher in areas without hunting bans. Although the reason for this is unknown, one explanation could be that these districts were of high habitat quality, which also could explain why hunting was still allowed. High quality habitats will naturally have a higher density of birds than sub-optimal habitats (Pedersen et al 2003). The banned districts found in this study are most likely sub-optimal habitats, due to the low densities found. Usually, grouse species can compensate for modest harvest in the optimal habitats. This is because there are individuals in the surrounding habitats that act as buffers (Pedersen et al. 2003). These individuals are prevented from entering the attractive habitat to breed due to strong territorial birds. When one of these territory holders are hunted, a buffer will immediately fill the vacant spot in the habitat resulting in compensation for harvest (Pedersen et al. 2003). When this compensation disappears due to the empty surrounding habitats, one will see a reduction in density in the optimal habitats as well and harvest will add to the natural mortality (Pedersen et al. 2003). Thus, one should consider implementing hunting bans in optimal habitats as well, to counteract the overall decline and the declines in the sub-optimal habitats. Furthermore, one would expect a lesser need for longer bans when densities are slightly higher at beginning of ban. Lastly, by implementing hunting bans in districts with low densities one can avoid that the population ending up in a so called “predator pit”, making the population even more vulnerable to predation (Pedersen 2004).

Why there are so few areas that have implemented hunting bans in this study is difficult to say, as there can be many reasons for not implementing them. For instance, hunting is a large income for many and therefore this dilemma has a social-ecological nature (Andersen et al 2014). It is understandable that property owners and government-driven organisations that manages hunting that do not want to lose income through a reduction of issuing hunting permits. Furthermore, hunting in general in Norway is much rooted in tradition and a large part of activities in rural Norway. However, there has also been a large increase in the number of hunters due to an increase in accessibility of hunting terrain. It has therefore been discussed to enforce bans in areas close to roads and cabins (Breisjøberget et al. 2018). It is these types of bans that are the least popular with hunters, as it seems that access to hunt is more important than bagging a large amount of birds (Breisjøberget et al. 2018). It may thus seem that implementing hunting bans is an unpopular choice among many hunters, as hunting holds a fundamental value for many.

The aim for the future should therefore be to attempt to increase length of ban when they are in place if no difference is seen after one year. With the steady decline of ground-nesting birds across Fennoscandia, it seems like it is an appropriate way of management when there is so much uncertainty in the complex system that is nature.

Conclusion

From this study one can therefore conclude that hunting bans do have an effect in areas where there has been a serious decline in ptarmigan density and population levels are low. Based on this study, it is the less productive areas that have enforced bans, while the more productive areas are open for hunting, probably due to a higher level of compensation. Furthermore, adding a year to the ban seemed to have an effect on population development but only density-wise and not for population growth, however, this could be due to the small sample size. Therefore, it might be of interest in the future to counteract the overall decline in ground-nesting birds by increasing the duration of bans. Predation, small rodents and climate are also aspects that affect the ptarmigan population, but these factors are hard to test for. Hunting, however, is a factor that is more easily managed and might therefore be a solution to slow the decline of the Norwegian willow ptarmigan.

References

Andersen, O., Kaltenborn, B.P., Vittersø, J., Willebrand, T., 2014. Preferred harvest principles and regulations amongst willow ptarmigan hunters in Norway. *Wildlife Biology* **20:** 285-290

Breisjøberget, J.I., Odden, M., Storaas, T., Nilsen, E.B., Kvasnes, M.A.J. 2018. Harvesting a red-listed species: determinant factors for willow ptarmigan harvest rates, bag sizes, and hunting efforts in Norway. *European Journal of Wildlife Research* **64**

Brøseth, H., and Pedersen, H.C., 2010. Disturbance effects of hunting activity in a willow ptarmigan *Lagopus lagopus* population. *Wildlife Biology* **16:** 241-248

Henden, J.-A., Ims, R.A., Yoccoz, N.G., Killengreen, S.T. 2011. Declining willow ptarmigan populations: The role of habitat structure and community dynamics. *Basic and Applied Ecology* **12:** 413-422

Henriksen S og Hilmo O (2015) Rødlista - hva, hvem, hvorfor? Norsk rødliste for arter 2015. Artsdatabanken <http://www.artsdatabanken.no/Rodliste/HvaHvemHvorfor>. Nedlastet <03/03/20>

Hörnell-Willebrand M. 2005. Temporal and spatial dynamics of willow grouse *Lagopus lagopus*. *Doctoral thesis No. 2005*:**23**, Faculty of Forest Sciences, Swedish University of Agricultural Sciences, Umeå

Kaltenborn, B.P., Andersen, O., Vittersø, J., Bjerke, T.K. 2012. Attitudes of Norwegian ptarmigan hunters towards hunting goals and harvest regulations: the effects of environmental orientation. *Biodiversity Conservation* **21:** 3369-3384

Kastdalen L. 1992 Skogshøns og jakt. Norges Bondelag, Norsk Skogbruksforening, Norges Skogeierforbund, Norges Jeger- og Fiskerforbund, Oslo, Norway [In Norwegian]

Kvasnes, M.A.J., Pedersen, H.C., Storaas, T., Nilsen, E.B. 2014. Large-scale climate variability and rodent abundance modulates recruitment rates in Willow Ptarmigan (*Lagopus lagopus*). *J Ornithol* **155:** 891-903

Kålås JA (2015) Kvifor er rype og hare på Raudlista? Norsk raudliste for artar 2015. Artsdatabanken <http://www.artsdatabanken.no/Rodliste/RypeOgHare>. Nedlasta <10/04/2020>

Lehikoinen, A., Green, M., Husby, M., Kålås, J.A., Lindström, Å. 2014. Common montane birds are declining in northern Europe. *Journal of Avian Biology* **45:** 3-14

Lehikoinen, A., Brotons, L., Calladine, J., Campedelli, T., Escandell, V., Flousek, J., Grueneberg, C., Haas, F., Harris, S., Herrando, S, Husby, M., Jiguet, F., Kålåa, J.A., Lindström, Å., Lorrillière, R., Molina, B., Pladevall, C., Calvi, G., Sattler, T., Schmid, H., Sirkiä, P.M., Tefuelbauer, N., Trautman, S. 2018. Declining population trends of European mountain birds. *Global Change Biology* **25:** 577-588

Milner-Gulland, E.J., Bennet, E.L. 2003. Wild Meat: The Bigger Picture. *Trends in Ecology and Evolution* **18:** 351-357

Nilsen E B, Vang R, Asbjørnsen E, Nilsen E 2018. Tetraonidae line transect surveys from Norway: Data from Finnmarkseiendommen (FeFo). Norwegian Institute for Nature Research. Sampling_event Dataset https://doi.org/10.15468/s7c8qd accessed via http://data.nina.no:8080/ipt/archive.do?r=line-transect_data_tetraonidae_fefo

Nilsen E B, Vang R, Breisjøberget, J.I., 2018. Tetraonidae line transect surveys from Norway: Data from Statskog. Norwegian Institute for Nature Research. Accessed via https://www.gbif.org/dataset/6a948a1c-7e23-4d99-b1c1-ec578d0d3159

Nilsen E B, Vang R, Kjønsberg, M., Kvasnes, M.A.J., 2018. Tetraonidae line transect surveys from Norway: Data from Fjellstyrene. Norwegian Institute for Nature Research. Accessed via https://www.gbif.org/dataset/b49a2978-0e30-4748-a99f-9301d17ae119

Pedersen, H.C., Steen, H., Kastdalen, L., Brøseth, H., Ims, R.A., Svendsen, W., Yoccoz, N.G. 2003. Weak compensation of harvest despite strong density-dependent growth in willow ptarmigan. *Proc. R. Soc. Lond.* **271:** 381-385

Pedersen, H.C., 2004. Årets fugl 2004: Lirypa, vår egentlige nasjonalfugl? *Vår fuglefauna* **27:** 5-9

RStudio Team 2015. RStudio: Integrated Development for R. RStudio, Inc., Boston, MA URL http://www.rstudio.com/.

RSPB 2019. White tailed eagle threats and conservation. https://www.rspb.org.uk/birds-and-wildlife/wildlife-guides/bird-a-z/white-tailed-eagle/threats-and-conservation/ 20.02.20

Smith A., Willebrand T. 1999 Mortality causes and survival rates of hunted and unhunted willow grouse. *J Wildl Manag* **63**:722–730

Statistisk Sentralbyrå. 2019 https://www.ssb.no/jord-skog-jakt-og-fiskeri/artikler-og-publikasjoner/flere-ryper-felt 13.03.20.

Storch, I., 2013. Human disturbance of grouse- why and when? *Wildlife Biology* **19:** 390-403

Veberg, V., 2019. Kraftig nedgang i felte ryper på Statskogs områder. https://jaktogfiske.njff.no/jakt/2019/11/kraftig-nedgang-i-felte-ryper-pa-statskogs-omrader 04.04.20.

Virkkala, R., & Lehikoinen, A. 2014. Patterns of climate-induced density shifts of species: Poleward shifts faster in northern boreal birds than in southern birds. *Global Change Biology* **20**: 2995– 3003

Whytock, R.C., Morgan, B.J., Awa Il, T., Bekokon, Z., Abwe, E.A, Buij, R., Virani, M., Vickery, J.A., Bunnefeld, N. 2018. Quantifying the scale and socioeconomic drivers of bird hunting in Central African forest communities. *Biological Conservation* **218:** 18-25

Willebrand T., Hörnell-Willebrand M., Asmyhr L. 2011 Willow grouse bag size is more sensitive to variation in hunter effort than to variation in willow grouse density. *Oikos* **120**:1667–1673

Willebrand, M.H., Willebrand, T., Smith, A.A. 2014. Seasonal movements and dispersal patterns: Implications for recruitment and management of willow ptarmigan (*Lagopus lagopus*). *The Journal of Wildlife Management* **78:** 194-201

WWF Norway 2019. Arctic fox https://www.wwf.no/dyreleksikon/fjellrev/ 20.02.20