Preface

I would like to express my sincere gratitude to Geir A. Sonerud for excellent supervising throughout this study. Many a time he managed to calm me down when I thought there was more than one good reason to panic. Furthermore I would like to thank Gunnar Nyhus for his dedication in teaching me how to track the owls and making sure I was comfortable in the field. Visits by friends and family kept me sane throughout the fieldwork. Lastly, I want to thank Stephen Bryne and Christine Bryne for reading my drafts and improving my language.

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Abstract

I studied the home range and behaviour of 11 Ural Owls *Strix uralensis* over a period of eight weeks during the breeding season in 2008. Mean 100 % MCP home ranges were 1.7 km^2 for females breeding, 4.6 ± 3.0 km^2 for females not breeding, 3.6 ± 2.0 km^2 for all females, 8.4 ± 0.2 km^2 for males breeding, 5.09 ± 3.6 km^2 for males not breeding and 7.4 ± 0.8 km^2 for all males. Mean 95 % MCP home ranges were 1.4 km^2 for females breeding, 3.6 ± 2.3 km^2 for females not breeding, 2.9 ± 1.5 km^2 for all females, 5.7 ± 1.7 km^2 for males breeding, 3.2 ± 1.1 km^2 for males not breeding and 4.8 ± 0.9 km^2 for all males. Males had on average larger home ranges than the females, but this result was affected by the breeding behaviour of two of the females. There was a fairly large degree of overlap between individuals in a couple when considering that 2008 was a poor vole year. Home range sizes were affected by how frequently the individuals had been located, the sex of the individual and the proportion of forest class 1-2 within the home range. The probability of hunting behaviour increased with solar height and cloud cover and decreased with perch height. Perch heights were affected by whether the owl was hunting or roosting, the type of perching post and the height of the forest. The timidity of the owl decreased when located in wet coniferous forest, at denser forest structure and at increased perch heights.

Contents

Introduction

Home range sizes, home range characteristics and territoriality are important factors to study for most species that make their homes in habitats exploited by humans. It is crucial knowledge for the correct application of management techniques. When discussing territory and home range I have used the definitions explained by Burt (1943). Home range was in his paper defined as the entire area within the landscape utilised by the animals when performing normal activities, such as food gathering, caring for young and mating. Territory on the other hand is defined as the area which the animal protects. For territorial animals the size of their home range may vary according to their sex, age and season (Burt 1943). For Tawny Owls, however, it is more likely that the amount of suitable habitat or availability of resources within the home range will determine the size (Eldegard 1996). If this applies to the Ural Owl, then a home range which contains many bodies of water or a large amount of agricultural fields would probably be larger than one consisting of forests intercepted by peatland or clear-fellings. This is an aspect which will be explored in this study.

Radio-telemetry is a method of studying birds which has been extensively used throughout the last two decades (e.g. Bolin et al. 1991; Carey et al. 1989; Carey et al. 1992; Ganey et al. 1999). It provides a manner of locating birds which is relatively precise and uncomplicated when compared to other methods like auditory censuses (e.g. Sidorovich et al. 2003), observing ringed birds (e.g. Vrezec 2003) or analysing traces in the nests (e.g. Pietiainen 1989). As for any method used to study animals, radio-telemetry is not flawless. Rooney, Wolfe *et al.* (1998) pointed out that the level of autocorrelation was fairly high when using radio-telemetry. They illustrated how many factors owing both to the animal's behaviour and to short-comings in the statistical analysis may cause autocorrelation. However, autocorrelation may also occur using other methods. In order to compare the results generated with other studies conducted on Ural owls, I have reasoned that radio-telemetry is the best method of studying home range and territoriality for this study.

The Ural Owl's (*Strix uralensis*) distribution stretches over the entire northern Eurasian area, from Japan in the east to Scandinavia in the west (Cramp 1985). They are associated with the northerly coniferous forests, but occur even in Central Europe's mountainous regions and in isolated places in China (Svensson et al. 1999). The owls have a considerable total population size with 110 000 to 280 000 individuals in Europe alone (IUCN 2007). In Fennoscandia the owls also occur at fairly high numbers with 3000 pairs in Sweden and 700 pairs in Finland as recorded in 1985 (Cramp 1985).

The Ural owl is often described as a larger, paler version of the Tawny owl (*S. aluco*) (e.g. Petterson 2002). On average females weigh 871 g and males weigh 720 g (Mikkola 1983), which makes it larger than the Tawny owl, but slightly smaller than the Great Grey owl (*S. nebulosa*). The Ural Owl is a sedentary and territorial owl and will not leave its territory even if the primary prey is scarce (Mikkola 1983). The Ural Owl's primary food source is the bank vole (*Clethrionomys glareolus*) and different species of *Microtus* voles. However, it will also readily feed on other small mammals (Mikkola 1983; Sidorovich et al. 2003). Although the owl is considered to be a generalist, it has in numerous studies shown a cyclic reproduction pattern which corresponds to the cyclic population pattern of its preferred prey (Brommer et al. 1998; Brommer et al. 2002; Solonen 2004; Sundell et al. 2004). This suggests that it is fairly dependent on the availability of suitable prey, if not for survival, at least for reproduction. It is possible that the size of the owls' home ranges or territories are affected by availability of prey and that the sizes may vary from season to season according to the cycle of the prey's population. For instance it may include greater areas of bog or mire if the vole population is low and it needs to hunt bog dwelling animals, such as frogs.

Although availability of prey is often thought of as the predictor of owl abundance, Lundberg and Westman (1984) claimed that the limiting factor for Ural Owls is the scarcity of nest sites as a result of forest management in Central Sweden. The Ural Owl prefers to build their nests in hollows found in old trees or tree stumps, often using pines *Pinus sylvestris*, aspens *Populus tremula* or birches *Betula* spp. (Lundberg & Westman 1984). Besides stump nests Ural owls also occasionally use old nests of other birds, and to an increasing degree, nest boxes provided by humans (Cramp 1985). Lundberg (1981) found that in his study area in Central Sweden as much as 35% of established territories lacked suitable nest sites. The owls inhabiting the territories had been staying for years in an area without the possibility of breeding. This illustrates the strong sedentary behaviour of the owl, but also the lack of natural nest sites available for the owls. In all the territories lacking nest sites, the owls readily started using nest boxes when these were offered. In the same study Lundberg and Westman (1984) argued that the supply of nest boxes only partially compensate for the loss of natural stump nests, and that forest management may be a factor hindering the expansion of the population. If the provision of nest boxes makes the owls less dependent on a certain type of forest, there is a possibility that the proportion of different habitat types within the home ranges are changed. As previously mentioned, the Ural Owl is associated with coniferous forests (Bolin et al. 1991; Solheim 1994; Svensson et al. 1999), but it will also use mixed forests where nest sites are more available (Lundberg & Westman 1984). Bolin, Fuglsang *et al.* (1991) found that the most important habitat types during the breeding season were old coniferous forests and peatland, both in terms of proportion of these in the home range, and in terms of location of the owl within the home range. However it should be noted that this study only observed one individual during one breeding season and that preferences could vary between individuals and seasons. Although coniferous and mixed forests are largely agreed to be the Ural Owl's preferred habitat, there is also evidence demonstrating its use of clear-fellings and open peatland (Bolin et al. 1991; Lundberg 1980). In some habitat studies for Ural Owls it has been demonstrated how the owls showed preference for extensively cultured land and could even take up residency in parks in the middle of cities (Cramp 1985). However later studies have revealed that this preference is weak and that the Ural Owl is more likely to avoid human settlements than for instance the Tawny Owl (*S. aluco*) (Lundberg 1980; Mikkola 1983; Vrezec & Tome 2004). Further exploration into this field will help to strengthen these findings.

Using radio-telemetry I will try to answer the following questions: 1) What are the sizes of the home ranges of Ural Owls in Värmland county in Sweden and what degree of overlap is there between individuals? 2) Does the size of the home range vary according to habitat components or availability of prey? 3) What factors affect normal behaviour of Ural owls?

Methods

Study area

The field work was conducted in Torsby municipality, Värmland county in Sweden (60°10'N - 60°35'N, 12°40'E - 13°38'E), where a total of 17 Ural owls have for a previous study been equipped with radio transmitters (Biotrack, UK). The radio transmitters had been fitted as a backpack weighing 17 g for the males and 23 g for the females (2.1 % and 2.3 % of body mass, respectively) (Fredriksson 2008). This is an appropriate way of equipping owls with transmitters due to their sit-and-wait form of hunting. Considering that the owl delivers prey that weigh from < 1 g to on average 26 g (Rønning 2007), it is fairly safe to assume that the backpack was not a hindrance to its performance of normal activities. From the previous study where 20 owls were radio-tagged (Fredriksson 2008) (17 of which belonged to my study area) a total of two owls were confirmed to have died (own observation), and this is to be expected according to normal death rates for adult Ural owls in Sweden (Cramp 1985). In addition, three of the owls were confirmed to have lost their transmitters (one of which we knew was still alive as she was hatching during my field study). The last owl was lost during winter, and we are not sure what happened to it. Thus, 11 owls were available for study in 2008 (table 1). The study area is about 382 km^2 and the vegetation is typical for the mid- and south boreal vegetation zone and consists of coniferous forests intercepted by areas of bog and mires (Helmfrid 1996). Due to a certain level of forestry there is a considerable amount of clear-cuts and all stages of forests can be found in the area. However, unlike many other places where there is a history of forestry, one can also find areas of natural old forest where naturally occurring forest fires have been the only controlling and forming factor for the vegetation (Nyhus & Mæhlen 2003).

Table 1: Overview of Ural owls studied, their codes used in the study and whether or not they were nesting.

Location	Male code	Female code	Nesting
Flybäcksåsen	M11	F01	No
Kårebol	M13		No
Granberg		F05	No
Fastnessäteren	M16	F06	Yes
Svarttjern		F10	Yes
Flybäck	M17	F07	No
Fäbroslogarna	M18		Yes
Varmestad		F09	No

Radio-tracking

The field study was conducted from 29 May until 31 July 2009. I used the Biotrack Sika receiver and Biotrack yagi antenna to locate the owls. First I deducted the approximate location by using triangulation from the roads. Then I parked at the closest possible spot and proceeded by foot to find the exact location.

Once an owl was located, I noted the position using a GPS (Global Positioning System) receiver, date and time, temperature (°C), precipitation (none, slightly, much), wind speed (none, slightly, much), cloud cover (clear, 50 %, overcast), behaviour (hunting or roosting), perching post (spruce, pine, birch, other), perch height (m), fright distance (m), forest type (dry coniferous, moist coniferous, wet coniferous, dry deciduous, moist deciduous, wet deciduous, mire, other), dominating tree (spruce, pine, birch), forest height (m), age (forest age classes 1-5 and whether it was natural or planted), structure (open, medium, dense), distance to open habitat (m), distance to wet habitat (m) and finally additional comments. The habitat factors were recorded using a checklist.

I tracked each individual throughout the 24 hour cycle excluding the two darkest hours around solar midnight (00.00-02.00 am local summer time) when tracking became inefficient to minimize autocorrelation. I left at least six hours between each attempt at locating any one individual. On a couple of occasions I followed an owl I had just noted the location for in order to get an idea of how far they fly when startled. In these cases, when I noted the second location, I only noted the coordinates, as the habitat choice would have been affected by my presence. I acquired a total of 323 locations, divided between 11 individuals. However as two of the females were mostly sitting in their nesting boxes, some of the recordings will be excluded in the various statistical tests.

Statistics and home range analysis

I estimated the home range using the Minimum Convex Polygon (MCP) method. I did this using ArcView GIS 3.2 (ESRI, 1996). I calculated 100 % MCP as well as 95 % MCP so that the effect of outliers could be estimated. Figures and tables concerning the home range calculations were produced in Microsoft Excel (2003). I did all statistical calculations in JMP 4.0 (SAS, 2000). Means are reported with standard error.

I first examined the relationship between the home range size and number of locations per owl. I then determined 100 % and 95 % MCP home range for breeding females, females not breeding and all females and breeding males, males not breeding and all males. Territoriality was examined by the degree of overlap (percentage of male territory in female territory and vice versa for each of the three couples). Then I calculated what determines the size of the home ranges, what determines whether a Ural owl is hunting or not, what determines their perch height, and what determines how close the observer can get to an individual before it takes flight. The behaviour of the owls studied were defined as hunting when it was constantly changing position, caring for offspring when it was sitting in the nest box or perching nearby showing aggressive behaviour upon confrontation, and resting if it was neither hunting or caring for offspring. When, on a few occasions, the owl suddenly disappeared before it was located, I assumed that it had flown back to its nest with prey. I did not in these instances note down any positions but rather relocated the owl after a few hours.

For determining the variables that affect home range size I used a stepwise regression test in which backwards elimination was used to disregard the insignificant variables. By using AIC values the variables that caused ΔAIC > 2 were chosen to be tested individually. For determining the variables affecting hunting behaviour I used a nominal logistic regression test. In this test the recordings in which the owl was caring for offspring were excluded. For determining the variables affecting perch height and fright distance, I again used a stepwise regression test with backward elimination. Again the variables were chosen by looking at which caused ΔAIC > 2 and then tested individually.

Results

Home range: Size in relation to number of locations

The size of the home range may be affected by several factors. However, one factor which much be addressed is the frequency of observations and how this affects the size. As the focus was on the males in this study, they have been located more frequently (mean 39.8 ± 1.07) than the females (22.4 ± 2.58). The female F10 has been excluded from the home range calculations as she spent a considerable amount of time within the nest box, and after the young had left the box, they still did not venture very far from it. Her home range is thus disproportionately small, and including her would have skewed the results.

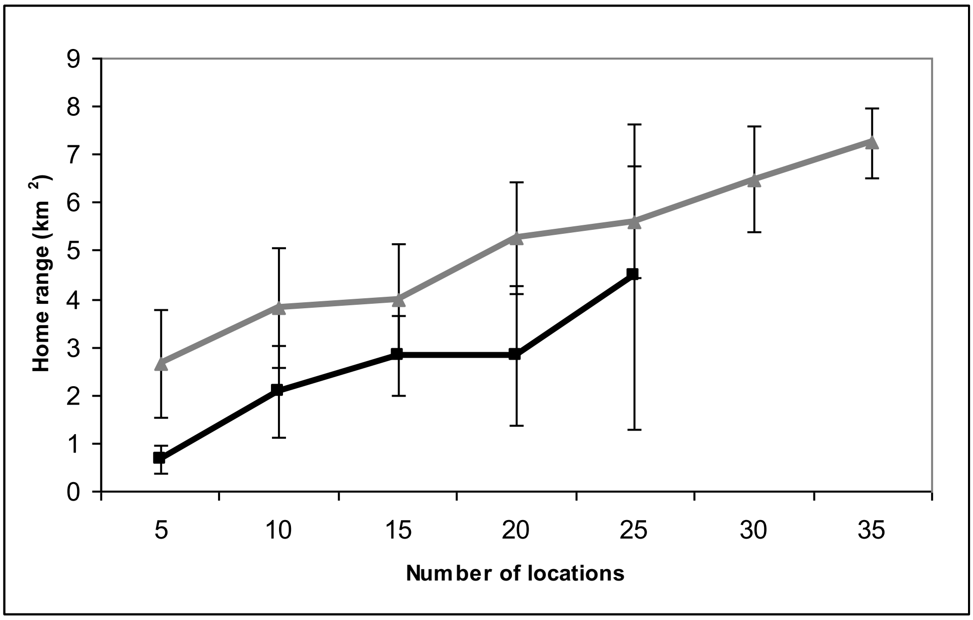


Figure 1. Estimated 100 % mean (± SE) home range size of male (grey line) and female (black line) Ural owls as a function of number of locations. Sample size was 5 for males, and 5 for females, except at 20 locations (3 females) and 25 locations (2 females). Female F10 was excluded from this graph on the basis of her home range being limited by her nesting behaviour.

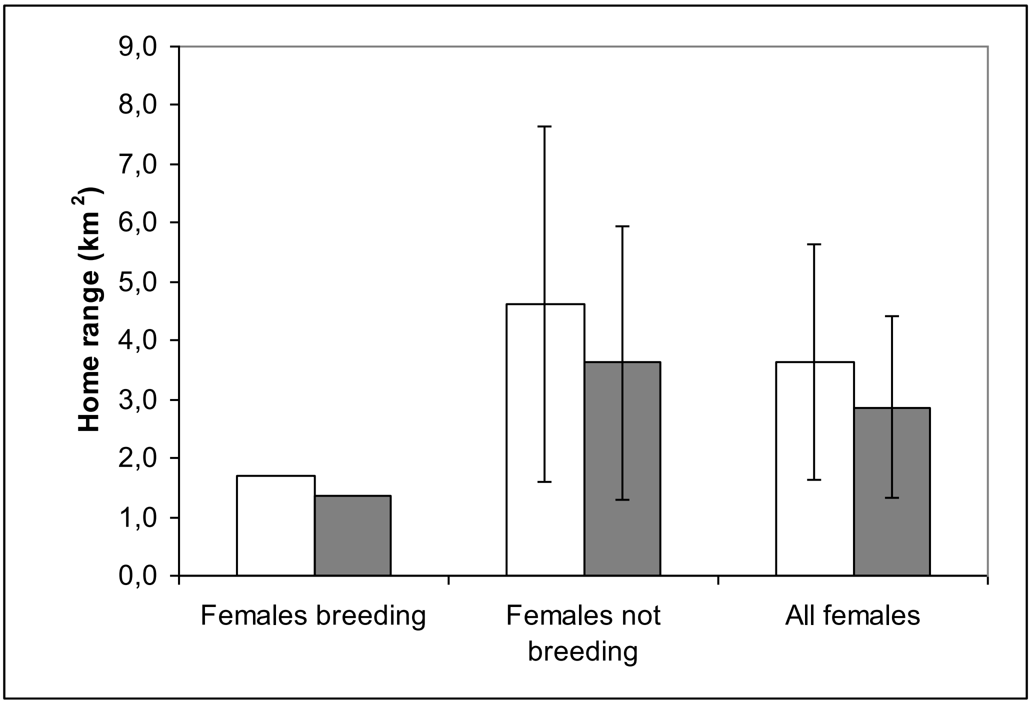
Neither the males' nor the females' home range size levelled off as a function of number of locations. It is therefore viable to assume that the full extent of each home range was not found during the eight weeks of field study. The females' home ranges have a distinct increase from 20 to 25 locations. This is probably due to the sample size being reduced to include just two owls at 25 locations. One of these females had a distinctly larger home range than the others. The males' home range sizes increase more steadily, and at 35 locations had a mean of 7.24 ± 0.74 km^2.

Home range: 100% and 95%

Both for 100% and 95% MCP home range the males used a larger area than the females (figs. 1 and 2). However, when excluding the individuals that were breeding (*i.e.* female F06 and males M16 and M18), the difference is less distinct (fig. 2). There is also a notable difference between the sexes in the difference between 100% and 95% MCP home ranges. The difference between the two is greater for the males than the females, whether or not the breeding owls are included (fig. 2).

For females, mean 100% MCP home range was 1.7 km^2 for the one breeding, 4.6 ± 3.0 (range 1.6 - 7.7) km^2 for those not breeding and 3.6 ± 2.0 (range 1.6 - 7.7) km^2 for all (fig 2 a). The corresponding values for males were 8.4 ± 0.2 (range 8.3 - 8.6) km^2 for those breeding, 5.09 ± 3.6 (range 4.4 - 8.4) km^2 for those not breeding and 7.4 ± 0.8 (range 4.4 - 8.6) km^2 for all (fir 2 b). For females, mean 95 % MCP home range was 1.4 km^2 for the one breeding, 3.6 ± 2.3 (range 1.3 - 6.0) km^2 for those not breeding and 2.9 ± 1.5 (range 1.3 - 6.0) km^2 for all (fig a). For males these values were 5.7 ± 1.7 (range 4.1 - 7.4) km^2 for those breeding, 3.2 ± 1.1 (range 2.7 - 6.3) km^2 for those not breeding and 4.8 ± 0.9 (range 2.7 - 6.3) km^2 for all (fig 2 b).

a)



b)

Figure 2 Mean (± SE) 100 % (white bars) and 95 % (grey bars) MCP for a) females breeding (n = 1), females not breeding (n = 2) and all females (n = 3), and b) males breeding (n = 2), males not breeding (n = 3) and all males (n = 5). Females F05 and F09 were excluded as the number of observations were too low to calculate 95 % MCP.

Home range: Overlap and territoriality

Overlap between 100 % and 95 % MCP home ranges occurred mostly between paired individuals (fig. 4). The only exception was the male M18 whose 100 % MCP home range slightly overlapped with that of the male M17 (1.7 %) and the female F07 (2.2 %). Generally the females had a large proportion of their home ranges within the males' home ranges. Mean male home range overlap with female home range was 45.1 ± 20.4 (range 19.6 – 85.5) % for 100 % MCP home range and 49.3 ± 18.7 (range 27.8 – 86.5) % for 95 % MCP home range. Mean female home range overlap with male home range was 92.2 ± 5.2 (range 82.5 – 100.0) % for 100 % MCP home range and 89.9 ± 6.1 (range 78.7 – 99.7) % for 95 % MCP home range.

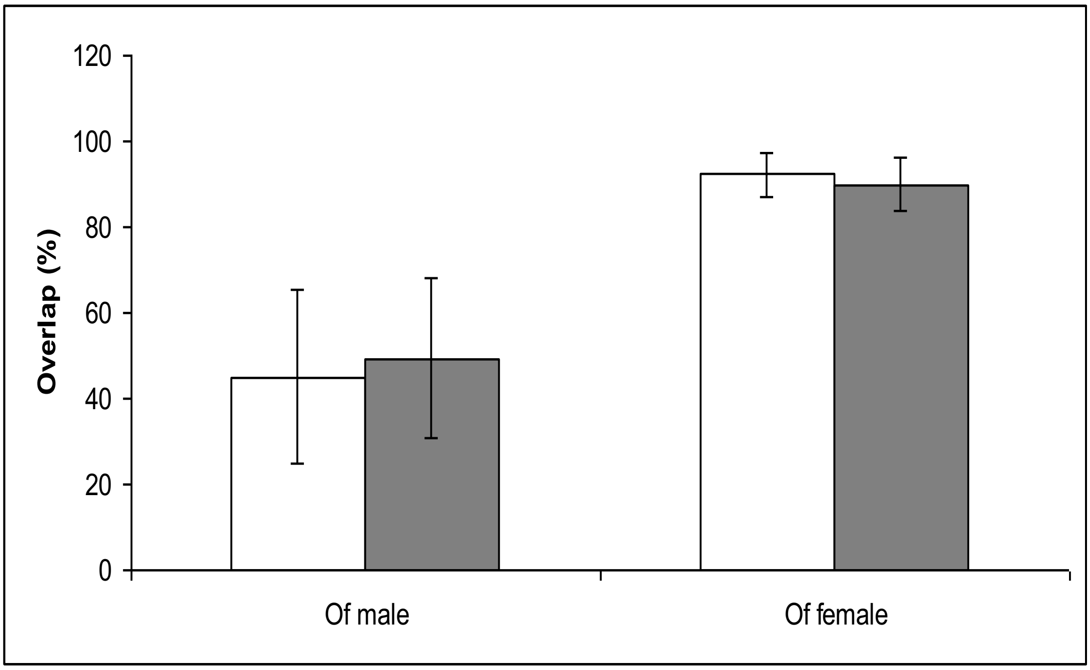


Figure 3. Mean (± SE) overlap (%) between overall home ranges of Ural owls mates (n = 3), as proportion of the male's home range (left) and the female's home range (right). White bars represent 100 % MCP home range and black represent 95 % MCP home range.

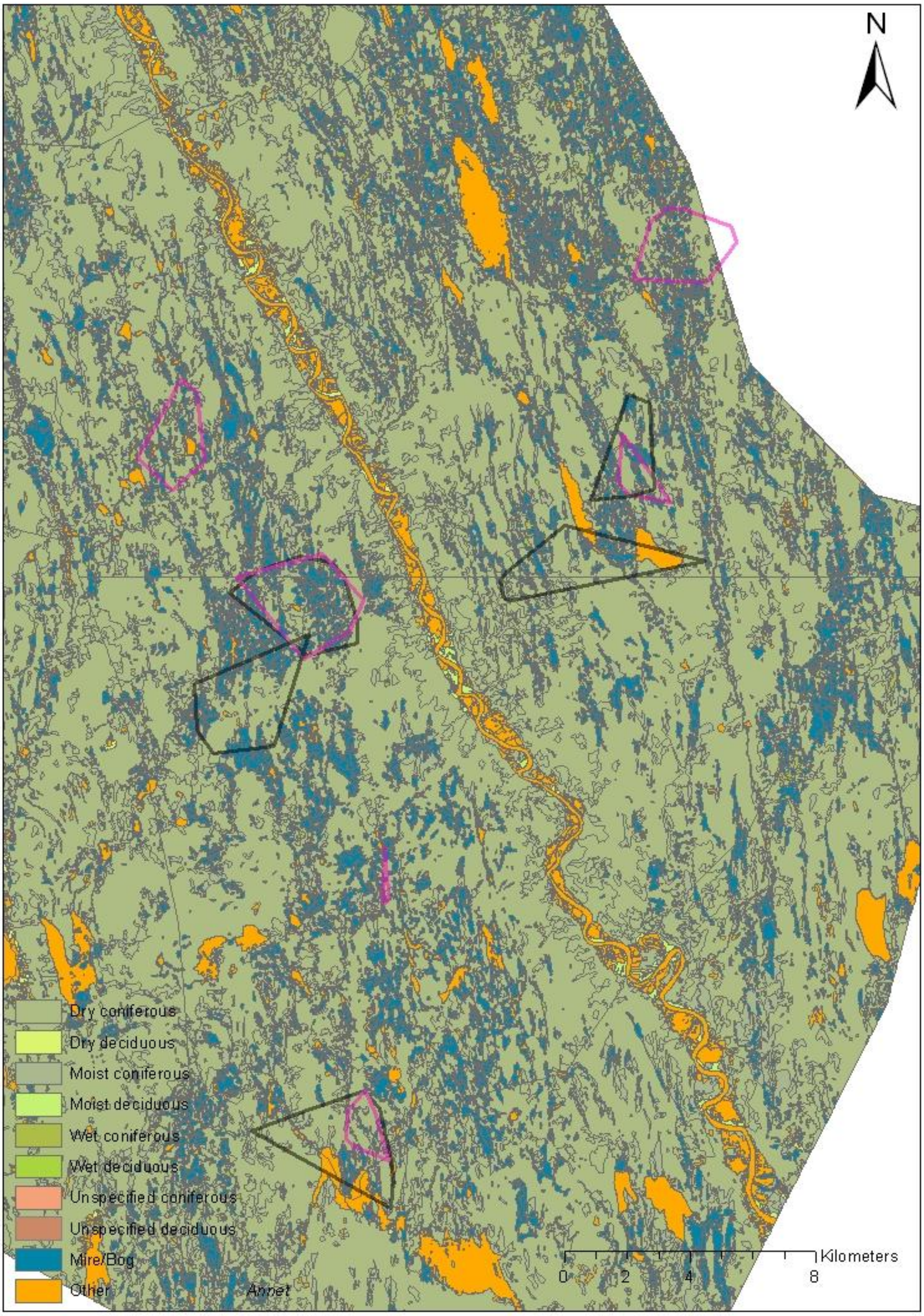


Figure 4. Map of study area showing 100 % MCP home ranges for males (black outlines) and females (purple outlines

Variables affecting home range size

Variables determining home range size were found using a stepwise regression model. Potential variables tested were as follows: number of locations, sex, proportion of vegetation types in home range and proportion of forest stages in home range. Vegetation types included dry coniferous forest, moist coniferous forest, wet coniferous forest and mire/bog. Forest stages were divided into five, where forest stage 1 and 2 were pooled into one classification, forest stages 3, 4 and 5 were classified separately, and mires encompassed the remaining area. Of these, number of plots, proportion of forest class 1-2 (clear cut and plantations), and the owl's sex determined home range size (table 2). The home ranges increased as the number of locations increased (fig. 6) and as the proportion of forest stage 1-2 decreased (fig. 6). Males had significantly (t = -2.30, p = 0.051) larger home ranges than females (mean 7.4 ± 1.0 and 4.2 ± 1.0 respectively) (figs. 1 and 2).

Table 2. Stepwise regression model for variables affecting 100 % MCP for all Ural owls studied excluding F10 (n=10). Cumulative variables are given for R^2 and AIC. The remaining values are from the whole model. Variables were selected by backward elimination.

Variable	df	Regression coefficient	SE	R^2	P	AIC
Intercept		-1.31	2.42		0.61	20.81
Number of locations	1	0.40	0.088	0.44	0.0038	17.05
Forest stage 1-2	1	-0.48	0.082	0.80	0.0011	8.61
Sex	1	2.58	0.88	0.92	0.027	1.80

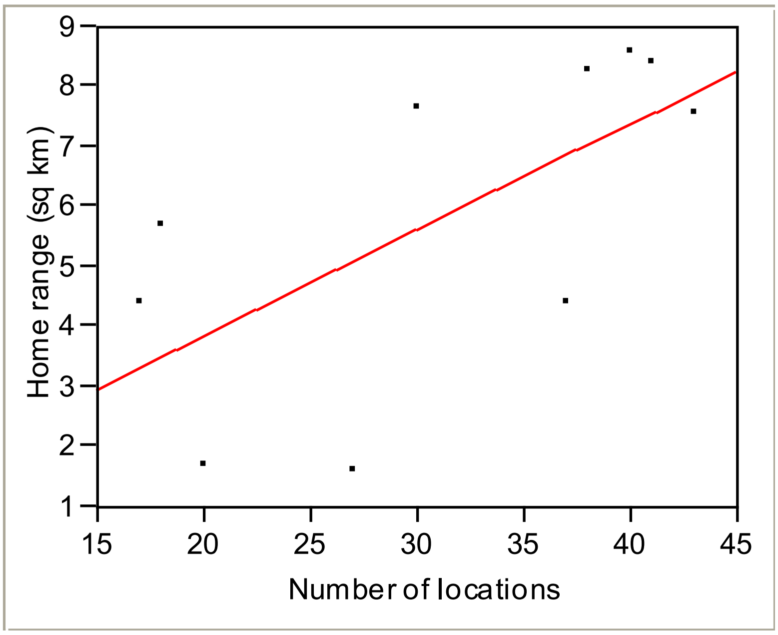


Figure 5. Size of home range in relation to number of locations of ten Ural owls (n = 10, df = 1, $R^2 = 0.44$, t = 2.50, p = 0.037). Y = 0.18x + 0.30.

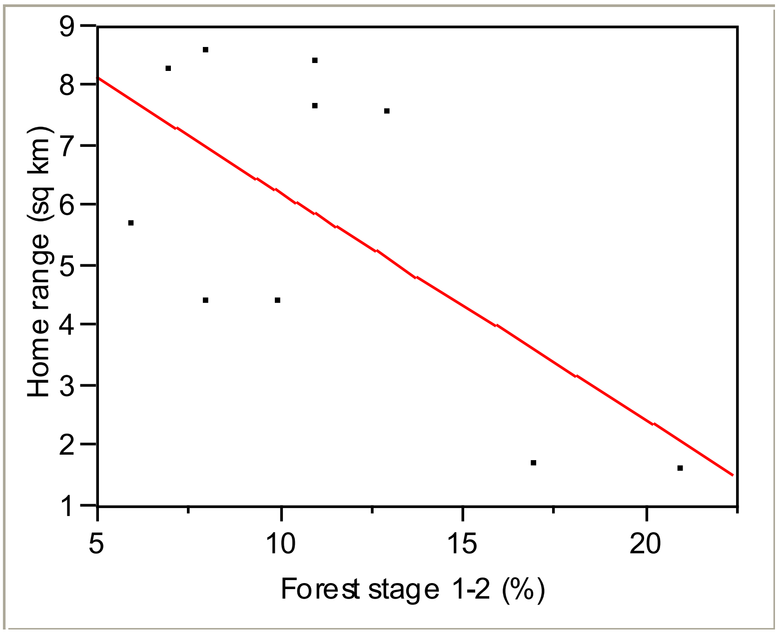


Figure 6. Size of home range in relation to percentage of forest stage 1-2 within ten Ural owl home ranges (n = 10, df = 1, $R^2 = 0.43$, t = -2.47, p = 0.039). Y = -0.38x + 10.04.

Behaviour of Ural owls

When analysing the behaviours of the Ural owls, I used data on all the owls (n = 11). However, I excluded the observations of owls that were guarding their young or nesting. This ensured that any irregularities in behaviour, brought about by protecting the young, would not skew the results. The variables I used in the tests included sex, individual (random effect), solar height to indicate light intensity (measured in minutes from the darkest time, taken as 01.00 am local summer time), temperature, wind, cloud cover, behaviour, perching post, perch height, fright distance, forest type, dominating tree, forest height, forest stage, natural vs. cultural forest, forest structure, distance to open habitat, distance to wet habitat, and amount of dry coniferous forest, moist coniferous forest, wet coniferous forest and mires/bogs within 25 m of the perching owl. Each variable was used according to its appropriateness for each specific test.

Behaviour: Predicting the probability that a Ural owl is hunting when located

Of the variables tested, darkness, cloud cover and perch height significantly affected the probability that an individual owl was hunting (table 3). A Ural owl was 50 % likely to be hunting at 7.50 pm and at 6.10 am, and the period between these times it was more often found hunting than not (fig 7). The cloud cover also had a similar affect, with the probability of finding an individual hunting being highest in heavy cloud cover (fig 7).

Table 3. Nominal logistic regression model of variables significantly affecting the probability that the Ural owls were hunting when located. Whole model: n = 91, df = 14, x^2 = 59.18, R^2 = 0.54, p < 0.0001.

Variable	Whole model			Parameter estimates			
	df	x^2	P	Estimate	SE	x^2	P
Intercept				-7.65	2.26	11.47	0.0007
Individual (random effect)	10	23.03	0.0081				
Darkness	1	8.21	0.0042	0.0075	0.0029	6.68	0.0098
Cloud cover	2	7.18	0.028				
Cloud cover 2-1				1.92	1.12	2.96	0.0852
Cloud cover 3-2				-3.28	1.35	5.94	0.0148
Perch height (m)	1	20.02	<0.0001	0.72	0.21	11.61	0.0007

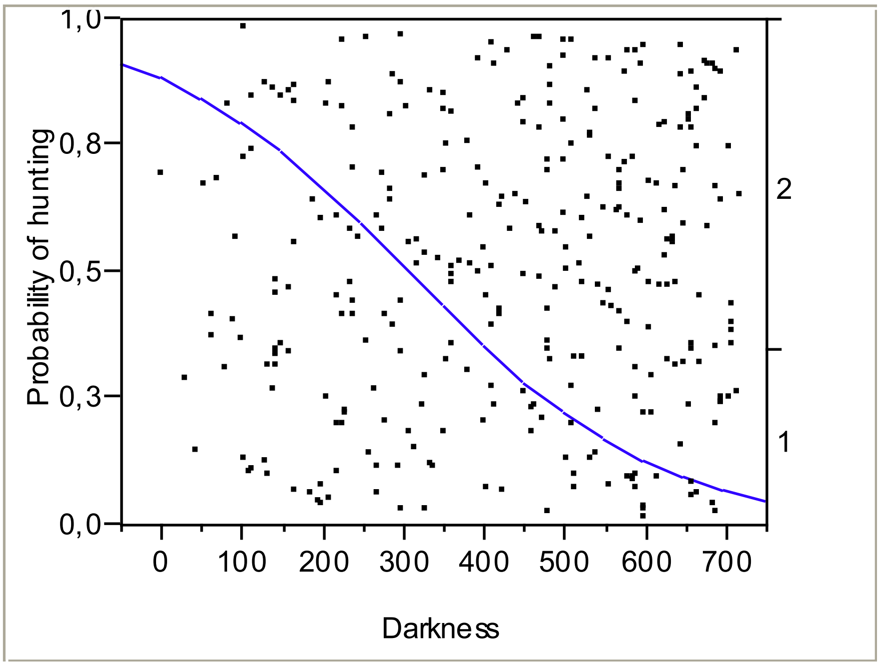


Figure 7. The probability that a Ural owl (n = 11) were hunting when located as a function of darkness measured as minutes from 01.00 am (n = 305, df = 1, x^2 = 82.45, p < 0.0001).

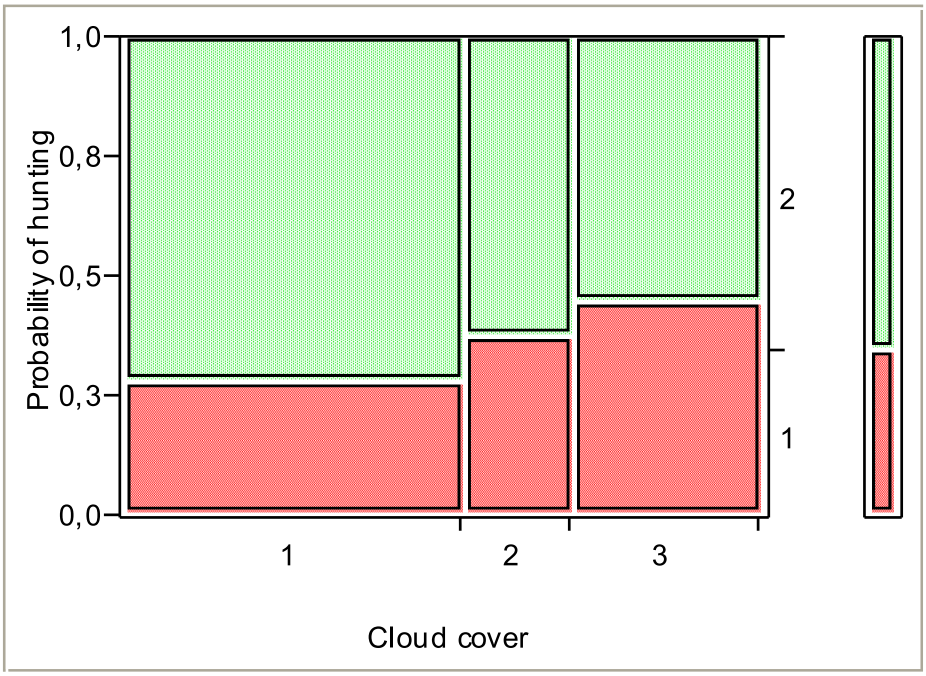


Figure 8. The probability that a Ural owl (n = 11) was hunting when located when the sky was 1) clear, 2) 50 % cloud covered or 3) overcast (n = 305, df = 2, x^2 = 7.31, p = 0.03)

The probability that an individual was found hunting increased with decreasing perch height. At a perch height of 3.5 m, there was a 50% chance the owl was hunting, and if found perching at lower heights, it was more often hunting than not.

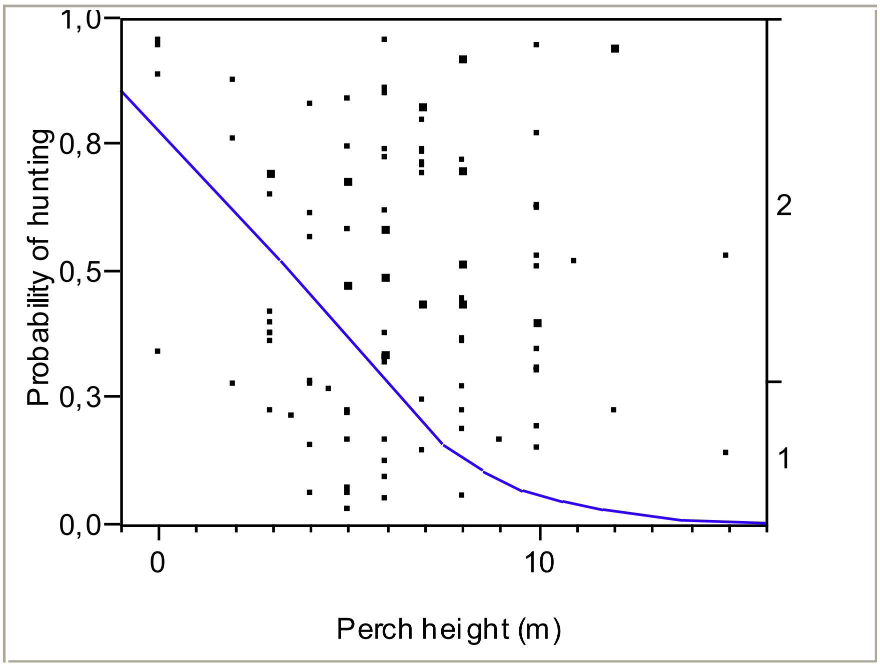


Figure 9. The probability that a Ural owl (n = 11) was hunting when located as a function of perch height (n = 91, df = 1, x^2 = 18.64, p < 0.0001)

Behaviour: Perch height

The variables affecting perch height were found to be behaviour (whether the owl was hunting or roosting), type of perch post, and forest height (tab 4). As a rule, the higher the forest within a sited location, the higher the owls were likely to perch (fig 10). Whilst hunting the Ural owl sat significantly ($n = 91$, $df = 1$, $R^2 = 0.18$, $p < 0.0001$) lower (4.4 ± 0.54 m) than when it was resting (7.1 ± 0.34 m). The Ural owl also significantly ($n = 90$, $df = 3$, $R^2 = 0.17$, $p = 0.001$) varied its perch height according to what kind of tree it was sitting in, with spruce (6.7 ± 0.34 m) being the most common sitting post, followed by pine (7.6 ± 0.79 m), birch (5.6 ± 1.04 m) and finally other sitting posts e.g. stumps (2.2 ± 1.12 m).

Table 4. Stepwise regression model of variables significantly affecting perch height of Ural owls when they were not protecting a young (n = 11). Cumulative values are given for R^2 and AIC. The remaining values are from the whole model (n = 91). Variables were selected by backward elimination.

Variable	Df	Regression coefficient	SE	R^2	P	AIC
Intercept		0.94	0.76		0.22	151.32
Behaviour	1	1.18	0.26	0.21	<0.001	135.22
Perching post	1	-1.89	0.46	0.40	<0.001	115.90
Forest height	1	0.20	0.04	0.53	<0.001	100.22

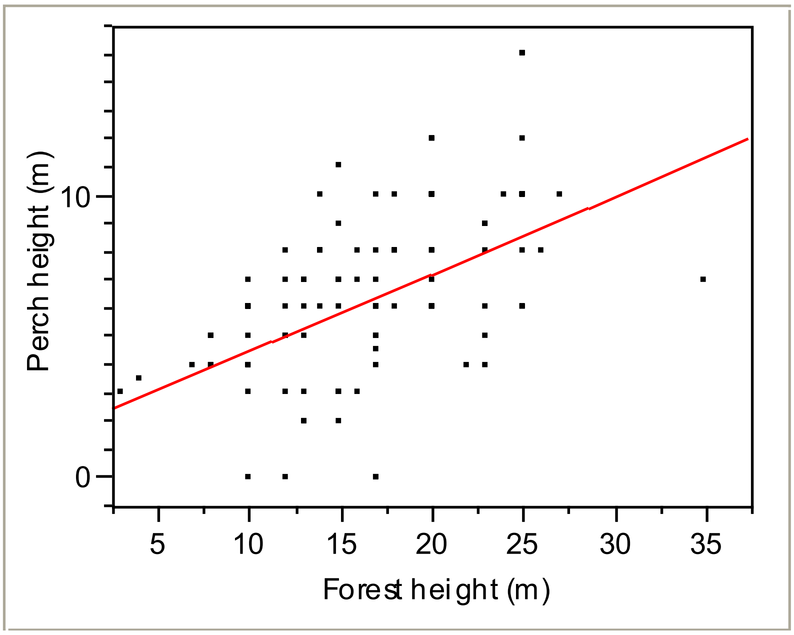


Figure 10. The perch height of eleven Ural owls (n = 11) in relation to the forest height where they were located ($n = 91$, $df = 1$, $R^2 = 0.27$, $t = 5.68$, $p < 0.0001$). The curve describes the linear regression model. $Y = 0.27x + 1.87$.

Behaviour: Predicting fright distance of Ural owl

Fright distance describes how close I could get to an owl in the field before it took flight. I analysed which variables predicted the Ural owls fright distance by using a stepwise regression model, and found that amount of wet coniferous forest, the structure of the forest and perch height significantly affected this behaviour (tab 5). The greater the amount of wet coniferous forest within 25 m of the perching owl, the shorter the fright distance was (fig 10). The owls had also shorter fright distance if found in denser forest (fig 11) or on higher perches (fig 12).

Table 5. Stepwise regression model of variables significantly affecting the fright distance of eleven Ural owls. Cumulative values are given for R^2 and AIC. The remaining values are from the whole model (n=91). Variables were selected by backward elimination.

Variable	DF	Regression coefficient	SE	R^2	P	AIC
Intercept		1.31	0.063		<0.0001	-212.38
Wet coniferous forest	1	-0.0004	0.00009	0.15	0.0002	-224.24
Forest structure	1	0.082	0.027	0.23	0.0032	-230.49
Perch height	1	-0.018	0.009	0.27	0.044	-232.77

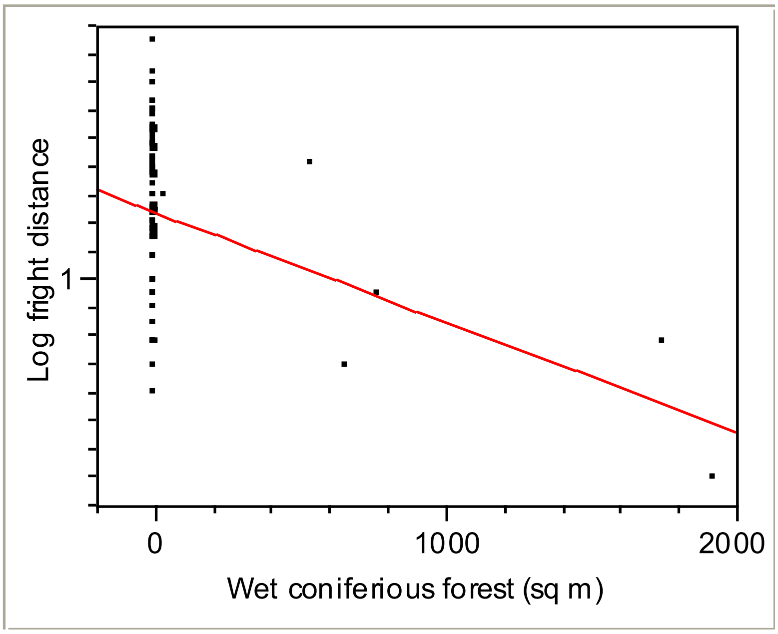


Figure 11. Fright distance ($\log_{10}$ transformed) in relation to amount of wet coniferous forest within 25 m of the perching owl for of eleven Ural owls (n = 96, df = 1, R^2 = 0.14, t = -3.93, p = 0.0002). The curve describes the linear regression model. Y = -0.00039x + 1.25.

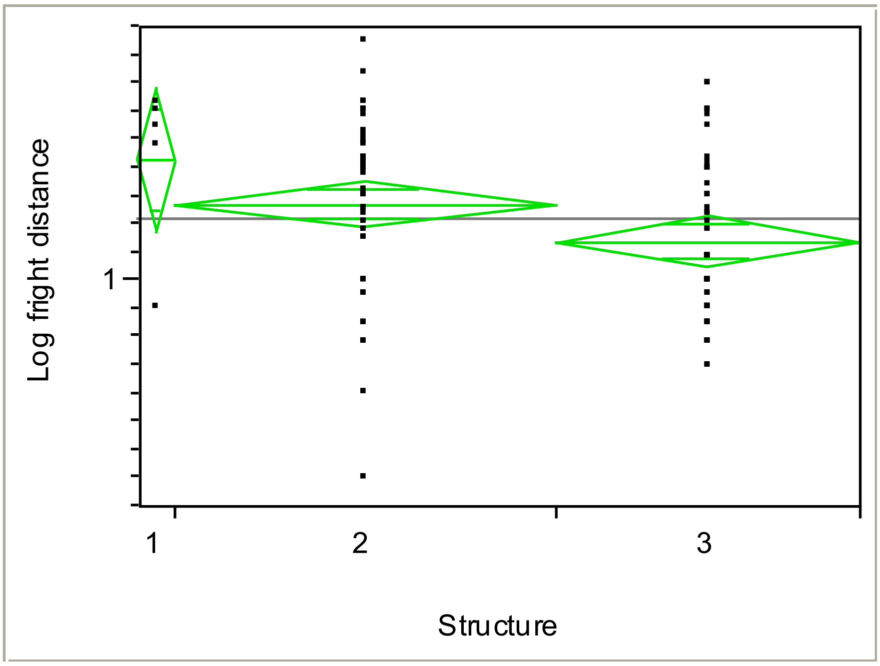


Figure 12. Fright distance ($\log_{10}$ transformed) in relation to structure of forest at location for eleven Ural owls (n = 102, df = 2, $R^2 = 0.07$, p = 0.022) where 1 = open (mean 1.43 ± 0.13), 2 = medium (mean 1.28 ± 0.04), 3 = dense (mean 1.14 ± 0.04).

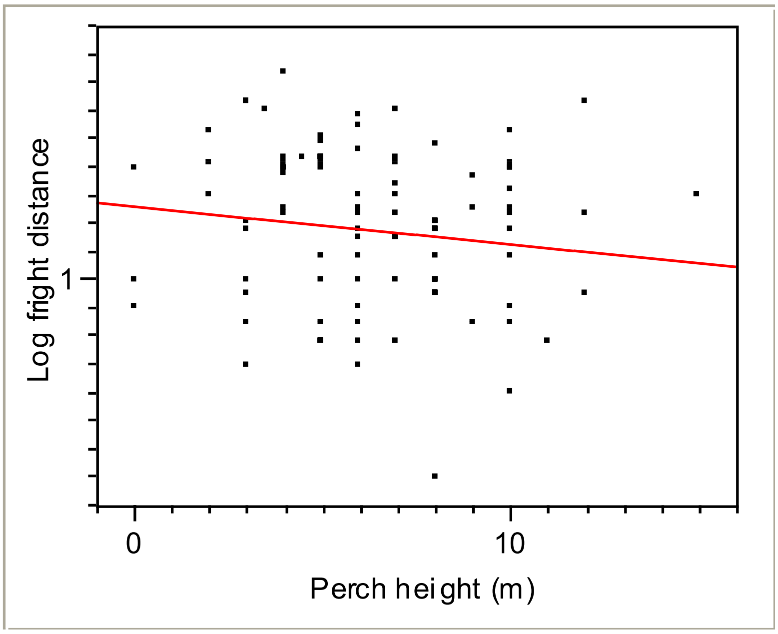


Figure 13. Fright distance ($\log_{10}$ transformed) in relation to perch height for eleven Ural owls (n = 89, df = 1, $R^2 = 0.02$, t = -1.35, p = 0.18). The curve describes the linear regression model. Y = -0.013x + 1.27.

Discussion

Home range

The home range calculations were performed on the data obtained from eight weeks of field work. This was not enough time to find the full extent of the home ranges. At the end of the field work (31 July), the young had just started becoming independent (young of F06 hatching at some point between 12 and 28 April and young of F10 hatching at some point between 12 April and 3 May), enabling the females F06 and F10 to move around more freely. Considering that the study on the same owls in 2007 was conducted over a longer period (Fredriksson 2008), the home range sizes found in this study corresponds quite well. He found that 100 % MCP mean hunting home range was 6.5 km^2 for males and 3.1 km^2 for all females. Mikkola (1983) states that a Ural owl's home range is on average 4.5 km^2, but this figure is not based on radiotelemetry. Bolin *et al.* (1991), on the other hand, found a much larger home range for the Ural owl. However this study involved radio-tracking of just one bird. Individual differences may explain why this home range was so much bigger, as does the differing techniques used. The males in my study had generally bigger home ranges than the females, whether it be 95 % or 100 % MCP home ranges. This is in accordance with the study on the same owls in 2007 (Fredriksson 2008). I have not been able to find any other studies about this subject on Ural owls, but larger home range of males than females in the breeding season is well documented for the Ural owl's smaller cousin, the Tawny owl (*S. aluco*) (Steel 1998; Sunde & Bolstad 2004). The males' task throughout the breeding season is to provide the family with food (Mikkola 1983). This is reflected in the results which showed that whilst females who were not breeding had a much larger home range than the one which bred, the males not breeding had a decreased home range in comparison to males which did breed. Considering 2008 was a poor vole year (G. A. Sonerud pers. com.) the breeding males were most likely forced to extend the hunting grounds a considerable amount in order to keep themselves, their females and the young in good health. Excluding the couples that were breeding, there was little difference in the 100 % MCP home range, and the 95 % home range show non-breeding females actually having covered slightly more ground than the non-breeding males, which is to be expected when considering the females' larger body mass. This further reflects the effect the tasks during breeding have on home range size.

Territoriality and overlap

There was a fair degree of overlap between two individuals in a couple. The males had a smaller proportion of their home ranges overlapping with the females' than did females with the males'. This is easily explained in the instance of couples that were breeding. These males had much larger home ranges than their females due to the fact that they had to hunt for two adults and a young and due to the fact that the females were always in close proximity to the nest box, protecting the nestlings. Regarding the couples that did not breed, there were individual differences. One couple (Flybäcksåsen) showed similar behaviour to the breeding couple (Fastnessäteren), whereas the other couple (Flybäck) differed in that both individuals had the vast majority of their home range within the other individual's home range. It should be noted here that the latter couple had rather equally sized home ranges, and that their home ranges were fairly large. The former couple had rather small home ranges and the male's home range was approximately three times larger than the female's. The differences in sizes were probably due to lack of suitable habitat for hunting in the largest home ranges. It is more difficult to explain why the female F01 and the male M11 (Flybäcksåsen) would have such differing sizes to their home ranges. It could be that individual differences in behaviour was expressed through increased territoriality in the female F01 compared to the female F07 (Flybäcken), forcing the male M11 to travel further in order to hunt.

It is notable that there is such a large degree of overlap even when a couple is not breeding. According to (Fretwell & Lucas 1969) one might assume that the individuals would improve their condition for the winter by choosing to forage in different areas, especially in years where there is a scarcity of the preferred prey. However, as the Ural owl is extremely territorial, even when not breeding (Lundberg 1981; Mikkola 1983) it could be that it is not the bond between the individuals which results in the high degree of overlap, but rather the bond to the territory. One factor which may contradict this, however, is that I observed the individuals in the two couples that did not breed, perching in very close proximity to each other, sometimes even in the same tree. It would be very interesting to research whether this is a significant behaviour or not in poor vole years.

Variables affecting home range size

The variables affecting home range size were the sex of the owl and the number of locations made on each owl. However, the result that home range size increased significantly with decreasing amount of forest class 1-2 is quite interesting. This does not correspond to the findings from the year before (Fredriksson 2008) where the proportion of pine forest of the lichen type was an important vegetation type in male MCP home ranges, and proportion of forest class 5 and the proportion of bog was important in female MCP home ranges. Earlier research (Solheim 1994) has established that the Ural owl is a strict forest bird, and is only on occasions seen in open areas. However, in accordance with Lundberg (1981), one of the important prey for the Ural owl, *i.e.* the field vole (*Microtus agrestis*) (e.g. Rønning 2007) is only found in open or wet habitat, such as clear cuts and mires. Because I studied the owls in a poor vole year, the owls may have had to include more of clear-cut in its home range in order to succeed in bringing up their nestling and for own survival. In good vole years, this may not be as apparent because other factors become more limiting. Further investigation into this could be possible by comparing breeding owls with non-breeding owls in poor years and check for any correlation with an increased need for prey with the amount of this habitat in the home range.

Hunting

The probability of hunting increased as it got darker. This is in accordance with established facts (Cramp 1985; Mikkola 1983). The owls did on occasions hunt during daytime as well. However, the effect of denser cloud cover was also significant in predicting hunting behaviour independent of time of day which further shows the species' tendency for hunting when there is less light. Since the Ural owl does not hunt on eyesight primarily (Petterson 2002), it may seem illogical that the degree of light should be of consequence. However the degree of light may alter the activity level of, and therefore access to prey, thus indirectly affecting the hunting behaviour of the owls, much in the same manner Clarke (1983) describes for short-eared owls (*Asio flammeus*). Another possible explanation is that prey are less able to detect the presence of an owl when it is darker, increasing the owl's success rate. The probability of hunting was also inversely correlated with perch height. This has to do with the technique used by the Ural owl when hunting. Similarly to other owls which use auditory perception to detect prey, such as the Boreal owl (*Aegolius funereus*), they need to adjust the height at which they perch in order to optimise success rate (Bye et al. 1992) . The height at which they are best able to detect sound from the ground is lower than the height at which they prefer to roost. Roosting at increased height may reflect the timidity of the owls. It may feel more secure if it can perch at a height where it has better overview.

Perch heights

I have already discussed how the owls perched higher when not hunting. At high forest heights the owls further increased the height at which they perched. This may simply reflect the branch structure. As the height of a tree increases, the owl would be forced to perch higher even if choosing the lowest branches. It is worth noting that the perch height was also influenced by the type of perching post used. The highest perch heights occurred in pines, followed by spruce, birch, and lastly other perching posts. It is possible that this was caused by the structure of the trees, and the amount of thermal and protecting cover it offers, comparable to Hayward and Garton's (1984) findings for the Boreal owl. This may add to the statement by Cooke *et al. (2002)* that powerful owls (*Ninox strenua*) do not show any preference for specific roosting trees. It may not prefer one specific type of roosting tree, but rather actively choose perching posts within the trees it perches on based on factors like temperature, radiation from sun or level of disturbance in the area. The lowest perch heights in my study occurred in the category "other perching posts". This is easily explained by the fact that this category includes posts such as tree stumps and dead trees, often not providing much height.

Fright distance

The owls' timidity was measured by recording how close I could get to an individual before it took flight (fright distance). Fright distance decreased in wet coniferous forests. This may be due to the structure of forests becoming denser in wetter surroundings. The dominating trees in wet coniferous forests are pines, and these have a dense canopy falling lower to the ground than spruce which is a tree associated with drier surroundings. There may also be more bush vegetation and a higher occurrence of smaller deciduous trees. All this may add to the owls' sense of security. This is also evident in the results showing that density of forests affected the fright distance, independent of vegetation type. In addition, the owls seemed to feel more secure when perching higher. Fredrikson (2008) made similar findings in last year's study, stating that forest density and perch height made the owls less timid. This behaviour did not apply only to the Ural owl. As Anthony (1894) notes, many species of owls put great trust in their ability to blend in with the vegetation and will often use hiding tactics upon disturbances. The habituation of Mexican spotted owls (*Strix occidentalis lucida*) has been studied by Delaney *et al.* (1999), and although they are careful to draw any conclusion due to small sample size, there were indicative trends showing habituation to helicopters. This was also affected by terrain and forest height. If there is such a level of habituation possible, it seems likely that the Ural owls I studied could have been habituated by my presence. This could affect the fright distance throughout the study period.

Conclusion

This study builds on the study conducted by Fredriksson (2008), and provides answers to questions raised. The low prey abundance did seem to have an affect on home range sizes and the factors that alter these. However, territoriality was not affected much. Couples remained together although spacing themselves out would probably have been beneficial in such a poor vole year. It would be interesting to study whether there is such a strong bond between individuals, or if it is the bond to the territory that results in a high degree of overlap. Because this study has been conducted in the same manner as the previous study, the comparability between the two offer a unique possibility to expand our knowledge of the ecology of the Ural owl. This may provide insight into how management of Ural owl habitat should be conducted in future.

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