P-07-122

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# Surveys of mammal populations in the areas adjacent to Forsmark and Oskarshamn

## Results from 2007, compared with results from 2002/2003

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May 2007

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*Keywords:* Mammals, Survey, Population, Density, Index, AP PS 400-06-143, AP PF 400-06-102.

# Abstract

A selection of terrestrial mammals was surveyed in the SKB site investigation areas near Forsmark and Oskarshamn between January and April 2007. The methods that were used include snowtracking along line transects, snowtracking along water, aerial survey and fecal pellet counts. The data that were collected generated either indices of population density or estimates of actual density. Comparing the density of species in 2007 relative to 2002/2003 reveals a number of changes within populations during this time. Density of wild boar, fox, and squirrel were higher in 2007 in all areas, whilst roe deer was lower. Other species showed variation that was less coherent or of minor magnitude.

# Sammanfattning

Ett urval av däggdjursarter inventerades i SKB:s platsunderökningsområden i Forsmark och Oskarshamn under perioden januari–april 2007. Inventeringarna omfattade snöspårning längs linje, snöspårning längs vattendrag och strandkanter, flyginventering samt spillningsinventering. Mätvärdena resulterade antingen i skattningar av absolut täthet eller ett täthetsindex. Flera däggdjurspopulationer uppvisar en täthet som skiljer sig från de resultat som erhölls vid motsvarande inventering 2002/2003. Vildsvin, räv och ekorre har ökat i alla områden som inventerades, medan rådjuren minskat. Andra arter uppvisar en variation som ej är lika enhetlig, eller av mindre omfattning.

# Contents

# 1 Introduction

This document reports the results gained by a survey of mammal populations, which is one of the activities performed within the site investigations at Forsmark and Oskarshamn. The work was carried out in accordance with the activity plans AP PS 400-06-143 (Oskarshamn) and AP PF 400-06-102 (Forsmark), see Table 1-1. Activity plans are SKB's internal controlling documents.

At each investigation site mammal surveys were undertaken in two separated areas. In Forsmark the areas are entitled Forsmark and Hållnäs, and in Oskarshamn the areas are entitled Simpevarp and Blankaholm (Figures 1-1 and 1-2).

The purpose of the surveys is to estimate population density, number of individuals per unit land area, for some of the terrestrial mammals in the areas. Mammal surveys are usually based on samples from a proportion of the area of interest. Methods where individuals are counted on the sampling units can generate estimates of actual population density. However, often a proportion of the individuals on the sample units are missed by the observers. If that proportion is unknown, the results should be considered as an index of population density, proportional to actual density.

Counts of field signs (e.g. tracks, droppings, sounds) also generate either indices or actual estimates of population density. Counts of field signs are sometimes the only alternative when surveying animals that are rare or difficult to observe. One disadvantage is that relevant comparisons between areas and species are limited, and is only valid if the proportionality to the actual population size remains the same for areas, species, survey occasions etc.

The methods that were used in Forsmark and Oskarshamn include snowtracking along line transects, snowtracking along water, aerial survey and fecal pellet counts. The data that were collected generated either indices of population density or estimates of actual density.

The original results are stored in the primary data base SICADA and are traceable by the activity plan number. Only data in SKB's databases are accepted for further interpretation and modelling. The data presented in this report are regarded as copies of the original data. Data in the databases may be revised, if needed. Such revisions will not necessarily result in a revision of the P-report, although the normal procedure is that major data revisions entail a revision of the P-report. Minor data revisions are normally presented as supplements, available at www.skb.se.

**Table 1-1. Controlling documents for performance of the activity.**

| Activity plan | Number | Version |
|---|---|---|
| Inventering av däggdjur 2006–2007 | AP PS 400-06-143 | 1.0 |
| Viltinventering 2007 | AP PF 400-06-102 | 1.0 |


***Figure 1-1.*** *Forsmark site investigation area. The blue lines indicate the border of the study areas. Forsmark in the south and Hållnäs in the north.*

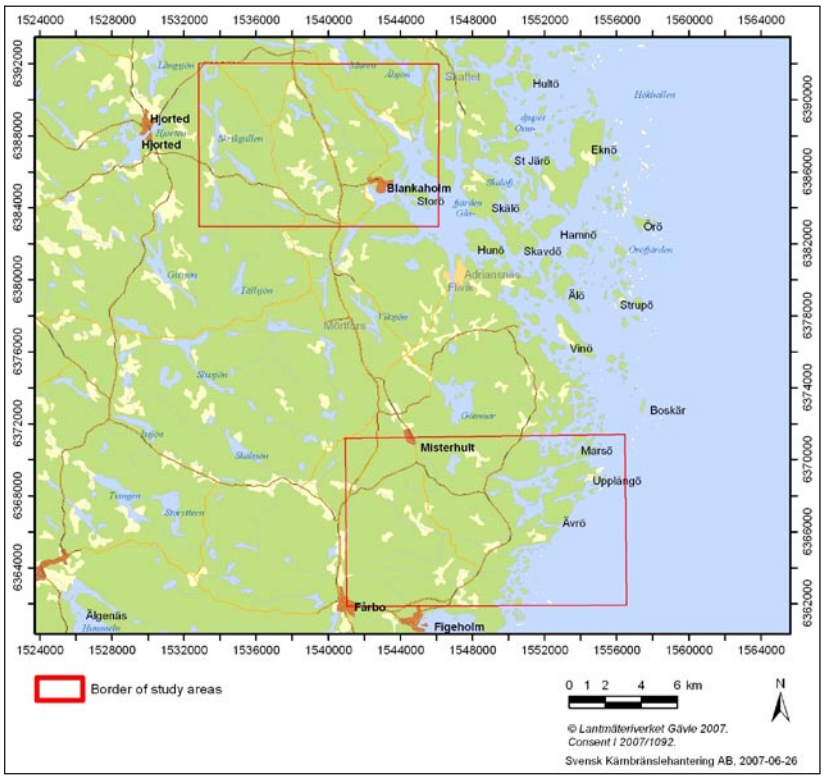


***Figure 1-2.*** *The two study areas in Oskarshamn, Simpevarp in the south and Blankaholm in the north.*

# 2 Methods

## 2.1 General

There is a vast literature about methods for estimating population density and related parameters for mammals. Some of the most well known hand books are: Seber, G.A.F. /Seber 1982/ The estimation of animal abundance and related parameters (Charles Griffin & Company Ltd, London) and Krebs, C.J. /Krebs 1989/ Ecological methods (Harper & Row, New York).

A different set of methods were applied in each area. Date and location of surveys are listed in Table 2-1. In addition to the surveys, information on the presence of lynx was supplied from the County Administrative Boards of Uppsala and Kalmar. All methods used in the surveys are described in the following sections.

## 2.2 Aerial survey

***Species: moose, deer, wild boar***

The aerial survey is a direct method where animals are counted in sample plots from a helicopter. The method is primarily adapted for moose and generates an actual estimate of density, see Figure 2-1. Observations of several other species e.g. roe deer, red deer, fallow deer and wild boar are recorded during the survey and generates an index of density.

Aerial surveys are carried out during winter when land areas are covered with > 20 cm snow. If possible, the survey is initiated one day after snowfall, when fresh tracks are easy to detect. At least two helicopters are used on each occasion. One reason is to reduce the operating time and use the opportunity of good weather conditions (e.g. between snowfalls). Another reason is that the method requires control surveys by two independent observation teams (see below).

In each study area sample plots (2 $km^2$) are evenly distributed, covering 25–30% of the entire area (Figure 2-2). Each plot is thoroughly searched for animals. The time and position of each observation as well as number of animals, their sex and age are recorded.

Location makes it possible to discriminate between observations that are within and outside the plot. The mean density, e.g. individuals or number of moose/$km^2$, and the variance is then calculated.

Weather conditions, flight speed, snow depth, etc, might influence the observability. It is important to calculate the probability to observe animals in the plots since some animals will not be observed. Therefore, two teams independent of each other both search 25–30% of the plots. Time lag between the visits in the plots should not be more than 5 minutes so the chances to observe the same animals are as high as possible. By comparing the results from the two teams using a capture-recapture procedure /Seber 1982, Skalski and Robson 1992/ it is possible to calculate the observability of a given species each day and to correct the mean values calculated from the standard methods.

Spatial variation in moose density was analysed using standard procedures for interpolation of three dimensional data by spline interpolation in SAS /SAS Version 8.02/. Negative values from the interpolation was set to zero.

Aerial surveys were performed only at Simpevarp and Blankaholm.

**Table 2-1. Overview of survey methods and date of surveys in different areas.**

| Survey method | Forsmark | Hållnäs | Simpevarp | Blankaholm |
|---|---|---|---|---|
| Snowtracking – line transects | 070125 | 070123 | 070127 | 070209 |
| Snowtracking – transects along watersystems | 070131–070209 | 070123–070209 | – | – |
| Aerial survey | – | – | 070208–070210 | 070208–070210 |
| Fecal pellet counts – forest and field | 070411–070414 | 070411–070414 | 070403–070425 | 070412–070426 |

***Figure 2-1.*** *Helicopter (Hughes 300) in operation (Photo: Curt Robert Lindqvist).*

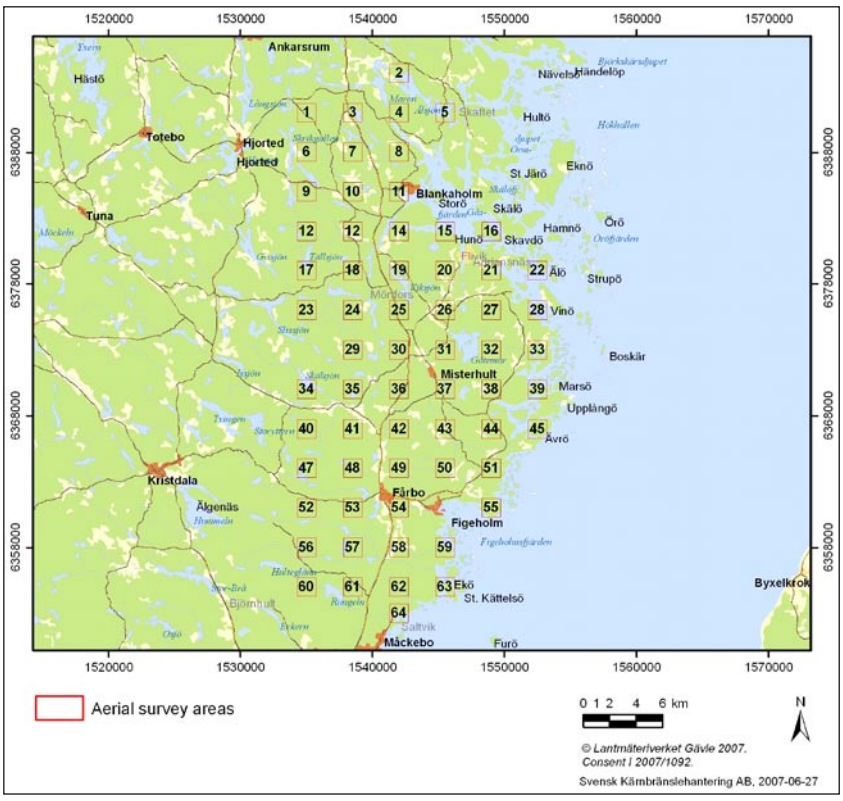


***Figure 2-2.*** *Map showing distribution of aerial survey areas in Oskarshamn.*

## 2.3 Line transects

Line transects include a variety of methods and can be used both as indices and for actual density estimates. In line-intercept sampling, a sample of lines is selected in a study area and objects of interest that cross the line are recorded. In this survey line transects were walked when the ground was covered with snow, and tracks of animals crossing the line were recorded.

### 2.3.1 The Buffon method

***Species: Wolf, lynx, marten***

The method is based on the classical problem called the "Buffon's needle problem" /Becker et al. 1998/. Line transects that run parallel to each other with an even distribution are used and tracks crossing the line are followed in each direction and mapped (Figure 2-3). The method is well suited for species that roam over relatively large areas and occur at low densities.

The tracking must not be started until 8 hours after snowfall. One moves along transects that are evenly distributed over the research area. The first line is randomly chosen but the additional lines are parallel and distributed 4 km apart. Each track crossing the transect is followed backwards to the position where the first track is found after snowfall. Preferably the track is also followed onwards until the animal is observed, the day bed is found etc. Positioning is done with GPS. If possible, sex, age and number of animals are recorded. The shortest distance to the transect from the outer ends of the track is calculated. However, following animals is in violation of Swedish law and was not applied in the survey. Instead the distance between the line and the backward position was doubled, assuming that the outer end of tracks on average are located at the same distance from the line.

The Buffon method makes it possible to estimate the actual density but is not realistic to use for common species because it would be very time consuming to follow too many tracks in both directions, therefore the method was only used for lynx and marten. However, all tracks crossing the line can easily be recorded and used as an index, e.g. as 'number of tracks per km of transect and day' where day denotes days since last snowfall.

Figure 2-4 and 2-5 shows where tracking on snow was performed in Oskarshamn and Forsmark, respectively.

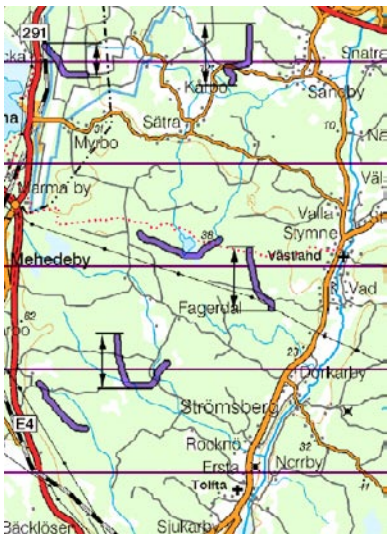


***Figure 2-3.*** *Principle for the Buffon method. Blue, filled lines indicate tracks of animals. The arrows show the shortest distance from the end points of the track to the transect. Tracks not crossing transects are excluded from the data set.*

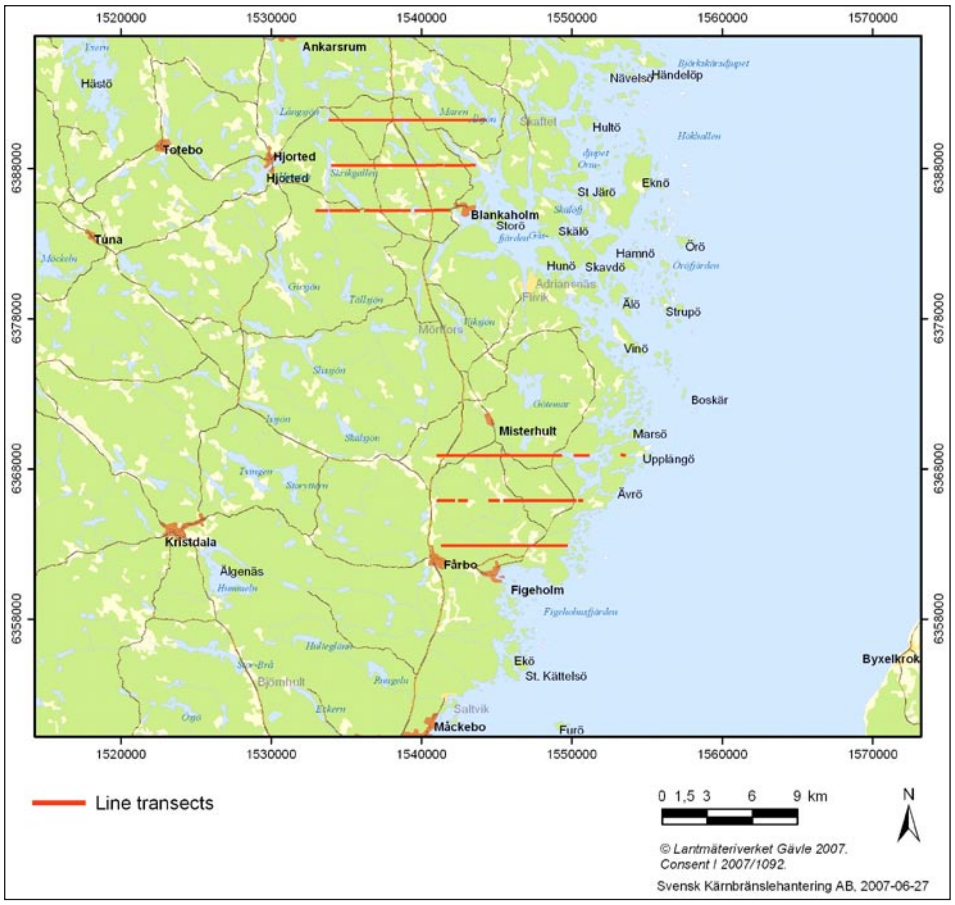


***Figure 2-4.*** *Line transects where tracking on snow was performed in Simpevarp and Blankaholm.*

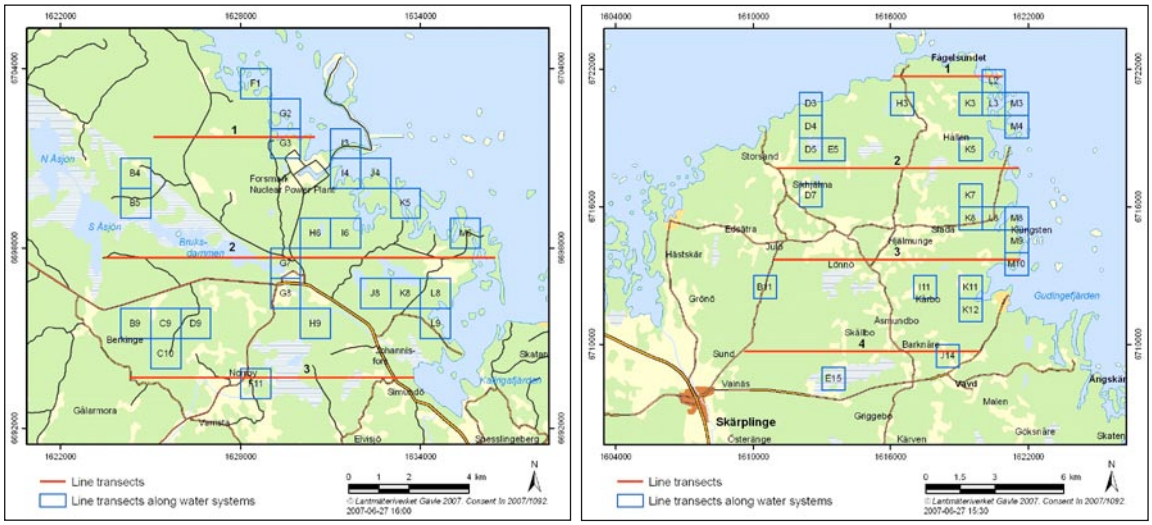


***Figure 2-5.*** *Line transects where tracking on snow was performed in Forsmark (left) and Hållnäs (right).*

### 2.3.2 Transects along water systems

***Species: Otter, mink, fox, beaver, wolf, lynx, marten***

To facilitate the distribution of sampling plots, each area was divided in squares of 1 km$^2$ (1×1 km). Since it is more likely to find tracks of semi-aquatic species along the coast and the larger streams than in any other areas, the landscape was stratified into two categories: 1) coast/larger streams; 2) other water areas. Sampling was made in two stages. The first stage consisted of sampling among squares containing the required strata. The second stage consisted of sampling among the strata inside the squares (Figure 2-6). Transects are adjusted to the edges of all the water areas within the selected square. Larger ditches are included if they are considered to be filled with water most of the year. Burrows, dens and other signs of presence of the species are recorded as well as tracks of other mammals that cross the line. The results should be considered as an index of population density with the unit 'tracks per km transect and day'.

## 2.4 Fecal counts

***Species: Moose, red deer, roe deer, wild boar, hares***

Animal droppings are counted in sample plots and, given the number of pellet groups or pellets (hares) produced per day, and the number of days since leaf fall, it is possible to calculate an estimate of actual population density. Pellets are counted in late winter and early spring. At this time of year the problems of not detecting pellet groups due to overgrowth by ground vegetation are minimal. Pellets that are considered as dropped during the period between leaf fall and the day of counting are recorded, that is if they are not covered with leaves or are in a considerable stage of decay. October 15 was used as date of leaf fall for all areas. Defecation rates for individual species are necessary for calculating population densities (Table 2-2).

Population density is calculated with the formula:

$$N\ (\text{individuals/km}^2) = \frac{\text{pellet groups/km}^2}{\text{defecation rate} \times \text{days between leaf and survey}}$$

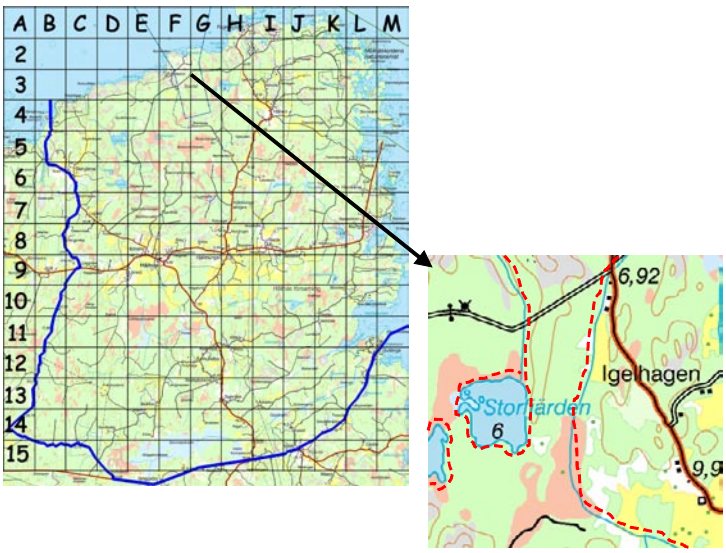


***Figure 2-6.*** *Principle for sampling of tracks crossing transects oriented along the water system. The red dashed lines indicate transects.*

**Table 2-2. Defecation rates of species included in the fecal count.**

| Species | Defecation rate (pellet or pellet groups/day) | Reference |
|---|---|---|
| Moose | 16.6 | Kjell Wallin, Göteborg University, unpublished |
| Roe deer | 21 | /Mitchell et al. 1985/ |
| Red deer | 25 | /Deer Commission for Scotland 2003/ |
| Fallow deer | 20 | /Deer Commission for Scotland 2003/ |
| Wild boar | 5 | Giovanna Massei Smith Central Science Laboratory UK, unpublished |
| Hare | 475 | Kjell Wallin, Göteborg University, personal communication, april 2007 |

Sample plots were distributed along transects, forming a square (500×1,000 m). Squares, or subareas, are evenly distributed over each study area (Figure 2-7).

In addition to the ordinary plot system hare pellets were also counted in a stratified plot system associated to fields and arable land. From the 1 $km^2$ square system (see section 2.3.2) squares containing fields and arable land were randomly selected. In each square, line transects were distributed at least 50 m apart. The total transect length for each square was, if possible, one kilometer. Sample plots were evenly distributed along the transects with 10 m between individual plots. The transects began and ended in the forested area 10 m from the edge of the open area.

### *Specification of the sampling units*

Approximately 1,000 sampling plots are drawn per area and survey (forest and field). However, several plots can't be searched since they are distributed without respect to geographical obstacles like lakes, nuclear plants etc.

The following criteria are used in the survey:

- Pellet groups or droppings laying with > 50% within the plot are counted.
- Moose, red deer, fallow deer, wild boar.
  - Plot size is 100 $m^2$ (radius 5.64 m).
  - Only pellet groups containing > 20 pellets are counted. All wild boar droppings are counted.
- Roe deer.
  - Plot size is 10 $m^2$ (radius 1.78 m).
  - Only pellet groups containing > 10 pellets are counted.
- Hares.
  - Plot size is 1 $m^2$ (radius 0.56 m).
  - All pellets are counted.

The fecal count areas in Oskarshamn and Forsmark are presented in Figure 2-8 and 2-9, respectively.

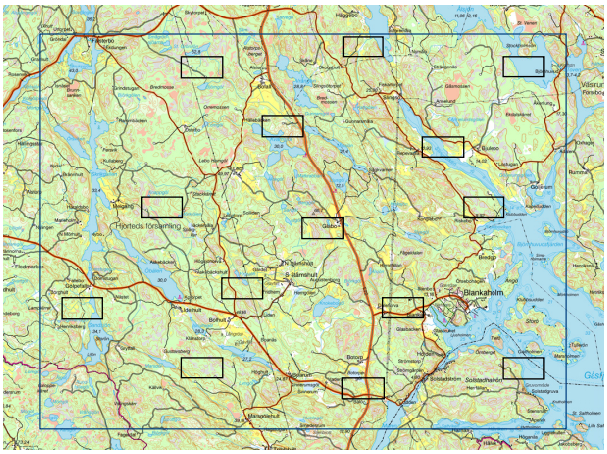

***Figure 2-7.*** *Principle for sample area distribution in forested habitats when counting pellets from cervids (moose and deer), hares and wild boar. Each sample area contains 74 sample plots aligned along the border.*

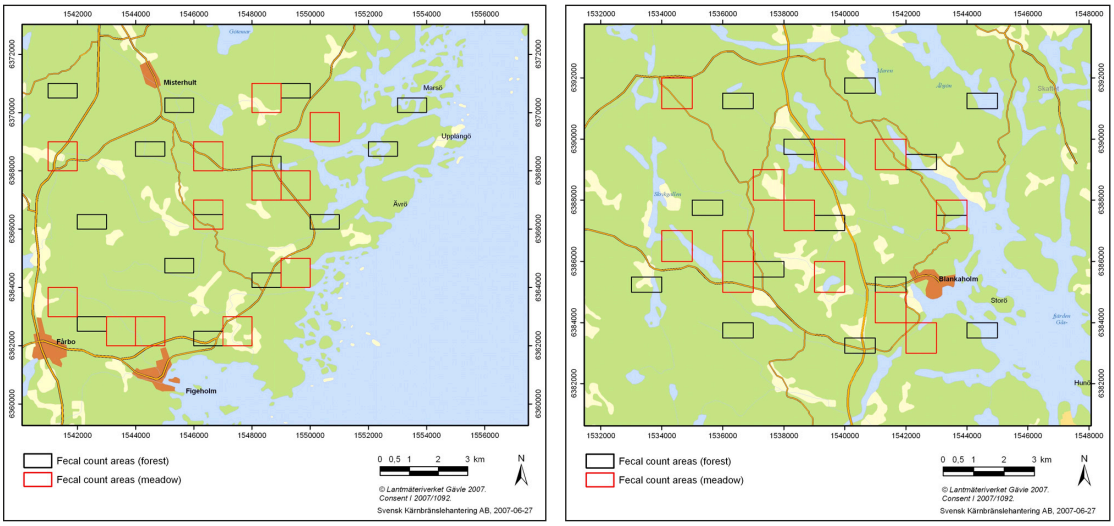


***Figure 2-8.*** *Fecal count areas in Simpevarp (left) and Blankaholm (right).*

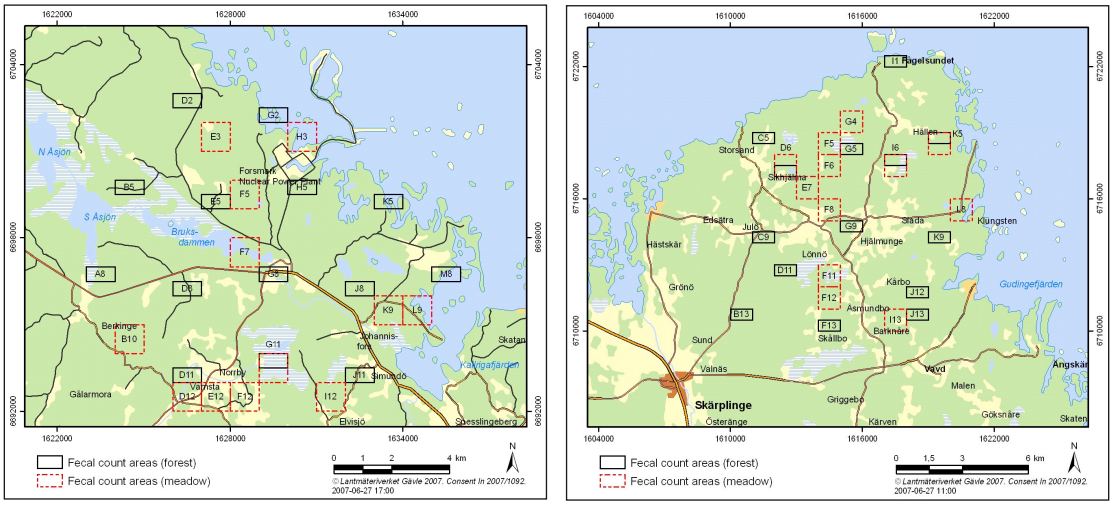


***Figure 2-9.*** *Fecal count areas in Forsmark (left) and Hållnäs (right).*

## 2.5 Nonconformities

With respect to activity plans and method descriptions the following nonconformities are accounted for.

### 2.5.1 Aerial Survey

One sample plot was not searched during the aerial survey (sample plot nr 46, IDCODE: ASM002575). This deviation has no significant effect on the results.

### 2.5.2 Line transects

The intention was to record the positions of tracks from all predators along line transects. This was only done for marten and lynx along one of the transects in Hållnäs (IDCODE: AFM000200). In Simpevarp, the positions of tracks from squirrels were not recorded along one of the lines (IDCODE: LSM000612). However, all tracks were noted and the deviation from the planned registration of positions does not affect the index.

# 3 Results

The results are presented in tables with mean values of indices and density estimates. When population density is estimated, standard error (SE), or 95% confidence intervals ($SE_{95\%}$) are also presented. The column denoted $SE_{95\%}$ lists the value that should be subtracted from the mean to get the lower confidence limit, or added to get the upper confidence limit.

## 3.1 Forsmark 2007

### 3.1.1 Snowtracking

#### *Lynx*

Tracks were found both in Forsmark and Hållnäs (Table 3-2). A few tracks crossed the lines during the line-tracking in Forsmark but they were difficult to follow since they passed lakes and wetlands with thin ice. Consequently it was not possible to estimate population density of Lynx in the area. However, results from regional surveys made by the County Administrative Board of Uppsala show that there is one family group in Forsmark and Hållnäs respectively. A family group consists on average of 5.5 individuals (Johan Månsson, personal communication, April 2007).

**Table 3-1. Frequency of tracks crossing line transects in Forsmark and Hållnäs.**

| Species | | Number of tracks | Tracks per day and 10 km | Individuals per 10 km² | $SE_{95\%}$ |
|---|---|---|---|---|---|
| **Forsmark** | | | | | |
| Badger | *Meles meles* | 1 | 0.44 | | |
| Dog | *Canis familiaris* | 4 | 1.76 | | |
| Fox | *Vulpes vulpes* | 39 | 17.18 | | |
| Lynx | *Lynx lynx* | 2 | 0.88 | | |
| Marten | *Martes martes* | 5 | 2.20 | 14.44 | 7.43 |
| Mink | *Mustela vison* | 1 | 0.44 | | |
| Squirrel | *Sciurus vulgaris* | 20 | 8.81 | | |
| Weasel | *Mustela nivalis* | 4 | 1.76 | | |
| Wild boar | *Sus scrofa* | 17 | 7.49 | | |
| **Hållnäs** | | | | | |
| Cat | *Felis catus* | 1 | 0.29 | | |
| Dog | *Canis familiaris* | 3 | 0.87 | | |
| Fox | *Vulpes vulpes* | 88 | 25.43 | | |
| Marten | *Martes martes* | 4 | 1.16 | 4.69 | 3.71 |
| Squirrel | *Sciurus vulgaris* | 21 | 6.07 | | |
| Weasel | *Mustela nivalis* | 1 | 0.29 | | |
| Wild boar | *Sus scrofa* | 2 | 0.58 | | |

**Table 3-2. Frequency of tracks crossing transects along water systems in Forsmark and Hållnäs.**

| Species | | Number of tracks | Tracks per day and 10 km |
|---|---|---|---|
| **Forsmark** | | | |
| Badger | *Meles meles* | 1 | 0.07 |
| Fox | *Vulpes vulpes* | 155 | 17.58 |
| Lynx | *Lynx lynx* | 9 | 0.76 |
| Marten | *Martes martes* | 7 | 0.97 |
| Mink | *Mustela vison* | 22 | 3.14 |
| Otter | *Sciurus vulgaris* | 1 | 0.10 |
| Squirrel | *Lutra lutra* | 39 | 4.56 |
| Stoat | *Mustela erminea* | 3 | 0.62 |
| Weasel | *Mustela nivalis* | 3 | 0.21 |
| Wild boar | *Sus scrofa* | 17 | 2.66 |
| **Hållnäs** | | | |
| Badger | *Meles meles* | 2 | 0.15 |
| Cat | *Felis catus* | 1 | 0.08 |
| Dog | *Canis familiaris* | 3 | 0.23 |
| Fox | *Vulpes vulpes* | 84 | 11.37 |
| Lynx | *Lynx lynx* | 8 | 1.14 |
| Marten | *Martes martes* | 4 | 0.68 |
| Mink | *Mustela vison* | 19 | 2.43 |
| Otter | *Lutra lutra* | 2 | 0.45 |
| Squirrel | *Sciurus vulgaris* | 36 | 5.19 |

### 3.1.2 Fecal counts

**Table 3-3. Density estimates from fecal counts in Forsmark and Hållnäs.**

| Species | | n | Ind/10 km$^2$ | $SE_{95\%}$ |
|---|---|---|---|---|
| **Forsmark** | | | | |
| Moose | *Alces alces* | 774 | 5.63 | 1.33 |
| Roe deer | *Capreolus capreolus* | 774 | 33.3 | 9.34 |
| Wild boar | *Sus scrofa* | 774 | 0.43 | 0.49 |
| Hare – forest | *Lepus sp.* | 774 | 24.11 | 20.54 |
| Hare – field | *Lepus sp.* | 1,077 | 9.5 | 10.24 |
| **Hållnäs** | | | | |
| Moose | *Alces alces* | 886 | 5.53 | 1.08 |
| Roe deer | *Capreolus capreolus* | 886 | 24.28 | 6.32 |
| Wild boar | *Sus scrofa* | 886 | 0.25 | 0.34 |
| Hare – forest | *Lepus sp.* | 886 | 3.44 | 2.74 |
| Hare – field | *Lepus sp.* | 740 | 22.16 | 9.66 |

## 3.2 Oskarshamn 2007

### 3.2.1 Snowtracking

#### *Lynx*

No tracks were found crossing the line transects in Simpevarp or Blankaholm. The county administrative board in Kalmar received reports on observations of tracks of lynx during the winter 2006/2007, indicating that a solitary male was roaming in the area /Mattias Persson, Personal Communication, April 2007/.

**Table 3-4. Frequency of tracks crossing line transects in Simpevarp and Blankaholm.**

| Species | | Number of tracks | Tracks per day and 10 km |
|---|---|---|---|
| **Simpevarp** | | | |
| Cat | *Felis catus* | 1 | 0.38 |
| Dog | *Canis familiaris* | 13 | 4.98 |
| Fox | *Vulpes vulpes* | 59 | 22.61 |
| Squirrel | *Sciurus vulgaris* | 29 | 11.11 |
| Weasel | *Mustela nivalis* | 3 | 1.15 |
| Wild boar | *Sus scrofa* | 74 | 28.35 |
| **Blankaholm** | | | |
| Dog | *Canis familiaris* | 4 | 1.41 |
| Fox | *Vulpes vulpes* | 121 | 42.57 |
| Mink | *Mustela vison* | 1 | 0.35 |
| Squirrel | *Sciurus vulgaris* | 37 | 13.02 |
| Weasel | *Mustela nivalis* | 2 | 0.70 |
| Wild boar | *Sus scrofa* | 67 | 23.57 |

### 3.2.2 Fecal counts

**Table 3-5. Density estimates from fecal counts in Simpevarp and Blankaholm.**

| Species | | n | Ind/10 km$^2$ | $SE_{95\%}$ |
|---|---|---|---|---|
| **Simpevarp** | | | | |
| Moose | *Alces alces* | 955 | 8.34 | 1.34 |
| Fallow deer | *Cervus dama* | 955 | 0.36 | 0.32 |
| Red deer | *Cervus elaphus* | 955 | 1.34 | 0.6 |
| Roe deer | *Capreolus capreolus* | 955 | 37.7 | 8.3 |
| Wild boar | *Sus scrofa* | 955 | 3.36 | 1.62 |
| Hare – forest | *Lepus sp.* | 955 | 10.36 | 5.5 |
| Hare – field | *Lepus sp.* | 949 | 9.65 | 4.32 |
| **Blankaholm** | | | | |
| Moose | *Alces alces* | 866 | 4.2 | 1.03 |
| Fallow deer | *Cervus dama* | 866 | 0.41 | 0.36 |
| Red deer | *Cervus elaphus* | 866 | 1.81 | 0.64 |
| Roe deer | *Capreolus capreolus* | 866 | 34.7 | 8.1 |
| Wild boar | *Sus scrofa* | 866 | 6.66 | 3.23 |
| Hare – forest | *Lepus sp.* | 866 | 2.78 | 3.12 |
| Hare – field | *Lepus sp.* | 1,076 | 17.38 | 9.43 |

### 3.2.3 Aerial survey

**Table 3-6. Results from The aerial survey in Oskarshamn.**

| Aerial survey Oskarshamn | Moose/10 km$^2$ | $SE_{95\%}$ |
|---|---|---|
| Total area | 9.1 | 1.3 |
| Total area excluding water | 10.3 | 1.5 |
| Simpevarp area (same as 2003) total area | 9.5 | 1.29 |
| Simpevarp area (same as 2003) total area excluding water | 11.0 | 1.5 |
| Males (total area) | 1.7 | |
| Females (total area) | 4.9 | |
| Calves (total area) | 2.5 | |

| Population features | |
|---|---|
| Calf/female | 0.51 |
| Calf/adult | 0.35 |
| Females without calf | 59% |
| Females with one calf | 32% |
| Females with two calves | 8% |
| Sex ratio (proportion of males among adults) | 26% |

| Survey features | |
|---|---|
| Total area surveyed (km$^2$) | 626 |
| Area excluding water (km$^2$) | 548 |
| Sample size | 63 |
| Proportion of area surveyed | 0.20 |
| Moose observability | 92% |

| Additional observations | | nr ind |
|---|---|---|
| Roe deer | *Capreolus capreolus* | 53 |
| Fallow deer | *Cervus dama* | 11 |
| Red deer | *Cervus elaphus* | 31 |
| Wild boar | *Sus scrofa* | 4 |
| Capercaille | *Tetrao urogallus* | 3 |
| Black grouse | *Tetrao tetrix* | 2 |
| White-tailed eagle | *Haliaeetus albicilla* | 20 |

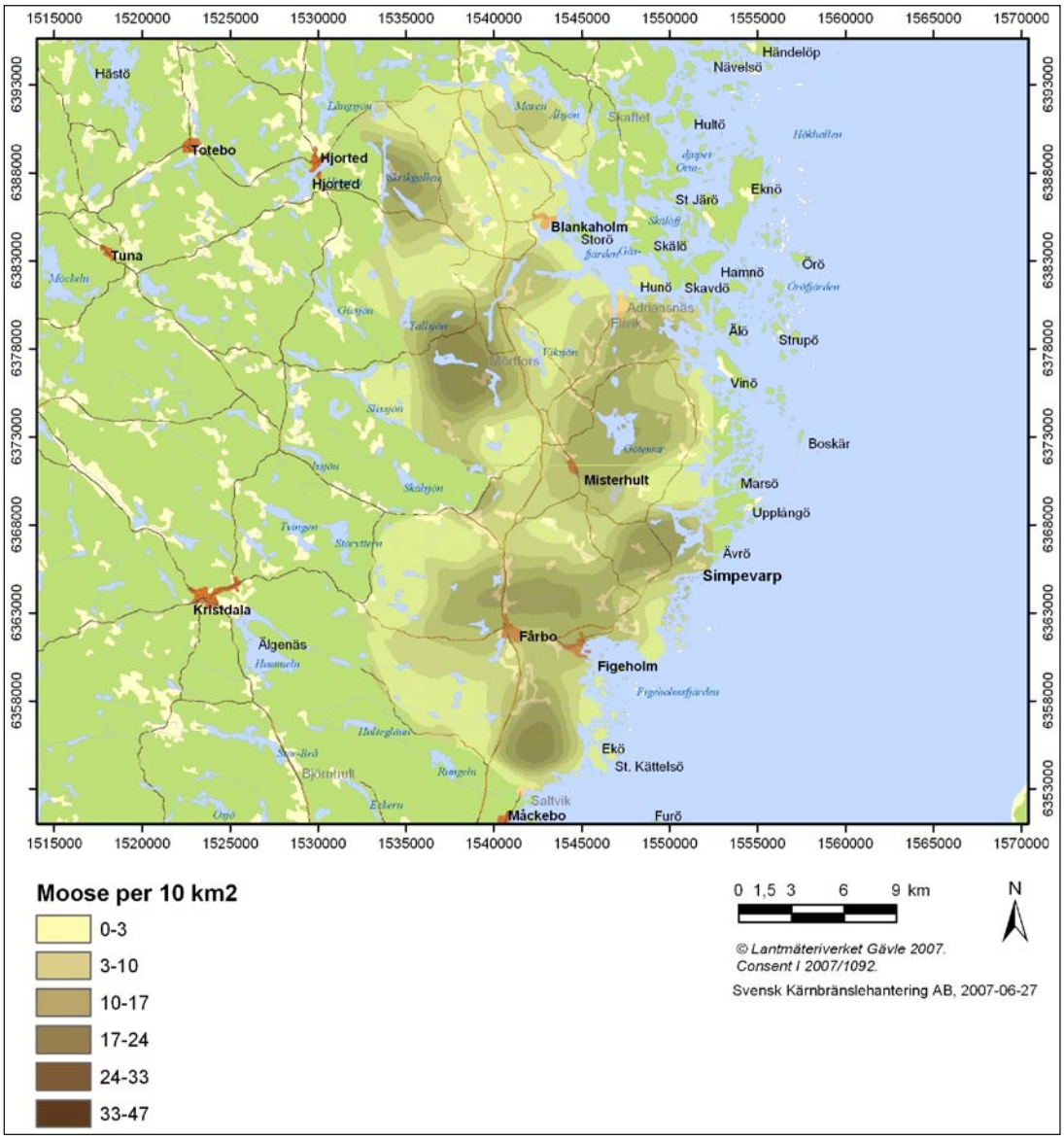


***Figure 3-1.*** *Moose density during the aerial survey in Oskarshamn, February 2007. Variation in density is indicated by different colours.*

# 4 Results 2007 versus 2002/2003

The results from the survey in 2007 are summarized in Table 4-1 together with the corresponding results from 2002 and 2003. The results from the surveys in 2002/2003 are collected from previous reports /Cederlund et al. 2003, 2004/. An exception is the data from snowtracking along water in Forsmark and Hållnäs in 2002 and 2003. The unit was converted from "number of tracks per km" to "number of tracks per day and 10 km". Since snowtracking along water was undertaken in both 2002 and 2003 in Forsmark and Hållnäs, an average value from both years is presented. The difference in results from the survey occasions is presented as percentage changes in population parameters. Some mammal species were absent or not detected in some areas on one of the occasions. If mammals were absent or not detected in 2002/2003 but present in 2007 the relative change is denoted with a '+' in Table 4-1. If mammals were absent or not detected in 2007 but present in 2002/2003 the relative change inevitably becomes –100%.

**Table 4-1. Results from the surveys in Forsmark and Oskarshamn in 2002/2003 and 2007. The figures in the 'Relative change' column show the percentage changes in population parameters during 2002/2003–2007. An asterisk denotes that the figure is an average value from surveys that were undertaken in 2002 and 2003.**

| Species | Area | 2002/2003 | 2007 | Relative change | Method | Parameter |
|---|---|---|---|---|---|---|
| Badger | Forsmark | 0.00 | 0.44 | + | Line transects | Tracks/day/10 km |
| Badger | Forsmark | 0.00 | 0.07 | + | Transects/water | Tracks/day/10 km |
| Badger | Hållnäs | 0.00 | 0.15 | + | Transects/water | Tracks/day/10 km |
| Cat | Hållnäs | 0.00 | 0.29 | + | Line transects | Tracks/day/10 km |
| Cat | Hållnäs | 0.00 | 0.08 | + | Transects/water | Tracks/day/10 km |
| Cat | Simpevarp | 0.00 | 0.38 | + | Line transects | Tracks/day/10 km |
| Dog | Forsmark | 0.00 | 1.76 | + | Line transects | Tracks/day/10 km |
| Dog | Hållnäs | 0.12 | 0.87 | +625% | Line transects | Tracks/day/10 km |
| Dog | Hållnäs | 0.00 | 0.23 | + | Transects/water | Tracks/day/10 km |
| Dog | Simpevarp | 0.00 | 4.98 | + | Line transects | Tracks/day/10 km |
| Dog | Blankaholm | 0.00 | 1.41 | + | Line transects | Tracks/day/10 km |
| Fox | Forsmark | 8.71 | 17.18 | +97% | Line transects | Tracks/day/10 km |
| Fox | Forsmark | 5.48* | 17.58 | +221% | Transects/water | Tracks/day/10 km |
| Fox | Hållnäs | 9.20 | 25.43 | +176% | Line transects | Tracks/day/10 km |
| Fox | Hållnäs | 9.44* | 11.37 | +20% | Transects/water | Tracks/day/10 km |
| Fox | Simpevarp | 21.00 | 22.61 | +8% | Line transects | Tracks/day/10 km |
| Fox | Blankaholm | 27.16 | 42.57 | +57% | Line transects | Tracks/day/10 km |
| Lynx | Forsmark | 0.95 | 0.88 | –7% | Line transects | Tracks/day/10 km |
| Lynx | Forsmark | 0.50* | 0.76 | +51% | Transects/water | Tracks/day/10 km |
| Lynx | Hållnäs | 0.04* | 1.14 | +2,907% | Transects/water | Tracks/day/10 km |

| Species | Area | 2002/2003 | 2007 | Relative Change | Method | Parameter |
|---|---|---|---|---|---|---|
| Marten | Forsmark | 2.30 | 2.20 | –4% | Line transects | Tracks/day/10 km |
| Marten | Forsmark | 2.4 | 14.44 | +502% | Buffon estimate | Ind/10 km² |
| Marten | Forsmark | 0.82* | 0.97 | +18% | Transects/water | Tracks/day/10 km |
| Marten | Hållnäs | 0.82 | 1.16 | +41% | Line transects | Tracks/day/10 km |
| Marten | Hållnäs | 4.2 | 4.69 | +12% | Buffon estimate | Ind/10 km² |
| Marten | Hållnäs | 0.36* | 0.68 | +89% | Transects/water | Tracks/day/10 km |
| Marten | Simpevarp | 1.02 | 0.00 | –100% | Line transects | Tracks/day/10 km |
| Marten | Blankaholm | 0.40 | 0.00 | –100% | Line transects | Tracks/day/10 km |
| Mink | Forsmark | 0.40 | 0.44 | +10% | Line transects | Tracks/day/10 km |
| Mink | Forsmark | 2.42* | 3.14 | +30% | Transects/water | Tracks/day/10 km |
| Mink | Hållnäs | 0.98* | 2.43 | +149% | Transects/water | Tracks/day/10 km |
| Mink | Blankaholm | 0.00 | 0.35 | + | Line transects | Tracks/day/10 km |
| Otter | Forsmark | 0.40 | 0.00 | –100% | Line transects | Tracks/day/10 km |
| Otter | Forsmark | 0.75* | 0.10 | –87% | Transects/water | Tracks/day/10 km |
| Otter | Hållnäs | 0.06* | 0.45 | +691% | Transects/water | Tracks/day/10 km |
| Squirrel | Forsmark | 4.30 | 8.81 | +105% | Line transects | Tracks/day/10 km |
| Squirrel | Forsmark | 0.48* | 4.56 | +856% | Transects/water | Tracks/day/10 km |
| Squirrel | Hållnäs | 1.18 | 6.07 | +414% | Line transects | Tracks/day/10 km |
| Squirrel | Hållnäs | 0.52* | 5.19 | +906% | Transects/water | Tracks/day/10 km |
| Squirrel | Simpevarp | 8.85 | 11.11 | +26% | Line transects | Tracks/day/10 km |
| Squirrel | Blankaholm | 10.09 | 13.02 | +29% | Line transects | Tracks/day/10 km |
| Stoat | Forsmark | 0.00 | 0.62 | + | Transects/water | Tracks/day/10 km |
| Weasel | Forsmark | 0.40 | 1.76 | +340% | Line transects | Tracks/day/10 km |
| Weasel | Forsmark | 0.09* | 0.21 | +143% | Transects/water | Tracks/day/10 km |
| Weasel | Hållnäs | 0.24 | 0.29 | +21% | Line transects | Tracks/day/10 km |
| Weasel | Hållnäs | 0.63* | 0.00 | –100% | Transects/water | Tracks/day/10 km |
| Weasel | Simpevarp | 0.34 | 1.15 | +238% | Line transects | Tracks/day/10 km |
| Weasel | Blankaholm | 0.39 | 0.70 | +79% | Line transects | Tracks/day/10 km |
| Fallow deer | Simpevarp | 0.00 | 0.36 | + | Fecal counts | Ind/10 km² |
| Fallow deer | Blankaholm | 0.40 | 0.41 | +2% | Fecal counts | Ind/10 km² |
| Moose | Forsmark | 10.30 | 5.63 | –45% | Fecal counts | Ind/10 km² |
| Moose | Hållnäs | 6.50 | 5.53 | –15% | Fecal counts | Ind/10 km² |
| Moose | Simpevarp | 8.70 | 11.00 | +26% | Aerial survey | Ind/10 km² |
| Moose | Simpevarp | 5.70 | 8.34 | +46% | Fecal counts | Ind/10 km² |
| Moose | Blankaholm | 4.00 | 4.20 | +5% | Fecal counts | Ind/10 km² |
| Red deer | Simpevarp | 0.30 | 1.34 | +347% | Fecal counts | Ind/10 km² |
| Red deer | Blankaholm | 1.50 | 1.81 | +21% | Fecal counts | Ind/10 km² |
| Roe deer | Forsmark | 76.50 | 33.30 | –56% | Fecal counts | Ind/10 km² |
| Roe deer | Hållnäs | 42.90 | 24.28 | –43% | Fecal counts | Ind/10 km² |
| Roe deer | Simpevarp | 49.00 | 37.70 | –23% | Fecal counts | Ind/10 km² |
| Roe deer | Blankaholm | 51.60 | 34.70 | –33% | Fecal counts | Ind/10 km² |

| Species | Area | 2002/2003 | 2007 | Relative Change | Method | Parameter |
|---|---|---|---|---|---|---|
| Wild boar | Forsmark | 0.00 | 0.43 | + | Fecal counts | Ind/10 km$^2$ |
| Wild boar | Forsmark | 0.00 | 7.49 | + | Line transects | Tracks/day/10 km |
| Wild boar | Forsmark | 0.03* | 2.66 | +10,167% | Transects/water | Tracks/day/10 km |
| Wild boar | Hållnäs | 0.05 | 0.25 | +400% | Fecal counts | Ind/10 km$^2$ |
| Wild boar | Hållnäs | 0.00 | 0.58 | + | Line transects | Tracks/day/10 km |
| Wild boar | Hållnäs | 0.00* | 0.00 | . | Transects/water | Tracks/day/10 km |
| Wild boar | Simpevarp | 2.60 | 3.36 | +29% | Fecal counts | Ind/10 km$^2$ |
| Wild boar | Simpevarp | 0.68 | 28.35 | +4,069% | Line transects | Tracks/day/10 km |
| Wild boar | Blankaholm | 1.20 | 6.66 | +455% | Fecal counts | Ind/10 km$^2$ |
| Wild boar | Blankaholm | 0.39 | 23.57 | +5,944% | Line transects | Tracks/day/10 km |
| | | | | | | |
| Hare – field | Forsmark | 3.20 | 9.50 | +197% | Fecal counts | Ind/10 km$^2$ |
| Hare – field | Hållnäs | 12.70 | 19.87 | +56% | Fecal counts | Ind/10 km$^2$ |
| Hare – field | Simpevarp | 35.10 | 9.65 | –73% | Fecal counts | Ind/10 km$^2$ |
| Hare – field | Blankaholm | 19.10 | 17.38 | –9% | Fecal counts | Ind/10 km$^2$ |
| | | | | | | |
| Hare – forest | Forsmark | 3.35 | 24.11 | +620% | Fecal counts | Ind/10 km$^2$ |
| Hare – forest | Hållnäs | 1.90 | 3.44 | +81% | Fecal counts | Ind/10 km$^2$ |
| Hare – forest | Simpevarp | 5.20 | 10.36 | +99% | Fecal counts | Ind/10 km$^2$ |
| Hare – forest | Blankaholm | 3.20 | 2.78 | –13% | Fecal counts | Ind/10 km$^2$ |

# 5 Summary and discussion

## 5.1 Assessing population change

Comparing the density of species in 2007 relative to 2002/2003 reveals a number of changes within populations during this time. The underlying causes to such changes are often unknown, and can originate from several processes of more or less complicated nature. Surveys made on two subsequent occasions are not sufficient to make statements about long term trends of populations. Such statements require longer time series of data. For instance, variation in population index between two subsequent occasions can either be a result of a long term trend, or a result of a fluctuating population size, with a normally distributed annual variation (Figure 5-1).

Some of the results in the surveys can be related to other indices based on samples from a regional level, e.g. number of reported animals killed in traffic (Figure 5-2). Such relations do not necessarily aid in explaining the causes of variation, but they imply if variation is caused by small scale processes, e.g. local management, or larger scale processes, e.g. regional management, weather conditions etc.

In the following two sections the results from the surveys in Forsmark and Oskarshamn in 2007 are discussed and also compared to the results from 2002/2003. Differences between the surveys are commented, and for moose, roe deer and wild boar also related to trends in number of traffic killed animals. Not withstanding the limitations of using the indices from the surveys as actual estimates of density, they are treated in the discussion as if they were so.

Two things are important to bear in mind when analysing surveys including several species and methods. Variation in different indices for single species is not necessarily coherent, e.g. rare species and small samples produce indices with large stochastic impact. Secondly, variation in one index between different species is not necessarily comparable, e.g. when counting snowtracks there is a varying probability of inclusion between different species due to variation in movement patterns /Thompson 2002/.

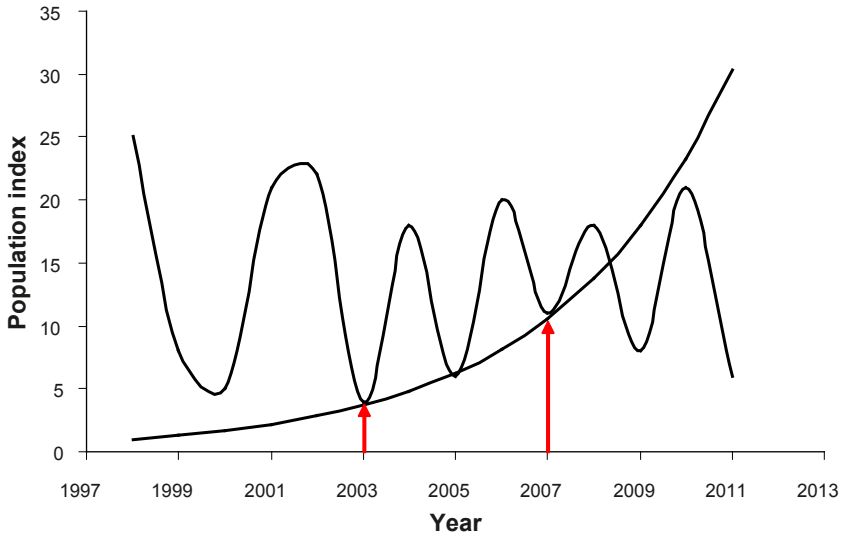


***Figure 5-1.*** *Hypothetic example of population variation over time. Variation in population index between two subsequent occasions can either be a result of a long term trend or a result of a fluctuating population size, with a normally distributed annual variation.*

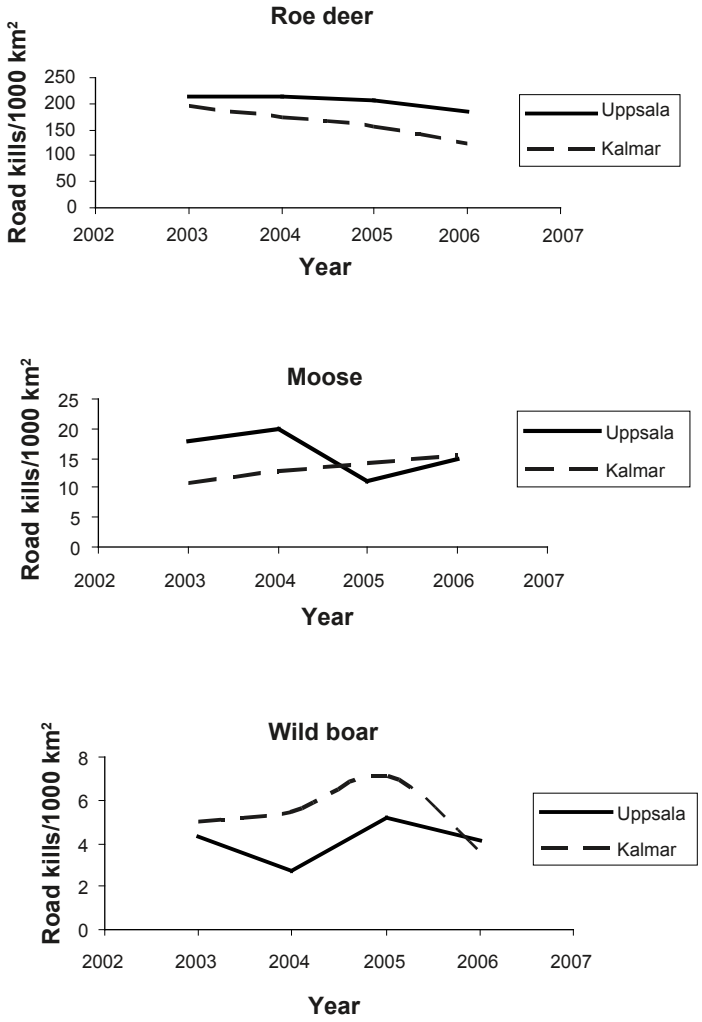


***Figure 5-2.*** *Number of road killed roe deer, moose and wild boar per 1,000 km²land area reported to the police in the counties of Uppsala and Kalmar between 2003 and 2006 /Nationella Viltolycksrådet 2007/.*

## 5.2 Forsmark

Cat, badger and stoat were present in 2007, although in low numbers, but were not detected in 2002/2003. Badgers hibernate in winter and snowtracking is not a reliable method. Cat and stoat were probably present in the areas in 2002/2003, but mammals with low population density are often unobserved in sample surveys where a small proportion of the area is investigated.

### *Fox*

Indices of fox based on snowtracks show that the population has increased since 2003 with on average 159% in Forsmark and 98% in Hållnäs. The difference between the survey occasions is probably reliable since tracks of fox are numerous and variation in population index of this magnitude is not likely to occur by chance.

### *Lynx*

According to the County Administrative Board of Uppsala at least one family group of lynx has resided in the Forsmark area since 2002, and a family group was established in the Hållnäs area in 2004 (Johan Månsson, personal communication, April 2007). These results are also supported by the survey which indicate that the number of tracks in Forsmark are nearly the same as in 2002/2003 while there has been an increase in Hållnäs, reaching approximately the same index level as in Forsmark.

### *Marten*

Density indices of marten have increased since 2002/2003. The Buffon estimate from Forsmark (14.4 ind/10 km$^2$) seems exceptionally high and requires a comment. Totally five tracks were found, but only two could be followed backwards to their full extent. When tracks are impossible to follow, it results in a shorter distance to the transect from the outer ends of the tracks, and generates a higher estimate of density.

### *Mink*

Indices from Forsmark are nearly the same as in 2002/2003. In Hållnäs there was an increase.

### *Otter*

Tracks from otter were found in both areas. In Hållnäs more tracks were found compared to 2002/2003, in Forsmark less.

### *Weasel and stoat*

Tracks from these species are difficult to separate. There has been an increase in Forsmark and a decrease in Hållnäs.

### *Squirrel*

Squirrel was one of the most abundant species in both areas and populations have grown since 2002/2003.

### *Moose and roe deer*

Moose and roe deer populations have decreased in both areas, and seemingly in the whole county (Figure 5-2).

### *Wild boar*

The wild boar populations have increased with an amazing rate, a phenomenon the area share with many other parts of the country. Population growth is seemingly more rapid than the average rate in the county (Figure 5-2).

### *Hare*

Population density of hares, in forest and field, is higher than in 2002/2003. Hare populations have high interannual variation and the results are within the limits of what can be expected.

## 5.3 Oskarshamn

Cat and dog were present in 2007, but were not detected in 2002/2003. Evidently, tracks from dogs increase if the survey is performed during the weekend, especially if the hunting season is still on.

### *Fox*

Index of fox based on snowtracks is nearly the same in Simpevarp but the population has increased with 57% in Blankaholm.

### *Lynx*

According to the County Administrative Board of Kalmar there is no family group of lynx residing in any of the areas. Several tracks from a single male roaming in the area were recorded during the winter /Mattias Persson, personal communication, April 2007/.

### *Marten*

Marten has either vanished from both areas, or more likely, none of the tracks in the areas crossed the survey transects.

### *Mink*

Tracks of mink were found in Blankaholm.

### *Weasel*

Populations have increased in both areas.

### *Squirrel*

Squirrel was one of the most abundant species in both areas and populations are slightly larger than 2003.

### *Moose*

According to the results from the fecal count, the moose population in Blankaholm has nearly the same density as in 2003. Moose density in Simpevarp is higher than in 2003, as shown both by the aerial survey and the fecal count. Noteworthy is that there is a constant proportionality between the results of the fecal count and the aerial survey (Figure 5-3). The number of moose killed by traffic indicate that the population is increasing in the county (Figure 5-2).

### *Roe deer*

Roe deer populations have decreased in both areas, and seemingly in the whole county (Figure 5-2).

### *Fallow deer*

Density is about the same as in 2003.

### *Red deer*

Density in 2007 is about the same in both areas and the population has increased in Simpevarp since 2003.

### *Wild boar*

There are large differences in rates of change between the results from snowtracking and fecal counts, but neither of the methods has been thoroughly evaluated, which makes it difficult to assign either of the methods a higher credibility. The regional variation in wild boar abundance (Figure 5-2) differs from the local development in Simpevarp and Blankaholm. Wild boar population growth is varying in time and space and variation in local growth is considerably higher than variation in regional growth /Truvé 2004/.

### *Hare*

Population density of hares, in forest and field, differs from the survey in 2003 to various extents. The results are within the limits of what can be expected.

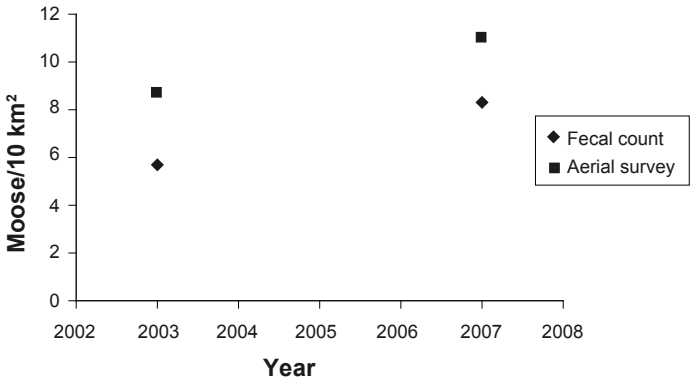


***Figure 5-3.*** *Estimates of moose density from aerial survey and fecal count in Simpevarp in 2003 and 2007.*

## 5.4 Future scenario

Identifying change in local populations requires detailed studies in the place of interest. Mammal surveys are rarely repeated frequently enough to separate the underlying population change from natural between-year variation. Annual monitoring is important for a number of other reasons, including the setting of conservation priorities, the management of pest species and sustainable use of game species and for examining the effect of change in land-use, habitat or climate.

Future predictions of population development can be based on time series data, and assuming that development will continue with the same rate into the near future. A qualitative scenario for some of the mammal species in Forsmark and Oskarshamn can be drawn by analyzing the results from the surveys, and the regional development of populations.

Species that are still expanding geographically and probably will continue to do so include lynx, wild boar, red deer and fallow deer. An increase in the distribution and the size of the lynx population is expected in Oskarshamn while the population in Forsmark probably will be kept on the same level as today. Wild boar populations will continue to expand geographically since there still are suitable areas not yet colonized. Abundance of red deer and fallow deer is increasing in several areas in Sweden. The populations are probably expanding, although not with the same rate as wild boar populations since both dispersal rates and birth rates are lower. However, red deer and fallow deer are absent in Forsmark and are not expected to establish in the area in the nearest future.

Populations of red fox are increasing in both Forsmark and Oskarshamn, perhaps still recovering from the sarcoptic mange epidemic in the 1980's. Also, the hunting pressure on fox is believed to have decreased during the years of the epidemic, and have not reassumed former levels.

Roe deer populations increased rapidly when predation from fox decreased during the sarcoptic mange epidemic. Populations have decreased during the last ten years and will most likely continue to do so since both fox and lynx populations are increasing. Density in Swedish moose populations have declined since they peaked in 1980, but the negative growth rate seems to have levelled out in recent years. Both aerial- and pellet counts show an increase in density in Oskarshamn but populations are still declining in Forsmark. Moose populations are under the influence of extensive management and will probably continue to be kept at densities between 5 and 15 animals/10 $km^2$ in both areas.

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