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Oskarshamn site investigation

Survey of mammal populations at Simpevarp

Spotlight survey 2004

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Keywords: Fox, Badger, Roe deer, Spotlight inventory.

Summary

We have estimated mammal population densities within the environmental monitoring programme at Simpevarp, near Oskarshamn, in the spring of 2004. The main goal was to estimate pre-breeding absolute population densities of red foxes and badgers, as well as of other mammal species. We used the spotlight distance sampling method to generate density estimates and population indices. In a total of 129.1 km transects, 167 mammals of six species were seen: 119 roe deer, 29 hares, 13 moose, 3 red foxes, 2 badgers and 1 hedgehog. Population indices were acquired for all species, and estimates of absolute densities were acquired for roe deer (38.96 individuals/10 km^2) and hares (27.59 individuals/10 km^2). Sample sizes were small for the main target species, fox and badger, presumably due to their evasive behaviour and the landscape structure. All observed species were documented by index and/or absolute density estimates. Spotlight surveys were successful for non-evasive species such as roe deer and hares. We therefore recommend the method to be used as a compliment to other estimates of herbivore populations. For comparisons between or within populations of foxes and badgers, we would instead suggest the use of indirect index methods.

Sammanfattning

Vi har uppskattat tätheten hos däggdjurspopulationer inom undersökningsprogrammet vid Simpevarp, Oskarshamn, våren 2004. Huvudsyftet var att uppskatta absolut populationstäthet före reproduktion hos räv och grävling. Vi använde spotlight-metoden för att genom ”distance sampling” generera täthetsuppskattningar samt populationsindex. På transekter om totalt 129.1 km observerades 167 individer av 6 olika däggdjursarter: 199 rådjur, 29 harar, 13 älgar, 3 rödrävar, 2 grävlingar och en igelkott. populationsindex erhölls för alla arter, samt täthetsuppskattningar för rådjur (38.96 individer/10 km^2) och harar (27.59 individer/10 km^2). Stickprovsstorlekarna för räv och grävling var små, troligen beroende på deras skygga beteende liksom det till stor del slutna landskapet. Alla observerade arter dokumenterades genom populationsindex och/eller absoluta tätheter. Spotlight-metoden fungerade väl för oskygga arter såsom rådjur och harar. Vi rekommenderar därför att metoden används som ett komplement till övriga populationsuppskattningar av herbivorer. För jämförelser mellan eller inom populationer av räv och grävling föreslår vi istället att man använder indirekta indexmetoder.

Contents

1 Introduction

This document reports the results gained by the spotlight survey of mammal populations at Simpevarp, which is one of the activities performed within the site investigation at Oskarshamn. The work was carried out in accordance with activity plan AP PS 400-04-026 (SKB internal controlling document). Data from the performance of the activity have been stored in the SICADA database under field note number 470.

The Swedish Nuclear Fuel and Waste Management Co (Svensk Kärnbränslehantering AB, SKB) is presently selecting a location for the deep-level repository of radioactive waste. In the investigated areas, SKB will make population estimates of mammal species that are of interest both for biodiversity and conservation purposes, as well as for local hunting and recreational purposes. Population estimates of most mammal species was made during the period 2002 and 2003 in Simpevarp as well as in a reference area 10 km north of Simpevarp, Blankaholm. Several methods have been used, but no reliable estimates of red fox and badger population densities were acquired /Cederlund et al. 2004/. The present study was aimed at finding reliable figures for pre-breeding densities and population indices of red foxes and badgers, as well as for other mammal species.

The 248 km^2 study area at Simpevarp is shown in Figure 1-1. The area covers and extends further than the 117 km^2 area used by previous mammal studies within the SKB test drilling programme. This enlarged study area was encompassed by the following Swedish grid coordinates:

N 6373000, E 1539000;
N 6373000, E 1560000;
N 6360000, E 1539000;
N 6360000, E 1560000.

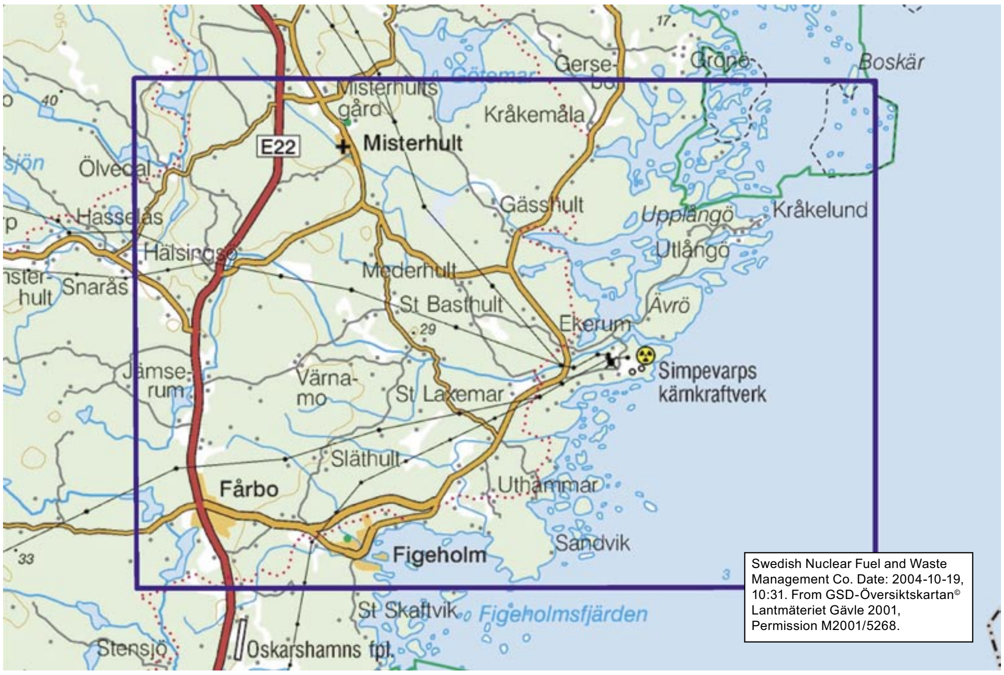

***Figure 1-1**. The 248 km^2 study area at Simpevarp, north of Oskarshamn.*

Simpevarp in the county of Oskarshamn is strongly influenced by the Baltic Sea. The study area is flat (less than 25 m above sea level) and contains few lakes and streams. It is also characterised by a mosaic of habitats with different tree- and understory composition. The Baltic Sea keeps the temperature relatively high in the fall, and delays the onset of winter compared to the inland. The ground might be snow covered for short periods, in total less than 50 days each winter.

The surface of the study area is characterized by a coarse moraine creating a terrain with an irregular surface profile (10–25 m.a.s.l.). Approximately 80% are forest land with agricultural areas less than 10%. A mostly poor soil cover support a forest of spruce (*Picea abies*) with elements of birch (*Betula sp.*) in most areas. In the north, where the upland terrain has thinner soil cover and a higher degree of flat rock, pine (*Pinus silvestris*) dominates. Patches of open land are scattered in the area, mostly fallow fields.

2 Species

All wild mammals were considered target species for the survey. However, the main aim was to acquire reliable estimates of red fox and badger population densities, as this had not been possible with the previously applied census methods. Population index and density figures were to be achieved by distance sampling through spotlight surveys. The following list contains English, Swedish and scientific names of the most common large and medium sized mammals in the area:

Moose (älg)	*Alces alces*
Roe deer (rådjur)	*Capreolus capreolus*
Wild boar (vildsvin)	*Sus scrofa*
Mountain hare (skogshare)	*Lepus timidus*
European hare (fälthare)	*Lepus europeus*
Red fox (räv)	*Vulpes vulpes*
Badger (grävling)	*Meles meles*
Hedgehog (igelkott)	*Erinaceus europaeus*

3 Methods

3.1 Survey description

Spotlight sampling is based on nocturnal observations of animals along roads, using strong halogen spotlights. Spotlight counts were conducted from dusk to dawn, approximately 21:00 to 05:30, between 28 April and 2 May 2004. Transects covered the main habitat types in the study area, using all accessible medium sized and small roads (Figure 3-1). Most transects were repeated once. The largest road, E22, was avoided because of the low speed during surveys. All landowners in the study area were informed before the survey. If objections were raised the affected sections were excluded. This was the case for the area around the village Värnamo (Figure 3-1).

The line transect team comprised one driver and two observers in the backseat. The vehicle, a Volkswagen van, was driven at a speed of 10–15 km/h, slowing down or stopping at gaps in the terrain or open land when necessary. Through open windows, the observers scanned each side of the road with a 1 million Candela power hand-held halogen spotlight (12V/55W) and with standard 8×32 field binoculars. The driver surveyed the road directly ahead. The car was stopped when shining eyes were seen. The observer located the initial position of the animal and kept track of that position before identifying the animal using binoculars. In most cases, the animal was identified by two or all three persons in the team. The vehicle was then placed perpendicular to the initial position of the animal for distance measurement. The perpendicular distance of each animal from the centre of the road was then measured using a two-way laser beam device; Bushnell Yardage Pro 400, with maximum detection range 400 m. The GPS coordinates were also recorded for each observation.

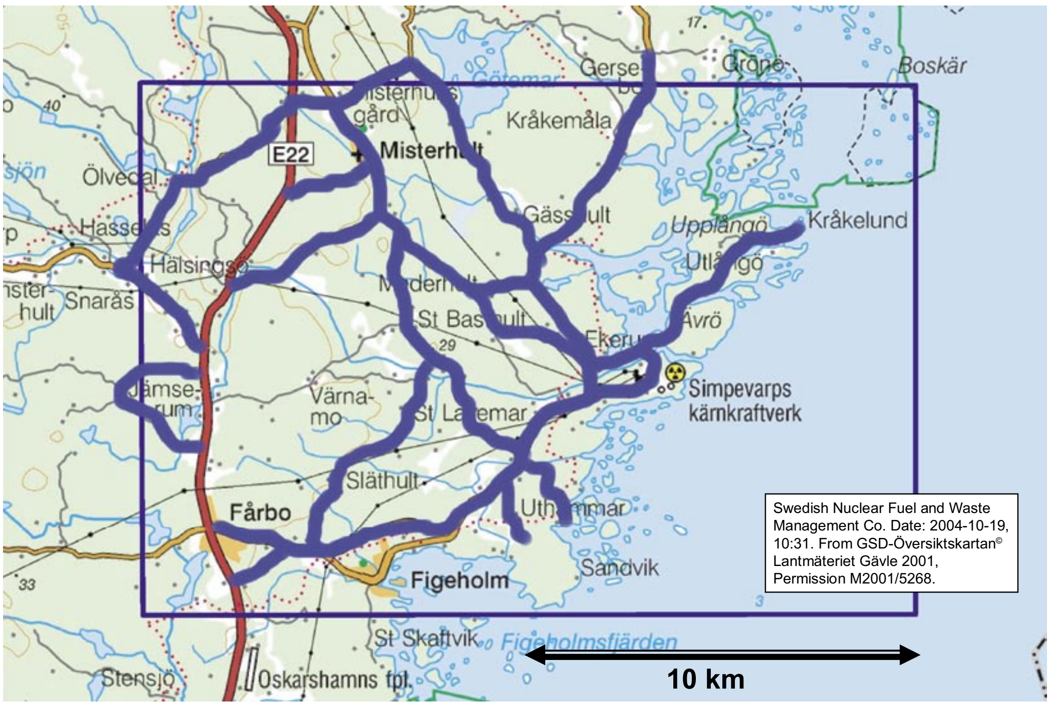

Figure 3-1. *Spotlight survey transects at Simpevarp in 2004. Transects (blue lines) crossed all main habitat types in the study area, using medium sized and small roads.*

To limit observer bias, team members exchanged positions at regular intervals. All line transects surveys were conducted by the same three persons. The weather was fair with good visibility throughout the study. Portions of transects under local mist conditions were excluded from spotlight counts. Visibility in coniferous forests was low. Visibility in deciduous woodland was good, as only small leaves had erupted. The terrain profile was irregular on a small scale. Rock walls and forests with sections of thick undergrowth along the roads were interspersed with open clearings. All transects passed through numerous open fields (felled forest or arable land) which provided visibility up to and exceeding 300 m.

3.2 Identification of routes

The spotlight method is described by /Ruette et al. 2003/ where it was used in relatively open cultural landscapes with patches of broadleaved forest. Using detailed topographical and vegetation maps (1:10,000 to 1:50,000), possible transect routes were identified beforehand. The habitat adjacent to chosen roads may be unrepresentative and animals may show a density gradient perpendicular to such a landscape. Also the visibility along chosen roads can prove to be poor. Yet, these roads provide realistic means of surveying a sufficient length of transect to obtain a required number of sightings for density estimation.

Spotlight surveys had not previously been used in this area. There was initially a plan to perform replicates and surveys also in the control area at Blankaholm. However, following analyses of sample sizes for foxes and badgers at Simpevarp, it was decided that replicates and surveys in the control area at Blankaholm should not be performed.

3.3 Data collection and analyses

All observations, including starting and end points of each transect, were given a unique number and were noted in a detailed protocol by the observers, and also in a summary protocol by the driver.

Estimates of density using line transects followed recommendations in /Buckland et al. 1993/. Individual animals were used as the sighting units in the analyses as most sightings were of solitary animals. Densities were estimated according to the general equation $D = n/(2 \times L \times ESW)$, where n is the number of sightings, L the total transect length, and ESW the effective strip width. The encounter rate, n/L, corresponds to the common index used to express spotlight counts. Estimates of ESW were calculated from the probability density function of the estimated detection function at zero distance for line transects. Line transect density estimates with their log-normal confidence intervals were computed with the software DISTANCE /Laake et al. 1993/. Before model fitting, a truncation of the more distant data was operated. These extreme observations are difficult to model and provide little information for estimating the density function at zero distance, which is the most critical part of the curve. The truncation distance was chosen for each species so that the probability of detection was near 0.15 /Buckland et al. 1993/. Data were grouped a posteriori into 20-m intervals to improve model fit. In the exploratory phase of the analysis, we used five a priori robust models: a uniform key function with either cosine (i.e. Fourier series) or polynomial series expansion, a half-normal key function with either cosine or Hermite polynomial series expansion, and a Hazard rate key function with cosine series expansion. Plots of model fit to histogram distance data were assessed visually to ensure a good fit of the data /Buckland, 1985/. The Fourier (cosine) series model fit our data sets well, gave similar density estimates compared with the other models and led to small differences (< 2) in Akaike Information Criterion (AIC) relative to other models. Analyses were carried out separately for each species, pooled over all sessions. Theoretically, sighting frequencies should decline progressively with increasing distance from the transect centreline. If sighting frequencies are low near the centreline because animals avoid the roads or their immediate vicinity, model fit to the data can be improved by excluding roadside data from the analysis by selecting a left truncation point (full left truncation; /Alldredge and Gates, 1985/). This was the case for roe deer, where the best model fit was acquired with 5m left truncation.

4 Results

The total transect length, L, was 129.1 km. Each observer side was recorded separately, so the computed transect length was 258.2 km, with a sampling fraction of 0.5.

Table 4-1. Summary of results from the spotlight surveys at Simpevarp in 2004. The total distance travelled in four consecutive nights was 129.1 km.

Species	n	Index	Density	$CV_{density}$	N_{estim}	ESW	CV_{ESW}
Roe deer	119	9.22	38.96	20.96	966	111.3	7.96
Hare	29	2.25	27.59	27.3	684	39.3	17.47
Moose	13	1.01					
Fox	3	0.23					
Badger	2	0.15					
Hedgehog	1	0.08					

Table headers are as follows: *n* is the sample size before selection criteria have been applied; population index is the observed encounter rate (ind/10 km); population density is the estimated absolute density (ind/10 km^2); $CV_{density}$ is the coefficient of variance for the density estimate (%); N_{estim} is the estimated total number of individuals within the study area, ESW is estimated one-sided strip width (m); CV_{ESW} is the coefficient of variance for the ESW.

***Figure 4-1**. Mapped observations of mammals during distance sampling in spring 2004. Red squares denote all 122 transect points where mammals were observed. A total of 167 mammals were observed in two-sided surveys on routes totalling 129.1 km during 4 nights. A summary of the observations is shown in Table 4-1.*

4.1 Roe deer

A total of 119 roe deer were observed, all adults. The observed encounter rate was 9.22 individuals/10 km (Table 4-1). With the selection criteria applied as below, the encounter rate was 8.68 individuals/10 km (n = 112, CV = 19.40%). The maximum observation distance for roe deer was 280 m.

Data pooling over all four consecutive nights led to a sufficient number of sightings to model a detection function. Following initial data analyses as previously explained, the left truncation point was set at 5 m, and the right truncation point at 220 m. With these truncation points, 7 observations (5.9%) were excluded. Sighting frequencies were lower near the centre line, while a peak was observed at more distant intervals (Figure 4-2). The half-normal function model with a Fourier series estimator and a 20-m grouping provided a good fit to the distance frequencies (Figure 4-2). For this model, the P-value corresponding to the chi-square goodness-of-fit of the model was 0.013, and Akaike's Information Criteria, AIC = 492.5.

The density estimate for roe deer was 38.96 individuals per 10 km^2 (coefficient of variance, CV = 20.96%). This corresponds to a total population of 966 individuals within the study area (Table 4-1). Effective strip width (one-sided), ESW = 111.3 m; CV = 7.96%.

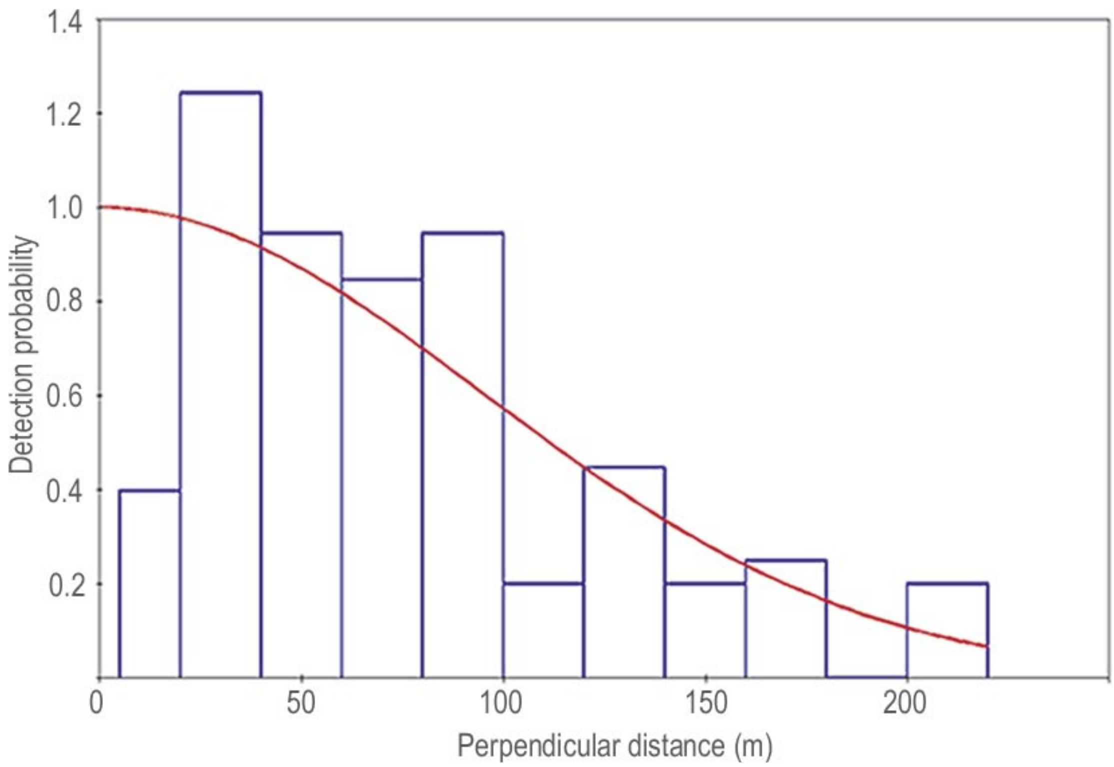

Figure 4-2. *Numbers of roe deer sightings (20 m interval grouping) at different distances from the transect centreline, using the best model fit obtained. Detection function is half-normal key with cosine correction. Observations are left truncated at 5 m and right truncated at 220 m (n = 112).*

4.2 Hares

Mountain hares and European hares were often difficult to separate, so all observations of *Lepus sp.* were categorized as hares. A total of 29 hares were observed, all adults. The observed encounter rate was 2.25 individuals/10 km (Table 4-1). With the selection criteria below applied, encounter rate was 2.17 individuals/10 km (n = 28, CV = 21.01%). The maximum observation distance for hares was 217 m.

Data pooling over all four consecutive nights led to a sufficient number of sightings to model a detection function. Following initial data analysis, the right truncation point was set at 120 m, which excluded 1 observation (3.4%). Sighting frequencies decreased from the centrelines expected. The half-normal function model with a Fourier series estimator and a 20-m grouping provided a good fit to the distance frequencies (Figure 4-3). For this model, the P-value corresponding to the chi-square goodness-of-fit of the model was 0.307, and AIC = 81.579.

The density estimate was 27.59 hares per 10 km^2 (CV = 27.3%). This corresponds to a total population of 684 individuals within the study area; Table 4-1). ESW (one-sided) = 39.3 m (CV = 17.47%).

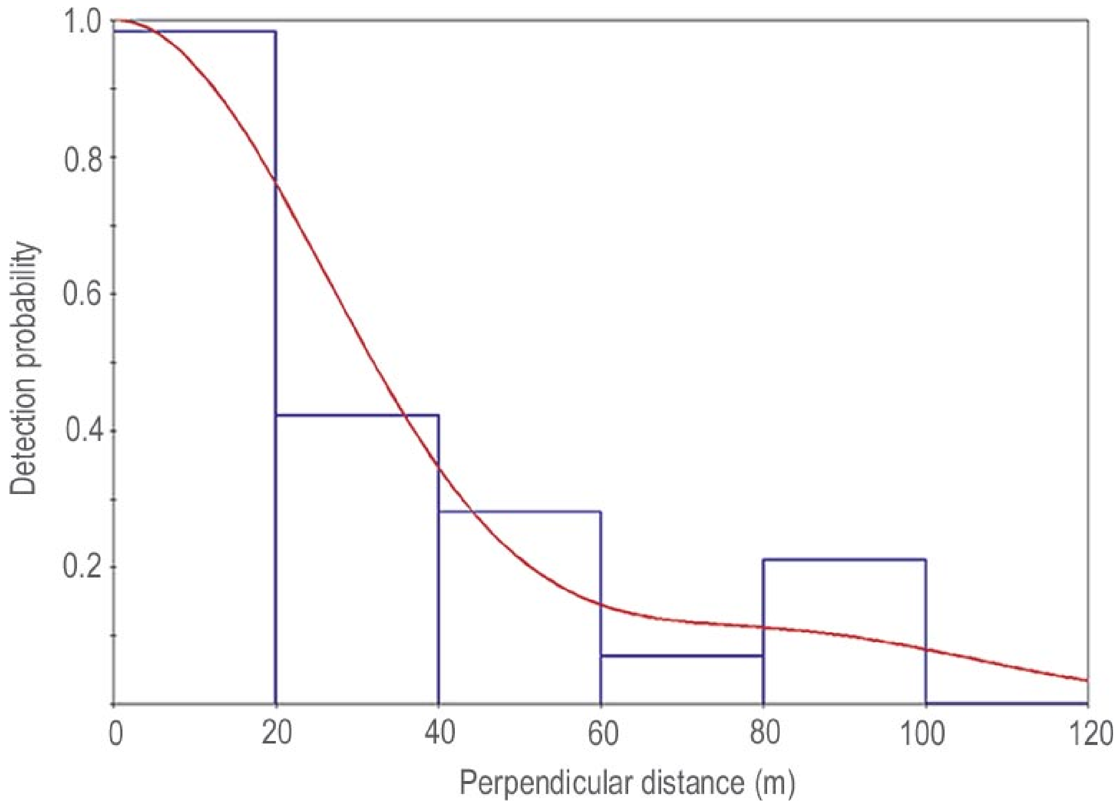

Figure 4-3. *Numbers of hare sightings (20 m interval grouping) at different distances from the transect centre line, using the best model fit obtained. Detection function is half-normal key with cosine correction. Observations are right truncated at 120 m (n = 28).*

4.3 Moose

A total of 13 moose were observed, 9 adults and 4 young of the year. Observed encounter rate was 1.01 individuals/10 km (n = 13; Table 4-1). The number of sightings were not sufficient to model a detection function, and no density estimate was obtained. The maximum observation distance for moose was 180 m.

4.4 Foxes

A total of 3 foxes were observed, all adults. All individuals exhibited strong evasive movements when spotted. Observed encounter rate was 0.23 individuals/10 km (n = 3; Table 4-1). The number of sightings were not sufficient to model a detection function, and no density estimate was obtained. The maximum observation distance for foxes was 29 m.

4.5 Badgers

A total of 2 badgers were observed, both adults. Like foxes, badgers exhibited strong evasive movements. Observed encounter rate was 0.15 individuals/10 km (n = 2; Table 4-1). The numbers of sightings were not sufficient to model a detection function, and no density estimate was obtained. The maximum observation distance for badgers was 19 m.

4.6 Other species

In addition, one hedgehog was observed walking along the road (encounter rate 0.08 individuals/10 km (n = 1; Table 4-1).

5 Discussion and conclusions

5.1 Discussion

After initial adjustments in the field, the equipment and the recording procedures worked well. The time of year was good for these surveys, but mid April would probably be optimal, with regards to both mammal breeding times and leaf eruption on trees and shrubs. Using the spotlight method also revealed weaknesses in its application when visibility is obstructed by highly irregular terrain, rocks, dense forests and undergrowth along the roads.

The sampling intensity was adequate for roe deer and hares despite a quite large fraction of closed forest. Hares and roe deer can be expected to exit the forest at night to forage in open fields, where they are readily visible. This would lessen the effect of drastically different detectability in closed and open habitats. However, the number of observations of the main target species, foxes and badgers, was low. This was most likely due to their evasive movements. When detected, roe deer, moose and hares usually stopped in the spotlight for a moment, allowing easy identification and distance measurements. When foxes and badgers were detected, they were either already on the run or immediately started fleeing away from the vehicle. Evasiveness and an aggregated distribution might further explain the lack of observations of wild boars.

As expected, roe deer were the most frequently observed mammal. The number of observations was large enough for solid estimations of population density. Fewer roe deer than expected were observed in the immediate vicinity of the road. Hares, on the other hand, were often seen on the roadside. This can be explained by the lack of suitable forage for roe deer along the roads, since roe deer prefer the newly emerged shoots of grass and herbs on the open fields, whiles hares may eat the sturdier roadside vegetation.

The number of observations of hares was on the low side for the application of distance sampling statistics (n = 28 after truncation), yet above the limit of n = 20 recommended by /Jenkins et al. 1999/. The obtained estimates must be treated carefully, however, as there were no replicates. This is especially true for the estimates of absolute density, and for the index values (encounter rates) for foxes, badgers and hedgehogs.

The estimates of absolute population density of roe deer and hares were similar to previous results from the same area, yielded by other methods (pellet counts and aerial surveys; /Cederlund et al. 2004/). Comparing the population index from encounter rates, the moose index was also within the expected order of magnitude. Densities of foxes and badgers were most likely underrated by the survey method, due to evasive movements allowed by the landscape structure. With a larger number of samples, however, one could acquire index values for comparisons between areas and years also for these species.

5.2 Conclusions

All observed species were documented by index and/or absolute density estimates. The methods used were appropriate for non-evasive species such as roe deer and hares. The indices obtained from observed encounter rates could be used for comparisons between years or with adjacent areas with similar habitat, although low sample sizes for some species warrant cautious use of data.

A spotlight survey is a direct method for rendering estimates of absolute density for easily observed species. Compared to indirect methods it requires less field work, and when successful yields both absolute population density estimates and index values. We therefore recommend the method to be used as a compliment to other estimates of herbivore populations. For comparisons between or within populations of foxes and badgers, we would instead suggest the use of indirect index methods, e.g. systematic faecal counts or surveys of fox dens and badger setts.

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