

## Scandlynx: a vision for coordinated lynx research in Scandinavia

John D. C. Linnell  
Henrik Andréén  
Olof Liberg  
John Odden  
Ketil Skogen  
Reidar Andersen



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Inga E. Bruteig

SIGNATURE OF RESPONSIBLE PERSON

Head of research division, Inga E. Bruteig

CLIENT(S)

Directorate for Nature Management (N), Swedish Environmental Protection Agency (S)

CLIENTS' CONTACT PERSON(S)

DRAWING FRONTPAGE

Manuela Panzacchi

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CONTACT DETAILS

**NINA Trondheim**

NO-7485 Trondheim

NORWAY

Phone: +47 73 80 14 00

Fax: +47 73 80 14 01

**NINA Oslo**

Postboks 736 Sentrum

NO-0105 Oslo

NORWAY

Phone: +47 73 80 14 00

Fax: +47 22 33 11 01

**NINA Tromsø**

Polarmiljøsentret

NO-9296 Tromsø

NORWAY

Phone: +47 77 75 04 00

Fax: +47 77 75 04 01

**NINA Lillehammer**

Fakkelgården

NO-2624 Lillehammer

NORWAY

Phone: +47 73 80 14 00

Fax: +47 61 22 22 15

<http://www.nina.no>

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## Sammendrag

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Rapporten presenterer en planer for framtidig forskning på gaupe i Skandinavia. Fokuset er satt på forskning som skal gi forvalterne kunnskap til å sikre en bærekraftig forvaltning av gaupa i framtida. Vi foreslår at all forskning på gaupe i Skandinavia koordineres under én paraply med navnet Scandlynx. Dette vil gi en best mulig utnyttelse av ressursene. I tillegg vil et skandinavisk prosjekt gjøre oss bedre i stand til å konsentrere forskningen til steder som gir mest relevante data. Vi foreslår 3 intensive studieområder – et i Sarek nord i Sverige, et i Bergslagen sør i Sverige og et område på begge sider av grensen mellom de sørøstre deler av Norge (Hedmark, Akershus and Østfold fylker) og de svenske länenene Värmland og Västra Götaland. Forskning i disse områdene vil oppfylle de fleste av kriteriene skissert i rapporten. Prosjektet vil prioritere langtidsoppfølging av voksne hunngauper og deres avkom for å få data på demografi og spredningsatferd. De viktigste forskningstema aktuelle for forvaltningen er etter vår mening (1) høsting (krever data på demografi hos gaupe under ulike miljøforhold), og (2) rekolonisering av sørlige deler av Sverige (krever data på spredning). I tillegg vil aktuelle tema være rovdyr – byttedyr forhold, “intra-guild” interaksjoner med rødrev, ulv og jerv og predasjon på tamrein.

John D. C. Linnell, John Odden & Ketil Skogen, Norsk institutt for naturforskning, Tungasletta 2, N-7485 Trondheim, Norge. [john.linnell@nina.no](mailto:john.linnell@nina.no)

Henrik Andrén & Olof Liberg, Grimsö forskningsstation, Inst. för naturvårdsbiologi, SLU, SE-730 91 Riddarhyttan, Sverige. [henrik.andren@nvb.slu.se](mailto:henrik.andren@nvb.slu.se).

Reidar Andersen, Zoologisk Institutt, Norges teknisk-naturvitenskapelige universitet, N-7491 Trondheim, Norge. [reidar.andersen@bio.ntnu.no](mailto:reidar.andersen@bio.ntnu.no).

## Abstract

Linnell, J. D. C., Andrén, H., Liberg, O., Odden, J., Skogen, K. & Andersen, R. 2005. Scandlynx: a vision for coordinated lynx research in Scandinavia. - NINA Rapport 86. 26 pp.

This document presents a vision for research needs on Eurasian lynx in Scandinavia. The focus is on applied research to provide managers with the knowledge they need to ensure lynx management is sustainable in the future, although we underline the scientific value of this research as well. We propose to fully integrate lynx research in Norway and Sweden under the umbrella of a coordinated project called Scandlynx. This allows us to address research questions in the site which offers the best opportunities and reduced duplication of effort. We propose to maintain 3 intensive study sites - one in Sarek in northern Sweden, a second in Bergslagen in south-central Sweden and a third spanning the border between southeastern Norway (Hedmark, Akershus and Østfold counties) and the Swedish counties of Värmland and Västra Götaland. Together these sites should fulfill most of the needs outlined in our vision. The priority for data collection is to follow a sample of adult females and their offspring for as many years as possible. This allows the collection of demographic data, and dispersal data. The management issues which are regarded as being most important (1) harvest - which requires data on lynx demographics in contrasting conditions, and (2) lynx colonization of southern Sweden which requires data on dispersal. Secondary topics focus on predator-prey relationships with roe deer, intra-guild interactions with red fox, wolf and wolverine, and depredation on semi-domestic reindeer.

John D. C. Linnell, John Odden & Ketil Skogen, Norwegian Institute for Nature Research, Tungasletta 2, N-7485 Trondheim. [john.linnell@nina.no](mailto:john.linnell@nina.no)

Henrik Andrén & Olof Liberg, Grimsö Wildlife Research Station, Department of Conservation Biology, Swedish University of Agricultural Sciences, SE-730 91 Riddarhyttan, Sweden. [henrik.andren@nrb.slu.se](mailto:henrik.andren@nrb.slu.se).

Reidar Andersen, Department of Zoology, Norwegian University of Science and Technology, N-7491 Trondheim, Norway. [reidar.andersen@bio.ntnu.no](mailto:reidar.andersen@bio.ntnu.no).

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## **Preface**

Intensive lynx research has been ongoing in Scandinavia since 1994. During this period cooperation between Norway and Sweden has become closer, to the extent that we now wish to present the activity in both countries as a common concept - Scandlynx. As requested by the Fennoscandian Coordination Committee for Large Carnivore Research in June 2005 this document aims to set out an outline of the most important knowledge needs, and a research plan for filling in these gaps.

Trondheim, september 2005

John D. C. Linnell  
Project coordinator  
Norway

Henrik Andrén  
Project coordinator  
Sweden



# 1 Background

Ecological research on Eurasian lynx (*Lynx lynx*) in Scandinavia dates back into the 1960's with the classic snow-tracking studies of Bertil Haglund, and continued through the 1970's and 1980's with Svein Myrberget's and later Tor Kvam's studies of lynx status, reproduction and diet based on hunter killed animals. In the 1980's attempts were made to begin using radio-telemetry methods in both Norway and Sweden, however these projects never got beyond the pilot stage.

The modern era of lynx research started in 1994 when large scale radio-marking projects started in both Nord-Trøndelag (Norway) and Sarek (Sweden) (**Figure 1**). These were followed by projects starting in southeastern Norway in 1995 and Bergslagen (Sweden) in 1996. The lynx studies in Bergslagen and southeastern Norway have both been complimented by intensive studies of their main prey, the roe deer (*Capreolus capreolus*), mainly making use of radio-collared animals (>500 individuals collared), and of red fox (*Vulpes vulpes*) that are a fellow guild member (they also prey on roe deer), a common victim of intra-guild predation by lynx, and a source of scabies infection that occasionally kills lynx.

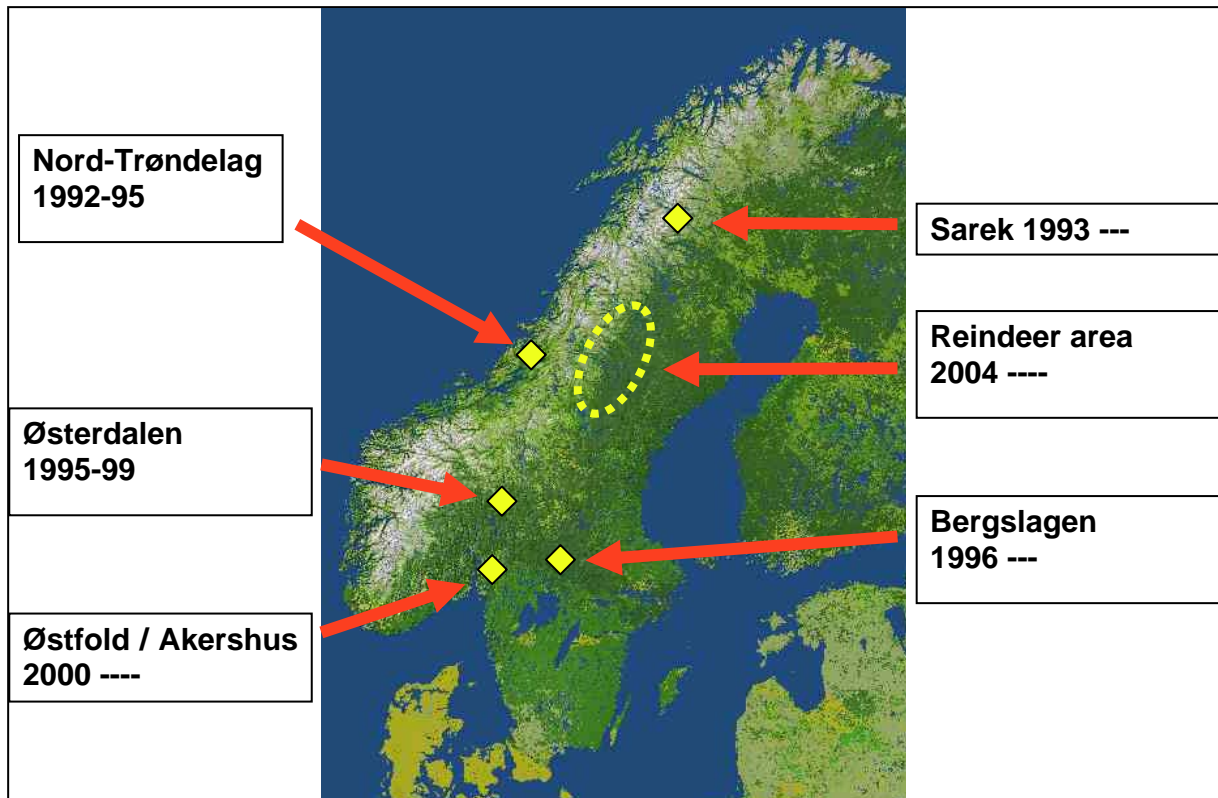
In the period from 1994-2005 a total of 258 individual lynx have been captured and radio-marked, in addition to more than a hundred more being marked with ear-tags, tattoos or microchips (**Figure 2**). This field activity has already led to >30 peer reviewed scientific papers (printed, in press or submitted), 66 technical reports or other Scandinavian language publications, 39 completed student theses, and a wide range of popular articles. These publications however, only represent the tip of the iceberg as the main projects are only just entering the analysis and writing stage. In addition to this field activity there has also been some research on lynx genetics, parasites, diseases and radio-nucleotide pollution conducted by other research groups. Finally, lynx have been peripherally covered in human-dimensions studies of societal attitudes to large carnivores in general in both Norway and Sweden.

Since 1995 there has been a high degree of cooperation between field researchers in Norway and Sweden, originally loosely referred to as the "Scandinavian lynx projects". This cooperation has already produced a number of common publications and led to cooperation in the field. During recent years this cooperation has increased to the extent that we now wish to present a common research agenda where specific activities are assigned to specific study areas and specific teams. In order to underline this cooperation and to help build a group identity (both internally and externally) we have decided to call the common project "Scandlynx".

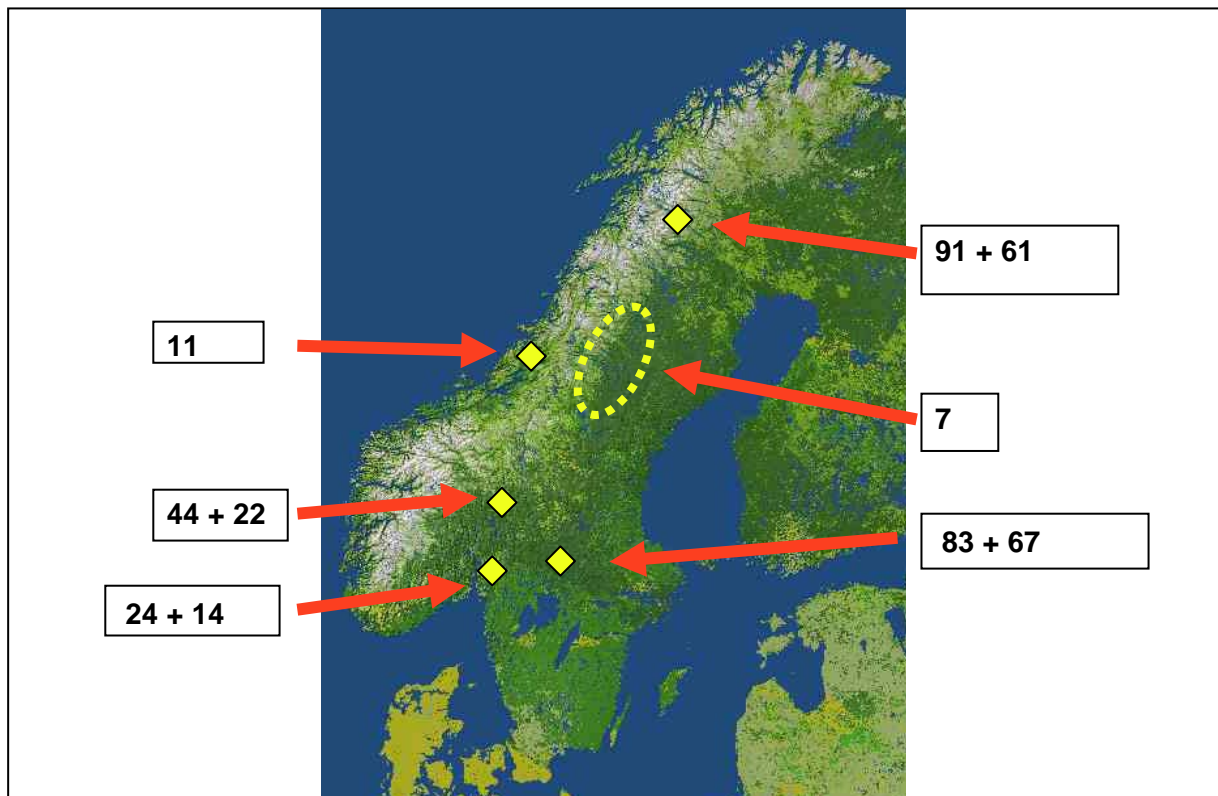
## 2 Present status - animals marked, location, funding

At present field work is ongoing in 3 broadly defined study sites. In southeastern Norway a total of 9 lynx are presently radio-collared, with 16 collared in Bergslagen, and 15 in Sarek. A total of 6 PhD students (3 in Norway and 3 in Sweden) are working with lynx related theses.

The Norwegian field study has currently secured financing for the period 2005-2007 with funding from the Norwegian Directorate for Nature Management, the Research Council of Norway, and several of the county offices of environmental affairs. The Sarek study has funding for 2005-2006 from the Swedish Environmental Protection Agency and WWF-Sweden. The Bergslagen study has funding through 2005 from the Swedish Environmental Protection Agency.



**Figure 1.** Study sites from 1992 to present



**Figure 2.** Lynx capture 1992 – 2005 (radio collared + kittens marked with eartags, tattoos or microchips)

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### 3 State of knowledge

The last 12 years of intensive lynx research in Scandinavia have provided a wealth of information about the ecology of this species. Together with studies that have been conducted in Switzerland, France and Poland our knowledge of lynx as a species is such that lynx are now among the best studied large carnivore species, maybe only rivaled by wolves (*Canis lupus*), brown and black bears (*Ursus* sp.), and puma (*Puma concolor*). The basic descriptive elements of aspects of lynx natural history such as reproduction, diet, space use, general patterns of social organization, and behaviour, the ecology of their depredation on livestock, and habitat use are well understood. The further analysis of existing data will reveal further details about all these topics. A summary of the data collected so far can be found in a number of reports, including Andersen et al. 1998, 2003a, 2005; Andrén et al. 1998.

Given this background our plans for the future will focus on carefully targeted topics where more detail is needed. These topics will be selected to provide the data needed for their effective management / conservation in Scandinavia and to further develop the use of lynx as a model species for investigating questions of ecological interest.

### 4 Lynx in Scandinavia - status and management contexts

During the early to mid 20<sup>th</sup> century lynx were heavily persecuted in both Norway and Sweden to such an extent that their ranges were greatly reduced to relicts in central Scandinavia. Progressive restrictions on hunting methods, shortened hunting seasons, and the removal of bounties allowed the populations to increase to their present status of approximately 300 lynx in Norway and c. 1500 in Sweden. The Norwegian population is heavily controlled by hunting to the extent that it declined during the period 1997-2004, but has since begun to increase again following reductions in harvest quotas. Management goals call for an increase to the 1997 level of c. 400 lynx in Norway. Further growth beyond this will be prevented in order to minimize depredation on domestic sheep and semi-domestic reindeer. The Swedish population in the reindeer husbandry areas is subject to lethal control actions that are effectively limiting its population size in order to keep depredation on semi-domestic reindeer within acceptable limits. The southern Swedish population is not currently harvested in order to foster expansion into southern Sweden. Both countries have monitoring programs in place that use the recording of tracks in snow to estimate a minimum population size. Furthermore, the carcasses of all lynx shot or found dead are collected and processed by central laboratories.

### 5 Knowledge needs and work program

This overview of knowledge needs is in part based on Andersen et al. 2003b. We have chosen to present knowledge needs from a very applied point of view in this section. However in section 5.13 we outline some of the values the study will have for more fundamental ecological questions.

#### 5.1 Analysis and publication

The amount of data that is presently available following 12 years of intensive field work, in addition to the data collected from population monitoring and the carcasses of dead lynx, is considerable. The analysis and publication of this existing data must be regarded as a priority for both countries in the coming years. Our ambition is to pool data and jointly publish results wherever possible, although many single study area publications will also be produced.

## 5.2 Communication

There is a considerable time-lag between data generation and the integration of this data into management systems and the realm of public knowledge. We will continue our efforts to spread knowledge through writing popular articles and holding presentations. However, we realize that we need to supplement scientific publication with targeted popular publications that present our new results in a relevant and understandable format. The first of these will focus on the ecology of lynx depredation on sheep, to be followed by ones on lynx and roe deer, lynx and semi-domestic reindeer, and lynx and human harvest.

## 5.3 Colonization of south Sweden

Allowing the spread of lynx into southern Sweden (Götaland) is central to Sweden's conservation objectives. Understanding the natal dispersal behaviour of juvenile lynx, especially females, from areas of varying lynx density is central to understanding this process, and how it may be influenced by different forms of lynx management. This process can be studied in two complimentary ways;

- Examining the dispersal behaviour of radio-collared lynx captured on the southern edge of the area of lynx distribution.
- Sampling (DNA from scats, and live-capture for radio-marking) the few lynx that have currently established in the south.

As well as providing data important for managers, this also provides fundamental insights into dispersal behaviour and gives us a unique opportunity to study a colonizing population.

## 5.4 Lynx - semi-domestic reindeer conflicts

Throughout northern Scandinavia the main (in many areas the only) large prey species available for lynx is the semi-domestic reindeer (*Rangifer tarandus*). This implies that to a large extent lynx persistence in the north depends on maintaining a conflict with humans. Unfortunately, the only mitigation measure that seems to be applicable is to limit the size of the lynx population through lethal control. Accordingly, there is a need to;

- Quantify the effect that lynx have on semi-domestic reindeer, which can help form the basis for a fair compensation system.
- Provide data that helps monitor lynx population size.
- Study the impact that lethal control has on lynx population size and demography.

Wolverines are also a species of conservation importance that depend on semi-domestic reindeer as prey. In areas of overlap it is crucial to determine what the combined effect of wolverines and lynx is on reindeer. This requires studies of;

- How wolverine scavenging influences lynx kill rates and how the presence of carcasses supplied by lynx influences wolverine kill rates.

## 5.5 Monitoring validation

Effective management depends heavily on accurate numbers, especially in Norway where harvest pressure is high and in northern Sweden where compensation for reindeer depredation is linked to lynx numbers. There is also a large data-conflict between managers and the public concerning the actual size of the lynx population. Therefore, an important benefit of our studies is to use telemetry methods and genetical methods to validate the routine methodology in carefully selected areas where there is either a high degree of data conflict or uncertainty concerning numbers, where snow-conditions do not permit the easy collection of track

observations or where special landscape features raise questions about the universal validity of current methods.

- Use telemetry data to validate the snow-track based monitoring.
- Explore the potential use of genetic methods (using hair and faeces) to validate the snow-track based monitoring.

## 5.6 Demographic data

Planning for long term population viability and setting sustainable harvest quotas requires a detailed knowledge of a species population dynamics. Although the analysis of reproductive tracts from carcasses can provide some basic data, the best data is when reproduction and survival data are available from individually marked animals. Our work to date has allowed us to quantify in general terms the reproductive and mortality rates, as well as the mortality causes for lynx. However, this work has also revealed considerable spatial and temporal variation in both reproduction and survival that we cannot yet explain. Therefore, for the coming years we aim to;

- Continue to collect long term reproductive and survival data from radio-marked lynx under a range of different environment conditions.
- Use the different management regimes in Norway and Sweden to understand how harvest and population density influence lynx demographics.
- Analyse the reproductive data available from lynx carcasses that have been collected from hunter harvest and accidents.
- Identify how landscape configuration influences lynx vulnerability to various mortality factors.
- Produce a harvest model that aids managers in setting lynx harvest quotas.

## 5.7 Lynx and roe deer predator-prey relations

We currently have collected a large amount of data on both the kill rates of radio-collared lynx and the survival / mortality of radio-collared roe deer. This allows us to quantify the potential impact of lynx on roe deer under a range of densities. It is important, however, to further explore how this impact can be influenced by factors such as landscape. Therefore, we aim to;

- Analyse existing data on an individual scale to determine how landscape influences roe deer vulnerability to predation, and if this linked to roe deer dispersal can provide a stabilizing effect on the predator-prey relationships.

Secondly, our data is based on rather short term intensive studies, which may not accurately reflect the full range of environmental conditions in space and time. There is therefore a need to;

- Establish a series of sites where roe deer density is monitored such that its development can be linked to changes in lynx population density.

Thirdly, we want to avail of the many data sets available on roe deer demographics from Europe in study sites with and without predators, and explore how predation influences roe deer demography and life history.

- Conduct comparative analyses of roe deer mortality from all sites where data is available.

Finally, the return of wolves to many areas raises questions about the combined impact of lynx and roe deer predation. There is therefore a need to;

- Establish a telemetry based study of roe deer mortality in an area where wolves and lynx occur together.

## 5.8 Intra-guild interactions - wolf, wolverine and red fox

Parallel to the recovery of lynx in Scandinavia there has been an increase in wolf and wolverine numbers as well as a recovery of red fox populations after the scabies epidemic of the 1970's and 1980's. This underlines the importance of viewing lynx within a wider ecosystem context, with special focus on intra-guild interactions. The fox-lynx relationship is especially complicated as both compete for the same prey, lynx often kill foxes, foxes can scavenge on lynx kills, and lynx occasionally die from scabies infections that can originate from foxes. Likewise wolverines can scavenge from lynx killed reindeer. The wolf-lynx relationship is the subject of much speculation. On one level they both compete for roe deer as prey, and there is the possibility that wolves may constitute intra-guild predators of lynx. Wherever possible we;

- Aim to coordinate lynx research with that on wolves, wolverines and foxes to gain the maximum synergy for studying intra-guild interactions and ecosystem relations.

## 5.9 Lynx and barriers: fragmented landscapes and infrastructure

In southern Scandinavia lynx populations live in landscapes that have been heavily modified by humans, both in terms of fragmenting forest landscapes with agricultural and urban land-uses, and in the construction of linear barriers such as roads and railroads. It is presently unclear what the critical limits of fragmentation are for lynx, but this will be important for understanding the potential for lynx in southern Sweden, and for ensuring that future infrastructure development is adequately mitigated. Therefore we;

- Analyse existing and future data on lynx distribution and movement with respect to landscape fragmentation and infrastructure development to determine critical levels and recommend mitigation measures.

## 5.10 Social organization

Our telemetry data has confirmed that lynx almost invariably demonstrate year-round intra-sexual territoriality under the range of conditions that we have worked. However, it would provide much added value if we could compliment our telemetry studies with genetical studies that could;

- Determine the paternity of lynx kittens to enable us to relate territorial behaviour with mating success.
- Examine the extent to which limited female dispersal produces so called "kin-clusters".

Conducting these studies along the colonization gradient, and under varying harvest intensities, will provide interesting insights into how social organization varies with ecological conditions and how human activities influence it. This work is especially important in Norway where the annual hunting season corresponds with the mating season.

## 5.11 Lynx and human societies

Lynx management does not only require biological data - there is also a need to understand the societal context. Although lynx do not produce the extreme social conflicts that have been seen with wolves, there are still a range of conflicts that occasionally find expression in poaching. Social science studies should focus on the following;

- The issue of how lynx harvest influences attitudes of various interest groups and the public towards lynx.

- Investigate the motivations of those hunting lynx to determine to what extent lynx are regarded as a game species or as a pest.
- How do the public accept the different compensation systems that are practiced in Norway and Sweden (paying for damage vs paying for lynx presence)?

## 5.12 Lynx without large prey

Although impossible to do in Scandinavia, one of the main questions about lynx concerns their ecology in an area where large prey (roe deer, red deer *Cervus elaphus*, reindeer) are absent. While the Russian literature contains some basic data from such areas, there has never been a telemetry based study of such a population. The closest area where such a study is possible is in southeastern Finland.

## 5.13 Scientific value

Although we have chosen to underline the applied nature of our research agenda, the results from these studies will also make a valuable contribution to mammalian science. The long term data sets on radio-collared individuals from widely differing environments (in terms of climate, prey density and lynx density) will be of particular interest and have fundamental value for understanding how individual variation can influence the dynamics of populations. The parallel data collected on the offspring of marked females will also provide unique insights into how natal dispersal contributes to both social organization and population dynamics. The parallel focus on roe deer and lynx will make these studies into a unique predator-prey study. The opportunity to focus on lynx in an environment where other predators, such as wolves, are also studied will give us a unique ecosystem perspective on the issue. Finally, placing the studies into the context of a human-dominated environment will make this a classic contribution within the field of conservation biology.

# 6 A plan for addressing knowledge needs

Although the above list of knowledge needs may seem long, many of these objectives can be simultaneously met within the framework of relatively low intensity field projects. The basic need within each site is to radio-collar a sample of lynx, especially mature females. The young born to marked females should also be captured prior to their dispersal. The availability of duty-cycle VHF-collars means that animals only need to be remarked every 5-6 years, greatly reducing both costs and animal welfare concerns. This marking, coupled with monthly or bi-monthly aerial tracking provides for relatively low cost data collection.

Because Scandinavia contains widely different ecological conditions it is not possible to answer all questions and obtain universally representative data within one study site. We propose a future structure with 3 main study sites, which may be supplemented by smaller scale projects and data collection from other sites when needed. The ability to study comparative sites greatly increases the scientific interest of the results.

## 6.1 Sarek

Sarek represents the best site for conducting research relevant for the conflict with semi-domestic reindeer and studying lynx-wolverine interactions. In addition, the fact that the study has been ongoing since 1994 provides an opportunity to maintain long term data collection on individual females, and follow-up animals of known age and relationship. The existence of wolverine and bear projects within the same site provides opportunities for sharing the costs of field work and for conducting intra-guild studies.

## 6.2 Bergslagen

This study site represents the ideal study area to collect long-term data on individually marked animals of known age and relationship in an area where roe deer form the main prey. The location close to Grimsö wildlife research station implies that activities can be very cost-effective, and the existence of 10 years of data on marked individuals provides an irreplaceable chance to maintain a long term study on lynx in area with relatively low annual mortality rates. The fact that wolves are also studied in the surrounding area provides opportunities for studying intra-guild interaction. The existence of up to 30 years of background census data on other species provides the opportunity of studying the impact of lynx restoration on an entire ecosystem. Finally, the area is well located to study the lynx expansion process southwards through the corridor between lakes Vänern and Hjälmaren.

## 6.3 The Norwegian-Swedish border

A study area along the Norwegian-Swedish border (Hedmark, Akershus, Østfold - Värmland, Västra Götaland) provides a unique opportunity to study the impact of harvest on lynx ecology. Moving west-east through more or less similar habitat, lynx management changes from very high harvest rates to protection, resulting in a very steep gradient of lynx density. This permits a study of how lynx reproduction varies under conditions with differing densities and mortality schedules, as well as allowing an analysis of how lynx dispersal maintains the Norwegian population in the face of non-sustainable harvest rates. The study area is also located such that it can provide insights into lynx dispersal along the western side of Vänern. Together with the Bergslagen study this covers both of the major potential routes for lynx to recolonize southern Sweden.

## 6.4 Additional sites

In addition to these major intensive study sites there will occasionally be a need for short-term targeted studies in other areas. For example, monitoring data will occasionally need to be validated in various regions through the use of either telemetry or genetical methods. In addition, when lynx become established in southern Sweden it may be necessary to capture a few individuals to help monitor population development during the recolonization phase.

# 7 Project organisation

There are two previous models for cross-border coordination in large carnivore projects within Scandinavia, the Scandinavian bear project and the Scandinavian wolf project (Skandulv). The Scandinavian bear project is in effect a single project (working in two Swedish sites) under a single leader, whereas Skandulv consists of a wide range of research environments with a coordinator. Scandlynx lies somewhere in between. The research is mostly conducted by two environments, the Norwegian Institute for Nature Research (NINA) and Grimsö Wildlife Research Station. We feel that the combination of having only two main environments, coupled with our existing long-term tradition of cooperation do not require too many formalities. We would rather think of Scandlynx as being a coordinated cooperation between our respective research groups. However, each field site will be under clear control of one group, with Sarek and Bergslagen run by Grimsö and the border area lead by NINA in close cooperation with Grimsö. Our ambition is to establish a common project database for basic data that facilitates cooperative publication wherever possible. When it comes to fieldwork, we aim to continue the exchange of personnel between study sites.

Scandlynx does not have the ambition to expand to the extent that its umbrella embraces all lynx research activity within Scandinavia - and the references at the end reveal just how much activity has been conducted by other groups. However, we hope that by building a clear and



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visible Scandlynx identity that other research groups will see the potential of synergy effects by coordinating their activity with ours.

## 8 Funding

Our projects have gone beyond the stage of uncovering basic aspects of lynx natural history. This implies that our interest is now in getting to grips with many of the complex details that explain variation in various life-history traits or ecological relationships across environmental gradients. As well as producing data of general scientific interest this also will provide managers with data that will permit more precise management of lynx populations. Such work is not done within the framework of short-term studies. Periods of 5 to 10 years are probably going to be needed, and during this period it is necessary to ensure sufficient funding to maintain the research teams with their field and analytical skills. Replacing such competence if lost will be difficult. We believe that given sufficient time and funding Scandlynx will blossom into far more than a set of applied research projects. We have the potential to turn Scandlynx into a major project that gets to grips with some fundamental aspects of population biology, predator-prey relations and ecosystem thinking, as well as being a classic case study within conservation biology.

**Table 1.** Summary of the list of knowledge needs and where to address them

Topic	Intensive study sites			Additional sites			study	Analysis only
	Sarek	Bergslagen	Border	Norway	Northern Sweden	Central & Northern Sweden		
<b>Colonization of south Sweden</b>								
- female dispersal		X	X					
- genetic sampling							X	
<b>Lynx - reindeer conflicts</b>								
- kill rates on reindeer	X							
- effects of lethal control	X							
<b>Validate monitoring data</b>								
- radio-collaring	X	X	X	X	X		X	
- genetics				X	X		X	
<b>Demographic data</b>								
- long term study of females	X	X	X					
- effects of harvest	X		X					
- landscape & mortality								X
- harvest model								X
<b>Lynx and roe deer</b>								
- landscape and vulnerability								X
- comparative mortality								X
- monitoring of roe deer		X	X	X			X	
- additional effect of wolves		X	X					
<b>Intra-guild interactions</b>								
- lynx - wolverine	X							
- lynx - fox - wolf		X	X					
<b>Lynx and barriers</b>								
- fragmented landscape and infrastructure		X	X				X	
<b>Social organisation</b>								
- paternity	X	X	X					
- kin clusters	X	X	X				X	
<b>Lynx and human societies</b>								
- compensation	X							
- harvest & attitudes		X	X					

## 9 Publications from Scandlynx

### 9.1 International peer reviewed publications

- Andersen, R., Karlsen, J., Austmo, L.B., Odden, J., Linnell, J.D.C. & Gaillard, J.M. in press: Selectivity of Eurasian lynx and recreational hunters for age, sex and body condition in roe deer. - *Wildlife Biology*.
- Andersen, R., Linnell, J. D. C. & Solberg, E. J. (in press) The future role of large carnivores on terrestrial trophic interactions: the northern temperate view. In: Danell, K., Bergström, R., Duncan, P. & Pastor, J. (editors) *The Impact of Large Mammalian Herbivores on Biodiversity, Ecosystem Structure and Function*. Cambridge University Press
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## 9.5 International publications on Scandinavian lynx by research groups outside the Scandlynx umbrella

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## Norwegian Institute for Nature Research

NINA Head Office

Postal address: NO-7485 Trondheim, NORWAY

Visiting address: Tungasletta 2, NO-7047 Trondheim, NORWAY

Phone: + 47 73 80 14 00

Fax: + 47 73 80 14 01

Organisationsnumber: 9500 37 687

<http://www.nina.no>