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

Results from 2003

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Svensk Naturförvaltning AB

April 2004

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Summary

In the two areas where SKB are conducting site investigations, Forsmark and Oskarshamn, studies of the populations of larger mammals have been performed. The objectives have been to obtain information which will be used in the Environmental Impact Assessment for the deep repository, to have a base for monitoring and to supply ecosystem models with data.

Selected species were wolf, lynx, otter, marten, mink, red fox, beaver, wild boar, red deer, fallow deer, roe deer, moose, European hare and mountain hare, small rodents and insectivores. Several methods were used and adapted to expected habitat use and variations in local density of the species. An aerial survey was done in the Oskarshamn area in order to count larger mammals like moose, deer species and wild boar. Line transects were used on snow to index (frequency of tracks crossing the transects) or calculate actual number (for example the Buffon method). Pellet counts were used in spring to calculate hare and cervid (moose and deer species) density. The aquatic mammals were tracked on snow along selected parts of the streams and larger ditches. Density of small rodents was estimated in spring and autumn by trapping. Most of the methods were conducted in the two study areas and also in the reference areas.

Some of the basic data presented in the report are as follows for each of the areas:

Forsmark

- No aerial survey was done in 2003. Moose density, based on pellet counts, was 6.7 animals/10 km^2 in Hållnäs and 12.3 animals/10 km^2 in Forsmark.
- No fallow deer was fund (pellet counts). Red deer density was low, 0.1 deer/10 km^2 in Forsmark (no deer found in Hållnäs).
- Roe deer was clearly the most numerous deer species (48.0 deer/10 km^2 in Hållnäs and 93.6 deer/10 km^2 in Forsmark).
- Hare density in the fields varied considerably between Hållnäs (22.8 hares/10 km^2) and Forsmark (3.2 hares/10 km^2). In the forest, mean density was generally lower as was the variation between the two areas (Hållnäs: 1.5 hares/10 km^2, and Forsmark: 2.3 hares/10 km^2).
- Red listed species like otter are present in the areas, although in low numbers. No wolf tracks were found in 2003 and it is unlikely that they were present in the region (personal communication with local managers).
- As indicated by track indexes, red fox and marten are common predators in both areas. Lynx is present, but at low numbers. Tracks were found in both areas.
- Wild boar is probably highly aggregated in the region. Occasional tracks of wild boar were also found in the transects in Forsmark. Density, based on pellet counts, was 0.1 boar/10 km^2, which is probably too low.
- Small rodents (voles and mice) and insectivores (shrews) were captured in spring and in autumn. The autumn population density was higher for all species (field vole: 6.9 vs 8.3 animals/0.01 km^2; bank vole: 46.2 animals vs 56.4 animals/0.01 km^2; water vole: 8.9 vs 11.5 animals/km^2; mice: 30.4 /0.01 km^2 vs 54.9 /0.01 km^2).

Oskarshamn

- During the aerial survey moose was unevenly distributed in a 400 km^2 area along the coast (mean density approximately 8 moose/10 km^2 in the aerial survey).
- Red deer and fallow deer are generally aggregated in small, scattered groups at low densities (mean density < 1 deer/10 km^2) while roe deer density is approximately 50 deer/10 km^2 in both Simpevarp and Blankaholm.
- Hare density in the fields were between 19.1 hares/10 km^2 (Blankaholm) and 35.1 hares/10 km^2 (Simpevarp) while in the forest hare density was much lower and varied between 3.2 hares/10 km^2 (Blankaholm) and 5.2 hares/10 km^2 (Simpevarp).
- Red listed species like wolf and otter are not found in the areas, although they may occasionally traverse the region.
- As indicated by track indexes, red fox is the most common predator in all areas. Marten appear in all areas and tracks are frequently recorded in all habitats. No track of lynx has been found.
- Wild boar are highly aggregated in both areas (2.6 boars/10 km^2 in Simpevarp and 1.2 boars/10 km^2 in Blankaholm).
- Small rodents (voles and mice) and insectivores (shrews) were captured in a limited number of sub areas (5) in the spring, allowing calculations of density only for bank vole and mice. The autumn population was inevitably higher for these species (bank vole: 29.3 animals vs 71.0 animals/0.01 km^2; mice: 23.5 /0.01 km^2 vs 136.8 /0.01 km^2).

Sammanfattning

I de två platsundersökningsområdena, Forsmark och Oskarshamn, har populationerna av de större däggdjursarterna studerats. Syftena har varit att erhålla information till en miljökonskevensbeskrivning för ett djupförvar, att erhålla en kunskapsbas för monitering samt att leverera data till systemekologiska modeller.

Följande arter valdes ut: varg, lo, utter, mård, mink, räv, bäver, vildsvin, kronhjort, dovhjort, rådjur, älg, skogshare, fälthare, smågnagare och insektsätare. Ett antal metoder har använts och anpassats till förväntade habitatval och lokala densitetsvariationer. En flyginventering genomfördes i Oskarshamnsområdet för att räkna större däggdjur som älg, hjortdjur och vildsvin. Linjetransekter på snö användes för att indexera (frekvensen av spår som korsar transekterna) eller beräkna det verkliga antalet (t ex med Buffonmetoden). Spillningsräkning genomfördes under våren för att beräkna densiteten av hare och klövdjur (älg och hjortdjur). De akvatiska däggdjuren spårades på snö längs utvalda delar av bäckar och större diken. Tätheten av smågnagare uppskattades via fällfångst under våren och hösten. De flesta metoderna användes i de två undersökningsområdena liksom i referensområdena.

Några av de basdata som presenteras i denna rapport är följande:

Forsmark

- Ingen flyginventering genomfördes under 2003. Älgtätheten, baserad på spillningsräkning, var 6,7 djur/10 km^2 i Hållnäs och 12,3 djur/10 km^2 för Forsmark.
- Inga kronhjortar hittades (spillningsräkning). Dovhjortstätheten var låg; 0,1 hjort/10 km^2 i Forsmark (inga hjortar hittades i Hållnäs).
- Rådjur var helt klart den mest numerära arten (48,9 djur/10 km^2 i Hållnäs och 93,6 djur/10 km^2 i Forsmark).
- Tätheten av harar i öppna marker varierade betydligt mellan Hållnäs och Forsmark (22,8 respektive 3,2 harar/10 km^2). I skogen var medeltätheten generellt lägre liksom variationen mellan de två platserna (Hållnäs: 1,5 harar/10 km^2 och Forsmark 2,3 harar/10 km^2).
- Rödlistade arter som utter finns i områdena men i lågt antal. Inga vargspår hittades 2003 och det är osannolikt att de uppehöll sig i regionen.
- Räv och mård är vanliga predatorer i båda områdena. Lo finns men i lågt antal. Spår hittades i båda områdena.
- Vildsvin finns antagligen i anhopningar i regionen. Enstaka spår av vildsvin hittades också i transekterna i Forsmark. Tätheten, baserad på spillningsräkning, var 0,1 vildsvin/10 km^2 vilket antagligen är för lågt.
- Smågnagare (sorkar och möss) och insektsätare (näbbmöss) fångades under våren och hösten. Höstpopulationens täthet var högre för samtliga arter (åkersork: 6,9 respektive 8,3 djur/0,01 km^2; ängssork: 46,2 respektive 56,4 djur/0,01 km^2; vattensork: 8,9 respektive 11,5 djur/km^2; möss: 30,4 /0,01 km^2 respektive 54,9 /0,01 km^2)

Oskarshamn

- Under flyginventeringen var älgarna ojämt fördelade inom ett 400 km^2 stort område längs kusten (medeltätheten var ungefär 8 älgar/10 km^2).

- Kronhjort och dovhjort är oftast aggregerade i små, spridda grupper med låg täthet (medeltäthet <1 hjort/ 10 km^2) medan rådjurstätheten är ungefär 50 djur/10 km^2 i både Simpevarp och Blankaholm.

- Tätheten av harar i öppna marker varierade mellan 19,1 harar/10 km^2 (Blankahom) och 35,1 harar/10 km^2 (Simpevarp). Tätheten av skogshare var mycket lägre och varierade mellan 3,2 harar/10 km^2 (Blankaholm) och 5,2 harar/10 km^2 (Simpevarp).

- Rödlistade arter som varg och utter hittades inte i områdena även om de kan ha genomkorsat regionen.

- Räv var den vanligaste predatorn i alla områden. Mård finns i området och spår hittades i frekvent i alla habitat. Inga spår efter lodjur hittades.

- Vildsvin är mycket aggregerade i båda områdena (2,6 vildsvin/10 km^2 i Simpevarp och 1,2 vildsvin/10 km^2 i Blankaholm).

- Smågnagare (sorkar och möss) och insektsätare (näbbmöss) fångades i ett begränsat antal delområden (5) under våren, vilket tillåter täthetsberäkningar endast för ängssork och möss. Höstpopulationen av båda dessa arter var ofrånkomligt högre (ängssork: 29,3 respektive 71,0 djur/0,01 km^2; möss: 23,5 respektive 136,8 djur/0,01 km^2).

Contents

1 Introduction

The Swedish Nuclear Fuel and Waste Management Co. (Svensk Kärnbränslehantering AB, SKB) is in the process of selecting a safe and environmentally acceptable location for the deep-level repository of radioactive waste. SKB has expressed the importance of monitoring mammal species that are of interest both in biodiversity issues and for local hunting and recreational purposes.

To get relevant data on the dynamics of the mammal populations, it is important to estimate the abundance and variations over time. Data achieved can be used to specifically monitor endangered species (like wolf, *Canis lupus*, and otter, *Lutra lutra*), detect long-term effects on populations (important to hunters) and be used for assessment programs (MKB). Two of the major goals are: 1) to monitor populations over several years, and 2) to obtain information that is essential for modelling of energy/carbon flows in the biosphere and calculations of the risks of exposure to radionuclides.

The following main objectives of the study are to

- Obtain data on abundance and local densities of the selected species. The results from the SKB areas shall be compared both in a regional and a national perspective. It is also vital to make information available to public interests (like hunters, conservation agencies, forestry companies, county boards (länsstyrelser) etc). Furthermore, data can be used in the context of regular evaluation of the effect of the field operations on the environment (MKB).
- Set up a monitoring system for population surveys that measures annual variation in density, and if possible in other parameters like body mass and reproduction.
- Make data available for modelling of, for example, energy/carbon flows in the biosphere and, ultimately, calculations of the risks of exposure to radionuclides. If necessary, specific projects could be created in order to obtain better data of the selected species, about for example distribution and dispersal, or to better understand the flow of energy between trophical levels (including consumption of vegetation as well as prey species).

In 2002 a pilot study was done in Tierp area and in Forsmark. A reference area was selected near the coast, north of Forsmark (Hållnäs). The methods were evaluated and the first set of data compiled and presented in a report /see Cederlund et al, 2003/. After revision, a similar concept was used for the Oskarshamn area in 2003. Since Tierp is no longer of interest for the future project, no data were sampled from that area in 2003. In this report we present data from 2003 for Forsmark (including the control area in Hållnäs) and Oskarshamn (including the control area in Blankaholm).

Comparative data from the main areas are in some cases available also from 2002 (data from Forsmark). However, we do not attempt to further explain differences and variations in animal numbers here. This will be done in a more comprehensive report, presented at the end of 2004.

The investigations in Forsmark during 2003 were specified in Activity Plan AP PF 400-03-35 and in Oskarshamn in Activity Plan AP PS 400-02-013 (SKB Internal controlling documents).

2 Study areas

Forsmark

After the pilot study in 2002, both Forsmark (approximately 110 km^2) and Hållnäs (control area; approximately 140 km^2) were selected for future studies (monitoring). The two areas are shown in Figure 2-1. In the following text in this report, data from the two different areas are referred to either Forsmark or Hållnäs. Sometimes "control" or "control area" is used instead of Hållnäs.

In general, the northern part of the Uppland county is strongly influenced by the Baltic Sea. The landscape is flat and contains few lakes and streams. It is also characterised by a mosaic of habitats with different tree and understory composition. Near the coast the vegetation is influenced by lime and considered to be more productive than the inland.

Figure 2-1. A map indicating the border of the selected study areas in Forsmark: Forsmark in the south and Hållnäs (control area) in the north.

The climatic variation is larger than in other areas at the same latitude in the inland of Sweden. This means for example periods of stormy weather and deep snow in winter that might have effect on mobility as well as survival of mammals. 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, on average, 100–125 days each winter. Precipitation in the region is > 500 mm annually.

Most land is forested and can be classified as belonging to the hemi boreal zone. Near the coast, temperate, broad-leaved tree species may occur. More patchily distributed are rowan and alder. In poor soils conifers are dominating (inland areas). Agricultural areas constitute less than 10% of the total land area.

Oskarshamn

We identified the main study area centred around the suggested drilling activities in Simpevarp (area size approximately 120 km^2). As a control area we selected an area east of Blankaholm area size (approximately 120 km^2) some 20 km north of Simpevarp. The location of the two sub areas is shown in Figure 2-2. In the following text in this report data from the two areas are referred to either Simpevarp or Blankaholm. Sometimes "control" or "control area" is used instead of Blankaholm.

The landscape is interspersed with ridges and contain numerous small lakes (Blankaholm) and streams. Open water constitutes approximately 10% in the two main study areas Simpevarp and Blankaholm. It is also characterised by a mosaic of habitats with different tree- and understory composition. The coast is considered to be more productive than the inland.

The climatic variation is larger than other areas at the same latitude in the inland of Sweden. This means for example periods of stormy weather and short periods of deep snow in winter that might temporary have effect on mobility as well as survival of mammals. 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.

Most land is forested and can be classified as belonging to the hemi boreal zone. Near the coast, temperate, broad-leaved tree species such as elm and oak may be frequent. More patchily distributed are rowan and alder. In poor soils conifers are dominating (inland areas). Agricultural areas constitute less than 10% of the total land area and forested areas approximately 80%.

There are no obvious differences between Simpevarp and Blankaholm as concerns habitat structure and composition.

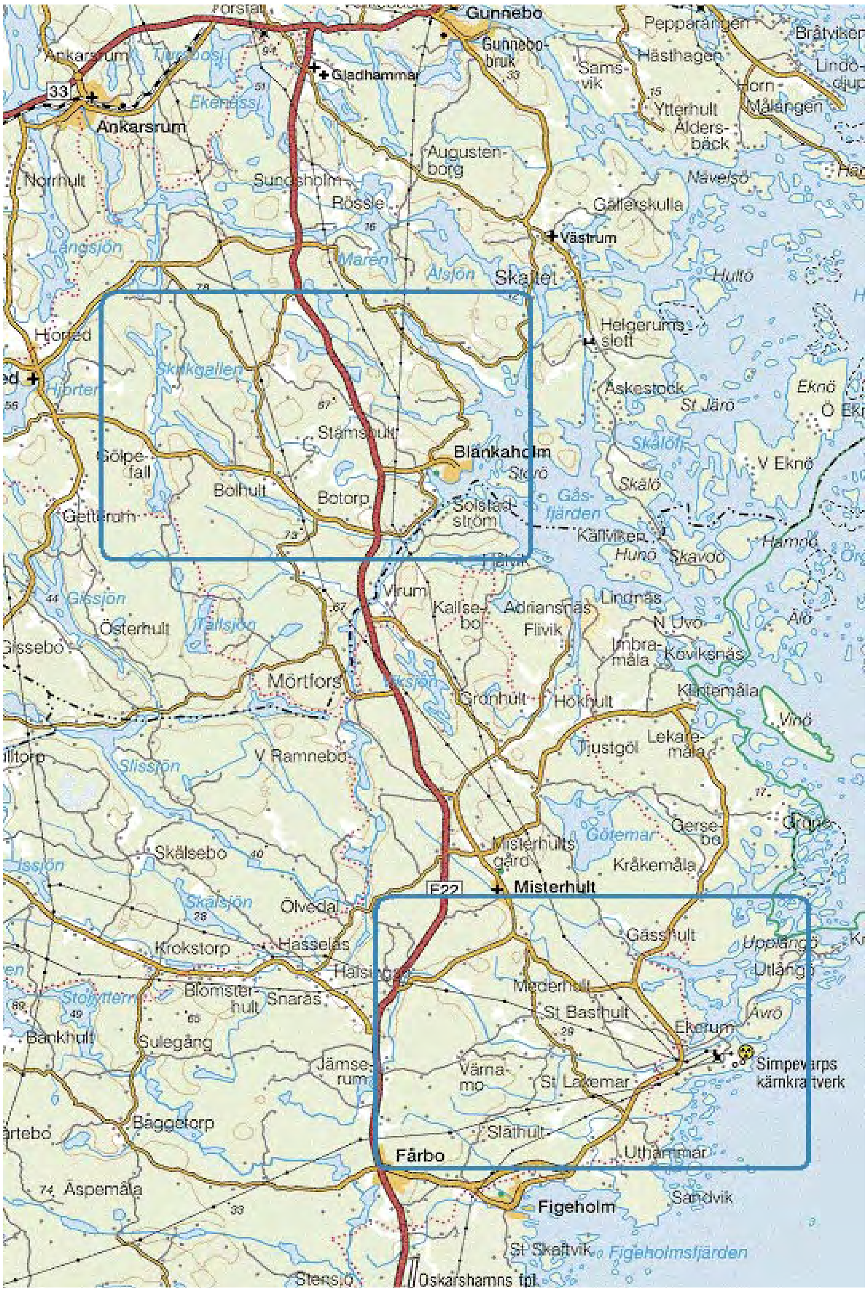

Figure 2-2. *A map indicating the border of the selected study areas Simpevarp in the south and Blankaholm (control area) in the north.*

3 Selected species

We selected mammal species that were of special interest (endangered) or dominant as prey, predators or consumers of vegetation. Small rodents (e.g. microtines) and insectivores (e.g. shrews) were also included in 2003. Badger (*Meles meles*) was excluded since the study was mainly accomplished during winter when the species usually is hibernating. However, density estimates of badger as well as fox (*Vulpes vulpes*) will be achieved by using a capture-recapture technique in Forsmark during 2004.

The following list contains selected species:

Artiodactyla (eventoed ungulates (partåiga hovdjur)):

Moose (älg) *Alces alces*
Red deer (kronhjort) *Cervus elaphus*
Fallow deer (dovhjort) *Cervus dama*
Roe deer (rådjur) *Capreolus capreolus*
Wild boar (vildsvin) *Sus scrofa*

Lagomorpha (lagomorphs (hardjur)):

Mountain hare (skogshare) *Lepus timidus*
European hare (fälthare) *Lepus europeus*

Rodentia (rodents (gnagare)):

Beaver (bäver) *Castor fiber*
Voles (sorkar) *Arvicola sp; Clethrionomus sp; Microtus sp*
Mice (möss) *Apodemus sp*
Gliridae (sovmöss) *Muscardinus arvellanarius*

Insectivora (insectivores) (insektsätare)):

Shrews (näbbmöss) *Sorex sp*

Carnivora (carnivores (rovdjur)):

Wolf (varg) *Canis lupus*
Red fox (räv) *Vulpes vulpes*
Marten (mård) *Martes martes*
Otter (utter) *Lutra lutra*
Mink (mink) *Mustela vison*
Lynx (lo) *Lynx lynx*

4 Methods

There are two main ways of estimating animal density: indirect and direct methods. Direct methods have in theory no actual limitations and give absolute numbers of density, for example animals per square kilometre. Data can be used in many ways and are easily adapted as input to models.

Indirect methods provide us with data that are proportional to the actual number of individuals of a given species. They are usually used as index and give trends rather than actual figures on density and can offer relevant information when following long term trends in population development. One disadvantage is that relevant comparisons between areas and species are limited. Furthermore, data are usually insufficient for e.g. predicting flows of energy between trophical levels.

In conclusion, in order to fulfil the demands and give the most relevant data, this survey project will focus on direct measurement of mammals, although some are indirect at this stage. The methods used during the pilot study will briefly be presented in this chapter. All methods are well known and earlier published elsewhere (see references). We have in some cases adapted the methods with minor changes. There is a vast literature about methods for estimating animal abundance and related parameters. Some of the most well known handbooks are: /Seber, 1982/ The estimation of animal abundance and related parameters (Charles Griffin & Company Ltd, London) and /Krebs, 1989/, Ecological methods (Harper & Row, New York).

All methods used so far are presented below, even if they have not been used in 2003 (aerial surveys in Forsmark).

All data (raw data as well as processed data) have been stored in the database SICADA under field note no "Forsmark 208" and "Simpevarp 206" respectively.

4.1 Aerial survey

Species: Moose, deer, wild boar.

The method is primarily adapted for large cervids and gives direct density estimates, but observations of all larger mammal species are recorded (although we have not yet tried to calculate their absolute densities).

Aerial surveys are normally performed during midwinter when land areas are covered with > 20 cm snow. If possible, the survey is initiated 1 day after snow fall, which makes the tracks easy to detect. We use small helicopters (Hughes 300) that are relatively cheap and easy to manoeuvre. At least two helicopters are used on each occasion. One reason is to concentrate as much operating time as possible to good weather conditions (e.g. between snow falls). Another reason is that the system 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. Each plot is thoroughly searched for animals. Each observation is recorded in a computer as to sex and age, time etc. Location is achieved by GPS. With the computer it is possible to discriminate observations that should be included in the sampling plots from those outside the plots. The mean density (like moose/km^2) and variance is then easily calculated.

It is important for the final density estimate to calculate the probability to observe animals in the plots, since some animals will not be observed. Weather conditions, flight speed, snow depth, etc, might influence the observation rate. Therefore, 30–40% of the plots are searched by two teams independent of each other. 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, 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.

4.2 Capture – recapture

Species: Badger, moose, roe deer, fox.

This method is commonly named The Peterson method (Seber 1982) and includes a number of methods based on the capture – recapture technique. The basic idea is that the population density can be calculated if we have knowledge of the number of marked individuals and the proportion of marked and unmarked animals in a sample of the total population at a specific time. The method is flexible and does not necessarily require physical marking (like ear tags, collars, rings etc), but can also be used by comparing observations by two or more independent teams made at the same time (see aerial surveys of moose, 4.1).

This year, the method did not include any marking or capturing in traps. However, in the future this might be the only way to obtain actual density estimates of the badger and the fox populations in the areas. It can also be used as an additional method for roe deer.

The Leslie method can be associated with the capture technique and can also be used when harvesting a population, marking, observing or doing effort estimates etc /Ricker, 1975/. This method might be useful for roe deer, foxes and badger.

4.3 Line transects

Line transects include a variety of methods and can be used both as indexes and for actual density estimates.

4.3.1 The Buffon method

Species: Wolf, lynx and marten.

The method is normally used in snow. It is based on the classical problem called the "Buffon´s needle problem" /Becker et al, 1998/. We have adapted the method for large animals by using line transects in the snow and the possibility to follow tracks crossing the transects. If the procedure is repeated it is also possible to get variance estimates. The method is adapted for species that roam over relatively large areas and occur at low densities (marten has normally relatively small home ranges but is easy to track and occurs at low densities).

As indicated in Figure 4-1, transects lines are covering the entire area. The first line is randomly chosen, but the additional lines are parallel and distributed 4 km apart.

The tracking must not be started until 8 hours after snowfall. The method is quite uncomplicated in the field. One moves along transects that are evenly distributed over the research area. Each track crossing a transect is followed backwards to the position where the first track is found after snowfall and onwards until the animal is observed, the day bed is found etc. The shortest distance to a transect from the outer ends of the track is calculated (see Figure 4-1). Positioning is done with GPS. If possible, sex, age and number of animals are recorded.

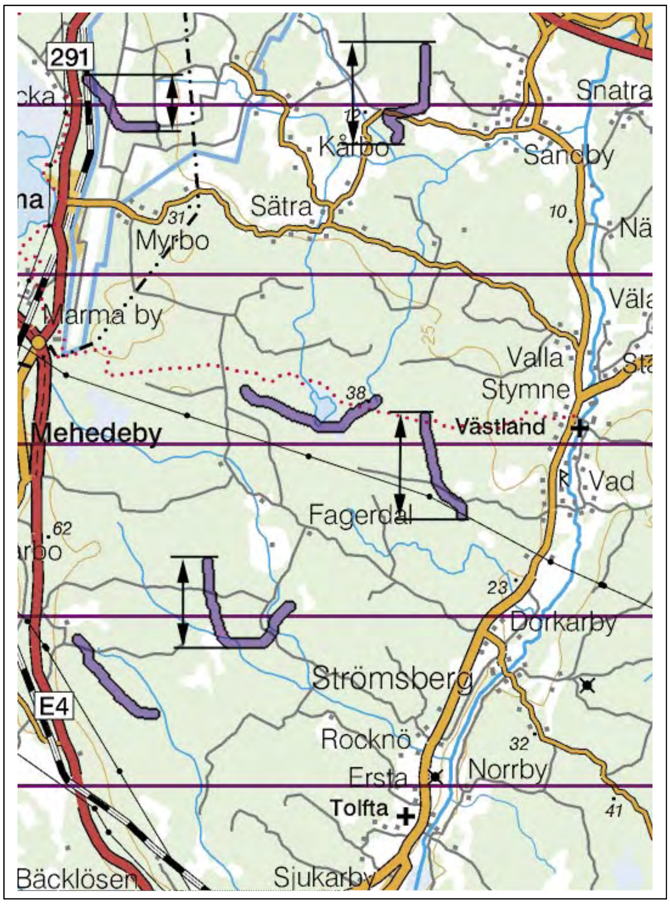

Figure 4-1. Principle for the Buffon method (see Methods 4.3). Blue, filled lines indicate tracks of animals. The arrows show the shortest distance from the end points of the track to the transect. Tracks not crossing transects are excluded from the data set.

4.3.2 Transects along water areas

Species: Otter, mink, fox, beaver, wolf, lynx, and marten.

The method is actually a combination of the Buffon method and an ordinary line transect method (walking along transects counting tracks). The entire area is divided in 1 km^2 squares. Since we expect that it is more likely to find tracks along the coast and the larger streams than in any other areas, we have stratified the landscape into the two categories: 1) coast/larger streams; 2) other water areas. Data are sampled from randomly chosen 1 km^2 squares (see Figure 4-2).

The 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.

Tracks are recorded and followed in the same manner as in the Buffon method (see above).

Burrows, dens and other signs of the presence of the species are recorded as well as crossing tracks of other mammals.

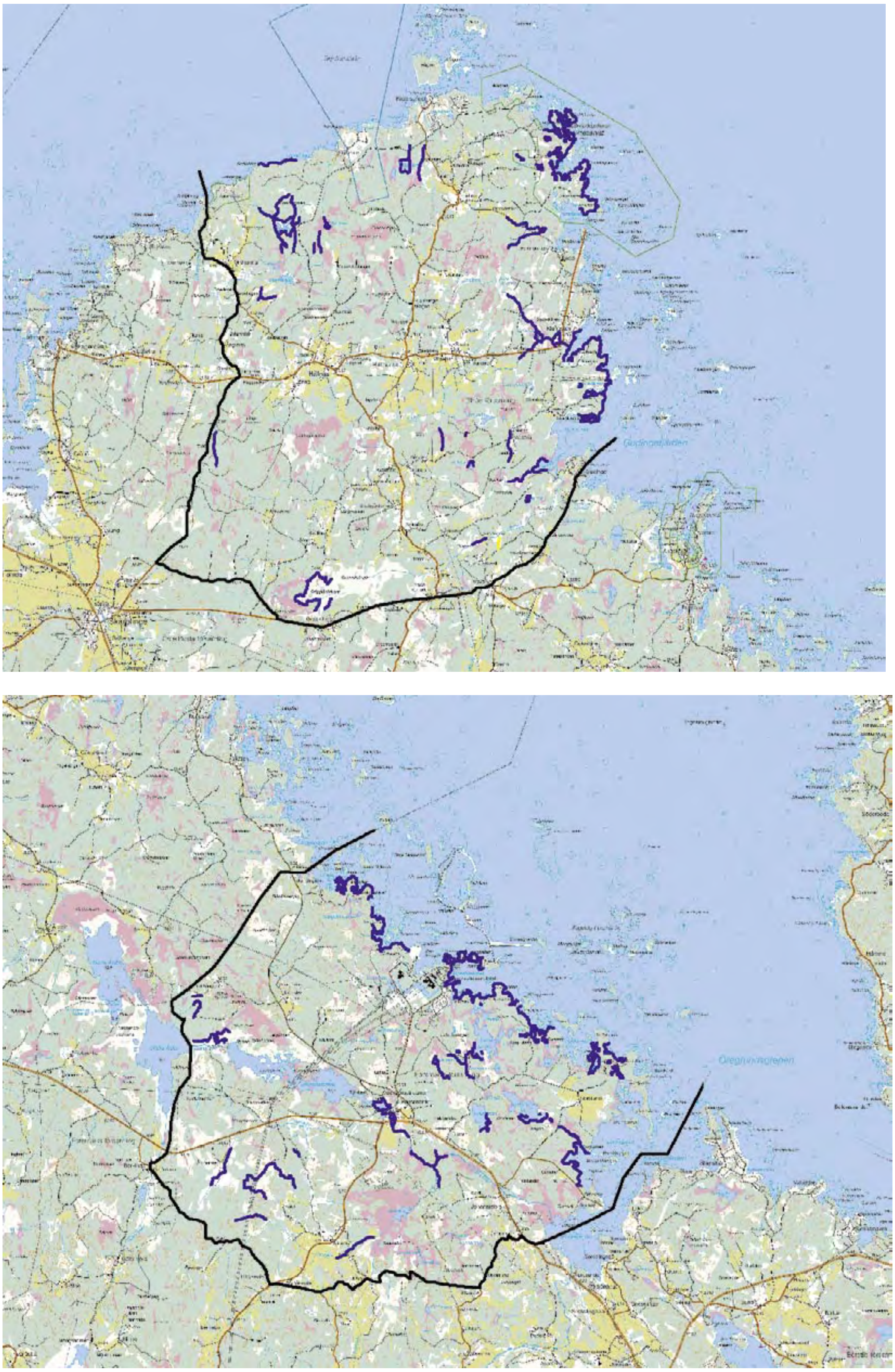

Figure 4-2a. *Stratified sampling of tracks crossing transects oriented along the water system in Forsmark and Hållnäs (blue lines indicate selected transects).*

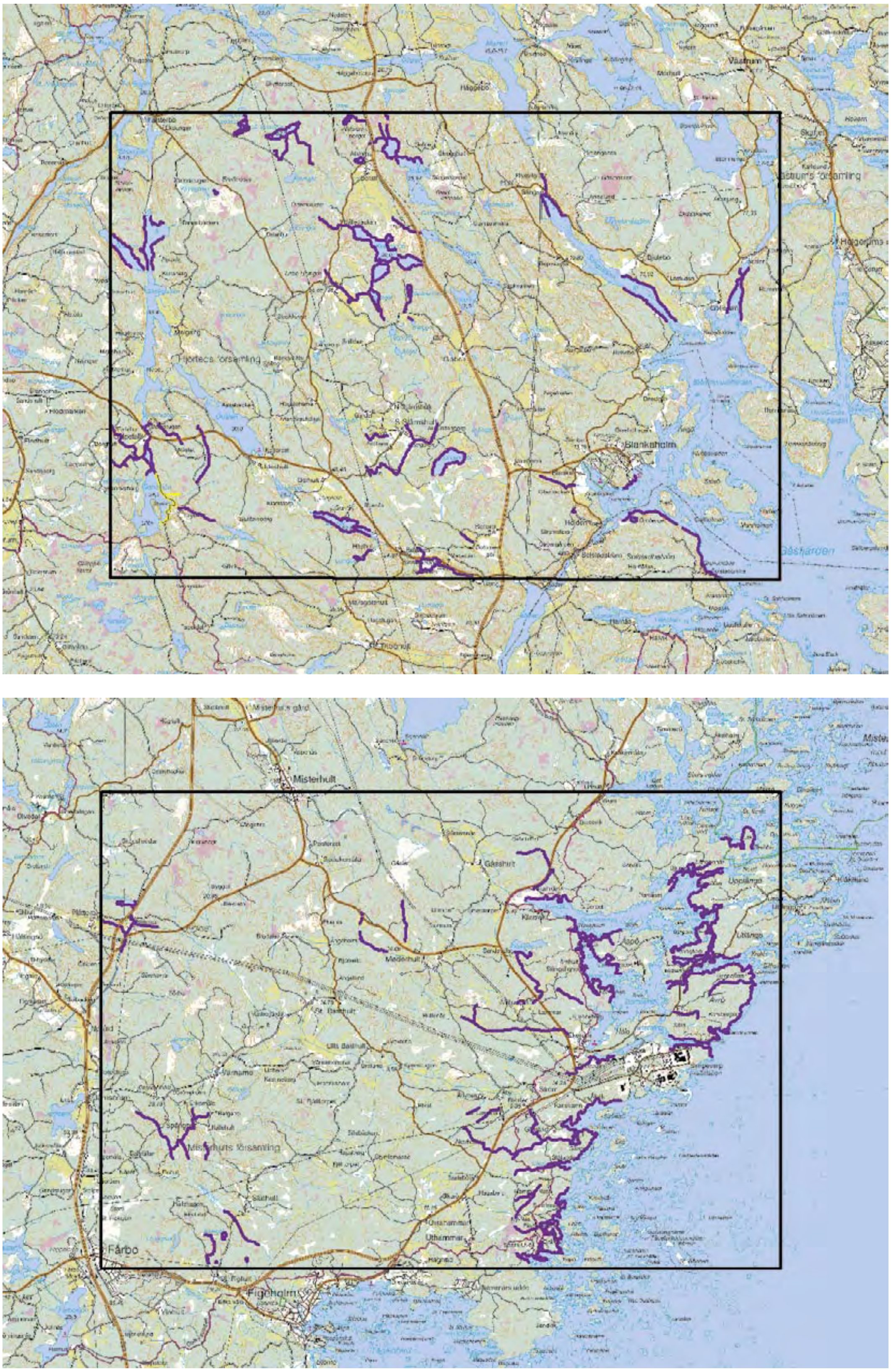

Figure 4-2b. *Stratified sampling of tracks crossing transects oriented along the water system in Simpevarp and Blankaholm (blue lines indicate selected transects).*

4.4 Fecal (pellet) counts

Species: Moose, red deer, fallow deer, roe deer, wild boar, hares.

The method is basically used as an indirect estimate of local densities. However, we intend to calculate absolute numbers and calibrate with other survey methods (aerial surveys of moose for example). In this study, pellets are counted in early spring when pellets are easily found and are dropped during the period between leaf fall and the day of counting. Given that we know number of pellet groups or pellets (hares) produced per day, and the number of days since leaf fall, it is possible to get a rough estimate of population density.

In order to do data collection more efficient than in 2002 (sample plots along line transects crossing the entire area), sample plots are distributed along transects, forming a square (500 m x 1000 m). Each square, or sub area, is randomly distributed over each research area, see Figure 4-3.

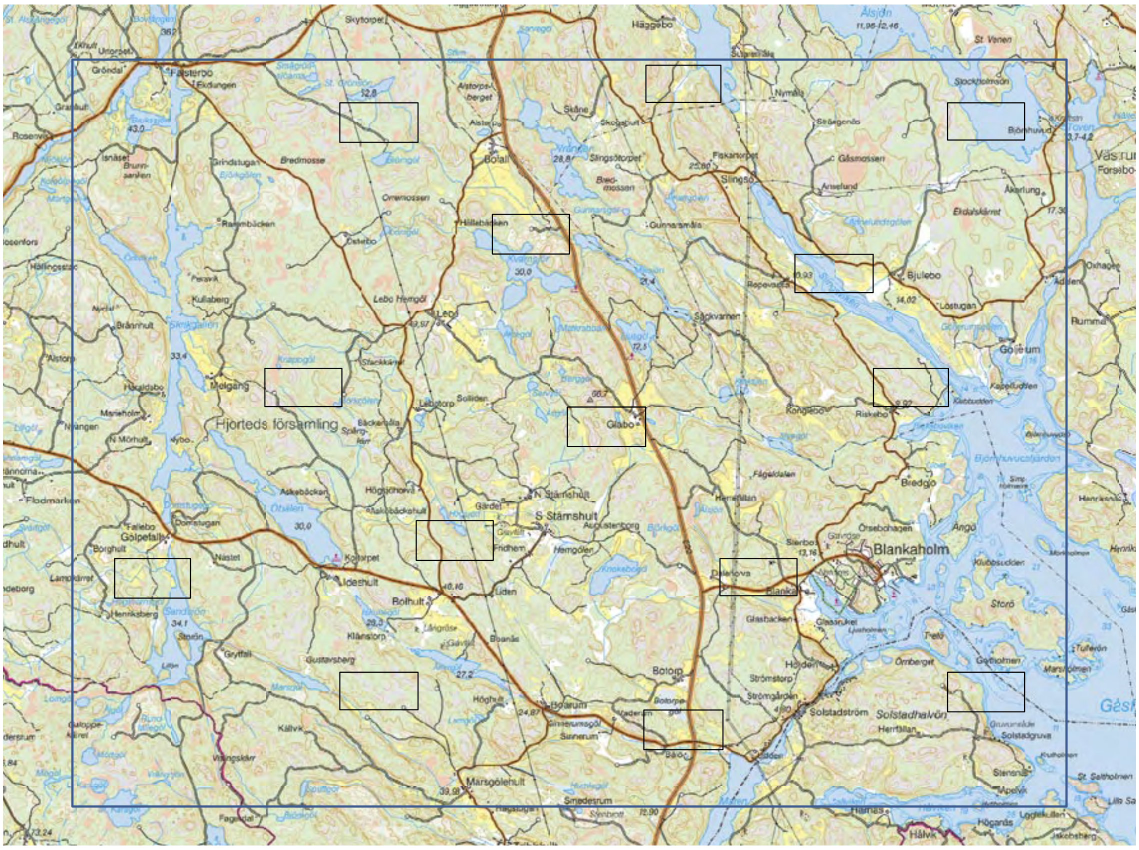

Figure 4-3. *Principle for sample area distribution in forested habitats when counting pellets from cervids (moose and deer), hares and wild boar. Each sample area contains 72 sample plots aligned along the border. The map is from the control area in Blankaholm, Oskarshamn.*

Moose, deer species and wild boar. No stratification is done. The distance between plots along the line is 72 m.

Many species, hares for example, use small patches quite heavily. If pellets are rare or expected to be found in clusters, adaptive sampling /Thompson, 1991/ can be used. When pellets are found in a plot, searching is also done in the adjacent plots, until no plots contain pellets (see the blue plots with white figures in Figure 4-4). This also means that plot clusters with pellets between transects are not included in the data set if they are not "hit" by the sampling procedure (see red figures in Figure 4-4.).

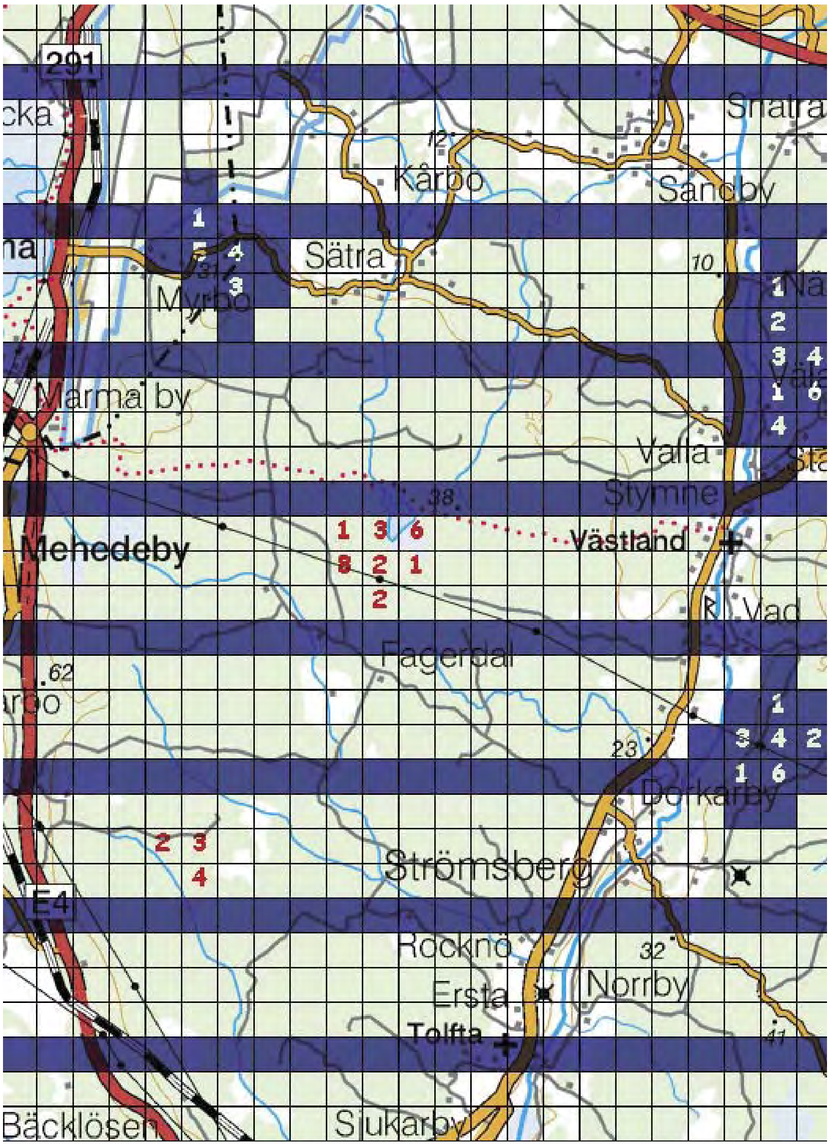

Figure 4-4. *Principle for adaptive sampling of hare pellets. Blue squares indicate plots along transects and plots searched in the cluster generated by the local pellet distribution (see Method 4.4). Squares with red figures indicate clusters of pellets that are not "hit" by the transects lines and therefore not included in the data set.*

Hares – Forest. For hares we basically use a similar sampling plot system as for moose and deer.

Hares – Field. In addition to the ordinary plot system, hare pellets are also counted in a stratified plot system associated with fields and arable land. From the 1 km^2 square system (see Transects along water areas, 4.3.2) we randomly selected squares containing fields and arable land. Plot density is higher than the ordinary system with 10 m between individual plots. The transects start and stop in the forested area 10 m from the edge of the open area. The procedure is similar as described above.

Specification of the sampling units

- **Moose, red deer, fallow deer, and wild boar** Plot size is 100 m^2 (radius 5.64 m).
  Only pellet groups containing > 20 pellets are counted. Pellet groups with > 50% of the pellets within the plot are counted.
- **Roe deer** Plot size is 10 m^2 (radius 1.78 m).
  Pellets are counted as above.
- **Hares** Plot size is 1 m^2 (1m x 1m square).
  All pellets are counted.

4.5 Frequency of capture of small rodents and insectivores

The method is well known and used frequently by many biologists all over the world /Williams et al, 2001/. In order to get sufficient data from different habitats and enough sample size to calculate total density for each of the species captured, we randomly selected 25 areas as sample units. Each area contains 100 steel traps (similar to ordinary "mouse traps") at a distance of 10–15 m. Each trap is baited one day and checked the following 3–5 days (depending on the trapability). If necessary, the trap is baited again during the period. Animals captured are aged (adult or juvenile) and sexed.

In order to catch water voles, 25 traps are put out on 5 randomly chosen sample areas along streams and ditches (other species might also be captured). Distance between traps is approximately 20 m. This investigation was only performed in Forsmark and Simpevarp and not in Hållnäs or Blankaholm. Location of the traps are presented in Figure 4-5.

To get data on the rate of increase within the year, capturing is accomplished in seasons when they are supposed to: 1) have a low density (May–June); and 2) reach peak density (September–October).

There were no attempts to catch dormouse in the areas. Instead, we made an enquiry among persons that might have data or knowledge about the species and its possible presence in Forsmark and Oskarshamn. The results are in brief presented in the Result section.

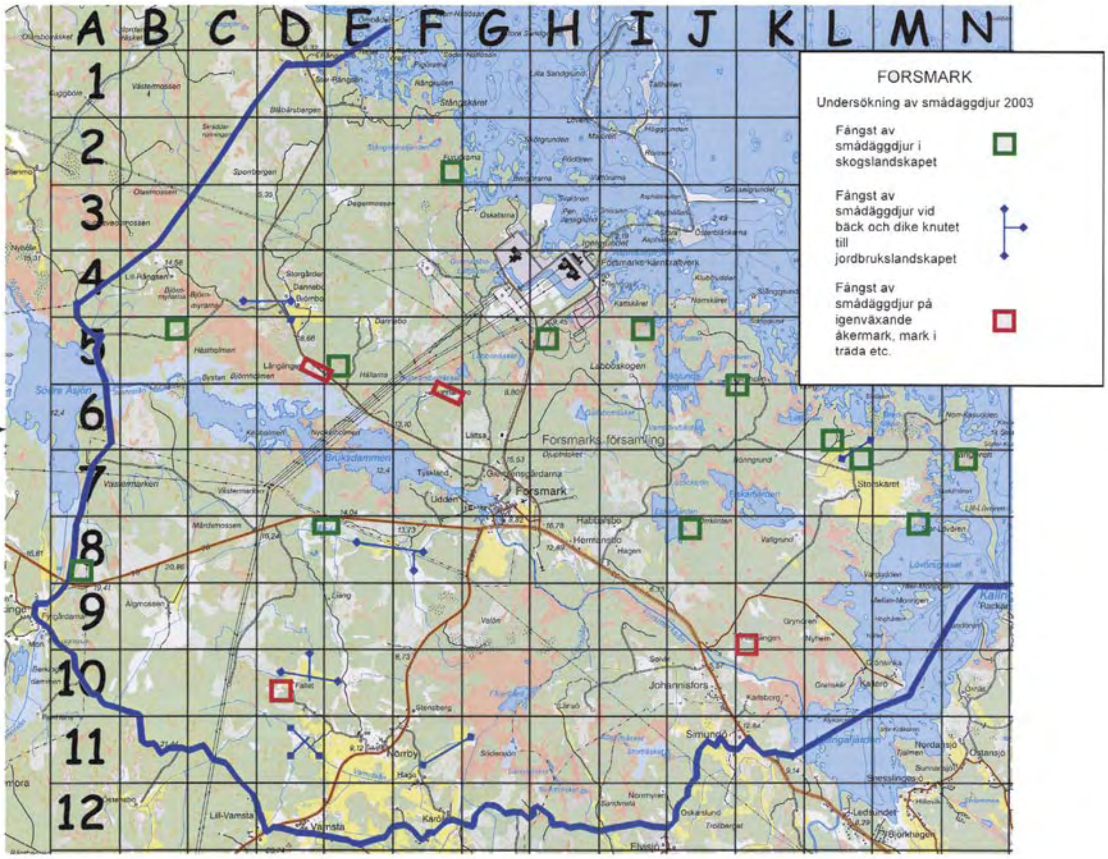

Figure 4-5a. *Rodent trapping in Forsmark. Green markings=forest, blue markings=small waters in agricultural landscape, red markings=agricultural land (in fallow).*

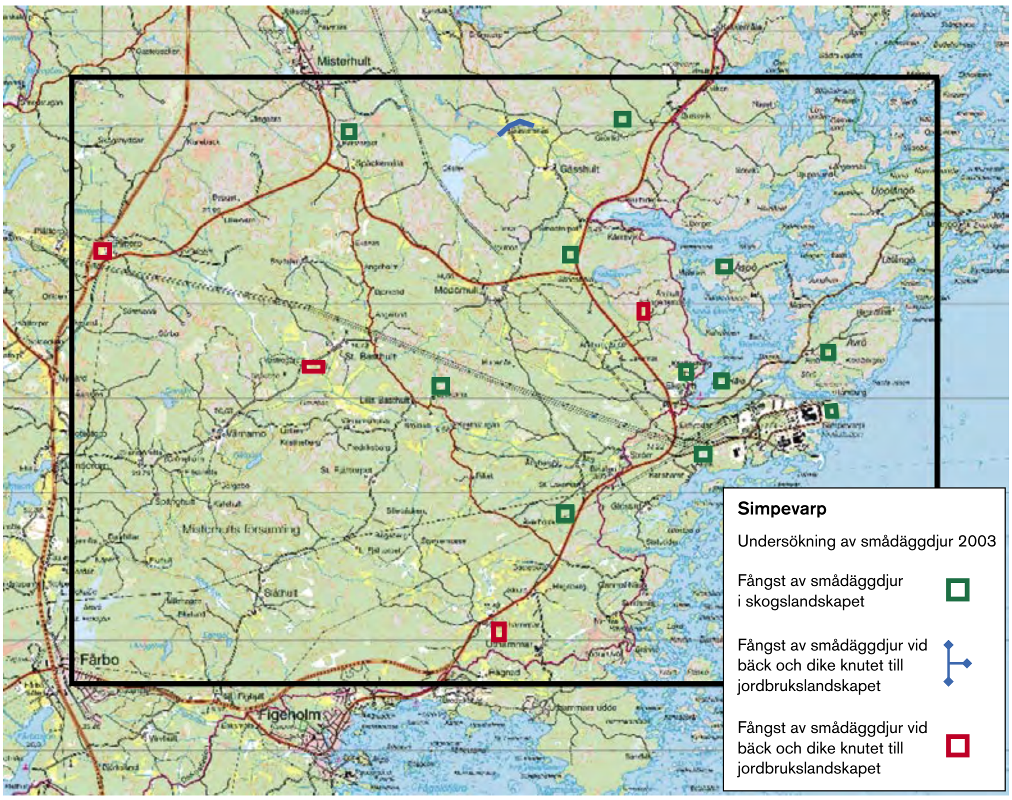

Figure 4-5b. *Rodent trapping in Oskarshamn.*

5 Results

5.1 Moose

Forsmark

No aerial survey was done in the winter 2003.

Pellet counts indicated somewhat higher density in Forsmark (12.3 moose/10 km^2) compared to Hållnäs (6.7 moose/10 km^2) (Table 5-1). There was no change in density between the two years of collection in Hållnäs, while moose density in Forsmark increased almost 50%. This might be due to random movements among moose and the relatively small area in relation to moose home ranges.

In addition to aerial surveys and pellet counts, the future co-operation with the local hunters will provide data on age structured density estimates (based on annual age determination of killed animals) and observations (ÄLGOBS). Different methods could then be calibrated with each other. Most of these data will be achieved and processed in a special project in co-operation between SKB and the local hunters.

Table 5-1. Estimated population density in the two sub areas in Forsmark (individuals/ 10 km^2) of moose, deer species, wild boar and hares based on pellet sampling in the spring 2002 and 2003. Number of sample plots is denoted as n. The $SE_{95\%}$ figures indicate the 95% probability to find the mean density estimates within the interval.

	Hållnäs						Forsmark					
	2002			2003			2002			2003		
	Population density (ind/10km²)											
	n	Mean	$SE_{95\%}$	n	Mean	$SE_{95\%}$	n	Mean	$SE_{95\%}$	n	Mean	$SE_{95\%}$
Moose	549	6,3	1,65	908	6,7	1,62	656	8,3	2,09	595	12,3	2,77
Roe deer	549	37,7	9,20	908	48,0	8,24	656	59,3	11,86	595	93,6	20,77
Red deer	549	0,0	0,00	908	0,0	0,00	656	0,0	0,00	595	0,1	0,13
Fallow deer	549	0,0	0,00	908	0,0	0,00	656	0,0	0,00	595	0,0	0,00
Wild boar	549	0,0	0,00	908	0,1	0,10	656	0,0	0,00	595	0,0	0,00
Hare - forest	1048	2,3	1,97	908	1,5	2,23	1274	4,4	3,80	595	2,3	2,08
Hare - field	2402	2,5	0,40	658	22,8	8,50	832	3,2	1,75	883	3,2	1,90

Oskarshamn

An aerial survey with helicopters was performed between 3 and 4 January 2003. The entire area was approximately 400 km^2 and covered the coastline from Oskarshamn in the south to the municipality of Blankaholm in the north (see the map in Figure 5-1). The larger islands in the archipelago outside the main area were also included in survey. There were no attempts to structure the area into sub areas since the area is relatively small in relation to mean moose home range size.

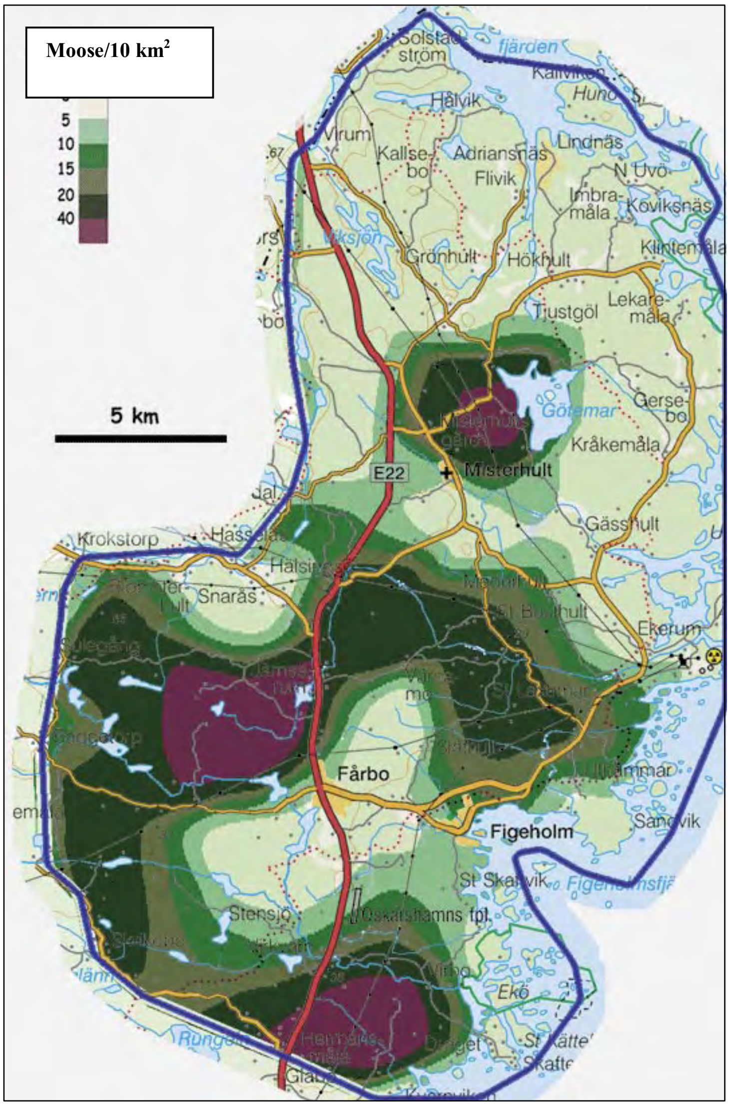

__Figure 5-1.__ The distribution of moose during the aerial survey in Oskarshamn, January 2003. Aggregations with different density of moose are indicated by different colours. For further data on composition of the moose population, see also Table 5-1.

As indicated by the map (Figure 5-1) the moose were unevenly distributed over the area during the survey. This is normal for this part of Sweden and is certainly associated with factors like hunting pressure, snow depth, availability and distribution of food. Mean density was approximately 8 moose/10 km^2, or 313 moose within the entire surveyed area. Although we have no good data from the adjacent areas, a guess is that the density is fairly similar to an average for the region (comments from local managers and from observations of moose during the hunt (ÄLGOBS). The pellet counts indicate that the winter population is lower (approximately 5 moose/10 km^2 (see Table 5-3). It should be noticed that the aerial survey describes the situation for a limited period, while pellet counts reflect the distribution of moose during the entire winter. Furthermore, occasional movements of moose may randomly have effect on the counts, since home ranges are relatively large in relation to the borderline of the area.

The age structure (adults and calves) and the sex composition from the aerial survey is presented in Table 5-2 and relatively similar to other areas. The dominance of adult females (75%) is due to a long-term effect of high hunting pressure on adult bulls. The unusually high proportion of calves indicates a high fecundity among adult females and/or low hunting pressure.

Like in Forsmark, additional data will be provided by co-operation between SKB and the local hunters in the future.

Table 5-2. Data from the aerial survey in January 2003 in the coastal area surrounding Simpevarp.

AERIAL SURVEY OSKARSHAMN		
	Total	
Moose/10 km^2 (observed)	5,7	Total number of moose
Observability	73%	
Moose/10 km^2 (adjusted)	**7,8**	313
Standard error	1,8	±70
		Moose/10km^2 land area
Moose category/10 km^2		
Males	1,2	8,7
Cows	3,7	
Calves	2,9	Moose/10km^2 forest
Calf/cow	0,80	9,8
Calf/adult	0,55	
		Water 10%
Cows without calf	33%	
Cows with one calf	53%	Fields 4%
Cows with two calves	13%	
		Forest 80%
Sex ratio (adult males/female	25%	
		Others 4%
Areal (10 km^2)	400	

Table 5-3. Estimated population density in the two sub areas in Oskarshamn (individuals/10 km²) of moose, deer speciesr, wild boar and hares based on pellet sampling in the spring 2003. Number of sample plots is denoted as n. The $SE_{95\%}$ figures indicate the 95% probability to find the mean density estimates within the interval.

	Simpevarp			Blankaholm		
	Population density (ind/10km²)					
	n	Mean	$SE_{95\%}$	n	Mean	$SE_{95\%}$
Moose	887	5,7	1,08	746	4,0	1,06
Roe deer	887	49,0	9,30	746	51,6	11,00
Red deer	887	0,3	0,18	746	1,5	0,58
Fallow deer	887	0,0	0,00	746	0,4	0,34
Wild boar	887	2,6	1,95	746	1,2	0,80
Hare - forest	887	5,2	2,83	746	3,2	1,86
Hare - field	1113	35,1	13,11	1257	19,1	7,37

Forsmark

There were no signs of fallow deer in any of the survey methods (only pellet counts this year). Red deer was found at low density in Forsmark (0.1 deer/10 km²) (Table 5-1). Red deer are living patchily in small groups along the coastal area (probably released from small fences). The patchiness might lead to too low estimates. However, according to local managers the population is increasing, as is the entire population in Sweden (Long et al, 2002). We intend to include both deer species in the future work.

Oskarshamn

Red deer as well as fallow deer are living in small groups along the coastal area. According to local managers the populations are increasing, as is the entire population in Sweden (Long et al, 2002). Pellet counts indicated 0.3 red deer/10 km² in Simpevarp and 1.5 deer/10 km² in Blankaholm. Local managers consider these data to be too low. On the other hand, the figures are given as a mean over the entire area. The clustering of deer creates a great variation in densities. Many areas are empty or contain very few deer. Small groups of red deer were also observed from the air during the aerial survey. The observations are too few to allow density estimates (21 red deer were seen, Table 5-4).

Fallow deer were only found in Blankaholm (pellet counting indicated 0.4 deer/10 km²).

Table 5-4. Other species than moose observed during the aerial survey in Oskarshamn, January 2003. Second search refers to the control survey in those sampling plots where observation tests for moose were done (see Methods 4.1.). No such tests were done for other species. Therefore, observations listed here should be considered as minimum figures and used as an index if aerial surveys are repeated.

Species	First search	Second search
Roe deer	46	18
Red deer	21	0
Wild boar	19	0

5.3 Roe deer

Forsmark

As in 2002 roe deer was the most numerous cervid species in both areas. However, pellet counts indicated that there was at least 2 times more deer in Forsmark (93.6 deer/10 km^2) than in Hållnäs (48.0 deer/10 km^2) (Table 5-1). It is well known that roe deer density varies considerably between adjacent, local areas. There is no reason to believe that the densities found in this study are exceptional. However, the difference between 2002 and 2003 in density is probably due to random aggregations of roe deer correlated to food and snow conditions. Future monitoring will reveal the cause of the variation.

If the co-operation with the local hunters is successful, we will be able to compare density estimates over time with harvest data and observation series (this is a separate project, see moose, 5.1; includes also Oskarshamn).

Roe deer is relatively easy to capture. A "campaign" project based on capturing can give additional data on density (see Methods 4.2.) as well as mortality and dispersal.

Oskarshamn

Roe deer was the most numerous cervid species in both sub areas and with similar density (49.0 deer/10 km^2 in Simpevarp; 51.6 deer/10 km^2 in Blankaholm) (Table 5-3). Although it is well known that roe deer density varies considerably between local areas, there is no reason to believe that the densities found in this study are exceptional. The density is of the same magnitude as in Forsmark.

Roe deer were observed from the helicopter during the aerial survey (Table 5-4). However, no attempts were made to calculate the actual number since the proportion of the total population seen was too small. Hopefully, these observations can be used as indexes when the aerial survey is repeated.

5.4 Wild Boar

Forsmark

According to the local game managers, the wild boar population has still a low mean density in the region, but is expected to increase in the near future like in many other areas in Sweden (Long et al, 2002). The animals live in groups and use the landscape patchily. That might be one reason why we did not find more than just occasional tracks on the line transects when tracking along the water (Table 5-5; see also the report from 2002). Data from pellet counts indicate a mean density of 0.1 boar/km^2 in the Hållnäs area, which is probably too low (Table 5-3).

Table 5-5. Frequency of tracks of different species crossing the transects along the water system in Forsmark and Hållnäs. The number of transects is indicated by n. The $SE_{95\%}$ figures indicate the 95% probability to find the mean density estimates within the interval.

Hållnäs														
	2002							2003						
	Number of tracks				Number of tracks per km			Number of tracks				Number of tracks per km		
	Sum	Mean	$SE_{95\%}$	n	Mean	$SE_{95\%}$	n	Sum	Mean	$SE_{95\%}$	n	Mean	$SE_{95\%}$	n
Squirrel	2	0,09	0,18	23	0,05	0,02	23	5	0,2	0,21	24	0,1	0,11	24
Lynx	0	0,0	0,00	23	0,0	0,00	23	1	0,04	0,09	24	0,02	0,02	24
Mink	21	0,91	1,23	23	0,50	0,22	23	2	0,1	0,12	24	0,05	0,14	24
Marten	8	0,35	0,21	23	0,19	0,06	23	0	0,0	0,00	24	0,0	0,00	24
Fox	103	4,48	2,26	23	2,47	0,56	23	58	2,4	0,70	24	1,3	0,64	24
Veasel	3	0,13	0,15	23	0,07	0,02	23	8	0,3	0,44	24	0,2	0,37	24
Otter	0	0,0	0,00	23	0,0	0,00	23	1	0,04	0,09	24	0,02	0,07	24
Wild boar	0	0,0	0,00	23	0,0	0,00	23	0	0,0	0,00	24	0,0	0,00	24
Forsmark														
	2002							2003						
	Number of tracks				Number of tracks per km			Number of tracks				Number of tracks per km		
	Sum	Mean	$SE_{95\%}$	n	Mean	$SE_{95\%}$	n	Sum	Mean	$SE_{95\%}$	n	Mean	$SE_{95\%}$	n
Squirrel	2	0,1	0,14	20	0,1	0,03	20	4	0,17	0,06	24	0,1	0,04	24
Lynx	2	0,1	0,14	20	0,1	0,06	20	13	0,54	0,06	24	0,3	0,11	24
Mink	35	1,8	1,17	20	0,9	0,55	20	19	0,79	0,50	24	0,4	0,17	24
Marten	2	0,1	0,14	20	0,1	0,07	20	9	0,38	0,06	24	0,2	0,08	24
Fox	75	3,8	4,53	20	1,9	1,88	20	42	1,75	1,91	24	0,9	0,37	24
Veasel	0	0,0	0,00	20	0,0	0,35	20	2	0,08	0,00	24	0,0	0,02	24
Otter	15	0,8	0,83	20	0,4	0,35	20	4	0,17	0,35	24	0,1	0,04	24
Wild boar	0	0,0	0,00	20	0,0	0,0	20	1	0,04	0,00	24	0,02	0,01	24

Oskarshamn

According to the local game managers, the wild boar population is fairly new in the region and in many areas still at low density, also indicated by the pellet counting data (Table 5-3). A rapid increase is expected like in Forsmark. A relatively high frequency of tracks on the line transects when tracking on snow supported this hypothesis (see Table 5-6, 5-7). Wild boar were also observed from the helicopter (19 animals; Table 5-4).

Additional methods, like counting with air borne, infrared cameras and distance sampling techniques with spotlights during night time can probably be used to provide additional data about wild boar.

Based on experiences from other regions in this part of Sweden, it is reasonable to believe that wild boar will increase in numbers and expand its range dramatically in the near future. It will then be one of the most important game species in the area.

Table 5-6. Frequency of tracks on snow of different species crossing the transects in the forested areas in Simpevarp and the control area (Blankaholm). Density estimates (Buffon method) are presented in those cases where data are sufficient. The $SE_{95\%}$ figures indicate the 95% probability to find the mean density estimates within the interval.

Simpevarp											
Transect length (km) 29,4	Marten	Fox	Mink	Otter	Lynx	Wild boar	Badger	Squirrel	Vesel	Cat	Dog
Number f racks t	3,0	62	0	0	0	2	0	26	1	0	0
Tracks per day and 10 km	1,02	21	0,00	0,00	0,00	0,68	0,00	8,85	0,34	0,00	0,00
Tracks per 10 km	**1,0**	**21**	**0,0**	**0,0**	**0,0**	**0,7**	**0,0**	**8,8**	**0,3**	**0,0**	**0,0**
The Buffon method											
Number of animals in the area	13,0					4,4					
SE	13,0					4,4					
Number of animals per 10 km	**1,3**					**0,4**					
Blankaholm											
Transect length (km)	Marten	Fox	Mink	Otter	Lynx	Wild boar	Badger	Squirrel	Vesel	Cat	Dog
Number f racks t	1	70	0	0	0	1	0	26	1	0	0
Tracks per day and 10 km	0,4	27,16	0,00	0,00	0,00	0,39	0,00	10,09	0,39	0,00	0,00
Tracks per 10 km	**0,4**	**27,2**	**0,0**	**0,0**	**0,0**	**0,4**	**0,0**	**10,1**	0,39	**0,0**	**0,0**
The Buffon method											
Number of animals in the area	6,0					4,9					
SE	6,00					4,90					
Number of animals per 10 km^2	**0,5**					**0,5**					

Table 5-7. Frequency of tracks of different species crossing the transects along the water system in Simpevarp and the control area (Blankaholm). The number of selected sample areas (see Methods 4.3.2) is indicated by n. The $SE_{95\%}$ figures indicate the 95% probability to find the mean density estimates within the interval.

Simpevarp							
	Number of tracks				Number of tracks per km		
	Sum	Mean	$SE_{95\%}$	n	Mean	$SE_{95\%}$	n
Squirrel	64	2,7	2,91	24	0,9	1,27	24
Lynx	0	0,0	0,00	24	0,0	0,00	24
Mink	46	1,9	1,64	24	0,7	0,61	24
Marten	15	0,6	0,48	24	0,2	0,16	24
Fox	995	41,5	12,26	24	14,1	6,12	24
Veasel	35	1,5	0,75	24	0,5	0,29	24
Otter	0	0,0	0,00	24	0,0	0,00	24
Wild boar	16	0,7	0,71	24	0,2	0,38	24
Blankaholm							
	Number of tracks				Number of tracks per km		
	Sum	Mean	$SE_{95\%}$	n	Mean	$SE_{95\%}$	n
Squirrel	30	1,3	0,93	24	0,6	0,71	24
Lynx	0	0,0	0,00	24	0,0	0,00	24
Mink	48	2,0	1,43	24	0,9	0,68	24
Marten	10	0,4	0,35	24	0,2	0,48	24
Fox	538	22,4	7,81	24	10,5	4,09	24
Veasel	7	0,3	0,38	24	0,1	0,16	24
Otter	0	0,0	0,00	24	0,0	0,00	24
Wild boar	58	2,4	4,56	24	1,1	1,47	24

5.5 European and mountain hares

Hare density was calculated from the pellet counts. Data sets from the fields and from the forested areas were separated. Normally, the mountain hare is associated with forest and European hare with fields, but there is no absolute border in habitat use between the species. Since we are not able to discriminate pellets from the two species, calculations refer to the two main habitat types.

Forsmark

Hare density in the fields varied from 3.2 hares/10 km^2 (Forsmark) to 22.8 hares/10 km^2 (Hållnäs). Whether the high figure in Hållnäs is accidental remains to be seen (compare with 2.5 hares/10 km^2 in 2002). In the forest, density was generally low in both years, between 2.3 and 1.5 hares/10 km^2 in Hållnäs); 4.4 and 2.3 hares/10 km^2 (Forsmark) (Table 5-1).

In general, the density of hares seems fairly low. However, hares in the area might be under strong pressure from several predators like fox, marten and lynx, which all have hares as an important food species.

Oskarshamn

Hare density in the fields was rather high in Simpevarp (35.1 hares/10 km^2) and somewhat lower in Blankaholm (19.1 hares/10 km^2). In the forest, density was much lower, between 5.2 hares/10 km^2 (Simpevarp) and 3.2 hares/10 km^2 (Blankaholm). In general, the density of hares in forest seems fairly low (Table 5-3; see also Cederlund, Hammarström and Wallin, 2003).

5.6 Beaver

Forsmark and Oskarshamn

There have been no observations of tracks or indications of burrows in any of the study areas so far. This is also verified by local managers and hunters. However, it is reasonable to believe that beaver will appear in the areas during the monitoring period (within 5–7 years).

5.7 Wolf

Forsmark

There were no tracks of wolves in 2003. The small group of wolves (2–3 animals) that probably lived in northern Uppland the entire winter 2002, was either killed or left the region. It is likely that wolves will appear again in this part of Uppland in the coming years.

Oskarshamn

There were no tracks or observations of wolves.

5.8 Fox

The objective was to include fox tracks in the Buffon method. However, the high frequency of tracks in combination with long distances between end points (see Methods) and highly irregular movement patterns, made it difficult to distinguish tracks from different animals and the procedure tended to be very time consuming. Therefore, as suggested in the previous report, density of the fox population will be estimated by a capture-recapture technique (see Methods 4.2.). A pilot study is carried out in Forsmark in 2004. If the project is successful the method might be accomplished also in Oskarshamn.

Forsmark

Fox tracks were frequently found in both areas. In fact, fox tracks were the most numerous of all tracks both in 2002 and in 2003 (Table 5-5).

Oskarshamn

Fox tracks were frequently found in both areas, in forests as well as along the water system. Like in Forsmark, fox tracks were by far the most numerous of all tracks, irrespective of habitat (Table 5-6; 5-7).

5.9 Marten

Forsmark

Marten seems to be fairly common in both areas (Table 5-5) like the previous year. No density estimates were made this year.

Oskarshamn

Marten seems to be common in both areas (Table 5-6; 5-7). Like in Forsmark tracks were found along the water system in Simpevarp as well as Blankaholm. Density estimates are relatively uncertain (high confidence intervals) but seem quite reasonable.

5.10 Otter

Forsmark

Otter is a red listed species but is probably recovering due to special aid programs. Tracks were found in Forsmark along the water system transects in both years (Table 5-5). Tracks were also found in Hållnäs in 2003. No density estimates have been made due to small data sets.

Oskarshamn

No tracks or any other signs of otter were found in the two areas (Table 5-6: 5-7).

5.11 Mink

Forsmark

Mink is fairly common in the region and tracks were relatively frequent along the water system, especially in Forsmark (Table 5-5).

Oskarshamn

Mink is common, like in Forsmark. Consequently, tracks were relatively frequent along the water system in both areas, but not found in the forest (Table 5-6; 5-7).

5.12 Lynx

Forsmark

Lynx is a spectacular species that has become more common in recent years. Regular hunting was allowed on a limited number in northern Uppland in 2003. Tracks were found both in Forsmark and Hållnäs (Table 5-5). There were no attempts to estimate density this year (estimated density from a small data set in Forsmark 2002 indicated 0.2 lynx/10 km^2).

Oskarshamn

Lynx has become more common in the recent years in southern Sweden (personal communication with local managers and scientists at Grimsö Research Station).

No tracks were found (Table 5-6; 5-7). However, since the lynx move over large areas, it is reasonable to believe that they occasionally pass through the Oskarshamn area.

5.13 Badger

Badger was not included in this study, and no tracks were found on snow (tracks were noticed in the Tierp area in 2002). Badger must be considered as an important species since it is probably numerous /Long et al, 2002/. Capture-recapture techniques best full-fill the requirements for population estimates and will be accomplished in 2004 in Forsmark.

Forsmark

No tracks on snow of badger in Forsmark in 2003.

Oskarshamn

No tracks on snow of badger in Oskarshamn in 2003.

5.14 Squirrel

Tracks on snow were frequently found in both Forsmark and Oskarshamn (Table 5-5; 5-6; 5-7) in 2003. Prey for marten, foxes and some birds of prey (like goshawk). Not selected for density estimates in this study.

5.15 Small mustelids

Tracks on snow in both Forsmark and Oskarshamn (Table 5-5: 5-6; 5-7). Includes for example *Mustela erminea* and *M. nivalis*. Not selected for density estimates in this study.

5.16 Cats, dogs and other domestic species

At least cats might be found in all kinds of habitats. They are potential predators on juvenile hares and birds. Not selected for density estimates in this study.

No tracks were found. Not selected for density estimates in this study.

5.17 Small rodents and insectivores

Trapping was done in spring-early summer for the first time in Forsmark and in Oskarshamn. The procedure was repeated in September–October. Trapping proved to be successful in both periods and revealed data for fair calculations of density estimates.

The following species were captured:

Clethrionomus glareolus (Skogssork/ängssork) Bank vole.
Apodemus fluviatilis (Större skogsmus) Yellow necked mouse.
Apodemus sylvaticus (Mindre skogsmus) Wood mouse.
Sorex araneus (Vanlig näbbmus) Common shrew.

Forsmark

As expected spring density was clearly lower than autumn density for bank vole and mouse, the only species we were able to compare between seasons (see Table 5-8). Data for the mouse species are pooled in the table. The proportion of wood mouse of all mice trapped was similar in spring and autumn (32%).

Limited data on shrews did not permit density estimates during spring in Forsmark.

Table 5-8. Density estimates of microtines, voles and shrews in spring (bottom density) and autumn (peak density) 2003 in Forsmark. The number of selected sample areas (see Methods 4.5) is indicated by n. In some cases sample size was too small to allow fair calculations and is therefore not presented in the table. The $SE_{95\%}$ figures indicate the 95% probability to find the mean density estimates within the interval.

Forsmark	Spring			Autumn		
	Population density (ind/0,01km²)					
	n	Mean	$SE_{95\%}$	n	Mean	$SE_{95\%}$
Field vole	15	6,9	2,80	15	8,3	2,40
Bank vole	15	46,2	2,60	15	56,4	13,70
Water vole	15	8,9	1,70	5	11,5	4,30
Mouse	15	30,4	13,80	15	54,9	3,90
Shrew	15			15	29,1	21,20

Oskarshamn

Due to limited access to some areas we were allowed to use traps in only 5 sample areas in the spring period. Therefore, data should be used carefully. During the autumn period trapping was performed in 20 sample areas. Unfortunately, the water vole trapping excluded in autumn, either because of frost and early snow in the Oskarshamn region.

Fairly ggod data were achieved from the autumn period for all common species except water vole. As expected spring density was clearly lower than autumn density for bank vole and mouse, the only species we were able to compare between seasons (see Table 5-9). Data for the two mouse species are pooled in the table. In spring, the proportion wood mouse trapped was 32% of all mice, and in autumn nearly twice as much (59%).

No data are available about water vole density, because we have not been able to put out sufficient number of traps in 2003.

Table 5-9. Density estimates of microtines, voles and shrews in spring (bottom density) and autmn (peak density) 2003 in Simpevarp. The number of selected sample areas (see Methods 4.5) is indicated by n. In some cases sample size was too small to allow fair calculations and is therefore not presented in the table. The $SE_{95\%}$ figures indicate the 95% probability to find the mean density estimates within the interval.

Simpevarp	Spring			Autumn		
	Population density (ind/0,01km²)					
	n	Mean	$SE_{95\%}$	n	Mean	$SE_{95\%}$
Field vole	5			13	31,6	16,00
Bank vole	5	29,3	10,40	13	71,0	14,00
Water vole	5			5		
Mouse	5	23,5	32,20	13	136,8	16,90
Shrew	5			13	28,2	9,00

The dormouse

The dormouse is found in small populations in Europe. It is considered to be one of the most endangered mammal species in many countries, and the population is said to decline /Mammal Society, London/. However, very little is known about the status of the species.

There are several reasons for the decline, such as loss of deciduous woodland and hedgerows, competition with Grey Squirrel for food, and other environmental changes.

In Sweden, dormouse is found occasionally south of the latitude of Stockholm /Berg, 1990/. The northernmost population is encountered in the county of Närke, near Örebro. Most observations are recorded in the county of Blekinge.

Forsmark. It is unlikely that dormouse will live and breed permanently in Forsmark although there has been an unverified observation from a site near Gävle /Lena Berg, personal communication/.

Oskarshamn. Evidently, the Oskarshamn area has potential dormouse habitats. During mouse trapping in 1989, 3–4 dormice were caught near Virbo, just south of Figeholm /Tommy Larsson, personal communication/. Important tree species, such as hazel and oak are frequent in the area. There have been no observations from the SKB areas reported to the biologists at the county board, although breeding populations are permanent some ten kilometres west of Simpevarp /Thomas Järnetun, personal communication/.

Concludingly, it is unlikely to find breeding dormouse in Forsmark, while we can expect to find the species along the coast in the Oskarshamn area, probably at low numbers.

6 Conclusions

As mentioned earlier (see page 9) this report primarily presents data from the field studies in 2003, including both Oskarshamn and Forsmark. Further evaluation in the context of representability in relation to other regions, annual variations, long-term changes etc, will be presented in a separate report at the end of 2004. This section is limited to some conclusions about the methods in the perspective of obtaining relevant data for this project and their use in the future monitoring program.

- All larger mammal species, that are expected to live in the areas all the year round, except badger, are documented either as indexes or in absolute numbers.
- Snow tracking gives relevant indexes of the present species in the areas. It also indicates spatial distribution and habitat selection. However, tracking is depending on unpredictable snow conditions that may obscure results some years (particularly in Oskarshamn). The method is also relatively time consuming.
- The Buffon method has given the density data on large predators like lynx and marten. Data are unique, since very few data on absolute densities from these species exist.
- In principle, the Buffon method works for fox. However, since fox moves erratically over the area, is very active and produces a high number f tracks, the method becomes very time consuming. Tracks may best be used as indexes.
- Badger and fox are common species in both areas and might therefore be important for further calculations of trophical interactions. Density estimates should be of high priority. It is best done with conventional traps and from capture – recapture data.
- Pellet counts are relatively easy to do and give either index or density estimates. The method might be selected for future monitoring.
- Conventional trapping of small rodents and insectivores is suitable for a monitoring program. There is no realistic alternative to the trapping method.
- Aerial surveys are best used over large areas and provide good data on moose. The method can also be used for fallow deer and red deer if the animals are spread over the entire area (both species are highly aggregated in both Forsmark and Oskarshamn).
- We suggest tests of alternative methods for density estimates of the larger mammals. One feasible method is distance-sampling technique, for example by observing animals with lamp light (in combination with IR cameras) during different periods of the year. The method can include most of the larger species.
- Additional data of some species (mostly game species) can be obtained from hunters observations and hunting records. This is taken care of in a specific project where local hunting organisations are involved in a co-operative venture. SKB (through Svensk Viltförvaltning AB) is initiating hunter-based collection of specific data and is returning information relevant for game management (particularly moose).

In the suggested future program focus will be on monitoring of the most important species. If we define their role based on biomass and suggested impact on the ecosystem, we can distinguish three categories:

1. Large herbivores (moose, deer species and hares).

2. Small rodents and insectivores.

3. Large predators (fox and badgers, eventually including lynx and wolf).

The monitoring program should include annual estimates of the species listed above. Estimations can be either as index or as absolute densities, depending on what type of data is needed. We suggest that the following methods are used:

1. Aerial survey (every 3–4 year; gives absolute number of moose and deer, index of wild boar and roe deer). A part of the management system together with the local hunters.

2. Pellet counting each spring (density estimates of moose and deer, wild boar, and hares).

3. Trapping of small rodents and insectivores each spring and autumn.

4. Observations with light (including IR). Distance sampling technique provides density estimates. Can also be used as index. The method needs to be tested. Probably the only way to get annual data of fox and badger at reasonable cost.

Finally, we suggest that data are presented to the public (hunters, local county boards, conservation agencies etc) each year. Data are of general interest and easily transformed to anyone who wants information from wildlife in these areas. It should be noted that we will be able to present data that are unique, since this is probably the first time in Sweden actual density estimates of a number of mammal species within the same area and over several years are available.

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