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Forsmark site investigation

Bird monitoring in Forsmark 2006

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January 2007

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This report concerns a study which was conducted for SKB. The conclusions and viewpoints presented in the report are those of the author and do not necessarily coincide with those of the client.

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Abstract

This report is the fifth annual report summarizing changes in the breeding bird fauna in Forsmark during the ongoing SKB site investigations (2002–2006). The general aim is to monitor possible effects from the site investigations on bird numbers and breeding results. This report covers a selected number of listed species, included in the Swedish Red List and/or the EU Birds Directive Annex 1. The selected listed species were monitored by check-ups of known territories and/or by visits to species-specific suitable habitats both within the candidate area and the regional model area at large.

2006 was again a good year for several of the monitored bird species in Forsmark. The black-throated divers had a very good breeding success for the first time since the start of the site investigation period. As a result of this, local average breeding success for the last five years is exactly what is needed for keeping the population at a constant level. Honey buzzards and ospreys again had a very good breeding season with high numbers of young produced. All three species of ‘forest hens’ (black grouse, capercaillie and hazelhen) were registered in the highest numbers for the five years in 2006. The ural owls had their best breeding season during the five years and no less than 20 large young were produced. Lesser spotted woodpeckers and red-backed shrikes kept their population sizes on a high level from last year. Wrynecks decreased in numbers from the peak year in 2005. Numbers registered in 2006 were on the same level as in the years before 2005. White-tailed eagles on the other hand had their worst breeding season since 2002, and only one pair managed to raise large young. On a general level none of the monitored species has shown any decrease in local numbers over the five year period within the regional model area.

In summary the present analysis shows the following results regarding possible effects from the site investigations on the breeding bird fauna (selected listed species).

- There are no general, large-scale general effects from the site investigations on species listed in the Swedish Red List and/or the EU Birds Directive Annex 1, neither in the candidate area nor in the regional model area.
- No species has decreased in overall numbers during 2002–2006.
- No effects at all have been recorded for honey buzzards, ospreys, black grouse, ural owl, wryneck and redbacked shrike.
- For some of the above mentioned species, this may be due to that no pairs nest close to where the disturbing parts of the site investigations are conducted.
- Black-throated divers did not use one of the lakes regularly holding divers in other years, possibly due to activities within the site investigations. On the other hand breeding success of divers was really good in 2006 on a general level.
- The white-tailed eagles had their worst breeding success since 2002. In part this was certainly due to other factors, but an impact from the site investigations can not be ruled out. When comparing breeding results in Forsmark between before and during the site investigations, breeding output has been halved during the latter period. The same comparison for reference areas south and north of Forsmark does not reveal any such pattern. There, the breeding success has been stable, and high.
- The forest hens, capercaillie and hazelhen seem to re-establish themselves in areas that they avoided during the most intensive period of the site investigations.
- The same pattern is shown for lesser spotted woodpeckers.

Sammanfattning

Denna rapport sammanfattar populationsförändringar och i en del fall häckningsframgång hos ett urval listade (Svenska Rödlistan och/eller EU:s Fågeldirektiv) fågelarter i Forsmark under perioden 2002 till 2006. Syftet är att utvärdera den eventuella påverkan som SKB:s platsundersökningar kan ha på de häckande fåglarnas numerär och i vissa fall häckningsframgång. Rapporten behandlar ett urval av de arter som är upptagna i den Svenska Rödlistan och/eller i EU:s Fågelskyddsdirektiv Annex 1. Listade arter har följts upp i hela det *Regionala modellområdet* (inklusive *Kandidatområdet*) genom att besöka tidigare kända revir och/eller genom eftersök i lämpliga biotoper för aktuella arter.

2006 var ännu ett bra år för flera av de övervakade arterna i Forsmark. Storlommarna hade för första gången sedan platsundersökningarna startade en mycket god häckningsframgång. Detta innebär att unproduktionen för den senaste femårsperioden i genomsnitt ligger exakt på den nivå som krävs för att hålla den lokala populationen konstant. Bivråkarna och fiskgjusarna hade ännu ett gott häckningsår med god unproduktion. Alla tre skogshönsen (orre, tjäder, järpe) uppträdde med de högsta antalen som noterats under de fem åren. Slagugglorna hade sin absolut bästa häckningssäsong under de fem åren och inte mindre än 20 ungar kom på vingarna. Mindre hackspett och törnskata låg kvar på de höga nivåer som registrerades under 2005. Göktytorna minskade i antal från fjolårets toppnivå och noterades nu i samma antal som under åren innan 2005. Havsörnarna hade däremot en dålig säsong 2006 och endast ett par lyckades få ut ungar. Generellt sett är det ingen av de övervakade arterna som har minskat i antal under de fem åren.

Sammantaget blir slutsatsen av analyserna av platsundersökningarnas eventuella påverkan på häckfågelfaunan som följer:

- Ingen generell, storskalig påverkan har skett på listade arter vare sig inom *Kandidatområdet* eller inom det *Regionala modellområdet*.
- Ingen av de övervakade arterna har minskat i antal under de fem år som platsundersökningarna pågått.
- Ingen påverkan överhuvudtaget har noterats för bivråk, fiskgjuse, orre, slaguggla, göktyta och törnskata.
- För några av ovanstående arter beror detta troligen på att inga boplatser finns i anslutning till delar där de mer intensiva delarna av platsundersökningarna har utförts.
- Storlommarna använde inte en av de sjöar där de funnits under de tidigare fyra åren under 2006, möjligen på grund av platsundersökningsaktiviteter under våren. Å andra sidan var den generella häckningsframgången under 2006 mycket god.
- Havsörnarna hade dålig häckningsframgång under 2006. Till viss del berodde detta på andra faktorer än platsundersökningarna, men att även sistnämnda spelat in kan inte uteslutas. En jämförelse av häckningsresultaten i Forsmark mellan perioden före och under platsundersökningarna visar att häckningsframgången var blott hälften så hög under sistnämnda period. Samma jämförelse för referensområden norr och söder om Forsmark visar inte på någon skillnad mellan perioderna. Där har framgången varit konstant hög.
- Skogshönsen tjäder och järpe visar tecken på att återetablera sig i områden som de föreföll undvika under den mest intensiva fasen av platsundersökningarna.
- Samma mönster antyds hos mindre hackspett.

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1 Introduction

This document reports the results from the bird monitoring in Forsmark for 2006. The bird surveys started in 2002 and for some species the data set hence covers a five-year period. For some of the species presented here good data are available from 2003 onwards, allowing comparisons during a four-year period. The aim of this report is to evaluate the effects of the ongoing site investigations on the breeding bird fauna in the area for a number of selected listed species (according to the Swedish Red List and/or the EU Birds Directive). The surveys were made according to activity plan AP PF 400-06-006. The project has been conducted by the Department of Animal Ecology, Lund University. The report covers the whole regional model area.

2 Objective and scope

The site investigations in Forsmark started in 2002. 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 are carried out in such a way that disturbances to the fauna, especially sensitive and vulnerable species, can 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/ 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 will affect the bird fauna in some way. The investigations are not only likely to affect the specific sites where drilling is made or new roads are 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 is greatly increased with more traffic on the roads, more people out in the landscape sampling different things etc. In Forsmark this means 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.

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 are adding up, conclusions will be more and more robust. With five years of monitoring made, the results presented here are of an acceptable standard for a first more detailed analysis of the possible impact on breeding birds of the selected species.

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 km². 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 km². 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 function as a reference area to the candidate area.

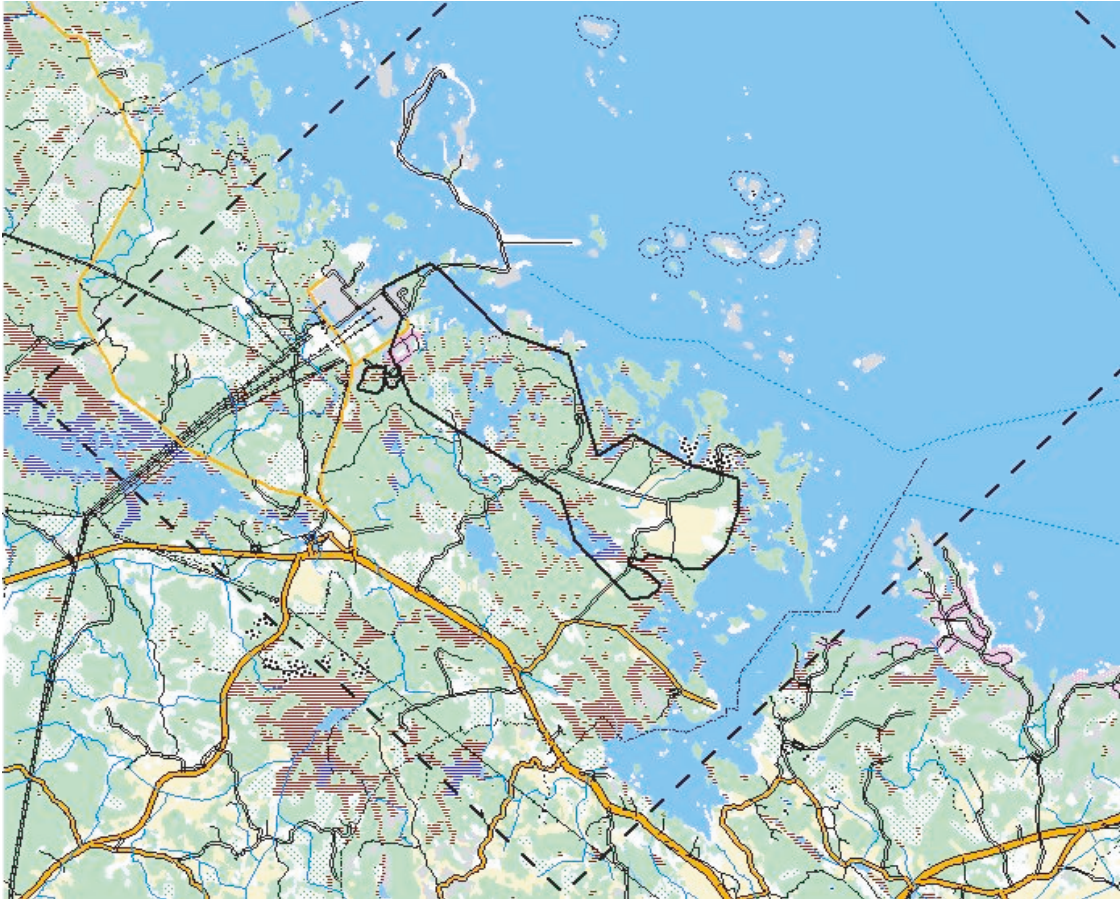


Figure 2-1. Map of the survey area in Forsmark. The regional model area is shown with a thick broken line and the candidate area is illustrated with a thick unbroken line.

3 Equipment

3.1 Description of equipment

The following equipment was used when conducting the bird surveys.

- GPS (Garmin 12).
- Binoculars and telescope.
- Field maps showing each days work.
- Note books and protocols.
- 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 400-06-006.

4.1 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. Since the Swedish Red List was updated in 2005, with some earlier listed species being removed from the list and some new species being added /Gårdenfors 2005/, both species being red-listed before- and after 2005 are shown together with the latest updates on estimated local population size in Forsmark.

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 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 shows a negative population trend at the national level (but not necessarily in Forsmark); iv) Forsmark holds high densities of the species.

These species were monitored in 2006 by visiting known nesting places/territories used in 2002–2005, 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, that is 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.

Table 4-1. Listed species (Swedish Red List and/or EU's Birds Directive) selected for monitoring in Forsmark in 2004–2006.

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

4.2 Execution

The monitoring field work in 2006 was carried out during the period 2006-03-20 to 2006-08-04. The major part of the field work was done 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.

4.3 Data handling

In the field all registered birds of interest were recorded in notebooks and on field maps with data on species, number of individuals and time together with additional data on bird behaviour and circumstances where such data were relevant. Observations were registered with exact position taken directly from the GPS in the field. After each days field work the bird, position and time data were transferred to pre-made protocols. Data were then entered into an Excel-file (from protocols) where after the file was cross-checked against the field notes by the project leader. Positions 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.

4.4 Analyses and interpretations

Changes in numbers of territories at species level are compared and discussed but only statistically tested if data are available for at least a five-year period in this report. The same procedure is also used for comparing breeding results in a few cases. This means that for some species data are tested statistically while for others they are not. The rationale for this is that with a time series of only four years, any such test is non-sensical. Statistical testing is only possible after a time series of five years, although statistical power will 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.

For most species the actual numbers of recorded territories/nests/pairs are reported, compared and shown in figures. For the 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, at least not in the early 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. The procedure is then repeated for the next two following years and the new change (in percent) is added/subtracted to 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).

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 r_s , which varies between -1 and 1 . A value of 0 means that there is no correlation at all, the higher the value of r_s , the stronger the positive correlation (increase in this case), the lower the value of r_s , 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 r_s 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.).

4.5 Nonconformities

The activity was performed according to the plans (no nonconformities).

5 Results

Data from this survey are stored in the SKB GIS database and are traceable by the Activity plan number. 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. A complete list of English, Latin and Swedish names for all listed bird species possibly breeding in Forsmark during 2002–2006 is given in Appendix 1.

5.1 Listed species

The following section gives a summary of the population development during the last four to five 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.

Black-throated diver *Gavia arctica* Storlom (EU Annex 1)

Number of pairs was on the same level as in the earlier years. Over the five year period the local population size has remained very stable, varying between five and six (possibly seven in 2005) stationary pairs. Hence, there is no statistically significant trend in diver numbers over the five years (Spearman rank correlation: $r_s = -0.29$, $p = 0.64$, $N = 5$). There has been some geographical variation between the years in where the pairs have been found. Six localities have been used during the period, four in lakes and two at the coast. Of these, three to four have been occupied by the same number of pairs in all five years, one has been used in four years, one in three years and one in two years only. The situation at the coastal sites seems more stable than in the lakes. At the coastal sites the situation has been very similar in all years, but there is only one lake that has held divers in all five years. Interesting, and potentially connected to the site investigations, is that Bolundsfjärden did not (for the first time in five years) have any divers in 2006.

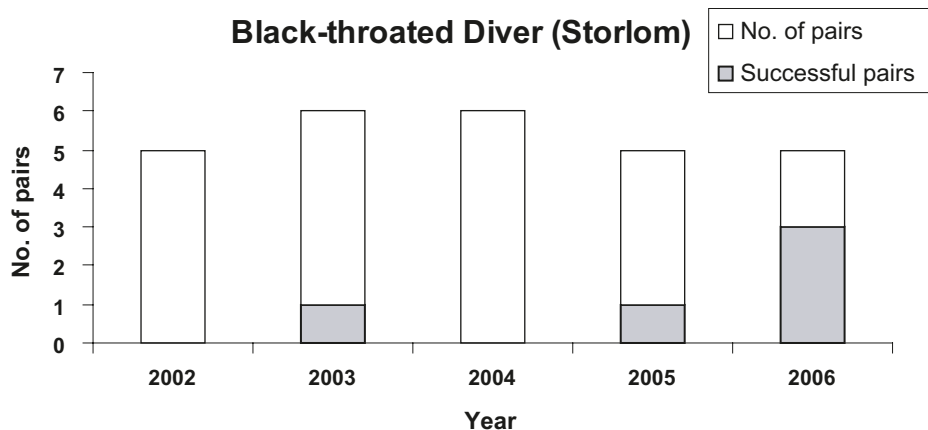


Figure 5-1. Number of stationary pairs of black-throated divers in Forsmark 2002–2006. Shading shows the number of successful pairs. Minimum numbers are shown, total numbers of pairs in 2005 might have been seven and there might have been four successful pairs in 2006.

The big difference between 2006 and earlier years was that breeding success was very good in 2006. At least three of the five pairs (possibly four out of five) succeeded in producing large young. In total at least seven (and possibly nine) young were produced giving a local breeding success of 1.4–1.8 large young/pair. Breeding success was higher at the coast compared to in the lakes (1.7–2.3 vs. 1.0 large young/pair). Especially remarkable is a pair with three large young close to the Forsmark power plant. According to data from Finland only 1% of all clutches of black-throated divers contain three eggs, the most common clutch size is two eggs /BWP 1977/.

These figures mean that overall local breeding success for the whole five-year period is between 0.34 and 0.44 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/.

The results from 2006 answer some of the questions posted in the earlier years. First of all the results show that the divers are actually trying to breed in the area, i.e. they are not just using the lakes and bays around Forsmark for foraging (see /Green 2006/). Furthermore, the findings indicate that earlier speculations /Green 2005/ about that divers, being long-lived birds as they are, may have a large annual variation in breeding success but still retain population size constant if they manage to produce many young now and then may be correct.

Why then was breeding success so good in 2006 compared to earlier years? A quick look at water level fluctuations during the expected nesting period (May–June), a factor known to be important for breeding divers /Eriksson et al. 2005/, showed that the variation was between two and three dm (increasing levels during the period) at two coastal sites holding breeding divers. These figures do not give any support for that water levels should have been exceptionally stable in 2006. We do not have any data on water level fluctuations from the only lake with a successful breeding, but in another lake where the divers did not succeed in producing young, water levels were very stable (± 5 cm) during the nesting stage of the breeding season. Breeding success was in other words higher at sites with a larger variation in water levels, a finding completely at odds with expectations. Hence stability in water levels seems unlikely as the explanation for the good breeding results.

As mentioned above, breeding results in lakes were poorer than at the coast. Furthermore, no divers were stationary in Bolundsfjärden this year, a site that held divers in all earlier years. These findings may indicate negative effects from the site investigations although this conclusion is speculative. Never the less, there were site investigation activities in and at Bolundsfjärden during spring 2006 that may have disturbed the divers and prevented them from using that lake. Furthermore, the only lake with a successful breeding in 2006 was not visited during any other part of the site investigation work. In other words, this lake is ‘undisturbed’ when it comes to activities associated with the site investigations.

These results show that longer time periods are needed for monitoring long-lived species like the divers if one is going to reach any well based conclusions.

Honey buzzard *Pernis apivorus* Bivråk (Sw. Red List; EU Annex 1)

Honey buzzard numbers were at the same level as in 2005. At least eight territories were registered in both years. Over the five-year period 2002–2006 the local population shows a significantly positive, increasing trend (Spearman rank correlation: $r_s = 0.95$, $p = 0.014$, $N = 5$). 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.

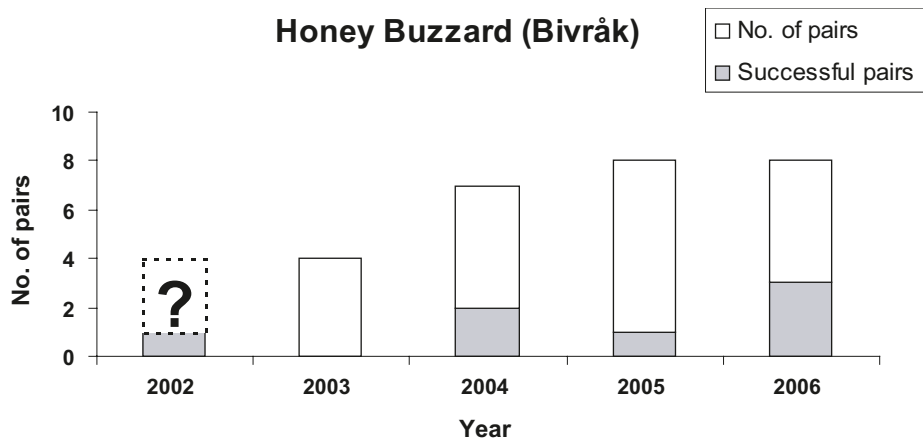


Figure 5-2. Number of territorial pairs of honey buzzards within the regional model area in Forsmark 2002–2006. Shading shows number successful pairs. The exact number of territorial pairs in 2002 is not known. An (at the time) well based estimate is shown.

Still, the numbers do certainly show that on a general level, honey buzzards are doing fine in Forsmark. At least one territory had its centre within the candidate area in 2006 and one more had parts extending into the candidate area. As usual, some territories were situated along the borders of the regional model area, with parts both inside- and outside of this. In the calculations of numbers of pairs such territories are counted as half territories. The geographical distribution of territories seems to be rather stable between years. In and around the regional model area eleven territories have been used during the five years. At least eight have been used for three-five of these years. Used nest sites seem to vary between years but the territories essentially remain the same.

Breeding results were not monitored in detail in 2006, but the general impression is that breeding success was good. At least three pairs produced young, six large young in total giving a minimum local breeding success of 0.75 young/territorial pair. For the whole five year period 2002–2006 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 and Ryttman 1994/), but within the calculated interval for what is needed to keep population size constant (0.34–0.67 young/pair and year /Tjernberg and Ryttman 1994/). Long-time breeding output at a national level in Sweden is estimated to be 0.30 young/pair and year /Tjernberg and 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. More detailed studies would allow us to get more correct values on this.

There are no signs of any impact from the site investigations on local population size or breeding output of honey buzzards in Forsmark.

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 /Artdatabanken 2005/. 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.

White-tailed eagle *Haliaeetus albicilla* Havsörn (Global Red List, Sw. Red List; EU Annex 1)

In 2006, the breeding success of white-tailed eagle in the Forsmark area dropped to its lowest level since 2002. Breeding success was lower than in 2002–2005 also in the reference areas this year. The aerial survey in April revealed that an unusually large proportion of the pairs present at the nest sites were not breeding. This was most probably in part due to weather conditions.

Table 5-1. Per cent successfully breeding pairs of White-tailed Eagles in 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	N
Forsmark	85	25	33	50	75	25	32
Reference S	79	100	80	100	83	50	47
Reference N	72	83	67	86	29	29	51

A cold spell during March (egg-laying period) in this area apparently made some pairs not lay eggs or terminate their breeding attempt at an early stage. As an example from a survey flight, one non-breeding adult pair in a reference area was observed sitting together on a thick icy cake of snow covering the nest, and were apparently unable to scratch the snow away. About 70% of the non-productive pairs in Forsmark including reference areas were not producing eggs this year, a very unusual situation in this species.

Although there is no conclusive evidence that the poor breeding success in the Forsmark area this year was linked to human disturbance, the considerably lower average success over the period from 2002 as compared to previous years in this study area and the reference areas implies an impact from the strongly increased activities in the area. If activities in the area will decrease in coming years it will be interesting to follow what will happen with the breeding success of the white-tailed eagles.

Osprey *Pandion haliaetus* Fiskgjuse (EU Annex 1)

Osprey results in Forsmark have been extremely stable during the last three years. During these, numbers of pairs have been at the same level and breeding success has been high. For 2006 this is somewhat surprising as at least four nests fell down during the winter 2005–2006. This meant that there were several changes in the geographical distribution of birds since last year. The ospreys built new nests and population size and breeding output were essentially unchanged. The redistribution of nests meant that some pairs moved out of the regional model area, but the new nests are still in the vicinity of this and hence included in the total sum.

Also for the last five years there is no significant change in osprey numbers breeding around Forsmark (Spearman rank correlation: $r_s = 0.78$, $p = 0.12$, $N = 5$).

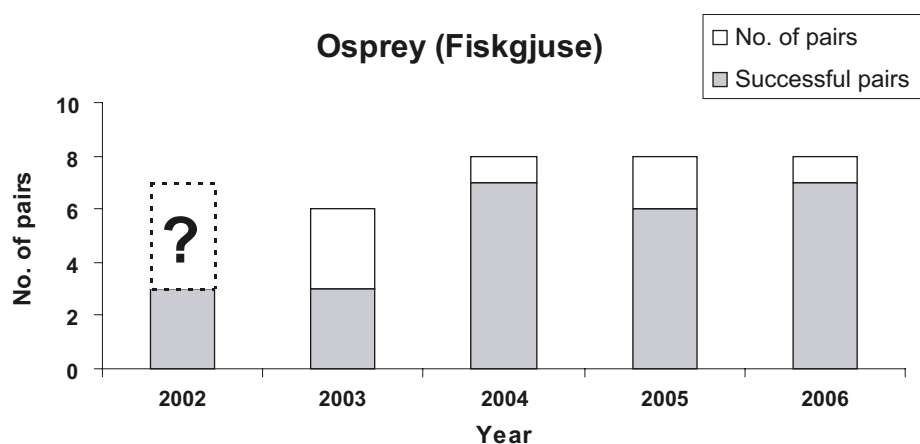


Figure 5-3. Number of nesting attempts (territorial pairs) of ospreys in Forsmark 2002–2006. Number of successful nests (shaded parts) are shown as well. The exact number of territorial pairs in 2002 is not known. A well based estimate is shown.

Osprey breeding output

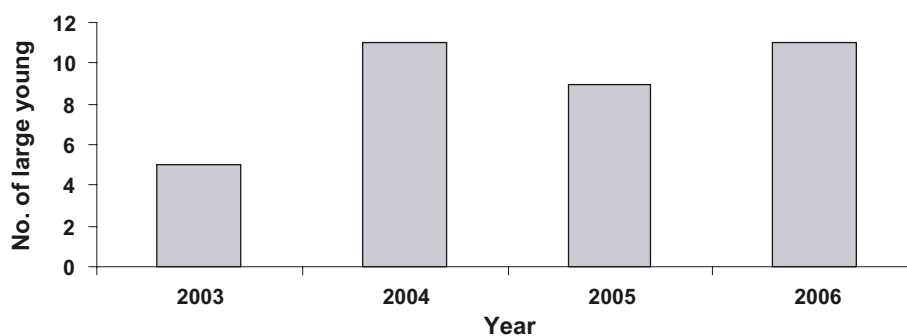


Figure 5-4. Number of large young of ospreys produced in Forsmark 2003–2006. Number of large young per breeding attempt was 0.83 in 2003, 1.38 in 2004, 1.12 in 2005 and 1.38 in 2006.

Eight pairs started breeding in 2006 and seven of these produced in total eleven large young, yielding an average of 1.38 young/pair. These figures are very similar to what was found in 2004–2005.

In the years 2003–2006 a total of 36 large young have been fledged in Forsmark, giving an overall average local breeding output of 1.20 young/pair. This 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/.

No pairs bred within the candidate area in 2006. Actually not a single breeding attempt has been registered within this area during the five years. One pair bred relatively close to the candidate area. The other pairs breeding in these parts in earlier years probably moved to other places in 2006.

Black grouse *Tetrao tetrix* Orre (EU Annex 1)

The increase in black grouse numbers continued in 2006 (cf. /Green 2006/). Numbers of lekking males increased significantly both in the candidate area (Spearman rank correlation: $r_s = 0.98$, $p = 0.005$, $N = 5$) and in the regional model area at large (Spearman rank correlation: $r_s = 0.99$, $p = 0.004$, $N = 5$). To some extent the degree of increase may be somewhat inflated by the low estimated population level in 2002 (no full coverage of lekking males was attained in that year, but an estimate is used in the comparison). Numbers within the candidate area were however monitored in a detailed way also in 2002, lending support for that the pattern shown is the true one.

As in earlier years the pattern found within the regional model area corresponds well with patterns experienced at a larger regional scale as well (author's observations). Numbers of black grouse are known to follow cyclical patterns with periods of relatively low numbers alternating with periods of higher numbers. Apparently we are now in one of these 'higher number periods', after a 'low period' in the late nineties and early 2000's. Should the local population follow these patterns we would expect black grouse numbers to start declining again in the years to come.

Interestingly a shift in lekking habits has been registered in parallel with the general population increase. While most registered lekking males were solitary in the early part of the five year period, we are now getting larger, multiple male leks. In 2006 16 males (57% of the total number) were at leks containing more than one male. Four leks in 2006 held more than one

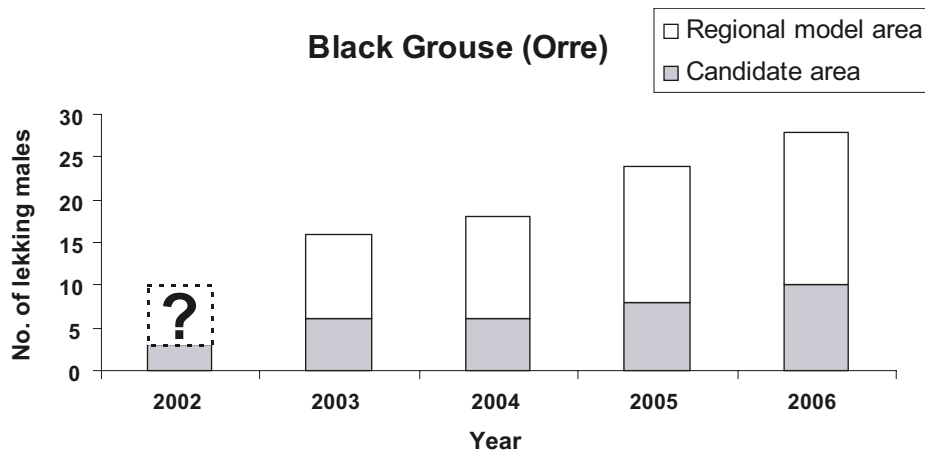


Figure 5-5. The recorded number of lekking black grouse males in Forsmark 2002–2006. Shaded parts show the numbers within the candidate area. Exact number of lekking males in 2002 is not known. A well based estimate is shown.

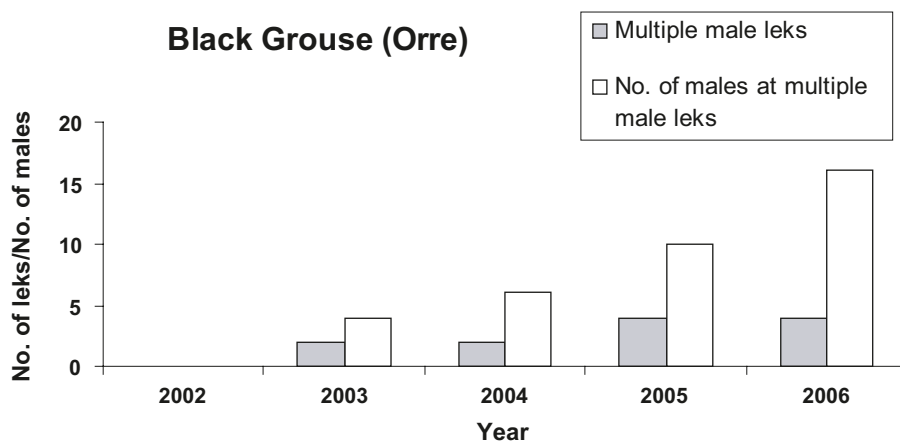


Figure 5-6. The recorded number of lekking black grouse males in Forsmark 2002–2006 found at leks containing more than one male. Shaded bars show the number of such multiple male leks within the regional model area.

male. At the largest lek eight males were present in 2006. At the same time as leks are getting bigger, flocks of females have also been registered during the lekking period in a way not seen during the earlier years. In 2006, three such flocks were seen in and around the regional model area containing in total 18 females (5+5+8).

There are no signs of any impact from the ongoing site investigations. On the contrary lekking males are found in close proximity to ongoing human activities within the candidate area.

Capercaillie *Tetrao urogallus* Tjäder (EU Annex 1)

Capercaillies have not been intensively monitored in the whole regional model area in all years. Instead, the number of males present at a central lekking ground has been counted annually since 2003. This lekking ground is situated outside, but relatively close to, the candidate area. Numbers of males here have been fluctuating between three and five during the last years, and in 2006 the highest number so far, six males, was recorded.

Special effort was in 2006 directed at monitoring the home ranges and numbers of capercaillies in the whole regional model area. The aim was to follow up results gathered during the first years of the site investigation period. These indicated that the capercaillie was one of the few

Capercaillie (Tjäder)

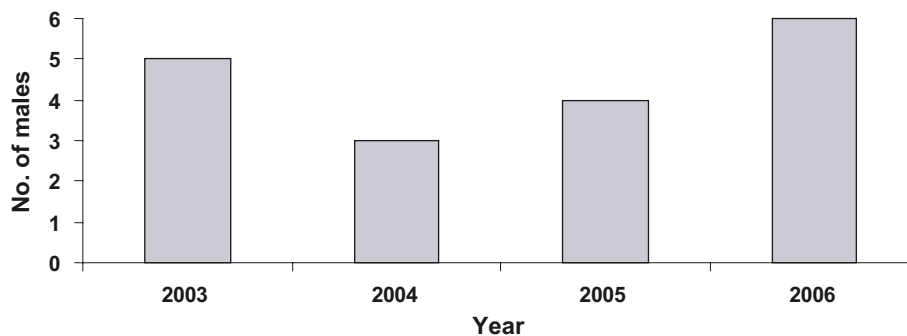


Figure 5-7. The recorded number of capercaillie males in 'the central area' at Forsmark 2003–2006 (see text).

species where there might be a negative effect of the site investigations. The data indicated a change in utilisation of the area with birds avoiding parts with increased human presence, parts that they used before the site investigations started /Green 2005/. Hence home ranges were monitored during spring 2006 in areas where capercaillies were registered during 2002–2004.

Results from 2006 show that:

- i) Home ranges of capercaillies around the 'central area' were larger in 2006 compared to 2004, but smaller than what was recorded in 2002. In essence the birds moved around within an area very similar to the one found in 2003 (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 similar or larger than the ones registered during the early years of the site investigations.
- iv) General numbers of capercaillies must have increased in later years, compared to the 2002–2003 situation. In all, at least twelve lekking males and at least 10 females were registered in 2006.

In conclusion, overall numbers of capercaillies have increased during the five years. It seems as if the home ranges of capercaillies now are increasing again, possibly as a result of less human activities in the area when the most intensive parts of the site investigations are over and probably also connected to the overall population increase. The situation found in 2006 was somewhere in between what was found in 2002 and the one found in 2004. It will be interesting to follow whether the situation in 2007 will reach the 2002 level again.

Capercaillie numbers have undoubtedly been increasing also at a larger regional scale (outside the regional model area), in a similar way as black grouse numbers (author's observations, Peter Hunger pers. comm.). At least three more lekking grounds, holding a minimum of ten (5+3+2) males were found outside but close to the regional model area during other work in 2006.

Hazelhen *Bonasia bonasia* Järpe (EU Annex 1)

As for capercaillies, hazelhens have not been monitored in every year during the five years. Basically there has been only one full survey of the species and this was made in 2004. In 2002–2003 all parts of the regional model area were visited but no survey specifically directed at hazelhens was made. The aim of the survey in 2006 was very similar as the one regarding the capercaillies. Earlier results indicated that the species might be sensitive to disturbances from the site investigations /Green 2004, 2005/.

Hazelhen (Järpe)

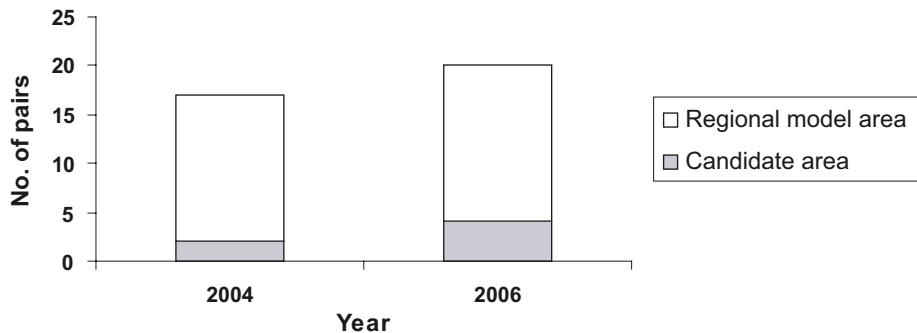


Figure 5-8. The recorded number of hazelhen pairs at sites in Forsmark visited both 2004 and 2006. Shaded bars show numbers in the candidate area.

In total 23 sites holding hazelhens in earlier years or being classified as suitable for hazelhens (from vegetation maps) and visited in 2004 were visited again in 2006.

Number of occupied territories were similar between the two years as shown in Figure 5-8 above. Overall, a small increase from 17 to 20 occupied territories was registered. Going more into detail, the results were that, in the regional model area, eleven territories were occupied both in 2004 and 2006, four were occupied only in 2004 (vacant in 2006) and five were vacant in 2004 and occupied in 2006. Corresponding figures for the candidate area were that two territories were occupied in both years, and two only in 2006 (vacant in 2004). Interestingly the two territories occupied only in 2006 were both in association with the drilling site at Jungfruholm (active drilling made in 2003). At least one occupied territory was found here in 2002 but no hazelhens were recorded in 2003 and 2004. It seems as if the disappearance was only temporary and coinciding with more disturbing activities within the site investigations. Whether the disturbance was the actual cause of the disappearance we can never know for sure, but it seems likely that there was a connection.

21 occupied hazelhen territories were registered in 2006, including one found at a site not visited in 2004. Furthermore, about five sites holding hazelhens in earlier years were not visited in 2006 at the same time of the year. Thus all sites suitable for hazelhens could not be visited neither in 2004 nor in 2006, making it possible that the earlier estimate of total local population size (30 pairs) still holds as a reasonable estimate.

Ural owl *Strix uralensis* *Slaguggla* (EU Annex 1)

Local population size of ural owls increased further up to a new record level of seven active territories (containing pairs). The increase registered in later years is statistically significant (Spearman rank correlation: $r_s = 0.89$, $p = 0.041$, $N = 5$) and 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.

Breeding success was exceptionally good in 2006, even better than in 2005. Of the seven stationary pairs, six produced large young. Altogether no less than 20 large young were registered during the early part of summer, giving an average of 2.86 fledged young/occupied territory. Overall average breeding output during 2002–2006 was 1.46 fledged young/occupied territory and year.

Ural Owl (Slaguggla)

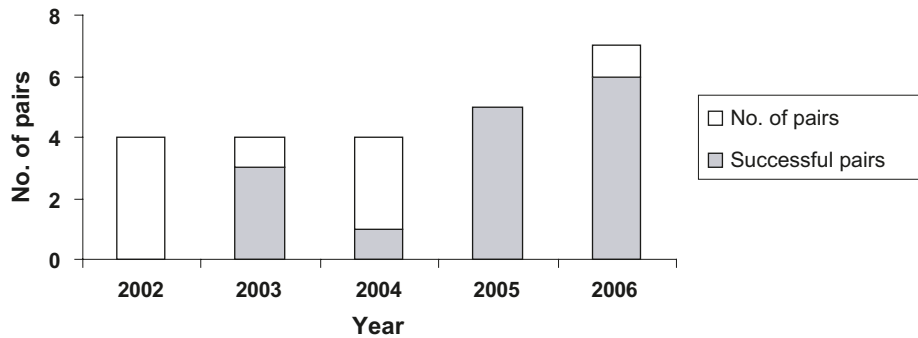


Figure 5-9. Number of territorial pairs of ural owl within the regional model area in Forsmark 2002–2006. Shown is also the number of successful pairs (shaded).

Ural Owl (Slaguggla)

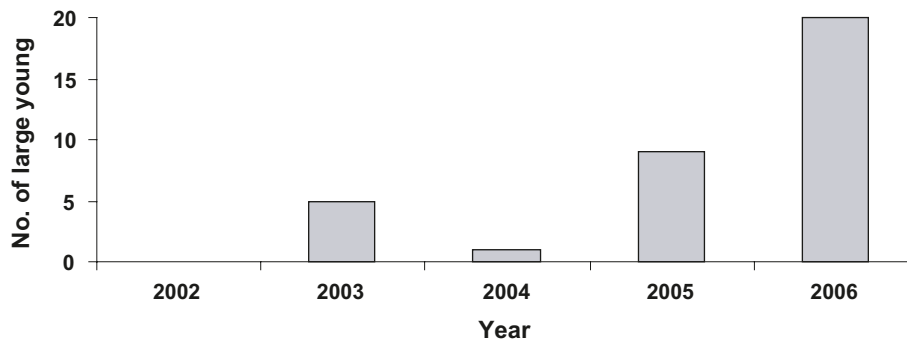


Figure 5-10. Number of large ural owl young produced per year in Forsmark 2002–2006.

The obvious reason behind the high breeding output in 2006 was the high abundance of voles, especially bank voles, the favourite prey of ural owls. Bank voles were present everywhere and many predators were seen bringing these to feed their young during the summer.

There does not seem to be any impact from the site investigations on the ural owls in the area. However, records from the pre-site investigation period (before 2002) indicate established territories also within the candidate area, something that has not been the case during the last five years. Overall, the local distribution of ural owls is somewhat puzzling. The distribution is very clumped with several pairs breeding relatively close to each other (inter-territory distances of 1.5–2 km) in certain parts, at the same time as other parts with suitable habitat and access to nest sites are empty.

Wryneck *Jynx torquilla* Göktyta (Sw. Red List)

After the record year in 2005, cf. /Green 2006/, it was more or less expected that numbers should drop in 2006, and so they did. Numbers dropped from 59 occupied territories in 2005 to 38 in 2006, a 36% decrease. This means that numbers in 2006 were back at the same level as recorded in 2003–2004. The patterns have been more or less parallel in the candidate area and in the regional model area at large. There are no tendencies of any impact from the site investigations on local population size.

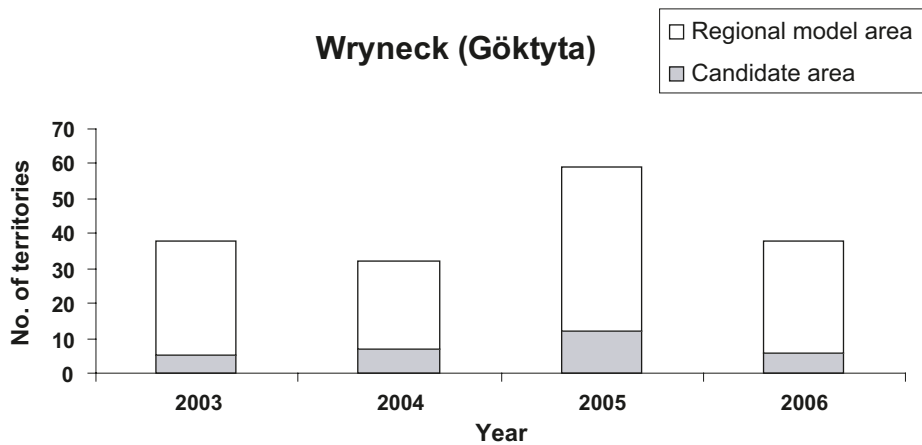


Figure 5-11. Number of occupied wryneck territories in well monitored parts of Forsmark in 2003–2006. Shading shows the number of occupied territories within the candidate area.

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 and Svensson 2006/. 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 1900’s. National population size is estimated to be 5,500–15,000 pairs /Artdatabanken 2005/. 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)

Fifteen territories were registered in parts covered well in all years of the site investigations. This is a continued small increase from last year when fourteen territories were registered. In total, sixteen occupied territories were found within the regional model area in 2006, again a small increase from last years fifteen.

Within the candidate area numbers increased again after two years with just one recorded pair. The additional site used in 2006 is the same as the one used in the early years of the site investigations and it might be that birds were actually disturbed during the most intensive parts of the investigations, but now when human presence is lower, the territory is occupied again.

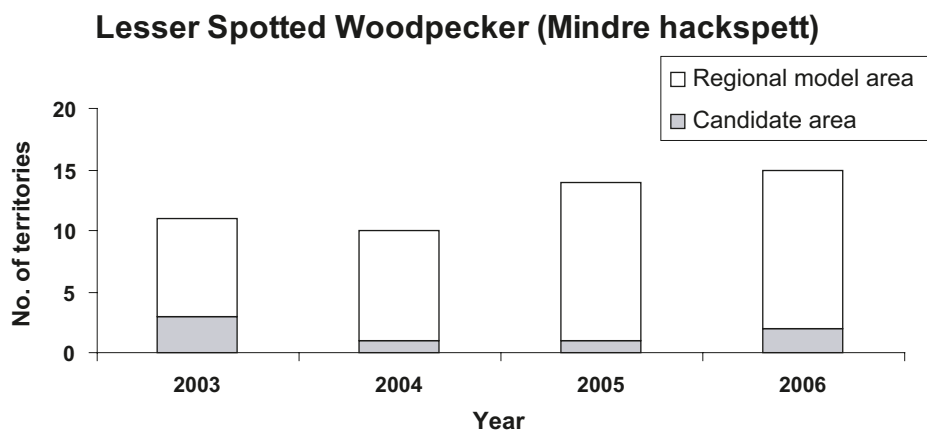


Figure 5-12. Number of occupied territories of lesser spotted woodpeckers in areas monitored in all four years 2003–2006 in Forsmark. Shading shows numbers of occupied territories in the candidate area.

This looks like a parallel case to what has been recorded for capercaillies and hazelhen, but unlike in those cases, the results are rather unexpected.

Numbers within the regional model area were stable between 2005 and 2006 and it seems as if the increase registered in 2003–2005 now has levelled off. Territories used in 2006 were almost exactly the same ones as were used in 2005.

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 are thought to have remained fairly stable during the last decade. The lesser-spotted woodpecker has been negatively affected by the loss of dead wood due to modern forestry and also by the conversion of mixed and deciduous forests to monoculture conifer forests. National population size is estimated to about 3,000 pairs /Artdatabanken 2005/.

Red-backed shrike *Lanius collurio* Törnskata (Sw. Red List; EU Annex 1)

Shrike numbers were again high in 2006. 64 occupied territories were recorded and in parts checked equally well in both 2005 and 2006, the number of pairs were exactly identical in 2005 and 2006. There are no indications of any negative impact from the site investigations on the local shrike population.

As in 2005, the population development of shrikes in Forsmark is shown below with an index (Figure 5-13). As areas covered during the site investigation period have differed between the years, at least outside the candidate area, the development is shown as an index instead of absolute numbers. Here I have used a chain index where the percent change between areas checked equally well in years following each other are compared. Index for 2003 (the first year with decent coverage of the species) is set to one. The figure should be read as there has been a 41% increase in red-backed shrike numbers within the candidate area between 2003 and 2006, and a 60% increase in the regional model area outside the candidate area, i.e. general population development is positive and the increase is more or less parallel in the candidate area and in the regional model area.

Habitat distribution of shrike territories in Forsmark in 2006 was similar to the patterns found in earlier years cf. /Green 2005/. The absolute majority of territories are found under electrical power wires (39%), in clear-cuts (36%) and in semi-natural pastures (19%). The proportion using semi-natural pastures has increased somewhat, probably as result of management actions in order to restore such areas in later years.

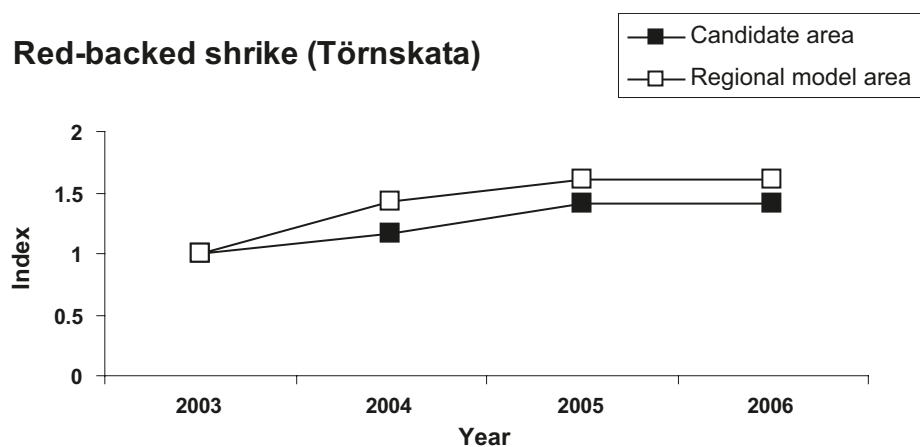


Figure 5-13. Population development of red-backed shrikes in Forsmark 2003–2006 shown as a chain index. Index for year 2003 is set to 1. See text for further explanations.

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 and Svensson 2006/ and numbers in a well-studied, predominantly farmland area outside Uppsala decreased from 120 to 60 pairs during 1998–2003 /Artdatabanken 2005/. 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 /Artdatabanken 2005/.

Table 5-2 presents a summary of general population changes of the monitored species in Forsmark between 2005 and 2006.

Table 5-2. General population changes of selected listed species in Forsmark between 2005 and 2006. (In a few cases, the difference between 2004 and 2006 is shown, i.e. for capercaillie and hazelhen). 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 2006 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	0	Good
White-tailed Eagle			0	Poor
Osprey	0	0	0	Good
Black grouse	+	+	+	
Capercaillie	+	+	+	
Hazelhen	+	+	+	
Ural owl	+	0	+	Extremely good
Wryneck	–	–	–	
Lesser Spotted Woodpecker	0	+	+	
Red-backed shrike	0	0	0	

6 Discussion

The bird monitoring in Forsmark has now been running for five years, and for the first time we can, at least for some species, analyse the results statistically. Still, it should be remembered that five years is a short period and even if statistical testing now is possible, the power of such tests is low. In other words, there is a risk of missing relationships even if they exist since sample size is very small. Never the less, most results from Forsmark are relatively clear and there is not much controversy in the findings. As in earlier years, the majority of the monitored species are doing fine, showing a positive or stable population development and do not show any signs of being affected at all by the site investigations. Instead it seems as if the factors behind changes in population size are multifaceted and different from impacts from the site investigations.

Looking back at the five years and trying to summarize found patterns species for species, we find that six out of the eleven species selected for monitoring have not shown any signs at all of being disturbed by the increase in human presence in the area due to the site investigations. These are honey buzzard, osprey, black grouse, ural owl, wryneck and red-backed shrike. For some of these species, the findings are in part dependent on that no nests have been situated within close distance from site investigation activities (honey buzzard, osprey and ural owl) and the situation might have been different if nests had been closer to such activities. Furthermore we can not rule out that the absence of ospreys and ural owls from the candidate area actually is related to a high level of human presence. At least for ural owls we know that there used to be occupied territories in the candidate area before the site investigations started.

For the remaining five species there may have been, or still are, impacts from the site investigations at least on geographical distribution of birds. We do however not have any signs at all of that the site investigations should have affected the general population size in any way. Black-throated diver numbers have been very stable in all years, but breeding success was low in four out of five years. The low breeding success is probably not related to the site investigations but have other explanations. Still, disturbing activities in Bolundsfjärden may have affected the divers use of that site in 2006.

The white-tailed eagles show another pattern through the period. Number of pairs has been stable but breeding output has varied. During the first year of the site investigations breeding success was very low, possibly a response to the sudden increase in human presence in the area. In the following three years, breeding success progressively became better giving indications of that the mitigation efforts taken to reduce the disturbance of eagles were working and/or that the eagles were acclimatizing to the increased human presence. This trend was broken in 2006 when breeding output again was very low. Still, this was in part due to other factors than human disturbance (at least one nest fell down during the incubation period, Björn Helander pers. comm.) and 2006 was generally a poor breeding year for the eagles also at a larger scale.

Comparing local breeding success for white-tailed eagles between the four years before the site investigations started (1998–2001) with the five years of site investigations (2002–2006) we find that average breeding success was only half (42% of all attempts successful, $N = 19$) during the latter period compared to the earlier period (85% of all attempts, $N = 13$). Making the same comparison for the reference areas north and south of Forsmark, average breeding success for the first period was 76% of all attempts and for the latter period 71% of all attempts (overall $N = 98$, data from Björn Helander, Swedish Museum of Natural History, Stockholm). Both these comparisons indicate that something has been going on in Forsmark during the site investigation period, that did not happen there before and that this has not happened in surrounding areas. The most plausible explanation is possibly that this in fact is a negative effect due to the site investigations.

The forest hens, capercaillie and hazelhen did initially show signs of avoiding areas with high levels of human activities. Now there are signs of that they are getting back to their pre-site investigation period (or at least early site investigation) distributions. It should also be remembered that at the same time as there have been indications of changes in distribution, there have not been any signs of population decrease. On the contrary both species seem to do fine and have, at least during the last years, actually increased in numbers. Capercaillies have still not been found within the candidate area since 2002, and it will be interesting to follow if they will get back into these parts as well when (if?) human presence in the area decreases even more.

The lesser spotted woodpeckers show a similar pattern as the capercaillies and hazelhens. While overall population size has increased, numbers within the candidate area initially decreased. In 2006 there were signs of that lesser spotted woodpeckers are getting back to the distribution found in earlier years.

The summarized results above show, as mentioned many times before, that finding true patterns and disentangling possible effects of activities like the site investigations requires continued monitoring for long time periods. Every year of data collection add further insight and statistical power to the analyses and interpretations that are possible to make. We are now getting a nice time series of monitoring data from Forsmark, enabling much more detailed analyses and conclusions than earlier comparisons. It is therefore strongly recommended that monitoring of the selected listed species should continue for as long as the site investigations continue.

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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 2002–2005. Since the Swedish Red List was updated in 2005, a few species being red-listed before, but not after, 2005 are included as well. These species are shown within parenthesis. Otherwise the listing follows the updated version of the Red List /Gärdenfors 2005/. Species added to the Red list in 2005, not included before 2005 are marked with an asterisk (*).

English name	Swedish name	Latin name	Listing	Estimated population size (pairs/territories) in Forsmark (regional model area)
Whooper Swan	Sångsvan	<i>Cygnus cygnus</i>	EU	5
(Gadwall)	(Snatterand)	(<i>Anas strepera</i>)	(SRL)	4
Shoveler	Skedand	<i>Anas clypeata</i>	SRL	6
Pochard	Brunand	<i>Aythya ferina</i>	SRL	1
Velvet Scoter	Svärta	<i>Melanitta fusca</i>	SRL	7
Hazelhen	Järpe	<i>Bonasia bonasia</i>	EU	30
Black Grouse	Orre	<i>Tetrao tetrix</i>	EU	28
Capercaillie	Tjäder	<i>Tetrao urogallus</i>	EU	12
Quail	Vaktel	<i>Coturnix coturnix</i>	SRL	1
Black-throated Diver	Storlom	<i>Gavia arctica</i>	EU	5
Slavonian Grebe	Svarthakedopping	<i>Podiceps auritus</i>	SRL, EU	0–1
Bittern	Rördrom	<i>Botaurus stellaris</i>	SRL, EU	3–4
Honey Buzzard	Bivråk	<i>Pernis apivorus</i>	SRL, EU	8
White-tailed Eagle	Havsörn	<i>Haliaeetus albicilla</i>	SRL, EU	4
Marsh Harrier	Brun kärrhök	<i>Circus aeruginosus</i>	EU	5
Osprey	Fiskgjuse	<i>Pandion haliaetus</i>	EU	8
Spotted Crane	Småfläckig sumphöna	<i>Porzana porzana</i>	SRL, EU	1–3
Corncrake	Kornknarr	<i>Crex crex</i>	SRL, EU	0–1
Crane	Trana	<i>Grus grus</i>	EU	25
Curlew*	Storspov*	<i>Numenius arquata*</i>	SRL	3
Turnstone	Roskarl	<i>Arenaria interpres</i>	SRL	10
Lesser Black-backed Gull	Silltrut	<i>Larus fuscus</i>	SRL	97
Common Tern	Fisktärna	<i>Sterna hirundo</i>	EU	95
Arctic Tern	Silvertärna	<i>Sterna paradisaea</i>	EU	234
(Black Guillemot)	(Tobisgrissla)	(<i>Ceppus grylle</i>)	(SRL)	50
Stock dove	Skogsduva	<i>Columba oenas</i>	SRL	10
Pygmy Owl	Sparvuggla	<i>Glaucidium passerinum</i>	EU	20
Ural Owl	Slaguggla	<i>Strix uralensis</i>	EU	7
Tengmalms Owl	Pärluggla	<i>Aegolius funereus</i>	EU	0–2
Wryneck	Göktyta	<i>Jynx torquilla</i>	SRL	40–60
Grey-headed Woodpecker	Gråspett	<i>Picus canus</i>	EU	0–2
Black woodpecker	Spillkråka	<i>Dryocopus martius</i>	EU	13
Lesser Spotted Woodpecker	Mindre hackspett	<i>Dendrocopus minor</i>	SRL	16
Three-toed Woodpecker	Tretåig hackspett	<i>Picoides tridactylus</i>	SRL, EU	1–2
Wood Lark	Trädlärika	<i>Lullula arborea</i>	EU	1–2
Skylark*	Sånglärika*	<i>Alauda arvensis*</i>	SRL	9

English name	Swedish name	Latin name	Listing	Estimated population size (pairs/territories) in Forsmark (regional model area)
Wheatear*	Stenskvätta*	<i>Oenanthe oenanthe</i> *	SRL	6
Grasshopper Warbler*	Gräshoppstångare*	<i>Locustella naevia</i> *	SRL	1–2
River Warbler	Flodsångare	<i>Locustella fluviatilis</i>	SRL	0–1
Greenish Warbler	Lundsångare	<i>Phylloscopus trochiloides</i>	SRL	0–1
Red-breasted Flycatcher	Mindre flugsnappare	<i>Ficedula parva</i>	SRL, EU	5
Marsh Tit*	Entita*	<i>Parus palustris</i> *	SRL	20
Red-backed Shrike	Törnskata	<i>Lanius collurio</i>	SRL, EU	80
Nutcracker	Nötkråka	<i>Nucifraga caryocatactes</i>	SRL	5
Linnet*	Hämpling*	<i>Carduelis cannabina</i> *	SRL	4
Scarlet Rosefinch*	Rosenfink*	<i>Carpodacus erythrinus</i> *	SRL	50
Ortolan Bunting	Ortolansparv	<i>Emberiza hortulana</i>	SRL, EU	1