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ORIGINAL PAPER

The effect of recreational homes on willow ptarmigan (*Lagopus lagopus*) in a mountain area of Norway

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Abstract The increasing development of recreational resorts and second homes in mountain regions worldwide require substantial infrastructure, and have large impact on habitats and ecosystems. We hypothesized that developed areas would attract predators and lead to higher predation on willow ptarmigan and lower their abundance. In a 500-km^2 study area in south-central Norway, we sampled the density of territorial cocks in spring and the breeding success of willow ptarmigan along a 3-km gradient extending out from clusters of cabins. We also sampled red fox scats and corvid birds and measured nest predation on artificial nests across this gradient. Densities of cocks in the spring and of adults and brood sizes in August did not vary along the gradient. However, the density of chicks in August was higher beyond 1.5 km from cabin areas, presumably because more hens lost their clutches in the vicinity of cabins. This was supported by the results from the artificial nest experiment where significantly more nests were depredated near cabin areas than further away. The number of scats of red fox along trails increased with distance from cabins, whereas more corvid birds were observed near cabins. We conclude that corvid birds were the main cause of higher loss of ptarmigan nests near cabin areas, which led to lower production of chicks. Breeding density, however, did not seem to vary along the gradient, presumably because of suitable habitat for breeding and little human activity in these areas during the period of pair formation and nesting.

Keywords Anthropogenic disturbance · Breeding · Willow grouse · Red fox · Nest predation · Small game

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Introduction

Development of recreational resorts and second homes are increasing worldwide and growing rapidly in mountain regions, such as Norway (Martin 2001; UNEP 2001; Nellemann et al. 2007; Patthey et al. 2008). In addition to the human activity, many resorts and second homes are becoming more luxurious and require an extensive infrastructure in terms of sewage, power supply and a road network, infringing upon mountain ecosystems (Bevanger 1998; Vistnes et al. 2008; Nellemann et al. 2009). Several studies have highlighted vulnerability of wildlife to growing human recreational activity and infrastructure in mountain regions (Martin 2001; Arlettaz et al. 2007; Kerbiriou et al. 2009), but there are fewer studies of the effects on predator–prey relationships and small game (Lindsay et al. 2008; Patthey et al. 2008).

In 2007, Norway had a total of 383,112 recreational homes with an average increase close to 5,000 new such homes annually (SSB 2009). Cabins in mountain areas are particularly popular and existing cabin areas are expanding and new areas are opened to meet the demands. This has augmented a concern for the impacts on neighbouring natural ecosystems, yet these potential effects have not received much scientific attention.

One example is the potential effects on willow ptarmigan (*Lagopus lagopus*), which is an important game species in the transition zone between forests and treeless mountains. The very same areas contains the most popular sites for cabins, which implies a negative effect of cabin constructions on ptarmigan both due to habitat loss and human presence *per se*. In addition, several studies have shown that human activity and urbanization increase the abundance of small game generalist predators such as corvid birds (*Corvidae*) and red fox (*Vulpes vulpes*), which are important predators on ptarmigan nests (Erikstad et al. 1982; Parker 1984; Myrberget 1985; Storch and Leidenberger 2003; Watson and Moss 2004). Nest predation on willow ptarmigan is therefore likely to increase leading to fewer birds in the vicinity of cabin areas.

In this study, we measured the effect of recreational homes on willow ptarmigan by studying the density of territorial cocks in the spring, breeding success, the spatial distribution of corvid birds and red fox, and predation on artificial nests, in relation to distance from cabin areas.

Materials and methods

Study area

The study area at Sjusjøen (61° 15′ N, 10° 40′ E) covered approximately 500 km^2 and was located in Hedmark and Oppland counties, south-central Norway. Below the tree line (980 m a.s.l.), the area is dominated by large bogs and forests of birch (*Betula* spp.) and scattered Norway spruce (*Picea abies*), with a field layer of mainly bilberry (*Vaccinium myrtillus*). Areas above the tree line have a belt of willow-species (*Salix* spp.) followed by low-growing dwarf birch (*Betula nana*) and heather (*Calluna vulgaris*). Main ground predators are red fox and mustelids such as stoat (*Mustela erminea*) and least weasel (*M. nivalis*); avian nest predators are hooded crows (*Corvus cornix*) and ravens (*C. corax*). The study area contains some of Norway's largest areas of recreational homes, in total close to 5,700 buildings giving an overall density of 11.4 buildings per square kilometre. Most of these buildings are cabins concentrated in various clusters in the south-eastern parts of the area. The study area contains 4 km^2 of cultivated land, mostly grassy pastures in close vicinity to active and abandoned summer farms. The area provides a gradient in human presence from high densities in the south, via areas with summer pastures and some spread-out cabins, towards more remote areas in the north-east with only a few single cabins and no roads. During summer, hikers, hunters and sport fishermen frequently use the network of foot trails that cover most of the area, and during winter the area is popular for cross country skiing.

Cabin areas and artificial nests

We defined cabin areas as areas where five or more buildings were less than 150 m apart, which resulted in 72 such areas within the study area. The study area was divided into 1-km^2 squares. We randomly selected 1-km^2 squares in equal distance categories from cabin areas. All squares were within an elevation zone between 850 and 1,100 m above sea level with less than 50% bogs or lakes. In most distance categories, adjacent 1-km^2 squares were added in order to increase the sample size. This resulted in a total of 88 1-km^2 squares (Fig. 1). Two artificial nests were created minimum 200 m apart in each of these squares on the forest edge with an in situ estimated canopy cover as close to 50% as possible, allowing up to 10% variance if no better site was within range. Two medium-sized brown eggs of domestic hens (*Gallus gallus*) were placed in the nest on top of coloured wooden golf pegs pressed into the ground. The coloured pegs were not visible before the eggs were depredated. The golf pegs and a GPS position allowed us to relocate the nests even if both eggs were removed.

The 176 artificial nests were created between the 7th and 11th of June 2007 and revisited after 12 days. A nest was considered depredated if one or more eggs were removed or damaged. The artificial nests were not meant to mimic real nests, but were used to assess if nest predation varied with distance from cabin areas. Distances of the artificial nests to nearest building and nearest cabin area were normally distributed (Kolmogorov–Smirnov p values>0.05), and the probability of nests to be predated in relation to the distances to nearest cabin area were tested using binomial regression.

Distribution of corvid birds and red fox

Corvid birds were counted during a 15 min period in early morning between 05:00 and 09:30 from 4th to 6th of July 2007 from an observation point within 35 of the squares spread out in the study area. The number of corvids observed was regressed against distance to cabin areas using a generalised linear model with a poisson link. During searches along 148 km of foot trails in June and July 2007 encountered fox scats were recorded giving an index of the number of scats recorded per kilometre of searched foot path within each 1 km^2 UTM square. All squares with less than 500 m searched foot trails were excluded. This index was then regressed against the distance from each square to nearest cabin area. A linear regression showed that the distance of foot trails in the squares searched for fox scats did not differ with distance from cabin areas ($\beta=-0.11$, $t=-1.05$, $p=0.30$).

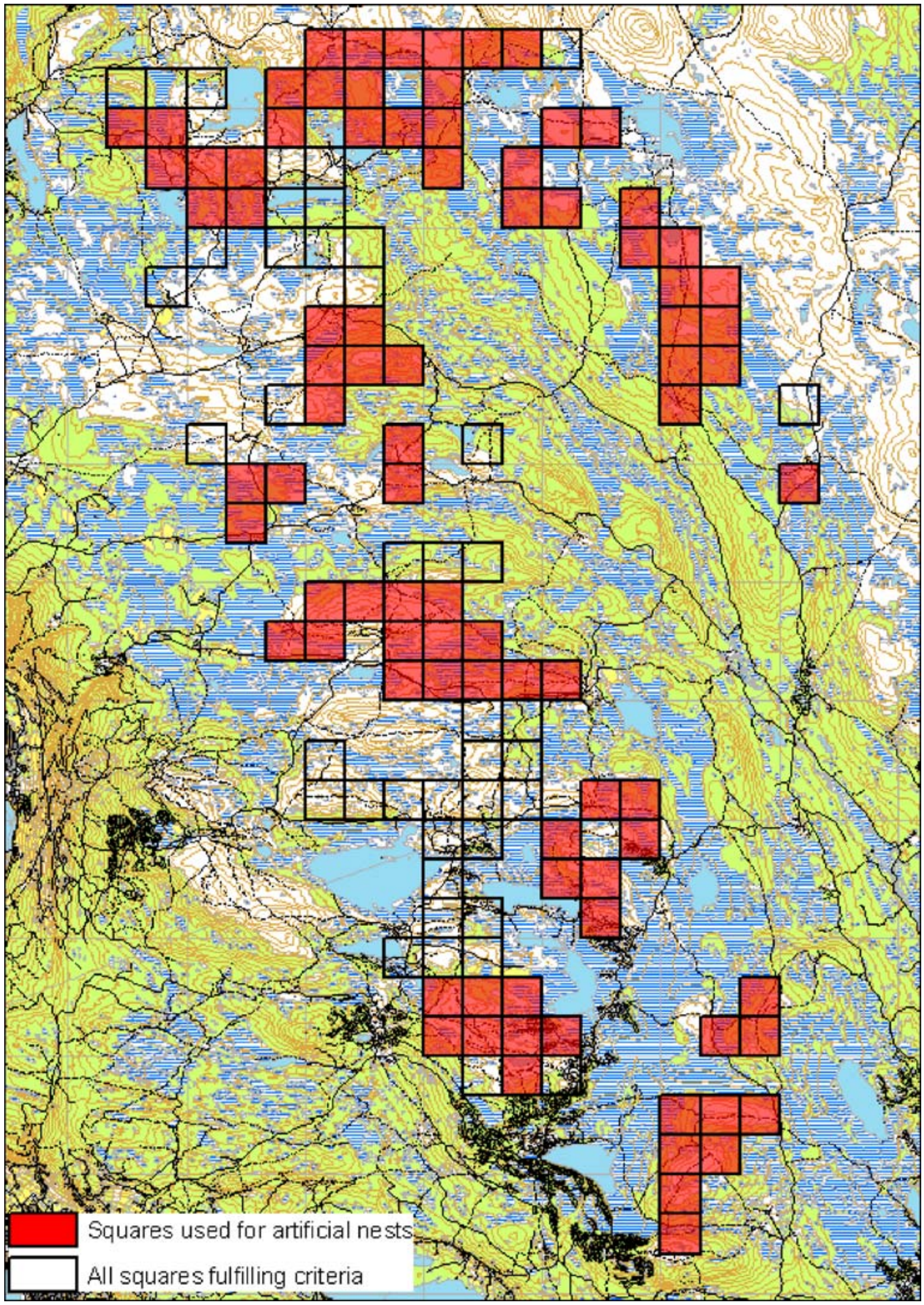

Fig. 1 Map of the study area at Sjusjøen in Norway in 2007 with the sample squares full-filling the selection criterias and used in the study. *Black dots* are buildings, *dotted and black lines* are roads, *green* are forest, *solid* blue are water, *blue* stripes are bogs, *white* is areas above treeline

Distribution of territorial cocks in spring

To estimate the spring density distribution of cocks we selected 35 squares of 1 km^2 that covered most of the study area. In each square, we selected a site at the border between forest and open areas. All sites were visited around sunrise (between 03:15 and 06:30) in the period between 1st and 3rd of May 2007. At each site, we counted how many different cocks we could hear making territorial display calls during 10 consecutive minutes, and how many calls were made in total. The data was analyzed in ArcGIS 9.1 to extract the distance from each site to nearest cabin area. We analyzed the data statistically by linear regression with number of cocks located within squares versus distance to nearest cabin area.

Distribution of broods in August

Distribution and demographic characteristics of willow ptarmigan was investigated between 7th and 19th of August

2007 by experienced hunters with pointing dogs seeking through areas as if they were hunting, trying to locate as many willow ptarmigan as possible. Each hunter was equipped with a GPS generating a detailed track of their movements. All observations were registered with GPS positions, number of birds and demographic composition if possible. The observations were divided into groups of broods and non-broods. A brood was defined as an observation of three or more birds, or two birds if one of them was a chick. The number of adult hens and cocks in observations without demographic data were estimated from their distribution in observations with such data. The data was analyzed in ArcGIS 9.1 to find the distance from each observation to the nearest cabin area, and tested statistically by linear regression with number of birds observed per km transect versus five distance zones to nearest cabin area.

Results

Distribution of willow ptarmigan

In spring, territorial cocks were present in 33 of the 35 1-km^2 squares, and the distribution did not differ in relation to cabin area (β=0.00, t=0.620, df=33, p=0.54) (Fig. 2a). In early August, 116.3 km in 71 km^2 were sampled with pointing dogs, covering the study area fairly well. This resulted in 68 willow ptarmigan observations consisting of 46 cocks, 53 hens and 297 chicks and two unidentified individuals, giving a breeding success of 3.0 chicks per two adults and 5.6 chicks per hen.

The observations were grouped into 19 non-broods and 49 broods. Brood sizes (mean=6.1, SD=3.0) did not differ (β=−0.00, t=0.006, df=47, p=0.57), but the number of chicks observed per km transect with pointing dogs showed a tendency to increase with distance from cabin areas (β=1.03, t=2.46, df=3, p=0.09) (Fig. 2b). This was not due to a higher density of adult birds further away (β=0.42, t=1.31, df=3, p=0.28), but seemingly because there were more broodless adult birds nearer the cabin areas (Fig. 2b).

Five hens did not have chicks, all of them were observed less than 1.5 km from nearest cabin area. Here, 38 successful broods were found. This indicates a maximum nest predation rate of 11.6%, assuming that all broodless hens observed in August had attempted to nest but had lost their clutches before hatching. Beyond 1.5 km all hens had broods.

Distribution of corvid birds and red fox

A total of 23 corvid birds, mainly hooded crow (*Corvus corone*), were recorded in 8 of 35 squares (Fig. 2c) and the number of corvid birds observed decreased with distance from cabin areas (β=−0.0006, z=−2.31, df=34, p=0.02). A total of 172 fox scats were recorded along 144 km of searched foot trails in 113 km squares (Fig. 2d). The mean frequency was 1.2 scats per km. A linear regression showed a significant higher fox scat index with increasing distance from cabin areas (β=0.16, t=4.21, df=3, p=0.01).

Artificial nest predation

A total of 111 of the 176 artificial nests were depredated, giving a total predation of 63% (Fig. 2e). Both eggs were predated in 106 of the nests. The probability for a nest to be depredated decreased with distance (m) to the nearest cabin area (β=0.0005, z=−3.035, df=175, p=0.002).

Discussion

The densities of territorial cocks in spring and adults (both sexes) in August were not lower near cabin areas than further away. However, within a distance of 1.5 km of cabins, chick production was lower probably due to a higher proportion of broodless hens. Egg predation typically causes a total loss of the clutch, whereas chick predation is usually only partial, leading to a reduction in brood size (Myrberget 1988). As brood sizes did not vary across the gradient from the cabin areas, this strongly suggests that nest predation was the main cause of the lower chick production there.

This interpretation is supported by the higher predation on artificial nests closer to cabins. Because the number of scats of red foxes increased with distance from cabin areas, thus indicating no preferential activity near cabins in June and July, red fox was probably not the cause of the skewed nest predation pattern. Corvid birds usually remove all eggs from the nests (Fjeld and Sonerud 1988), like we found in our study. Thus, since the number of corvid birds increased closer to cabin areas, and eggs in artificial nests are robbed mainly by visually hunting predators (Storaas 1988; Willebrand and Marcström 1988), and corvid birds are known to be attracted to areas of human activity (Myrberget 1985; Storch and Leidenberger 2003; Watson and Moss 2008), we conclude that the higher nest predation near cabins was caused by corvid birds rather than by mammalian predators. Corvid birds are well-known predators of willow ptarmigan nests (Myrberget 1985; Schieck and Hannon 1993; Watson and Moss 2008).

In some years, stoats are also important nest predators (Parker 1984; Myrberget 1985). The species is a rodent specialist and track the distribution of such prey (Korpimäki et al. 1991). Thus, if the abundance of small rodents was higher around cabin areas during this study, predation by stoats could also have explained the skewed spatial predation

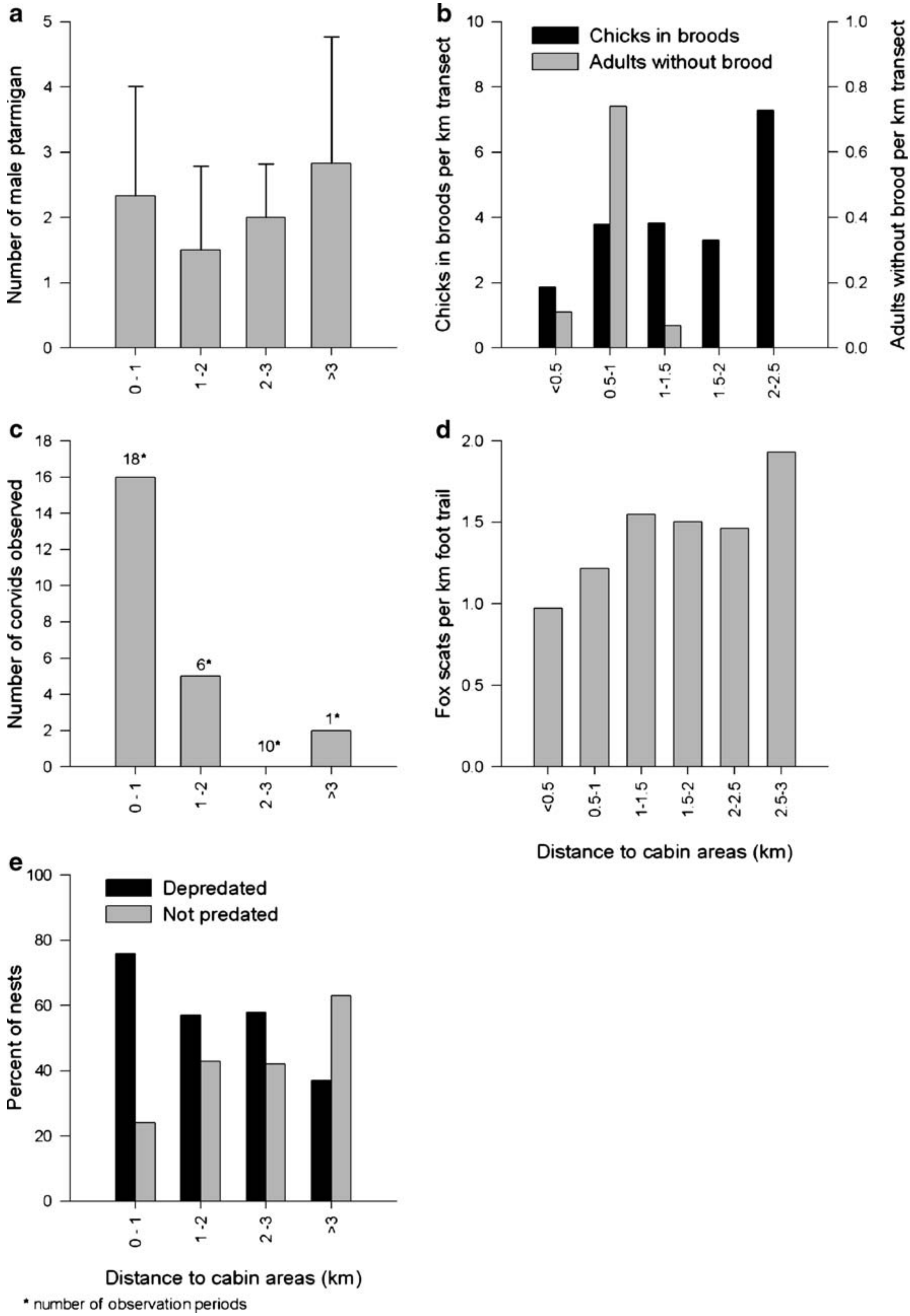

Fig. 2 Mean number of territorial willow ptarmigan cocks (± SD) (**a**), willow ptarmigan chicks and adults without broods per kilometer transect using pointing dogs (**b**), number of corvids observed (**c**), mean number of red fox scats per km foot trail (**d**), and percent depredated and not predated artificial nests (**e**), in distance zones from the nearest cabin area at Sjusjøen in Norway in 2007

pattern on artificial nests. However, in August the overall abundance of microtine rodents was high, but the relative abundance was not higher near cabin areas then elsewhere in the study area (Heid 2008). With high availability of microtine rodents, the egg predation should be reduced because the most efficient egg predators such as stoats and red foxes have more of alternative prey. This also supports the hypothesis that the higher artificial nest predation close to cabins were mainly caused by corvid birds.

Breeding density did not seem to be affected by the cabins as there were just as many territorial cocks close to cabins as further away. Presumably, most of these cocks paired with hens and attempted to raise chicks. Territorial behaviour, pair formation and nesting take place shortly after the Easter holidays when there is very little human activity in and around the cabin areas, and habitat quality for breeding appeared to be equally good close to cabins as further away. This combination of suitable habitat and minimal human activity at the time of breeding initiation might explain why the density of breeding birds was unaffected by the presence of nearby cabins. The absence of a gradient in the breeding population in our study area could be due to a rescue effect in ptarmigan (Martin et al. 2000; Martin 2001), where the population of breeding birds close to cabin areas might have been kept relatively stable, despite the higher predation on nests and chicks, because of immigration from nearby areas.

Willow ptarmigan typically produces ten eggs in one clutch per year (Myrberget 1988). The mean breeding success of 5.6 chicks per hen across the whole study area, or 5.8 chicks per hen beyond 1.5 km from the cabin areas, indicates relatively high production, comparable to what was found in a regional census of 13 areas with 658 ptarmigan observations that year (Norskog 2009). The maximum proportion of nests that was depredated within 3 km of the cabin areas was less than 10%, which is much lower than in an average breeding year (Myrberget 1985). Thus, predation on eggs (and chicks) was quite low during the year of this study. This might explain the weak statistical relationship observed. In years with a higher and more "normal" predation pressure, the difference in breeding success between cabin areas and further away might possibly be more accentuated. If recreational homes are built in or nearby good willow ptarmigan breeding areas, local breeding success is therefore likely to be suppressed more than recorded in this study.

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