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Forsmark site investigations

Bird monitoring in Forsmark 2007

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Abstract

This report is a summary of the monitoring of breeding bird species in Forsmark 2002–2007. A repeated survey of all breeding bird species in the area was done in 2007 and the results are compared with data collected in 2002–2003 (2004 for the candidate area). The report also summarizes the population development of listed species (Swedish Red List and/or the European Unions' Birds Directive) in the area, with special focus on eleven species selected for annual monitoring. The aim of the report is to evaluate possible impacts from the now completed site investigations, conducted by SKB, on the breeding bird fauna. The repeated survey of all breeding birds covered most of the regional model area, including the candidate area. Here, the line transect method was used in exactly the same way as in 2002–2003 (2004 in the candidate area). Selected listed species were monitored in the whole regional model area with specially designed methods. For other listed species, data from the line transects and collected during monitoring of the selected species was used to describe the population development. For most species selected for detailed monitoring proper data is now available for five years, which means that from now on data can be analysed statistically.

The general conclusion from both the repeated surveys of all breeding birds and from the more detailed monitoring of selected listed species is that the site investigations, associated potentially disturbing activities and increased human presence in the area, have had very little impact on the breeding birds of the area. For the bird fauna as a whole, a significant increase in numbers was recorded between 2002/2003 and 2007. Two thirds of all species showed a stable population between the early surveys and the one in 2007. At large, this pattern follows the general pattern at the national level during later years. A comparison between population development between the candidate (with potentially disturbing site investigations) and the regional model area outside of the local area (with a much more limited amount of site investigation activities) indicated a small statistical difference. In general terms however numbers of birds increased in both parts, but the increase was larger outside of the candidate area.

The possible impact on the breeding bird fauna from the increased human presence in the area due to the site investigations was analysed together with data on forestry actions during later years. This analysis showed no significant effects from the level of people working (with the site investigations) in the area on bird numbers. There was however significant effects on some groups of birds from forestry actions. Clear-cutting was, not surprisingly, positively associated with population development of birds connected to clear-cuts or forest edge as well as, perhaps more surprising, generalist species.

2007 was, compared to later years, an average-good year for the listed species being monitored in any detail. The black-throated divers had a good breeding success for the second time since the start of the site investigation period. Honey buzzards and ospreys again had a very good breeding season with high numbers of young produced. White-tailed eagles had an average season (for later years), and half of the pairs raised large young. Numbers of 'forest hens' (black grouse, capercaillie and hazelhen) showed different patterns between species. Black grouse numbers decreased, while capercaillies and hazelhens where recorded in similar numbers as in 2006. None of the ural owls produced young, probably due to low rodent numbers in the area. Lesser spotted woodpeckers continued to increase. Wrynecks kept their population size on the level from last year. Red-backed shrikes decreased somewhat in numbers. On a general level none of the monitored species has shown any decrease in local numbers over the six year period within the regional model area.

Sammanfattning

Denna rapport sammanfattar övervakningen av bestånden av häckande fåglar i Forsmark 2002–2007. Under 2007 genomfördes en upprepad inventering av områdets totala häckfågelfauna (exkl. skärgården) med samma metoder som användes 2002–2003 (till 2004 i kandidatområdet). I denna rapport sammanfattas även populationsutvecklingen för listade arter (upptagna i Svenska rödlistan och/eller EU:s Fågeldirektiv), med särskild fokus på de elva arter som varit föremål för, i de flesta fall, detaljerad årlig, uppföljning. Syftet med rapporten är att belysa och utvärdera eventuella effekter på de häckande fågelbestånden från de nu avslutande platsundersökningarna.

Den upprepade inventeringen av den totala häckfågelfaunan täckte större delen av det regionala modellområdet, inklusive kandidatområdet. Dessa delar inventerades med linjetaxering på precis samma sätt, längs samma linjer som under 2002–2003 (och 2004 i kandidatområdet). Utvalda listade arter följdes upp i hela regionala modellområdet med speciella metoder. För andra listade arter har data från linjetaxeringarna och annat uppföljningsarbete använts för att beskriva populationsutvecklingen.

Den allmänna slutsatsen både från den upprepade inventeringen av den totala fågelfaunan och den mer detaljerade uppföljningen av vissa listade arter är att platsundersökningarna har haft en väldigt liten påverkan. Totala antalet fåglar i området har ökat sedan platsundersökningens första år. Ungefär två tredjedelar av alla arter som registrerats under linjetaxeringarna har ökat eller hållit sina populationsstorlekar på en stabil nivå mellan 2002 och 2007. I stort följer detta mönstret i landet som helhet under senare år.

En jämförelse mellan populationsutvecklingen inom kandidatområdet och det regionala modellområdet utanför detta visade på en liten statistisk skillnad. I allmänna ordalag så ökade dock antalet fåglar i båda områdena, men ökningen var större utanför kandidatområdet än inom detsamma.

Eventuella effekter på häckfågelfaunan från den ökade mänskliga närvaron i området under plastundersökningarna, analyserades tillsammans med uppgifter om förändringar i skogstäcke (genom aktivt skogsbruk i vissa delar). Denna analys visade att det inte fanns några som helst tecken på att antalet personer som rört sig i området har påverkat fågelfaunan i stort. Däremot fanns vissa effekter av skogsbruk genom att arter knutna till hyggen och öppna miljöer gynnades av aktivt skogsbruk (avverkningar). Mer förvånande var kanske att det även fanns ett positivt samband mellan avverkningar och fågeltäthet för vanliga fåglar, s k generalistarter.

2007 var ett normalt eller bra år för de listade arterna som följdes upp mer detaljerat. Storlommarna lyckades för andra året i rad få ut goda antal med ungar. Bivråk och fiskgjuse lyckades även de väl med häckningarna, samtidigt som antalet par var konstant eller något fler än tidigare. Havsörnarna hade ett medelår, med senare års mått mätt. Hälften av paren fick ut ungar. Häckningsframgången är dock markant lägre än innan platsundersökningarna startade. Skogshönsen visade lite olika mönster, där orrarna minskade i antal (från toppnivån året innan) medan tjäder och järpe förekom i samma antal som året innan. Slagugglorna hade en usel häckningssäsong troligen på grund av låg gnagartillgång. Den mindre hackspettens ökning fortsatte och nu är antalet inom kandidatområdet tillbaka på samma nivå som innan minskningen för några år sedan. Göktytorna förkom i normalt antal och törnskatorna minskade något. Generellt sett har ingen av de uppföljda arterna minskat i antal i Forsmark under platsundersökningsåren.

Contents

1 Introduction

This document reports the results from the bird monitoring in Forsmark for 2007. The bird surveys started in 2002 and have now been going on for six years. In 2007 a repeated census of all breeding bird species in the area (excl. the archipelago) was made for comparison with data collected during the first years of the site investigations (primarily 2002–2003, but for the candidate area 2002–2004). For most of the listed species (according to the Swedish Red List and/or the EU Birds Directive) presented more in detail here, data enabling proper comparisons are available from 2003 onwards, allowing comparisons during a five-year period. The aim of this report is to evaluate the effects of the now finished site investigations on the breeding bird fauna in the area. The surveys were made according to Activity plan AP PF 400-06-098. The project has been conducted by the Department of Animal Ecology, Lund University. The report covers the whole regional model area.

Original data from the reported activity are stored in the primary database Sicada, where they are traceable by the Activity Plan number (AP PF 400-06-098). Only data in SKB's databases are accepted for further interpretation and modelling. The data presented in this report are regarded as copies of the original data. Data in the databases may be revised, if needed. Such revisions will not necessarily result in a revision of the P-report, although the normal procedure is that major data revisions entail a revision of the P-report. Minor data revisions are normally presented as supplements, available at www.skb.se.

2 Objective and scope

The site investigations in Forsmark started in 2002 and finished in 2007. SKB has from the start of the investigations aimed at monitoring the effects from all the ongoing activities on the bird fauna in the area. This in order to ensure that the site investigations were carried out in such a way that disturbances to the fauna, especially sensitive and vulnerable species, could be held at a minimum level (without hindering the essential parts of site investigations).

Forsmark is an area rich in birds, holding high densities of both common species and more rare ones /Green 2003, 2004, 2005, 2006, 2007/ such as species listed in the Swedish Red List /Gärdenfors 2005/ and European Unions Birds directive 79/409/EEG: Annex 1, (www.naturvardsverket.se). It is inevitable that site investigations as those conducted by SKB affect the bird fauna in some way. The investigations were not only likely to affect the specific sites where drilling was made or new roads were constructed. In addition to these direct impacts, involving small, but none the less direct losses of available areas for birds (both directly in a pure physical sense and indirectly through high, long-lasting levels of disturbance), the general level of human activity in the area was greatly increased with more traffic on the roads, more people out in the landscape measuring and sampling different objects etc. In Forsmark this meant a quite dramatic change from the pre-site investigation period, as the area had a rather low level of human disturbance then.

For certain listed species (Swedish Red List and the EU:s Birds Directive) the objective of the monitoring is to follow the population development in the whole regional model area. In addition to looking at overall numbers for these species, the programme aims at investigating breeding success when this is possible.

In 2002–2003 line transects were used to get a complete overview of the breeding bird fauna in the whole regional model area (2002–2004 in the candidate area). These line transects were repeated in 2007 for comparison with earlier years. By this approach it is now possible to evaluate possible impacts from the site investigations on the breeding bird fauna in general.

The results shown in this report still only concern short-time effects (≤1 or a few generations for the involved species) from the site investigations. The long-time effects (several generations) will not be possible to analyse for some years yet. Hence, the results presented here should be taken as indications of possible effects more than as firm conclusions about long-time effects. However, as the monitoring years have been adding up, conclusions presented here are more robust than earlier ones.

Within the bird surveys, the Forsmark area has been divided in two parts:

The regional model area (area of possible large-scale effects). In Forsmark the land area of the regional model area is about 60 km^2. This area is shown by a thick broken line in Figure 2-1.

The candidate area. A smaller area which is the core area of the site investigations. The size of the area in Forsmark is about 10 km^2. The candidate area is shown with a thick unbroken line in Figure 2-1.

Direct impacts from activities within the site investigations are only likely to occur in the candidate area and the close surroundings of this, while indirect effects could be possible also in the regional model area. For some species however, the regional model area mainly functions as a reference area to the candidate area.

Line transects, used for collecting data on the complete breeding bird fauna, have been conducted both in the candidate area and in adjacent parts of the regional model area.

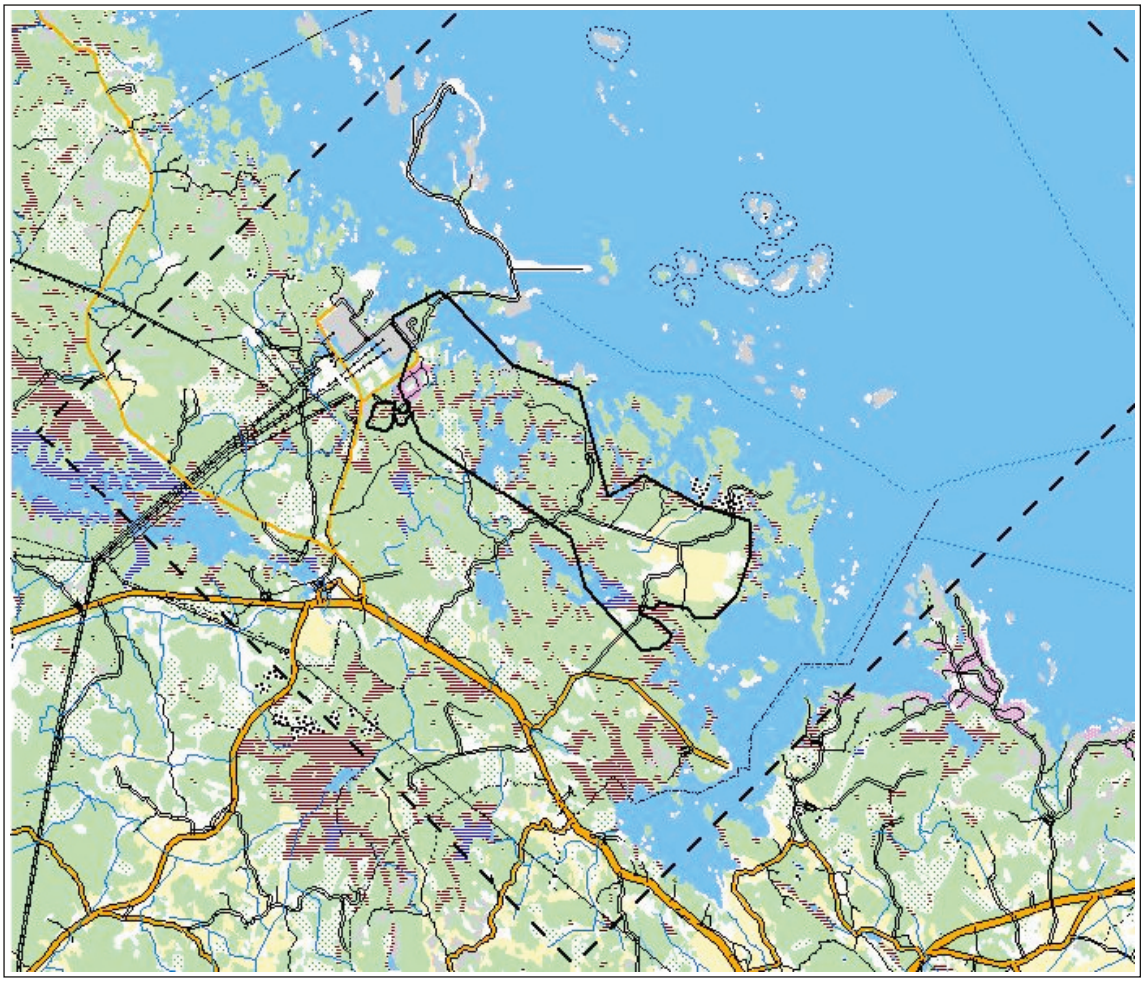

Figure 2-1. *Map of the survey area in Forsmark. The regional model area is shown with a thick broken line and the candidate area is illustrated with a thick unbroken line.*

3 Equipment

3.1 Description of equipment

The following equipment was used when conducting the bird surveys.

- GPS (Garmin 12 or Garmin GPS 60).
- Binoculars and telescope.
- Field maps showing each day's work.
- Note books and paper forms.
- Vehicles for transport to and from the study area.
- Cell phones (safety equipment when working alone in the field).

4 Methods

The methods used are described in detail in Activity plan AP PF 400-06-098. To cover the bird fauna in general, incorporating also the commoner bird species, a combination of line transects and point counts was used. The method was also used in the years 2002–2004 for gathering data of the same kind /see Green 2003, 2004, 2005/. Using this method again gives the possibility of directly comparing data gathered in 2007 with data collected in earlier years. The method is more or less directly taken from the manual for standardised breeding bird counts used by the Swedish Environmental Protection Board in the National Monitoring Programme since 1996 /http://www.biol.lu.se/zooekologi/birdmonitoring/.

In addition to the surveys of the complete breeding bird fauna in the area, special surveys were made for monitoring selected listed species.

An overview of the methods used for monitoring purposes is presented below.

4.1 Line transects (and point counts)

The aim of the line transects (and point counts) is to get a good overview of the breeding bird fauna in the area in a way that can yield comparisons between years (population development, if repeated in time series trends can be calculated) and that can be compared with other areas. The surveys were geographically based on the Swedish Grid (RT-90). The line transects were done along the north-south axis of this grid, with grid lines being 1 km apart. To get a more detailed coverage, an additional transect in between the RT-90 lines was added so that the area was covered along north-south directed lines being 500 m apart. Point counts were made at every full km, at the corners of the km-squares of the Swedish Grid. The point for the extra lines (in between the RT-90 lines) was moved to the midpoint of the km square (according to the grid) to get a better geographic coverage of the area.

In the presentation of results down below only line transect data are shown. The point count data set is not shown since the results from these completely follow the line transect results, with the only exception that fewer birds (both species and individuals) were recorded on the points. That fewer birds are recorded during the point counts is due to that a) point counts cover much less total area than line transects, b) point counts are made during a much shorter time (five minutes at each point) than line transects and c) while walking (line transects) the observer will flush birds that otherwise would have stayed obscured by vegetation. During point counts the observer is standing still and will not flush any hiding birds. Hence, line transects yield much larger data sets and cover more species, and to avoid unnecessary repeating of results I have chosen to present the larger of the two data sets here. The point counts are not discussed further in this report.

Each line transect was done once in May–June 2007. Along the lines all birds seen and heard were counted while the observer was walking at slow speed, stopping, listening and looking around when needed. The observer should as long as possible try to follow the pre-determined route (line). If the pre-determined route cannot be followed, if impassable obstacles are encountered, counting of birds is allowed as long as the observer does not deviate more than 250 m from the route. If the observer has to deviate more from the pre-determined route bird counting should stop and be started again when reaching within 250 m of the route.

The observer register bird species, number of individuals and the local time. To allow rapid data gathering in the field, all common species were summed (by the observer in the field) per five minute period. The registration of time is important for linking the bird observations to the GPS-registered route and hence for positioning all bird observations correctly (see below).

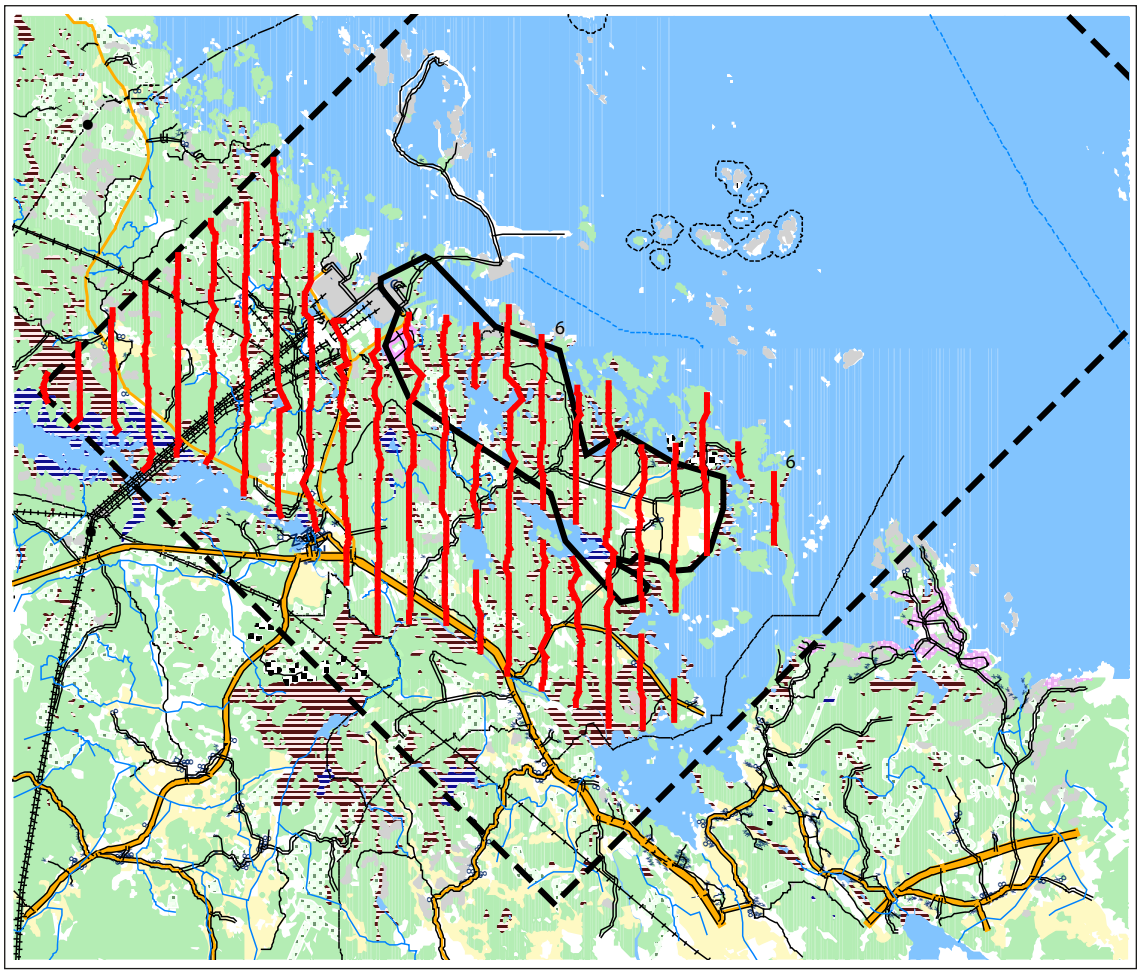

Figure 4-1. *Line transects conducted in 2007 (red dotted lines). The regional model area is shown with a thick broken line and the candidate area is illustrated with a thick unbroken line.*

Observations of selected listed species (see Section 4.2), were registered individually with data on time and position (from GPS) directly in the field.

During line transects a GPS was used for registration of the route. The GPS logged position data automatically every five minutes and after each days field work the logged positions (all with data on time as well) were down-loaded and stored as conventional text files in PC-format.

Most of the planned routes could be covered during 2007 (Figure 4-1).The whole regional model area could however not be covered by line transects in 2007 (all covered in 2002–2003), due to lack of field personnel. The parts situated south and west of road 76, the parts the farthest away from the candidate area were not covered. Comparisons with earlier years in this report are made between parts *covered equally well* in 2002, 2003 and 2007 for the regional model area and in 2002, 2003, 2004 and 2007 for the candidate area.

4.2 Listed species (Swedish red list; EU Birds directive Annex 1)

The species occurring in Forsmark and included in the Swedish Red List and/or the EU:s Birds Directive are shown in Appendix 1. Starting from 2004, a selection of these species is monitored on a yearly basis. During 2002–2003, all listed species were monitored although the project was still in the exploratory phase then resulting in that all species did not receive proper coverage in the very first year. The species in question are shown in Table 4-1. Selection of monitoring

Table 4-1. Listed species (Swedish Red List and/or EU: Birds Directive) selected for monitoring in Forsmark in 2004–2007.

English name	Swedish name
Black-throated Diver	Storlom
Honey Buzzard	Bivråk
White-tailed Eagle	Havsörn
Osprey	Fiskgjuse
Black Grouse	Orre
Capercaillie	Tjäder
Hazelhen	Järpe
Ural Owl	Slaguggla
Wryneck	Göktyta
Lesser spotted Woodpecker	Mindre hackspett
Red-backed shrike	Törnskata

species was made according to a set of different criteria. A species was included for further monitoring if one or more of the following criteria was met: **i)** Forsmark is a vital area for the species in a larger (e.g. national) perspective; **ii)** The species in question is suspected to be sensitive to disturbances and thus possibly affected in a negative way by the ongoing site investigations; **iii)** The species showed a negative population trend at the national level at the start of the site investigations (but not necessarily in Forsmark); **iv)** Forsmark holds high densities of the species.

These species were monitored in 2007 by visiting known nesting places/territories used in 2002–2006, combined with visits to habitats suspected to possibly hold the species in question. Visits to nest sites/territories/suitable habitats were made during relevant periods, when presence of the birds is expected to be easy to detect. Detailed following up of breeding results was made for some species, i.e. black-throated diver, white-tailed eagle, osprey and ural owl. All observations of the selected listed species were registered with data on bird species, number of birds, position (from GPS or recorded on field maps) and local time during the field work.

4.3 Execution

The monitoring field work in 2007 was carried out during the period 2007-03-19–2007-08-06. The line transects were done by Mikael Rhönnstad and Martin Green. The rest of the field work was carried out by Martin Green. Alf Sevastik assisted in some of the field work and additional information on bird observations has been received from Peter Hunger. The white-tailed eagle work was carried out within the ongoing national project concerning this species by Björn Helander, Swedish Museum of Natural History, Stockholm. Organisation, data handling, analysis work and interpretations were carried out by Martin Green, Dep. of Animal Ecology, Lund University.

4.4 Data handling

In the field (line transects, listed species) all registered birds were recorded in notebooks with data on species, number of individuals and time together with additional data on bird behaviour and circumstances where such data were relevant. During line transects, common (numerous) species were summed already in the field in five minute periods while more scarce, and especially selected listed species were recorded with individual data for each observation.

At the same time, position and time were automatically registered by GPS every fifth minute. Observations of selected listed species were registered with exact position individually taken directly from the GPS in the field. After each days field work the bird and time data were transferred to pre-made paper forms. The logged position and time data were down-loaded from the GPS to text files in PC-format with the programme Waypoint1803. Bird and time data were then entered into Excel-files from paper forms whereafter the files were cross-checked against the field notes by the project leader. After this, the bird and time data were linked to the position/time data whereby each observation was given a geographic position. The time resolution (five minutes for common species) gives a geographical resolution of about 100–150 m for these. Positions for selected listed species have the same resolution as the GPS-system. This base-file with data on species, numbers and positions can then be used for different GIS applications, for evaluating bird densities and further calculations.

4.5 Analyses and interpretations

The results gathered during line transects in 2007 are compared with results gathered in an identical way in 2002–2004 (2002–2003 for the regional model area, 2002–2004 for the candidate area), with the aim of evaluating possible impacts from the site investigations on bird numbers in the candidate area, the regional model area and in the Forsmark area at large. With this method, statistical testing is not possible at the species level as too few data points exist. For any proper statistical analysis on species level data are needed from at least five years if one should evaluate trends in local population size. For the breeding bird community as a whole, however, the number of recorded birds can be tested to look for differences between different years. As the data do not conform to normal distributions, non-parametric tests are generally used. All statistical testing was made in the software SPSS for Windows version 12.0.1 (SPSS Inc.).

The following statistical comparisons were made:

a) Number of recorded bird individuals per km and species during line transects in the candidate area between the years 2002, 2003, 2004 and 2007.

b) Number of recorded bird individuals per km and species during line transects in the regional model area, excluding the candidate area, between the years 2002, 2003 and 2007.

c) Number of recorded bird individuals per km and species during line transects in the whole area between the years 2002, 2003 and 2007.

Any general decrease or increase in the bird fauna would turn up as statistical differences using this approach. The tests do in reality check whether the number of decreasing and increasing species between years is significantly different from each other. If the total bird community should decrease one would expect that more species are decreasing than increasing etc.
The normal, undisturbed level would be that similar numbers of increasing and decreasing species are found (i.e. no significant differences).

Patterns (increases, decreases or stability) in bird numbers recorded in Forsmark were compared with national trends for the last ten year period (data from the Swedish Bird Survey, the national breeding bird monitoring programme /http://www.biol.lu.se/zooekologi/birdmonitoring/).

Possible differences in bird population development between the candidate area and the regional model area between years were analysed by simple Pearson's' correlation and by paired t-tests.

Possible impacts on the bird fauna by human presence due to the site investigations as well as forestry actions was evaluated using a General Linear Model (GLM) approach with bird density (for different groups) as the dependent variable and year (2002, 2003 and 2007), subarea (1, 2, 3, 4 or 5), human activity levels (man-days during the breeding season in resp. year), proportion of mature or semi-mature forest, proportion of young forest or old clear-cut (cut pre 2002) and

proportion of new clear-cut (cut 2002–2007) as factors. The idea behind such an analysis is to analyse whether any of the factors govern the pattern in the dependent variable, while taking all other factors into account. The analyses were started with full models, incorporating all factors. Non-significant factors were then omitted until only significant ones remained.

Changes in numbers of territories at the species level for selected listed species are now for the first time statistically tested in this report. The same procedure is also used for comparing breeding results in a few cases. The rationale for this is that with a time series of (in most cases) five years, testing is now possible. Statistical power will however still be low (i.e. there is a low probability of finding statistically significant results even though true, biologically significant changes may have occurred), due to the short time frame. Another way to put it is that really large differences are required (strong trends) to reach statistical significance.

For most species the actual numbers of recorded territories/nests/pairs are reported and shown in figures. For hazelhen and red-backed shrike however, population change is shown in the form of a chain-index. The reason for not using the recorded number of territories directly in this case is that the monitored areas have not remained exactly the same during the years. To come around this problem, but still be able to compare the population development in an easily understandable way, a chain index is constructed. The chain index is created by comparing areas checked equally well in two following years and calculating the change in percent between these two. Then the procedure is repeated for the next two following years and the new change (in percent) is added/subtracted to/from the figure. In the red-backed shrike case the calculation was made as follows (in this case with the regional model area, excluding the candidate area as an example).

Index for the start year is set to 1. This is the basis for all future comparisons.

- In our first year with a reasonable coverage of shrikes in Forsmark (2003), 27 occupied territories were recorded. Of these, 14 were in areas covered equally well also in the following year (index calculations can only be made when at least two years of data are collected, since it is made in a back-wards calculating mode).
- In 2004, our second year of good coverage, 41 occupied territories were recorded. Of these, 20 were in parts checked equally well in 2003.
- The index for 2004 is calculated as: ((20–14)/14) + 1 = 1.43. Interpreted as a 43% increase in numbers between 2003–2004.
- All the 41 recorded territories in 2004 were in areas covered equally well also in 2005.
- 48 occupied territories were recorded in these parts in 2005.
- The index for 2005 is then calculated as: ((48–41)/41) + 1.43 = 1.60. Interpreted as a 17% increase in numbers between 2004 and 2005 (and a 60% increase from 2003 to 2005).
- And so on.

For statistical tests of trend data the Spearman rank correlation test /Sokal and Rohlf 1997/ was used. This test is a non-parametric correlation test where one simply test whether a variable y (number of bird pairs in most of our cases) has changed in a significant direction (upwards or downwards) in relation to variable x (year in this case). Statistical results presented are the correlation coefficient rs which varies between –1 and 1. A value of 0 means that there is no correlation at all, the higher the value of rs, the stronger the positive correlation (increase in this case), the lower the value of rs the stronger the negative correlation (decrease in this case). p is the probability that the true result is actually different from the obtained result, or to put it in other words, the probability to find the significant result by random. N is number of data points entered into the correlation. Hence, a high or low rs value (close to 1 or –1) means that there is a strong correlation and will yield a low p-value. Non-parametric tests were used to avoid assumptions about data distributions. All tests were performed in the software SPSS 12.0.1. for Windows /SPSS inc./.

4.6 Nonconformities

The activity was performed according to the plans except for that the whole regional model area could not be covered by line transects (see Section 4.1).

5 Results

Data from this survey are stored in the SKB GIS database and are traceable by the Activity plan number AP PF 400-06-098. The use of the data is restricted since it concerns sensitive species.

English names of the birds are used throughout the results section. Swedish names are given in the species headlines (for listed species). A complete list of English, Latin and Swedish names for all listed bird species possibly breeding in Forsmark during 2002–2007 is given in Appendix 1.

5.1 The breeding bird fauna in Forsmark (Line transects)

General results for the whole area

A total of 81.2 km of line transects were conducted in 2007. Of these, 23.8 km were done in the candidate area and 57.4 km in the regional model area outside of the candidate area. These figures should be compared with that a total of 68.1 km of line transects were made in exactly the same areas in 2002 and 84.0 km in 2003. During 2002 a total of 41.7 km of line transects were conducted in the candidate area. Corresponding figures for 2003 and 2004 were 45.7 and 45.5 km respectively. Note that in 2002–2004 two rounds (two visits to each route) of line transects were done in the candidate area compared to only one round in 2007. There were no line transects made outside of the candidate area in 2004.

The line transects were conducted between 12 May and 29 June in 2007, with the bulk of the routes made 22 May–20 June (88%). Line transects in earlier years were made within the same general time frame although some variation in timing between years occurred. For comparisons of the general bird fauna of the whole area I have in the following presentation only used data from earlier years from exactly the same routes covered in 2007. These routes were surveyed between 25 April and 24 June in 2002, with the 94% of the routes covered between 14 May and 24 June, and between 28 April and 27 May in 2003, with 62% covered between 12 and 27 May. Note here that timing of the surveys was very similar in 2002 and 2007, but earlier in the season in 2003.

Summary data of numbers of species, individual birds and densities are shown in table 5-1. Total numbers of birds and densities per species recorded during the line transects in 2002, 2003 and 2007 are shown in Appendix 2.

Table 5-1. Number of species, number of individual birds and total bird densities recorded during line transects in Forsmark during 2002, 2003 and 2007.

Year	No. of species	No. of individuals	Density (no. of individuals/km)
2002	100	4,876	71.6
2003	94	4,242	50.5
2007	112	8,129	100.1
Total	124		
Average			74.1

8,129 birds of 112 species likely to breed in the area were recorded during the line transects in 2007, giving an overall density of 100.1 birds/km. As seen in Table 5-1, both numbers of recorded species and the density of bird individuals were higher in 2007 than in any of the earlier years. The low values recorded in 2003 may partly be explained by the difference in timing between the surveys in this and the other years. Timing was however more or less identical in 2002 and 2007, lending support for a general increase in bird numbers (revealed by density) in Forsmark during the period.

Including all species in a comparison between 2002, 2003 and 2007 revealed a highly significant difference in the number of increasing and decreasing species between the years (Kendall's W-test, $\chi 2 = 29.6$, $p << 0.001$, $df = 2$, $N = 124$). A post-hoc test showed that there was no significant difference between 2002 and 2003 (Wilcoxon sign rank test, $Z = 1.522$, $p = 0.13$, $N = 124$). 48 species increased in density, 62 decreased and 14 had the same density in both years. Comparing 2007 with both 2002 and 2003 separately showed significant differences in both cases (Wilcoxon sign rank test, $Z = 3.685$, $p < 0.001$, $N = 124$ for 2002–2007; $Z = 5.327$, $p << 0.001$, $N = 124$ for 2003–2007). Between 2002 and 2007, 79 species increased in density, while 42 decreased and three showed identical densities in both years. Between 2003 and 2007, 88 species increased, 32 decreased and four showed identical densities. In other words there were more species that increased than decreased in density between the early years and 2007.

Dividing the data set in land birds (93 species) and water birds (31 species) revealed that while there was a highly significant difference in the number of increasing and decreasing species between years for land birds (Kendall's W-test, $\chi 2 = 38.3$, $p << 0.001$, $df = 2$, $N = 93$), there was no such difference for water birds (Kendall's W-test, $\chi 2 = 1.2$, $p = 0.536$, $df = 2$, $N = 31$). The post-hoc tests showed the same pattern for land birds as for all species above, i.e. no difference between 2002 and 2003 (36 species increased, 45 decreased), but significantly more increasing than decreasing species between 2002 and 2007 (67 vs. 26) and between 2003 and 2007 (72 vs. 19) (statistical details not shown). For water birds no differences were found between any of the years (statistical details not shown). In other words, while there were significantly more land bird species that were increasing than decreasing in numbers between the early years and 2007, there was no significant difference in numbers of increasing and decreasing species of water birds during the same period.

Some species are recorded in very low numbers because they are rare, because they have secretive habits or because they have their activity peaks during other parts of the year or day than covered by the surveys. The variation in recorded numbers of these species is likely to depend not only on their true abundance in the area, but also on purely stochastic factors. Excluding these species and re-running the analysis only for land birds recorded with at least ten individuals in any of the years of the comparison, did however show more or less the same result as above. 60 species met the required criteria for inclusion and among these there were 46 species that increased and 14 that decreased in density between 2002 and 2007 (Wilcoxon sign rank test, $Z = 4.358$, $p < 0.001$, $N = 60$). Between 2003 and 2007 there were 49 species that increased and 11 that decreased in density (Wilcoxon sign rank test, $Z = 4.778$, $p << 0.001$, $N = 60$). There was no difference between 2002 and 2003 (statistical details not shown).

The tests above do not take the size of the increase or decrease in numbers (density) into account and this is of course a very important aspect in a comparison like this one. There is always variation in numbers between years and part of this variation can be considered as being so small that we can not really say whether a species has increased in numbers or not. Normal annual variation is in many cases as large as 30% and hence a division based on this criterion may shed some light on this aspect of the changes in bird numbers between the studied years. Including all species in the comparison, and comparing the highest recorded density in 2002 or 2003 with the one recorded in 2007, we find that 56 species (45%) increased in density with > 30%, 27 species (22%) increased or decreased with less than 30% and 41 species (33%) decreased with more than 30%. Classifying the three categories as 'clearly increasing', 'stable' and 'clearly decreasing' gives that two thirds (2/3) of all species have been stable or increasing in numbers between the early years and 2007 in Forsmark.

For water birds nine species (29%) clearly increased, two species (6%) showed stable densities and 20 species (65%) decreased in density, giving a somewhat different picture than the one found above. For this group of birds it should however be noted that a high amount of stochasticity is involved depending on if flocks used this or that locality during survey days etc. Hence, results are not as robust as for land birds.

For land birds, and only including the most numerous ones (recorded with more than ten individuals in any of the years), 28 species (47%) clearly increased in numbers, 22 species (36%) showed stable numbers and ten species (17%) clearly decreased in numbers.

Summarizing the results above, the surveys showed that birds in general increased in numbers in Forsmark between 2002/2003 and 2007, and that the increase mainly occurred among land birds, while water birds may even have decreased in numbers during the period.

Comparison with national population development

In order to evaluate the situation recorded in Forsmark in relation to the one recorded for the whole of Sweden, a comparison was made with data from the Swedish Bird Survey, the national bird monitoring programme (see /http://www.biol.lu.se/zooekologi/birdmonitoring/). Here we used the subset of species for which we have the best data, i.e. land birds with more than ten individuals recorded in any of the survey years, and compared the development of these in Forsmark with the national population trend for the last ten years. Dividing the data in the same categories as above (increasing, stable and decreasing), the national patterns for the same 60 species were as follows: 37 species (62%) increased, 17 species (28%) were stable and six species (10%) decreased in numbers in Sweden as a whole. Testing the two distributions against each other (Sweden vs. Forsmark) showed a small, but still significant difference (χ2–test, $p = 0.042$). So even though the tendencies were in the same directions (the majority of the species were increasing or stable in numbers during the period), the bird fauna in Forsmark showed a slightly less positive development than what has been recorded on the national level. However, bearing in mind that we partly compare different time periods here (1998–2007 at the national level, 2002–2007 on the regional level), and that part of the small difference may be a result of this, the interpretation is rather that the results are strikingly similar.

Going more into detail and making comparisons of population development species for species, we found that 30 of 60 species (50%) show exactly the same development on both levels (nationally and in Forsmark), but only five species (8%) show totally opposite trends. Of these, three are decreasing nationally but increasing in Forsmark. Interestingly all three are small birds connected to forest (coal tit, treecreeper and goldcrest) that may have experienced more favourable conditions in Forsmark, with relatively little forestry activity during the site investigation years, compared to the overall Swedish landscape. Two species increase nationally but decrease in Forsmark (jackdaw and fieldfare). These are species occurring in flocks and missing a flock or two during the line transects have a big impact on recorded density. The remaining 25 species show different but adjoining trends (increase in Forsmark-stable nationally etc).

Taken together, this short and quick comparison shows that there is a fairly good correspondence between what is happening in Forsmark and patterns found in the whole of Sweden. The conclusion from this is that the increase in bird numbers found in Forsmark is part of a larger pattern and not just something happening locally.

Comparison between the candidate area and the regional model area

The comparisons above showed that bird numbers in the whole surveyed area increased during later years, a pattern in good correspondence with national population developments. An interesting question is of course also to look for possible differences within the surveyed area, and in this case especially between the candidate area (where the site investigations were carried out in 2002–2007) and the surrounding regional model area (with a much more limited number of site investigation activities). In this case the regional model area can be thought of as a refer-

ence area to the candidate area, experiencing the same general factors in terms of weather and other things. General results of recorded numbers of bird species and numbers are shown below in table 5-2. Total numbers of birds and densities per species recorded during the line transects in 2002, 2003, 2004 and 2007 in the candidate area and during 2002, 2003 and 2007 in the regional model area outside of the candidate area are shown in Appendix 3 and 4 respectively.

The general picture from the whole area was shown both in the candidate area and the regional model area. Bird densities were higher in 2007 than in the earlier years in both. The proportional increase was however larger in the regional model area outside of the candidate area. In these parts overall bird densities in 2007 were 70% higher compared to 2002 and 128% higher than in 2003. Corresponding figures from the candidate area were that densities in 2007 were 71% higher compared to 2004, 29% higher than in 2003 and 36% higher than in 2002. As explained above, part of the large difference between densities in the regional model area in 2007 and 2003 can be explained by a certain difference in timing of the surveys, and the shown figure of increase is hence probably too high compared to true levels. In all other comparisons however there was no difference in timing and presented increases must have other reasons.

Number of species recorded varied during different years, but remained on a relatively constant level. In most years more species were recorded outside of the candidate area than inside this, probably simply as a result of that a larger area was covered in the regional model area.

Bird densities were generally somewhat higher in the candidate area compared to the regional model area, especially in the earlier years. Densities in 2007 were however very similar and there is no obvious reason for why there should be difference between the two. Both the candidate area and the regional model area outside of this contain a wide variety of habitats ranging from purely coastal ones, through inland wetlands to both deciduous and coniferous forests.

Making the same comparisons as above (for the whole area) for the candidate area and the regional model area separately, showed that there were significant differences between years in the number of species increasing or decreasing in density in both areas (Kendall's W–test, $\chi2 = 18.3$, $p < 0.001$, $df = 3$, $N = 111$ for the candidate area; $\chi2 = 46.0$, $p << 0.001$, $df = 2$, $N = 118$). Further post-hoc analyses (Table 5-3) showed that in the candidate area there were no differences in the number of increasing or decreasing species between 2002 and 2003, or between 2003 and 2007, but that significantly more species were decreasing than increasing in density from 2002 to 2004 and from 2003 to 2004. The opposite pattern was found when comparing between 2002 and 2007 and 2004 and 2007 with more species increasing than decreasing in numbers. In the regional model area outside of the candidate area there was no difference in the number of increasing or decreasing species when looking at 2002 to 2003, but significantly more increasing than decreasing species between 2002 and 2007 and 2003 and 2007.

Table 5-2. Number of species, number of individual birds and total bird densities recorded during line transects in the candidate area (Candidate) and the regional model area (Regional) in Forsmark during 2002, 2003, 2004 (only for the candidate area) and 2007.

Year	Area	No. of species	No. of individuals	Density (no. of individuals/km)
2002	Candidate	85	3230	74.5
2003	Candidate	94	3582	78.3
2004	Candidate	82	2694	59.2
2007	Candidate	81	2404	101.0
2002	Regional	90	2713	58.8
2003	Regional	90	2606	43.8
2007	Regional	108	5725	99.7

Table 5-3. Statistical comparisons (Wilcoxon sign rank test) between years of number of increasing and decreasing species in the candidate area (Candidate) and the regional model area (Regional) in Forsmark during 2002, 2003, 2004 (only for the candidate area) and 2007. ns = no significant difference (p > 0.05), – = significantly more species decreasing than increasing, + = significantly more species increasing than decreasing. Stars show statistical significance levels, * p < 0.05, ** p < 0.01, *** p < 0.001.

Years	Candidate area	Regional model area
2003–2002	ns	ns
2004–2002	–*	
2004–2003	–***	
2007–2002	+*	+***
2007–2003	ns	+***
2007–2004	+***	

Analysing only the 43 most numerous species (at least ten individuals counted in any year in each of the areas) essentially yielded the very same results (statistical results not shown).

Even more interesting is of course to compare the absolute change in density from the early years of the site investigations to 2007 between the two areas. Here I used the difference between density in 2007 and the highest recorded density in any of the other years (2002–2003 for the regional model area, 2002–2004 for the candidate area). This analysis showed significant correlations between the numerical change in density in the candidate area and corresponding change in the regional model area (Pearson's correlation, $r = 0.43$, $p < 0.001$, $N = 104$, when including all species; Pearson's correlation, $r = 0.72$, $p << 0.001$, $N = 43$; when including only species observed with at least ten individuals in both areas in any of the years, Figure 5-1).

Testing the density changes for each species for the candidate area vs. the regional model area did reveal a small difference when comparing all species (paired t–test, $t = 2.101$, $p = 0.038$, $N = 104$) with a more positive development in density per species in the regional model area. Including only the more numerous species, observed with at least ten individuals in both areas in any of the years, showed a tendency in the same direction but no significant difference ($t = 1.805$, $p = 0.078$, $N = 43$).

These analyses taken together show that population changes followed a general pattern, both in the candidate area and in the regional model area. In both parts the bird densities were higher in 2007 compared to earlier years in general. If anything the small difference there showed that population development was more positive outside of the candidate area, than inside it.

5.2 A comparison of general changes in bird numbers in relation to human activities around Forsmark

Only very small impacts from the site investigations on the breeding bird fauna in Forsmark have been recorded during the site investigations (se above, below and earlier reports /Green 2003, 2004, 2005, 2006, 2007/). Never the less, it may still be of interest to have a closer look at possible relationships between changes in bird numbers and different levels of disturbance. The site investigations brought on a completely different situation around Forsmark compared to the years before these. The levels of human presence have been much higher in certain parts of the area during these years as, during times, many persons have been involved in drilling and other activities.

In the following part I analyse whether there has been any general differences in the development of the bird fauna in different parts of the study area (as at least partly indicated by the results above), and if so, if these differences in any way could be connected to the increased levels of human presence due to the site investigations. This analysis is based on line transect

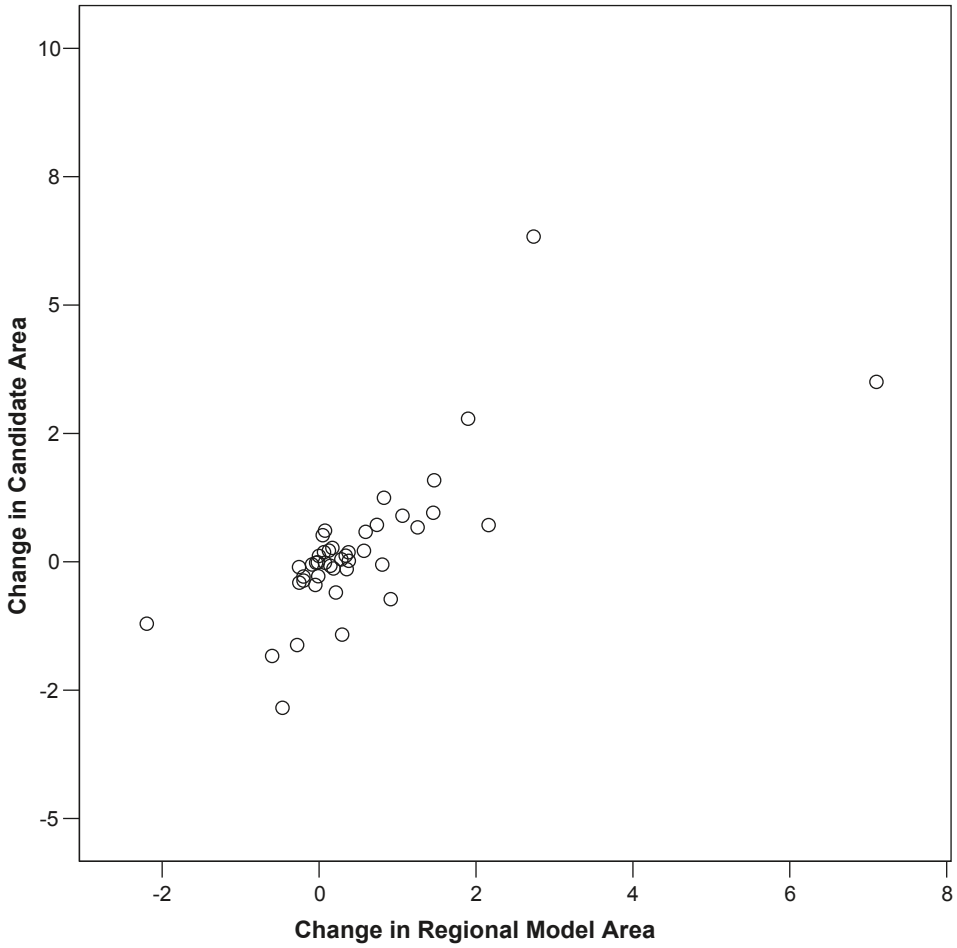

Figure 5-1. *Relationship between density changes in the regional model area vs. density changes in the local area. Each circle represents a bird species. Shown here are the 43 species where at least ten individuals were recorded during any year in both areas. The relationship is highly significant (Pearson's correlation, r = 0.72, p << 0.001, N = 43.*

bird data collected in 2002, 2003 and 2007 together with data from SKB on the number of persons working with site investigations and where and when the activities have been going on. For this purpose, the regional model area was divided into five different subareas (1–5 in Figure 5-2). Division in subareas was based on the records kept by SKB on where different activities had been conducted.

In general terms subarea 1 and 2 corresponds to the candidate area; subarea 3 and 4 to areas outside of the candidate area but still where some site investigation activities have been conducted, while subarea 5 consists of the rest of the regional model area where no (or at least very few) potentially disturbing activities have taken place.

Levels of human presence due to the site investigations

The site investigations consisted of many activities, where drilling at different sites was one of the most important both in terms of people involved and regarding duration. Other activities were collection of data of a wide variety at many sites around Forsmark. Figure 5-3 shows how the overall number of man days within the site investigations was distributed on the different subareas.

There were large differences in the levels of human presence between different areas. While human presence was large in some, levels in others were very low. Furthermore, neither drilling

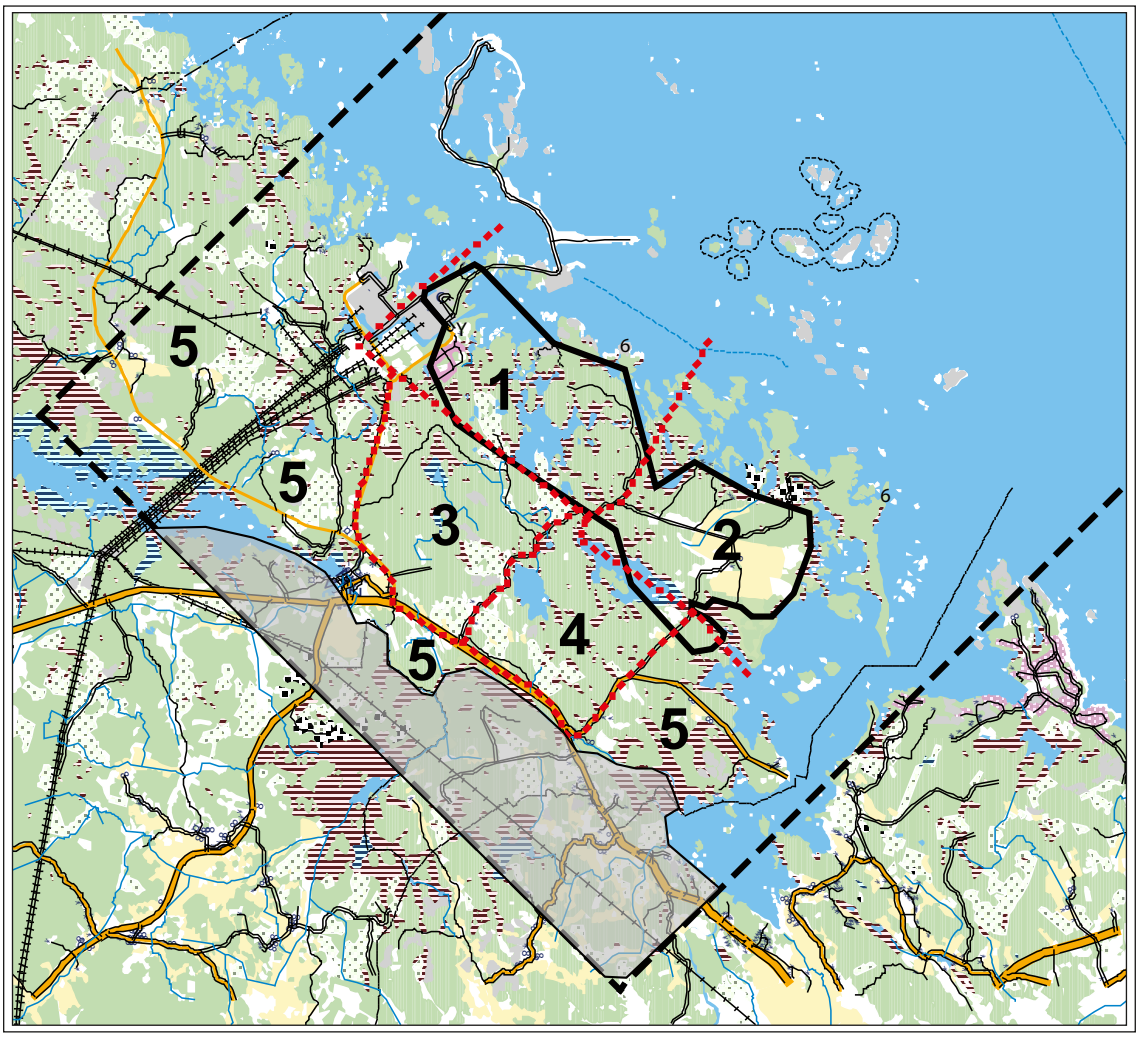

Figure 5-2. *Division in subareas (1-5) within red dotted lines. Note that subarea 5 consists of several different parts. Shaded parts were not included in the analysis.*

nor other activities were confined to the candidate area only. Almost 60% of all man days were conducted in area 1, but drilling was also done in areas 2 and 3. No drilling was made in area 4, only other activities. No activities (or at least very few) were conducted in area 5. The absolute majority of all man-days were connected to drilling activities.

Levels of human presence were not the same during the whole site investigation period either (Figure 5-4). The highest levels were reached in 2003 and 2006.

The intensity of human presence did also vary between subareas at different times. While general intensity in subarea 1 increased during the investigation period, intensity in other areas showed distinct peaks at certain times. Activity in subareas peaked in 2003–2004, with another peak in subarea 3 in 2005–2006.

Other forms of human impact around Forsmark

The site investigations were not the only possible human impact on the bird fauna in Forsmark during these years. There were also other activities that may have affected the birds. Forestry is probably one of the most important human-induced factors shaping the local bird fauna, both in the past and in present time. During the site investigation years there has been a moratorium on forestry within the candidate area (subareas 1 and 2). This means that no active forestry has

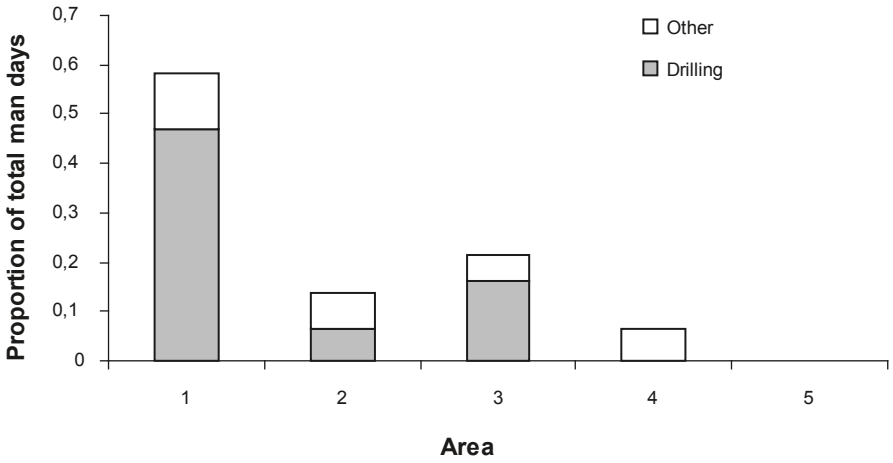

Figure 5-3. *Proportional distribution of total number of man days of work during the site investigations (2002–2007) in different subareas (see Figure 5-2) in Forsmark. Man days are shown for drilling and other activities separately.*

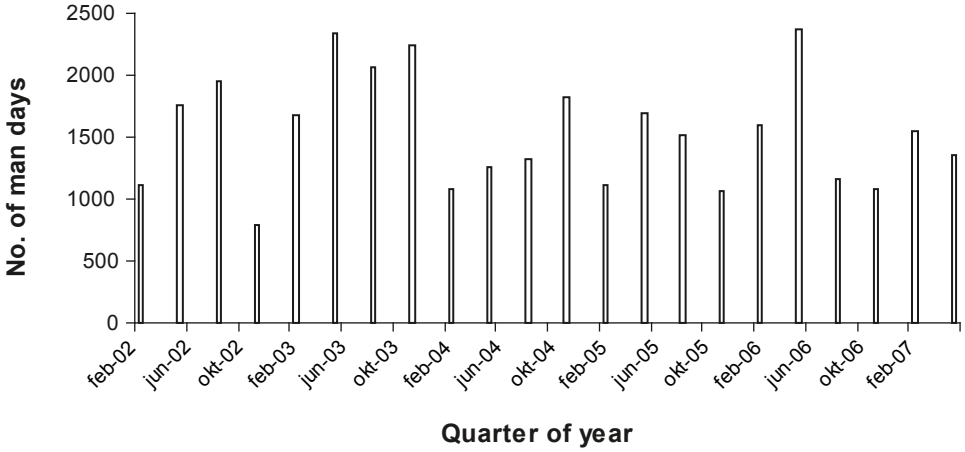

Figure 5-4. *Total number of man days per quarter of years within the site investigations in Forsmark (1 man day = 1 person working one day in the area). When estimating the total number it was assumed that each quarter of a year contained 60 man days.*

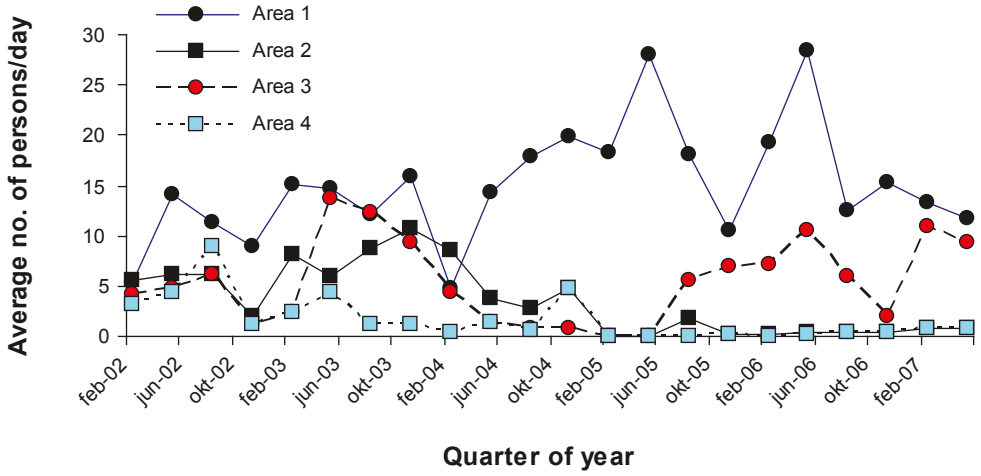

Figure 5-5. *Seasonal variation in human presence in the four areas where the site investigations were conducted (Area 1-4).*

been going on and that no new clear-cuts have been created. In some of the remaining parts of the regional model area, normal forestry has been allowed and new clear-cuts have been taken up in all three remaining subareas. Cutting action has however varied in importance and all areas have not been equally affected. In Figure 5-6 I show how large proportion of the land area in respective subarea that consisted of older mature or semi-mature forest, young forest or older clear-cut (cut before 2002), or new clear-cut (cut between 2002 and 2007) in 2007. This presentation is based on measurements from ortho-photos (done in ArcGIS 9.1) combined with own data on cutting actions in the years 2002–2007.

Not only new cutting actions will affect the development of the bird fauna, also clear-cuts taken up earlier will be of importance. This because a mature forest may be seen as a more stable environment where changes in the bird fauna are expected to be smaller than in clear-cuts or young forest stands, where the succession of growing vegetation will cause a gradual change in the bird fauna irrespective of any other factors. Six years may seem as a short time frame in this respect, but depending on initial conditions a clear-cut or a young forest may look completely different already after such a short time. Hence, it is of importance also to know how large proportion of respective subarea that was clear-cut or young forest already by the start of the site investigations.

Predictions of bird population development in different areas

With the background information presented in the last three sections, we can formulate a set of different predictions on how we would expect the bird populations to develop in the five subareas depending on different factors.

Site investigation activities should, if they in any way disturb the birds, lead to the most positive development (we already know that general development of bird populations in Forsmark was positive during these years) in area 5, followed by area 4 and then area 2 and 3. The least positive development should be in area 1, receiving a large part of the human activities within the site investigations. We can call this the ‘site investigation hypothesis’.

Taking **active forestry in the form of clear-cutting** into account yields a completely different set of predictions. Should active clear-cutting be the main negative driver of bird populations in Forsmark 2002–2007 we would expect that areas 1 and 2 should have the most positive development, followed by areas 4 and 5. Area 3, loosing the highest proportion of mature forest by clear-cutting actions would have the least positive development. Negative effects from clear-cutting will however only affect birds connected to closed forest. There are also species

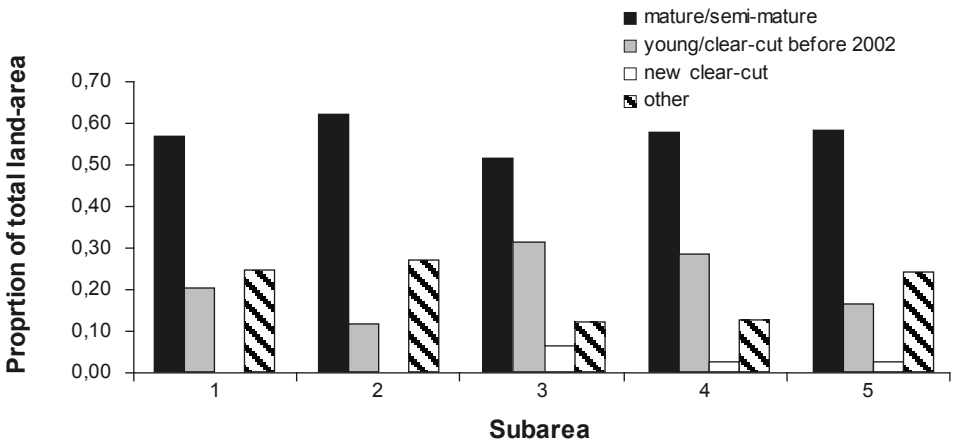

Figure 5-6. *Proportion of land area that was semi-mature/mature forest, young forest/clear-cut before 2002 or newly clear-cut in 2007 in Forsmark.*

for which clear-cutting of forest create new available habitat. Population size of these birds will instead increase with increasing area of clear-cuts. Hence, the 'active forestry hypothesis' has to be formulated in different steps:

For birds connected to mature forest as well as probably for the majority of birds areas 1 and 2 should have the most positive development, followed by areas 4, 5 and 3.

For birds connected to open areas and forest edge, areas 3, 5 and 4 should have the most positive development, followed by areas 1 and 2.

Regarding **past forestry, clear-cuts and young forest present already in 2002**, it is less straight forward to predict how they would affect the change in bird populations. Probably, bird numbers in general will increase in such areas as the vegetation develops and more and more forest species will find suitable habitat within these. Initial colonizers of new-clear cuts will slowly disappear and hence these particular species are expected to decrease in numbers as the years from cutting goes by. This means that as for active forestry, we also need to formulate the 'past forestry hypothesis' in different steps.

For the majority of birds as well as birds connected to closed forest, areas 3 and 4 should have the most positive development, followed by areas 1, 5 and 2.

For birds connected to open areas and forest edge, areas 2 and 5 should have the most positive development, followed by areas 1, 4 and 3.

Bird population development and human impact in different areas

The general presentation of results from the line transects above shows that bird numbers increased in Forsmark from the early years of the site investigations (2002–2003) to 2007. Overall bird densities were much higher in 2007 than in the earlier years. There were more species that increased than decreased in numbers, both in the candidate area and in the regional model area outside of this. The absolute increase in numbers was however bigger in the parts outside of the candidate area. At large, there was a good correspondence between patterns found in Forsmark and population development at the national scale, indicating that the increase in bird numbers in Forsmark is the result of general trends over a larger scale and not (only) governed by local factors.

Before analysing whether there can be any relationships between human activities in Forsmark and changes in bird numbers we must look at the bird population development in the different subareas. A first glance is done in Figure 5-7, where total bird density during line transects (number of birds, irrespective of species, per km line transect) is compared between areas, both for all registered birds and for land birds only. The rationale for using land birds only is, as explained above, that variation in the number of water birds is high. Due to that these birds occur in flocks, and there is large variation in where the flocks choose to be within the area, variation during single routes will be large irrespective of true population development.

The general pattern is that bird densities are higher in most (for all species) or all (for land birds) areas in 2007 compared to the earlier years, but that the difference is smaller in the candidate area (subareas 1 and 2) than in other parts. A quick comparison with our predictions from above shows that although there is some correspondence between general patterns and at least the 'site investigation hypothesis' and 'the past forestry hypothesis' there is by no means a perfect match. The 'active forestry hypothesis' finds no support at all in the figures above.

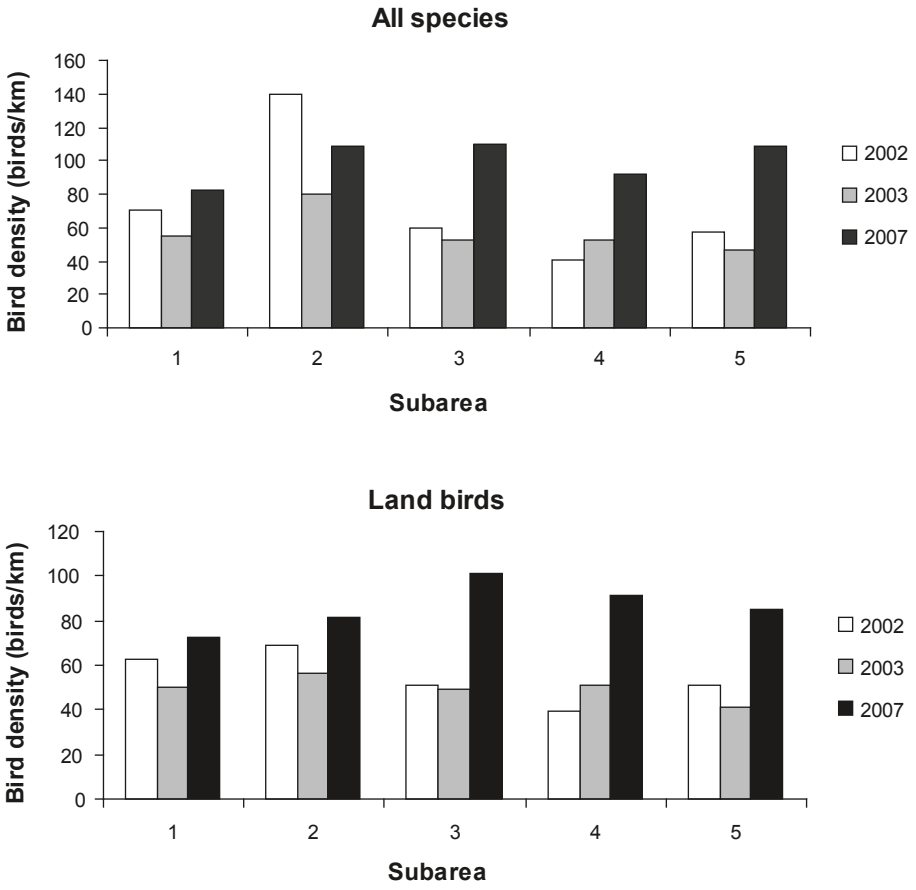

Figure 5-7. *Recorded bird densities (total bird numbers per km line transect) in Forsmark 2002, 2003 and 2007 in different subareas (see Figure 5-2). a) shows densities for all species, b) for land birds only.*

The general comparison is taken one step further in Figure 5-8 by using only species with more robust data (recorded during at least two of the three years with > 3 individuals/year and area) and looking at the proportion of species clearly increasing (with > 30%), being stable (increasing or decreasing with < 30%) or clearly decreasing (with > 30%) (see "Comparison with national population development" in Section 5.1). Note that this will be a conservative measure of change as only the more numerous (common) species, probably being least likely to be affected, can be included. Note also that number of species meeting the criteria for inclusion in such a comparison will be relatively small when dividing the data set in smaller subareas.

Comparing 2002 with 2007 again shows a general increase in the bird fauna, but a much higher proportion of the species were increasing in areas 3, 4 and 5 than in 1 and 2. Between 2003 and 2007 the development was more positive in all areas. Note though that the difference in timing between the surveys in 2003 (earlier in the season) and 2002 and 2007 (later in the season) automatically will create a pattern of more increasing species, as late migrants had not arrived in full numbers during the 2003 survey. Once again there is some support for the 'site investigation hypothesis' and 'the past forestry hypothesis' but again no perfect match. The 'active forestry hypothesis' finds little support.

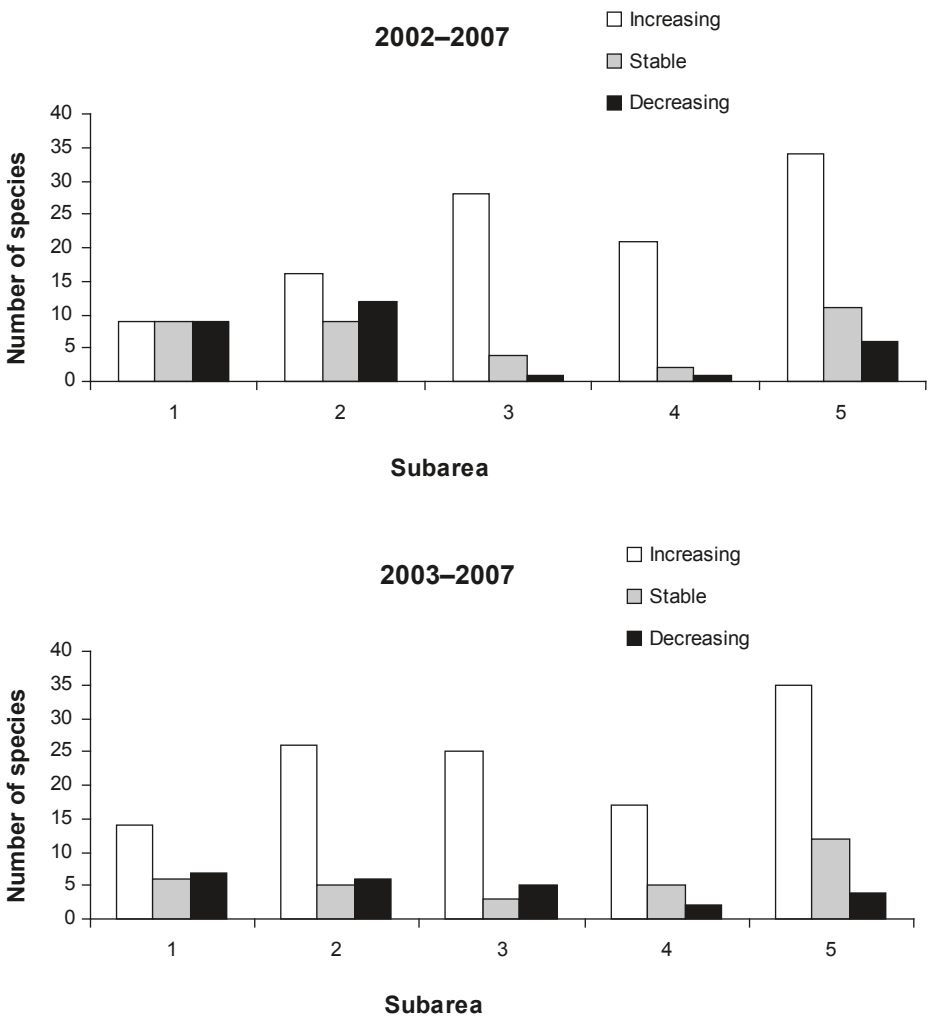

Figure 5-8. *Number of increasing (> 30% increase), stable (< 30% increase or decrease) or decreasing (> 30% decrease) species per subarea between 2002 and 2007 (top) and 2003 and 2007 (bottom).*

For getting a more detailed picture that can be used also for statistically testing our hypotheses above, an analysis of a couple of selected groups of species may be rewarding. For this purpose, groups of birds connected to mature forest, open areas (clear-cuts), generalist species and listed species were selected. Summarized population development 2002–2007 for these groups are shown in Figure 5-9 to 5-12. Selected species are shown in the figure texts.

Density of forest birds increased in all subareas. The overall increase (from the highest of the levels in 2002 or 2003 to 2007) was smallest in area 2 (39%), and much larger in all other areas (99–199%). The largest increase was registered in area 5.

Density of birds connected to clear-cuts decreased in area 1 and 2 (–46 and –11% respectively, again from the highest of the levels in 2002 or 2003 to 2007), but increased in the other subareas (6–99%). The largest increase was registered in area 4.

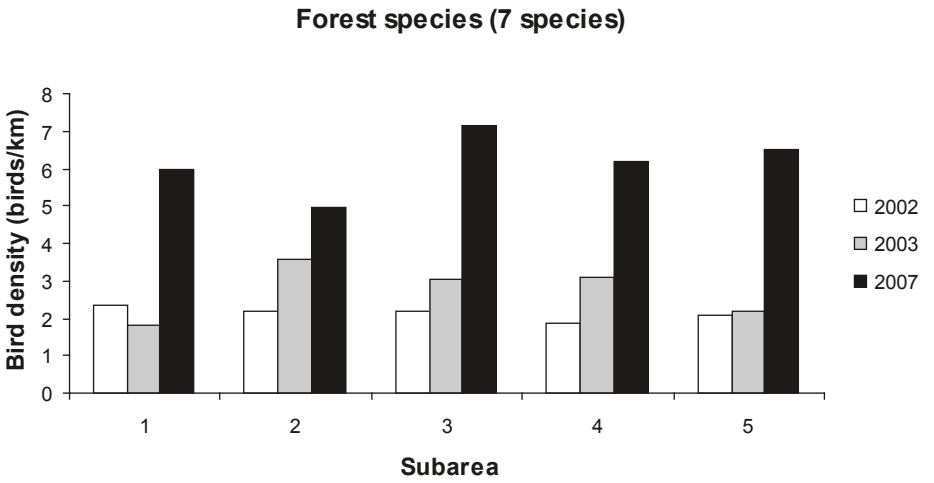

Figure 5-9. *Recorded densities (birds/km line transect) of seven species connected to mature forest (wood warbler-grönsångare, goldcrest-kungsfågel, coal tit-svartmes, willow tit-talltita, crested tit-tofsmes, treecreeper-trädkrypare, bullfinch-domherre).*

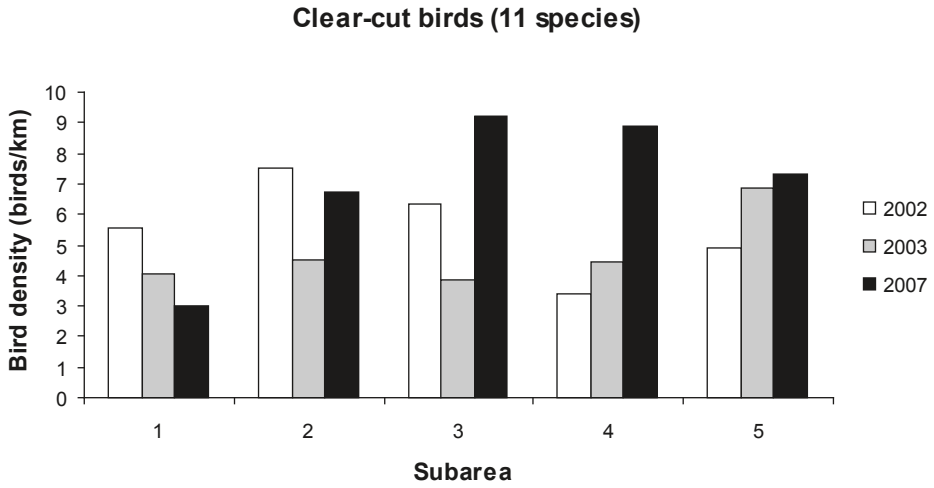

Figure 5-10. *Recorded densities (birds/km line transect) of eleven species connected to clear-cuts or forest edge (black grouse-orre, common snipe-enkelbeckasin, white wagtail-sädesärla, tree pipit-trädpiplärka, wren-gärdsmyg, winchat-buskskvätta, common whitethroat-törnsångare, lesser whitethroat-ärtsångare, red-backed shrike-törnskata, greenfinch-grönfink, yellowhammer-gulsparv).*

Figure 5-11. *Recorded densities (birds/km line transect) of 14 generalist species, connected to a wide variety of habitats ranging from young forest to more mature forest (wood pigeon-ringduva, robin -rödhake, blackbird-koltrast, song thrush-taltrast, redwing-rödvingetrast, blackcap-svarthätta, garden warbler-trädgårdssångare, willow warbler-lövsångare, chifchaff-gransångare, great tit-talgoxe, blue tit-blåmes, raven-korp, hooded crow-kråka, chaffinch-bofink)*

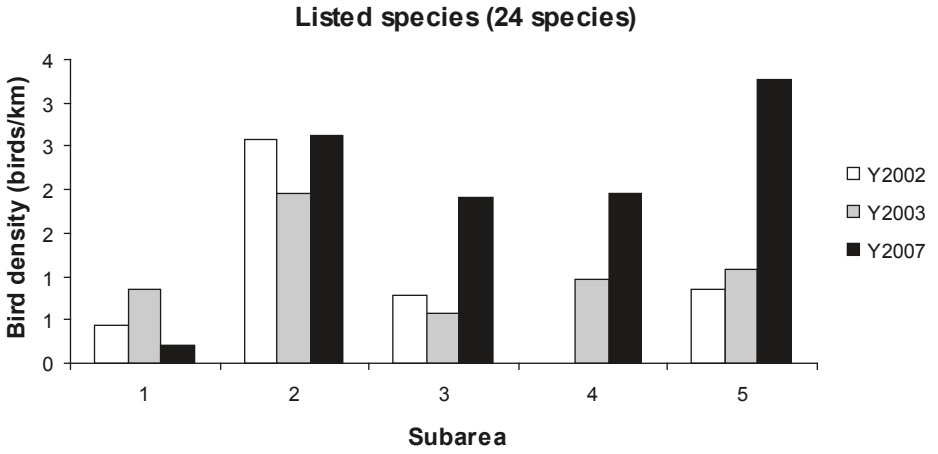

Figure 5-12. *Recorded densities (birds/km line transect) of 24 listed species (Swedish red list and/ or the EU Birds Directive) (honey buzzard-bivråk, white-tailed eagle-havsörn, osprey-fiskgjuse, black grouse-orre, capercaillie-tjäder, hazelhen-järpe, quail-vaktel, crane-trana, stock dove-skogsduva, wryneck-göktyta, black woodpecker-spillkråka, lesser spotted woodpecker-mindre hackspett, three-toed woodpecker-tretåig hackspett, skylark-sånglärka, wood lark-trädlärka, wheatear-stenskvätta, grasshopper warbler-gräshoppsångare, greenish warbler-lundsångare, red-breasted flycatcher-mindre flugsnappare, nutcracker-nötkråka, penduline tit-pungmes, marsh tit-entita, red-backed shrike-törnskata, scarlet rosefinch-rosenfink).*

Generalist species increased in all subareas. The overall increase (from the highest of the levels in 2002 or 2003 to 2007) was smaller in areas 1 and 2 (18 and 26% respectively), and larger in all other areas (45–98%). The largest increase was registered in area 4.

Listed species decreased in area 1 (–76%), were relatively stable in area 2 (+2%) and increased in areas 3, 4 and 5 (102–205%, from the highest of the levels in 2002 or 2003 to 2007). The largest increase was registered in area 5.

The relationship between population development and human activity levels (number of man days within the site investigations) and forestry actions (proportions of land area for different forest classes) for the selected groups above as well as a group consisting of the 19 most common species (recorded in all areas with at least three individuals in two of the years) was statistically tested with a General Linear Model approach (see Section 4.5 analyses and interpretations). The results are summarized in Table 5-4.

The statistical analysis showed that there was no general difference between subareas in bird population development for any of the groups. There were however significant differences for most groups between years (the already shown increase in bird numbers in all cases). The level of human activity connected to the site investigations had a very limited effect on bird population development. Only for birds connected to clear-cuts and forest edge there was a non-significant tendency ($0.10 < p > 0.05$) that there could be a negative effect. Proportion of older forest was significantly negative for the population development of the most common species, generalist species and for species connected to clear-cuts and forest edge. Proportion of young forest or older (pre 2002) clear-cuts had no effect at all, while the proportion of new clear-cuts was positive for the most common species, clear-cut birds and generalist species.

Summing up this analysis and comparing with our initial hypothesis we can reject the 'site investigation hypothesis' immediately. There was no effect of the number of people taking part in the site investigations on the local bird fauna. We can also reject the 'past forestry hypothesis'. The 'new forestry hypothesis' finds some support in that this factor positively affected the species connected to open areas (that also were negatively affected by the proportion of mature forest), but it was somewhat surprising that also generalist birds as well as the sub-set of the most common species were positively affected. In other words, we could not find full support for any of the hypotheses, but the 'new forestry hypothesis' was partly supported.

5.3 Listed species

The following section gives a summary of the population development during the last five to six years for some of the species listed as endangered, threatened or vulnerable according to the Swedish Red List /Gärdenfors 2005/, and/or species listed in the European Unions' Birds Directive Annex 1 (79/409/EEG) within the regional model area in Forsmark. For some of these species, breeding results have also been monitored and are hence reported.

The text about the breeding results of white-tailed eagle in Forsmark and surrounding reference areas is written by Björn Helander, Swedish Museum of Natural History, Stockholm.

Table 5-4. Statistical results from the GLM analyses of bird population development in relation to human impact (site investigations and/or forestry). Differences between years and areas are also evaluated. Significance levels used are ns = not significant, (ns) = not fully significant, 0.10 > p < 0.05, * p < 0.05, ** p < 0.01, *** p < 0.001.

Bird group	N (number of species)	Area	Year	Man-days	Prop. mature forest	Prop. Young forest/ old clear-cut	Prop. New clear-cut
Most common species	19	ns	+ **	ns	– *	ns	+ *
Birds connected to mature forest	7	ns	+ ***	ns	ns	ns	ns
Birds connected to clear-cut/forest edge	11	ns	ns	(ns)	– *	ns	+ *
Generalist species	15	ns	+ ***	ns	– *	ns	+ *
Listed species	24	ns	+ **	ns	ns	ns	ns

Black-throated Diver *Gavia arctica* Storlom (EU Annex 1)
Population size of black-throated divers in Forsmark has remained very stable over the six years, varying between five and six (possibly seven in 2005) stationary pairs. Hence, there is no statistically significant trend in diver numbers over the period (Spearman rank correlation: $r_s = 0.10$, $p = 0.85$, $N = 6$). As in 2006, there were no divers in Bolundsfjärden in 2007. This locality held divers in all the earlier years (2002–2005). Otherwise the geographical pattern has also been fairly stable between years with only some variation regarding which lakes that have been occupied in different years.

Breeding success was relatively good in 2007. Two of the pairs produced two young each, yielding a local overall breeding success of 0.67 large young/resident pair. Both successful breedings were in lakes this year, in contrast to the situation in 2006 when breeding success was higher for coastal pairs (1.7–2.3 vs. 1.0 large young/pair for coast vs. lakes in 2006). These figures mean that overall local breeding success for the whole six-year period is between 0.40 and 0.48 young/pair and year. This is more or less identical to what is calculated as the required long-term breeding output for keeping population size constant in the long run (0.37–0.47 young/pair and year) /Nilsson 1977/. For further discussions on this topic, see /Green 2005, 2006, 2007/.

Honey Buzzard *Pernis apivorus* Bivråk (Sw. Red List; EU Annex 1)
According to the survey results honey buzzard numbers have increased in Forsmark over the six-year period 2002–2007 (Spearman rank correlation: $r_s = 0.97$, $p = 0.001$, $N = 6$). We should however bear in mind that part of this increase is probably a result of that:

i) We do not have any accurate data from the start year 2002, only an estimate.

ii) It usually takes a few seasons to get the complete picture of the occurrence of a species in an area (especially for species with secretive habits like the honey buzzard), hence numbers of registered pairs during the later years may be more accurate than earlier on.

However, as pointed out in earlier reports /Green 2005, 2006, 2007/ the results clearly indicate that honey buzzards are doing fine in Forsmark.

Breeding results were not monitored in detail in 2007, but incidental observations indicated that breeding success was good. At least four pairs together produced four young, giving a minimum local breeding success of 0.44 young/territorial pair. Over the whole study period minimum local breeding success has been 0.45 young/ territorial pair and year. This is still lower than figures recorded in southern Uppland 1986–1991 (0.60 young/pair and year /Tjernberg, Ryttman 1994/), but within the calculated interval for what is needed to keep population size

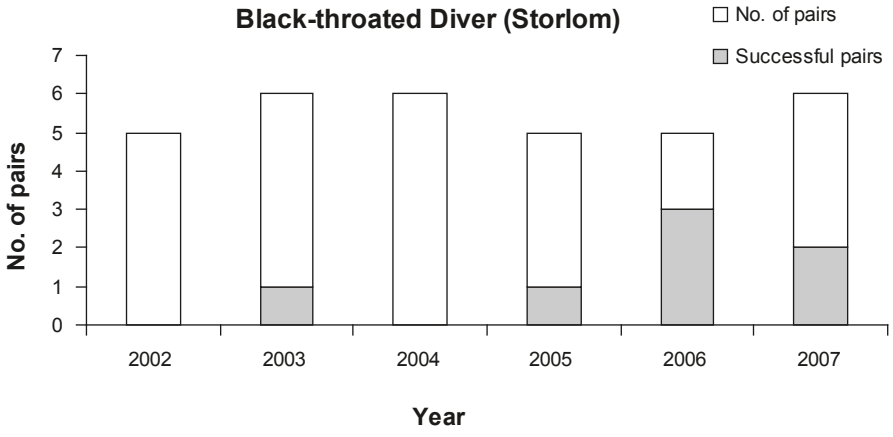

Figure 5-13. *Number of stationary pairs of black-throated divers in Forsmark 2002–2007. Shading shows the number of successful pairs. Minimum numbers are shown, total numbers of pairs in 2005 might have been seven and there might have been four successful pairs in 2006.*

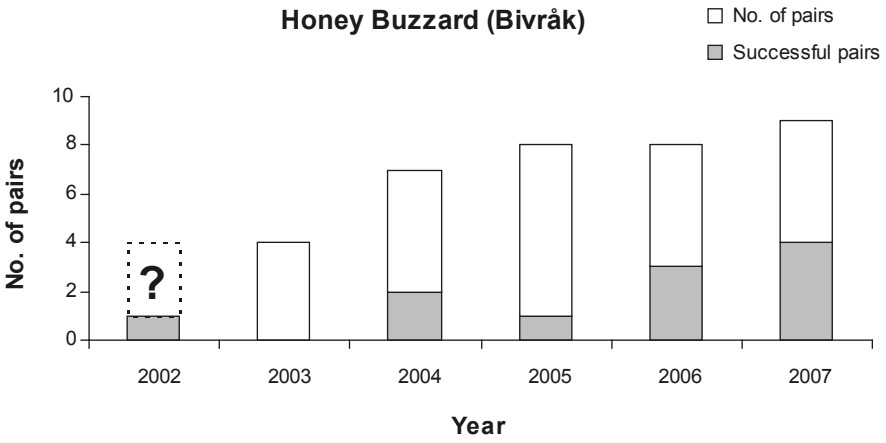

Figure 5-14. *Number of territorial pairs of honey buzzards within the regional model area in Forsmark 2002–2007. Shading shows number of successful pairs. The exact number of territorial pairs in 2002 is not known. An (at the time) well based estimate is shown.*

constant (0.34–0.67 young/pair and year /Tjernberg, Ryttman 1994/). Long-time breeding output at a national level in Sweden is estimated to be 0.30 young/pair and year /Tjernberg, Ryttman 1994/. In this context it should be remembered that presented figures on breeding success in Forsmark are minimum ones, more young can have been produced but unrecorded.

The honey buzzard is classified as 'Endangered' (starkt hotad) in the Swedish Red List. National population size has declined with 50–70% during the last three decades and was estimated to about 5,000 pairs in 2004 /Tjernberg, Svensson 2007/. The main causes of the decline are thought to be large-scale landscape changes due to both agriculture and forestry, at the same time as conditions along the migration routes and in the wintering areas have deteriorated. Recorded tendencies at the national level are that the decline has levelled out in recent years.

White-tailed eagle *Haliaeetus albicilla* Havsörn (Global Red List, Sw. Red List; EU Annex 1)
Breeding success of white-tailed eagles in the Forsmark area in 2007 was again clearly below the background level from before the site investigations began within the candidate area in 2002. The average breeding success for the period 2002–2007 was 42%, (% successful breeding attempts) which is only half the background level for this area (see Table 5-5).

Breeding success in the southern reference area was by and large unaltered during the study period, whereas breeding success in the northern reference area remained unaltered in 2002–2004 but dropped strongly in 2005–2007. Reasons for this lowered success in the northern reference area include human disturbance (fresh footprints under deserted nest, two years), forestry activities during the incubation period, and replacements of mates within the adult pairs. Natural turnover of adults followed by replacements is commonly resulting in temporary breaks in the succession of breeding attempts in raptor territories.

Table 5-5. Per cent successfully breeding pairs of white-tailed eagles in 2007, 2006, 2005, 2004, 2003, 2002 and 1998–2001 in Forsmark and two reference areas north and south of Forsmark respectively (N = number of checked territorial pairs).

Area	1998–2001	2002	2003	2004	2005	2006	2007	2002–2007	N
Forsmark	85	25	33	50	75	25	50	42	36
Reference S	79	100	80	100	83	50	67	79	53
Reference N	72	83	67	86	29	29	33	54	58

(Report by Björn Helander, Swedish Museum of Natural History, Stockholm)

Forestry activity has not been a disturbing factor in the Forsmark area during the study period. Indications of human disturbance at nests have been noted in some cases, but such activities are almost impossible to prove after they happened. Employees engaged in the site investigations have been encountered on a number of occasions, and the strongly increased human activities in the Forsmark area since 2002 are most likely a major reason behind the observed reduction in breeding success among white-tailed eagles in this study area.

Osprey *Pandion haliaetus* Fiskgjuse (EU Annex 1)
The local osprey population in Forsmark is very stable and production of young has also been stable and high throughout the study period. There is no significant trend in neither population size nor in number of successful pairs over the years (Spearman rank correlation: $r_s = 0.37$, $p = 0.47$, $N = 6$ for population size, $r_s = 0.60$, $p = 0.21$, $N = 6$ for number of successful pairs).

Seven pairs started breeding in 2007 (plus an additional pair in relatively close contact with the study area) and six of these produced in total nine large young, yielding an average of 1.29 young/pair. These figures are very similar to what was found in 2004–2006.

Production of young in Forsmark (1.25 young/pair during 2003–2007) is well within the limits for calculated values of what is needed for keeping the population stable (0.80–1.25 young/pair and year /Ryttman 1994/).

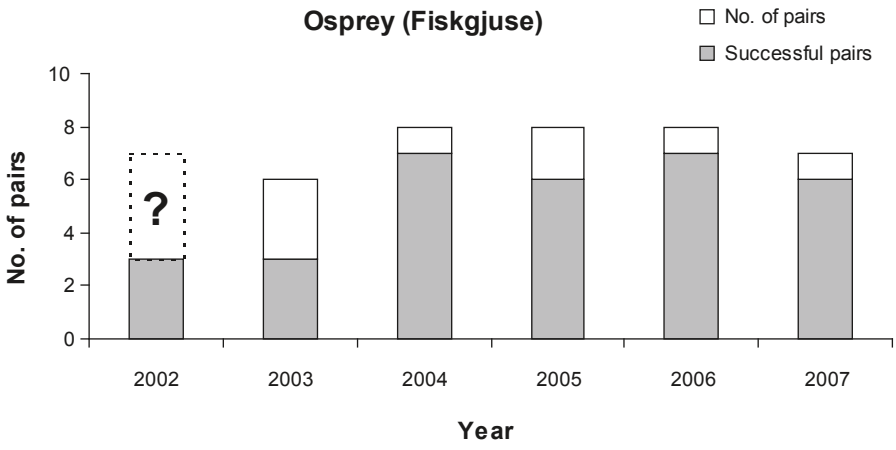

Figure 5-15. *Number of nesting attempts (territorial pairs) of ospreys in Forsmark 2002–2007. Number of successful nests (shaded parts) are shown as well. The exact number of territorial pairs in 2002 is not known. A well based estimate is shown.*

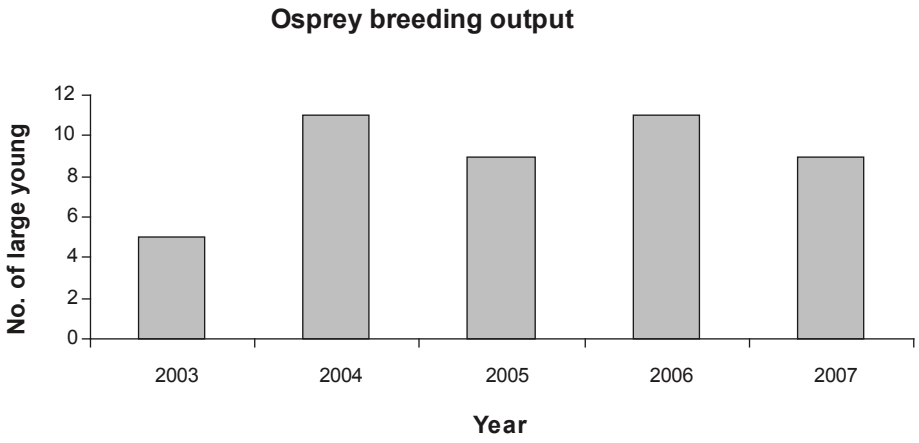

Figure 5-16. *Number of large young of ospreys produced in Forsmark 2003–2007. Number of large young per breeding attempt was 0.83 in 2003, 1.38 in 2004, 1.12 in 2005, 1.38 in 2006 and 1.29 in 2007.*

Black grouse *Tetrao tetrix* Orre (EU Annex 1)
As anticipated in last years report /Green 2007/ black grouse numbers decreased in between 2006 and 2007. A closer look at the pattern revealed that the decrease was only confined to the candidate area where numbers in 2007 were only half of the ones in 2006. In the regional model area outside of the candidate area numbers actually increased slightly. Seen over the complete study period numbers have still increased significantly within the whole area (Spearman rank correlation: $r_s = 0.83$, $p = 0.04$, $N = 6$) but all of this increase is now due to the increase in the regional model area outside of the candidate area.

There are no reasons to suspect that black grouse should have been disturbed by the site investigations in any way. On the contrary, the patterns found probably follow normal population dynamics found over a larger geographical scale. The decrease within the candidate area in 2007 could be due to stochastic factors or to that many of the clear cuts (a habitat favoured by lekking black grouse) within these parts are now covered in too high vegetation for being suitable for the birds. Note that no forestry activity has been going on within the candidate area during the site investigation period, in contrast to the situation in the remaining area.

The number of multiple male leks /cf Green 2007/ continued to increase (four in 2006, six in 2007). The total number of males at these leks were however the same in both years (Figure 5-18).

Capercaillie *Tetrao urogallus* Tjäder (EU Annex 1)
Capercaillie numbers at the central lek in 2007 remained at the high level recorded in 2006 (Figure 5-19).

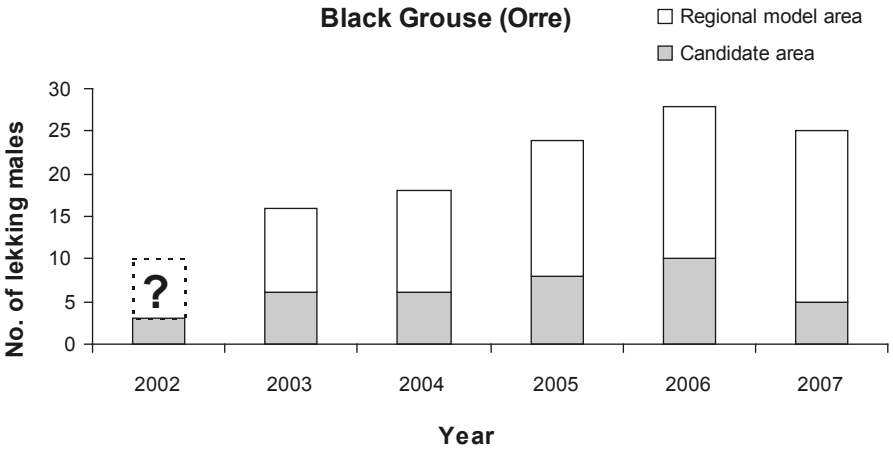

Figure 5-17. *The recorded number of lekking black grouse males in Forsmark 2002–2007. Shaded parts show the numbers within the candidate area. Exact number of lekking males in 2002 is not known. A well based estimate is shown.*

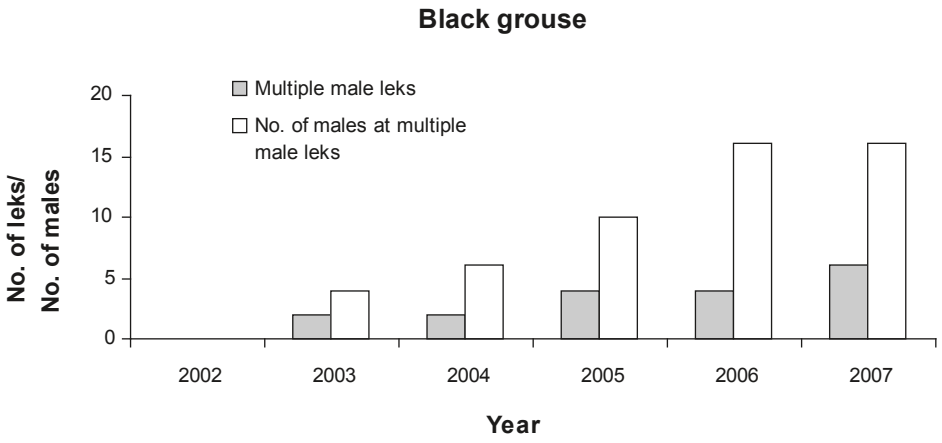

Figure 5-18. *The recorded number of lekking black grouse males in Forsmark 2002–2007 found at leks containing more than one male. Shaded bars show the number of such multiple male leks within the regional model area.*

Home ranges and numbers of capercaillies in the whole regional model area was monitored in 2007 again, exactly in the same way as in 2006.

Results from 2007 show that:

i) Home ranges of capercaillies around the 'central area' were larger in 2007 compared to 2006, and much larger compared to 2004 /cf Green 2005/.

ii) No signs of birds were found within the candidate area (birds were found here in 2002, but not in later years).

iii) Home ranges in other parts of the regional model area were larger than the ones registered during the early years of the site investigations and in 2006.

iv) General numbers of capercaillies were at the same level as in 2006 and higher than in 2002–2003. In all, at least 13 lekking males and at least 6 females were registered in 2007.

Hazelhen *Bonasia bonasia* Järpe (EU Annex 1)
Hazelhens were monitored in 2007 in the same way as in 2006 and 2004 /cf Green 2007/. In 2002–2003 all parts of the regional model area were visited but no survey specifically directed

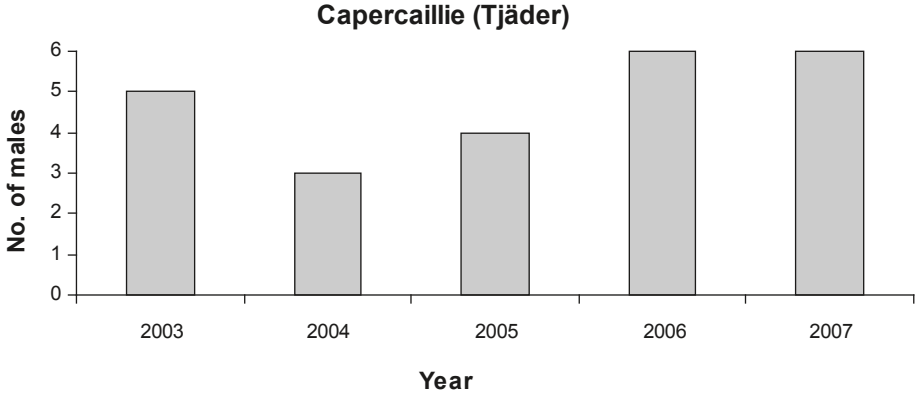

Figure 5-19. *The recorded number of capercaillie males in 'the central area' at Forsmark 2003–2007 (see text).*

at hazelhens was made. Earlier results indicated that the species might be sensitive to disturbances from the site investigations /Green 2004, 2005/.

As a different number of sites (known territories or sites classified as suitable for hazelhens identified from vegetation maps) were visited in different years, population development for hazelhens is shown with an index in the same way as has been used for Red-backed shrikes in earlier reports (Figure 5-20).

In general, numbers have been very stable in the regional model area during the three surveys. Index has varied between 1 and 1.15. Overall index decreased slightly from 2006 to 2007, but this decrease is well within the error margin of the method used. Numbers within the candidate area have increased slightly, but were stable between 2006 and 2007. This pattern indicates that hazelhens have now re-occupied areas deserted during the most intensive site investigation period (see earlier reports /Green 2004, 2007). Results during earlier years indicated that hazelhens were disturbed and avoided the areas with the most intensive parts of the site investigations. Most probably this did not affect overall numbers much, but only the small-scale distribution of birds.

In all, 26 occupied hazelhen territories were registered in 2007, eight in the candidate and 18 in the regional model area.

Ural owl *Strix uralensis* Slaguggla (EU Annex 1)
The number of occupied territories of ural owls almost remained at the high level recorded in 2006, although one territory occupied in 2006 was vacant in 2007. Over all years there has been a statistically significant increase in ural owl numbers in Forsmark (Spearman rank correlation: $r_s = 0.88$, $p = 0.021$, $N = 6$), probably connected to a relatively good breeding output in the last years. Ural owls have rather short post-natal dispersion distances and it is likely that the new established territories are held by birds being born relatively close to the area. As earlier, only one of the territories is situated completely within the regional model area. The others are situated along the borders with parts both inside and outside the regional model area. No territory is found within the candidate area, although hunting birds are occasionally observed there.

None of the pairs produced young in 2007, a result more or less expected as breeding output in the preceding years (2005, 2006) was very good (Figure 5-21, 5-22). Breeding success of owls follow rodent numbers in general and after the peak year in 2006, with very high numbers of the favourite prey of ural owls (bank voles), rodents were much fewer in 2007.

Wryneck *Jynx torquila* Göktyta (Sw. Red List)
Wryneck numbers remained more or less constant on the same level as recorded in 2006. Overall 39 territories were recorded in 2007 compared to 38 in 2006. In the candidate area num-

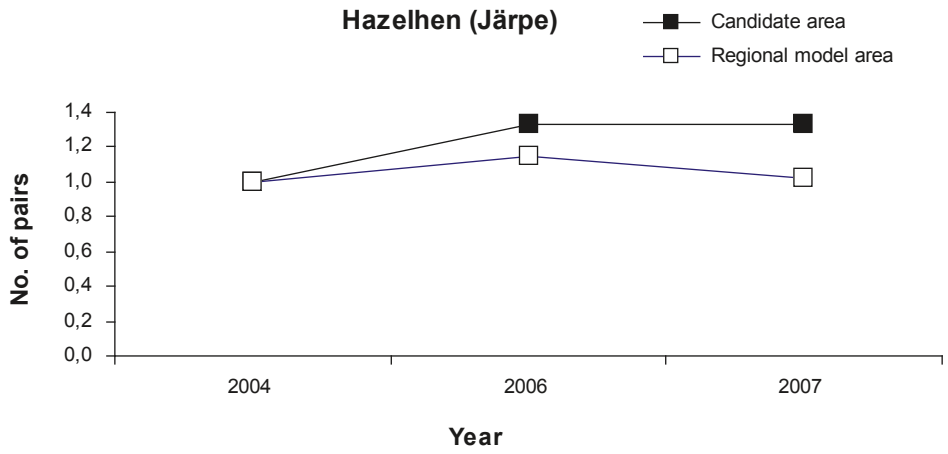

Figure 5-20. *Population development of hazelhens in Forsmark 2004–2007 shown as a chain index. Index for year 2004 is set to 1. See text for further explanations.*

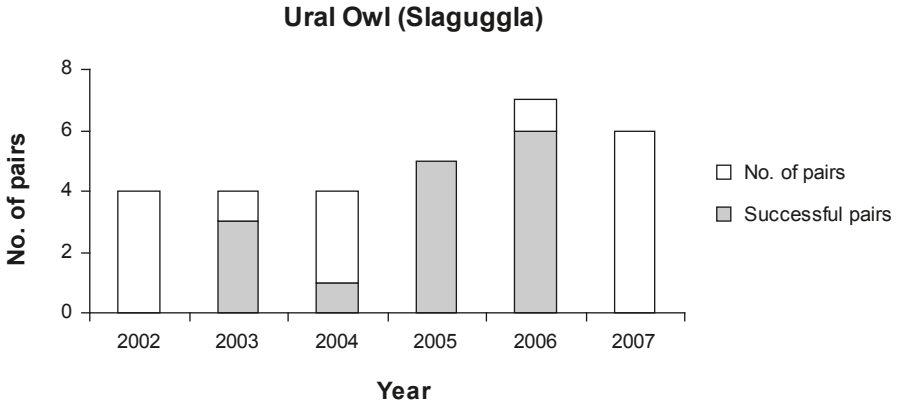

Figure 5-21. *Number of territorial pairs of ural owl within the regional model area in Forsmark 2002–2007. Shown is also the number of successful pairs (shaded).*

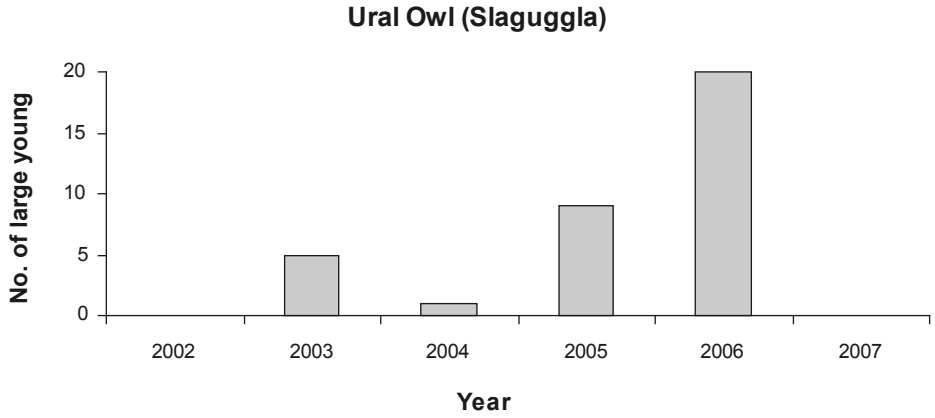

Figure 5-22. *Number of large ural owl young produced per year in Forsmark 2002–2007.*

bers increased from six to eight occupied territories. There is no significant trend in wryneck numbers within the area during 2003–2007 (Spearman rank correlation: $r_s = 0.60$, $p = 0.28$, $N = 5$ for the whole area; Spearman rank correlation: $r_s = 0.50$, $p = 0.39$, $N = 5$ for the candidate area; Spearman rank correlation: $r_s = –0.20$, $p = 0.75$, $N = 5$ for the regional model area).

The wryneck is classified as 'Near-Threatened' (missgynnad) in the Swedish Red List /Gärdenfors 2005/. The number of wrynecks in Sweden decreased with over 50% between 1975 and 2004, but the numbers have remained fairly stable during the last decade /Lindström, Svensson 2007/. The reason behind the large decline is probably loss of suitable habitats as a large proportion of small-scale farms in largely forested areas were abandoned in the mid 1900s. National population size is estimated to be 5,500–15,000 pairs /Tjernberg, Svensson 2007/. Should the lower number in the interval be closest to reality, Forsmark holds about 0.5–1% of the national population.

Lesser spotted woodpecker *Dendrocopus minor* Mindre hackspett (Sw. Red List)
The positive development for lesser spotted woodpeckers in Forsmark continued in 2007, well in accordance with the general pattern in Sweden as a whole (see below). 21 occupied territories were recorded, where four were within the candidate area. This means that numbers within the candidate area are now back at the level (actually even higher!) than before the more intensive parts of the site investigations started (see earlier reports /Green 2007/).

Statistically speaking there is a significantly increasing overall trend during 2003–2007 (Spearman rank correlation: $r_s = 0.90$, $p = 0.037$, $N = 5$ for the whole area), but no significant change for the candidate area (Spearman rank correlation: $r_s = 0.53$, $p = 0.36$, $N = 5$).

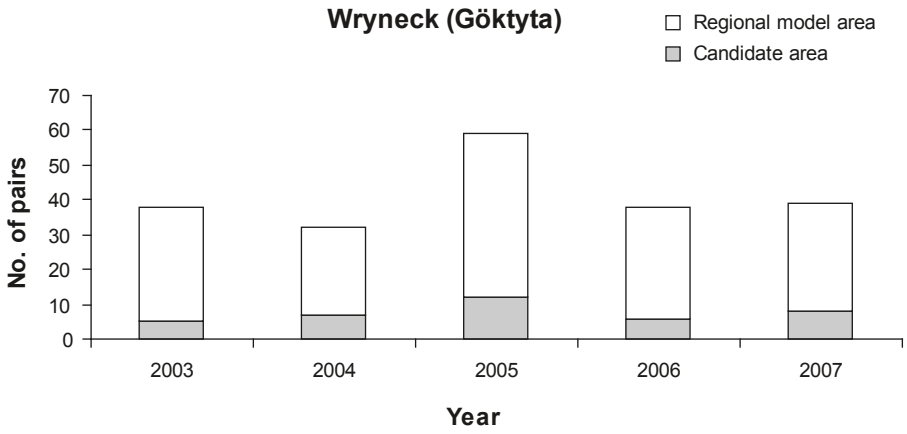

Figure 5-23. *Number of occupied wryneck territories in well monitored parts of Forsmark in 2003–2007. Shading shows the number of occupied territories within the candidate area.*

The lesser-spotted woodpecker is classified as 'Near-Threatened' (missgynnad) in the Swedish Red List. National numbers decreased with about 50% between 1975 and 1990, but have during recent years, according to the national environmental monitoring programme, increased back to the original levels again. The reason behind the initial decline was loss of dead wood and conversion of mixed and deciduous forests to monoculture conifer forests due to forestry. Recent increases are thought to be a result of increased conservation efforts by general forestry. National statistics indicate that both the amount of dead wood and of deciduous trees has increased again since the new environmental policy of forestry was launched in the mid 1990s. Lesser spotted woodpeckers can have a very high fecundity, produce many young per year, if conditions are beneficial for them. Hence, this is a species that can increase rapidly in numbers as obviously has been the case in Forsmark as well as nationally.

Red-backed shrike *Lanius collurio* Törnskata (Sw. Red List; EU Annex 1)
Numbers of occupied shrike territories decreased somewhat between 2006 and 2007 in areas checked equally well in both years. As in the last two years, the population development of shrikes in Forsmark is shown below with an index (Figure 5-25). The figure should be read as there has been an 11% increase in red-backed shrike numbers within the candidate area between 2003 and 2007, and a 44% increase in the regional model area outside the candidate area. None of these trends are however statistically significant (Spearman rank correlation: $r_s = 0.36$, $p = 0.55$, $N = 5$ for the candidate area; $r_s = 0.67$, $p = 0.22$, $N = 5$ for the regional model area). The interpretation of these figures is that although general population development tends to be positive, what we can say with any statistical confidence is that the local population is stable.

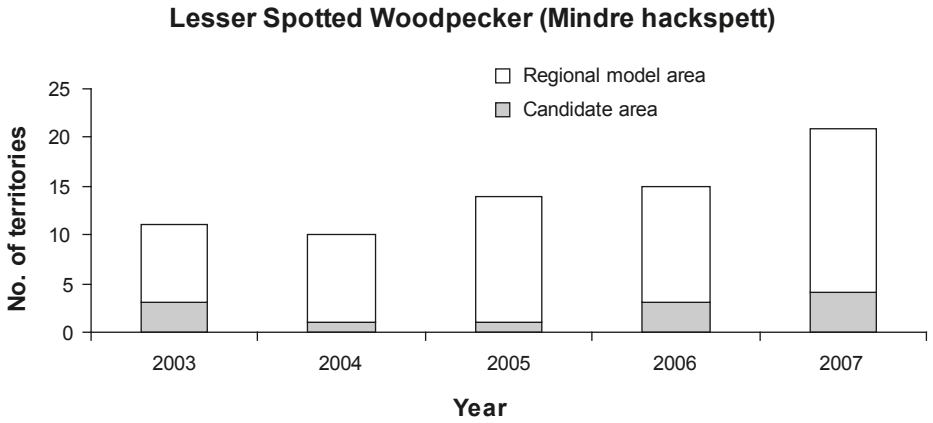

Figure 5-24. *Number of occupied territories of lesser spotted woodpeckers in areas monitored in all four years 2003–2007 in Forsmark. Shading shows numbers of occupied territories in the candidate area.*

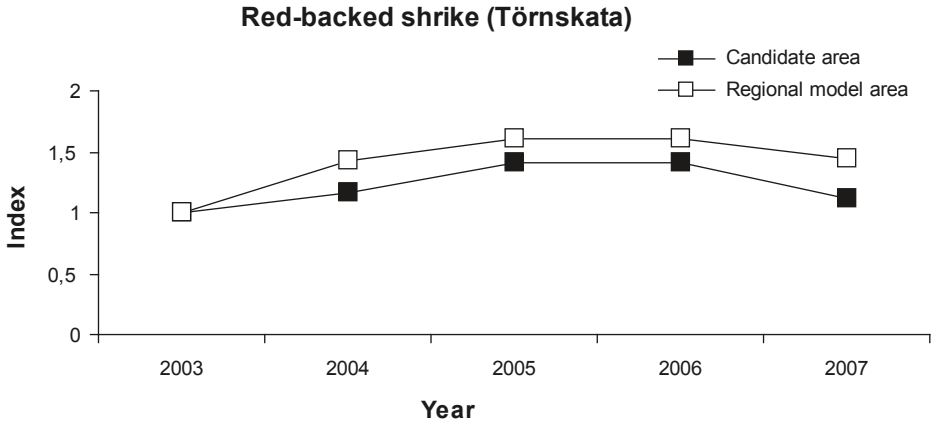

Figure 5-25. *Population development of red-backed shrikes in Forsmark 2003–2007 shown as a chain index. Index for year 2003 is set to 1. See text for further explanations.*

The red-backed shrike is classified as 'Near-Threatened' (Missgynnad) in the Swedish Red List /Gärdenfors 2005/. National numbers have decreased with over 50% during the last 30 years /Lindström, Svensson 2007/ and numbers in a well-studied, predominantly farmland area outside Uppsala decreased from 120 to 60 pairs during 1998–2003 /Tjernberg, Svensson 2007/. The reason for the decrease at a general level is thought to be due to habitat loss, as many semi-natural grazing pastures have disappeared during later decades. National population size of red-backed shrikes is estimated to be about 23,000 pairs /Tjernberg, Svensson 2007/.

Table 5-6 presents a summary of general population changes of the monitored species in Forsmark between 2006 and 2007.

Table 5-6. General population changes of selected listed species in Forsmark between 2006 and 2007. A + means that the number of occupied territories has increased, a – means that it has decreased, a 0 that there is no major change and ? denotes that the situation is unclear. Breeding output 2007 in general terms is shown for divers, raptors and owls.

Species	Regional model area	Candidate area	Whole area	Breeding output 2006
Black-throated Diver	+	0	0	Good
Honey Buzzard	+	0	0	Good
White-tailed Eagle			0	Decent
Osprey	–	0	–	Good
Black grouse	+	–	–	
Capercaillie	0	0	0	
Hazelhen	–	0	–	
Ural owl	–	0	–	Very poor
Wryneck	0	+	+	
Lesser Spotted Woodpecker	+	+	+	
Red-backed shrike	–	–	–	

Other listed species

The following section gives a short summary of the population development in the last six years of species listed as endangered, threatened or vulnerable according to the Swedish Red List /Gärdenfors 2005/, and/or listed in the European Unions' Birds Directive Annex 1 (79/409/EEG), but not selected for detailed monitoring within the Forsmark area. This group contains 34 species and as no detailed monitoring is made, the data for these species are mainly based on observations made during the line transects and/or during surveys for the selected species handled in the previous section. This means that data quality is not as good as for the latter group of birds. In the presentation below, species only occurring in the archipelago (nine species) of the area are omitted. The archipelago was surveyed in 2002 but no monitoring activity has taken place there after this. Further, two species not registered annually (river warbler and greenish warbler) are not dealt with either.

Whooper swan *Cygnus cygnus* Sångsvan (EU Annex 1)
During the site investigation period the number of stationary pairs in Forsmark has increased from three in 2002 to five or six in 2007. This increase nicely follows the one recorded at the national level. Breeding has been registered in several of the lakes in later years, including lakes within the candidate area. In 2007 at least two broods were registered, but more pairs can have been successful. The line transects indicate an increase from 2002 to 2007 in the regional model area, but a decrease in the candidate area. This decrease is however not connected to the number of breeding pairs but to the occurrence of non-breeding flocks in Kallrigafjärden and adjoining farmland at Storskäret.

Quail *Coturnix coturnix* Vaktel (Sw. Red List)
Quails have been present around Storskäret during all years 2002–2007. Breeding is hard to confirm, but young birds were registered in 2002. The number of displaying males is usually one or occasionally two, but in 2007 three males were present in June. The quail has a positive population trend in Sweden as a whole in later years.

Bittern *Botaurus stellaris* Rödrom (Sw. Red List, EU Annex 1)
The number of bitterns has been fairly stable during the period. In the first years (2002–2003) four territorial males were registered and in later years at least three have been present. This was also the case in 2007. Geographical pattern has also been relatively stable with Bruksdammen, Fiskarfjärden and Fågelfjärd being the lakes holding bitterns. Bruksdammen has held bitterns in all years 2002–2007.

Marsh harrier *Circus aeruginosus* Brun kärrhök (EU Annex 1)
Not very well studied in the area, but occurring every year in varying numbers. 2002–2003 at least three pairs were present and several of them bred successfully as well. After this there were a couple of years with up to five occupied territories, although some of them probably were held by males only (and hence no breeding attempts were made in these). In 2007 only a single territorial male was recorded.

Spotted Crake *Porzana porzana* Småfläckig sumphöna (Sw. Red List, EU Annex 1)
Present in all years with one to three displaying males. Two males were recorded in 2007, both in Bruksdammen which is also the lake were most birds have been registered in later years. Historically this species was more common and between five and ten males could be heard in a good year /Referens?/.

Corncrake *Crex crex* Kornknarr (Sw. Red List, EU Annex 1)
Displaying males registered in three out of the six years 2002–2007. None heard in 2007 within the regional model area, but one male held a territory about two km outside of this.

Crane *Grus grus* Trana (EU Annex 1)
The first estimate of the population size in the whole regional model area, including the candidate area, was around 15 pairs (2002). Based on the records from 2007 it seems likely that the present population size is somewhere around 30 pairs! Line transect data indicate very strong

increase in numbers between the early years and 2007, but these are inflated by the presence of a flock of non-breeding cranes (more than 50 birds) in the area in 2007. The local trend in Forsmark is part of a general large-scale increase over the whole country.

Stock dove *Columba oenas* Skogsduva (Sw. Red List)
A species that we do not have very good data on. Too few birds are being recorded during the line transects to allow any proper comparison over the years. Around ten pairs are probably present in the area.

Pygmy Owl *Glaucidium passerinum* Sparvuggla (EU Annex 1)
Full surveys have not been made in all years, but local population size seems stable. A good coverage of the whole regional model area was reached in 2003, 2004, 2006 and 2007 and during these years 13-3-14-10 active territories were registered. Activity varies between years, depending on food supply (as well as other things). The low value in 2004 was probably due to low rodent numbers in that year. The timing of activity peaks also varies between years and some of the variation is probably due to if the survey coincided with peaks in owl activity or not. The estimated local population size is 15–20 territories, among these three to four are within the candidate area.

Tengmalms Owl *Aegolius funereus* Pärluggla (EU Annex 1)
Not regular within the study area. One permanent territory is situated a little more than one km outside of the border. Within the regional model area birds have been registered in 2002 (one) and 2006 (two).

Grey-headed Woodpecker *Picus canus* Gråspett (EU Annex 1)
Observed during the breeding season annually since 2004, but no breeding has been confirmed during these years. The species is very secretive and silent during breeding so this is no surprise. Usually present at one locality in any year, but localities vary between years. In 2005 grey-headed woodpeckers were registered at two sites within the study area.

Black Woodpecker *Drycopus martius* Spillkråka (EU Annex 1)
Numbers seem to be stable in Forsmark, between 12 and 14 occupied territories have been recorded annually. Line transect data also indicate stable numbers between the early years (2002–2003) and 2007.

Three-toed Woodpecker *Picoides tridactylus* Tretåig hackspett (Sw. Red List, EU Annex 1)
Registered in all years with one-three territories in and around the regional model area. In the years 2002–2007 the following number of annual occupied territories have been recorded 3-1-3-1-2-3. One of these has been occupied in all the years.

Wood lark *Lullula arborea* Trädlärka (EU Annex 1)
Single singing birds are registered every other year, but there does not seem to be a really stable occurrence in the area. At most two singing males have been recorded in any year.

Skylark *Alauda arvensis* Sånglärka (Sw. Red List)
Strongly connected to arable fields and hence only occurring at Storskäret, Forsmarks bruk and Björnbo within the study area. Line transect data indicate a decline from 2002–2003 to 2007, in parallel with the national trend. In 2007, 14 singing birds were observed, most at Storskäret. Despite the overall decline this is a few more than the latest estimates of local population size (nine territories). No skylarks were recorded at Björnbo in 2007.

Wheatear *Oenanthe oenanthe* Stenskvätta (Sw. Red List)
Very few birds registered during the line transects. Other observations indicate stable numbers in the few arable areas in Forsmark. More pairs occur in the archipelago, but these have not been surveyed (and are hence not included in the estimate of local population size).

Grashopper warbler *Locustella naevia* Gräshoppsångare (Sw. Red List)
Two singing males recorded in 2007. Yearly numbers do usually vary between one and two.

Red-breasted flycatcher *Ficedula parva* Mindre flugsnappare (Sw. Red List, Annex 1)
Four singing males registered in 2007 of this very hard-censused bird is a good figure. Recorded numbers are too low to allow any trend estimate. Nothing do however indicate a decrease in numbers, if anything more birds have been recorded in later years.

Marsh tit *Parus palustris* Entita (Sw. Red List)
Line transects indicate a decrease from 2002–2003 to 2007. Actually none was seen during the line transects in 2007. The marsh tit does still occur in the area, observed at seven sites in 2007, but it may be that the local population size is smaller than the estimate of 20 pairs.

Nutcracker *Nucifraga caryocatactes* Nötkråka (Sw. Red List)
Quite many observations made in 2007 and line transects indicate a substantial increase from 2002–2003 to 2007. Based on observations in 2007 the new estimate of local population size is twelve pairs.

Linnet *Carduelis cannabina* Hämpling (Sw. Red List)
Rare but seemingly holding its positions in the area, at odds with the national trend. Forsmark does however only hold a few pairs of the species.

Scarlet Rosefinch *Carpodacus erythrinus* Rosenfink (Sw. Red List)
27 singing males observed in 2007 and line transects indicate relatively stable numbers between 2002–2004 and 2007. If so, local population size is still around 50 singing males.

Ortolan Bunting *Emberiza hortulana* Ortolansparv (Sw. Red List, EU Annex 1)
The only territory in the area, at Storskäret was regularly occupied until 2005. Since then the species has not been observed within the area. This sad development closely follows the fate of this species in the rest of southern Sweden.

6 Discussion and conclusions

The main question evaluated by this report is whether the now completed (2007) site investigation in any aspects has affected the breeding bird fauna in Forsmark. Results presented are very much in line with earlier findings from the area /Green 2003, 2004, 2005, 2006, 2007/. Starting off with the complete bird fauna, earlier studies found that no immediate impact on number of species, number of bird pairs or their distribution occurred in small (30 ha) areas around drilling sites within the candidate area /Green 2004/. These results were here backed up by studies at a larger scale where it was shown that bird numbers increased in the whole Forsmark area between the early years of the site investigations (2002–2003) and 2007. This increase occurred both in the candidate area and in the regional model area outside of this, although the increase was larger outside of the candidate area. These results corresponded well with found patterns over most over Sweden where an increase has been registered during the last ten years. The conclusion here is that bird numbers in Forsmark at large follow general patterns on a larger scale.

But what about that the increase was larger outside the candidate area than inside this? Could this be signs of an impact from the site investigations? A more thorough analysis of this question revealed no significant effects on bird numbers from the number of people (a general measure of human presence) working with the site investigations in the area. The interpretation of these results is that neither the drillings (direct disturbances) or the general increase of human activity (general disturbance) have affected the bird numbers on a general scale in Forsmark. In other words, there was no general impact from the site investigations on breeding birds in Forsmark.

The analysis instead found significant effects on some groups of birds of the amount of area affected by forestry. Not very surprisingly, birds connected to clear-cuts and forest edge were positively affected by new clear-cuts. More surprisingly this positive effect was also found for generalist and the most common species. At the same time these groups were also negatively affected by the amount of mature forest. The reasons behind the found patterns are quite clear in the case with species connected to open areas. When it comes to generalist species, as well as the most common species, these may benefit from that closed forest is opened up and more fragmented. Many of these species may be more connected to edge zones as well, something we have not realized before. Also a bit surprising was that no relationships were found between the amount of young forest and older clear-cuts and generalist species. One could imagine that these species would benefit from the change of old clear-cut to young forest, but perhaps the time-frame of only six years is too short for finding such patterns. Equally surprising is the fact that there were no relationships between numbers of birds connected to mature forest and any of the forest variables. Here it could be expected that these species should do better in areas with higher proportion of mature forest and vice versa. Perhaps the variation in mature forest cover (51–62% of the land area), and in new clear-cuts (0–6% of the land area) between subareas is too small to find differences here.

Turning to the listed species selected for detailed monitoring, there are none of these where local population size has been negatively affected by the site investigations. Instead several species have increased in numbers in Forsmark during the site investigation years. Only for a few species any impact what so ever has been recorded. Local breeding success of white-tailed eagles has during the site investigation years only been about half of what it was before the site investigations. The success in Forsmark has also been lower than in surrounding reference areas during this period. It seems likely that the increased human presence in the area has affected the eagles negatively.

For other raptors and owls, no impacts have been recorded. In part this could be because no disturbing activities have been going on in close contact with nest sites of these.

The forest hens capercaillie and hazelhen showed signs of changed local distributions (but not numbers) during the early years of the site investigations. Capercaillies have still not been observed within the candidate area after 2002, but hazelhens seem to be back at the sites used during the early years again.

Lesser spotted woodpecker numbers within the candidate area decreased during the first years of the site investigations (although numbers increased in the regional model area outside of this). During the last years numbers have bounced back again and the number of active territories in 2007 was the highest recorded so far. We do not know if this was an effect of increased human presence in the area, but it cannot be ruled out as a possible cause.

Finally looking at the remaining listed species, not selected for special monitoring, there are no signs of negative impacts from the site investigations. Most species have either remained stable in numbers or increased. In the few cases where numbers have decreased (marsh tit and ortolan bunting), there are no signs indicating that the site investigations in any way should be responsible for the decrease.

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Appendix 1

Listed bird species in Forsmark

Table A-1. List of all listed (Swedish Red List, SRL, and EU Birds Directive Annex 1, EU) bird species, possibly breeding in Forsmark and recorded during 2002–2007. The listing follows the updated version of the Red List /Gärdenfors 2005/.

English name	Swedish name	Latin name	Listing	Estimated population size (pairs/territories) in Forsmark (regional model area)
Whooper Swan	Sångsvan	*Cygnus cygnus*	EU	5
Shoveler	Skedand	*Anas clypeata*	SRL	6
Pochard	Brunand	*Aythya ferina*	SRL	1
Velvet Scoter	Svärta	*Melanitta fusca*	SRL	7
Hazelhen	Järpe	*Bonasia bonasia*	EU	30
Black Grouse	Orre	*Tetrao tetrix*	EU	23
Capercaillie	Tjäder	*Tetrao urogallus*	EU	13
Quail	Vaktel	*Coturnix coturnix*	SRL	1–3
Black-throated Diver	Storlom	*Gavia arctica*	EU	6
Slavonian Grebe	Svarthakedopping	*Podiceps auritus*	SRL, EU	0–1
Bittern	Rördrom	*Botaurus stellaris*	SRL, EU	3–4
Honey Buzzard	Bivråk	*Pernis apivorus*	SRL, EU	9
White-tailed Eagle	Havsörn	*Haliaeetus albicilla*	SRL, EU	4
Marsh Harrier	Brun kärrhök	*Circus aeruginosus*	EU	1
Osprey	Fiskgjuse	*Pandion haliaetus*	EU	7
Spotted Crake	Småfläckig sumphöna	*Porzana porzana*	SRL, EU	1–3
Corncrake	Kornknarr	*Crex crex*	SRL, EU	0–1
Crane	Trana	*Grus grus*	EU	30
Curlew	Storspov*	*Numenius arquata**	SRL	3
Turnstone	Roskarl	*Arenaria interpres*	SRL	10
Lesser Black-backed Gull	Silltrut	*Larus fuscus*	SRL	97
Common Tern	Fisktärna	*Sterna hirundo*	EU	95
Arctic Tern	Silvertärna	*Sterna paradisaea*	EU	234
Stock dove	Skogsduva	*Columba oenas*	SRL	10
Pygmy Owl	Sparvuggla	*Glaucidium passerinim*	EU	15–20
Ural Owl	Slaguggla	*Strix uralensis*	EU	6
Tengmalms Owl	Pärluggla	*Aegolius funereus*	EU	0–2
Wryneck	Göktyta	*Jynx toruilla*	SRL	40–60
Grey-headed Woodpecker	Gråspett	*Picus canus*	EU	0–2
Black woodpecker	Spillkråka	*Dryocopus martius*	EU	12–14
Lesser Spotted Woodpecker	Mindre hackspett	*Dendrocopus minor*	SRL	16
Three-toed Woodpecker	Tretåig hackspett	*Picoides tridactylus*	SRL, EU	1–3
Wood Lark	Trädlärka	*Lullula arborea*	EU	1–2
Skylark	Sånglärka*	*Alauda arvensis**	SRL	14
Wheatear	Stenskvätta*	*Oenanthe oenanthe**	SRL	6
Grashopper Warbler	Gräshoppsångare*	*Locustella naevia**	SRL	1–2
River Warbler	Flodsångare	*Locustella fluviatilis*	SRL	0–1
Greenish Warbler	Lundsångare	*Phylloscopus trochi-loides*	SRL	0–1

English name	Swedish name	Latin name	Listing	Estimated population size (pairs/territories) in Forsmark (regional model area)
Red-breasted Flycatcher	Mindre flugsnappare	*Ficedula parva*	SRL, EU	5
Marsh Tit	Entita*	*Parus palustris**	SRL	20
Red-backed Shrike	Törnskata	*Lanius collurio*	SRL, EU	80
Nutcracker	Nötkråka	*Nucifraga caryocatactes*	SRL	12
Linnet	Hämpling*	*Carduelis cannabina**	SRL	4
Scarlet Rosefinch	Rosenfink*	*Carpodacus erythrinus**	SRL	50
Ortolan Bunting	Ortolansparv	*Emberiza hortulana*	SRL, EU	0

Appendix 2

Birds recorded during line transects

Table A-2. All birds registered during the *base programme* of line transects in Forsmark in 2002, 2003 and 2007. Shown here are results from the part of the regional model area (including the candidate area) covered in 2007 and exactly the same routes (route 1–16) in 2002 and 2003.

Bird species	Swedish name	No. of birds 2002	No. of birds 2003	No. of birds 2007	Density 2002 birds/km	Density 2003 birds/km	Density 2007 birds/km
Honey buzzard	Bivråk	0	0	1	0.000	0.000	0.012
Fieldfare	Björktrast	8	15	7	0.117	0.179	0.086
Blue tit	Blåmes	16	39	90	0.235	0.464	1.108
Chaffinch	Bofink	836	617	1,153	12.276	7.345	14.200
Winchat	Buskskvätta	27	9	7	0.396	0.107	0.086
Bullfinch	Domherre	4	7	11	0.059	0.083	0.135
Common sandpiper	Drillsnäppa	2	4	4	0.029	0.048	0.049
Mistle thrush	Dubbeltrast	4	6	3	0.059	0.071	0.037
Jack snipe	Dvärgbeckasin	0	0	1	0.000	0.000	0.012
Common snipe	Enkelbeckasin	13	52	39	0.191	0.619	0.480
Marsh tit	Entita	8	1	0	0.117	0.012	0.000
Common/ Arctic tern	Fisk/Silvertärna	0	0	30	0.000	0.000	0.369
Osprey	Fiskgjuse	6	2	3	0.088	0.024	0.037
Common gull	Fiskmås	66	196	57	0.969	2.333	0.702
Common tern	Fisktärna	0	5	3	0.000	0.060	0.037
Chiffchaff	Gransångare	24	24	51	0.352	0.286	0.628
Shelduck	Gravand	2	1	0	0.029	0.012	0.000
Spotted flycatcher	Grå flugsnappare	5	0	73	0.073	0.000	0.899
Greylag goose	Grågås	114	49	38	1.674	0.583	0.468
Herring gull	Gråtrut	4	1	21	0.059	0.012	0.259
Mallard	Gräsand	23	16	81	0.338	0.190	0.998
Grasshopper warbler	Gräshoppsångare	0	0	1	0.000	0.000	0.012
Greenfinch	Grönfink	11	14	59	0.162	0.167	0.727
Green woodpecker	Gröngöling	1	1	5	0.015	0.012	0.062
Siskin	Grönsiska	254	123	209	3.730	1.464	2.574
Wood warbler	Grönsångare	41	17	40	0.602	0.202	0.493
Yellowhammerr	Gulsparv	84	91	99	1.233	1.083	1.219
Wren	Gärdsmyg	79	67	101	1.160	0.798	1.244
Cuckoo	Gök	11	8	16	0.162	0.095	0.197
Wryneck	Göktyta	4	12	10	0.059	0.143	0.123
Great black-backed gull	Havstrut	5	2	2	0.073	0.024	0.025
White-tailed eagle	Havsörn	–	4	5	–	0.048	0.062
House martin	Hussvala	26	0	3	0.382	0.000	0.037
Grey heron	Häger	12	12	18	0.176	0.143	0.222
Icterine warbler	Härmsångare	2	3	10	0.029	0.036	0.123
Dunnock	Järnsparv	33	42	98	0.485	0.500	1.207
Hazelhen	Järpe	2	0	4	0.029	0.000	0.049
Jackdaw	Kaja	26	185	18	0.382	2.202	0.222
Canada goose	Kanadagås	102	4	21	1.498	0.048	0.259
Tawny owl	Kattuggla	0	0	1	0.000	0.000	0.012

Bird species	Swedish name	No. of birds 2002	No. of birds 2003	No. of birds 2007	Density 2002 birds/km	Density 2003 birds/km	Density 2007 birds/km
Goldeneye	Knipa	26	18	289	0.382	0.214	3.559
Mute swan	Knölsvan	57	19	16	0.837	0.226	0.197
Blackbird	Koltrast	163	117	273	2.394	1.393	3.362
Raven	Korp	12	16	22	0.176	0.190	0.271
Teal	Kricka	10	104	1	0.147	1.238	0.012
Hooded crow	Kråka	21	48	37	0.308	0.571	0.456
Goldcrest	Kungsfågel	43	93	247	0.631	1.107	3.042
Barn swallow	Ladusvala	12	2	18	0.176	0.024	0.222
Greenish warbler	Lundsångare	1	0	0	0.015	0.000	0.000
Hobby	Lärkfalk	1	0	2	0.015	0.000	0.025
Willow warbler	Lövsångare	864	361	1,277	12.687	4.298	15.727
Red-breasted flycatcher	Mindre flugsnappare	0	0	2	0.000	0.000	0.025
Lesser spotted woodpeccker	Mindre hackspett	0	6	7	0.000	0.071	0.086
Crossbill	Mindre korsnäbb	13	27	515	0.191	0.321	6.342
Woodcock	Morkulla	3	3	2	0.044	0.036	0.025
Thrush nightingale	Näktergal	0	0	1	0.000	0.000	0.012
Nutcracker	Nötkråka	1	2	8	0.015	0.024	0.099
Jay	Nötskrika	4	13	18	0.059	0.155	0.222
Nuthatch	Nötväcka	15	12	16	0.220	0.143	0.197
Buzzard	Ormvråk	6	3	2	0.088	0.036	0.025
Black grouse	Orre	1	7	12	0.015	0.083	0.148
Tree sparrow	Pilfink	0	0	2	0.000	0.000	0.025
Penduline tit	Pungmes	0	0	1	0.000	0.000	0.012
Wood pigeon	Ringduva	48	88	181	0.705	1.048	2.229
Scarlet Rosefinch	Rosenfink	11	0	12	0.162	0.000	0.148
Redshank	Rödbena	6	2	7	0.088	0.024	0.086
Robin	Rödhake	253	275	305	3.715	3.274	3.756
Redstart	Rödstjärt	17	2	3	0.250	0.024	0.037
Redwing	Rödvingetrast	44	124	120	0.646	1.476	1.478
Bittern	Rördrom	0	4	1	0.000	0.048	0.012
Reed warbler	Rörsångare	23	25	53	0.338	0.298	0.653
Arctic tern	Silvertärna	3	1	0	0.044	0.012	0.000
Magpie	Skata	0	0	3	0.000	0.000	0.037
Stock dove	Skogsduva	1	0	1	0.015	0.000	0.012
Shoveler	Skedand	0	2	0	0.000	0.024	0.000
Green sandpiper	Skogssnäppa	17	27	34	0.250	0.321	0.419
Black-headed gull	Skrattmås	53	27	162	0.778	0.321	1.995
Caspian tern	Skräntärna	2	11	1	0.029	0.131	0.012
Red-breasted merganser	Småskrake	4	0	0	0.059	0.000	0.000
Sparrowhawk	Sparvhök	1	1	0	0.015	0.012	0.000
Crested grebe	Skäggdopping	0	2	4	0.000	0.024	0.049
Black woodpecker	Spillkråka	3	9	5	0.044	0.107	0.062
Starling	Stare	21	31	12	0.308	0.369	0.148
Goldfinch	Steglits	0	0	2	0.000	0.000	0.025
Hawfinch	Stenknäck	0	3	6	0.000	0.036	0.074
Long-tailed tit	Stjärtmes	0	4	14	0.000	0.048	0.172
Wheatear	Stenskvätta	2	3	0	0.029	0.036	0.000
Black-throated diver	Storlom	3	0	1	0.044	0.000	0.012
Cormorant	Storskarv	500	0	60	7.342	0.000	0.739

Bird species	Swedish name	No. of birds 2002	No. of birds 2003	No. of birds 2007	Density 2002 birds/km	Density 2003 birds/km	Density 2007 birds/km
Goosander	Storskrake	31	46	501	0.455	0.548	6.170
Curlew	Storspov	3	0	0	0.044	0.000	0.000
Oystercatcher	Strandskata	3	0	7	0.044	0.000	0.086
Great spotted woodpecker	Större hackspett	10	22	16	0.147	0.262	0.197
Parrot crossbill	Större korsnäbb	3	168	10	0.044	2.000	0.123
Ringed plover	Större strandpipare	0	4	0	0.000	0.048	0.000
Blackcap	Svarthätta	45	32	147	0.661	0.381	1.810
Coal tit	Svartmes	11	31	56	0.162	0.369	0.690
Pied flycatcher	Svartvit flugsnappare	66	48	79	0.969	0.571	0.973
Skylark	Sånglärka	16	13	12	0.235	0.155	0.148
Whooper swan	Sångsvan	7	1	4	0.103	0.012	0.049
White wagtail	Sädesärla	23	16	24	0.338	0.190	0.296
Reed bunting	Sävsparv	32	23	40	0.470	0.274	0.493
Great tit	Talgoxe	82	127	207	1.204	1.512	2.549
Willow tit	Talltita	14	40	52	0.206	0.476	0.640
Song thrush	Taltrast	109	246	169	1.601	2.929	2.081
Feral pigeon	Tamduva	2	0	1	0.029	0.000	0.012
Capercaillie	Tjäder	2	5	2	0.029	0.060	0.025
Crested tit	Tofsmes	17	13	45	0.250	0.155	0.554
Lapwing	Tofsvipa	16	10	26	0.235	0.119	0.320
Swift	Tornseglare	22	0	10	0.323	0.000	0.123
Crane	Trana	5	20	93	0.073	0.238	1.145
Three-toed woodpecker	Tretåig Hackspett	1	0	0	0.015	0.000	0.000
Garden warbler	Trädgårdssångare	51	22	198	0.749	0.262	2.438
Treecreeper	Trädkrypare	21	2	44	0.308	0.024	0.542
Wood lark	Trädlärka	0	0	1	0.000	0.000	0.012
Tree pipit	Trädpiplärka	110	135	157	1.615	1.607	1.933
Red-backed shrike	Törnskata	3	1	10	0.044	0.012	0.123
Common whitethoat	Törnsångare	6	12	23	0.088	0.143	0.283
Water rail	Vattenrall	0	2	0	0.000	0.024	0.000
Quail	Vaktel	0	0	1	0.000	0.000	0.012
Tufted duck	Vigg	14	66	4	0.206	0.786	0.049
Barnacle goose	Vitkindad gås	0	0	1	0.000	0.000	0.012
Meadow pipit	Ängspiplärka	2	0	6	0.029	0.000	0.074
Lesser whitethroat	Ärtsångare	29	16	35	0.426	0.190	0.431
Total		4,876	4,242	8,129	71.601	50.500	100.111

Appendix 3

Birds recorded during line transects in the candidate area

Table A-3. All birds registered during all line transects (base programme + extra routes in some years) in the candidate area Forsmark in 2002, 2003, 2004 and 2007.

Bird species	Swedish name	No. of birds 2002	No. of birds 2003	No. of birds 2004	No. of birds 2007	Density 2002 birds/km	Density 2003 birds/km	Density 2004 birds/km	Density 2007 birds/km
Fieldfare	Björktrast	5	5	9	4	0.120	0.109	0.198	0.168
Blue tit	Blåmes	23	12	9	27	0.552	0.263	0.198	1.134
Chaffinch	Bofink	476	616	444	338	11.415	13.479	9.758	14.202
Winchat	Buskskvätta	17	1	2	1	0.408	0.022	0.044	0.042
Bullfinch	Domherre	2	9	1	0	0.048	0.197	0.022	0.000
Common sandpiper	Drillsnäppa	3	3	2	2	0.072	0.066	0.044	0.084
Mistle thrush	Dubbeltrast	0	3	3	0	0.000	0.066	0.066	0.000
Jack snipe	Dvärgbeckasin	0	0	0	1	0.000	0.000	0.000	0.042
Common snipe	Enkelbeckasin	9	16	32	6	0.216	0.350	0.703	0.252
Marsh tit	Entita	5	1	1	0	0.120	0.022	0.022	0.000
Osprey	Fiskgjuse	3	2	0	0	0.072	0.044	0.000	0.000
Common gull	Fiskmås	58	190	198	28	1.391	4.158	4.352	1.176
Common tern	Fisktärna	0	5	2	2	0.000	0.109	0.044	0.084
Chiffchaff	Gransångare	15	9	14	9	0.360	0.197	0.308	0.378
Spotted flycatcher	Grå flugsnappare	3	19	6	27	0.072	0.416	0.132	1.134
Greylag goose	Grågås	78	137	116	15	1.871	2.998	2.549	0.630
Herring gull	Gråtrut	6	4	0	9	0.144	0.088	0.000	0.378
Mallard	Gräsand	7	19	14	26	0.168	0.416	0.308	1.092
Greenfinch	Grönfink	10	19	21	15	0.240	0.416	0.462	0.630
Green woodpecker	Gröngöling	0	0	2	1	0.000	0.000	0.044	0.042
Siskin	Grönsiska	150	82	74	47	3.597	1.794	1.626	1.975
Wood warbler	Grönsångare	24	14	10	7	0.576	0.306	0.220	0.294
Yellowhammerr	Gulsparv	67	70	37	24	1.607	1.532	0.813	1.008
Wren	Gärdsmyg	34	32	24	16	0.815	0.700	0.527	0.672
Cuckoo	Gök	3	8	8	4	0.072	0.175	0.176	0.168
Wryneck	Göktyta	0	2	3	2	0.000	0.044	0.066	0.084
Great black-backed gull	Havstrut	6	6	1	0	0.144	0.131	0.022	0.000
White-tailed eagle	Havsörn	0	6	4	2	0.000	0.131	0.088	0.084
House martin	Hussvala	17	2	0	0	0.408	0.044	0.000	0.000
Grey heron	Häger	13	7	1	7	0.312	0.153	0.022	0.294
Icterine warbler	Härmsångare	3	8	5	9	0.072	0.175	0.110	0.378
Dunnock	Järnsparv	30	39	30	19	0.719	0.853	0.659	0.798
Hazelhen	Järpe	2	0	2	2	0.048	0.000	0.044	0.084
Canada goose	Kanadagås	39	2	0	19	0.935	0.044	0.000	0.798
Goldeneye	Knipa	15	90	19	124	0.360	1.969	0.418	5.210
Mute swan	Knölsvan	54	23	5	4	1.295	0.503	0.110	0.168
Blackbird	Koltrast	106	103	87	75	2.542	2.254	1.912	3.151
Corncrake	Kornknarr	0	1	0	0	0.000	0.022	0.000	0.000
Raven	Korp	6	7	0	1	0.144	0.153	0.000	0.042

Bird species	Swedish name	No. of birds 2002	No. of birds 2003	No. of birds 2004	No. of birds 2007	Density 2002 birds/km	Density 2003 birds/km	Density 2004 birds/km	Density 2007 birds/km
Teal	Kricka	0	52	0	0	0.000	1.138	0.000	0.000
Hooded crow	Kråka	30	37	18	18	0.719	0.810	0.396	0.756
Goldcrest	Kungsfågel	23	96	56	67	0.552	2.101	1.231	2.815
Barn swallow	Ladusvala	5	2	0	11	0.120	0.044	0.000	0.462
Hobby	Lärkfalk	0	0	1	0	0.000	0.000	0.022	0.000
Greenish warbler	Lundsångare	1	0	0	0	0.024	0.000	0.000	0.000
Willow warbler	Lövsångare	470	399	460	419	11.271	8.731	10.110	17.605
Red-breasted flycatcher	Mindre flugsnappare	0	0	1	1	0.000	0.000	0.022	0.042
Lesser spotted woodpeccker	Mindre hackspett	3	2	1	3	0.072	0.044	0.022	0.126
Crossbill	Mindre korsnäbb	0	5	0	86	0.000	0.109	0.000	3.613
Woodcock	Morkulla	2	2	0	0	0.048	0.044	0.000	0.000
Thrush nightin-gale	Näktergal	0	1	0	0	0.000	0.022	0.000	0.000
Jay	Nötskrika	1	4	0	4	0.024	0.088	0.000	0.168
Nuthatch	Nötväcka	7	2	4	2	0.168	0.044	0.088	0.084
Buzzard	Ormvråk	0	2	0	0	0.000	0.044	0.000	0.000
Black grouse	Orre	0	2	7	0	0.000	0.044	0.154	0.000
Ortolan bunting	Ortolansparv	0	1	0	0	0.000	0.022	0.000	0.000
Wood pigeon	Ringduva	43	49	67	51	1.031	1.072	1.473	2.143
Scarlet Rose-finch	Rosenfink	7	14	6	10	0.168	0.306	0.132	0.420
Redshank	Rödbena	5	3	2	2	0.120	0.066	0.044	0.084
Robin	Rödhake	151	185	206	74	3.621	4.048	4.527	3.109
Redstart	Rödstjärt	5	0	1	1	0.120	0.000	0.022	0.042
Redwing	Rödvingetrast	32	89	32	29	0.767	1.947	0.703	1.218
Bittern	Rördrom	0	1	0	0	0.000	0.022	0.000	0.000
Reed warbler	Rörsångare	18	33	29	20	0.432	0.722	0.637	0.840
Arctic tern	Silvertärna	4	5	12	0	0.096	0.109	0.264	0.000
Stock dove	Skogsduva	0	0	0	1	0.000	0.000	0.000	0.042
Green sandpiper	Skogssnäppa	8	7	14	10	0.192	0.153	0.308	0.420
Black-headed gull	Skrattmås	41	19	20	104	0.983	0.416	0.440	4.370
Caspian tern	Skräntärna	0	5	2	0	0.000	0.109	0.044	0.000
Crested grebe	Skäggdopping	0	0	2	0	0.000	0.000	0.044	0.000
Sparrowhawk	Sparvhök	0	0	1	0	0.000	0.000	0.022	0.000
Red-breasted merganser	Småskrake	2	0	0	0	0.048	0.000	0.000	0.000
Black wood-pecker	Spillkråka	2	4	1	0	0.048	0.088	0.022	0.000
Starling	Stare	18	20	20	8	0.432	0.438	0.440	0.336
Hawfinch	Stenknäck	0	4	0	1	0.000	0.088	0.000	0.042
Wheatear	Stenskvätta	1	3	1	0	0.024	0.066	0.022	0.000
Long-tailed tit	Stjärtmes	0	9	0	0	0.000	0.197	0.000	0.000
Black-throated diver	Storlom	2	1	2	0	0.048	0.022	0.044	0.000
Cormorant	Storskarv	500	0	1	0	11.990	0.000	0.022	0.000
Goosander	Storskrake	30	25	23	157	0.719	0.547	0.505	6.597
Curlew	Storspov	1	16	0	0	0.024	0.350	0.000	0.000
Oystercatcher	Strandskata	3	0	0	6	0.072	0.000	0.000	0.252

Bird species	Swedish name	No. of birds 2002	No. of birds 2003	No. of birds 2004	No. of birds 2007	Density 2002 birds/km	Density 2003 birds/km	Density 2004 birds/km	Density 2007 birds/km
Great spotted woodpecker	Större hackspett	1	7	2	3	0.024	0.153	0.044	0.126
Parrot crossbill	Större korsnäbb	0	57	0	1	0.000	1.247	0.000	0.042
Blackcap	Svarthätta	24	41	30	51	0.576	0.897	0.659	2.143
Coal tit	Svartmes	10	30	12	20	0.240	0.656	0.264	0.840
Pied flycatcher	Svartvit flugsnappare	38	31	35	34	0.911	0.678	0.769	1.429
Skylark	Sånglärka	20	25	14	10	0.480	0.547	0.308	0.420
Whooper swan	Sångsvan	13	30	35	0	0.312	0.656	0.769	0.000
White wagtail	Sädesärla	18	14	9	10	0.432	0.306	0.198	0.420
Reed bunting	Sävsparv	30	26	25	14	0.719	0.569	0.549	0.588
Great tit	Talgoxe	54	62	58	55	1.295	1.357	1.275	2.311
Willow tit	Talltita	5	13	13	12	0.120	0.284	0.286	0.504
Song thrush	Taltrast	78	176	98	48	1.871	3.851	2.154	2.017
Feral pigeon	Tamduva	2	0	0	1	0.048	0.000	0.000	0.042
Crested tit	Tofsmes	14	17	9	10	0.336	0.372	0.198	0.420
Lapwing	Tofsvipa	15	10	12	15	0.360	0.219	0.264	0.630
Swift	Tornseglare	19	2	0	4	0.456	0.044	0.000	0.168
Crane	Trana	1	4	5	2	0.024	0.088	0.110	0.084
Three-toed woodpecker	Tretåing hackspett	1	0	1	0	0.024	0.000	0.022	0.000
Garden warbler	Trädgårds-sångare	45	60	35	69	1.079	1.313	0.769	2.899
Treecreeper	Trädkrypare	12	26	22	18	0.288	0.569	0.484	0.756
Wood lark	Trädlärka	0	1	0	0	0.000	0.022	0.000	0.000
Tree pipit	Trädpiplärka	36	26	37	35	0.863	0.569	0.813	1.471
Red-backed shrike	Törnskata	0	1	1	1	0.000	0.022	0.022	0.042
Common whitethoat	Törnsångare	10	17	8	7	0.240	0.372	0.176	0.294
Quail	Vaktel	0	0	0	1	0.000	0.000	0.000	0.042
Tufted duck	Vigg	4	64	4	0	0.096	1.400	0.088	0.000
Meadow pipit	Ängspiplärka	1	0	0	2	0.024	0.000	0.000	0.084
Lesser whiteth-roat	Ärtsångare	20	18	18	11	0.480	0.394	0.396	0.462
Total		3,230	3,582	2,694	2,404	77.458	78.381	59.209	101.008

Appendix 4

Birds recorded during line transects in the regional area

Table A-4. All birds registered during line transects (base programme) in the regional model area outside of the candidate area Forsmark in 2002, 2003 and 2007.

Bird species	Swedish name	No. of birds 2002	No. of birds 2003	No. of birds 2007	Density 2002 birds/km	Density 2003 birds/km	Density 2007 birds/km
Honey buzzard	Bivråk	0	0	1	0.000	0.000	0.017
Fieldfare	Björktrast	6	10	3	0.130	0.168	0.052
Blue tit	Blåmes	13	30	63	0.282	0.504	1.098
Chaffinch	Bofink	567	412	815	12.299	6.924	14.199
Winchat	Buskskvätta	14	8	6	0.304	0.134	0.105
Bullfinch	Domherre	2	5	11	0.043	0.084	0.192
Common sandpiper	Drillsnäppa	1	3	2	0.022	0.050	0.035
Mistle thrush	Dubbeltrast	4	3	3	0.087	0.050	0.052
Common snipe	Enkelbeckasin	7	37	33	0.152	0.622	0.575
Marsh tit	Entita	7	1	0	0.152	0.017	0.000
Osprey	Fiskgjuse	3	0	3	0.065	0.000	0.052
Common gull	Fiskmås	11	25	29	0.239	0.420	0.505
Common tern	Fisktärna	0	4	23	0.000	0.067	0.401
Chiffchaff	Gransångare	14	21	42	0.304	0.353	0.732
Shelduck	Gravand	2	1	0	0.043	0.017	0.000
Spotted flycatcher	Grå flugsnappare	3	0	46	0.065	0.000	0.801
Greylag goose	Grågås	41	6	23	0.889	0.101	0.401
Herring gull	Gråtrut	0	1	12	0.000	0.017	0.209
Mallard	Gräsand	16	9	55	0.347	0.151	0.958
Grasshopper warbler	Gräshoppsångare	0	0	1	0.000	0.000	0.017
Greenfinch	Grönfink	9	9	44	0.195	0.151	0.767
Green woodpecker	Gröngöling	1	1	4	0.022	0.017	0.070
Siskin	Grönsiska	143	74	162	3.102	1.244	2.822
Wood warbler	Grönsångare	27	10	33	0.586	0.168	0.575
Yellowhammerr	Gulsparv	45	65	75	0.976	1.092	1.307
Wren	Gärdsmyg	52	49	85	1.128	0.824	1.481
Cuckoo	Gök	8	6	12	0.174	0.101	0.209
Wryneck	Göktyta	4	10	8	0.087	0.168	0.139
Great black-backed gull	Havstrut	2	2	2	0.043	0.034	0.035
White-tailed eagle	Havsörn	0	2	3	0.000	0.034	0.052
House martin	Hussvala	14	0	3	0.304	0.000	0.052
Grey heron	Häger	1	7	11	0.022	0.118	0.192
Icterine warbler	Härmsångare	0	1	1	0.000	0.017	0.017
Dunnock	Järnsparv	15	34	79	0.325	0.571	1.376
Hazelhen	Järpe	0	0	2	0.000	0.000	0.035
Jackdaw	Kaja	2	34	6	0.043	0.571	0.105
Canada goose	Kanadagås	102	4	2	2.213	0.067	0.035
Tawny owl	Kattuggla	0	0	1	0.000	0.000	0.017
Goldeneye	Knipa	21	7	165	0.456	0.118	2.875
Mute swan	Knölsvan	9	7	12	0.195	0.118	0.209
Blackbird	Koltrast	110	84	198	2.386	1.412	3.449
Raven	Korp	6	9	21	0.130	0.151	0.366

Bird species	Swedish name	No. of birds 2002	No. of birds 2003	No. of birds 2007	Density 2002 birds/km	Density 2003 birds/km	Density 2007 birds/km
Teal	Kricka	10	52	1	0.217	0.874	0.017
Hooded crow	Kråka	6	25	19	0.130	0.420	0.331
Goldcrest	Kungsfågel	23	58	180	0.499	0.975	3.136
Barn swallow	Ladusvala	8	2	7	0.174	0.034	0.122
Hobby	Lärkfalk	1	0	2	0.022	0.000	0.035
Willow warbler	Lövsångare	563	261	858	12.213	4.387	14.948
Red-breasted flycatcher	Mindre flugsnappare	0	0	1	0.000	0.000	0.017
Lesser spotted woodpeccker	Mindre hackspett	0	4	4	0.000	0.067	0.070
Crossbill	Mindre korsnäbb	13	22	429	0.282	0.370	7.474
Woodcock	Morkulla	3	1	2	0.065	0.017	0.035
Thrush nightingale	Näktergal	0	0	1	0.000	0.000	0.017
Nutcracker	Nötkråka	1	2	8	0.022	0.034	0.139
Jay	Nötskrika	4	10	14	0.087	0.168	0.244
Nuthatch	Nötväcka	13	12	14	0.282	0.202	0.244
Buzzard	Ormvråk	6	1	2	0.130	0.017	0.035
Black grouse	Orre	1	5	12	0.022	0.084	0.209
Tree sparrow	Pilfink	0	0	2	0.000	0.000	0.035
Penduline tit	Pungmes	0	0	1	0.000	0.000	0.017
Wood pigeon	Ringduva	25	60	130	0.542	1.008	2.265
Scarlet Rosefinch	Rosenfink	7	0	2	0.152	0.000	0.035
Redshank	Rödbena	2	1	5	0.043	0.017	0.087
Robin	Rödhake	172	178	231	3.731	2.992	4.024
Redstart	Rödstjärt	12	2	2	0.260	0.034	0.035
Redwing	Rödvingetrast	28	40	91	0.607	0.672	1.585
Bittern	Rördrom	0	3	1	0.000	0.050	0.017
Reed warbler	Rörsångare	9	14	33	0.195	0.235	0.575
Arctic tern	Silvertärna	2	1	8	0.043	0.017	0.139
Magpie	Skata	0	0	3	0.000	0.000	0.052
Stock dove	Skogsduva	1	0	0	0.022	0.000	0.000
Shoveler	Skedand	0	2	0	0.000	0.034	0.000
Green sandpiper	Skogssnäppa	10	25	24	0.217	0.420	0.418
Black-headed gull	Skrattmås	19	19	58	0.412	0.319	1.010
Red-breasted merganser	Småskrake	2	0	0	0.043	0.000	0.000
Caspian tern	Skräntärna	2	7	1	0.043	0.118	0.017
Sparrowhawk	Sparvhök	1	1	0	0.022	0.017	0.000
Crested grebe	Skäggdopping	0	2	4	0.000	0.034	0.070
Black woodpecker	Spillkråka	2	7	5	0.043	0.118	0.087
Starling	Stare	15	15	4	0.325	0.252	0.070
Goldfinch	Steglits	0	0	2	0.000	0.000	0.035
Hawfinch	Stenknäck	0	2	5	0.000	0.034	0.087
Wheatear	Stenskvätta	2	0	0	0.043	0.000	0.000
Long-tailed tit	Stjärtmes	0	4	14	0.000	0.067	0.244
Black-throated diver	Storlom	1	0	1	0.022	0.000	0.017
Cormorant	Storskarv	0	0	60	0.000	0.000	1.045
Goosander	Storskrake	5	34	344	0.108	0.571	5.993
Curlew	Storspov	3	0	0	0.065	0.000	0.000
Oystercatcher	Strandskata	0	0	1	0.000	0.000	0.017
Great spotted woodpecker	Större hackspett	10	17	13	0.217	0.286	0.226
Parrot crossbill	Större korsnäbb	3	140	9	0.065	2.353	0.157

Bird species	Swedish name	No. of birds 2002	No. of birds 2003	No. of birds 2007	Density 2002 birds/km	Density 2003 birds/km	Density 2007 birds/km
Ringed plover	Större strandpipare	0	4	0	0.000	0.067	0.000
Blackcap	Svarthätta	39	21	96	0.846	0.353	1.672
Coal tit	Svartmes	9	15	36	0.195	0.252	0.627
Pied flycatcher	Svartvit flugsnappare	34	30	45	0.738	0.504	0.784
Skylark	Sånglärka	0	2	2	0.000	0.034	0.035
Whooper swan	Sångsvan	0	0	4	0.000	0.000	0.070
White wagtail	Sädesärla	12	8	14	0.260	0.134	0.244
Reed bunting	Sävsparv	12	16	26	0.260	0.269	0.453
Great tit	Talgoxe	55	97	152	1.193	1.630	2.648
Willow tit	Talltita	12	34	40	0.260	0.571	0.697
Song thrush	Taltrast	60	161	121	1.302	2.706	2.108
Capercaillie	Tjäder	2	5	2	0.043	0.084	0.035
Crested tit	Tofsmes	15	7	35	0.325	0.118	0.610
Lapwing	Tofsvipa	1	1	11	0.022	0.017	0.192
Swift	Tornseglare	14	0	6	0.304	0.000	0.105
Crane	Trana	4	17	91	0.087	0.286	1.585
Garden warbler	Trädgårdssångare	36	20	129	0.781	0.336	2.247
Treecreeper	Trädkrypare	18	1	26	0.390	0.017	0.453
Wood lark	Trädlärka	0	0	1	0.000	0.000	0.017
Tree pipit	Trädpiplärka	84	122	122	1.822	2.050	2.125
Red-backed shrike	Törnskata	3	0	9	0.065	0.000	0.157
Common whitethoat	Törnsångare	1	8	16	0.022	0.134	0.279
Water rail	Vattenrall	0	2	0	0.000	0.034	0.000
Tufted duck	Vigg	12	4	4	0.260	0.067	0.070
Barnacle goose	Vitkindad gås	0	0	1	0.000	0.000	0.017
Meadow pipit	Ängspiplärka	2	0	4	0.043	0.000	0.070
Lesser whitethroat	Ärtsångare	21	11	24	0.456	0.185	0.418
Total		2,713	2,606	5,725	58.850	43.798	99.739

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