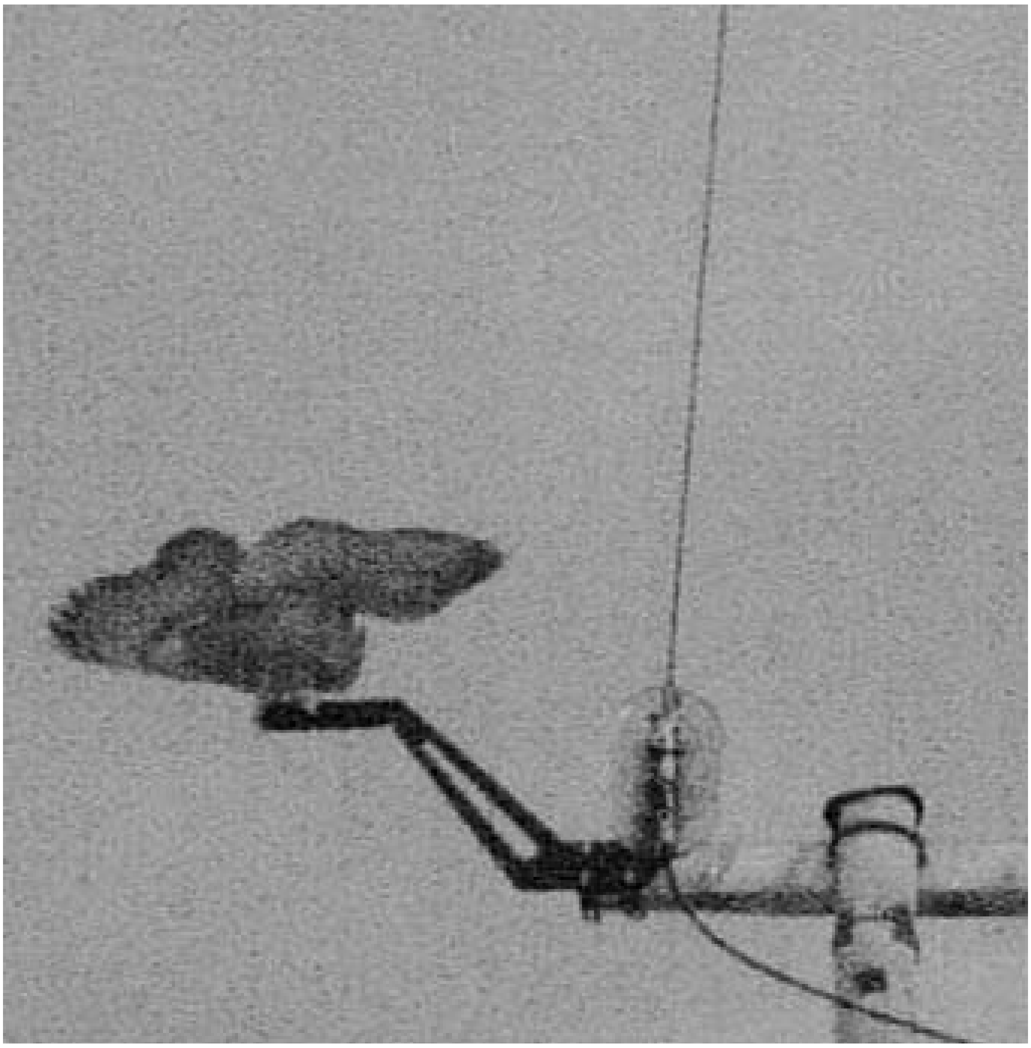
762

NINA Report

Optimal design and routing of power lines; ecological, technical and economic perspectives (OPTIPOL)

Progress Report 2011

Kjetil Bevanger, Gundula Bartzke, Henrik Brøseth, Espen Lie Dahl, Jan Ove Gjershaug, Frank Hanssen, Karl-Otto Jacobsen, Pål Kvaløy, Roel May, Roger Meås, Torgeir Nygård, Steinar Refsnæs, Sigbjørn Stokke, Jørn Thomassen



NINA
Norwegian Institute for Nature Research

Cooperation and expertise for a sustainable future

NINA Publications

NINA Report (NINA Rapport)
This is a electronic series beginning in 2005, which replaces the earlier series NINA commissioned reports and NINA project reports. This will be NINA's usual form of reporting completed research, monitoring or review work to clients. In addition, the series will include much of the institute's other reporting, for example from seminars and conferences, results of internal research and review work and literature studies, etc. NINA report may also be issued in a second language where appropriate.

NINA Special Report (NINA Temahefte)
As the name suggests, special reports deal with special subjects. Special reports are produced as required and the series ranges widely: from systematic identification keys to information on important problem areas in society. NINA special reports are usually given a popular scientific form with more weight on illustrations than a NINA report.

NINA Factsheet (NINA Fakta)
Factsheets have as their goal to make NINA's research results quickly and easily accessible to the general public. The are sent to the press, civil society organisations, nature management at all levels, politicians, and other special interests. Fact sheets give a short presentation of some of our most important research themes.

Other publishing
In addition to reporting in NINA's own series, the institute's employees publish a large proportion of their scientific results in international journals, popular science books and magazines.

Optimal design and routing of power lines; ecological, technical and economic perspectives (OPTIPOL)

Progress Report 2011

Kjetil Bevanger
Gundula Bartzke
Henrik Brøseth
Espen Lie Dahl
Jan Ove Gjershaug
Frank Hanssen
Karl-Otto Jacobsen
Pål Kvaløy
Roel May
Roger Meås
Torgeir Nygård
Steinar Refsnæs
Sigbjørn Stokke
Jørn Thomassen

Norwegian Institute for Nature Research

Bevanger, K., Bartzke, G., Brøseth, H., Dahl, E.L., Gjershaug, J.O., Hanssen, F., Jacobsen, K.-O., Kvaløy, P., May, R., Meås, R., Nygård, T., Refsnæs, S., Stokke, S. & Thomassen, J. 2011. Optimal design and routing of power lines; ecological, technical and economic perspectives (OPTIPOL). Progress Report 2011 - NINA Report 762. 52 pp.

Trondheim 1 December 2011

ISSN: 1504-3312
ISBN: 978-82-426-2354-6

AVAILABILITY
Open

PUBLICATION TYPE
Digital document (pdf)

EDITION
Kjetil Bevanger

QUALITY CONTROLLED BY
Signe Nybø (sign.)

SIGNATURE OF RESPONSIBLE PERSON
Signe Nybø (sign.)

CLIENT(S)
The Research Council of Norway (NFR), Statnett, The Directorate for Energy and Water Resources (NVE), Energy Norway, The Directorate for Nature Management (DN)

CLIENTS' CONTACT PERSON(S)
Geir Taugbøl (EnergyNorway)
Johan O. Bjerke (Statnett)
Nils Henrik Johnson (NVE)
Jo Anders Auran (DN)

COVER PICTURE
Eagle owl landing on a new designed crossarm on a 22 kV pylon. Photo: Wildlife camera NINA

KEY WORDS
Power line, transmission line, killer pole, collision, electrocution, bird, eagle owl, capercaillie, black grouse, moose, corridor, ROW, routing, LCP

NØKKELORD
Kraftledning, kollisjon, elektrokusjon, fugl, hubro, storfugl, orrfugl, elg, kraftledingstrase, ryddebelte

CONTACT DETAILS

NINA head office
Postboks 5685 Sluppen
NO-7485 Trondheim
Norway
Phone: +47 73 80 14 00
Fax: +47 73 80 14 01

NINA Oslo
Gaustadalléen 21
NO-0349 Oslo
Norway
Phone: +47 73 80 14 00
Fax: +47 73 80 14 01

NINA Tromsø
Framsenteret
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

www.nina.no

Abstract

Bevanger, K., Bartzke, G., Brøseth, H., Gjershaug, J.O., Hanssen, F., Jacobsen, K.-O., Kvaløy, P., May, R., Meås, R., Nygård, T., Refsnæs, S., Stokke, S. & Thomassen, J. 2011. Optimal design and routing of power lines; ecological, technical and economic perspectives (OPTIPOL). Progress Report 2011. – NINA Report 762. 52 pp.

Overall the activities in 2011 have developed satisfactorily and in accordance with the project schedule. The **wildlife and power-line corridor** subproject is focusing the moose habitat use of the clear-felled area beneath a selected transmission-line section in Bangdalen, Nord-Trøndelag County. Existing data from other NINA projects on moose habitat selection and behavioural responses of linear structures like roads is now included in the project and analysed in a comparative approach. Some data sampling still remain, in particular regarding seasonal variations on habitat use along the Bangdalen transmission section. In Ogndalen the data sampling on the **capercaillie and black grouse population** has started and so far the estimate indicate a black grouse and capercaillie density of 1.2 and 0.5 birds per km^2 respectively. Patrols along the 7 km long transmission-line section have located a total of 38 bird fatalitiesof which a majority are gallinaceous birds. Due to severe snow melting conditions during the data sampling period in March-April, only one sampling of excrements for DNA analyses could take place. To compensate this loss a final data sampling probably has to take place in spring 2013. **The Least Cost Path (LCP) modelling** project has chosen the Klæbu-Viklandet transmission line (built in 2002) as a pilot, in agreement with NVE and Statnett, to test the LCP methodology. Subjects and criteria from economical, technological, ecological and social perspectives are identified by the OPTIPOL/LCP research team, and the work ahead will focus on validating and mapping them. This will be done using a participatory dialog process with the key stakeholders during spring 2012. The first workshop will take place in February/March 2012. **The eagle owl project** on Sleneset in Lurøy has, apart from looking at population aspects, also concentrated on mitigating the electrocution hazard. Earlier solution to the electrocution problem has focused on e.g. covering the wires in their suspension points. This has, however, resulted in increased corrosion problems. Corrosion of power-line equipment is a major problem in Norway, particularly in coastal areas with a high marine corrosion index. A solution used in the US has been to construct perching structures on the top of the pylons, i.e. above the insulators and the pylon crossarm. In principle this is a good solution, however, in some environments it has some obvious disadvantages as bird excrements left on the pylons may serve as a conductor for electricity and increase the electrocution hazard. Based on combined biological and technological awareness of limitations and options we have now designed a new elevated perch construction in cooperation with Eltjeneste AS. The grid owner at Sleneset, Rødøy-Lurøy Kraftverk, has installed these alternative perching structures at a selection of 12 pylons. At the same time perching avoidance structures (racks of sharp plastic spikes) have been fixed to the crossarm, preventing the eagle owl to rest on the dangerous parts of it. So far the results have been very promising, and the surveillance cameras have confirmed that the eagle owl is using the new perching alternative (see cover photo).

Kjetil Bevanger (kjetil.bevanger@nina.no)
Gundula Bartzke (gundula.bartzke@nina.no)
Henrik Brøseth (henrik.broseth@nina.no)
Espen Lie Dahl (espenlie.dahl@nina.no)
Jan O. Gjershaug (jan.o.gjershaug@nina.no)
Frank Hanssen (frank.hanssen@nina.no)
Karl-O. Jacobsen (karl.o.jacobsen@nina.no)
Pål Kvaløy (pal.kvaloy@nina.no)
Roel May (roel.may@nina.no)
Roger Meås (roger.meas@nina.no)
Torgeir Nygård (torgeir.nygard@nina.no)
Steinar Refsnæs (steinar.refsnes@sintef.no)
Sigbjørn Stokke (sigbjorn.stokke@nina.no)
Jørn Thomassen (jorn.thomassen@nina.no)

Sammendrag

Bevanger, K., Bartzke, G., Brøseth, H., Gjershaug, J.O., Hanssen, F., Jacobsen, K.-O., Kvaløy, P., May, R., Meås, R., Nygård, T., Refsnæs, S., Stokke, S. & Thomassen, J. 2011. Optimal design og traseføring for kraftledninger; økologiske, tekniske og økonomiske perspektiver (OPTIPOL). Fremdriftsrapport 2011. – NINA Rapport 762. 52 s.

Arbeidet inneværende år har stort sett gått som planlagt, og for noen delprosjekter begynner det å komme resultater. Delprosjektet **vilt og kraftledningskorridorer** fokuserer primært på ryddebeltets potensial som beiteressurs for elg, og representerer en viktig del av PhD-opplegget til Gundula Bartzke. Feltarbeidet foregår i Bangdalen, Namsos kommune. Målsettingen med prosjektet er å finne ut hvordan og hvorfor enkelte viltarter bruker områdene i tilknytning til kraftledningens ryddebelte. Spesielt fokuseres det på elgens bruk av kraftledningskorridoren, og det trekkes også inn data innsamlet i tilknytning til tidligere prosjekter for å undersøke hvordan elgen bruker områder i tilknytning til andre lineære strukturer slik som vei. I og med at det fremdeles gjenstår en del datainnsamling er det så langt ikke mulig å trekke noen konklusjoner, men arbeidet videre vil bl.a. være konsentrert om å innhente flere data og se på sesongvise forskjeller i habitatbruken langs det valgte kraftledningsavsnittet. Det vil også bli gjort sammenligninger med hvordan elg benytter områder i tilknytning til andre landskapselementer som bebyggelse, elver og innsjøer. Etter hvert vil det også være mulig å si noe om eventuelle adferdsresponser hos elg i forhold til kraftledningskorridorer – eksempelvis om elgen bruker disse mer enn andre landskapstyper eller om den unngår å krysse kraftledningskorridorens ryddebelte. **Bestandseffekter hos skogsfugl som følge av dødelighet pga. kollisjoner**. På grunn av lite skogsfugl og vanskelig terreng ble dette delprosjektet flyttet fra Bangdalen til Ogndalen. I mars ble den første datainnsamlingen av ekskrementer foretatt. DNA-analyse av skogsfuglekskrementer, observasjoner av fugler under takseringene av transekter som går på tvers av selve kraftledningen (til sammen et ca. 28 km^2 stort område) og funn av kollisjonsdrepte fugler langs det 7 km lange kraftledningstransektet, danner grunnlag for de videre analysene. Så langt er det funnet 38 kollisjonsdrepte fugler i løpet av 10 patruljeringsrunder. Foreløpige analyser viser at undersøkelsesområdet har en orrfugl- og storfuglbestand på henholdsvis 1,2 og 0,5 pr km^2. **Least Cost Path (LCP) Modell for optimalt trasevalg av kraftledninger**. Prosjektets målsetting består i å utvikle en brukertilpasset LCP-metodikk basert på økologiske, økonomiske, teknologiske og samfunnsmessige kriterier. Utvalg, verdisetting og vekting av tema skal forankres i fagmiljø og organisasjoner, for så å lage et GIS-verktøy som kan brukes i arbeidet med konsekvensutredninger, konsesjonsbehandling og nettplanlegging. I samarbeid med Statnett og NVE er det valgt en ”pilot” for å teste denne metodikken. Piloten er en eksisterende kraftledning mellom Klæbu og Viklandet som ble bygget i 2002. Tema og kriterier ut fra økonomisk, teknologisk, samfunnsmessig og økologisk perspektiv er identifisert av forskergruppen i OPTIPOL/LCP, og det videre arbeidet vil nå være å verdisette og kartfeste disse. Arbeidet med verdisetting vil bl.a. skje gjennom en deltakende dialogprosess der berørte parter i tilknytning til kraftledningsbygging inviteres til å delta. Det første møte vil arrangeres i februar/mars 2012. **Hubro i Lurøy**. Målsettingen med dette prosjektet er å kvantifisere dødelighetsomfang hos hubro som følge av elektrokusjon og kollisjon med kraftledninger i et studieområde på Sleneset, Lurøy, samt identifisere hvilke strukturer som forårsaker størst dødelighet, og forsøke å finne avbøtende tiltak. Tidligere løsninger har bl.a. basert seg på å dekke til linene i opphengspunktene, men det har vist seg at dette øker korrosjonen på linene. Korrosjon på kraftledningsmateriell er et stort problem langs kysten, der man finner det mest korrosive miljøet. En amerikansk løsning har vært å montere sittepinner på toppen av stolpene, men det har vist seg at ekskrementene fører til krypstrøm og ytterligere risiko for elektrokusjon. Basert på teknologisk og biologisk kunnskap har vi nå designet en ny type, opphøyet sittepinne. I samarbeid med Rødøy-Lurøy Kraftverk i Nordland er disse montert som en forlengelse av stolpetraversen på noen utvalgte stolper. Samtidig er det montert sitteavvisere som er plastelementer med pigger som hindrer hubroen i å slå seg ned på de uønskede områdene på selve traversen. Resultatene så langt har vært svært lovende, og det viser seg at hubroene som har slått seg ned på stolpene har benyttet de nye sittepinnene (se rapportens forsidefoto).

Kjetil Bevanger (kjetil.bevanger@nina.no)
Gundula Bartzke (gundula.bartzke@nina.no)
Henrik Brøseth (henrik.broseth@nina.no)
Espen Lie Dahl (espenlie.dahl@nina.no)
Jan O. Gjershaug (jan.o.gjershaug@nina.no)
Frank Hanssen (frank.hanssen@nina.no)
Karl-O. Jacobsen (karl.o.jacobsen@nina.no)
Pål Kvaløy (pal.kvaloy@nina.no)
Roel May (roel.may@nina.no)
Roger Meås (roger.meas@nina.no)
Torgeir Nygård (torgeir.nygard@nina.no)
Steinar Refsnæs (steinar.refsnes@sintef.no)
Sigbjørn Stokke (sigbjorn.stokke@nina.no)
Jørn Thomassen (jorn.thomassen@nina.no)

Contents

Foreword

From 2009 inclusive, CEDREN has received economic support for research on environmental challenges connected to power lines from the Norwegian Research Council (NFR) through the RENERGI Programme. The project is named "*Optimal design and routing of power lines; ecological, technical and economic perspectives*" (OPTIPOL). It is a capacity building project with user participation (KPN), i.e. a project cooperating closely with the central energy and environmental-management authorities, together with the energy sector, particularly the grid owners. Apart from the Norwegian Water Resources and Energy Directorate (NVE), the Norwegian Directorate for Nature Management (DN), the Norwegian Electricity Industry Association (Energy Norway), and Statnett contributes with an annual economic support (approximately 20% of the total costs). The project has a 5 year lifespan (2009-2013).

Trondheim, 30 November 2011

Kjetil Bevanger
Project leader

1 Introduction

The OPTIPOL project - "*Optimal design and routing of power lines; ecological, technical and economic perspectives*" – has been active for three years, although the main operational phase was delayed until autumn 2009. The overall OPTIPOL objective is to develop knowledge and tools to improve the decision on environmental friendly power-line routing. To achieve this goal the work is subdivided into 9 focal areas and sub-projects:

- Develop a "*least-cost path*" (LCP) toolbox for an environmental friendly routing of power lines based on ecological, financial, social and technological criteria (Chapter 2).
- Assess power-line Rights-of-Way (ROW) as wildlife habitats, and in particular study how habitat selection by moose is influenced by power lines (Chapter 3).
- Assess population impact of bird mortality due to power-line collisions, relative to other human related mortality factors (primarily hunting) in gallinaceous birds (with capercaillie and black grouse as model species) (Chapter 4).
- Identify bird collision hot spots, i.e. environmental factors contributing to bird collisions, which cold be site-specific factors connected to topographic characteristics, including vegetation structure, season, weather and light conditions (Chapter 5).
- Establish a national web portal for management of dead bird data (including birds recorded as collision and electrocution victims) by developing an online web application enabling the general public to contribute with data on recorded dead birds via Internet (Chapter 6).
- Review available literature to assess 1) the possibilities for increased collision hazard to birds by making power-line structures less visible for humans given the present knowledge on bird vision, and 2) technical properties and constraints of camouflaging techniques on conductors and earth wires (Chapter 7).
- Review available literature on ecological and technical options and constraints for mitigating bird collisions and electrocution (Chapter 8).
- Develop guidelines for technical solutions to mitigate power-line induced mortality to birds (Chapter 9).
- Assess eagle owl mortality and population impact caused by power-line collision and electrocution; identify high-hazard collision and electrocution structures and possible mitigating measures (Chapter 10).

1.1 The 2011 Annual Meeting

The OPTIPOL project is dealing with activities addressed both by the grid owners as well as the environmental and energy authorities. Although the OPTIPOL research team and the users have an informal dialogue during the year on different topics, we gather for more formal discussions at "the Annual Meeting". In 2011 we met November 17 (**Appendix 1**). The presentations at this meeting gave an overview and status of the different OPTIPOL subprojects.

2 A Least Cost Path (LCP) toolbox for optimal routing of power lines

Objectives
Develop a "*least-cost path*" GIS-based application for an environmental friendly routing of power lines based on ecological, social, financial and technological criteria.

2.1 Background

Identifying the "optimal route" when planning to build a new power line is a highly challenging exercise. The great complexity of formal and informal stakeholder interests at different geographical levels has to be identified, organised and handled through standardized impact assessments. Additionally, legal, technological and financial criteria's have to be analysed prior to the final decision about how to route the new power line. The intention of this project is to demonstrate how such multi-criteria analysis efficiently can be performed with LCP in planning and decision making of power-line routing.

2.2 Research methods

The Least Cost Path (LCP) routing procedure has for many years been used in GIS-applications for siting of linear features and corridors. LCP demands a strict scheme for calibration and weighting of the input criteria.

2.3 Activities and findings

In 2011 we have refined the methodological frame for the LCP-pilot. To demonstrate and validate the LCP-principles we decided, in agreement with NVE and Statnett, to develop the LCP-pilot on a case study based on existing environmental impact assessments (2001) prepared for the construction of a 420 (300) kV power line between Klæbu and Viklandet in central Norway, completed in 2005.

Being a methodological exercise we delimited the case study area to five municipalities in the Sør-Trøndelag County (Trondheim, Melhus, Klæbu, Skaun and Orkdal local authorities) along the existing power line, completed in 2005 (see **Figure 1**).

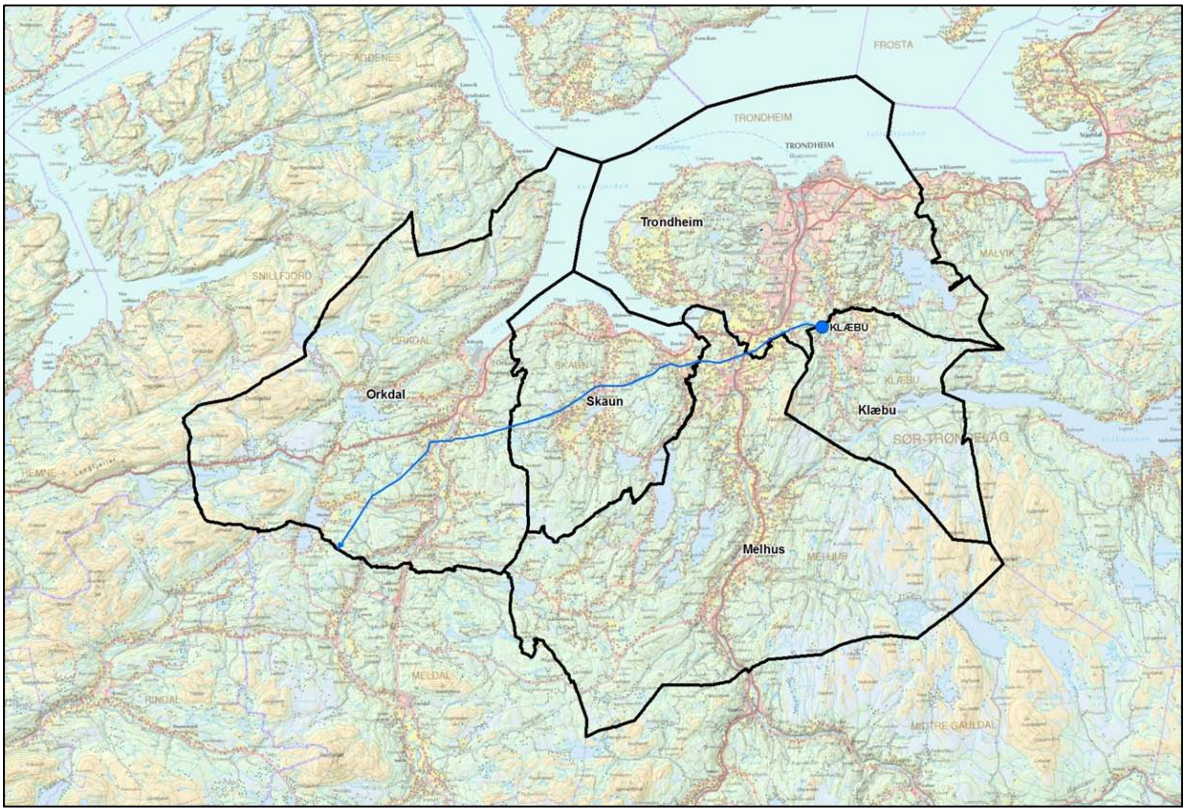


Figure 1. *Case study area for the LCP-pilot. Existing transmission line in blue.*

From the environmental impact assessments we have selected a subset of relevant themes and criteria and organized them into four perspectives: ecology, society, economy and technology. The set of themes and criteria will be validated by NVE and Statnett in December 2011. After having the themes and criteria validated we will continue to further develop the LCP-pilot and perform the case study.

The subset of themes and their criteria has to be transformed and aligned into a common value scale to be applied in LCP. In some cases there are law-enforced restrictions excluding particular areas. For the non-restricted areas we have developed a method for estimating values based on degree of acceptance on a continuous scale from 0 (acceptable) to 1 (not acceptable) with the help of fuzzy logic theory (e.g. Zadeh 1965, Zadeh et al. 1996). The relative importance of a theme in one perspective has to be weighted percentually in accordance to the relative importance of the other themes in the same perspective. In exactly the same way the relative importance of each perspective also has to be weighted according to the relative importance of the other perspectives (see **Figure 2**).

The general idea of the LCP-pilot and the case study is to demonstrate the principles of least cost path analysis. Before we extend the LCP-pilot into a professional LCP-toolbox we will consolidate the approach by hosting a couple of workshops for invited stakeholders in March and June 2012.

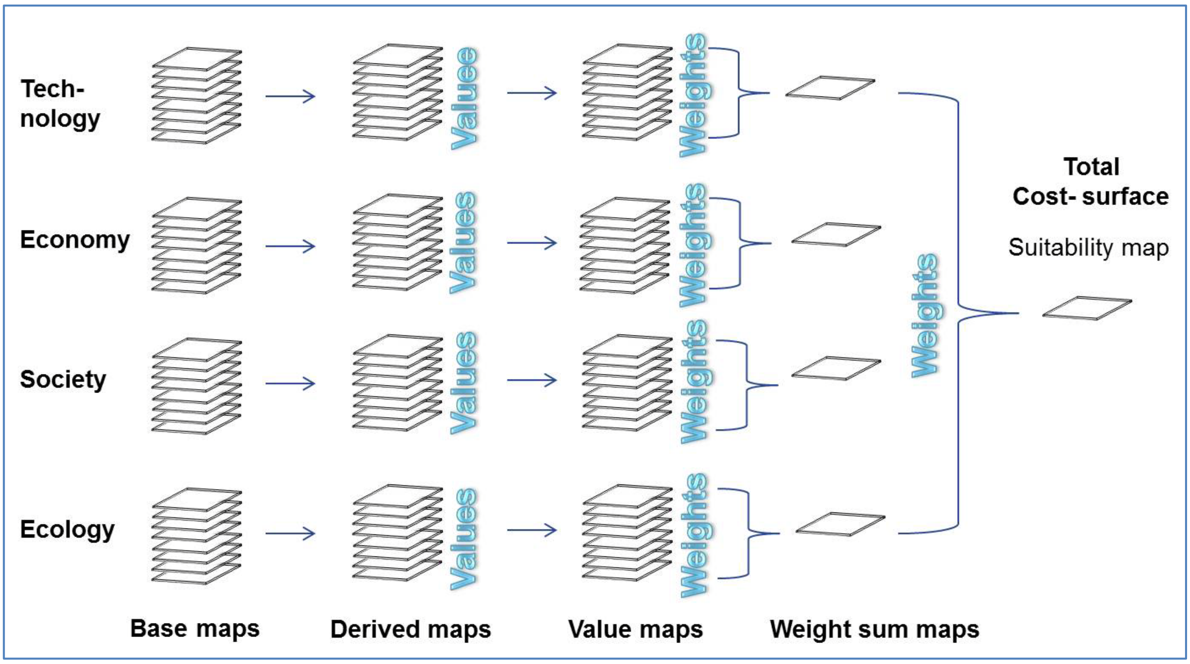


Figure 2. *The LCP concept.*

The stakeholders will first be introduced for the LCP-methodology through the LCP-pilot. They will then be guided through an intensive dialogue process in order to establish a high degree of consensus with respect to the selection of relevant themes, criteria, values and weights. The outcomes of these workshops will be user validated themes, criteria, values and weights that will be implemented in the LCP-toolbox at a desktop GIS-platform. **Figure 3** describes the timeline for this project.

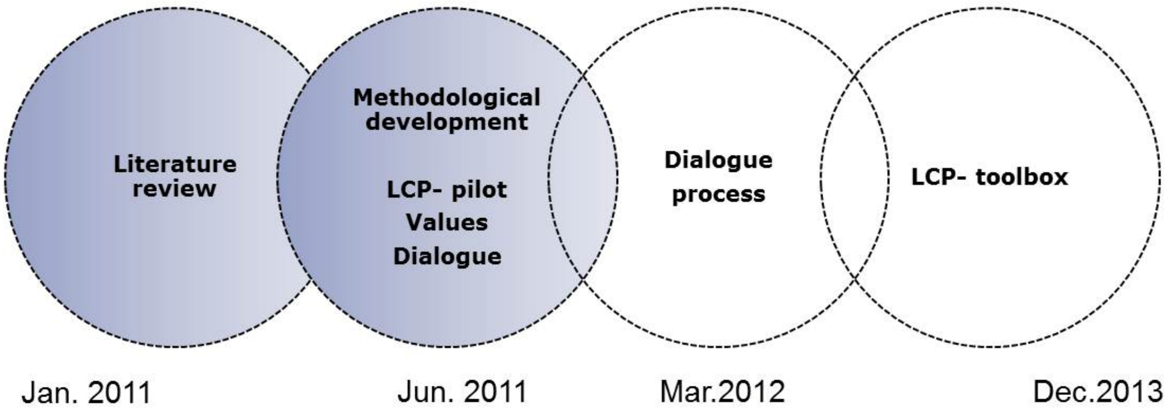


Figure 3. *Timeline for the LCP-pilot project.*

3 Power-line rights-of-way (ROW) as habitat for moose *(Alces alces)*

Objectives

- Assess habitat use of power-line ROWs by different wildlife species.
- Examine if power-line ROWs can represent suitable feeding grounds for moose.
- Investigate the influence of power lines on moose habitat selection.
- Find ways of improving power-line ROWs as wildlife habitats.
- Evaluate possible positive and negative effects of power-line ROWs on wildlife.

3.1 Background

Power-line rights-of-way have to be continuously cleared of trees to prevent power outages from trees growing into the lines. Such long open corridors may be perceived as a movement barrier by some wildlife species. A clear felled power-line corridor may not only affect animal abundance in the corridor itself, but also in adjacent edge habitat. Ecotones and edge habitats can be beneficial for edge-tolerant species, but detrimental for forest-dwelling species, and furthermore increase predation pressure along the edges by mesopredators (middle-sized predators). However, power-line rights-of-way containing young browse plant species may also constitute an attractive feeding ground for herbivores such as moose.

The aim of this project is to gain knowledge about the use of power-line rights-of-way by different wildlife species. The main species of interest are moose *(Alces alces)*, gallinaceous birds *(Galliformes sp.)* and red fox *(Vulpes vulpes).* Moose and gallinaceous birds are important game species. While power-line ROW may provide browsing resources for moose, they are a source for mortality in gallinaceous birds (cf. Chapter 4). Bird victims may again be prey for the red fox which may benefit from edge habitats (Storaas et al. 2001).

The proximity of woody cover of nearby forest habitats, as well as available browse within the power-line ROW, may make power-line edge zones particularly attractive to moose. While moose is an important game species, intense browsing pressure by moose may have negative effects on tree regrowth in forest ecosystems (Edenius et al. 2002, van Beest et al. 2010). To address these objectives we apply habitat preference modelling based on GPS-telemetry data, and by analyzing the distribution of browsing pressure and pellet groups surrounding power-line rights-of-way. These analyses will reveal where the preferred foraging habitats are.

The initial intention was also to find ways of improving the value of power-line ROW habitat not only for moose, but also for other wildlife species. Unfortunately it was possible to implement an alternative clearing regime to clear cutting only in a 1 km section in the Bangdalen study site. Although the lack of replicates are restricting the possibilities for suggesting improved vegetation management regimes from field data, we aim to evaluate if moose change browsing pressure due to the treatment, although the project lifetime might be too short to test the significance of possible responses.

3.2 Research methods

To find out if power lines affect moose habitat selection and movement, a preliminary movement model was developed for a subset of eight GPS-collared moose. Those were selected from 167 available moose in the Nord-Trøndelag County. The response variable was the probability of choosing a given movement step as a function of distance to power lines. A step selection function was employed for this purpose (Fortin et al. 2005). Distance to major roads, habitat and elevation were considered as covariates. Furthermore, changes in observed step lengths were analysed in response to distance from power lines. The same was done for roads.

The aim of the field study was to find out if moose browsing intensity increases near power-line ROW forest edges and other types of forest edges. For this purpose, moose browsing intensity and pellet deposition was recorded in 333 plots in the Bangdalen study area. The length of the power-line section surveyed was six kilometres. 120 plots were selected within a buffer of 30 meter around the power line and 120 plots were selected at ranges from 30 to 500 meters at each side of the power line. Of those, 333 plots were accessible and surveyed. The percentage of browsed shoots of each browsing plant species, pellet groups, count of browse plants and habitat variables were recorded in each plot. Browsing was further classified into peripheral browsing, leader stem browsing, last year browsing and previous to last year browsing. Browsing plants were classified into favourable (*S. aucuparia*, *Salix spp*., *J. communis*), 'Least Favourable' (*P. sylvestris*, *A. glutinosa*) and 'Birch' (*Betula spp*.) (O'Neill 2011).

Eight to fifteen wildlife cameras were deployed at a time in the Bangdalen study area in spring 2010. The aim was to detect differences in animal visitation rates and behaviour between inside/outside the power-line ROW and clearing regimes. Moose, red fox, other small carnivores as well as feeding behaviour of moose could be observed. However, the size of the accessible study area in relation to the home range sizes of the species of interest, the resource requirements to service the cameras every month, and the lack of special clearing area replicates led to the decision to terminate the data collection based on wildlife cameras.

Preliminary GIS-analyses concerning power-line routing across potential wildlife habitat was conducted for power-line routing data provided by the NVE. A comparison of the total length of different power line and road types in Norway was made.

3.3 Activities and findings

Hagen O'Neill from the University of Leeds made her MSc in connection to the project in 2011 with the dissertation "***Response of moose (*Alces alces*) to power-line rights-of-way/forest edges in Norway"*** as did Sarah Rochelle with the dissertation "***Effects of Power lines and their possible effects on the browsing behaviour of Moose (*Alces alces*) in Norway and how this relates to the browsing material available across Norway for* A.alces**".

Moose preferred to move towards power lines up to distances of approximately six kilometres from power lines (**Figure 4**). Selection towards power lines increased more strongly if moose were also selecting forested habitats. Selection increased with closer distances to roads in forest habitats. In non-forest habitats selection decreased at distances below 6 kilometres to roads. However, significant correlation could be detected between distances to roads and distances to power lines of observed moose positions.

The step length decreased when the animals approached the power lines, when distance ranges up to two kilometres from power lines are considered (**Figure 5**). However, those effects were not significant. Moose in forested habitats had shorter step lengths than in non-forested habitats. Limiting the analysis to distance ranges of up to 200 meters from power lines shows increased step length in close proximity to power lines. This effect was also not significant. The increase in step length in non-forest habitats in close vicinity of power lines was stronger than in forested habitats. Analysis of step lengths in distance ranges below 200 meters from roads is not presented, since too few individuals were available in this distance range.

The results are highly preliminary as only eight animals were included, and the reasons for the observed responses are currently unknown. Further analysis will include a greater number of individuals.

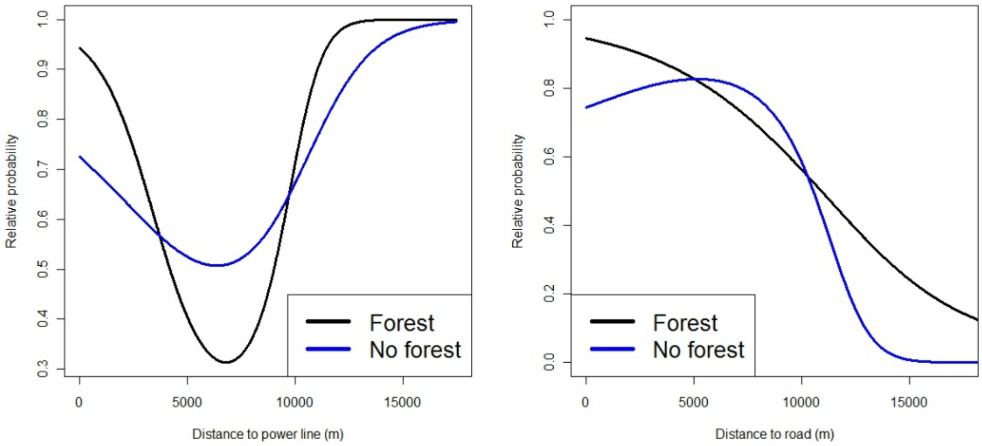


Figure 4. *Relative probability of step selection in response to distance from power lines and roads. Black and blue lines show different responses when selecting forested or non-forested habitats*.

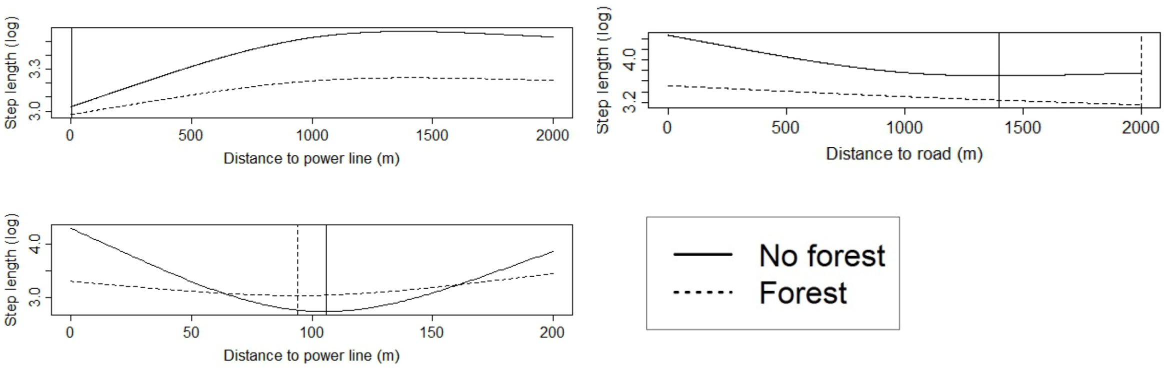


Figure 5. *Changes in moose step length with distance to power lines and roads.*

Analysis of pellet-group counts recorded in random plots in the Bangdalen study area shows an increasing probability of encountering moose pellets at distance ranges below 50 meters to the power line (**Figure 6**). This indicates increased habitat use near the power line.

No significant effect of distance to power-line edge and other edge types on browsing probability on different browse plant species could be detected (O'Neill 2011). Habitat and vegetative variables were accounted for in the analysis. The exception was browsing on leader stems of unfavourable plant species (*P. sylvestris* and *A. glutinosa*) (**Figure 7)**. Here a slight increase in the probability of browsing was found with increasing distance from the power line. This may be a result of reduced abundance of favourable browse species at larger distances from the power line so that less favourable browse plants are browsed upon. Further analysis would have to consider distribution of browse plant species in the study area. Improvement in the analysis may also be made by considering percentage browsed instead of probability of browsing.

Preliminary inspection of wildlife camera pictures indicates feeding activity of moose inside the power-line corridor in the Bangdalen study area, however, the time duration of different behavioural events has yet not been quantified. Analysis of power-line routing data from NVE shows that power lines are predominantly routed through forested habitat (**Figure 8)**. This analysis included all power-line classes from the database combined. Further analysis will reveal how power-line routing may vary in each Norwegian province and include other landscape parameters such as distance from roads, human settlements and elevation.

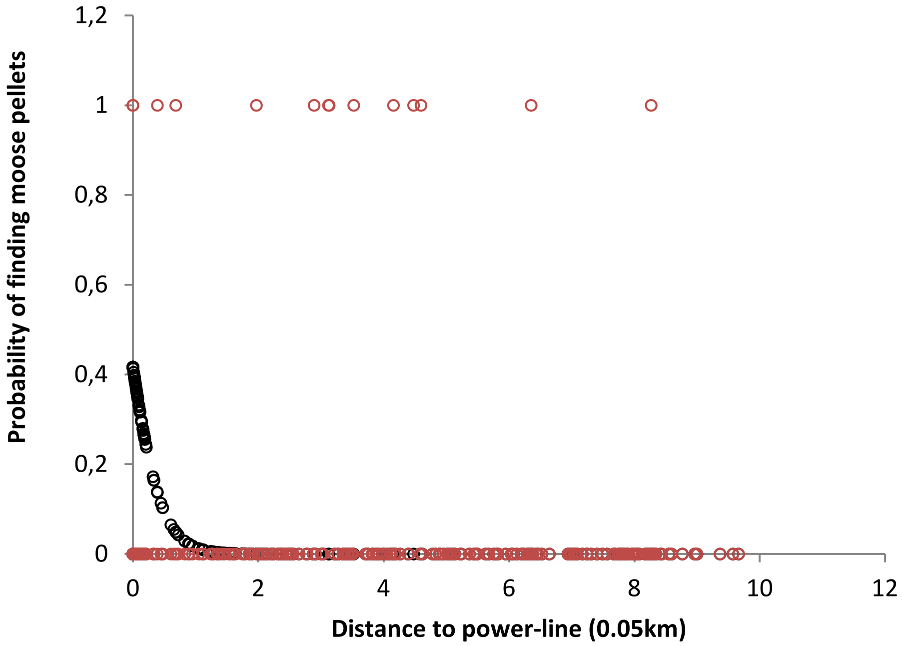


Figure 6. *Effect of increasing distance from power line on the probability on finding moose pellet groupings (in black) and observed binary data of moose pellet present/absent in plot (in red)* (from O´Neill 2011).

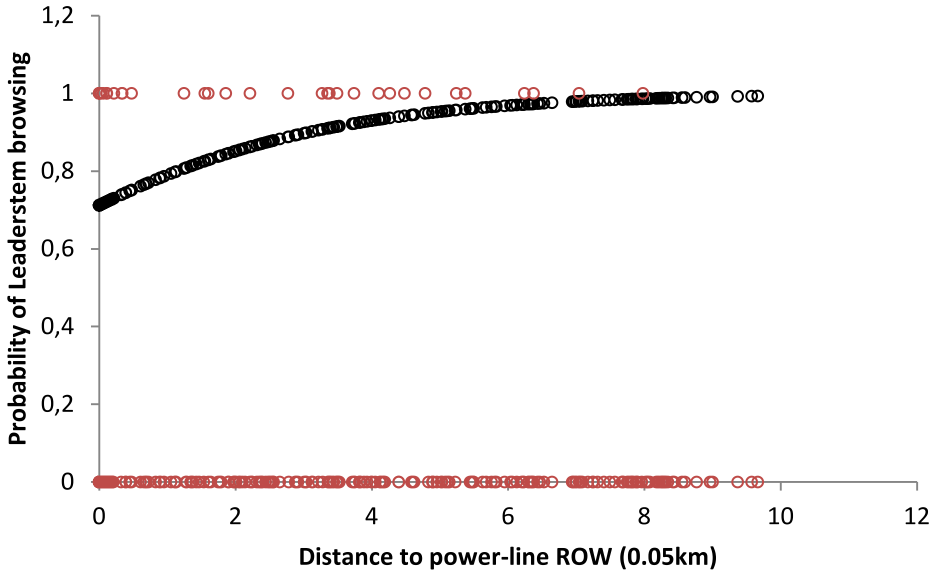


Figure 7. *Effect of increasing distance from the power-line on the probability of moose browsing upon leader-stems on unfavourable (*P. sylvestris *and* A. glutinosa*) tree species (in black) and observed binary data of browsed/unbrowsed unfavourable tree specimens (in red)* (from O'Neill 2011).

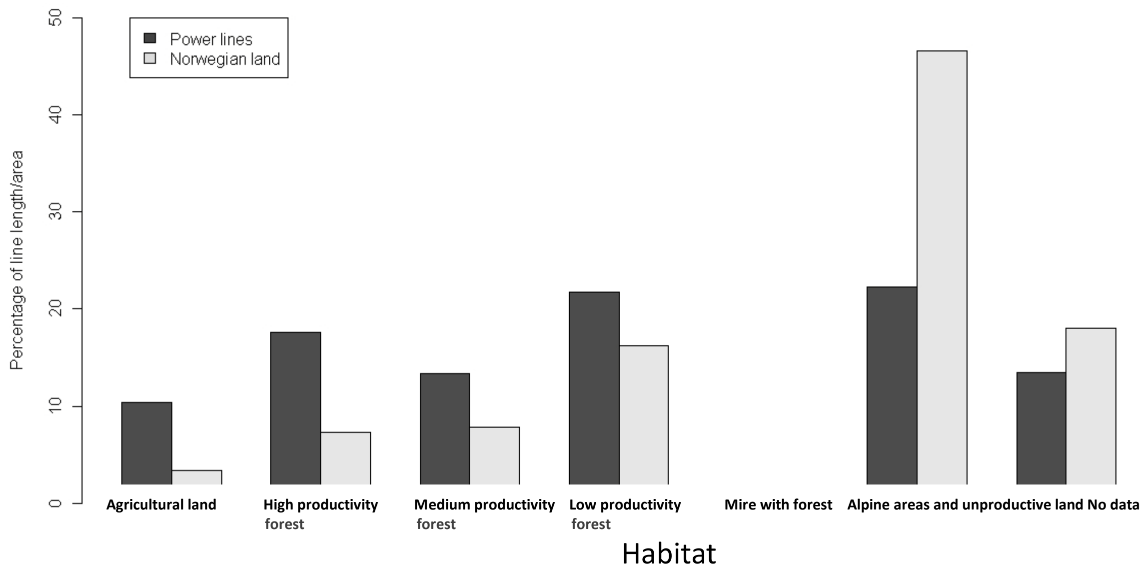


Figure 8. *Percentage of power line length and Norwegian land covering different habitat types. Power lines are situated predominantly in forested habitats in Norway*.

Of the total length of power lines, the distribution grid up to voltages of 24 kV constitutes by far greatest proportion (**Figure 9**). This part of the grid consequently affect the largest land areas and pose the greatest risk for bird electrocution and potentially collision (Bevanger 2011). Unfortunately accurate routing data for this power-line category is not available on a national scale.

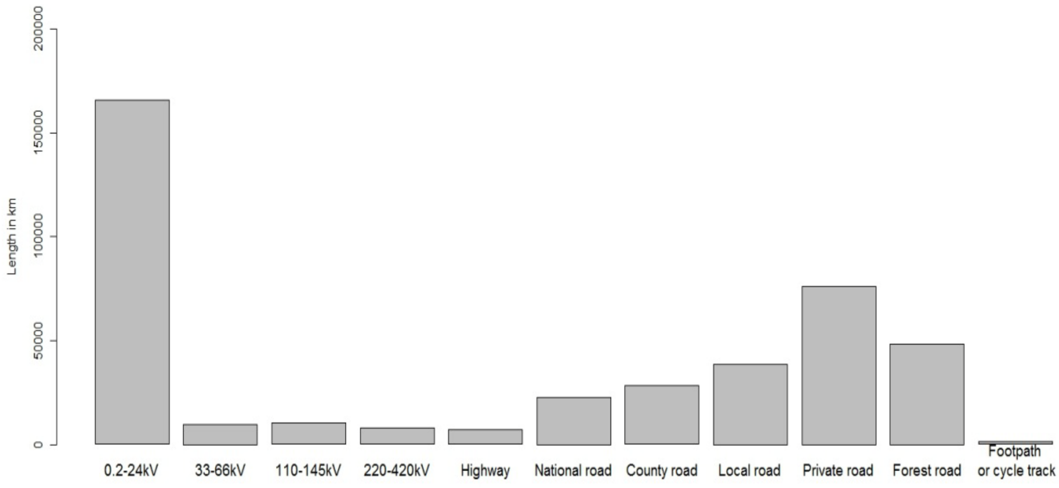


Figure 9. *Lengths of different power line and road categories in Norway. The power-line data are obtained from Statistics Norway (2011), and the length of different road types derived from a NINA GIS database.*

4 Bird population responses to power-line induced mortality

Objectives
Assess population impact of bird mortality due to power-line collisions, relative to other human related mortality factors (primarily hunting) in gallinaceous birds (with capercaillie and black grouse as model species).

4.1 Background

It is well documented that numerous bird species are running the risk of flying into over head wires with fatal consequences (Bevanger 1994, 1998). Some species are, however, more vulnerable to artificial air obstacles than others, and in Norway gallinaceous birds are among the most frequent collision victims. There are two main concerns connected to this; one is that the Norwegian gallinaceous bird species are popular small game species being extensively hunted, particularly during the autumn hunting period (Bevanger 1995). Due to declining population densities it has become increasingly important to regulate the hunting bag to avoid overexploitation. To advice on a safe hunting outtake, it is important to know the extent of other mortality factors, like collisions with power lines, and how this may influence on the population development. A particular concern is connected to the fact that mortality among the gallinaceous birds seems to be peaking during the spring season, i.e. adult birds going to reproduce are killed. A second aspect is connected to estimating the landowner's loss when he gets a power line routed across a high quality hunting area. The economic compensation extent due to reduced quality of a small game hunting ground is a question frequently debated both by the landowners, the grid owner and the consenting authorities.

4.2 Research methods

In an intensively studied area (30 km^2, Ogndalen in Steinkjer local authority) we are censusing the population of capercaillie and black grouse by transect sampling of droppings for DNA identification in winter/spring over a four year period. The number and location of leks used by these species are also identified. A 300 kV transmission line crossing through the area are searched for dead birds killed by colliding with the overhead wires using a special trained dog. By DNA-identification of the collision victims we get estimates of power-line related mortality rates in the population. Annual survival estimates from the capture-recapture DNA-design will be used to compare the risk of collision mortality relative to the distance to power lines.

4.3 Activities and findings

In March 2011 the study area was surveyed for a total of 99.9 km and 53 droppings collected for DNA analysis. DNA analysis was very successful and 18 and 8 black grouse and capercaillie were identified from the samples respectively. Based on this, the population in the study area was estimated to 35 black grouse (1.2 birds/km^2) and 14 capercaillie (0.5 birds/km^2) in March 2011 (**Figure 10**). Because of extreme snow melting conditions we had to cancel a second data survey for population estimation in spring 2011.

As by November 8 a total of 10 search patrols for dead birds with the trained dog have been conducted (**Table 1**). So far a total of 38 collided birds/bird remains have been discovered. Some of these may be from the same collision victim so 25 feather samples are currently being DNA-analysed to identify possible double counting. The list of discovered birds/bird remains (**Table 2**) show that the collision victims is as expected dominated by black grouse and capercaillie.

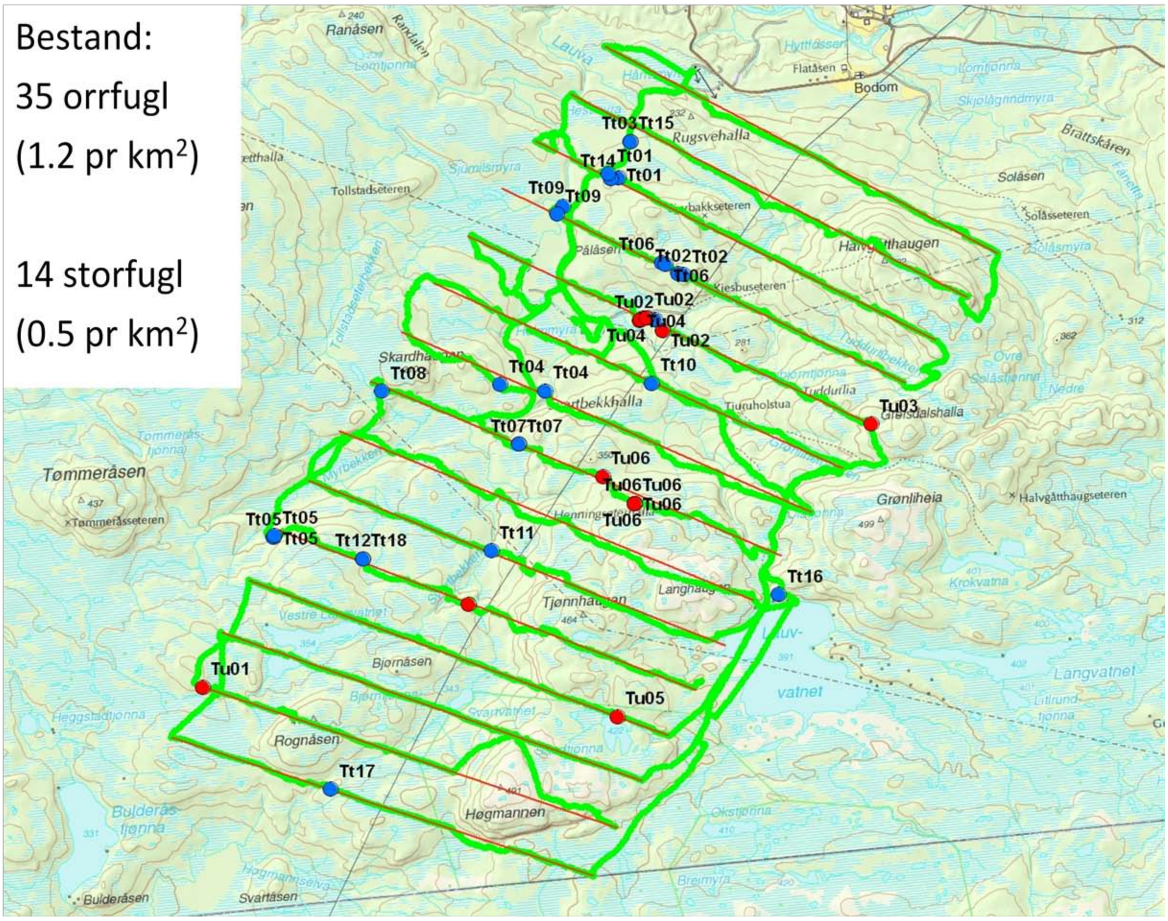


Figure 10. *Survey for bird droppings in March 2011. Green tracks = survey effort recorded with GPS. Blue dots=DNA identified black grouse. Red dots=DNA identified capercaillie*.

Table 1. *Summary of effort and findings on the 10 conducted patrols in 2011.*

Patrol no.	Hours in the field	Dog handler (km)	Dog (km)	No. recordings	Dog handler
1	8,0	8,0	10,5	5	1,3
2	8,4	8,0	12,2	10	1,5
3	7,0	7,9	10,9	6	1,4
4	6,5	7,8	10,9	2	1,4
5	5,5	7,9	10,0	1	1,3
6	5,7	8,3	12,4	3	1,5
7	5,2	7,8	11,6	2	1,5
8	5,8	7,8	11,2	3	1,4
9	6,0	8,3	11,4	5	1,4
10	5,0	8,0	11,7	1	1,5
SUM	**63**	**80**	**113**	**38**	

Table 2. *The 38 recorded bird fatalities identified during 10 patrols in 2011. Gallinaceous species in yellow*.

Patrol number	Species
1	Capercaillie
1	Capercaillie
1	Capercaillie
1	Capercaillie
1	Willow ptarmigan
2	Redwing
2	Capercaillie
2	Willow ptarmigan
2	Willow ptarmigan
2	Redwing
2	Capercaillie
2	Black grouse
2	Capercaillie
2	Black grouse
2	Black grouse
3	Black grouse
3	Redwing
3	Capercaillie
3	Willow ptarmigan
3	Capercaillie
3	Black grouse
4	Capercaillie
4	Capercaillie
5	Black grouse/capercaillie
6	Northern wheatear
6	Black grouse
6	Redwing
7	Capercaillie
7	Turdus sp.
8	Redwing
8	Willow ptarmigan
8	Redwing
9	Capercaillie
9	Capercaillie
9	Redwing
9	Capercaillie
9	Capercaillie
10	Capercaillie

Figure 11. *A special designed field journal is used during the data sampling in Ogndalen, covering both the excrements collected for DNA analyses, live bird observations and recordings of dead birds*.

5 Bird collision hot-spots

Objectives
Identify ecological high-risk factors for bird collisions, i.e. site-specific factors connected to topographic characteristics, including vegetation structure, season, weather and light conditions, using

- existing dataset from earlier projects on birds and power lines
- new sampled data (using special trained dog)
- the national dead-bird database
- advanced statistical/GIS-modelling

5.1 Background

Gallinaceous birds together with some other species groups are proved to be over-represented among power-line collision victims (Bevanger 1998). Searches for injured or dead victims in or near power lines are necessary to assess the number of victims and estimating species-specific collision risks, together with mortality extent and population impact. Moreover, to be able to identify topographic and external factors that influence the collision-risk factors, it is necessary to have detailed information on the place where collisions take place. This problem is addressed through several subprojects in OPTIPOL. Available data as well as new data will be the basement for modelling how birds use the terrain and thus enable – by means of GIS-tools - to predict what topographic structures, habitats and other environmental factors increasing the collision hazard.

5.2 Research methods

Over the last 25 years several projects in Norway have been sampling qualitative and quantitative data on birds colliding with power lines (Bevanger 1988, 1990, a,b,c, 1993, 1994, 1995, Bevanger & Sandaker 1993, Bevanger et al. 1998). Data that will be reanalysed derives from five counties, i.e. Finnmark, Sør-Trøndelag, Hedmark, Oppland and Buskerud (cf. **Table 3**). Both the power-line sections patrolled and the sites where dead birds have been located are being geographically referred and made ready for further GIS analyses and modelling.

In connection to the project on gallinaceous bird population responses to power-line induced mortality (cf. Chapter 4) a dog (wachtel breed) was bought and particularly trained to find dead birds. So far a total of 38 dead birds have been located by the dog and the dog handler. A standard set of parameters are recorded in connection to the spots where these dead birds are located. A special designed field journal is used during the data sampling in Ogndalen, covering both the excrements collected for DNA analyses, live bird observations and recordings of dead birds (**Figure 11**).

The third set of data for this bird-collision hotspot project hopefully will derive from the national database on dead birds (cf. Chapter 6). Unfortunately, so far the data volume has not met our expectations, and by November 9 it was only reported on 14 dead birds caused by collisions with power line and 5 dead in connection to electrocution. Thus, it will be considered if it will be necessary to contact specific knowledge or interest groups like employees at the energy companies, member of the BirdLife etc.

5.3 Activities and findings

The activities in 2011 have concentrated on old data arrangements and data collection in connection to subproject 4 and 6. Data analyses will start in 2012.

Table 3. Norwegian power line sections patrolled for dead birds 1984-1994.

Section no. (period of patrol)	Geographic name (pylon nos.)	Distance patrolled (km)	Tension category (kV)	No. phase conduc-tors/levels	No. earth wires	Phase-/earth wire diameter (mm)	Year of con-struction	Grid owner
ORKDAL-RENNEBU (Bevanger 1988 - cf. ØKOFORSK Report 1988:9)								
1 (29.8.84-27.8.85)	Orkla/Grana (69-102)	5.6	132	6/3 (2 circuits)	0	30.0	1982	Trønder Energi
2 (28.8.84-26.8.85)	Hoston (105-140)	4.2	66	3/1	0	10.0	1926	Trønder Energi?
3 (10.12.86-18.5.87)	Ren-nebu/Kvikne (192-222)	4.0	66	3/1	0	10.73	1968	Trønder Energi
4 (19.3.86-6.11.87)	Støren/ Innset (109-142)	5.0	66	3/1	0	10.73	1968	Trønder Energi
5 (21.3.86-19.5.87)	Brattset (parallell) (??-86/12-41)	3.7	132/72	6/3 og 3/1	0	21.66/16.73	1982/79	Trønder Energi
6 21.3.86-19.5.87)	Døåkjølen (2-12)	1.0	66	6/3	0	16.73	1979	Trønder Energi
7 (9.12.86-18.5.87)	Rennebu/ Kvikne Litjfossen-Brattset (72-86)	1.9	132	3/1	0	21.66	1982	Trønder Energi
POLMAK (Bevanger 1993 - cf. NINA Forskningsrapport 040 – 1993)								
1	Polmak (116/117-131/132)	3.8	220	3/1	2 top lines	21,66/10,66	1987/88	Statnett
HEMSEDAL (Bevanger et al. 1998, cf. NINA Oppdragsmelding 531 – 1998)								
1	Section 1 (87-101)	5.0	300	3/1	2 top lines	35.10/18.27	1974	Statnett
2	Section 2 (124-148)	2.5	66	3/1	0	12.33	1971/72	Hemsedal Energi
3	Section 3 (1-24)	2.5	22	3/1	1 located below	12.33/12.33	1977	Hemsedal Energi
4	Section 4	1.0	22	3/	1 located below	12.33/12.33	1990	Hemsedal Energi
MJØSA-RANDSFJORDEN (MSc Thesis 1993 Jo Wattum)								
1	Section 1	2.5	132	6/3 (2 circuits)	0	21.6	1957	Eidsiva
2	Section 2	5.0	132	3/1	0	21.6	1989	Eidsiva
3	Section 3	4.5	300	3/1	2 top lines	35.1/18.3	1963	Statnett

6 National web portal for management of dead-bird data

Objectives
Establish a national infrastructure for management of dead-bird data (including birds recorded as collision and electrocution victims) by developing an online web application enabling the general public to contribute with data on recorded dead birds via Internet.

6.1 Research methods

The aim of identifying species- and site-specific factors triggering increased collision risk is also the rationale behind this sub project. To identify the decisive factors triggering bird collisions with power lines and/or electrocution it is necessary to have as much data as possible on characteristics both of environmental parameters where the accidents take place, as well as design of site-specific power-line structures. Patrolling power lines is a very time and recourse consuming activity, thus it will be very useful to get additional data through public observations.

In 2009 a functional prototype of the web application for registering dead birds at NINA was developed (Bevanger et al. 2009, **Figur 12**). It incorporates topographical maps, and has the possibility of overlaying power-line maps. Some geocoding conversion functions are incorporated and it is possible to upload pictures of recorded dead birds. Some bird collision data in spreadsheet format from recent projects have been examined to determine a data structure which facilitates import.

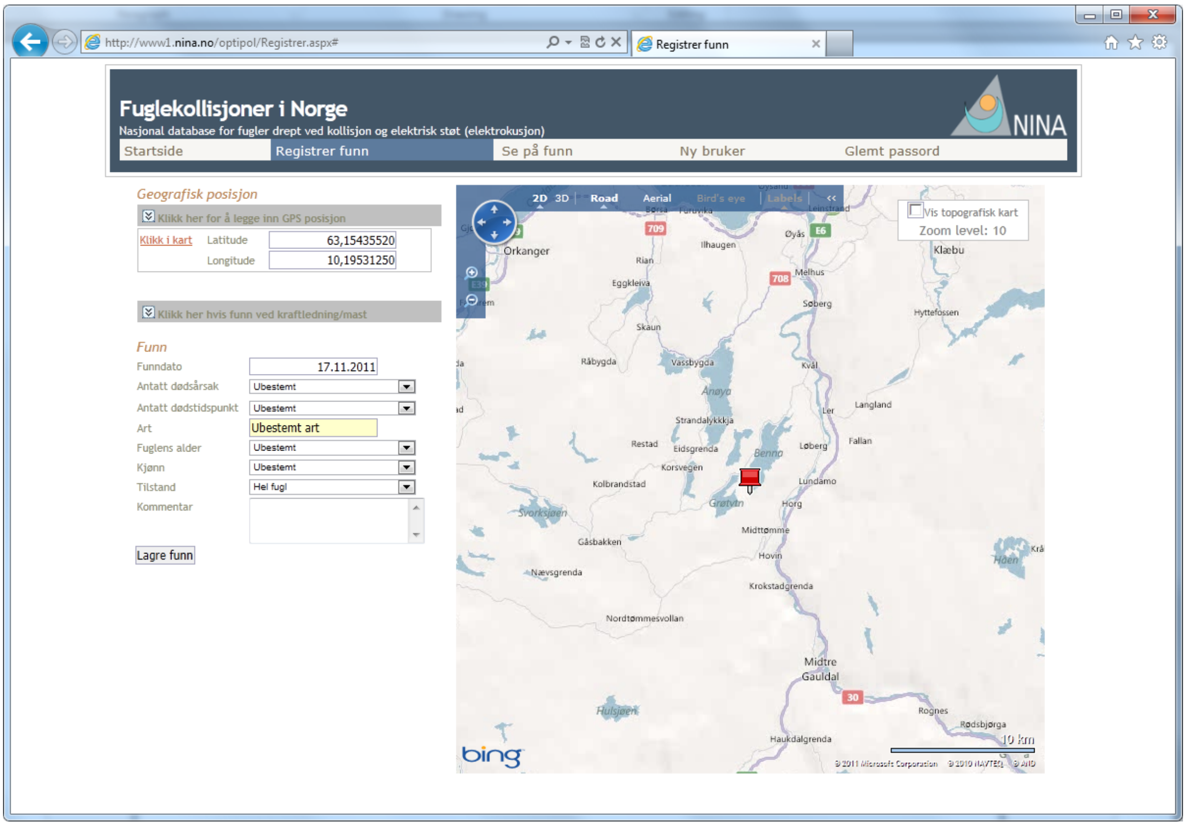


Figure 12. *In 2009 a functional prototype of the web application for registering dead birds at NINA was developed (http://www1.nina.no/optipol).*

6.2 Activities and findings

Although a functional prototype of the database was finished in 2009, NINA addressed the possibilities to co-operate with The Norwegian Biodiversity Information Centre (NBIC) in early 2010. The NBIC already has a species observation portal - *artsobservasjoner.no*. – which has become a very popular web site and is accessed by several people contributing with hundreds of observations daily (**Figure 13**). This system is also adopted by the Norwegian ornithological Society (NOF) which is part of BirdLife International. This is an organisation with a large number of members with solid bird knowledge that also can be activated to undertake specific task in some cases. By making some adjustments of the activity list for death causes in *artsobservasjoner.no*, (**Figure 14**) it was possible to use the NBIC observation portal to collect data on dead birds as well.

By early 2011 this system had become operational, and by November 9 2011 the following data had been received:

Death due to fence collision 5
Death due to vehicle collision 59
Death due to beacon light 1
Death due to window 33
Death due to power line collision 14
Death due to electrocution 5

Unfortunately the data catch from *artsobservasjoner.no* so far is rather limited, thus it will be considered if it is necessary to contact specific knowledge or interest groups like employees at the energy companies, member of the BirdLife etc. to make specific registrations on bird mortality in connection to utility structures and get these stored in the NINA-2009 application.

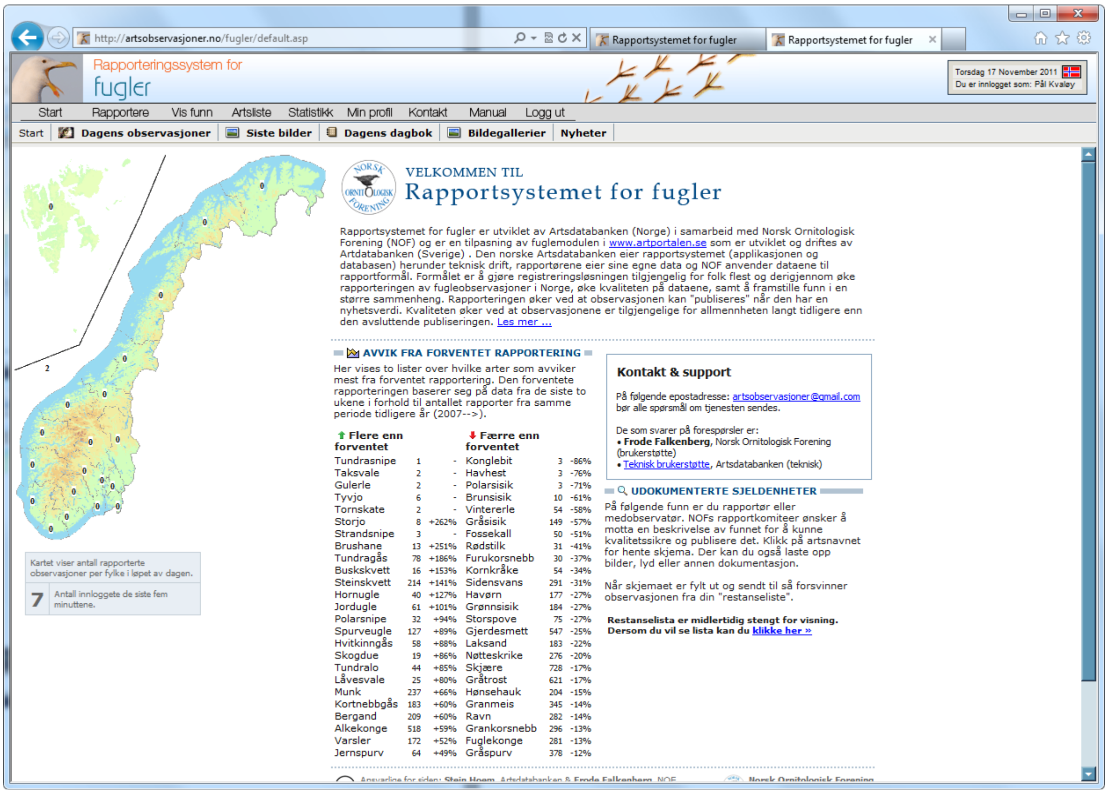


Figure 13. *The Norwegian Biodiversity Information Centre has a species observation portal -* **artsobservasjoner.no.** *– which has become a very popular web site and is accessed by several people contributing with hundreds of observations daily.*

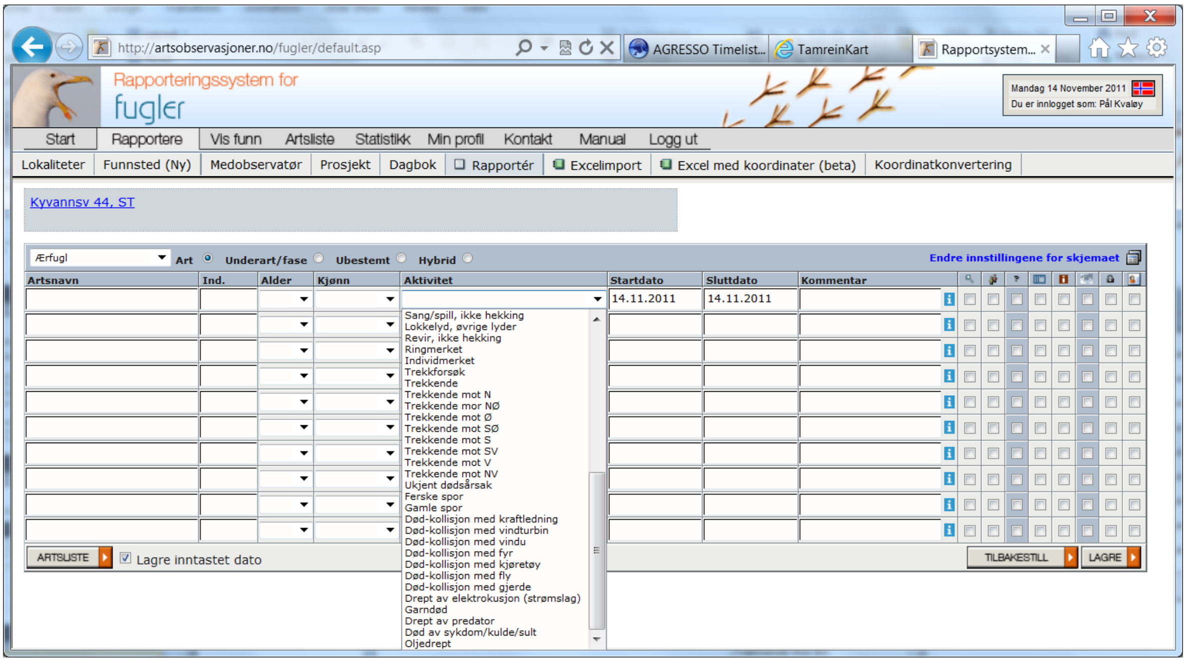


Figure 14. *The mortality-cause list was implemented in the Norwegian Biodiversity Information Centre's species observation portal -* **artsobservasjoner.no.** *in early 2011*.

7 A review on ecological and technical impact of power-line camouflaging

Objectives

- Review available literature to assess whether camouflaging techniques is to be recommended given the present knowledge on bird vision.
- Review technical properties and constraints of camouflaging techniques on conductors and earth wires.

7.1 Background

Local opposition to projects giving some auditive or visual "pollution", like power lines or wind power turbines, has become increasingly important to take into account for the energy authorities during the consenting process. The idea of "camouflaging" phase conductors and grounding wires through paint coating is probably reflecting the opposition to power lines as a visual polluting element and has been an issue for several years (e.g. Statnett 1998). Environmental and aesthetic considerations are commonly mixed into something which politicians may consider as a good solution, while it from an ecological point of view possibly could generate a problem for birds. Power lines as well as the supporting structures can be made less visible to humans by using paint and colours matching the background, thus reducing the visual impact. NVE recently delivered a report (Johnson 2008) to the Ministry of Oil and Energy suggesting supporting structures as well as the phase conductors to be painted in green. Unfortunately, the impact of camouflaging power lines regarding bird responses are not well understood, and in theory it could generate unwanted effects with respect to increased bird-collision hazard, depending on how birds perceive a coloured wire (Bevanger 1999b).

To achieve an optimal detectability of a power line for birds it is important to carefully consider and optimize the contrast of the wires against the background. Bird survival is strongly affected by their visual capacities and bird eyes are highly specialized instruments, with a visual acuity 2-8 times higher than a mammalian eye. Moreover, birds have highly developed colour vision. Birds see more colours than humans, and it is generally believed that the colours appear more saturated than they do to us. The reason is that birds have four cone types involved in colour detection, and pigmented oil droplets in these photo receptors. While humans have short, middle and long (also called blue, green and red) cones, birds also have a ultra-violet- (UV) cone with a UV-perception from 320 nm (e.g. Martin 1990, Butler 1996, McIlwain 1996, Valberg 1998). Thus, camouflaging power lines with the intention to make them less visible to humans includes several unanswered questions related to how this should be done without increasing the collision hazard to birds. However, Osorio et al. (1999) found that the ability of birds to distinguish between colours in the yellow range of the spectrum probably surpasses that of humans. It seems likely that some green and yellow colours, especially if they have a strong UV contribution will contrast greatly against a natural green background for birds while a human observer would find the same colour much less conspicuous.

7.2 Research methods

The biological objective of this subproject will be reached by making a literature regarding experiences gained on how a phase conductor surfaces with different colours and/or reflection affect the ability of birds to see them and thus avoid flying into them. An in-situ testing of bird behavioural responses to colour-coated power lines would be expensive and outside the economic capacity of the OPTIPOL project, thus it will remain as a review.

The technical part of the project will make an assessment of how power line coating possibly could affect system reliability. In the Norwegian grid system there are some power-line sections where surface coating have been used, and an inquiry will be made to get information from the grid owners on how their experiences on this issue have been.

7.3 Activities and findings

So far the main activities on this sub-project have concentrated on data sampling by identifying published articles and reports on the topic. The project results are planned reported in 2012.

8 A review of ecological and technical options and constraints for mitigating bird collision and electrocution

Objectives

1. Review available literature on technical modifying solutions and assess their effectiveness to mitigate bird collisions and electrocution, focusing
   - the effectiveness of reducing bird mortality by conductor marking equipment
   - the effectiveness of design methods and modifications to reduce electrocution hazard for birds
   - where and when earth cabling and other technical alternatives to mitigate bird collisions with overhead wires are justified from an ornithological point of view
2. Review available literature on the impact of the technical modifying solutions identified in 1) with respect to corrosion and other factors that could pose a threat to system reliability and electrocution, focusing
   - the technical properties of conductor marking equipment
   - insulating cover techniques on preferred poles associated with bird electrocution
   - cost effective line design modifications to mitigate bird strikes or electrocution hazard
   - when and where underground (earth) cabling will be a technical and economic solution to mitigate bird strikes

8.1 Background

Several technical issues are related to birds and energy transmission, e.g. how should structures connected to energy production and supply be designed to minimize electrocution hazard. Engineers, in cooperation with ecologists, have a good record in identifying electrocution high-risk areas and modifying electrical equipment to avoid or reduce the electrocution of birds (Ohlendorff et al. 1981, APLIC 2006, Lehman et al. 2007). Unfortunately, adoption and implementation of identified solutions has only been done to a limited extent in Norway, in spite of the fact that a particular concern about the electrocution and collision hazard to birds has been raised by the Convention on the Conservation of Migratory Species of Wild Animals (Bonn Convention) (Resolution 7.4 – Electrocution of migratory birds) and the Convention on the Conservation of European Wildlife and Natural Habitats (Bern Convention) (cf. Recommendation No. 110) (Bern Convention 2004). Both the Bonn and Bern Convention are adopted by Norway. Recommendation No. 110 also includes guidelines for a variety of remedial actions to be taken.

It is also possible to modify the design of power lines to reduce the collision hazard. Although a significant job has been made in several countries to develop alternative constructions both to mitigate bird electrocution as well as collisions these solutions may not be suitable for the environmental conditions we have in Norway. Wire marking which physically enlarge the wires may e.g. act as wind-catching objects, encouraging icing in winter and increasing the risk of wire breakage and outage of power supply due to line tension and stress loads. The attachment of devices may also cause physical damage through abrasion to the conductors. Neither optimal corridor location nor phase-conductor marking completely remove the collision problem, thus there is one reliable method left - underground cabling. The main argument against underground cables is their cost (e.g. Madsen 1979, Thompson 1978, Longridge 1986).

Mitigating measures to reduce power-line induced bird mortality (collisions and electrocution) has been a focal issue for many years in several countries – both due to the economic impacts of outages caused by these incidents as well as the bird species-specific impacts. Proposals to mitigate these problems have been numerous; however, it has been difficult to find general solutions of wide-ranging application and benefit. Moreover modifying utility structures has an economic cost for the net owner, and must not violate the energy supply security. The modifications must also be designed to fit the local design of the power-line structures, which are highly diverse and differ from country to country.

8.2 Research methods

To reduce bird mortality because they fly into overhead wires has been a challenge both to ecologists and engineers for several decades. Making e.g. power lines more visible using devices has been the logical “quick fix” to the problem; however, it has been extremely difficult to test the efficiency of these mitigating efforts. As stressed by other authors (e.g. Barrientos et al. 2011), the lack of sufficient well-designed experiments is responsible for few good data on the efficiency of marking equipment. It would probably be extremely difficult to raise money to make a long term *in situ* experiment (with controls), accurate enough to reveal a device specific excellence or efficiency.

The main method used within this subproject will be based on existing knowledge, both regarding the ecological and technical part, and a thorough literature review will be made. In order to clarify the degradation rate of the conductors if specific marking devices are being used, accelerated corrosion tests have been carried out on five electrocution prevention insulation systems (cf. Chapter 9).

8.3 Activities and findings

Apart from the accelerated corrosion test (cf. Chapter 9) the main activities on this sub-project have concentrated on data sampling by identifying published articles and reports on the topic. The project results are planned reported in 2012.

9 Guidelines for technical solutions to mitigate power-line induced mortality to birds

Objective
Prepare guidelines for safe technical solutions and mitigating techniques to mitigate bird strikes or electrocution hazard.

9.1 Background

A main goal for this subproject is to advice how to establish cost-effective line design modifications to mitigate bird strikes or electrocution hazard. This can be implemented when carrying out refurbishment, uprating and upgrading and when new power lines are constructed. Questionnaire answers by Norwegian power companies in the early 1990ies (Bevanger 1994a) revealed that top-mounted pin insulators, steel cross-arms, and pole-mounted transformers was electrical installations and equipment frequently associated with bird electrocution. Actual techniques to consider for use on preferred poles are e.g. insulated phase conductors, insulated cross arms, line design modifications; i.e. support or suspension insulators, elevated perch constructions and change critical distances between phase-phase or phase-ground.

Decisions on the management of existing overhead transmission lines are based on the need to maximize asset utilization and return on investment. In order to accomplish this, the grid owners must be proactive and aware of possible threats and opportunities to their assets. If a threat like load growth, approval for new lines, system ageing, outage constraints, lack of manpower, EMF-issues etc. is not recognized soon enough, the consequences can result in loss or underutilization of their assets. Some of the tools available to the grid owners are restoration, uprating and upgrading, new lines and underground cables. This gives an opportunity to determine and implement the most economical and technical viable options to minimize conflict with wildlife and meet the increasing demand for electricity and reliability for electricity supply to customers.

9.2 Research methods

Overhead power lines are crossing a variety of landscapes and habitats, and in some areas they pose a major threat to some bird species due to collisions or electrocution. Of special concern are threatened bird species like the eagle owl with a large mortality percentage from electrocution (Bevanger & Overskaug 1998).

There are several methods to remove or reduce the bird electrocution risks on existing or planned power transmission routes. Such methods include

- Choice of non-sensitive routes for overhead lines (e.g. routing in low risk areas for threatened species)
- Replacement of overhead lines with cables
- Re-design of overhead lines (e.g. increasing the distance between phases)
- Retrofitting of existing overhead line structures (insulation or perch guards)

The final product of this subproject will be a guideline based on the findings made in this sub project and the previous two subprojects (cf. Chapter 7 and 8).

9.3 Activities and findings

In 2011 a “mini guide” for avoiding bird collision and electrocution was prepared for NVE, supposed to be distributed to the Norwegian grid owners. This guide was mainly based on existing knowledge on general principles that can be deployed when power lines are constructed to minimize bird mortality. However, due to the acute need to find solution to reduce the eagle owl electrocution hazard (cf. Chapter 10) a particular focus has been on modifying solutions to the widespread 22 kV pylon the crossarm. A new type of elevated perch is developed by NINA, SINTEF and El-tjenester AS. The perch is combined with a perch discourager device on the top of the cross arm, preventing the birds from perching at hazardous places close to the phases or grounding (cf. **Figure 15**). The results of the test are presented in Chapter 10.

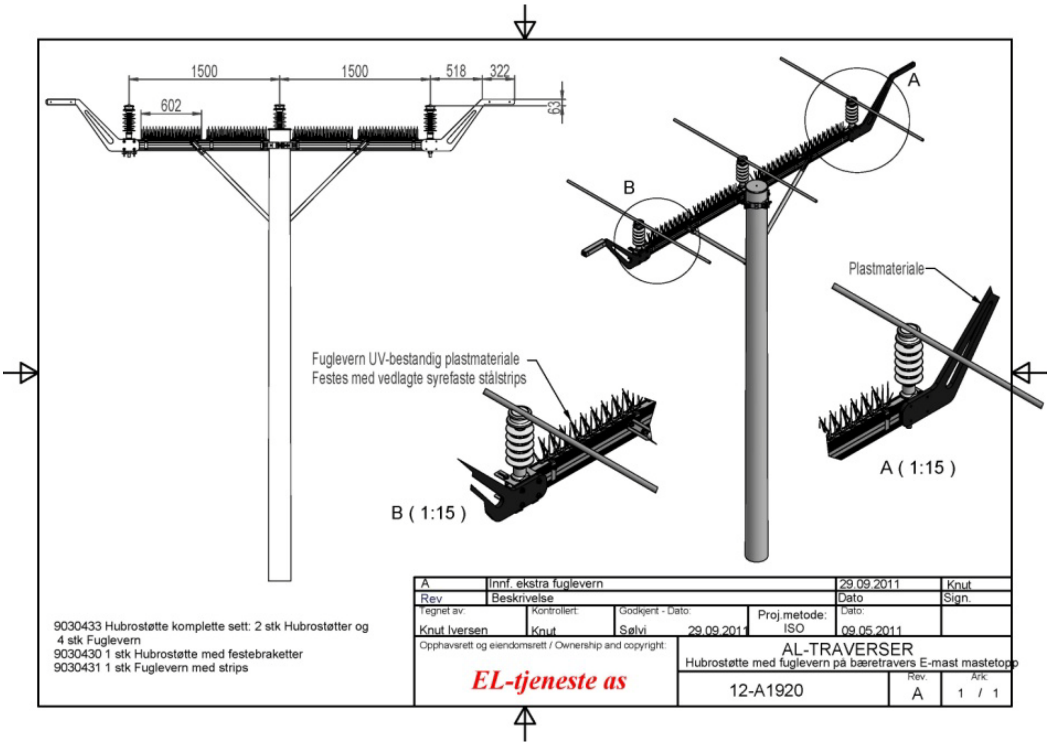


Figure 15. *Perch and anti-perch device developed in co-operation between NINA, SINTEF and El-tjeneste AS*.

Covers installed over the insulators and conductors is generally the preferred method for retrofitting of 22kV overhead lines with pin-type insulators (which is a design frequently causing electrocution accidents among birds) to avoid electrocution. However concerns regarding corrosion have been raised for such system for exposed marine locations at the Norwegian coast.

In order to clarify the degradation rate of the conductors, estimate the life expectancy and to work out guidelines where the phase covers may, or should not be installed; accelerated corrosion tests have been carried out on five electrocution prevention insulation systems. The corrosion tests simulated 12 years of exposure in two different marine corrosion environments (cf**. Table 4** and **5**).

Table 4. *Life expectancy for ACSR conductors in the supply area at a Norwegian utility. Covers are installed over the insulators and conductors*.

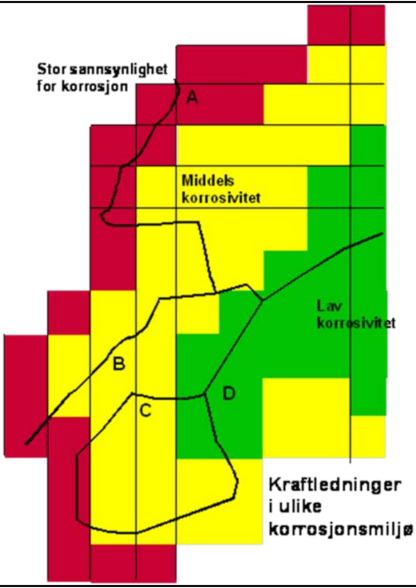
CORROSION ENVIRONMENT AT A UTILITY	LIFE ECPECTANCY
	Covers installed over the insulators should not be installed in exposed coastal areas where MCI = 7-8. The life expectancy of the conductors in these coastal locations is approximately 10 years ± 2 Covers may be considered in coastal areas with low corrosivity (MCI = 3-4). The life expectancy of the conductors in these locations is approx. 22years ± 6 Covers can be used in rural areas with very low corrosivity (MCI = 0-2).

Table 5. *Life expectancy for conductors in two different Marine Corrosion Environments [MCI]. Covers are installed over the insulators and conductors*.

Covers installed over the insulators and conductors		Estimated life expectancy (year) in two different Marine Corrosion Environments (MCI)	
		MCI = 4	MCI = 8
HUVEN UVEN AB Kabeldon		16-22	9-10
ARK 1053 Arkonia Systems		20-54	11-12
KE 116203 Kaddas Enterprises		16-25	11-13
BIC-3312 Tyco Electronics		17-29	10-11

10 Impact of power-line induced mortality on an eagle owl population

Objective
Assess eagle owl mortality and population impact caused by power-line collision and electrocution; identify high-hazard collision and electrocution structures and possible mitigating measures.

Figure 16. *Female eagle owl in the study area at Sleneset, Nordland County.* Photo: Jan Ove Gjershaug ©

10.1 Background and research methods

The Norwegian eagle owl (**Figure 16**) population has experienced a steep decline since the 1950ies. The number of breeding pairs is now estimated to be somewhere between 408 and 658 (Jacobsen et al. 2008). The species is categorised as endangered (EN) on the Norwegian Red List (Kålås et al. 2010). The most important mortality factor for the species, and possibly the main reason for the population decline, is electrocution (Bevanger & Overskaug 1998). Based on input from NINA, the authorities launched a national action plan in 2009 for the species (Direktoratet for naturforvaltning 2009). The responsibility for the following up of this plan is placed at the office of the County Governor in Nordland.

In 2008 NINA initiated a pilot study on the relations between power lines and eagle owl on Solværøyene/Sleneset in the municipality of Lurøy, Nordland County, a study funded by the Directorate for Nature Management (Gjershaug & Jacobsen 2008). Solværøyene and Lovund have at most 26 breeding pairs of eagle owls, and the entire Lurøy population could probably include some 40-50 pairs in good periods. Over the last twenty years members of the Rana Zoological Society have recorded 30-40 dead eagle owls in connection with utility structures, and about 90% of the specimens were most likely killed by electrocution, the rest by collisions (Espen R. Dahl pers. comm.). Ten of these records are shown in **Table 6**.This makes the area suitable for e.g. mitigation experiments. We have cooperation with Hedmark University College, who has provided information about eagle owl nest locations and breeding success and collected feathers for DNA analyses.

The study has the following approaches:

1) Use of GPS satellite telemetry to provide data the extent of eagle owl use of power poles during hunting activities, and to find electrocuted eagle owls.
2) Use of GPS satellite telemetry to study eagle owl home-ranges and movements.
3) Collecting feathers of eagle owls from the nests for DNA analysis to obtain a mortality estimate for adults.
4) Searches beneath all power lines and poles in the study area to find carcasses of eagle owls and other birds.
5) Build a population model based on local data on reproduction- and mortality rates to evaluate to what extent the extra adult mortality caused by power lines affects long-term population sustainability.
6) Testing of electrocution-safe structures like anti-perch devices and elevated perches on 22 kV power-line pylons.

10.2 Activities and findings

The eagle owl population showed improved breeding success in the study area in 2011 compared to 2010. Out of nine potential territories in our study area, six breeding attempts were recorded with four young fledged in three nest sites, compared to four breeding attempts and three young fledged in two nest sites in 2010. The population of water voles *Arvicola amphibius* (Linnaeus, 1758) in 2011 was still low compared to good vole years. Due to this, very few young were available for our study in 2011, and only four juvenile eagle owls were equipped with GPS satellite transmitters in 2011. The positions of juvenile #57270 in relation to power poles are shown in **Figure 17**. The bird was still in the territory of its parents by mid-November.

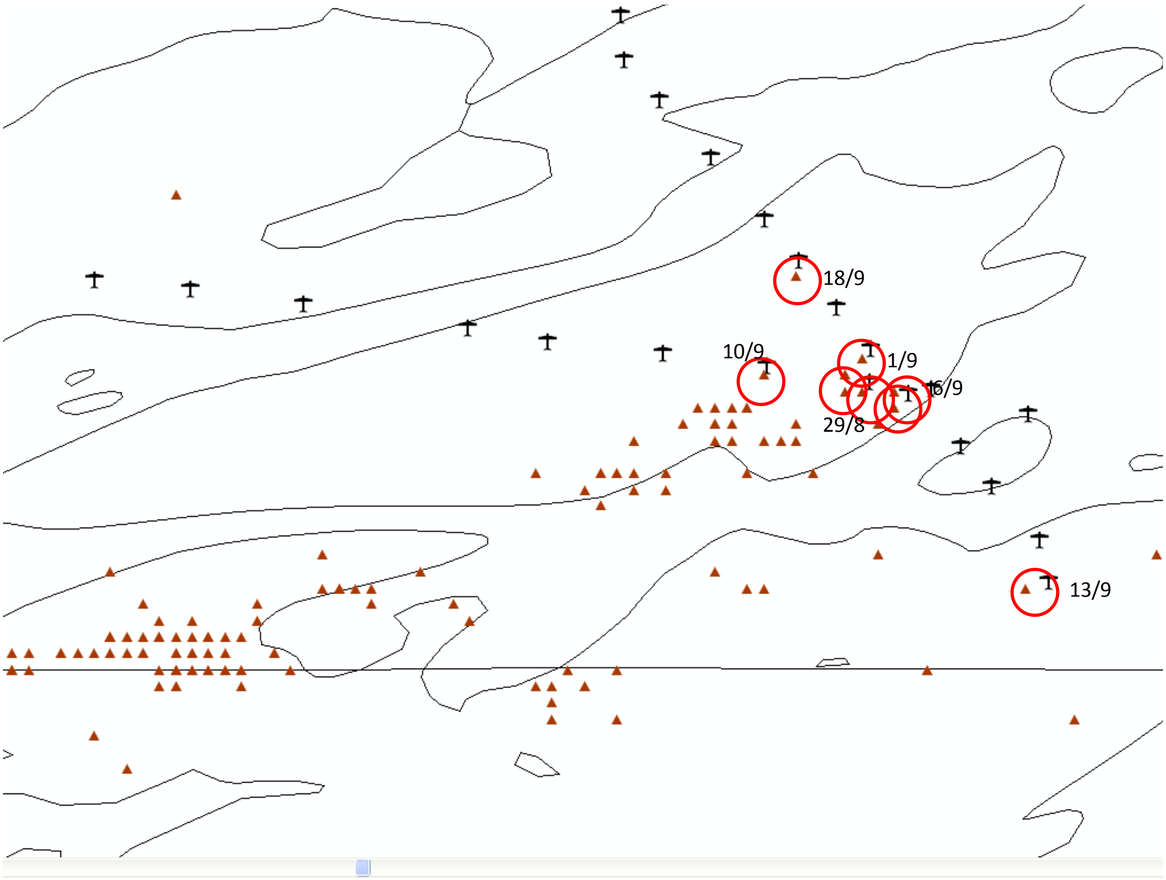


Figure 17. GPS *positions of juv. #57270 eagle owl in relation to power poles (crosses) in July-October 2011 at Sleneset, Nordland County. Circles with dates indicate possible perching on 22kV power poles.*

The GPS positions of juveniles #95331 and #95337 during July-October 2011 are shown in **Figure 18**. Juvenile 95331 was still in the nesting area in late November. The juveniles show strong site fidelity during summer and early autumn, probably because they are fed by their parents during this period. Dispersal will normally take place during late autumn.

The positions of juvenile #57269 in July-August 2011 are shown in **Figure 19**. This bird was equipped with a solar-cell transmitter that obviously was not able to deliver enough power after August. However, the bird was observed alive in the same area on October 22.

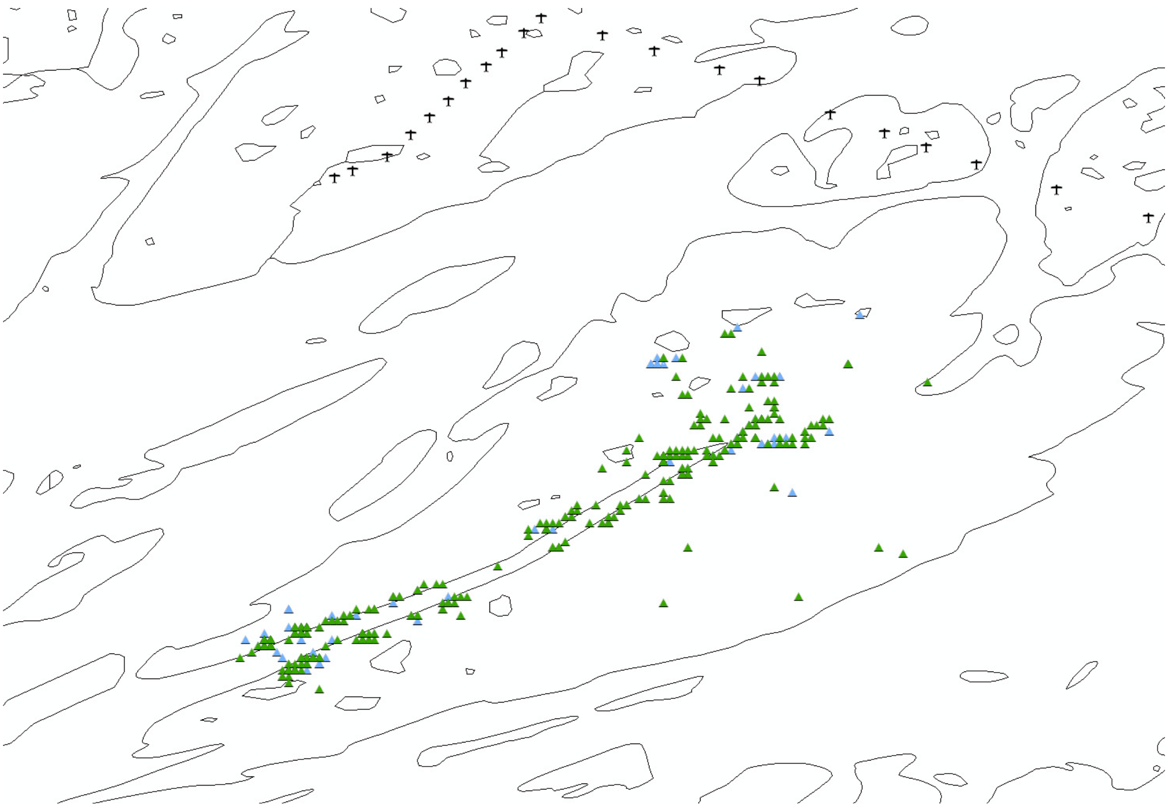


Figure 18. *The positions of juveniles #95331 eagle owl (green) and #95337 (blue) in relation to power poles (crosses) in July-October 2011 on Sleneset, Nordland County. #95331 was still in the same area in mid November.*

Figure 19. *The positions of juvenile #57269 eagle owl during the period July-August 2011 on Sleneset, Nordland County.*

Attempts to catch adults near the nest sites were unsuccessful in 2011. We tried three types of traps, also the trap we used in 2009 when three adult birds were caught (**Figure 20**). However, the male #195335 which was caught and equipped with a solar cell transmitter on July 7 2009 (**Figure 21**), gave both GPS-positions and Argos signals also in 2010 and 2011. Only the GPS signals are accurate enough to analyse the use of poles. A close-up of its GPS positions in the vicinity of a local power-line from the period 2009-2011 is shown in **Figure 22**, together with the positions of its female partner and juveniles from 2009.

Figure 20. *An unsuccessful catching attempt of eagle owl at Sleneset, Nordland County*. Photo: Karl-Otto Jacobsen/wildlife camera.

Figure 21. *The male eagle owl #195335 equipped with a GPS transmitter in 2009. This male was born and ringed on Buøya in 2002.* Photo: Jan Ove Gjershaug.

The GPS positions from this male during the periods July 17-September 14 2009, May 5-September 17 2010 and April 28-September 12 2011 is shown in **Figure 22,** along with the female from 2009 and two juveniles tagged on the same island. Few positions from these animals indicate positions on poles, but studies using automatic cameras have revealed perching on some of these poles (see below).

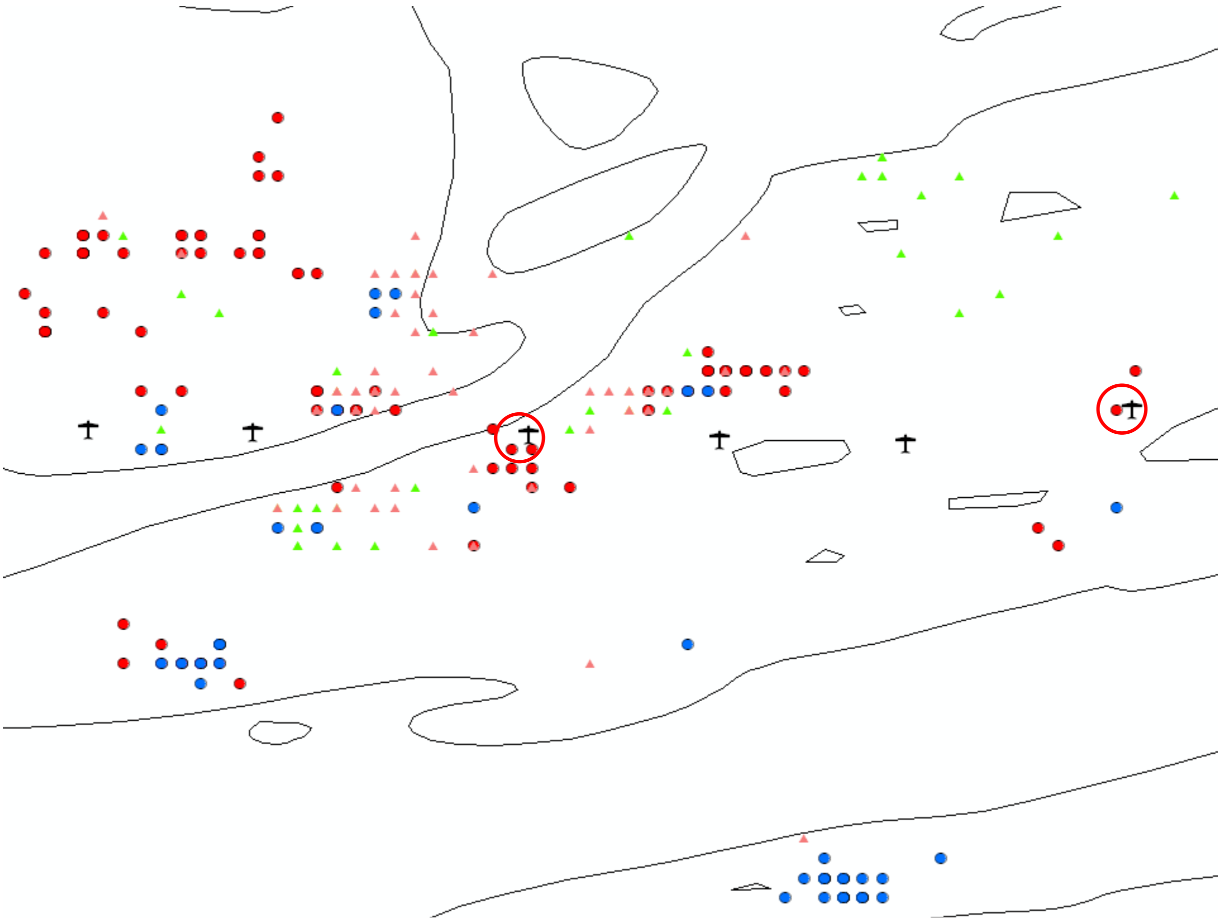


Figure 22. *Positions of the adult male (#195335) eagle owl from the period 2009-2011 (blue circles), adult female (#95335) (2009, red circles) and, juveniles #95334 (2009) and #195332 (2010) shown as triangles) in relation to poles (crosses) on Sleneset, Nordland County. Circles indicate possible perching on power poles.*

Positions obtained by the satellites have been used to do some home-range calculations. Using one position per day of female 195335 combining the three years of positions from the summers of 2009-2011, the 90% kernel utilisation distribution was calculated to be 3.2 km² and likewise the 50% area to be 1.1 km² (**Figure 23**). This means that this eagle owl is expected to within the 3.2 km² 90 % of the time, and within the 1.1 km² area 50% of the time.

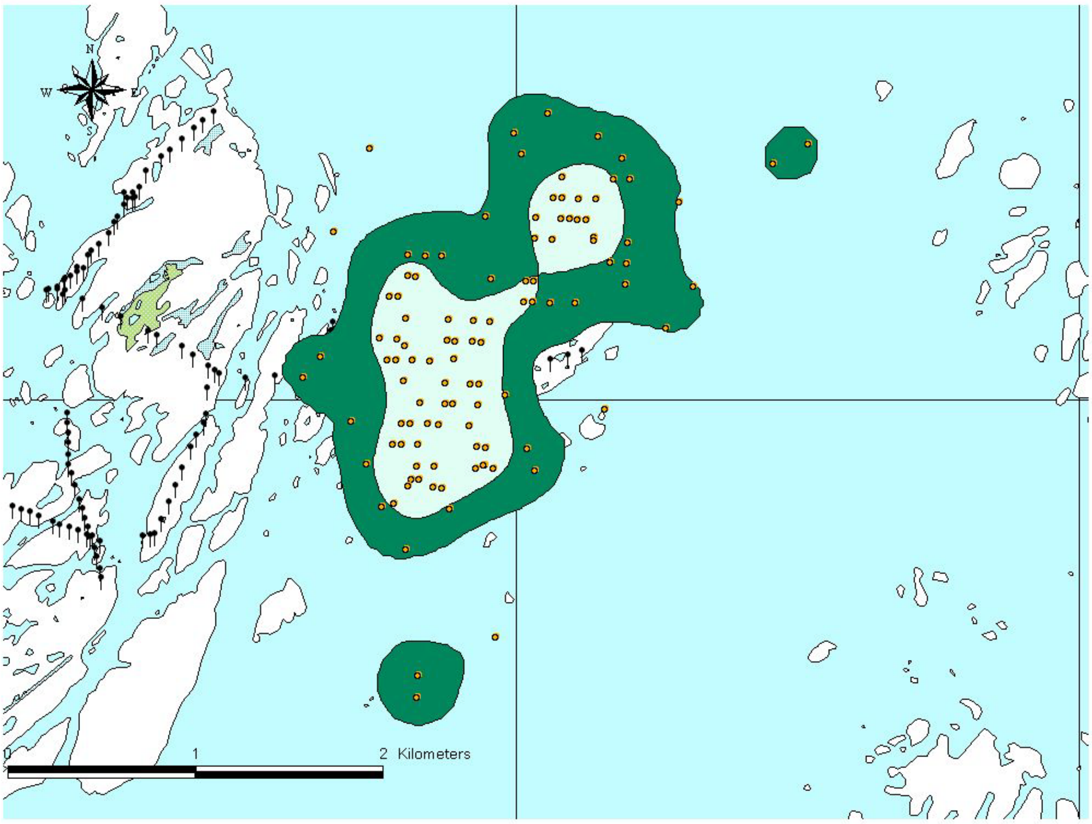


Figure 23. *The home range of adult male #195335 eagle owl from the period 2009-2011 shown by utilisation distribution based on a combination GPS and ARGOS positions, using one position per day. Dark green and light green together show the area of 90% probability contours, and light green the area alone shows the 50% probability contour. Only high quality positions (class 2 and 3) of ARGOS positions were used in case no GPS position was available, and only the best one for each day.*

Eagle owl feathers for future DNA-analyses were sampled also in 2011. Searches were carried out beneath all power lines and poles in the study area (**Figure 25**) to find carcasses of eagle owls and other birds. An overview of the dead birds found beneath power lines/poles during the period 2008-2011 is given in **Tables 6-8.**

Figure 24. *Eagle owls can use poles for perching during hunting. This pole has top-mounted insulators. The most dangerous poles have a grounded copper wire on the upper side of the crossarm. When sitting on this crossarm construction the eagle owl could be electrocuted when touching only one of the conductors.* Photo: Jan Ove Gjershaug.

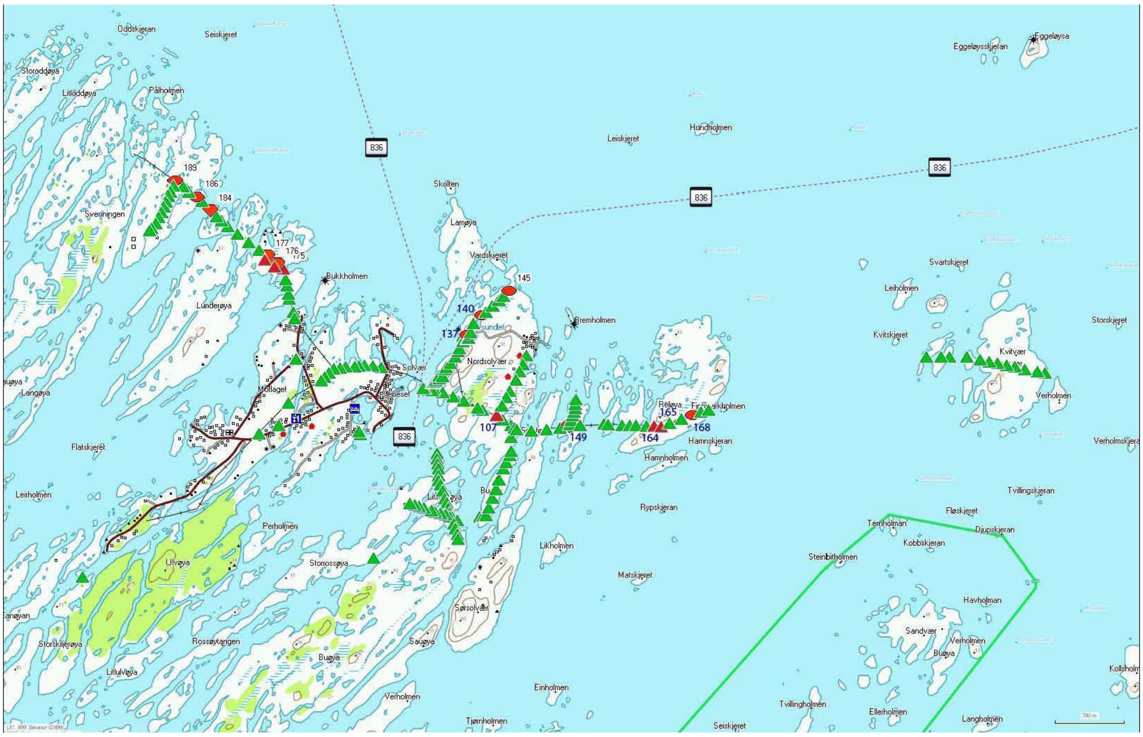


Figure 25. *Map of parts of Solværøyene with poles shown as triangles. Poles where eagle owl carcasses have been found indicated by red triangles, and other species by red circles.*

Table 6. *Some of the eagle owls located beneath power poles in the Sleneset area in the period 1995-2005 (compiled by Espen R. Dahl).*

Record	Date	Location	Type of poles	Reference
Adult bird	March 1995	Store Ulvøya	Transformer	Kjell A. Meyer NOF-Rana
Adult bird	June 1996	Store Ulvøya	Transformer	Kjell A. Meyer NOF-Rana
Adult bird	April 1997	Svenningen	Transformer	NOF-Rana
Adult bird	2000	Lunderøya	Transformer	Espen R. Dahl
Adult bird	April 2001	Lunderøya	Transformer	Espen R. Dahl
2 adult birds	June 2003	Reløya	Transformer	Gaute Dahl
Adult bird	January 2005	Lille Spjutøy	Transformer	Ringmerkingssentralen
Adult bird	April 2005	Nord-Solvær	Unspecified	Frode Johansen
Adult bird	May 2005	Lille Spjutøy	Transformer	Frode Johansen

Table 7. *All the bird* carcasses *and remains found beneath power lines/poles in 2008 – 2011.*

Pylon no.	Type of poles	2008	2009	2010	2011
107	Debranching			1 white-tailed eagle (adult)	
137	Cable debranching		1 black-backed gull		
140	Metal cross-arm			1 greylag goose (line)	
145	Cable debranching	1 gull sp.(black-backed/herring gull.)	2 hooded crow	1 hooded crow, 1 raven, 1 gull sp.(black-backed/herring gull.)	2 hooded crow
149	Pole-mounted transformer	1 eagle owl (bones)			
164	Top insulator			1 white-tailed eagle (juv.)	
165	Pole-mounted transformer	2 white-tailed eagle	1 white-tailed eagle (remains)		
168	Double top insulator	1 greylag goose			
175	Double top-insulator		1 white-tailed eagle (old remains)		
176	Cable debranching	1 eagle owl (from previous winter), 2 hooded crow	1 white-tailed eagle (old remains)		3 hooded crow, 1 raven
177	Double top-insulator	1 white-tailed eagle	1 eagle owl (bones)	1 eagle owl (from previous winter)	
184	Cable debranching	1 eagle owl (bones)			1 oystercatcher
186	Top-insulator			2 hooded crow	1 hooded crow, 1 raven
189	Pole mounted transformer			1 hooded crow	
213	Cable debranching				1 herring gull

Table 8. *All carcasses and bird remains recorded beneath power lines/poles in the period 2008-2011 by year and species/group.*

Species	2008	2009	2010	2011	Total
Eagle owl	3	1	1		**5**
White-tailed eagle	3	3	2		**8**
Crow/Raven	2	2	4	8	**16**
Gulls	1	1	1	1	**4**
Greylag goose	1		1		**2**
Oystercatcher				1	**1**
Sum per year	**10**	**7**	**9**	**10**	**36**

10.3 Testing of anti-perch devices and elevated perches

We tested elevated perches (**Figure 28**) and anti-perch devices (**Figure 29**) provided by El-tjeneste AS and mounted by Rødøy-Lurøy Kraftverk AS on 12 poles in three different eagle owl territories in the Sleneset area. These poles were selected based on recorded electrocuted owls, observations of perching owls or owl pellets found beneath poles. On two of the 12 poles elevated perches were not mounted because of technical reasons, and on one of these poles anti-perch devices were mounted on only one end of the crossarm.

The poles were monitored by Reconyx high performance cameras (**Figur 26** and **27**) which were deployed on October 8. Because of bad weather, the anti-perch devices and elevated perches were not deployed before October 27.The cameras' memory cards were replaced on October 27.

Figure 26. *Wildlife surveillance camera being deployed to monitor the eagle owl behavioural response to the redesigned pylon crossarm*. Photo: Jan Ove Gjershaug

Figure 27. *Reconyx high performance surveillance camera deployed to monitor the eagle owl behavioural responses on the new perching alternative on the pylon crossarm*. Photo: Jan Ove Gjershaug.

A total of 38,907 images were taken. Most of them showed no birds. The cameras had frequently been triggered by moving clouds in day-time and probably by heat from the conductors in night time, giving false positive recordings. Two of the cameras took photos in night time without using the infrared flash, and these images were to dark to be interpreted.

However, the cameras provided a significant number of interesting photos. Eagle owls were registered perching on eight of the 12 poles monitored. Twelve cases of eagle owls landing on the elevated perches were recorded (**Figure 30**), and three attempts of unsuccessful landings on the anti-perch devices on crossarms. The number of occasions of eagle owls landings on different structures, before and after deployment is shown in **Figure 31**. The four cases of landing on a crossarms without spikes also were on a pole without elevated perches.

It was somewhat surprising that the eagle owl landed on top-mounted insulators in four cases before mounting of alternative devices, and once on a horizontal insulator close to the crossarm (of the type shown in **Figure 28**) after deployment.

As a preliminary conclusion, taking into account the short testing-time, it seems that the anti-perch devices and the elevated perches have worked according to the intention, and hopefully additional will strengthen the preliminary conclusions. If so, this new design may significantly contribute to mitigate eagle owl electrocutions.

Figure 28. *Deployed anti-perch device to discourage perching on top of the crossarm, and elevated perch on each side.* Photo: Rødøy-Lurøy Kraftverk AS.

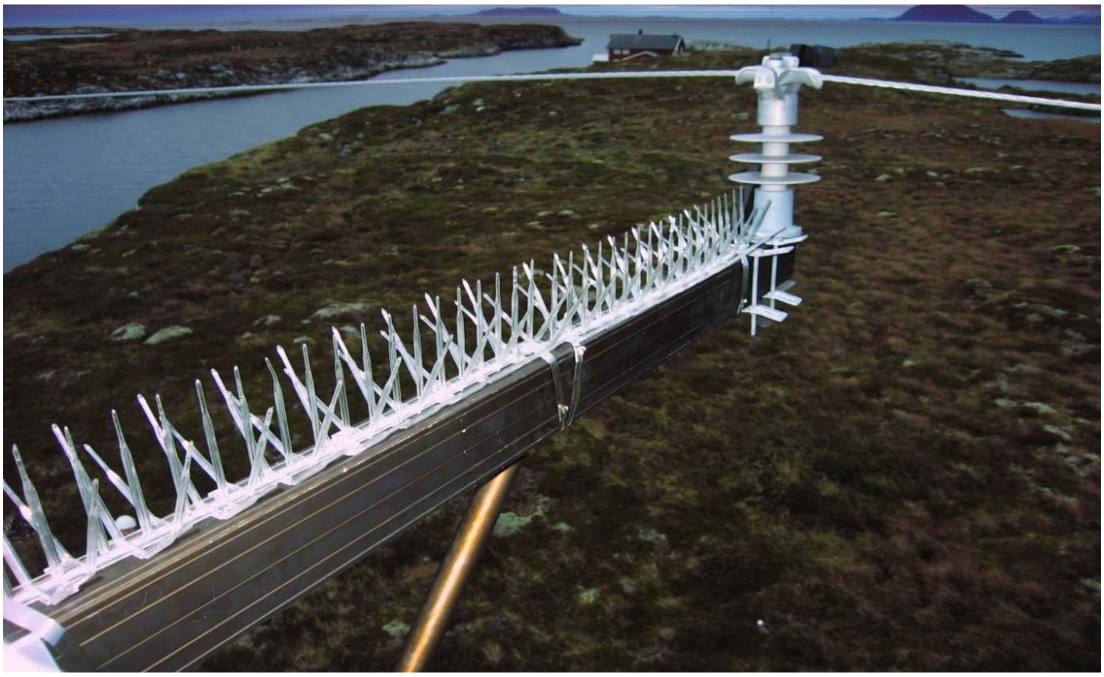


Figure 29. *Anti-perch device to discourage birds perching on the crossarm.* Photo Rødøy-Lurøy Kraftverk AS.

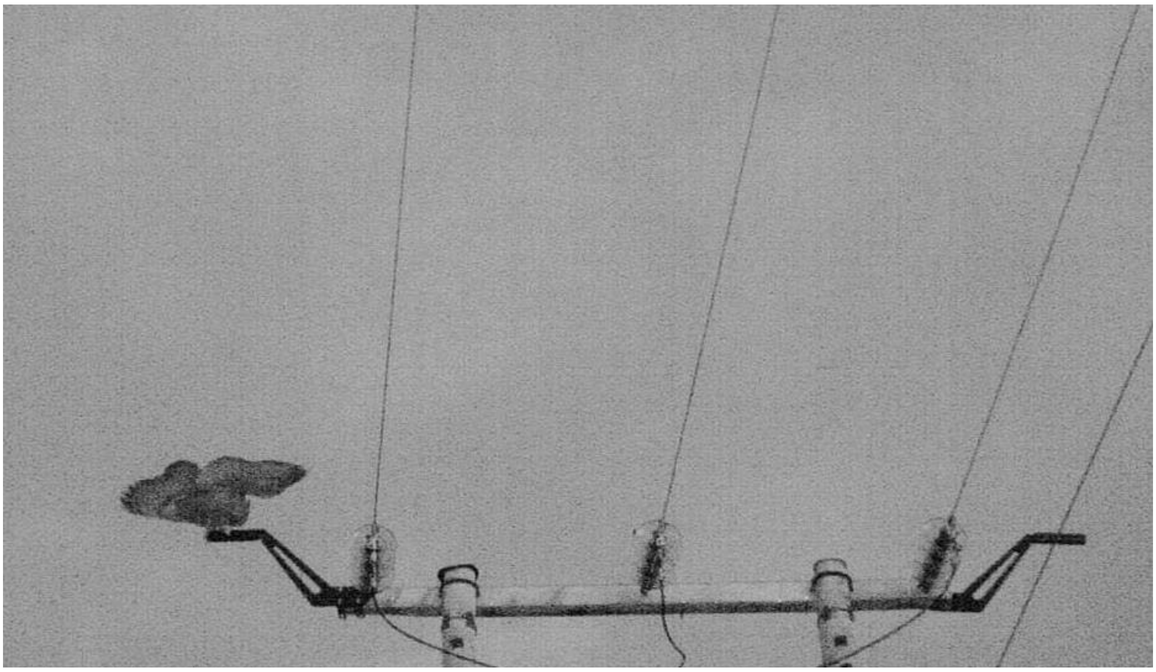


Figure 30. *Eagle owl on elevated perch. In one case the owl landed on the horizontal insulator on a pole without elevated perches.* Photo: NINA wildlife surveillance camera.

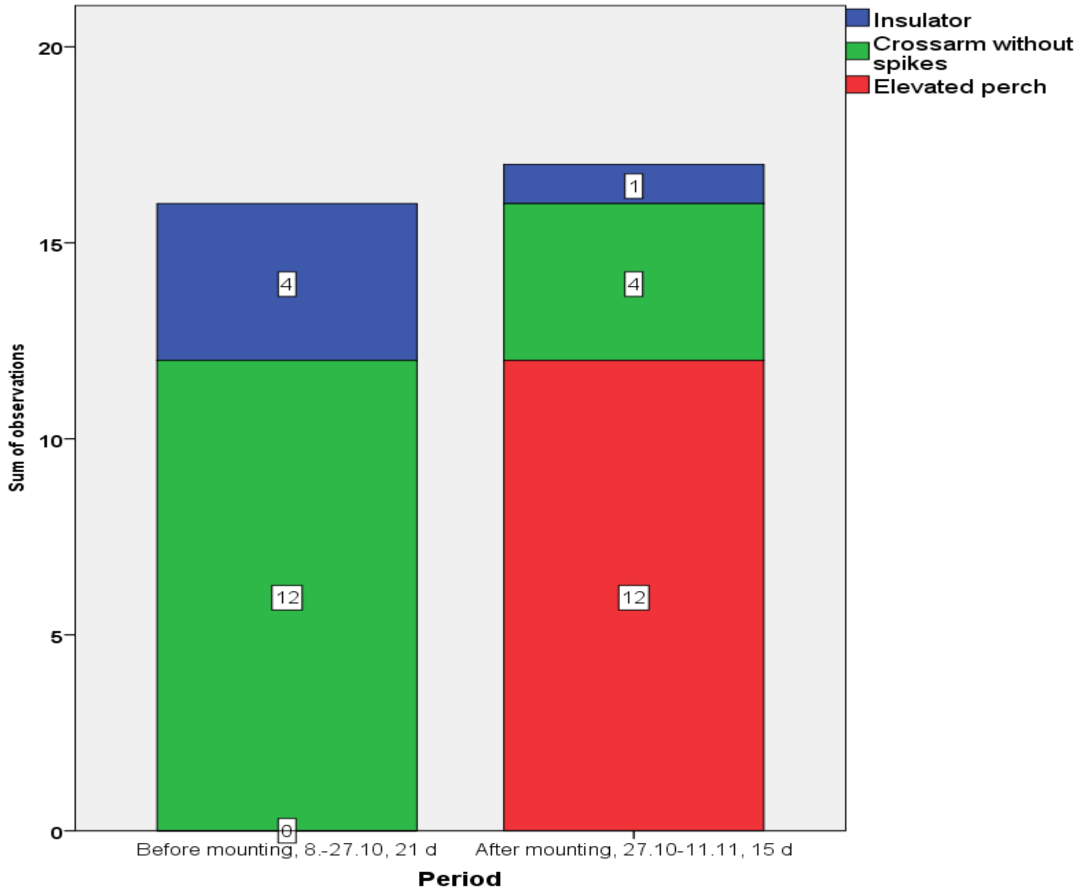


Figure 31. *The number of occasions where eagle owls landed on different structures before and after deployment of elevated perches and anti-perch devices.*

11 References

APLIC (Avian Power Line Interaction Committee). 2006. Suggested practices for avian protection on power lines: The State of the Art in 2006. - Edison Electric Institute, APLIC and California Energy Commission. Washington, DC and Sacramento, CA.

Barrientos, R., Alonso, J.C., Ponce, C. & Palacin, C. 2011. Meta-Analysis of the Effectiveness of Marked Wire in Reducing Avian Collisions with Power Lines. – Conservation Biology 25: 893–903.

Bevanger, K. 1988. Skogsfugl og kollisjoner med høgspentledninger i midtnorsk skogsterreng. - Økoforsk Rapport 9: 1-53.

Bevanger, K. 1990a. Konflikt fugl/kraftledning i Polmak. - NINA Oppdragsmelding 47: 1-13.

Bevanger, K. 1990b. Rypekollisjoner mot kraftledninger i Hemsedal. - NINA Oppdragsmelding 49: 1-15.

Bevanger, K. 1990c. Topographic aspects of transmission wire collision hazards to game birds in Central Norwegian coniferous forest. - Fauna norv. Ser. C, Cinclus 13: 11-18.

Bevanger, K. & Sandaker, O. 1993. Kraftledninger som mortalitetsfaktor for rype i Hemsedal - NINA Oppdragsmelding 135: 1-25.

Bevanger, K. 1993. Fuglekollisjoner mot en 220 kV kraftledning i Polmak, Finnmark. - NINA Forskningsrapport 40: 1-26.

Bevanger, K. 1994. Konsekvenser av en 66 kV kraftledning for fuglelivet ved Borrevann, Vestfold. - NINA Forskningsrapport 52: 1-37.

Bevanger, K. 1994. Bird interactions with utility structures; collision and electrocution, causes and mitigating measures. - Ibis 136: 412-425.

Bevanger, K. 1995. Tetraonid mortality caused by collisions with power lines in boreal forest habitats in central Norway. - Fauna norv. Ser. C, Cinclus 18: 41-51.

Bevanger, K. 1998. Biological and conservation aspects of bird mortality caused by electricity power lines: a review. – Biol. Conserv. 86: 67-76.

Bevanger, K. 1999. Kamuflering av kraftledninger - en ornitologisk vurdering. – NVE-seminar om materialvalg og fargebruk som kamuflerende tiltak på kraftledninger. – Foredrag på Rjukan august 1999.

Bevanger, K. 2011. Kraftledninger og fugl. NINA report 674, NINA (Norwegian Institute for Nature Research), Trondheim.
Bevanger, K. & Sandaker, O. 1993. Kraftledninger som mortalitetsfaktor for rype i Hemsedal - NINA Oppdragsmelding 135: 1-25.
Bevanger, K., Brøseth, H. & Sandaker, O. 1998. Dødelighet hos fugl som følge av kollisjoner mot kraftledninger i Mørkedalen, Hemsedalsfjellet. - NINA Oppdragsmelding 531: 1-41.

Bevanger, K. & Overskaug, K. 1998. Utility structures as a mortality factor for raptor and owls in Norway. – Pp. 381-392 in Chancellor, R.D., Meyburg, B.-U. & Ferrero, J.J. (eds). Proceedings Holarctic Birds of Prey; ADENEX-WWBP, Badajoz, Extremadura, Spain, 17-22 April 1995.

Bevanger, K., Bartzke, G., Brøseth, H., Gjershaug, J.O., Hanssen, F., Jacobsen, K.-O., Kvaløy, P., May, R., Nygård, T., Pedersen, H.C., Reitan, O., Refsnæs, S., Stokke, S. & Vang, R. 2009. ”Optimal design and routing of power lines; ecological, technical and economic perspectives” (OPTIPOL). Progress Report 2009. – NINA Report 504. 46 pp.

Bevanger, K., Bartzke, G., Brøseth, H., Dahl, E.L., Gjershaug, J.O., Hanssen, F., Jacobsen, K.-O., Kvaløy, P., May, R., Meås, R., Nygård, T., Refsnæs, S., Stokke, S. & Vang, R. 2010. Optimal design and routing of power lines; ecological, technical and economic perspectives (OPTIPOL). Progress Report 2010. – NINA Report 619. 51 pp.Butler, B.K. 1996. What should I wear while birding? – The Horned Lark, Kansas Ornithological Society.

Bern Convention 2004. Recommendation No. 110 on minimising adverse effects of above-ground electricity transmission facilities (power lines) on birds.

Bonn Convention 2002. Resolution 7.4. Electrocution of migratory birds.

Direktoratet for naturforvaltning 2009. Handlingsplan for hubro *Bubo bubo*. - Rapport 2009-1.

Gjershaug, J.O. & Jacobsen, K.-O. 2009. Hubro i Lurøy og kraftforsyning. - NINA Minirapport 251. 16 s.

Edenius, L., Bergman, M., Ericsson, G. & Danell, K. 2002. The role of moose as a disturbance factor in managed boreal forests. - Silva Fennica 36:57-67.

Fortin, D., Beyer, H.L., Boyce, M.S., Smith, D.W., Duchesne, T. & Mao, J.S. 2005. Wolves influence elk movements: behavior shapes a trophic cascade in Yellowstone National Park. - Ecology 86: 1320-1330.
Jacobsen, K.-O., Øien, I.J., Steen, O.F., Oddane, B. & Røv, N. 2008. Hubroens bestandsstatus i Norge. - Vår Fuglefauna 31: 150-158.
Johnson, N.H. (red.). 2008. Kamuflasjetiltak på kraftledninger. – NVE Rapport 4/2008. 109 s.
Kålås, J.A., Viken, Å., Henriksen, S. & Skjelseth, S. (red.). 2010. Norsk rødliste for arter 2010. - Artsdatabanken, Norge.
Lehman, R.N., Kennedy, P.L. & Savidge, J.A. 2007. The state of the art in raptor electrocution research: a global review. - Biological Conservation 136: 159-174.
Longridge, M.W. 1986. The impacts of transmission lines on bird flight behaviour, with reference to collision mortality and systems reliability. - Bird Res. Comm., ESCOM, Johannesburg. Report. 279 s.
Madsen, J.O. 1979. Luftledninger eller jordkabler - hvad skal vi have i fremtiden? - Elektroteknikeren 75: 313-321.
Martin, G. 1990. Birds by night. - London: Poyser.
McIlwain, J.T. 1996. An introduction to the biology of vision. – Cambridge University Press.
Olendorff, R.R., Miller, A.D. & Lehman, R.N. 1981. Suggested practices for raptor protection on power lines. The state of the art in 1981. - Raptor Res. Found. Raptor Res. Report 4. 111 s.
O'Neill, H. 2011. Response of moose *(Alces alces)* to power-line rights-of-way/forest edges in Norway. University of Leeds, Leeds, UK.
Osorio, D., Vorobyev, M. & Jones,C.D. 1999. Colour vision of domestic chicks. - The Journal of Experimental Biology 202: 2951–2959.
Statistics Norway. 2011. Electricity statistics, annual.Statistics Norway, www.ssb.no, accessed on 26.06.2010.
Statnett 1998. Kamuflasje av kraftledninger. Vurdering av 420 (300) kV-ledning Kristiansand – Evjeområdet. – Statnett Rapport 03-1998.
Storaas, T., Gundersen, H., Henriksen, H. & Andreassen, H.P. 2001. The Economic Value of Moose in Norway-A Review. Alces **37**:97-107.
Thompson, L.S. 1978. Transmission line wire strikes: mitigation through engineering design and habitat modification. - S. 51-92 i Avery, M.L. (red.). Impacts of transmisson lines on birds in flight. Proceedings of a conference. Oak Ridge Associated Universities, Oak Ridge, Tennessee.
Valberg, A. 1998. Lys, syn, farge. – Tapir Forlag, Trondheim.
van Beest, F.M., Gundersen, H., Mathisen, K.M., Milner, J.M. & Skarpe, C. 2010. Long-term browsing impact around diversionary feeding stations for moose in Southern Norway. Forest Ecology and Management 259:1900-1911.
Zadeh, L.A. 1965. "Fuzzy sets", Information and Control 8 (3): 338–353.
Zadeh, L. A., Klir, G.J. & Yuan, B. (eds.). 1996. Fuzzy Sets, Fuzzy Logic, Fuzzy Systems. Selected papers by Lofti A. Zadeh. - World Scientific Press.

11.1 Publications

Bevanger, K. 2011. Kraftledninger og fugl. Oppsummering av generelle og nettspesifikke problemstillinger. - NINA Rapport 674. 60 s.
O'Neill, H. 2011. Response of moose *(Alces alces)* to power-line rights-of-way/forest edges in Norway. University of Leeds, Leeds, UK. -passed with distinction-
Rochelle, S. 2011. Effects of power lines and their possible effects on the browsing behaviour of Moose *(Alces alces)* in Norway and how this relates to the browsing material available across Norway. University of Leeds, Leeds, UK.
Bevanger, K., Bartzke, G., Brøseth, H., Gjershaug, J.O., Hanssen, F., Jacobsen, K.-O., Kvaløy, P., May, R., Nygård, T., Pedersen, H.C., Reitan, O., Refsnæs, S., Stokke, S. & Vang, R. 2009. "Optimal design and routing of power lines; ecological, technical and economic perspectives" (OPTIPOL). Progress Report 2009. – NINA Report 504. 46 pp.
Bevanger, K., Bartzke, G., Brøseth, H., Dahl, E.L., Gjershaug, J.O., Hanssen, F., Jacobsen, K.-O., Kvaløy, P., May, R., Meås, R., Nygård, T., Refsnæs, S., Stokke, S. & Vang, R. 2010.

Optimal design and routing of power lines; ecological, technical and economic perspectives (OPTIPOL). Progress Report 2010. – NINA Report 619. 51 pp.

11.2 Lectures and conference participation

Bartzke, G. 2011. Potential of power-line rights-of-way as habitat resources for moose (*Alces alces*) and other wildlife. – OPTOPOL Annual Meeting, Rica Hell Hotel Stjørdal, November 17.

Bartzke, G., May R., Hedger R., Rolandsen C., Solberg E., Stokke S., Røskaft E. 2011. Effects of power lines on moose *(Alces alces)* movement and habitat selection. IRSAE conference. Evenstad 09.08. - won price for best presentation

Bartzke, G. 2010. Effects of power-line rights-of-way (ROW) vegetation management on habitat use, movement and behaviour of wildlife. Lunchseminar at NINA. Trondheim 08.04.

Bartzke, G. 2010. Effects of power line rights-of-way (ROW) vegetation management on habitat use, movement and behaviour of wildlife. CEDREN PhD meeting. Trondheim 14.04.

Bartzke, G. 2010. Presentation of PhD project. Effects of power-line rights-of-way (ROW) vegetation (management) on habitat use, movement and behaviour of wildlife. Large Herbivore Research Group (NTNU). Trondheim 19.04.

Bartzke, G. 2010. Potential of power-line rights-of-way as habitat resources for moose *(Alces alces)* and other wildlife. CEDREN Scientific Committee. Trondheim 27.10.

Bartzke. G. 2010. Power lines as wildlife biotopes. OPTOPOL Annual Meeting, Rica Hell Hotel Stjørdal, November 22.

Bevanger, K. 2011. Research activities on birds and power lines at CEDREN (Centre for Environmental Design of Renewable Energy). – Side-event at COP10/UNEP/CMS Bergen 20.-25. November.

Bevanger, K. 2011. Power lines - environmental impacts. - Lecture at NTNU/ESIA 08.11.

Bevenger, K. 2011. Prosjektstatus. – OPTOPOL Annual Meeting, Rica Hell Hotel Stjørdal, November 17.

Bevanger, K. 2010. NINA, BirdWind og OPTIPOL. Møte med OED. Trondheim 16.11.2010.

Bevanger, K. 2010. BirdWind & OPTIPOL. CEDREN Scientific Committee. Trondheim 26.10.2010.

Bevanger, K. 2010. OPTIPOL. Seminar om FoU på bærekraftig energiproduksjon, CEDREN og DNs Energiteam. Trondheim 08.01.2010.

Bevanger, K. project status, new applications etc. OPTOPOL Annual Meeting, Rica Hell Hotel Stjørdal, November 22.

Bevanger, K. 2010. Immediate actions to reduce mortality among birds due to power lines. OPTOPOL Annual Meeting, Rica Hell Hotel Stjørdal, November 22.

Brøseth, H.2011. Kraftledninger og dødelighet hos skogsfugl. - OPTOPOL Annual Meeting, Rica Hell Hotel Stjørdal, November 17.

Brøseth, H.2010. Power lines as a mortality factor for tetraonids. OPTOPOL Annual Meeting, Rica Hell Hotel Stjørdal, November 22.

Dahl, E.L. 2011. Kartlegging av elektrokusjonsfare på Smøla. - OPTOPOL Annual Meeting, Rica Hell Hotel Stjørdal, November 17.

Dahl, E.L. 2010. Bird electrocution recordings along the Smøla grid. OPTOPOL Annual Meeting, Rica Hell Hotel Stjørdal, November 22.

Hanssen, F., May, R. & Thomassen, J. 2011. Least Cost Path (LCP) modell for optimalt trasevalg av kraftledninger. Status november 2011. - OPTOPOL Annual Meeting, Rica Hell Hotel Stjørdal, November 17.

Hanssen, F.A. 2010. A ”least-cost path” GIS-based application for optimal routing of power lines. OPTOPOL Annual Meeting, Rica Hell Hotel Stjørdal, November 22.

Husdal, M.M. 2010. Status on the National Action Plan for the eagle owl. OPTOPOL Annual Meeting, Rica Hell Hotel Stjørdal, November 22.

Gjershug, J.O. 2011. Hubro i Lurøy. - OPTOPOL Annual Meeting, Rica Hell Hotel Stjørdal, November 17.

Gjershaug, J.O. 2010. Status on the eagle owl project atSleneset. OPTOPOL Annual Meeting, Rica Hell Hotel Stjørdal, November 22.

Jacobsen, K.-O. 2011. Eagle Owl study in Lurøy (OPTIPOL). Eagle Owl seminar. Rica Hell Hotel Stjørdal, Desember 1-2.
Kvaløy, P. 2011. Nasjonal database for registrering av fugl drept pga. kollisjon/elektrokusjon. - OPTOPOL Annual Meeting, Rica Hell Hotel Stjørdal, November 17.
Kvaløy, P. 2010. A national database for data recording of mortality among birds due to power lines. OPTOPOL Annual Meeting, Rica Hell Hotel Stjørdal, November 22.
May, R. 2010. Optimal design and routing of power lines; ecological, technical and economic perspectives (OPTIPOL). CEDREN generalforsamling, Trondheim 06.05.
Meås, R. 2010. How to get a dog trained to be interested in birds killed in connection to power lines? OPTOPOL Annual Meeting, Rica Hell Hotel Stjørdal, November 22.
Refsnæs, S. 2011. Tekniske muligheter og begrensninger av tiltak, som kan redusere faren for fuglekollisjoner eller elektrokusjon. - OPTOPOL Annual Meeting, Rica Hell Hotel Stjørdal, November 17.
Refsnæs, S. 2011. Technical possibilities and constraints to reduce the bird mortality in connection to power lines. Eagle Owl seminar. Rica Hell Hotel Stjørdal, Desember 1-2.
Refsnæs, S. 2010. Technical possibilities and constraints to reduce the bird mortality in connection to power lines. OPTOPOL Annual Meeting, Rica Hell Hotel Stjørdal, November 22.
Stokke, S. 2011. Forsøk med rydding etter alternative kriterier langs kraftlinjer. - OPTOPOL Annual Meeting, Rica Hell Hotel Stjørdal, November 17.
Stokke, S. 2010. NINA, OPTIPOL. Presentasjon for CEDREN Reference Group - BirdWind og OPTIPOL. Trondheim 19.10.

11.3 Coverage in public media

NRK Trønderlag Radia – 18.03.2011. Skogsfugltelling i Ongdalen (H. Brøseth).
Helgelands Blad – 22.07.2011. Satellittmerker hubro på Solværøyene (Lie-Dahl).
Helgelands Blad – 26.09.2011. Nordland parkert i Norges satsing på fornybar energi (J.O. Gjershaug).
UNEP.org. 24.11.2011. - UN Wildlife Meeting Pushes to Make Power Lines Safer for Birds (K. Bevanger).
PressReleasePoint 25.11.2011. UN Wildlife Meeting Pushes to Make Power Lines Safer for Birds (K. Bevanger).
Norsk institutt for naturforskning – 25.11.2011. Redder hubro fra grilling (K. Bevanger, S. Refsnæs).
IEWY News – 28.11.2011. UN Wildlife Meeting Pushes to Make Power Lines Safer for Birds (K. Bevanger).
NRK Nettavis – 29.11.2011. Denne pinnen skal hindre hubrogrilling (K. Bevanger, S. Refsnæs).
Avisa Nordland - 29.11.2011. Sittepinner skal redde hubro (K. Bevanger, S. Refsnæs).
Miljøverndepartementet - 30.11.2011. Redder hubro fra grilling (K. Bevanger, S. Refsnæs)
Adresseavisen – 30.11.2011. Slutt på hubro-grilling (K. Bevanger, S. Refsnæs).
Trønder-Avisa – 30.11.2011. Slutt på hubro-grilling (K. Bevanger, S. Refsnæs).
MyNewsdesk Norge – 01.12.2011. Redder hubro fra grilling (K. Bevanger, S. Refsnæs).
Romerikes Blad 01.12.2011. Slutt på hubro-grilling (K. Bevanger, S. Refsnæs)
Nordlys 01.12.2011. Slutt på hubro-grilling (K. Bevanger, S. Refsnæs).
Adresseavisen 01.12.2011. Slutt på hubro-grilling (K. Bevanger, S. Refsnæs).
Finnmark Dagblad 02.12.2011. Slutt på hubrogrilling (K. Bevanger, S. Refsnæs).
Fremover 02.12.2011. Hubro får egen sitteplass på strømstolper (K. Bevanger, S. Refsnæs).
Demokraten 02.12.2011. Slutt på hubrogrilling (K. Bevanger, S. Refsnæs).
Bladet Vesterålen – 23.12.2009. Andøy er på rypetoppen (K. Bevanger).

Appendix 1. *Program for the OPTIPOL Annual Meeting 2011.*

NINA
Norsk institutt for naturforskning

Møteinvitasjon

Brukermøte OPTIPOL 2011 – 17. november kl 0900-1600. Rica Hell hotell, Stjørdal

Som tidligere kommunisert samles vi til brukermøte på Rica Hell hotell torsdag 17. november. Intensjonen med møtet er å presentere status for prosjektet og diskutere veien videre.

0900-0915	Velkommen. Prosjektstatus; nye søknader m.m. (Kjetil Bevanger)
0915-1015	En "least-cost path" GIS-basert applikasjon for optimalt trasevalg av kraftledninger; (Frank Hanssen/Roel May/Jørn Thomassen)
1015-1035	Kaffepause
1035-1100	Kraftledningsgater som viltbiotoper (Gundula Bartzke)
1100-1115	Alternativ rydding langs kraftlinjer – et forsøksprosjekt (Sigbjørn Stokke)
1115-1130	Nasjonal database for registrering av fugl drept pga. kollisjon/elektrokusjon (Pål Kvaløy)
1130-1215	Lunsj
1215-1245	Kraftledninger og dødelighet hos skogsfugl. Har det noen betydning? (Henrik Brøseth)
1245-1300	"Strakstiltak" for å redusere kollisjons- og elektrokusjonsfare – miniguide utarbeidet for NVE (Kjetil Bevanger, Steinar Refsnæs)
1300-1330	Hubro på Sleneset. Prosjektstatus (Jan Ove Gjershaug)
1330-1400	Tekniske muligheter og begrensninger av tiltak, som kan redusere faren for fuglekollisjoner eller elektrokusjon (Steinar Refsnæs)
1400-1420	Kaffepause
1420-1440	Kartlegging av elektrokusjonsfare på Smøla (Espen Lie Dahl)
1440-1600	Diskusjon

Påmeldte:

NINA:
Gundula Bartzke
Kjetil Bevanger
Henrik Brøseth
Jan Ove Gjershaug
Frank Hanssen
Karl Otto Jacobsen
Pål Kvaløy
Roel May
Torgeir Nygård
Sigbjørn Stokke
Jørn Thomassen

SINTEF:
Steinar Refsnæs
Teknomedia:
Atle Abelsen
DN:
Arild Espelien
Statnett:
Martha Hagerup Nilsson
NVE:
Nils Henrik Johnson
EnergiNorge:
Geir Taugbøl

www.nina.no - Samarbeid og kunnskap om framtidas miljøløsninger

Org.nr: NO 950 037 687 MVA

ISSN: 1504-3312
ISBN: 978-82-426-2354-6

762

NINA Report

NINA

The Norwegian Institute for Nature Research (NINA) is Norway's leading institution for applied ecological research.

NINA is responsible for long-term strategic research and commissioned applied research to facilitate the implementation of international conventions, decision-support systems and management tools, as well as to enhance public awareness and promote conflict resolution.

Norwegian Instutute for Nature Research
NINA head office
Postal address: P.O. Box 5685 Sluppen, NO-7485 Trondheim, NORWAY
Visiting address: Tungasletta 2, NO-7047
Phone: +47 73 80 14 00, Telefax: +47 73 80 14 01
E-mail: firmapost@nina.no
Organization Number: 9500 37 687

Cooperation and expertise for a sustainable future