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*Research Article*

# Ptarmigan Hunting Restrictions: Effects on Hunters' Opinions and Harvest

**JO INGE BREISJØBERGET,**[1,2] *Faculty of Applied Ecology and Agricultural Sciences, Inland Norway University of Applied Sciences, Campus Evenstad, N-2480 Koppang, Norway*

**TORSTEIN STORAAS,** *Faculty of Applied Ecology and Agricultural Sciences, Inland Norway University of Applied Sciences, Campus Evenstad, N-2480 Koppang, Norway*

**MORTEN ODDEN,** *Faculty of Applied Ecology and Agricultural Sciences, Inland Norway University of Applied Sciences, Campus Evenstad, N-2480 Koppang, Norway*

**ABSTRACT** In Norway, willow (*Lagopus lagopus*) and rock ptarmigan (*Lagopus muta*) populations and harvests have declined during the last few decades, and the 2 species are considered as near threatened on the Norwegian Red List. The Norwegian State-Owned Land and Forest Enterprise (Statskog) is a main provider of ptarmigan hunting on public lands, and has recently introduced harvest restrictions in Nordland County. We investigated the relationship between hunters' opinions and the effects of restrictions on hunters and ptarmigan harvest using online structured questionnaires (2012, $n = 570$) and bag reports (2009–2011, $n = 8{,}795$). A majority of hunters (66%) supported harvest restrictions, and 89% were willing to shoot fewer birds to increase population size. However, opinions towards specific management alternatives were more negative and disparate. Residency of the hunters (local or non-resident) was the most influential factor on hunter opinions, and this reflected a tendency to approve of restrictions with the smallest effect on their own hunting practice. Our study indicates that access and the opportunity to hunt are more important to hunters than bag size. Daily and annual hunting bags were small, averaging 1.7 and 5.8 ptarmigan, respectively, and the daily bag limit of 4 birds was reached during 5.8% of hunting days. A harvest reduction of 50% implied a daily bag limit of 1 bird and a seasonal bag of 4, which were lower than what hunters found as acceptable. Hence, although hunter opinions may provide useful guidelines for the development of management practices, their opinions need to be evaluated for the actual effects they may have on the game populations.


**KEY WORDS** bag limits, harvest restrictions, *Lagopus lagopus*, *Lagopus muta*, Nordland County, rock ptarmigan, willow ptarmigan.

Willow (*Lagopus lagopus*) and rock ptarmigan (*L. muta*) are the most popular game birds in Norway, with annual harvests of 120,000 to 365,000 birds during the last decade (Statistics Norway 2016*a*). In Fennoscandia, ptarmigan populations have declined during the last decades along with several other montane bird species (Kålås et al. 2014, Lehikoinen et al. 2014). The 2 species are now considered near threatened on the Norwegian Red List (Henriksen et al. 2015). The causes and the extent of the population declines are unclear, but several studies emphasize the negative effect of range contractions and altered floral and faunal composition due to climate change (Lehikoinen et al. 2014, Elmhagen et al. 2015). The population declines have triggered a debate on the effect of hunting and the necessity of imposing more conservative hunting restrictions. In recent years, different types of harvest restrictions on small game have been introduced by managers to reduce the risk of over-harvesting. Some restrictions are daily bag limits, seasonal bag limits, shortened hunting season, prohibition of the use of dogs, or the use of source-sink systems with networks of hunted and protected area units (Tamisier 1985, Connelly et al. 2003, Novaro et al. 2005, Pedersen and Karlsen 2007, Sandercock et al. 2011).

In a study of the effect of hunting restrictions on the harvest of bobwhite quail (*Colinus virginianus*), Guthery et al. (2004) reported that bag limits generally affected hunting opportunities and harvest rates only when population levels were high. At low population levels, few hunters reached the bag

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[1]*E-mail: jo.breisjoberget@inn.no*
[2]*Current affiliation: Department of Forestry and Wildlife Management, Inland Norway University of Applied Sciences, Evenstad 2480 Koppang, Norway.*

limit, but the ratio of hunters to bobwhites increased. Thus, the proportion of birds harvested increased during periods of low population levels, rendering the restrictions insufficient at times when hunting control was most important. A somewhat similar pattern has been observed in Scandinavian ptarmigan hunting (i.e., an inverse density-dependent impact of hunting; Willebrand et al. 2011). Harvest rates were higher when ptarmigan populations were low, and Willebrand et al. (2011) concluded that effective control of hunting pressure was most important during these periods. Guthery et al. (2004) and Willebrand et al. (2011) demonstrated that knowledge about the actual effects of harvest restrictions on harvest rates is vital when introducing new management systems.

Wildlife agencies and managers are facing a desire from the public to be more involved in the management of wildlife (Decker and Enck 1996, Decker et al. 1996, Chase et al. 2000). The effectiveness of restrictions on harvests is assumed to depend on the acceptance and satisfaction of hunters (Wam et al. 2013, Andersen et al. 2014), 2 social concepts that are closely linked (Fulton and Manfredo 2004). Hence, several scientific studies have investigated factors associated with hunters' attitudes to different management regimes (Fulton and Hundertmark 2004, Fulton and Manfredo 2004, Collier and Krementz 2006, Mangun et al. 2007, Brunke and Hunt 2008). Schroeder et al. (2014) report that perceptions of new hunting regulations differ markedly among hunters and may change over time. Differences in acceptance could be related to the levels of experience among hunters; motivations and attitudes may change during a progressive development in their degree of hunting specialization (i.e., recreational specialization; Kuentzel and Heberlein 1992, Scott and Shafer 2001).

Statskog (The Norwegian State-Owned Land and Forest Enterprise) is responsible for providing ptarmigan hunting to a maximum number of hunters while ensuring a sustainable harvest of the resource (Statskog 2016). Securing hunting access for a large number of hunters may require smaller quotas than the hunters find acceptable, especially during periods of low population density. Alternatively, access can be restricted by reducing either the number of hunters or the timing or the duration of the hunting season (Peterson 2001, Angulo and Villafuerte 2004). Currently, little information exists about the relationship between restrictions imposed on hunters, their attitudes, and the actual impact on the harvests. We explored these relationships by analyzing data from bag records and a survey of hunters collected in a large state-owned mountain range in northern Norway. First, we investigated factors associated with hunter opinions about the different management systems and hunting restrictions. Second, we analyzed data on hunting practices and performances to recognize to what extent hunters are affected by the restrictions.

## STUDY AREA

We conducted this study on Statskog's land in the 3 municipalities of Grane, Vefsn, and Hattfjelldal in Nordland County, in north Norway (65°10′–65°88′ N, 12°76′–14°62′E). Statskog has ownership of 66% of the 6,623 km$^2$ of land in these municipalities (Fig. 1). During the study period, the area had

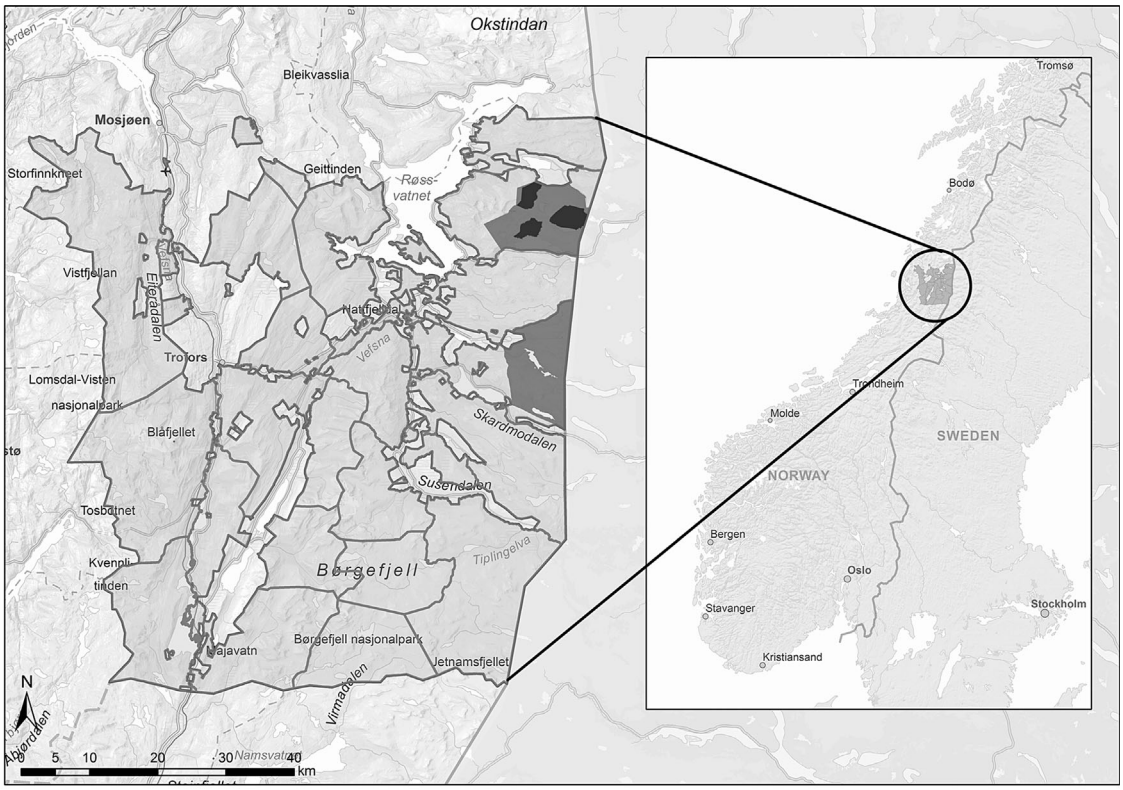


**Figure 1.** Twenty-five hunting blocks for ptarmigan on state-owned land in 3 municipalities: Grane, Vefsn, and Hattfjelldal, Nordland County, Norway. The 2 dark gray polygons are experiment area (north) and control area (south) for the source-sink experiment. The 3 black areas are refuges.

16,354 inhabitants living mainly in towns and villages (Statistics Norway 2016*b*). The study area was situated in a rugged landscape in the northern boreal birch (*Betula* spp.) forest and alpine tundra, with elevations ranging 200–1,450 m above sea level. The vegetation below the treeline was dominated by bilberries (*Vaccinium myrtillus*), mountain birch (*B. pubescens tortuosa*), and some Norway spruce (*Picea abies*). At higher elevations, vegetation was dominated by alpine heath, sedges, willows (*Salix* spp.), and patches of dwarf birch (*B. nana*). The higher fauna consisted of relatively dense populations of moose (*Alces alces*), domestic reindeer (*Rangifer rangifer*), and resident lynx (*Lynx lynx*) and wolverine (*Gulo gulo*). Main predators on ptarmigan were red fox (*Vulpes vulpes*), stoat (*Mustela erminea*), and large raptors (golden eagle [*Aquila chrysaetos*] and gyrfalcon [*Falco rusticolus*]). Before winter snowfall, willow ptarmigan resided in the subalpine zone, overlapping slightly with rock ptarmigan, which occupied the alpine zone. In winter, both species used the subalpine birch forest zone (Pedersen and Karlsen 2007). The climate was humid with an average annual precipitation between 1,200 mm and 1,500 mm, and 171 days with precipitation of >1 mm/day. The average temperature was 1.4°C with snow cover of 1–3 m depth during a period of approximately 200 days from October to late May between 1961 and 1990 (Norwegian Meteorological Institute 2016).

# METHODS

### Harvest Regulations

Statskog introduced harvest restrictions after a long tradition of unregulated sale of hunting permits. A new system termed accumulated hunter days (AHD) was introduced in 2009, where 25 hunting blocks were closed to ptarmigan hunting when the hunting effort exceeded 3 accumulated days of hunting/km$^2$. The size of the hunting blocks ranged from 41 km$^2$ to 425 km$^2$ ($\bar{x} = 201$ km$^2$) with an area of 4,130 km$^2$. There was a daily bag limit of 4 ptarmigan/hunter, no annual quota, and no restrictions in the use of dogs. The hunters had to report their daily harvests to Statskogs managers every 10 days of hunting to continue their hunt. Most (92%) hunters reported their harvest under this system.

In 2007, an experimental area of 110 km$^2$ was set aside to test the source-sink system, where dispersal of ptarmigan from high quality habitats with no hunting (sources, refuges) was intended to counteract higher mortality in areas with unrestricted hunting (sinks). In this area, hunting was unrestricted in terms of hunting bags and access within 72% of the area, whereas hunting was banned in the remaining 28%. Three refuges (30.5 km$^2$) were placed within the experimental area of 110 km$^2$ (Fig. 1). Near the experimental area, a control area of 118 km$^2$ had no refuges and no bag limit. In the source-sink experimental area, the hunters had to report their bag 3 times during the hunting season. The hunting season for ptarmigan was open from 10 September to the end of February.

### Hunter Survey

We conducted the survey using 2 data sets. First, we evaluated hunter opinions concerning ptarmigan management based on a structured questionnaire that was distributed to all small-game permit holders after the hunting season (2011–2012) ended. We also used this data set to investigate factors associated with daily and annual bag sizes of the hunters. Second, we used bag records from the years 2009–2011 (i.e., 8,795 hunting days, see description above) to evaluate the potential reduction in harvest that could have been obtained with more restricted seasonal and daily bag limits.

To evaluate the hunters' opinions, we used a digital online questionnaire administered by QuestBack Ask&Act$^{TM}$ (Oslo, Norway). We were granted permission by the Norwegian Data Protection Official for Research (permit 33455) to distribute the questionnaire and obtain information on the permit holders. We distributed the questionnaire (Table 1) to all small-game permit holders by e-mail ($n = 693$) or as a link in a text message ($n = 213$). We used text messages when e-mail addresses were not available. Thirty-six of 942 small-game license holders did not receive the questionnaire because of missing e-mail addresses or cell phone numbers. We sent a notice to optimize response rates prior to the questionnaire as recommended by Dillman (2000), and sent reminders 1 and 2 weeks after the delivery of the questionnaires according to Schaefer and Dillman (1998). Among the 906 distributed questionnaires, 543 were returned giving a preliminary response rate of 60%. After 14 weeks, we contacted 100 of the 362 non-respondents to investigate if their opinions differed from the respondent group. We obtained 27 responses from this group, and chi-squared tests showed that their answers did not differ significantly. We therefore pooled the results from the 2 groups, giving a final response rate of 63% ($n = 570$). Respondents answered categorical questions with a 5-point Likert scale (Likert 1932) from strongly agree to strongly disagree. None of the questions were mandatory. When relevant, the respondents were given the opportunity to answer "I do not know/unknown" or "other, please specify."

The questionnaire was part of a larger survey of hunter satisfaction and opinions about the ptarmigan management system at Statskog. Among 53 primary questions with 33 sub-questions, we selected 9 questions (Q1–9) that were the most relevant for our study (Table 1). These included a question regarding the necessity to regulate hunting pressure (Q1), and opinions regarding different alternatives to regulate hunting pressure (Q2–9). These alternatives included the AHD system (Q2), the source-sink system (Q3), bag reduction (Q4–6), periodic ban of hunting at low ptarmigan densities (Q7), and shortening the hunting season (Q8–9). We selected questions that were specific for this new management system, and excluded questions just relevant for Statskog.

### Statistical Analysis

We used program R for handling all data and analyses (R Version 3.3.0, www.r-project.org, accessed 6 May 2016). We examined factors affecting hunters' opinions towards different harvest regulations and scenarios with generalized linear models (binomial family) using the prettyR package. Response variables were the binary answers (i.e., agree vs. disagree and neutral) to 9 different questions (Table 1). We used the same set of explanatory variables in all full models. These were age, education (years of education), hunting dog

**Table 1.** Parameter estimates and test statistics from generalized linear models of factors associated with attitudes towards ptarmigan harvest restrictions in Nordland County, Norway, 2011–2012. We transformed responses in a 5-point Likert scale to binary response variables (disagree or neutral vs. agree). The explanatory variables were age, hunting dog (whether or not a dog was used during the hunt), target species (willow or rock ptarmigan), bag size (number of ptarmigan shot/day), residency (whether the hunter resided in the same municipality as the hunting area, or in another municipality within the same county, or out-of-county), and source-sink (whether the hunt had taken place in a source-sink experimental area).

| Question[a] | Predictor | Logit estimate | SE | $\chi^2$ | *P* |
|---|---|---|---|---|---|
| Is it necessary to regulate hunting pressure? (Q1) | Intercept | −0.17 | 0.34 | | |
| | Age | 0.02 | 0.01 | 7.06 | 0.008 |
| | Target species | | | 7.16 | 0.007 |
| | Willow ptarmigan | 0.00 | | | |
| | Rock ptarmigan | −1.10 | 0.42 | | |
| Is accumulated hunter days (AHD) a management tool that reduces risk of over-harvest? (Q2) | Intercept | −0.98 | 0.22 | | |
| | Residency | | | 58.81 | ≤0.001 |
| | Local | 0.00 | | | |
| | Regional | 0.20 | 0.26 | | |
| | Out-of-county | 1.51 | 0.26 | | |
| Is the use of refuge areas a management tool that reduces risk of over-harvest? (Q3) | Intercept | −0.64 | 0.09 | | |
| | Source-sink | | | 4.99 | 0.025 |
| | Hunted outside source-sink | 0.00 | | | |
| | Hunted inside source-sink | 0.74 | 0.33 | | |
| Are you willing to accept a seasonal quota of 10 ptarmigan? (Q6) | Intercept | 0.61 | 0.20 | | |
| | Residency | | | 6.68 | 0.035 |
| | Local | 0.00 | | | |
| | Regional | −0.10 | 0.25 | | |
| | Out-of-county | −0.52 | 0.24 | | |
| Should hunting be banned during periods of low ptarmigan density? (Q7) | Intercept | −0.30 | 0.26 | | |
| | Hunting dog | | | 8.04 | 0.005 |
| | With | 0.00 | | | |
| | Without | 0.53 | 0.19 | | |
| | Daily bag | −0.09 | 0.04 | 5.78 | 0.016 |
| | Residency | | | 7.39 | 0.025 |
| | Local | 0.00 | | | |
| | Regional | −0.09 | 0.25 | | |
| | Out-of-county | 0.43 | 0.25 | | |
| Are you willing to accept a 2-week delay in the opening of the hunting season? (Q8) | Intercept | 0.25 | 0.38 | | |
| | Age | 0.02 | 0.01 | 5.34 | 0.021 |
| | Residency | | | 22.72 | ≤0.001 |
| | Local | 0.00 | | | |
| | Regional | −0.05 | 0.27 | | |
| | Out-of-county | −0.96 | 0.26 | | |
| Are you willing to accept that the hunting season is shortened and ends 3 months earlier? (Q9) | Intercept | −0.93 | 0.22 | | |
| | Residency | | | 66.17 | ≤0.001 |
| | Local | 0.00 | | | |
| | Regional | 0.53 | 0.26 | | |
| | Out-of-county | 1.78 | 0.26 | | |

[a] The responses for the questions "Are you willing to shoot fewer birds to increase the ptarmigan population?" (Q4) and "Are you willing to accept a daily bag limit of 1 ptarmigan?" (Q5) were not influenced by any of the explanatory variables we tested.

(whether or not a dog was used during the hunt), target species (willow or rock ptarmigan), daily bag (no. ptarmigans shot/day), residency (whether the hunter resided in the same municipality as the hunting area, in another municipality within the same county, or out-of-county), and source-sink (whether the hunt had taken place in the source-sink experimental area). These variables (except source-sink) had been included in previous Scandinavian studies of hunter performance and attitudes (Asmyhr et al. 2012, Kaltenborn et al. 2012). We excluded gender from the analyses because of the very small number of female respondents. We used backwards selection to identify the most parsimonious model (i.e., a model with only significant terms at $P < 0.05$). We used the lsmeans package to calculate average proportions and 95% confidence limits of the responses.

We used generalized linear models (GLM) to identify factors associated with bag sizes. We obtained the data from the questionnaires, and the response variables were average daily bag of each hunter and total annual bag of each hunter. The explanatory variables were the same as listed in the previous paragraph. We used a quasi-poisson error structure in the models of annual bags because of data overdispersion, and a normal error structure in the models of daily bag size. In the latter, we normalized the response variable using ln-transformation.

## RESULTS

Respondents from the questionnaire survey averaged 46 (range = 17–81, SD = 12.58) and 41 (range = 24–59, SD = 9.00) years of age for men and women, respectively. Only 4% of the respondents were female. Hunters averaged 23 ± 13.68 (SD) years of hunting experience and had completed 13.4 ± 4.36 years of education (equivalent to high school and some college education). Most hunters did not use dogs while hunting (60.5%), and the majority (57.6%) had hunted in the same area for >3 years. Almost all hunted for willow ptarmigan or both species (95.1%), and 4.9% had hunted rock ptarmigan only. Most of the hunters came from Nordland County (59.6%) of which 19.2% came from the municipality they were hunting. Forty (7.0%) of 570 respondents had hunted in the source-sink experimental area.

### Hunter Opinions

Sixty-six percent of the respondents agreed that it was necessary to regulate hunting pressure, 20.0% were neutral, and 14.3% disagreed. Logistic regression models revealed that older respondents were more likely to support regulating the hunting pressure (Table 1). Furthermore, respondents who had hunted only rock ptarmigan were less supportive of regulating the hunting pressure.

The only variable with a significant influence on the opinion on whether AHD reduces risk of over-harvesting was hunter residency (Table 1). Out-of-county hunters residing outside Nordland County were more likely to agree (63% agree, 95% CI = 57–69%) than local hunters residing in the municipality of the hunting blocks (27% agree, 95% CI = 19–37%) and regional hunters residing within Nordland County (32% agree, 95% CI = 26–38%).

The only significant factor influencing the response on the use of refuge areas to reduce risk of overharvest was whether the respondents had actually hunted in areas with this source-sink management practice (Table 1). These hunters were positive (53% positive, 95% CI = 37–67%) compared to other hunters that had not hunted on the experimental source-sink areas (35% positive, 95% CI = 31–39%).

There was a strong willingness to kill fewer birds, if necessary (i.e., 89% agreed). Hence, we found no factors influencing this opinion (Table 1), probably because of the small proportion of neutral (8%) and disagreeing hunters (3%). Only 16% of the hunters were willing to accept a daily bag of 1 bird. None of the explanatory variables had any significant effect on the acceptance of this restriction (Table 1). On average, 58% agreed that a seasonal quota of 10 ptarmigan was an acceptable bag restriction. The most parsimonious model explaining opinions on a seasonal quota included only 1 significant term: the hunter's residency (Table 1). Out-of-county hunters were less likely to agree (52% positive, 95% CI = 45–59%) than local (65% positive, 95% CI = 55–73%) and regional (62% positive, 95% CI = 56–69%) hunters.

Fifty-one percent of the hunters agreed to a prohibition of hunting when ptarmigan densities are low. A significantly larger proportion of hunters without dogs agreed to this statement (55%, 95% CI = 49–60%) than hunters with dogs (41%, 95% CI = 34–49%). Furthermore, local (45%, 95% CI = 35–56%) and regional (43%, 95% CI = 36–50%) hunters were less positive than out-of-county hunters (56%, 95% CI = 49–62%). We also found a significant effect among the hunters regarding the number of birds shot/day. The more birds shot/day, the more likely the hunters would disagree (Table 1).

Sixty-four percent of the hunters were willing to accept a 2-week delay in the opening of the hunting season. Opinions on this restriction depended on the age and residency of the hunters (Table 1). Older respondents were more likely to agree. Furthermore, local (74%, 95% CI = 64–81%) and regional hunters (72%, 95% CI = 66–78%) were more positive than out-of-county hunters (51%, 95% CI = 45–58%).

The attitudes toward closing the hunting season 3 months earlier to avoid over-harvest at low densities differed according to the residency of the hunters (Table 1). A far larger proportion of out-of-county hunters were supportive of this restriction (70%, 95% CI = 64–76%) than local (28%, 95% CI = 21–38%) and regional hunters (41%, 95% CI = 34–47%).

### Hunting Quotas

The questionnaire respondents reported average daily bags of 1.7 ± 2.93 (SD) ptarmigan/hunter and GLMs revealed a significant effect of whether or not a hunting dog had been used (Table 2). Hunters with dogs shot more birds (2.5 ± 3.77) than hunters without dogs (1.3 ± 2.13). None of the other predictor variables had a significant effect. Regarding seasonal bags, the respondents reported an average of 5.8 ± 7.60 (SD) ptarmigan/hunter. Also in this case, the only predictor with a significant effect was whether or not a hunting dog had been used (Table 2). Hunters using dogs shot more birds (8.7 ± 9.47) than hunters who did not use dogs (4.0 ± 5.27).

According to the bag records from the period 2009 to 2011, no birds had been shot in a large proportion of the hunting days ($n$ = 8,795, 67%; Fig. 2). Furthermore, the daily bag limit of 4 birds had been reached in a relatively small proportion of the hunting days (5.8%; Fig. 2). Hence, a pronounced reduction in daily bag limit would have been required to obtain a noticeable reduction in the total harvest. A bag limit of 3 birds would lead to a reduction of <10% and to reduce total harvest by 50%, the bag limit would need to be 1 bird/day (Fig. 3). Furthermore, a large proportion of the hunters (51%) did not shoot a single bird during the whole season, and a small proportion (5%) shot ≥15 birds (Fig. 4). Accordingly, only a relatively small seasonal quota would lead to a marked reduction in the number of birds harvested (Figs. 4 and 5). A seasonal quota of 15 birds would reduce the harvest by only 8.6%, whereas a seasonal quota of 10 birds would produce a 19.2% reduction and a seasonal quota of 4 birds would produce a 48.2% reduction (Fig. 5).

## DISCUSSION

Previous literature suggests that hunters may agree about wildlife management aims but disagree concerning the strategies to accomplish them (Cornicelli et al. 2011). Our study concurs with this inference; the majority of hunters agreed to regulate hunting pressure and shoot fewer birds, if necessary, but the questions focusing on specific alternatives to

**Table 2.** Parameter estimates and test statistics from generalized linear models of factors associated with ptarmigan hunting bags in Nordland County, Norway, 2011–2012. The response variables were daily hunting bags per hunter and seasonal bags (no. birds shot during the season per hunter).

| Response | Predictor | Logit estimate | SE | $\chi^2$ | *P* |
|---|---|---|---|---|---|
| Daily bag | Intercept | 0.93 | 0.05 | | |
| | Hunting dog | | | 27.34 | ≤0.001 |
| | With | 0.00 | | | |
| | Without | −0.34 | 0.06 | | |
| Seasonal bag | Intercept | 2.13 | 0.08 | | |
| | Hunting dog | | | 36.76 | ≤0.001 |
| | With | 0.00 | | | |
| | Without | −0.73 | 0.12 | | |

achieve this outcome revealed more negative opinions and disagreement among the hunters. These results may be partially explained by the relatively short time frame of the management experiments; the AHD and source-sink systems had been introduced only 3 and 5 years prior to the questionnaire survey, respectively. Opinions about the introduced systems in our study may change; introduced hunting regulations have been reported to gain legitimacy over time (Schroeder et al. 2014). Hence, the negative responses may reflect a general skepticism towards unfamiliar management systems. An example of the effect of familiarity with management was revealed in the opinions concerning the source-sink system. In this case, respondents that had actually hunted within these experimental areas were more supportive of the management technique than those that had not.

A relationship between hunting specialization and environmental orientation could potentially explain the more positive attitudes of older hunters to regulate hunting pressure in our study. According to the recreation specialization concept, hunters are assumed to progress over time from novice to expert (Bryan 1977, Donnelly et al. 1986, Ditton et al. 1992). In this process, attitudes, satisfaction levels, management preferences, and hunting bags have been observed to change (Kuentzel and Heberlein 1992, Scott and Shafer 2001). Rather than being bag oriented, more specialized hunters are assumed to be

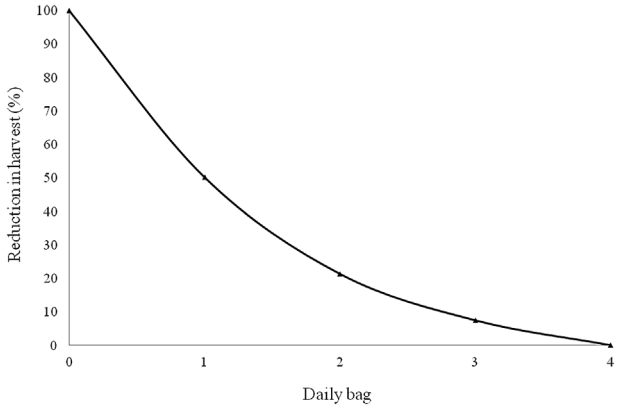


**Figure 3.** Proportional reductions in harvest given daily bag limits from 4 to 0 ptarmigan. The estimates are based on reported bags from 8,795 hunting days on state-owned land in 3 municipalities: Grane, Vefsn, and Hattfjelldal, Nordland County, Norway, during hunting seasons in 2009–2010, 2010–2011, and 2011–2012. We calculated estimates as the ratio between the number of ptarmigan that could have survived given a reduced bag limit ($\sum$ of current bags − $\sum$ of reduced bags) and the number of birds shot with the current bag limit of 4 birds.

motivated by the quality of the experience in terms of social and nature appreciation (Bryan 1977, Kuentzel and Heberlein 1992). Hunting with dogs suggests a high degree of specialization among the hunters. Still, in our study, hunters with dogs shot more birds/day and thus appeared more bag oriented than hunters without dogs. A possible explanation may be that bags are larger simply because hunting dogs find more dead and wounded birds, and not because of a different attitude among the hunters.

In our study, hunter age affected only the opinion about the need for hunting restrictions, but it was not the most important factor affecting opinions about the specific management alternatives. Instead, hunter residency was more important. A study of hunter perceptions and opinions about management of white-tailed deer (*Odocoileus virginianus*) in Minnesota, USA, revealed strong site fidelity among the hunters, and an approval of management strategies that first and foremost secured access to their hunting areas, even if quotas were

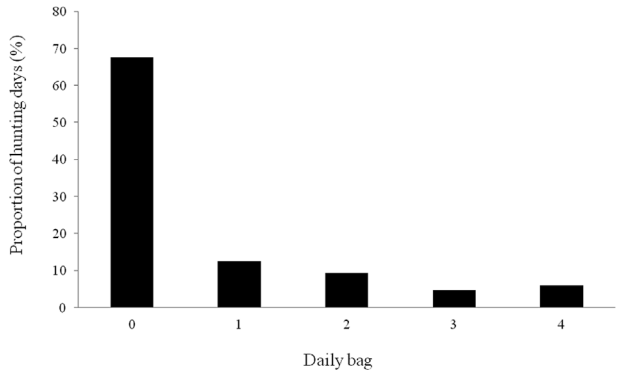


**Figure 2.** Proportions of hunting days with daily bags of 0–4 ptarmigan within areas with an accumulated hunter days management system and daily bag limit of 4 birds. Data are based on reported bags from 8,795 hunting days on state-owned land in the 3 municipalities: Grane, Vefsn, and Hattfjelldal, Nordland County, Norway, during hunting seasons in 2009–2010, 2010–2011, and 2011–2012.

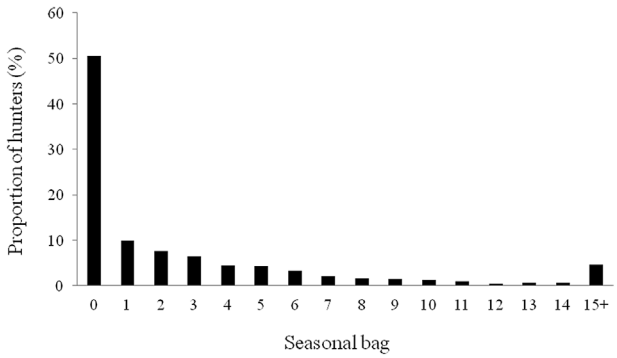


**Figure 4.** The proportion of hunters obtaining bags of 0 to >15 ptarmigan during the hunting season within areas with an accumulated hunter days management system and daily bag limits of 4 birds. Data are based on reported bags from 8,795 hunting days on state-owned land in 3 municipalities: Grane, Vefsn, and Hattfjelldal, Nordland County, Norway, during hunting seasons in 2009–2010, 2010–2011, and 2011–2012.

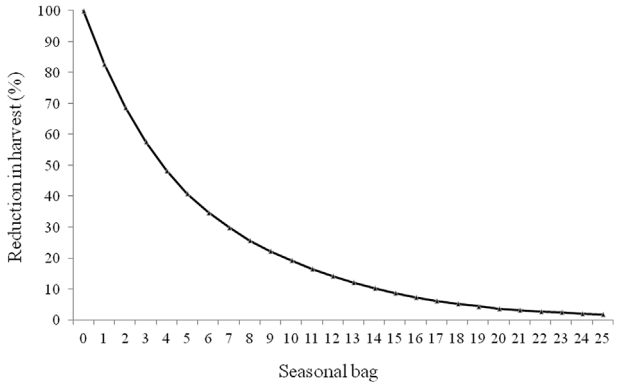


**Figure 5.** Proportional reductions in harvest given seasonal bag limits from 25 to 0 ptarmigan. Estimates are based on reported bags from 8,795 hunting days on state-owned land in 3 municipalities: Grane, Vefsn, and Hattfjelldal, Nordland County, Norway, during hunting seasons in 2009–2010, 2010–2011, and 2011–2012. We calculated estimates as the ratio between the number of ptarmigan that could have survived given a reduced bag limit and the number of birds shot with the current system of no seasonal bag limits.

limited (Cornicelli et al. 2011). In our case, a combination of site fidelity and fear of losing hunting opportunities may also explain the relationship between the opinions about the AHD system and the residency of the hunters. Out-of-county hunters were more positive than local hunters, and the majority of hunters from other counties visit these areas in the very beginning of the season. At this time, most of the blocks are open for hunting, but as time progresses, some blocks are closed for hunting because of the imposed limit of 3 accumulated hunting days per $km^2$. Hence, the restrictions are likely to affect the hunting opportunities of local residents later in the season when few out-of-county visitors are present.

The line of reasoning above may also explain why the residency of the hunters was an important factor determining the opinions towards bag restrictions and shortening the hunting season. Local hunters were more positive towards a 2-week delay in the opening of the hunting season, less positive towards closing the season 3 months earlier, and less positive towards a ban of hunting at low population densities. A 2-week delay in the opening of the hunting season would probably reduce hunting access for out-of-county hunters more than for local hunters, whereas the opposite would be the case if hunting was closed 3 months earlier. Likewise, the difference in attitudes towards a ban of hunting may be explained by higher site fidelity among local hunters.

Results indicate bag size had no influence on the opinions of hunters towards the different systems of harvest restriction. These results may reflect that hunting bags in general were small (i.e., below the daily bag limit of 4 birds). Possibly, the majority of the hunters therefore have no incentive to reduce their own impact on the ptarmigan population. Daily bag limit is a commonly used harvest restriction among managers of ptarmigan hunting in Scandinavia (Asmyhr et al. 2012, Andersen et al. 2014), but its effect on bag size and harvest rates have not been studied before. According to Peterson (2001) and Guthery et al. (2004) daily bag limits are regressive (i.e., harvest rates are only affected at high population densities when they are least needed). Hence, in many cases, daily bag limits will restrain the hunting practice and not affect the actual harvest. In our study area, a substantial reduction in bag limits to only 1 bird would have been needed to obtain a 50% reduction in the harvest, and this low bag limit was not found acceptable by the hunters.

## MANAGEMENT IMPLICATIONS

In our study, we have shown that although most hunters were positive to hunting restrictions in general, it was difficult to find management alternatives that hunters find acceptable and that have an actual impact on harvest rates. Hunter opinions may provide useful guidelines for the development of management practices, but the opinions need to be evaluated in view of the actual effect on the game populations (Peterson 2001). The negative attitudes towards the specific management alternatives may imply that other options should be evaluated. However, it may also reflect insufficient information on the necessity of hunting restrictions and the potential impact of the different restriction alternatives. This is not unexpected, as there is no unified consensus in the Scandinavian scientific community regarding the effect of hunting on ptarmigan populations or concerning which management options are best suited for reducing harvest. An improved knowledge of hunting effects and management options is clearly needed, and this information needs to be effectively communicated to the stakeholders to gain valuable insight into their attitudes towards management alternatives and factors associated with their satisfaction.

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