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A pilot study 2001–2002

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Svensk Viltförvaltning AB

April 2003

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Summary

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 effects from e g drilling activities on populations (important to hunters) and be used for assessment programs (MKB). One of the major goals is to monitor populations over several years and to obtain information that is essential for modelling of energy/carbon flows in the biosphere and ultimately calculations of the risks of exposure to radionuclide.

From late 2001 to late spring 2002 a pilot study was accomplished in the areas surrounding the suggested areas in the Tierp region and in Forsmark (Oskarshamn was not included in this pilot study). A reference area was chosen near the coast some 20 km north of Forsmark. The aim was to initiate surveys of most of the larger mammal species that were expected to be found in the region. Selected species were wolf, lynx, otter, marten, mink, red fox, beaver, wild boar, red deer, roe deer, moose, European hare and mountain hare. Several methods were used and adapted to expected habitat use and expected local density of the species. 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. In mid winter an aerial (helicopter) survey was conducted along the coast to count moose. The aquatic mammals were tracked on snow along selected parts of the streams and larger ditches.

The methods have been evaluated and should all be used next year with minor changes. Some of the basic data presented in the report are as follows:

- Moose were unevenly distributed in a 480 km^2 area along the coast (mean density 7.2 moose/10 km^2).
- No red deer was fund while roe deer density varied between 13 deer/10 km^2 (Tierp) and 59 deer/10 km^2 (Forsmark).
- Hare density in the fields were between 2.5 hares/10 km^2 (Control area) and 3.4 hares/10 km^2 (Tierp) while in the forest density varied between 0.2 hares/10 km^2 (Tierp) and 4.4 hares/10 km^2 (Forsmark)
- Red listed species like wolf and otter are present in the areas, although in low numbers. No wolf tracks were found, but a few individuals were observed elsewhere in the region during the winter.

- As indicated by track indexes, red fox and marten are common predators in all three areas. Lynx is present, but at low numbers (0.2 lynx/10 km^2).
- Occasional tracks of wild boar were found in the transects.

Based on the results from this pilot study, we suggest some modification of the methods and additional methods for density estimates (for example using capture-recapture techniques of fox and badger).

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 effects from e g drilling activities on populations (important to hunters) and be used for assessment programs (MKB). One of the major goals is to monitor populations over several years and to obtain information that is essential for modelling of energy/carbon flows in the biosphere and calculations of the risks of exposure to radionuclides.

- Obtain data on abundance and local densities of the selected species. When sufficient data is achieved 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 others parameters like body mass and reproduction. The monitoring should continue for at least 5–7 years.

- 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 trofical levels (including consumption of vegetation as well as prey species).

In September 2001 it was decided that a pilot study should be done in the Tierp area and in Forsmark. Methods should be evaluated, the first set of data compiled and presented in a report. After revision, similar concept should be done for the Oskarshamn area. Although Tierp is no longer of interest for the future project, we finished the field work and data from that area will presented in this report together with data from the Forsmark area.

2 Study areas

We identified two study areas centred around suggested drilling activities in Forsmark and Tierp. As a control area we selected the major part of the Hållnäs peninsula. All three areas are shown in Figure 2-1. In the following text in this report data from the three different areas are referred to either Forsmark, Tierp 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 (< 100 m above sea level) and contains few lakes and streams. It is also characterised by a mosaic of habitats with different tree- and understory composition. Near the coast the vegetation is influenced by lime and 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 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 such as elm and oak may be frequent. More patchily distributed is rowan and alder. In poor soils conifers are dominating (inland areas). Agricultural areas constitute less than 10% of the total land area.

The three areas can be characterised in the following way:

Forsmark

Area size: approximately 110 km^2

The area is rather flat and characterised by a mosaic of small forests, meadows and marches, the latter offering limited food supply for the herbivores in winter, especially in periods of snow cover.

Forest stands contain a mixture of conifers and deciduous trees.

Tierp

Area size: approximately 210 km^2

Lower diversity and probably lower productivity among plant species compared to the two coastal areas (Forsmark and Hållnäs).

Conifers dominate the forest, especially pine, which is the major food species in winter for moose.

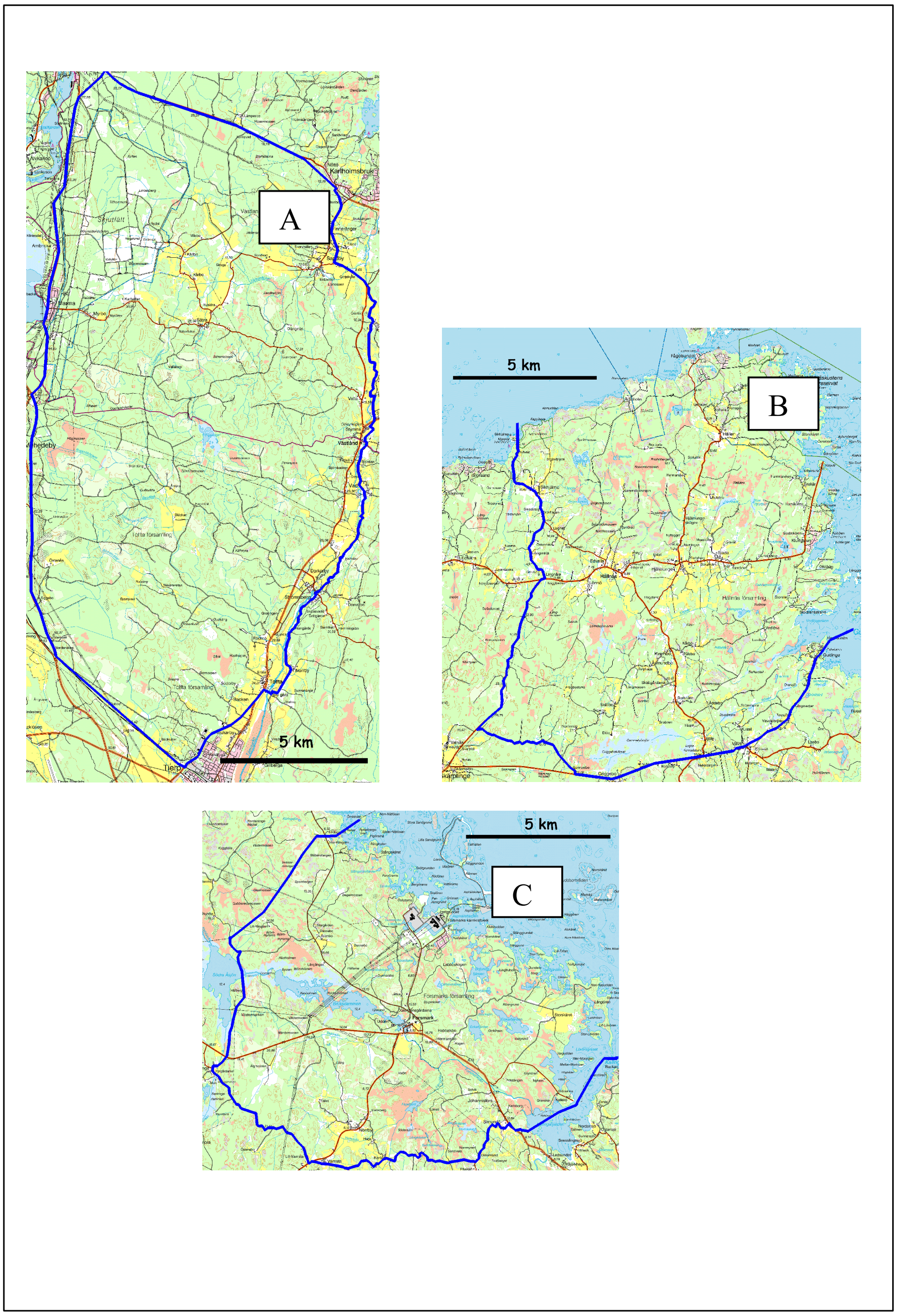

Figure 2-1. A map indicating the border of the selected study sites in Tierp (A), Hållnäs (Control area) (B), and Forsmark (C).

Hållnäs

Area size: approximately 140 km^2

In general considered to be an intermediate between Tierp and Forsmark as concerns forest composition.

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) were not included in this study. Neither was badger (*Meles meles*) since the pilot study was mainly accomplished during winter when the species usually is hibernating. However, badger is suggested be included in the future project. The following list contain selected species:

Artiodactyla (eventoed ungulates (partåiga hovdjur)):

Moose (älg) *Alces alces*

Red deer (kronhjort) *Cervus elaphus*

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*

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 gives 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. It is usually used as index and gives trends rather than actual figures on density and can give 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 trofical 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 hand books 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).

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 done during mid winter 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 reduce the operating time with 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 only are within the plot. The mean density (like moose/km^2) and variance is then easily calculated.

It is then 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 team 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 team 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.

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 includes 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 roams over relatively large areas and occur at low densities (marten has normally relatively small home ranges but is easy to track and occur 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.

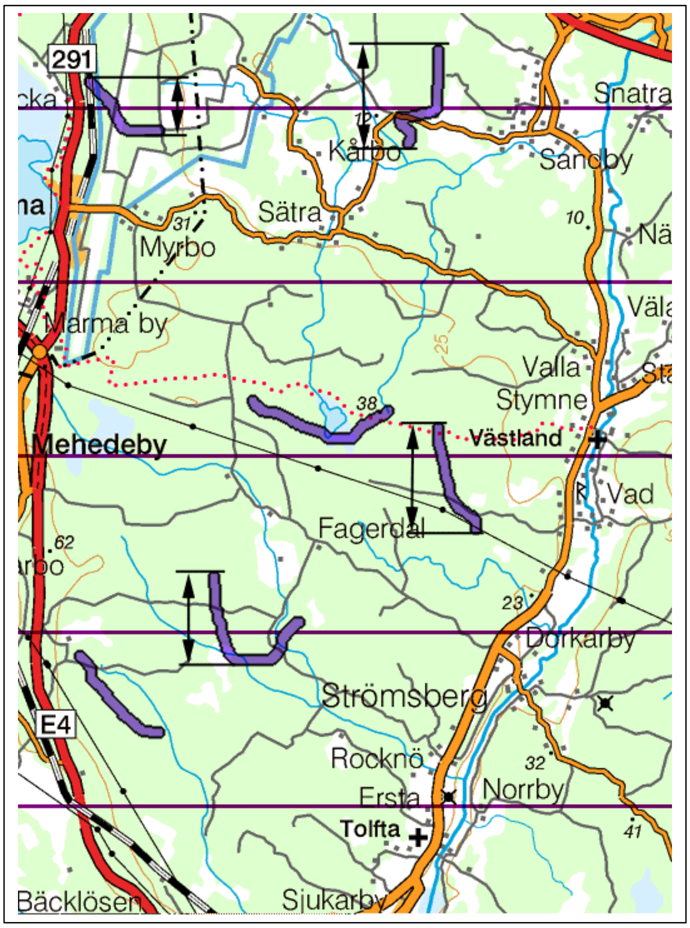

Figure 4-1. *Principle for the Buffon method (see methods 4.3). Blue, filled lines indicate tracks of animals. The arrows show the shortest distance from the end points of the track to the transect. Tracks not crossing transects are excluded from the data set.*

4.3.2 Transects along water areas

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

The method is actually a combination of the Buffon method and an ordinary line transect method. The entire area is devided in 1 km² 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 km² squares (see Figure 4-2).

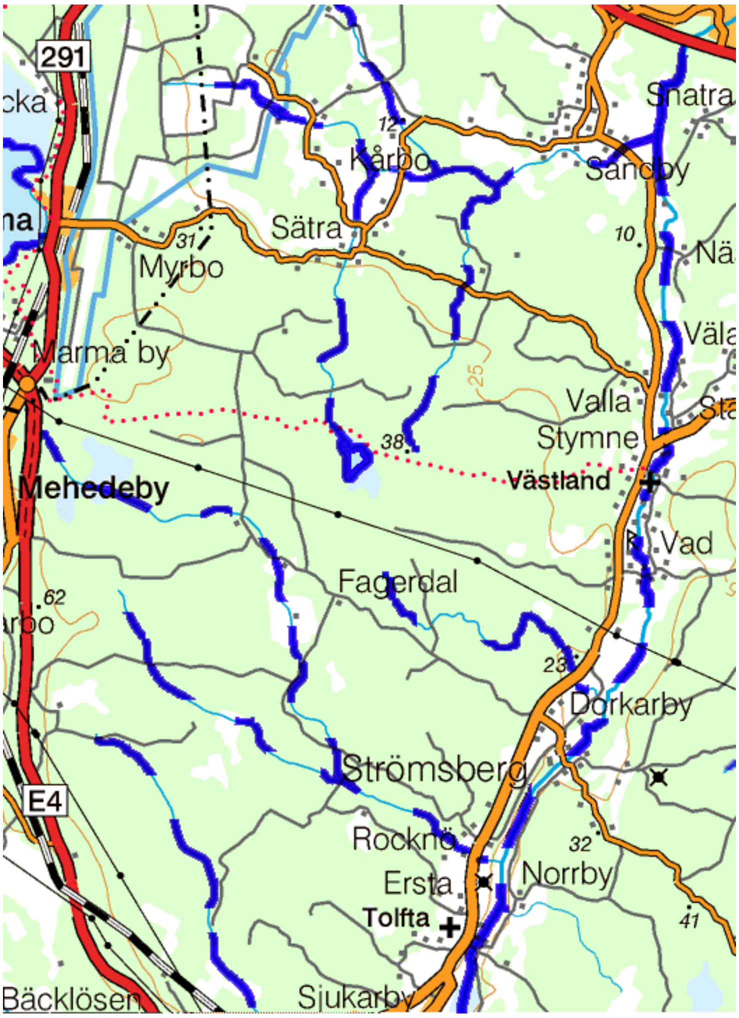

Figure 4-2. *Areas for stratified sampling of tracks crossing transects oriented along the water system (blue lines indicate selected stransects).*

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.

4.4 Fecal counts

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

The method is basically used as in 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, the number of days since leaf fall, it is possible to get a rough estimate of population density.

Data are collected in sample plots distributed along transects, which cover the entire area. The first transect is randomly chosen while the additional transects are 3 km apart in Tierp and 2 km in Forsmark and the control area (see also Figure 4-3). Basically, the sample plots are evenly distributed along the transect, but can be stratified depending on the expected relative distribution of the species. For moose and deer no stratification is done. The distance between plots are 70 m in Tierp and in the control area and 50 m in Forsmark.

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.).

Hares – Forest. For hares we basically use similar sampling plot system as for moose and deer, but with the double plot frequency (distance between plots are 35 m in Tierp and the control area and 25 m in Forsmark).

Hares – Field. In addition to the ordinary plot system hare pellets are also counted in a stratified plot system associated to 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.

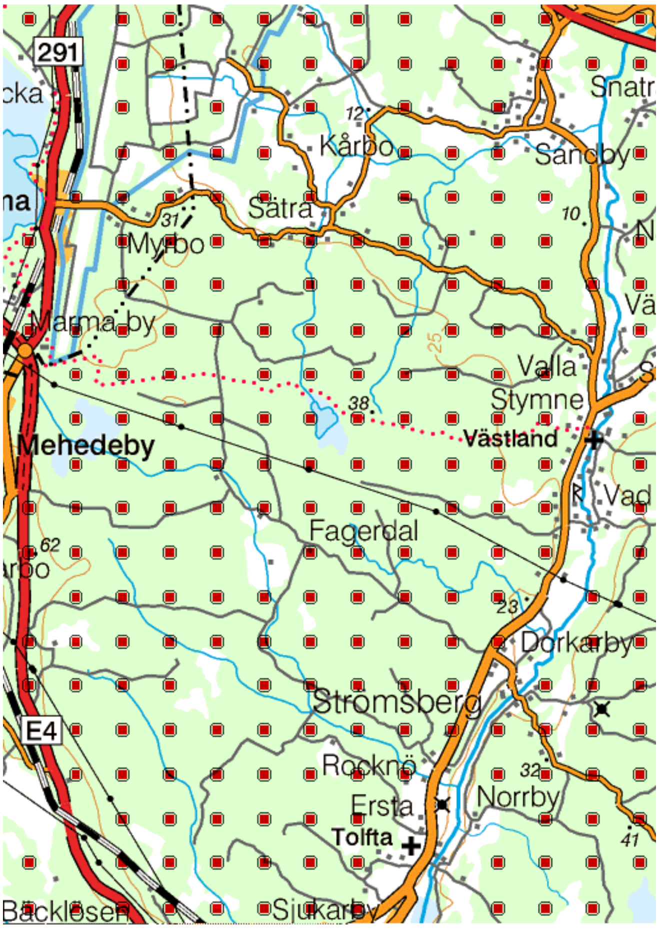

Figure 4-3. *Principle for plot distribution in forested areas when counting pellets from cervids (moose and deer) and hares.*

Specification of the sampling units

- **Moose, red deer, and wild boar**

Only pellet groups containing > 20 pellets are counted. Pellet groups with > 50% of the pellets within the plot are counted.

Plot size is 100 m^2 (radius 5.64 m).

- **Roe deer**

Pellets are counted as above.

Plot size is 10 m^2 (radius 1.78 m).

- **Hares**

All pellets are counted.

Plot size is 1 m^2 (1m x 1m square).

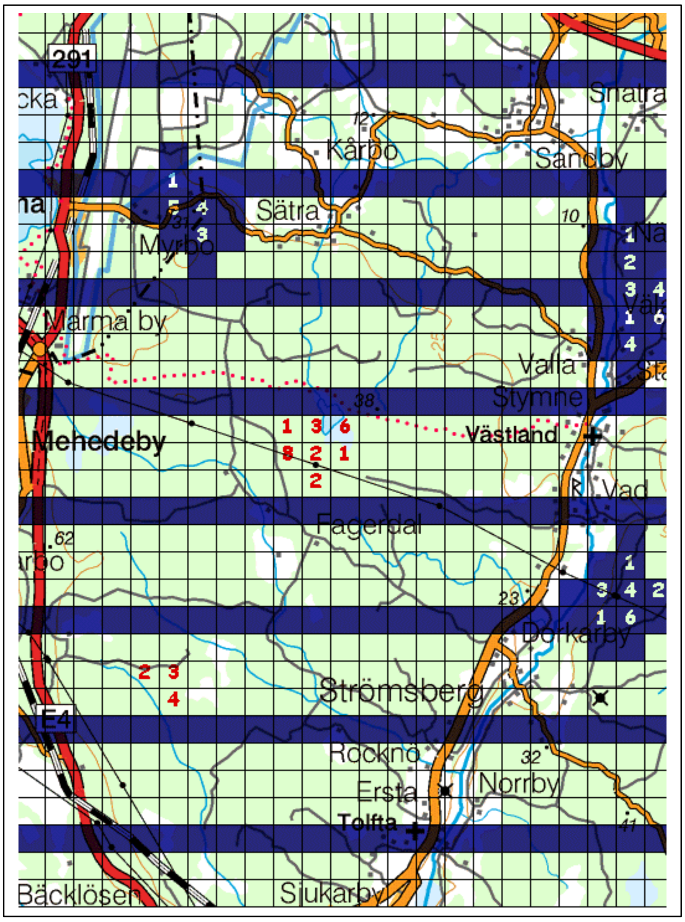

Figure 4-4. *Principle for adaptive sampling of hare pellets. Blue squares indicate plots along transects and plots searched in the cluster generated by the local pellet distribution (see method 4.4). Squares with red figures indicate clusters of pellets that are not "hit" by the transects lines and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

5 Results

5.1 Moose

An aerial survey with helicopters was done between 6 and 8 January 2002. The entire area was approximately 480 km^2 and covered the coast line from Forsmark in the south to the Hållnäs peninsula in the north (see the map in Figure 5-1). The area was also devided in three sections in order to structure local variations and to provide the hunters with data relevant for the local moose management (Table 5-1.). It should be noted that the Tierp area was not included in the survey.

As indicated by the map (Figure 5-1) the moose were unevenly distributed over the area during the survey. This is normal for any area in this part of Sweden and is certainly associated to factors like hunting pressure, snow depth, availability and distribution of food. Mean density was approximately 0.7 moose/km^2. The relatively low density in the sub area around Forsmark is unexplained but might be due to occasional movements out of the area in winter. The pellet counts indicate that the winter population is higher and fairly similar to the mean for the entire area (see Table 5-2).

It should also be noted that the moose population has been reduced, mainly due to hunting since the former survey, which was done in 1999. Then average density was 1.5 moose/km^2. That survey was sponsored by the local, large forest companies (Stora Enso and Korsnäs AB).

The age structure (adults and calves) and the sex composition are presented in Table 5-1 and relatively similar to other areas. The dominance of females is due to a long term effect of high hunting pressure on adult bulls. The high proportion of calves indicates a high fecundity among adult females and/or low hunting pressure.

In addition to aerial surveys and pellet counts, we hope that 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.

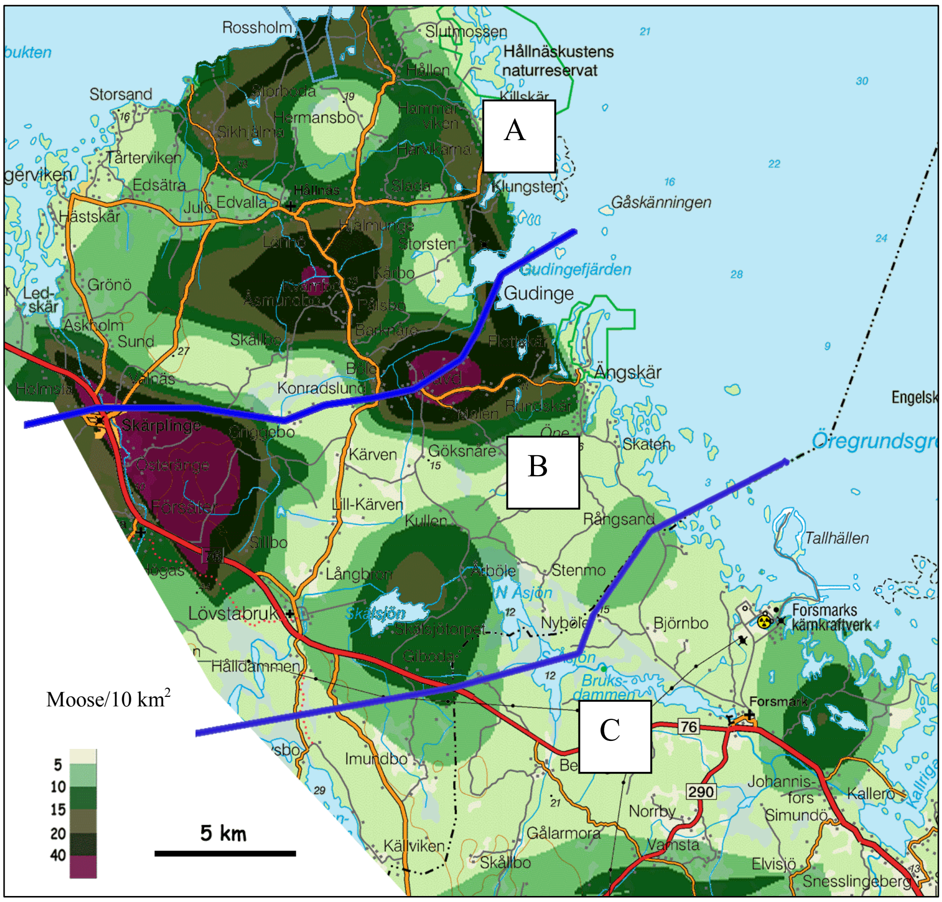

Figure 5-1. *Distribution of moose during an aerial survey in January 2002. Aggregations with different density of moose are indicated by different colours. The subareas A (Hållnäs); B (Saxmarken); and C (Forsmark) refer to Table 5-1.*

Table 5-1. Data from the aerial survey in January 2002 in the coastal area in northern Uppland. Hållnäs, Saxmarken and Forsmark is corresponding to A, B, and C resp. in the map in Figure 5-1. Note that arithmetic mean of the three areas might be somewhat different from Mean in the right column because of variation in distribution of sample plots in the subareas.

AERIAL SURVEY Jauary 2002				
	Hållnäs	*Saxmarken*	*Forsmark*	*Mean*
Moose/10km²	12.0	8.4	2.4	7.2
SE	2.9	2.6	0.9	1.7
Category/10km²				
Males	2.3	1.5	0.4	1.3
Females	6.4	4.4	1.2	3.8
Calves	3.3	2.4	0.7	2.1
Calf/cow	0.51	0.56	0.56	0.54
Calf/adult	0.32	0.34	0.34	0.34
Cows without calves	54%	50%	50%	51%
Cows with one calf	41%	44%	44%	44%
Cows with two calwes	5%	6%	6%	5%
Proportion males (among adults)	26%	26%	26%	25%

Table 5-2. Estimated population density (individuals/10km²) of moose, roe deer and hares based on pellet sampling in the spring 2002. Number of sample plots is denoted as n.

	Control			Forsmark			Tierp		
	Population density (ind/10km²)								
	n	Mean	$SE_{95\%}$	n	Mean	$SE_{95\%}$	n	Mean	$SE_{95\%}$
Moose	549	6.3	1.7	656	8.3	2.1	468	4.7	1.5
Roe deer	549	38	9	656	59	12	468	13	6
Hare -forest	1048	2.3	2.0	1274	4.4	3.8	926	0.2	0.4
Hare -field	2402	2.5	0.4	832	3.2	1.7	814	3.4	0.9

5. 2 Red deer

There were no sings of red deer in any of the survey methods (aerial survey, pellet counts, line transects). Red deer are living in small groups along the coastal area (probably released from small fences) and according to local managers the population is increasing, as is the entire population in Sweden /Long et al, 2002/. Therefore, we intend to include the species also in the future work.

5. 3 Roe deer

Roe deer was the most numerous cervid species in all three areas. However, the variation was high with at least 4 times more deer in Forsmark (59 deer/10 km^2) than in Tierp (13 deer/10 km^2) (Table 5-2). 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 confidence intervals indicate that we need more sampling plots in the future work.

Roe deer were also observed from the helicopter during the aerial survey (Table 5-3). No attempt was made to calculate the actual number since the proportion of the total population seen is too small. Hopefully, these observations can be used as indexes when aerial survey is repeated.

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.).

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.

Table 5-3. Other species than moose observed during the aerial survey in January 2002. Second search is the control survey in those 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	83	38
# Lynx	0	1

5. 4 Wild Boar

According to the local game managers, the wild boar population has still a low density, but is expected to increase in the near future like in many other areas in Sweden /Long et al, 2002/. Animals are supposed to 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 on snow (Table 5-4).

Table 5-4. Frequency of tracks on snow of different species crossing the transects in the forested areas in Forsmark, Tierp and the control area. Density estimates (Buffon method) is presented in those cases where data are sufficient.

Tierp											
Transect length (km) 50.7	Marten	Fox	Mink	Otter	Lynx	Wild boar	Badger	Squirrel	Veasel	Cat	Dog
Number of tracks	14.0	143	7	1	0	2	1	24	0	2	0
Tracks per day and 10 km	1.30	13.00	0.64	0.09	0.00	0.18	0.09	2.18	0.00	0.18	0.00
Tracks per 10 km	**2.8**	**28.2**	**1.4**	**0.2**	**0.0**	**0.4**	**0.2**	**4.7**	**0.0**	**0.4**	**0.0**
The Buffon method											
Number of animals in the area	278.0										
SE	105.0										
Number of animals per 10 km²	13.0										

Forsmark											
Transect length (km) 25.9	Marten	Fox	Mink	Otter	Lynx	Wild boar	Badger	Squirrel	Veasel	Cat	Dog
Number of tracks	6	46	2	2	5	0	0	11	1	0	0
Tracks per day and 10 km	1.1	8.70	0.38	0.38	0.95	0.00	0.00	2.08	0.19	0.00	0.00
Tracks per 10 km	**2.3**	**17.8**	**0.8**	**0.8**	**1.9**	**0.0**	**0.0**	**4.3**	**0.4**	**0.0**	**0.0**
The Buffon method											
Number of animals in the area	28.0				2.8						
SE	24.00				1.00						
Number of animals per 10 km²	**2.4**				**0.2**						

Control											
Transect length (km) 56.7	Marten	Fox	Mink	Otter	Lynx	Wild boar	Badger	Squirrel	Veasel	Cat	Dog
Number of tracks	7	78	0	0	0	0	0	10	2	0	1
Tracks per day and 10 km	0.82	9.20	0.00	0.00	0.00	0.00	0.00	1.18	0.24	0.00	0.12
Tracks per 10 km	**1.2**	**13.8**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**1.8**	**0.4**	**0.0**	**0.2**
The Buffon method											
Number of animals in the area	64.3										
SE	24.0										
Number of animals per 10 km²	4.2										

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 to the forest and European hare to the 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 (Table 5-2).

Hare density in the fields was rather similar between the areas and varied from 2.5 hares/10 km^2 (Control area) to 3.4 hares/10 km^2 (Tierp). In the forest, density varied somewhat more, between 0.2 hares/10 km^2 (Tierp) and 4.4 hares/10 km^2 (Forsmark).

In general, the density of hares seems fairly low. If this is coinsidal remains to be seen. 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.

5. 6 Beaver

There were no tracks or indications of burrows in the sample plots. 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

There were no tracks of wolves. A small group of wolves (2–3 animals) probably lived in northern Uppland the entire winter 2002. One was illegally killed and one was shot by a farmer after having attacked sheep in an enclosure.

If illegal killing and accidents are low in the coming years the potential for an establishment of a pack is high.

5. 8 Fox

Fox tracks were frequently found in all three research areas and in forests as well as along the water system. In fact, fox tracks were by far the most numerous of all tracks, irrespective of habitat (Table 5-4; 5-5).

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 patters, made it difficult to distinguish tracks from different animals and the procedure tended to be very time consuming. Therefore, we suggest that the density of the fox population is best estimated by a capture-recapture technique (see methods 4.2).

Table 5-5. Frequency of tracks of different species crossing the transects along the water system in Forsmark, Tierp and the control area. The number of transects are indicated by n.

	Number of tracks per km			Number of tracks per km			Number of tracks per km		
	Mean	$SE_{95\%}$	n	Mean	$SE_{95\%}$	n	Mean	$SE_{95\%}$	n
	Tierp			Forsmark			Control		
Mink	0.50	0.40	18	0.88	0.55	20	0.50	0.22	23
Fox	0.27	0.17	18	1.88	1.88	20	2.47	0.56	23
Squirrel	0		18	0.05	0.03	20	0.05	0.02	23
Lynx	0		18	0.05	0.06	20	0		23
Marten	0		18	0.05	0.07	20	0.19	0.06	23
Otter	0		18	0.38	0.35	20	0		23
Beaver	0		18	0		20	0		23
Veasel unspec.	0		18	0		20	0.07	0.02	23

5. 9 Marten

Marten seems to be fairly common and is found in all areas (Table 5-4; 5-5). Although, it is considered to be highly associated to tree dominated areas, tracks were fond along the water system in Forsmark and the Control area. Density estimates are relatively weak (high confidence intervals) and is probably too high. The Buffon method is relevant for density estimates, but more data are needed.

5. 10 Otter

Otter is a red listed species but is probably recovering due to special aid programs. Tracks were only found in Forsmark along the water system transects (Table 5-5). However, in Forsmark as well as in Tierp a few tracks were also crossing the transects in the forested areas (Table 5-4). Data were small and did not reveal any density estimate.

5. 11 Mink

Mink is fairly common in the areas and tracks were relatively frequent along the water system. Tracks were also found in the forested areas in Tierp and Forsmark (although rather few; see Table 5-4; 5-5).

5. 12 Lynx

Lynx is a spectacular species that has become more common in the recent years. Regular hunting is allowed on a limited number in northern Uppland. Tracks were only found in Forsmark (Table 5-4; 5-5). A first attempt to estimate the density revealed 0.2 lynx/10 km^2.

Since the lynx move over large areas it is reasonable to believe that they pass through the other areas also. One lynx was observed from the helicopter during the aerial moose survey in January 2002 (Table 5-3).

5. 13 Badger

Badger was not included in this study, but the tracks were found on the snow in the Tierp area and was therefore included in the data, together with some other species (see below). Badger must be considered as an important species since it is probably numerous /Long et al, 2002/. Population estimates are best done by capturing animals.

5. 14 Squirrel

Tracks were found in all areas (Table 5-4; 5-5). Prey for marten, foxes and some birds of prey (like goshawk). Not selected for density estimates in this study.

5. 15 Small mustelids

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 predator on juvenile hares and birds. Not selected for density estimates in this study.

6 Conclusions

The pilot study clearly indicated that the methods used were appropriate. All the selected species are documented by index and/or by actual density estimates.

Some changes are suggested for the future work.

- Tracking on snow must be intensified. Snow conditions are unpredictable and time effort on each occasion must be maximised in order to increase sample size and to get relevant data on each occasion.
- The Buffon method is in principle working for fox, but erratic movements and high local density, makes the method too time consuming.
- Badger should be included in the future project. The species is common and might therefore be important for further calculations of trofical interactions.
- It is important to get actual density estimates, at least of the most common species. Therefore, we suggest that fox and badger should be captured with conventional traps and density calculated from capture – recapture data.
- Additional data of some species (mostly game species) can be obtained from hunters observations and hunting records. This is done 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).

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 want 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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