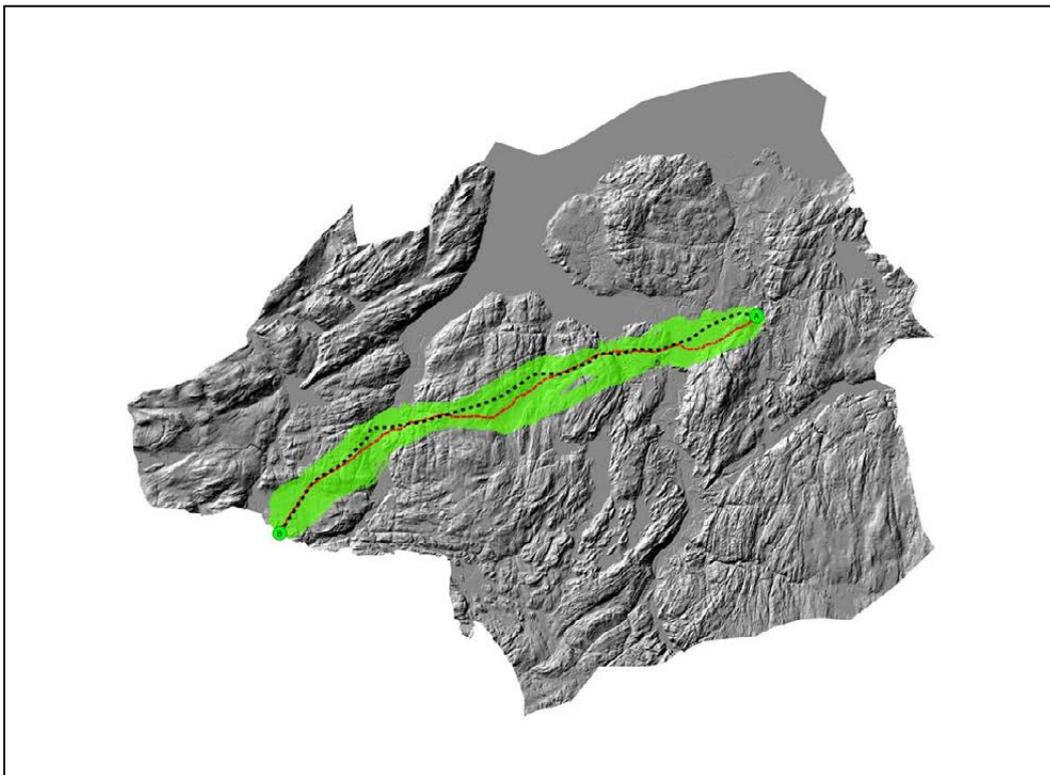


# Optimal design and routing of power lines; ecological, technical and economic perspectives (OPTIPOL)

Progress Report 2012

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



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Trondheim 1 December 2012

ISSN: 1504-3312

ISBN: 978-82-426-2507-6

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The publication may be freely cited where the source is acknowledged

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)

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COVER PICTURE

Frank Hanssen

KEY WORDS

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

NØKKEWORD

Kraftledning, kollisjon, elektrokusjon, fugl, hubro, storfugl, orrfugl, dødelighet, elg, kraftledningstrase, ryddebelte

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## Abstract

Bevanger, K., Bartzke, G., Brøseth, H., Gjershaug, J.O., Hanssen, F., Jacobsen, K.-O., Kleven, O., Kvaløy, P., May, R., Meås, R., Nygård, T., Refsnæs, S. Stokke, S. & Thomassen, J. 2012. Optimal design and routing of power lines; ecological, technical and economic perspectives (OPTIPOL). Progress Report 2012. – NINA Report 904. 57 pp.

**WP1** – “Power line ROW as habitat resources for moose (*Alces alces*) and other wildlife” has focused on moose browsing in power-line corridors in relation to adjacent areas in Bangdalen. Browsing surveys and pellet-group counts were also carried out in 2012 for this purpose and close to 200 plots were surveyed. A preliminary analysis of these data has been finalized. The paper - “Comparative effects of power lines and roads on moose (*Alces alces*) habitat selection” was presented and consequently submitted as a proceedings paper at the 10<sup>th</sup> ROW conference in Arizona. **WP2** – “Capercaillie and black grouse population responses to power-line induced mortality” has continued the data collection in Ogdalen also in 2012. As by January 2013 a total of 29 search patrols have been conducted and 50 locations with a bird or bird remains from collision victims in the study period were recorded. The DNA-analysis has identified 7 capercaillie and 5 black grouse among these birds and bird remains. Collision mortality rate varies between years and species, where capercaillie seems more exposed than black grouse. An oral presentation - “Black grouse and capercaillie mortality and population estimates by DNA identification” – was presented and consequently submitted as a proceedings paper at the 10<sup>th</sup> ROW conference in Arizona. In **WP3** - “Bird collision hot spots” - available data from earlier projects has been digitised and stored in a database. Some power line sections studied in connection to earlier projects turned out not to have been digitized, and resources were used to collect the missing data. The database, i.e. GPS-positions of all collision victims recording in connection to previous projects, as well as the patrolled power line sections, is now finalised. **WP4** – “National database for reporting on dead birds” - is now implemented as part of The Norwegian Biodiversity Information Centre (NBIC), and the data can be accessed at any time. As by early November 2012 379 casualties have entered the database, compared to 117 in 2011. **WP5** – “A Least Cost Path (LCP) toolbox for optimal routing of power lines” has developed an initial LCP-pilot to demonstrate the LCP-methodology, based on the EIA-work performed prior to the construction of the 420 kV transmission line in central Norway (2005). The economic, ecological, social and technological criteria, and how these translated to the landscape, were based on user inputs from relevant stakeholders. Using the pilot case study the LCP-pilot methodology and fuzzy-logic approach were demonstrated at the first dialog-based workshop 23-24 April 2012. The first workshop on *criteria definitions* was followed by a second workshop on *criteria values* 20 November 2012. An oral presentations - “A Least-Cost-Path (LCP) Toolbox for Optimal Routing of Power Lines” – was presented and consequently submitted as a proceedings paper at the 10<sup>th</sup> ROW conference in Arizona, at the 32<sup>nd</sup> annual conference of the international association for impact assessment (IAIA12) in Porto (Portugal), and at the the ESRI European User Conference in Oslo. **WP6** – “Birds and power line camouflaging” has nearly finalized its final report – “Power line camouflaging. Assessments of ecological and technical implications”. However, due to the overall budget situation in CEDREN the report will not be finalized until the end of April 2013. **WP7** – “Bird mortality mitigating effect of power line marking/modifications” has nearly finalized its final report – “Possibilities and constraints in reducing power line and electrocution induced mortality in birds” are nearly finalized. However, due to the overall budget situation in CEDREN the report will not be finalized until the end of April 2013. **WP8** - “Guidelines for technical solutions to mitigate power line induced mortality to birds” - has focused on topics related to marking, design, insulating, camouflaging and cabling. The gained experiences and results, described in articles and notes, will be implemented in WP6 and WP7. In **WP9** – “Eagle owl population impact of power line induced mortality” - four juvenile eagle owls were equipped with GPS satellite transmitters in 2012 together with one adult male and one adult female. Feathers for DNA-analyses were collected from active nests also in 2012 and the analyses of feathers collected in 2009-2012 have started. An oral presentation - “Mitigating eagle owl electrocution in Norway” – was presented and consequently submitted as a proceedings paper at the 10<sup>th</sup> ROW conference in Arizona.

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## Sammendrag

Bevanger, K., Bartzke, G., Brøseth, H., Gjershaug, J.O., Hanssen, F., Jacobsen, K.-O., Kleven, O., Kvaløy, P., May, R., Meås, R., Nygård, T., Refsnæs, S., Stokke, S. & Thomassen, J. 2012. Optimal design og traseføring for kraftledninger; økologiske, tekniske og økonomiske perspektiver (OPTIPOL). Fremdriftsrapport 2012. – NINA Rapport 904. 57 s.

**WP1** – “Kraftledningskorridorer som habitatressurs for elg (*Alces alces*) og annet villt” - har fokusert på hvordan elg beiter i kraftledningskorridorer sammenlignet med tilgrensende habitater i Bangdalen. Beitekartlegging og opptelling av ekskrementer i utvalgte ruter ble også foretatt i 2012 med dette for øye, og nærmere 200 ruter ble kartlagt. En foreløpig analyse av disse dataene er slutført. Foredraget – “Comparative effects of power lines and roads on moose (*Alces alces*) habitat selection” - ble presentert og innsendt som bidrag til konferanserapporten fra “The 10<sup>th</sup> ROW Conference” i Arizona. **WP2** – “Respons hos storfugl- og orrfuglpopulasjoner som følge av dødelighet i tilknytning til kraftledninger” - har fortsatt datainnsamlingen i Ogdalen i 2012. Fra prosjektoppstart frem til primo januar 2013 er totalt 29 søk etter døde fugler under kraftledningsavsnittet gjennomført, og 50 steder med døde fugler/rester etter fugler identifisert. DNA-analyse har identifisert 7 ulike storfugl og 5 ulike orrfugl blant funnene. Dødelighetsraten som skyldes kollisjoner mot kraftledningen varierer mellom år og art, og storfugl ser ut til å være mer utsatt for å bli drept enn orrfugl. Foredraget - “Black grouse and capercaillie mortality and population estimates by DNA identification” – ble presentert og innsendt som bidrag til konferanserapporten fra “The 10<sup>th</sup> ROW Conference” i Arizona. I **WP3** – “Bird collision hot spots” - er tilgjengelige data fra tidligere prosjekter digitalisert og lagret i en database. Enkelte av kraftledningsavsnittene fra tidligere prosjekter har vist seg ikke å være digitalisert og det er brukt ressurser på å få samlet manglende data. Databasen, dvs. GPS-posisjonene for alle døde fugler registrert som kollisjonsoffer i tilknytning til tidligere prosjekter, samt de patruljerte kraftledningsavsnittene, er nå klar for analyse. **WP4** – “Nasjonal database for rapportering om døde fugler” - er operativ og inngår som del av Artsdatabankens datainnsamlingssystem. Alle data er offentlig tilgjengelig. I begynnelsen av november 2012 var det lagt inn 379 observasjoner av døde fugler i databasen, sammenlignet med bare 117 ett år tidligere. **WP5** – “En Least Cost Path (LCP) verktøykasse for optimal traseføring av kraftledninger” - har utviklet en LCP-pilot for å kunne demonstrere LCP-metoden, basert på konsekvensutredningene som ble foretatt før bygging av en 420 kV overføringsledning i Midt-Norge i 2005. Relevante økonomiske, økologiske og teknologiske miljøkriterier basert på forslag fra berørte brukere (NGOer, forvaltning, industri m.fl.), ble benyttet. LCP-piloten og en fuzzylogikktilnærming fra denne ble demonstrert på det første dialogbaserte arbeidsseminaret 23.-24. april 2012. Seminaret, som hadde hovedvekt på *kriterie definisjoner*, ble fulgt opp med et arbeidsseminar som fokuserte *kriterieverdier* den 20. november 2012. Foredraget - “A Least-Cost-Path (LCP) Toolbox for Optimal Routing of Power Lines” – ble presentert og innsendt som bidrag til konferanserapporten fra “The 10<sup>th</sup> ROW Conference” i Arizona, “The 32<sup>nd</sup> Annual Conference of the International Association for Impact Assessment (IAIA12)” i Porto, Portugal, og “The ESRI European User Conference” i Oslo. **WP6** – “Fugler og kamuflering av kraftledninger” - har nesten ferdigstilt sluttrapporten – “Kraftledningskamuflering. En vurdering av økologiske og tekniske utfordringer”. På grunn av budsjettssituasjonen i CEDREN er imidlertid ferdigstillelse av rapporten utsatt til ultimo april 2013. **WP7** – “Effekt av linemerking/modifiseringer som avhjelpende tiltak mot fugledødelighet” har nesten ferdigstilt sluttrapporten “Muligheter og begrensninger i forhold til å redusere dødelighet hos fugl som følge av kollisjon og elektrokusjon”. På grunn av budsjettssituasjon i CEDREN er imidlertid ferdigstillelse av rapporten utsatt til ultimo april 2013. **WP8** - “Retningslinjer for tekniske løsninger som kan redusere dødelighet hos fugl på grunn av kraftledning” - har fokusert tema knyttet til merking, design, isolering, kamuflasje og kabling. Resultatene, som er presentert i notater og artikler, vil bli implementert i hhv. WP6 og WP7. I **WP9** – “Hubrobestandens påvirkning av dødelighet som skyldes kraftledninger” - ble fire ungfugler utstyrt med GPS satellittsendere i 2012, i tillegg til én voksen hann og én voksen hunn. Fjær for DNA-analyse ble samlet fra aktive reir også i 2012, og analyser av fjær samlet i 2009-2012 har startet. Foredraget - “Mitigating eagle owl electrocution in Norway” - ble presentert og innsendt som bidrag til konferanserapporten fra “The 10<sup>th</sup> ROW Conference” i Arizona.

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## 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 - "*Optimal design and routing of power lines; ecological, technical and economic perspectives*" (OPTIPOL) - 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); however some few activities will proceed into 2014.

Trondheim, ultimo December 2012

Kjetil Bevanger  
Project leader

# 1 Introduction

The OPTIPOL project - “*Optimal design and routing of power lines; ecological, technical and economic perspectives*” – started in early 2009, 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 nine focal areas and sub-projects (Bevanger et al. 2011).

## 1.1 The 2012 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 2012 we met November 19 (**Appendix 1**).

The meeting presentations gave an overview and status of the different OPTIPOL subprojects. As the project now proceeds into its final year the meeting was finalized with a discussion on possible topics to be continued. The user partners were very positive to a “OPTIPOL II”-project and 2013 should be used to single out particularly useful to the energy and environmental sector. The following key words mentioned were:

- Power-line corridors and biodiversity
- Impact of power-line corridors on ungulates
- Long term pruning experiments
- Long term studies on game birds, including before-after (BACI)
- Impact of power-line camouflaging
- LCP - real case study
- Collision hot-spots (including avian radar surveys)
- Landscape design surrounding ROWs
- Environmental impact of the area-consenting system

Among the possible financing options is the RENERGI X programme, recently launched by the Research Council of Norway.

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

### Objectives

The objective is to assess how and why different wildlife species use deforested areas below power lines and evaluate possible positive and negative effects of power line ROW's. The target species is moose (*Alces alces*).

### Secondary objectives

1. Assess habitat use of power-line ROWs by different wildlife species
2. Examine if power-line ROWs can represent suitable feeding grounds for moose
3. Investigate the influence of power lines on moose habitat selection
4. Find out if moose avoid crossing power lines, or if moose use these structures as movement corridors
5. Find ways of improving power-line ROWs as wildlife habitats
6. Evaluate possible positive and negative effects of power-line ROWs on wildlife

## 2.1 Background

Power-line rights-of-way (ROW) create long open corridors when intersecting forests. They may be considered as a source of loss and fragmentation of wildlife habitat. The physical structure and noise emitted by power lines could result in avoidance of those structures by reindeer (Nellemann et al. 2001, Vistnes et al. 2001, Nellemann et al. 2003) and barrier effects (Vistnes et al. 2004). However, power-line ROW have the potential to provide a stable source of additional browsing resources for moose (*Alces alces*) (Ricard and Doucet 1999), since they are continuously cleared of trees. Although moose avoid open habitat types providing little food and cover, they increase the selection of open habitat types when those provide abundant forage (Bjørneraas et al. 2011). When foraging opportunities as well as cover are in close proximity near power-line ROW forest edges, these areas could be particularly attractive for moose. The moose was chosen as model species, because moose's known preferences for habitats providing food and cover as well as moose's importance for hunting and forestry (Storaas et al. 2001, van Beest et al. 2010).

A combination of analysis of existing GPS relocation data with field work was applied in the study area in Bangdalen to better understand the effects of power-line ROW on moose habitat selection, movements and browsing preferences. Another objective is to compare potential effects of power lines to other types of linear features, roads and rivers. Power lines, roads and rivers are similar in shape and provide forest edge habitat but have differential disturbance potential through noise and the physical structure. The first part of the analysis of moose GPS relocation data is completed and now the focal aim is to find out if moose avoid crossing power-line ROW or use power-line ROW as movement corridors.

In addition, the possibilities for improving the value of power-line ROW habitat in an experimental clearing site in the Bangdalen study area is assess. The use of wildlife cameras was limited through difficult field work conditions but browsing and pellet group surveys to detect changes in moose browsing intensity and habitat use due to clearing regime are continuing.

Finally, an estimate on how much habitat is occupied by power-line ROW on a national scale compared to other land-use types was made to evaluate potential impacts on different wildlife species, particularly ungulates.

## 2.2 Main 2012 activities

The field work in 2012 focused on moose browsing in power-line corridors in relation to adjacent areas in Bangdalen. Browsing surveys and pellet-group counts were made for this purpose and close to 200 plots were completed. This information is important to understand how moose use the corridors as a browsing resource. The approach will also give valuable information about moose responses to alternative clearing regimes in the corridors. However, the time span since the clearing was performed (September 2010) might be too short to detect effects so far. A preliminary analysis of these data has been finalized. Together with previously sampled information from camera traps this will enable an evaluation of how the corridors are utilised.

A paper (paper 1 for the PhD) entitled "*Comparative effects of power lines and roads on moose (Alces alces) habitat selection*" was orally presented and consequently submitted as a proceedings paper of the 10<sup>th</sup> ROW conference in Arizona.

The data from the wildlife cameras will be analysed in early 2013. Based on information from the camera traps a report entitled "*Effects of vegetation edges and clearing regimes at a power-line rights-of-way on wildlife visitation rates*" will be ready in early 2013. The browsing surveys and pellet group counts will continue in 2013 to ensure that effects from the alternative clearing regime can be detected.

Papers to be written in 2013 (PhD) will be:

2) "*Barrier and corridor effects of power lines, roads and rivers*". The hypotheses are that moose avoid crossing power lines, roads and rivers (H1), power lines, roads and rivers channel moose movement (H2) and roads have stronger effects than power lines or rivers (H3). The data used is moose GPS location data from 167 moose captured in the area of Nord-Trøndelag County.

3) "*Potential impacts on wildlife of power lines routed across different habitats. A review*" This paper will be a general review but considered with an emphasis on Norwegian conditions and ungulates. The focus will be, what potential impacts are there, and where are the greatest impacts in Norway given the distribution of power lines. Power-line ROW habitats that could provide browsing resources for moose will be compared to other land-use types.

4) "*Edge effects of power lines*". The hypotheses are that moose increase browsing intensity (H1) and habitat use (H2) near power-line forest edges and other types of forest edges and that the availability of browse plant species increases at forest edges and inside the power-line corridor (H3). Field data from browsing surveys and pellet-group counts from the study are in Bangdalen will be used. Approximately 300 plots with a 4 m diameter were surveyed in 2011 up to 500 m from the power line. Pellet counts from 181 plots surveyed in 2010 up to 300 m from the power line may also be used.

## 2.3 Research findings

### 2.3.1 Material and methods

#### 2.3.1.1 Power-line ROW habitat use by wildlife

Pictures from wildlife cameras collected in 2010 were inspected and a preliminary analysis on wildlife visitation rates in power-line ROW and adjacent habitats was made.

#### 2.3.1.2 Power-line ROWs as moose feeding grounds

To find out, what makes areas attractive for browsing by moose, Eplett (2012) analysed data from 2234 forest inventory plots in Nord-Trøndelag County in central Norway. The plots, each 250 m<sup>2</sup> in size, were surveyed by the Norwegian Forestry Institute between 2005 and 2009 (Norsk institutt for skog og landskap 2007). In each of the plots the percentage browsed of over the last five years on the browsing trees rowan-aspen-willow, deciduous trees and pine trees was estimated. Moose browsing trees were trees between heights from 0.5 to three meters that moose can commonly reach in winter (Norsk institutt for skog og landskap 2007). Linear mixed effects models were used to test for the effects of browsing tree availability, tree height, count of trees per hectare, habitat type and moose density on the percentage browsed of each browsing tree class. The Holling's Type II functional responses were estimated (Holling 1959) describing a relationship between available and used browsing material from non-linear regression models for each browsing tree classes. In addition, we calculated the average availability of different browsing trees in plots of varying tree heights covering all forested areas in Norway. Then a rough visual estimation of tree heights in 500 random plots in power-line ROW routed through forests in Norway from aerial photographs was made. Power-line routing data was provided by the central-grid operator Statnett.

### 2.3.1.3 Power-line impact on moose habitat selection

Data from 60 radio-collared moose captured in Nord-Trøndelag County were analysed. These were found at least once within 2 kilometres from a transmission line. The transmission-line routing data was from Statnett. Random movement steps were created from the distribution of step lengths and turning angles for each observed moose movement step. Conditional logistic regression was applied to model the probability of moose choosing observed movement steps versus random movement steps (Fortin et al. 2005). The covariates were distance to power lines, distance to public roads, habitat and elevation. It was assumed that there were no effects above 2 kilometres distance from the central-grid transmission lines and public roads and the effect were set to zero by setting distance above 2 kilometres to 2 kilometres. The effects of all continuous variables were modelled using restricted cubic splines (Harrell 2001). The most parsimonious models were selected for each season after ranking them according to QIC models (Pan 2001, Craiu et al. 2008). Then the most parsimonious seasonal models were applied to each moose gender. To find out how important power lines are in relation to other variables, penalized Wald statistics (**Figure 5**) was calculated. These values increase with the significance of variables and are penalized by the number of parameters. Step selection probabilities were modelled for movements from the reference habitat type, old spruce forest, at the baseline distance, 2 kilometres from power lines and roads, towards other habitat types and distances (**Figure 4**). High step selection probabilities indicate high probabilities of movement from the reference habitat and baseline distance. For details see Bartzke et al. (2012).

### 2.3.1.4 Power lines, roads and rivers as barriers or movement corridors for moose

In a preliminary analysis, the same dataset and statistical method were used as described above to analyse the probability of moose choosing steps that cross central-grid transmission lines, public roads and rivers. No pre-selection of animals were made. The covariates were crossing of each structure, step length, forest cover and elevation. Rivers were classified into small rivers below 40 meters width within 10 meters to the point where movement steps crossed and large rivers above 40 meters width within 10 meters to the crossing point. To find out if moose move along power lines, public roads and rivers, the angle between each moose movement step and the nearest linear feature segment ranging between zero and 90 degrees were calculated. This angle is zero when the animal moves along the linear feature and 90 when the animal moves exactly towards or away from the linear feature. Forest cover was included as a covariate. Beta-regression was applied and non-linear effects of distance to linear feature with natural splines using two degrees of freedom were modelled. The effect of each linear feature separately was modelled whilst excluding moose relocations within distances of 2 kilometres to the respective other linear features.

### 2.3.1.5 Improving power-line ROWs as wildlife habitats

Moose browsing and habitat use were monitored also during the spring 2012 by surveying close to 200 random plots in the Bangdalen study area for pellet groups and browsing intensity with the same method as in 2011. Survey plots were located both in conventional clearing areas as well as in an experimental clearing site within the power-line corridor.

### 2.3.1.6 Positive and negative impacts of power-line ROWs on wildlife

To find out the habitat area impacted by power-line corridors, the lengths of aerial power-lines of different tension categories traversing different habitat types within the Norwegian counties was estimated. Power-line routing data provided by NVE (Norwegian Water Resources and Energy Directorate) together with the Norut raster vegetation map were used for this purpose (Johansen et al. 2009). The aerial power line length routed through different habitat types were multiplied with the corridor width of each power-line tension category (Bevanger & Thingstad 1988, Bevanger 2011) for area estimates. The same analysis was applied to different road classes. To relate the habitat area in power-line ROW to other land-use types the area of these were calculated from the same vegetation map.

## 2.3.2 Preliminary results

### 2.3.2.1 Power-line ROW habitat use by wildlife

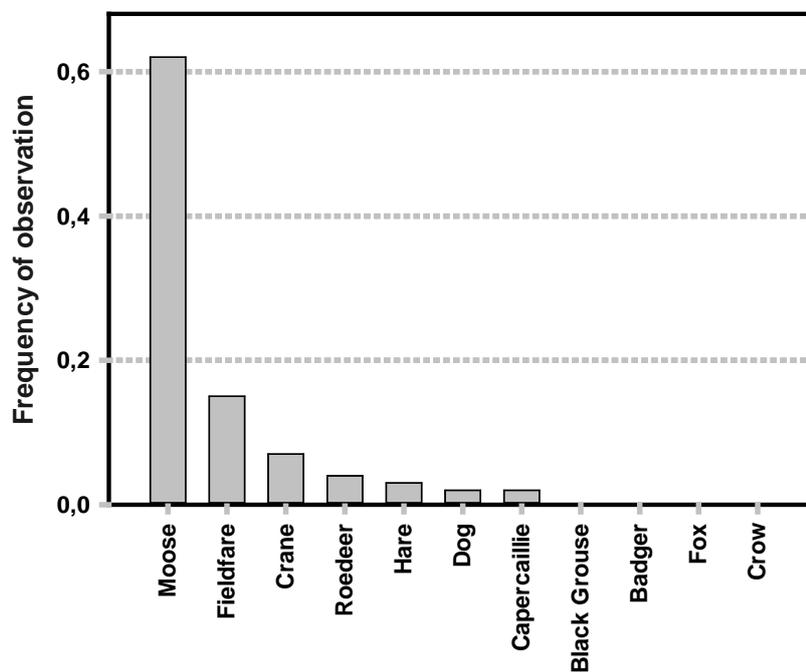
A total of 121 621 pictures from the wildlife cameras have been inspected and a preliminary analysis has been made. These cameras were active from June up to, and including parts of November 2010. During this period the cameras were alternated among 25 positions within the power-line corridor as well as outside the corridor. In total 15 different species were detected by the cameras. **Figure 1** shows the observation frequency for these species excluding livestock, humans and species detected only once. The most frequent species was moose. For the remaining species the frequencies of observation were quite low.

The probability of observing a species was highest when the cameras were positioned in the clear-cut areas within the power-line corridor (**Figure 2**;  $n=48$ ,  $\chi^2=11.9$ , population proportion=0.262, Bonferroni confidence limits=0.285-0.515). The remaining habitats were selected as expected in accordance to their occurrence except for mire that was selected less than expected ( $n=95$ ,  $\chi^2=6.5$ , population proportion=0.092, Bonferroni confidence limits=-0.012-0.062). These habitat categories apply to sites both inside and outside the ROW corridor.

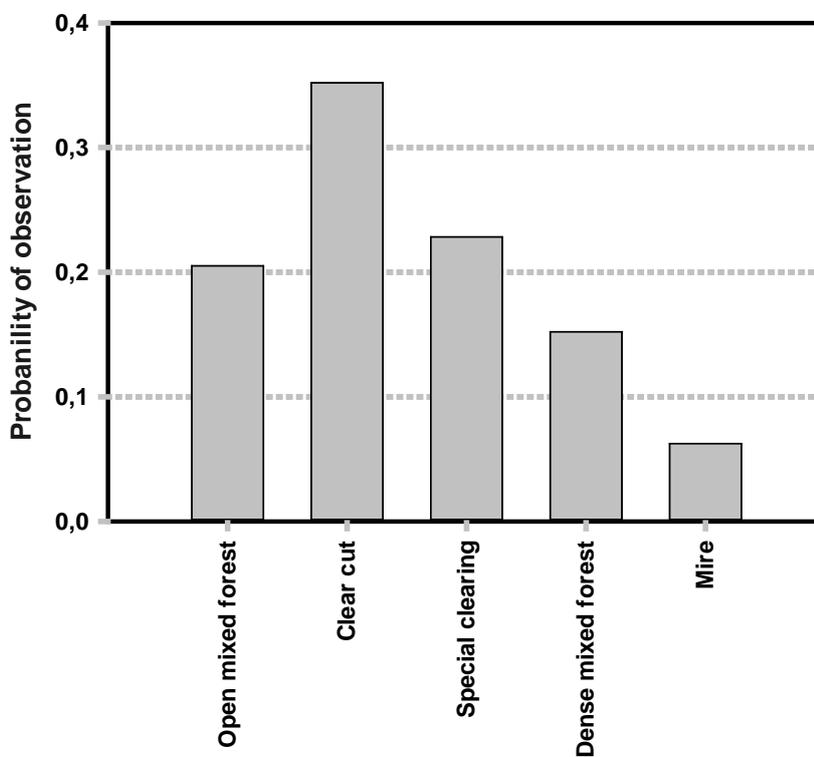
The preliminary results suggest that the probability of observing an individual, irrespective of species, was highest for cameras situated inside the power-line corridor (**Figure 3**;  $n=66$ ,  $\chi^2=8.7$ , population proportion=0.659, Bonferroni confidence limits=0.711-0.919). One possible interpretation of this result is that animals use the corridors for rapid translocations. Outside the clear-felled corridor animals were detected as expected in relation to distance from the power-line corridor, except for the stripe closest to the corridor where animals were detected less than expected ( $n=13$ ,  $\chi^2=4.5$ , population proportion=0.078, Bonferroni confidence limits=-0.017-0.066).

Several biasing factors may impact the data results. The significance tests need to be treated with care as the number of observations in several cases was less than five (Manly et al. 1993). Even though the number of pictures apparently is high, the amount of information that can be withdrawn from them is limited as one case might be represented by hundreds of pictures. It may also be difficult to determine when a picture represents a new case as individuals might move in and out of the field-of-view while moving around the fixed camera position. The area covered by the cameras may also vary according to topographic conditions as well as density of cover at the sites they were positioned, thus affecting detectability. The resolution of the preliminary results is consequently rather low as only a crude comparisons is applied so far. It has for instance not

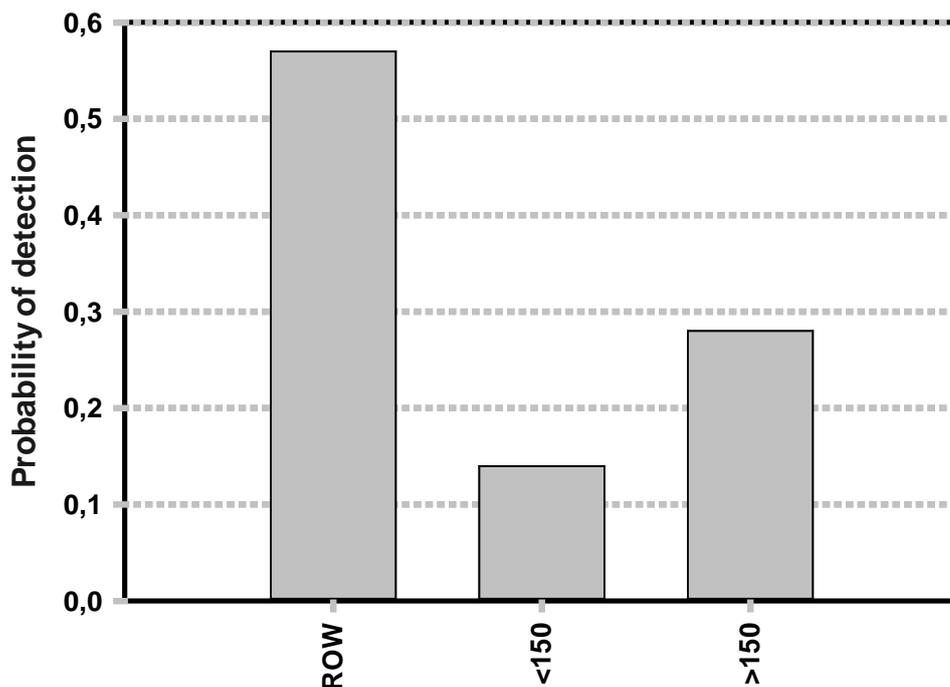
been discriminated among species when comparing detections in different habitat types and the clear-felled corridor. However, a further increase in resolution depends on how much information it is possible to extract from total picture dataset.



**Figure 1.** Species recorded by wildlife cameras in Bangdalen during 2010.



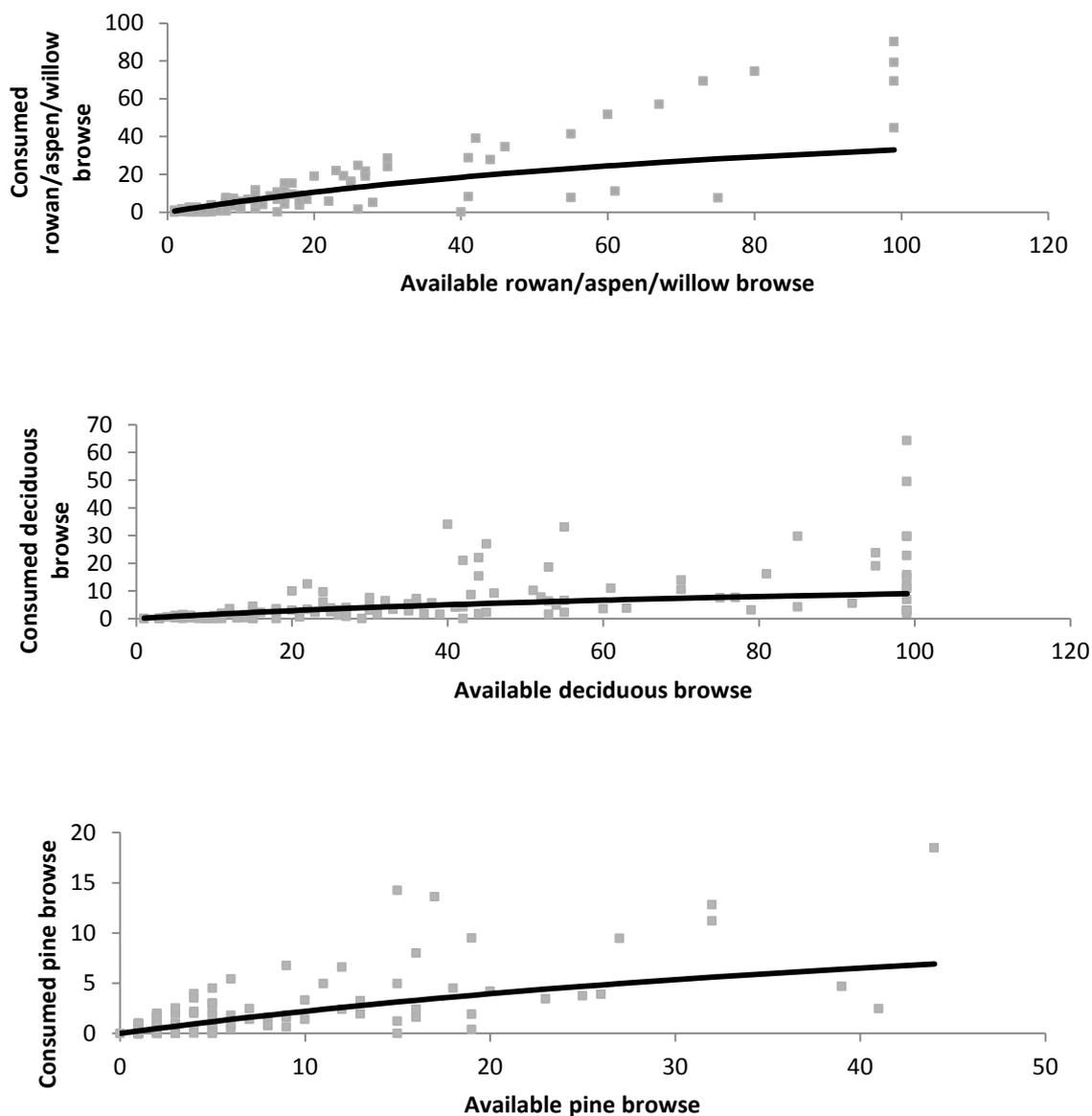
**Figure 2.** The probability of detecting a species in a specific habitat type in Bangdalen in 2010.



**Figure 3.** The probability of detecting an individual, irrespective of species, in relation to distance from the ROW corridor. ROW represents observations in the corridor, <150 means recordings between the corridor boundary and out to 150 meter, whereas >150 indicates recordings made more than 150 meter from the corridor.

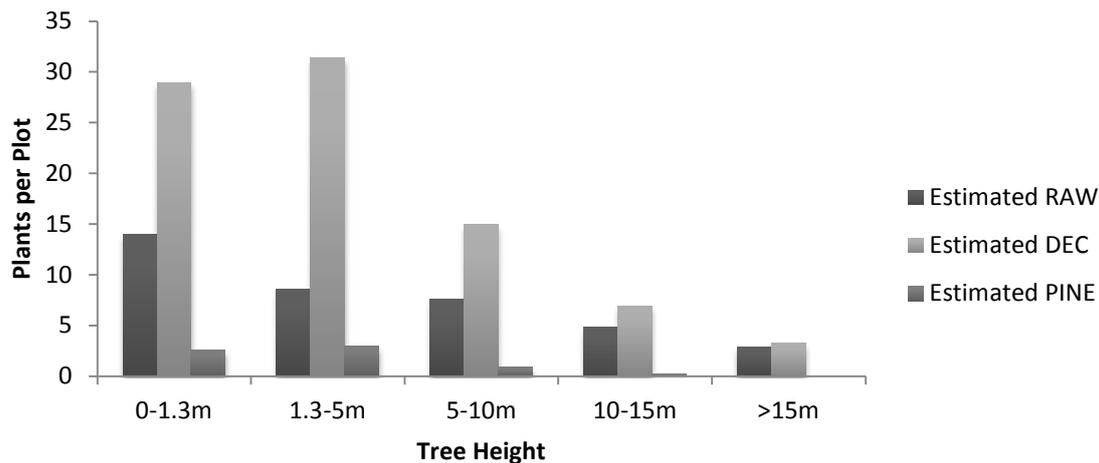
### 2.3.2.2 Power-line ROWs as moose feeding grounds

From a multivariate analysis using data of 2234 forest inventory plots from Nord-Trøndelag we found that the availability of browsing trees was the most significant predictor for moose browsing intensity on rowan-aspen-willow (RAW;  $P < 0.001$ ) as well as deciduous trees (DEC;  $P = 0.001$ ) (Eplett 2012). Habitat type had a significant effect on browsing intensity of rowan aspen-willow ( $P < 0.05$ ) and pine trees ( $P < 0.05$ ) (Eplett 2012). Moose density and tree cover represented by tree height and trees per hectare had no significant effect on browsing intensity on any tree species ( $P > 0.05$ ) (Eplett 2012). A Holling's Type II functional response was detected for each browsing tree class, where the amount of browse consumed increased with the availability of browsing plants in forest inventory plots (**Figure 4**) (Eplett 2012).



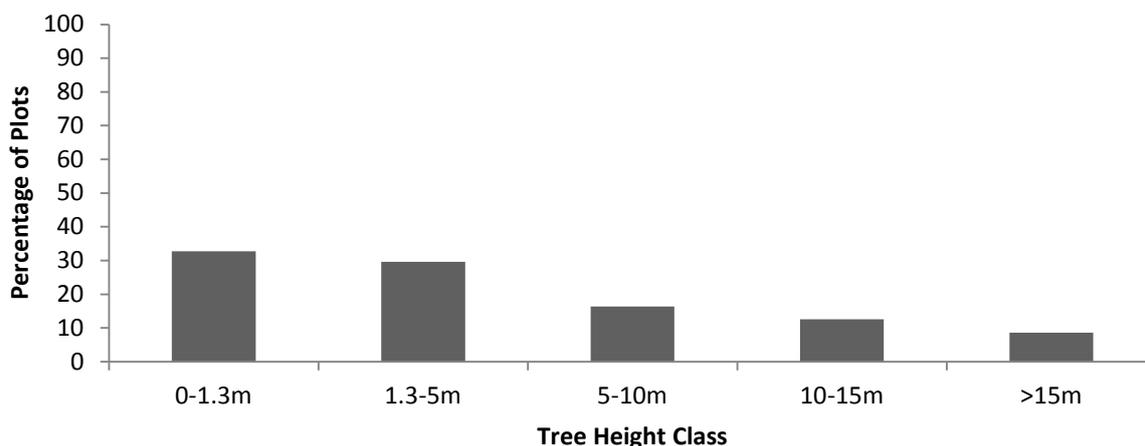
**Figure 4.** Functional response of moose feeding on rowan-aspens-willow (upper graph), deciduous (middle graph) and pine trees (lower graph) in response to availability of browsing plants. The black line represents fitted type II functional response, calculated using Holling's Type II equation with parameter estimated by nonlinear least squares. The grey points are data points from individual forest inventory plots within the Nord-Trøndelag County (from Eplett 2012).

Forest inventory plots with an average tree height below five meters contained more browsing plants for moose than plots with an average tree height above five meters (**Figure 5**) (Eplett 2012). Trees were woody plants with a diameter of at least 5 cm at breast height (Norsk institutt for skog og landskap 2007).



**Figure 5.** Estimates of mean number of browsing plants for 5 different tree height classes (0-1.3 m, 1.3-5m, 5-10m, 10-15m, >15m) in forest inventory plot in Norway. RAW are ro-wan/aspens/willow browsing trees, DEC are deciduous browsing trees and PINE is pine browsing trees (from Eplett 2012).

The results indicate that areas with tree heights below five meters hold the greatest amount of moose browsing trees. Thus areas inside power-line ROW, where tree heights do not exceed five meters, may provide larger amounts of forage compared to surrounding forest with tree heights exceeding five meters. Areas with tree heights below five meters could be attractive feeding grounds for moose, as the analysis shows that moose increase browsing in an area with increased availability of browsing plants in that area. Estimates revealed that approximately 60% of plots in power-line ROWs traversing forests have tree heights below five meters from visual surveys of aerial pictures (**Figure 6**). However, so far these estimates have not been ground-truthed.



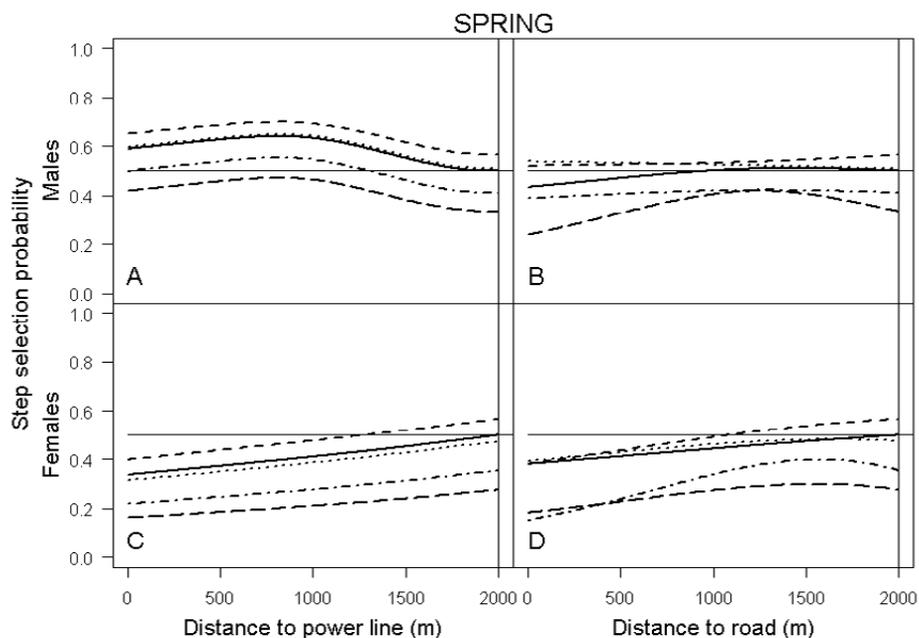
**Figure 6.** Proportion of plots within power-line corridors found within each of the tree height classes. Tree height was estimated through visual surveys of 500 random plots in central-grid power-line ROWs traversing forests across Norway using aerial photos (from Eplett 2012).

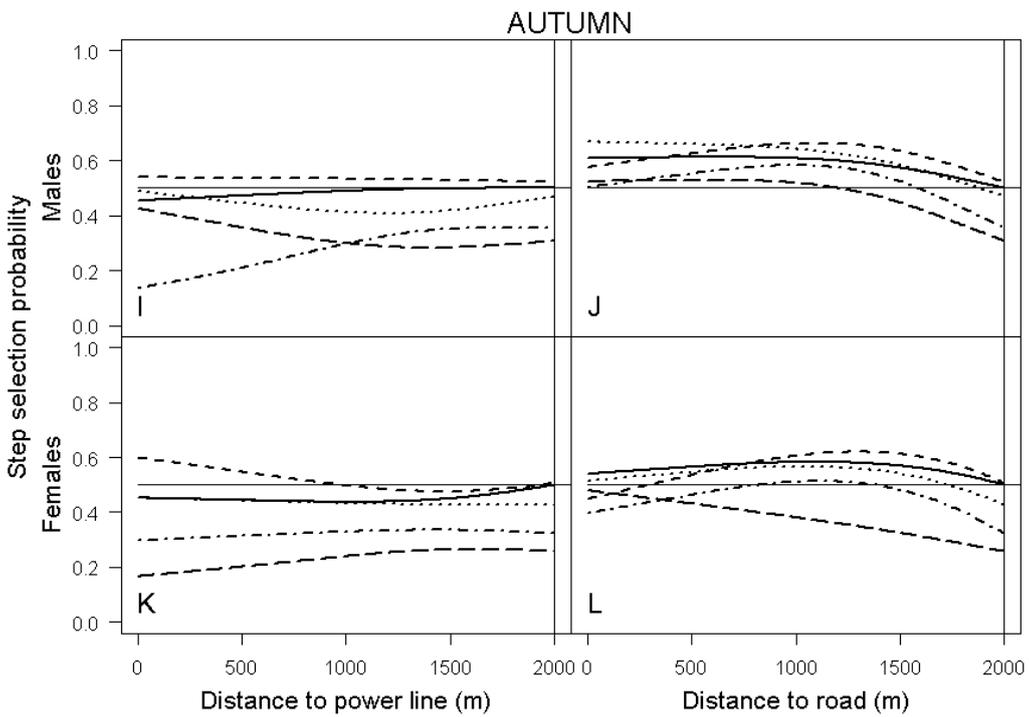
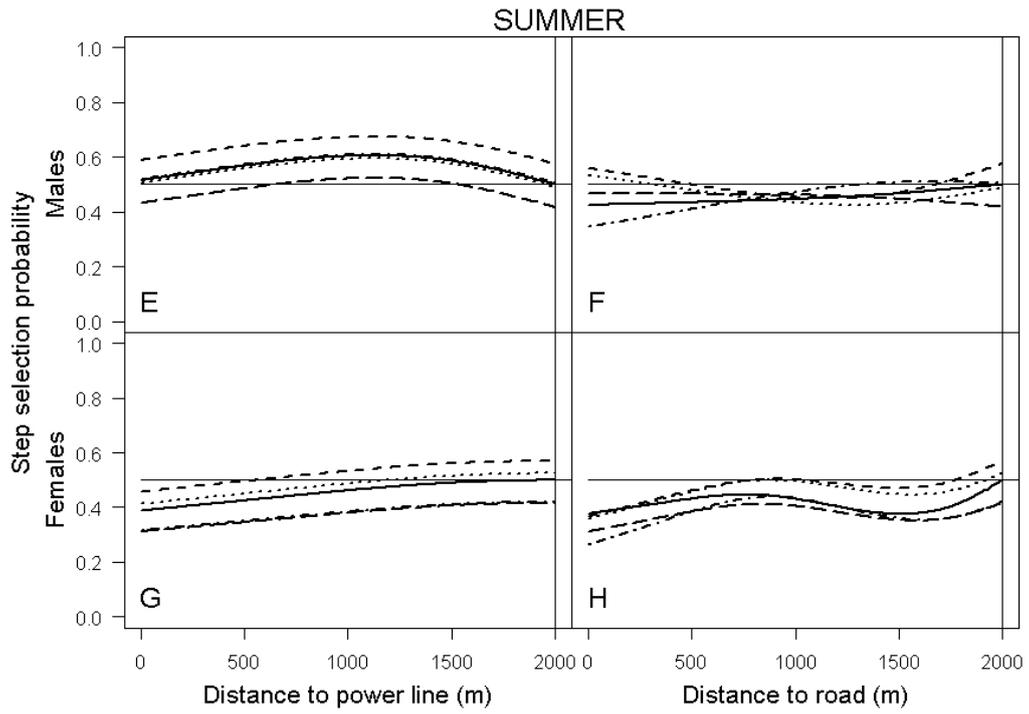
### 2.3.2.3 Power-line impact on moose habitat selection

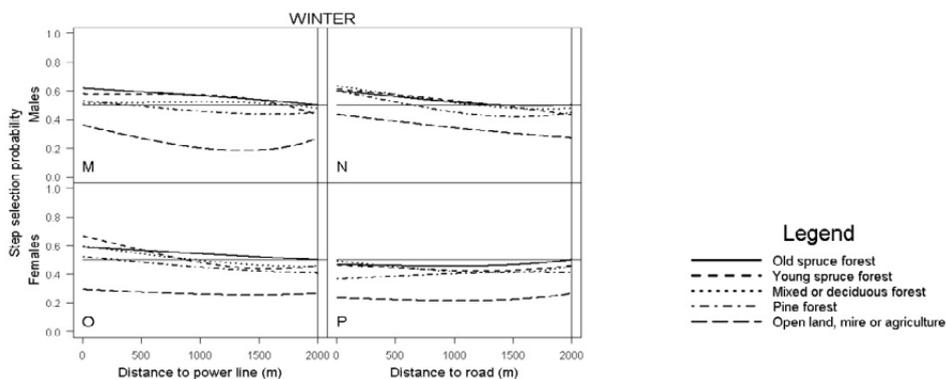
Seasonal responses indicate that moose avoid moving towards power lines and roads in most habitat types in spring and summer (**Figure 7A-H**) with the exception of male moose in summer (**Figure 7F**). Male moose showed higher preferences for the food-rich habitat types mixed and deciduous forests, young spruce forest, and the class open land, mire and agricultural land near roads, of which agricultural land may offer high-quality feeding material during this season (**Figure 7F**). Females in contrast were apparently seeking cover in old spruce forests below 250 meters from roads (**Figure 7H**). Thus males appear to be better in exploiting food-rich habitats closer to disturbance by infrastructure than females in times of raising young.

There was no clear pattern in movement probabilities towards power lines during autumn (**Figure 7I,K**), in which irregular movements probably occur due to rutting activity and hunting (Ericsson and Wallin 1996, Neumann 2009). Moose showed less avoidance of movement towards roads than in spring or summer in this season (**Figure 7J,L**). During winter moose were attracted to moving towards power lines and showed no road avoidance (**Figure 7M-P**). The significance of power lines was highest in winter, while the significance of roads increased in summer and autumn (**Figure 8**).

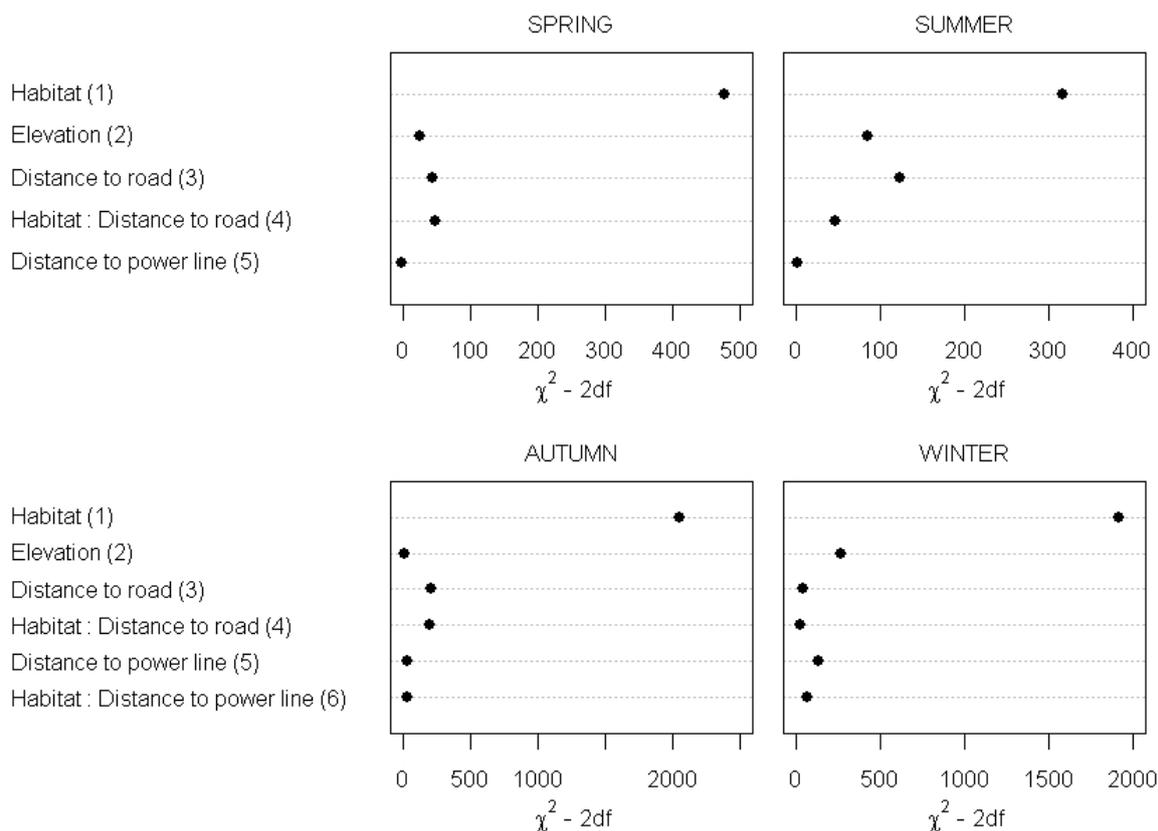
Movements towards power lines and roads during winter indicate that moose may exploit browsing resources in power-line ROW or along power-line and road edges. Responses in summer and autumn suggest that moose exploit agricultural land and other food-rich habitat types near roads during those seasons. However, migration of moose might also influence the movement pattern. Moose tend to move towards lower elevations in winter and autumn and towards higher elevations during spring and summer (Cederlund et al. 1987, Ballard et al. 1991). Power lines and roads were generally situated at lower elevations compared to the study area (roads: 135m ( $\pm 134$  SD); power lines: 287m ( $\pm 143$  SD), study area: 454 ( $\pm 244$  SD)). Our results indicate that moose are able to tolerate disturbance from infrastructure when nearby habitats warrant exploitation and point towards the potential of power-line ROW and road edges as browsing resources for moose in winter.







**Figure 7.** Step selection probabilities as a function of distance to central-grid power line or distance to public road is shown in spring (A-D), summer (E-H), autumn (J-L) and winter (M-P). Step selection probabilities for different gender and habitat types and are indicated. GPS relocation data was obtained from 60 radio-collared moose in the county of Nord-Trøndelag, Norway (from Bartzke et al. 2012).

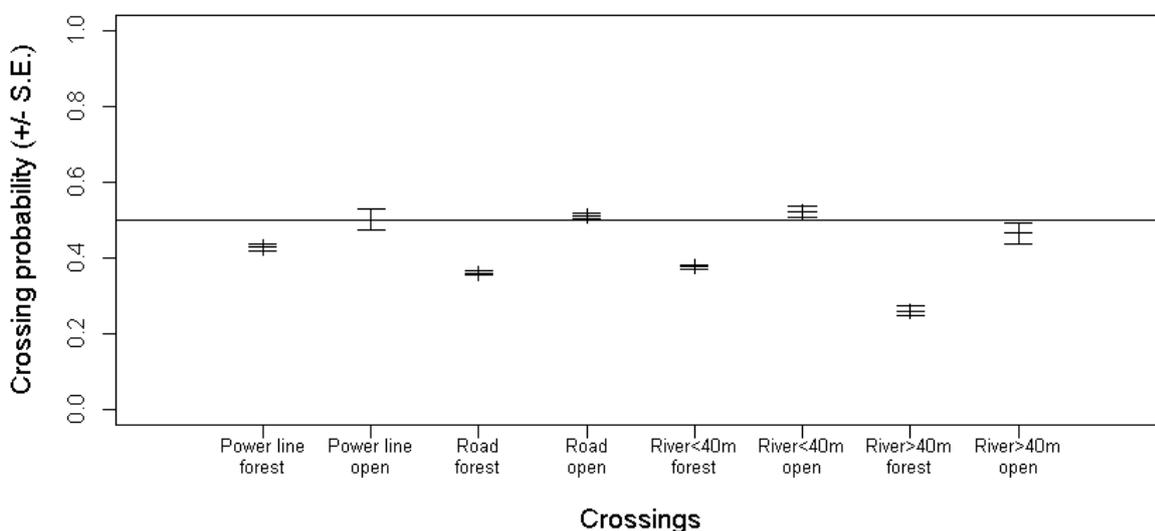


**Figure 8.** Importance of variables as indicated in the most parsimonious model based on GPS data from 60 radio-collared moose in the county of Nord-Trøndelag, Norway. The penalized Wald statistics are given of individual variables including their main effects (2) as well as interaction terms with other variables where applicable (1,3,5). “:” means that only the specified interactions were considered (4, 6). The penalized Wald statistics are shown for spring, summer, autumn and winter separately. The penalized Wald statistic was calculated from the Wald statistic minus twice the degrees of freedom (from Bartzke et al. 2012).

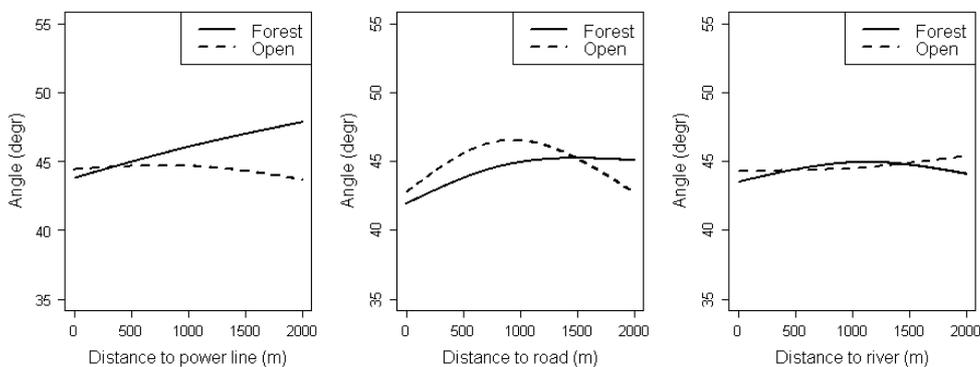
### 2.3.2.4 Power lines, roads and rivers as barriers or movement corridors for moose

Preliminary analysis indicates that moose avoid crossing central-grid power lines, roads and rivers with widths below 40 meter in forests, since predicted step selection probabilities for steps that cross were below 0.5 when ending in forest (**Figure 9**). Crossing of central-grid power lines was less avoided than crossings of public roads and rivers below widths of 40 meters (**Figure 9**). Moose did refrain from crossing public roads, central-grid power lines or rivers below width of 40 meters when steps ended in open habitats. Crossing of rivers with widths above 40 meters was avoided in open habitats as well (**Figure 9**).

In forest the angle between the moose movement step, and the nearest linear feature segment decreases with distance from that feature (**Figure 10**). This indicates that moose increase movement along linear features when getting closer. The angle between movement steps and central-grid transmission lines and rivers was generally larger than the angle between movement steps and public roads in forests (**Figure 10**). There was also a decrease in angle between movement step and public road when steps started in open habitats (**Figure 10**).



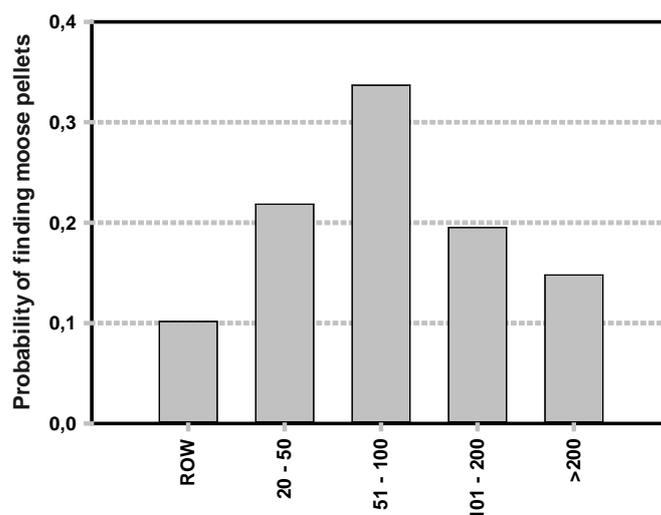
**Figure 9.** Crossing probabilities for central-grid transmission lines, public roads and rivers below 40 meters width and rivers above 40 meters width in forests and open habitats. Crossing probabilities are probabilities of moose choosing steps that cross over steps that don't cross when ending in forest or open habitats. Probabilities below 0.5 indicate avoidance of crossing.



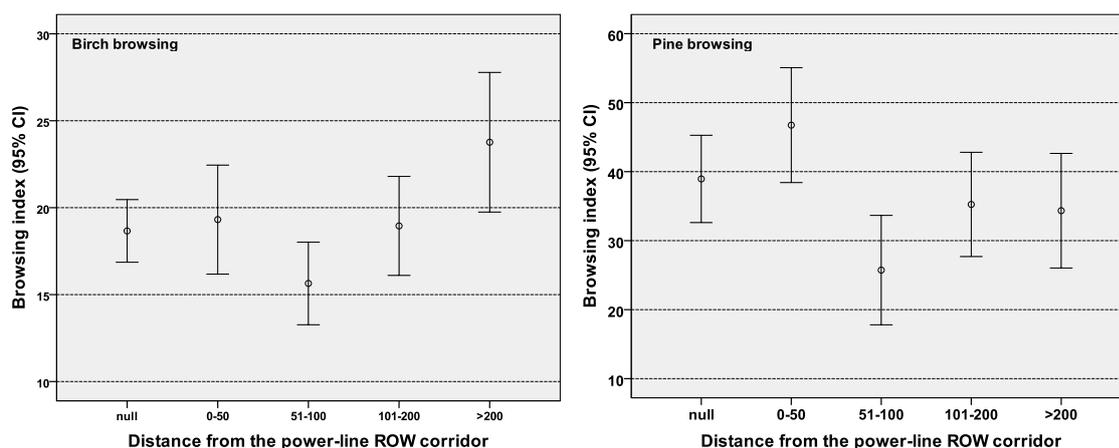
**Figure 10.** Predicted change in angle between moose movement steps and nearest power line, road and river segment for steps starting in forests (continuous lines) and open (dashed lines) habitats. A reduction in angle indicates a stronger tendency of movement along linear features.

### 2.3.2.5 Improving power-line ROWs as wildlife habitats

Information on moose browsing and pellet-group distribution was sampled from random plots inside and outside the power-line ROW. The preliminary analysis suggests that moose pellet-groups were unevenly distributed in relation to distance from the ROW corridor (**Figure 11**). There was an increased probability of locating pellet groups within 100 meter alongside the ROW corridor (n=173,  $\chi^2=76.1$ , population proportion=0.134, Bonferroni confidence limits=0.204-0.288), whereas the probability of detecting pellet groups within the ROW corridor was less than expected (n=112,  $\chi^2=56.4$ , population proportion =0.288, Bonferroni confidence limits=0.124-0.195).



**Figure 11.** The probability of locating moose pellet groups according to distance from the ROW centre-line. Four distance ranges (measured in m) are shown together with the ROW corridor.

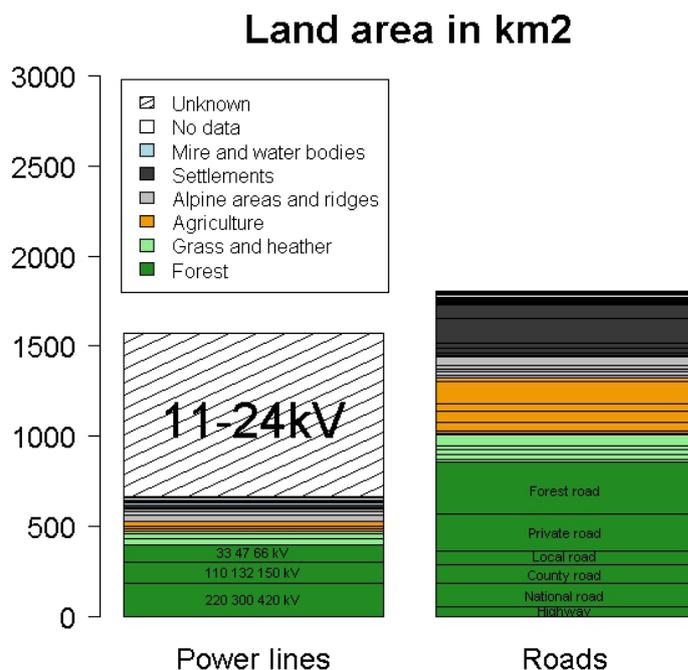


**Figure 12.** Moose birch and pine browsing in relation to distance from the power-line clear-felled corridor (distance categories along the x-axis). Null means inside the clear-felled corridor.

The preliminary analysis suggests that browsing intensity seems to occur more or less at the same level, within plant species, regardless of distance to the ROW corridor. Birch, which is an important winter resource, was browsed evenly across all distance categories alongside the ROW corridor (**Figure 12**; Kruskal-Wallis  $k=5.3$ ,  $df=4$ ,  $p=0.263$ ). Another important plant species for moose is pine. Browsing intensity on pine exhibited the same pattern as for birch, except for higher browsing intensity in the 0-50m distance class compared to 51-100m from the ROW corridor (**Figure 12**; Kruskal-Wallis  $k=12.0$ ,  $df=4$ ,  $p=0.017$ ). This suggests that moose were not attracted to the ROW corridor for browsing purposes but apparently spent proportionally more time in areas close to the ROW corridor as indicated by pellet-group counts. This is in accordance with findings of a pilot study conducted earlier at the study site (O'Neill 2011). However, these results are preliminary and should be interpreted as such. More detailed and in depth analyses will be done in 2013. For the time being, we have not evaluated if there are any effects of the special clearing regime that was effectuated between pylon 68 and 75 in 2010. At least one more data sampling period is needed to test possible differences in browsing patterns in this regard.

### 2.3.2.6 Positive and negative impacts of power-line ROWs on wildlife

The total land area intersected by power lines above 33 kV was estimated to 664 km<sup>2</sup>, of which 397 km<sup>2</sup> (~60%) are routed through forests (**Figure 13**). No accurate routing information for power line tension categories below 33 kV is available. High tension power lines between 11 and 24 kV may take up an additional area of ~900 km<sup>2</sup> assuming a corridor width of 15 meters (Bevanger 2011) and a total length of 60,546 km (Statistics Norway 2011). The habitat impacts of 104,196 kilometres power lines carrying voltages below 11 kV are unknown (Statistics Norway 2011). The land area tied up by roads, including road verges, was estimated to 1,805 km<sup>2</sup>, of which 859 km<sup>2</sup> (48%) are situated in forests (**Figure 13**). Private and forest roads impact larger areas of forests compared to other road types (**Figure 13**). For comparison, the area that is clear cut in Norway annually is estimated to be at least 270 km<sup>2</sup> (T.A. Steinset, pers. comm.). Human settlements and agriculture ties up 2,793 km<sup>2</sup> and 9,694 km<sup>2</sup>, respectively, according to the above estimates. This analysis indicates that power lines carrying voltages above 33 kV have lower, but not negligible, habitat impacts compared to other land-use types.



**Figure 13.** Area estimates of habitat types impacted by different power line and roads classes in Norway.

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## 3 Capercaillie and black grouse population responses to power-line mortality

### Objectives

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

### 3.1 Background

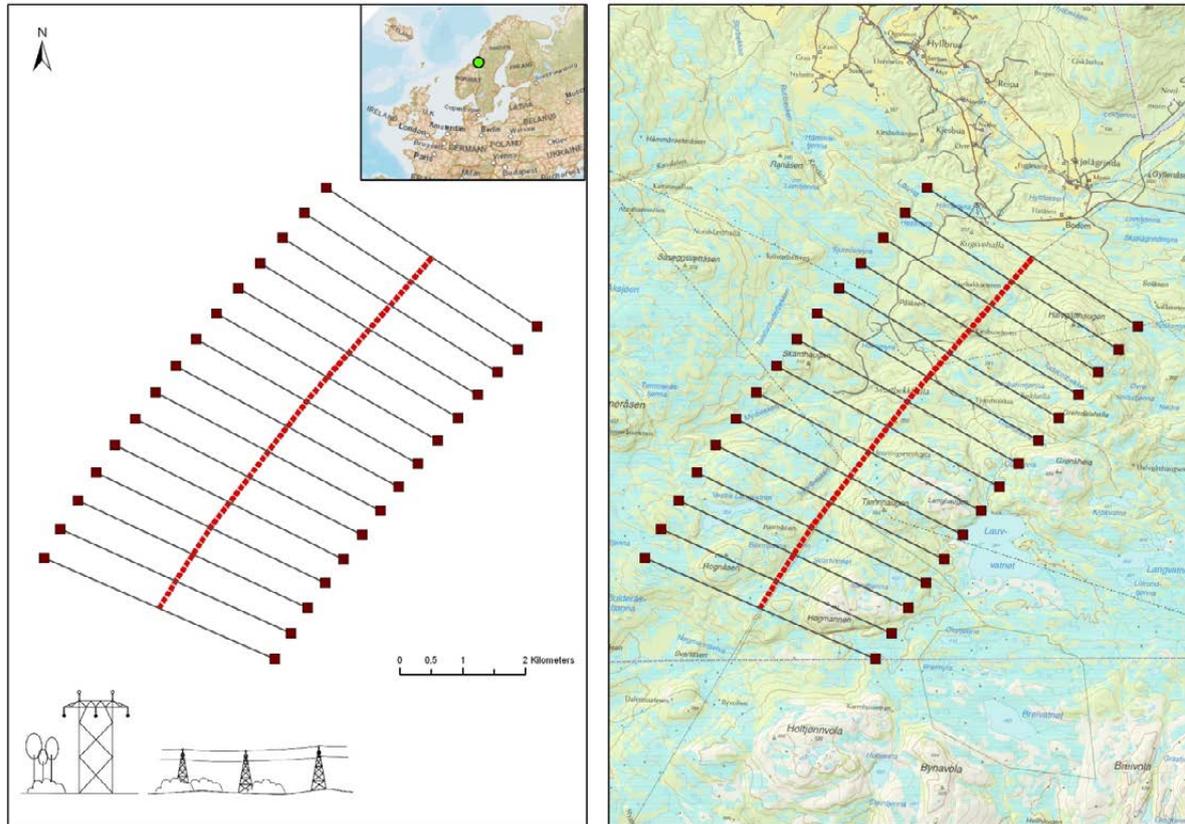
A steadily increasing environmental stress has made mortality factors for birds important that once were considered insignificant and thought to be compensated for among the survivors. It is now well known that overexploitation may cause serious problems for e.g. gallinaceous bird populations (Sandercock et al. 2011). Thus, the impact of additional bird mortality from collisions with power lines, hunting, electrocution, wind turbines, telegraph wires, ski lift wires, fences, windows etc. should not be dismissed as trivial (Bevanger 1994, 1998). Bird mortality due to collisions with overhead power lines are connected to the fact that birds need free airspace for performing a normal life. However, the mortality extent is species-, site- and seasonal-specific (Bevanger 1995a), depending on a range of biological as well as non-biological issues. A search for universal solutions to mitigate or remove all conflicts related to these issues is consequently not a realistic approach due to the complexity of both the biological as well as the technical aspects.

That some species have proved to be particularly vulnerable to collide with overhead power lines are well known (Bevanger 1994, 1998), and in Norway gallinaceous birds are documented to be particularly vulnerable (Bevanger 1995a, b, Bevanger and Brøseth 2004). 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 1995b). Due to declining population densities it has become increasingly important to regulate the hunting bag to avoid overexploitation (Sandercock et al. 2011). To advice on a safe hunting outcome, 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 a power line is routed across high-quality hunting areas. 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 (Bevanger 1995b). Thus, when OPTIPOL was designed back in 2007, it was decided that one of the 9 sub-projects should focus population impact of bird mortality due to power-line collisions.

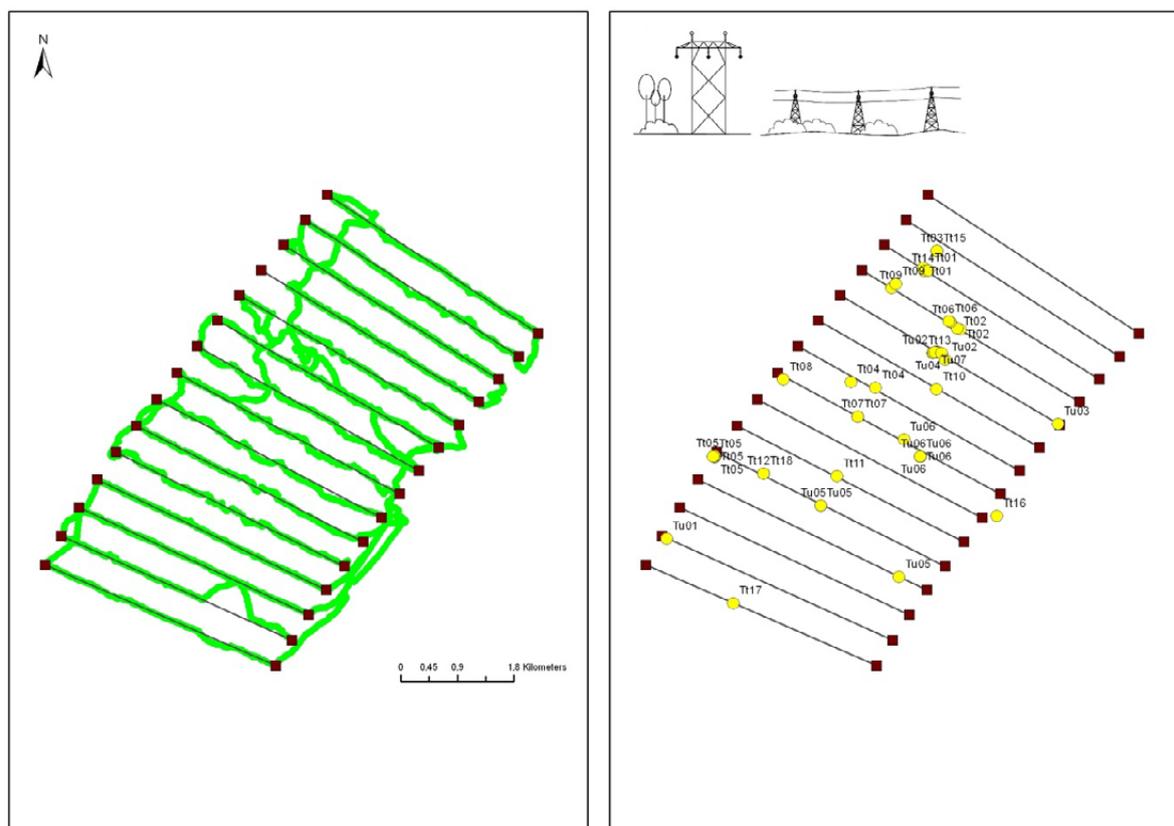
### 3.2 Methods

In an intensively studied area in Central Norway (30km<sup>2</sup>, Ogdalen in Steinkjer local authority, Nord-Trøndelag County) the population of capercaillie *Tetrao urogallus* and black grouse *Tetrao tetrix* is censused by transect sampling of droppings in connection to a 300kV transmission line section (**Figure 14**).



**Figure 14.** Transect lines across 7.1km of a 300kV transmission line section for capercaillie and black grouse dropping sampling in Steinkjer local authority, Central Norway.

During spring before the snow melts, 15 transect lines (each 4km long) are patrolled for data sampling by one person using cross country ski. During the transect line census visual observations of tracks/droppings in the snow on both sides of the line are conducted (**Figure 15**). All droppings assumed to come from a capercaillie or black grouse are collected for later DNA-analyses in small plastic tubes with silica grains for rapid drying. GPS-position and perpendicular distance to the transect line are used to estimate the effective search width for density and population estimates in the study area.



**Figure 15.** Sampling effort and DNA-samples in connection to a 300kV transmission line section in Steinkjer local authority, Central Norway.

DNA from droppings are analysed with several autosomal microsatellite loci to distinguish among individuals; seven in capercaillie (BG15, BG18, sTuD3, sTuD1, sTuT3, sTuT4 and sTuT1) and six in black grouse (BG15, BG18, BG16, sTuD1, sTuT3 and sTuT4). For sex determination we are using one sex-chromosome specific marker (P2P8).

The only efficient way to collect data on collision victims in low-density forest habitats is to count dead birds in the power-line corridor, by crisscrossing beneath the phase conductors in the clear-cut area. To increase the efficiency in the effort to find dead birds, searches should be accompanied by a special trained dog (Bevanger 1999). A wachtel dog, born in September 2009, was bought and trained for the project. A 7.1 km section of a 300kV transmission line crossing through the area are searched for dead birds killed by colliding with the overhead wires using the trained wachtel dog. The patrols take place once a week during the period March-May, and every second week during the period September-February. 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 the power line.

### 3.3 Some preliminary results

In March 2011 (week 10) the study area was surveyed for a total of 116km and 53 droppings were collected for DNA-analysis. The analysis was very good with a success rate of 81%. The majority of the failure samples were from droppings with possible mix-up species like willow ptarmigan *Lagopus lagopus* and hazel grouse *Bonasa bonasia*. A total of 18 and 7 different black grouse and capercaillie specimen were identified from the samples respectively. In March 2012

two data sampling periods with line transects and droppings for DNA-analysis was completed (week 10 and 11). During 230km of transect sampling on snow, 126 DNA-samples were collected. The analysis success rate was 75% in 2012. In the two sampling periods a total of 29 and 23 different black grouse and capercaillie specimen were identified from the samples. Population estimates for the study area show a higher density of both species in 2011 than 2012, and more black grouse than capercaillie (**Table 1**)

**Table 1.** Population estimates for black grouse and capercaillie in 2011 and 2012 from DNA-analysis of droppings in Ogdalen in Steinkjer local authority.

Year	Week	Effective search area (sqkm)	Capercaillie density	Black grouse density	Capercaillie no.	Black grouse no.
2011	11	6,07	1,2	3,0	34	86
2012	10	5,86	2,7	3,4	80	99
2012	11	6,16	1,6	2,4	47	71

In 2011/2012 a total of 14 search patrols for dead birds with the trained dog have been conducted. Altogether 29 locations with birds and bird remains from collision victims were recorded in the study period. DNA-analysis was used to identify 19 different individuals from five species among the birds and bird remains, among others 4 capercaillie and 4 black grouse.

In 2012/2013<sup>1</sup> a total of 15 search patrols for dead birds were conducted. A total of 21 places with birds and bird remains from collision victims were recorded. The number of individuals will be verified by DNA-analysis when the 2012/2013 season is completed, but based on the field assessment of the birds and bird remains from collision victims 3 capercaillie and 1 black grouse is found so far in 2012/2013. So far it looks like capercaillie have a higher collision mortality than black grouse (**Table 2**).

**Table 2.** Estimated collision mortality for capercaillie and black grouse during 2011/2012 and 2012/2013 in Ogdalen in Steinkjer local authority.

Year	Week	Population estimate		Collision victims		Collision mortality (%)	
		Capercaillie	Black grouse	Capercaillie	Black grouse	Capercaillie	Black grouse
2011	11	34	86	4	4	11,8	4,7
2012	10	80	99	3 <sup>1</sup>	1 <sup>1</sup>	3,8	1,0
2012	11	47	71	3 <sup>1</sup>	1 <sup>1</sup>	6,4	1,4

### 3.4 Discussion

<sup>1</sup> Preliminary results by 11 January 2013.

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Small-game hunting is economically important to local communities both in Norway and other countries (Steen 1989) and the question of hunting bags being lost through power lines crossing small-game hunting areas has been repeatedly raised in several countries (e.g. Thompson 1978; Gylstorff 1979; Hobbs 1987), especially by landowners. The owner may obtain higher revenues for hunting rights in an area reputed to be optimal, and with no power lines crossings. Norwegian courts have ruled that power lines kill tetraonid game birds, but there is disagreement on whether a grid owner should be required to reimburse financial losses (Nordmøre herredsrett 1988; Frostating lagmannsrett 1989) due to lack of data on the population impact.

Bird mortality due to anthropogenic causes is well documented world-wide (e.g. Erickson et al. 2005), however, the population impact is poorly understood (Bevanger 1998, Drewitt & Langston 2008). The reason for that is obvious – it is a big challenge to get reliable estimates for e.g. gallinaceous birds like the capercaillie and black grouse in low density forest habitats as in Norway. Censuses based on bird flushing needs to be long term and are extremely time consuming, i.e. expensive. Fortunately the OPTIPOL-project has generated sufficient resources to extend the baseline data collection for a four year period, which is a minimum of time needed due to e.g. natural population fluctuations and stochastic events influencing both the population development as well as and fieldwork conditions.

DNA-analyses based on dropping collection seem to prepare for reliably capercaillie and black grouse population estimates within a practicable timeframe and reasonable costs. The method would also reduce the possibility for overestimating the population size and the number of collision victims. There are several biases connected to dead bird collection in power-line corridors (Bevanger 1999), and sometimes it is difficult to decide whether separate feather and bird remains come from different fatalities. With DNA-analyses the subjectivity of the judgment disappears. Although the project still is only half way, the combined census methods and DNA-analyses seem promising.

## 4 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

### 4.1 Background

Gallinaceous birds 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, detailed information on the place where collisions take place are necessary. This problem is addressed through several subprojects in OPTIPOL. Available data as well as new data will be the basis for modelling how birds use the terrain and thus enable - by means of GIS-tools - to identify and predict factors that increases collision hazard.

### 4.2 Research methods

Over the last 25 years several projects in Norway have sampled qualitative and quantitative data on birds colliding with power lines (cf. Bevanger et al. 2011). Thus data is available from Finnmark, Sør-Trøndelag, Hedmark, Oppland and Buskerud counties. 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. The second data-set derives from the subproject on black grouse and capercaillie population responses to power-line induced mortality in Nord-Trøndelag. The third set of data will be obtained from the national database on dead birds.

### 4.3 Activities and findings

Available data from earlier projects has been identified and stored in a database together with new data collected in Ogdalen. Some of the power-line sections in connection to earlier projects have turned out not to be digitized, and some resources have been used to collect the missing data. The database, i.e. GPS-positions for all dead bird recordings in connection to previous projects, as well as the patrolled power line sections, is now finalised and the GIS-analyses will take place in 2013.

## 5 National database for reporting on dead birds

### Objectives

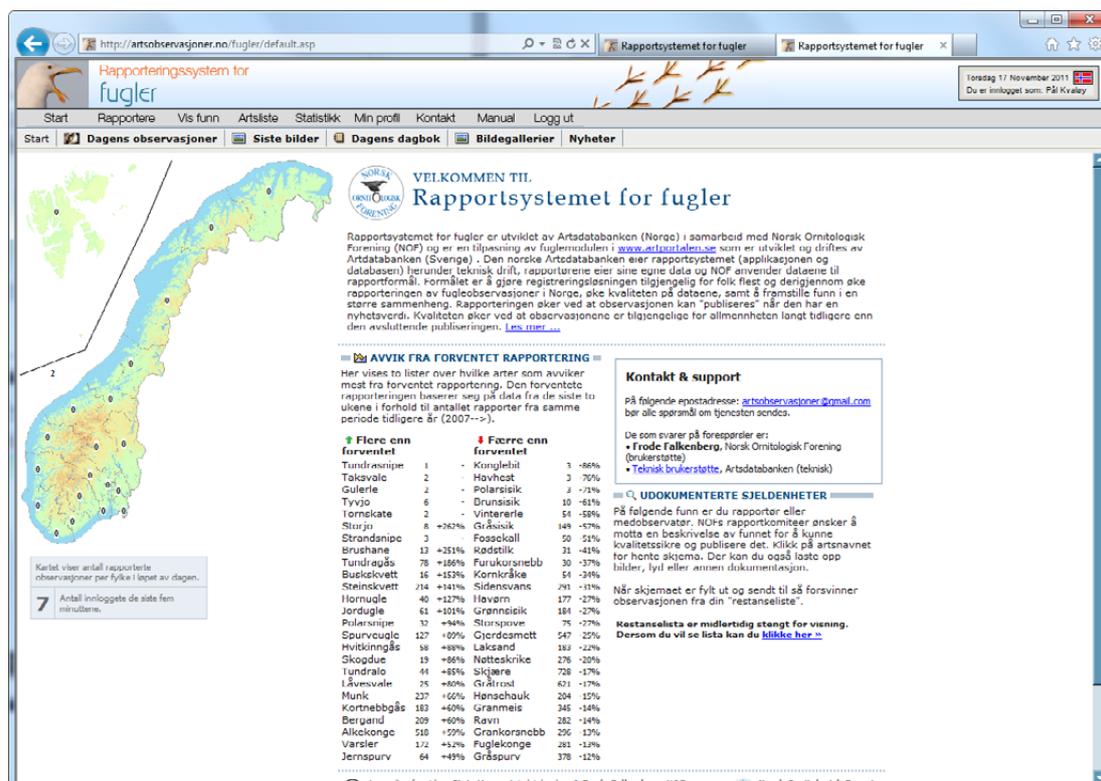
Establish a national infrastructure for management of dead-bird data (including birds recorded as collision and electrocution victims) by developing an online web application enabling the general public to contribute with data on recorded dead birds through internet.

Although a functional prototype of the database already was finished in 2009 (Bevanger et al. 2010, 2011), 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 popular web site and is accessed by people contributing with hundreds of observations daily (**Figure 16**). This system is also adopted by the Norwegian Ornithological Society (NOF) which is part of Bird Life 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 17**) it was possible to use the NBIC observation portal to collect data on dead birds as well.

The number of reported casualties has increased from 117 in 2011 to 379. By November 13 2012 the following data had been received:

Death due to fence collision 13 (5)  
 Death due to vehicle collision 179 (59)  
 Death due to beacon light 12 (1)  
 Death due to window 105 (33)  
 Death due to power line collision 49 (14)  
 Death due to electrocution 17 (5)  
 Death due to wind turbine 1 (0)

Although the data catch from *artsobservasjoner.no* was rather limited at the beginning, it now seems to work well.



**Figure 16.** 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.

The screenshot shows the 'Rapporteringssystem for fugler' web application. The browser address bar displays 'http://artsobservasjoner.no/fugler/default.asp'. The page title is 'Rapporteringssystem for fugler'. The navigation menu includes 'Start', 'Rapportere', 'Vis funn', 'Artsliste', 'Statistikk', 'Min profil', 'Kontakt', 'Manual', and 'Logg ut'. Below the navigation menu, there are several tabs: 'Lokaliteter', 'Funnsted (Ny)', 'Medobservatør', 'Prosjekt', 'Dagbok', 'Rapportér', 'Excelimport', 'Excel med koordinater (beta)', and 'Koordinatkonvertering'. The main content area shows a search bar with 'Kyvannsv 44, S1' entered. Below the search bar, there are filters for 'Ferugl', 'Art', 'Underart/fase', 'Ubestemt', and 'Hybrid'. The main table has columns for 'Artsnavn', 'Ind.', 'Alder', 'Kjønn', 'Aktivitet', 'Startdato', 'Sluttdato', and 'Kommentar'. The 'Aktivitet' column is expanded to show a list of mortality causes, including 'Sang/epill, ikke hekking', 'Lokkelyd, øvrige lyder', 'Køvir, ikke hekking', 'Ringmerket', 'Inaktivmerket', 'Trekkforsøk', 'Trekkende', 'Trekkende mot N', 'Trekkende mot NØ', 'Trekkende mot Ø', 'Trekkende mot SØ', 'Trekkende mot S', 'Trekkende mot SV', 'Trekkende mot V', 'Trekkende mot NV', 'Ukjent dødsårsak', 'Ferske spor', 'Gamle spor', 'Død-kollisjon med kraftledning', 'Død-kollisjon med vindurbin', 'Død-kollisjon med vindu', 'Død-kollisjon med fyr', 'Død-kollisjon med kjøretøy', 'Død-kollisjon med fly', 'Død-kollisjon med ørde', 'Direkt av elektrokusjon (strømslag)', 'Garnedød', 'Direkt av predator', 'Død av sykdom/kulde/sult', and 'Oljedrept'. At the bottom of the table, there are buttons for 'ARTSLISTE', 'Lagre inntastet dato', 'TILBAKESTILL', and 'LAGRE'.

**Figure 17.** The mortality-cause list was implemented in the Norwegian Biodiversity Information Centre's species observation portal - [artsobservasjoner.no](http://artsobservasjoner.no). in early 2011.

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

### Objectives

Develop a “*least-cost path*” GIS-toolbox for an environmental friendly routing of high tension transmission lines based on consensus on ecological, social, financial and technological criteria. This includes improvement of existing planning tools and conflict reduction through dialog.

### 6.1 Background

Identifying the “optimal route” when planning to build a new transmission line is a highly challenging exercise. The great complexity of formal and informal stakeholder interests influenced by power-line routing 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 multicriteria-analysis efficiently can be performed with LCP in planning and decision making of power line routing. Use of LCP will not replace Environmental Impact Assessments (EIA), but be a powerful tool in assessing where the optimal corridor should be planned and can be viewed as part of the scoping process in EIAs.

### 6.2 Research methods

The 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 (**Figure 18**). To ensure relevant criteria collection a standardized bottom up dialog approach have been developed where stakeholders are challenged to seek consensus on criteria selection, definitions, criteria values and weights. To standardize the stakeholder's preferred values into comparable criteria maps for the LCP- toolbox, a fuzzy-logic approach (e.g. Zadeh 1965, Zadeh et al. 1996) have been used. Here preferred criteria values are converted to a nonfinancial cost surface index based on the stakeholder's individual degree of accept for each criteria value. The stakeholder's degree of consensus is measure for criteria values by implementing basic summary statistics. The idea of this approach is to identify and visualize areas of consensus and conflict.

### 6.3 Activities and findings

From the beginning of the project (cf. Bevanger et al. 2009, 2010, 2011) stakeholders have been informed about the holistic approach and objectives in order to establish necessary support and anchoring. It has been important to communicate that the project initiative and objective not is intended as a replacement for EIAs in power-line planning, but as an effort to improve existing planning tools and to ensure dialog and consensus at an early stage of a power-line project. It has also been important to communicate that this is not about development of tools for detailed power line construction planning, but for a scoped planning process and the identification of geographically focused area for EIA, based on stakeholder's criteria. Thus, significant resources have been invested in literature reviews to learn from other projects and meetings with involved stakeholders.

A pilot version of the LCP-toolbox has been developed based on ESRI ArcGIS 10. The toolbox functionality is input data modelling, cost surface calculation, weighted sum overlay and least cost path and corridor calculation.



In April 2012 the toolbox was validated with an existing 420 kV power line route from central Norway built in 2005 (cf. Bevanger et al. 2011). Subsets of available EIA criteria and criteria values (2001/2002) prior to construction were systemized for the toolbox.

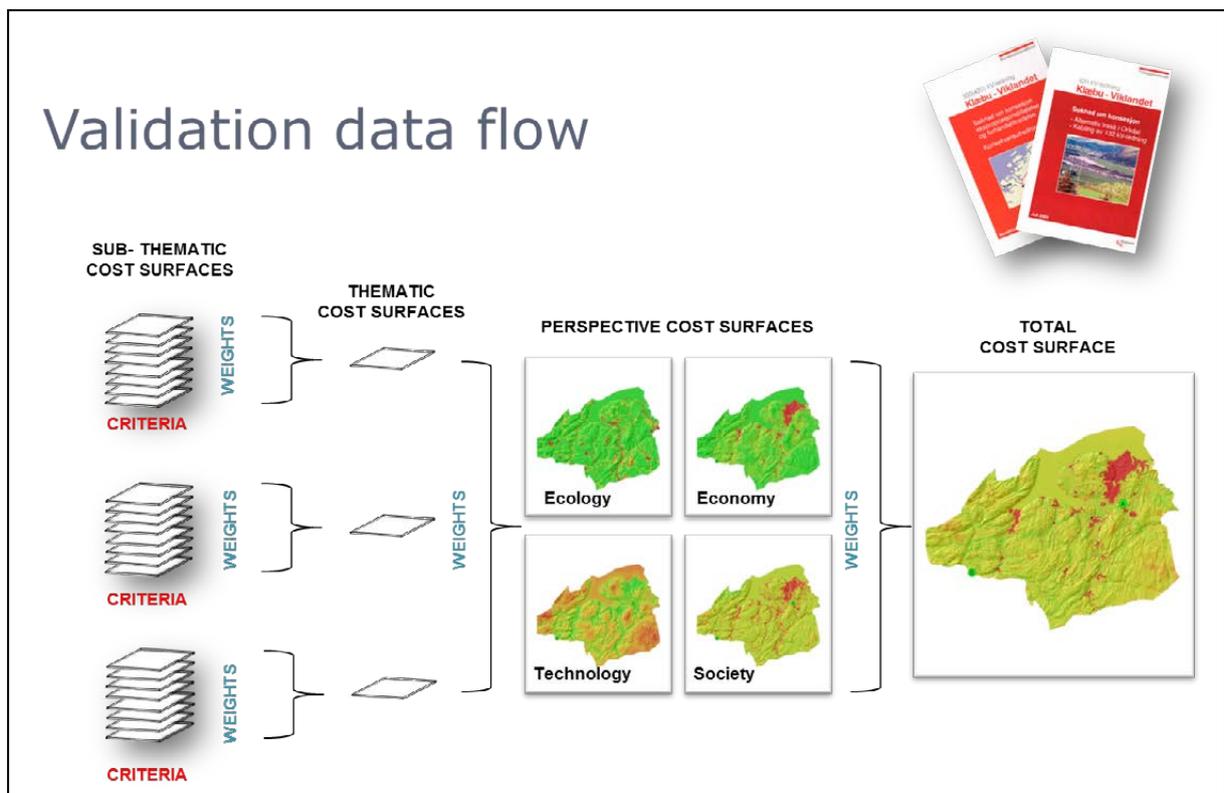
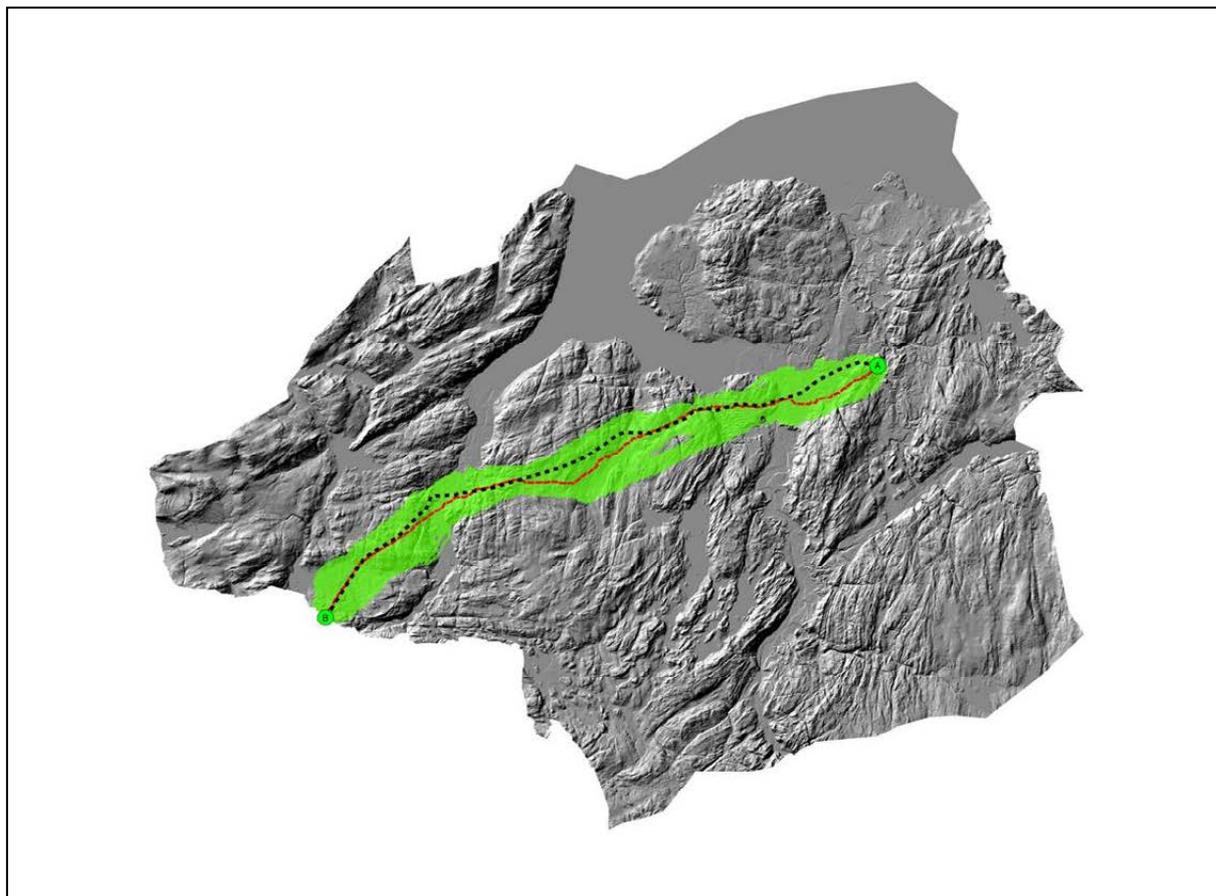


Figure 18. The LCP concept.

The cost index surfaces (**Figure 19**) for each perspective (ecology, financial replacement costs, technology and society) were weighted equally. Based on this weighting a total cost index surface was calculated. This total cost surface was the input data to the optimal routing calculation from A to B. The black dotted line is the actual power line route, the red line is the calculated least cost route and the green area is the least-cost corridor delimited by a chosen threshold value (here at 0.5 standard deviations).



**Figure 19.** Example of a cost index surface generated on the (equally weighted) perspective of ecology, financial replacement costs, technology and society.

Given the limited subset of implemented criteria in this validation exercise the modeled power line route correlates relatively well with the actual power-line route. When it comes to details like placements of poles, it is very difficult to process all kind information at ground level. A 100% automated way of calculating power-line routing is therefore not realistic because field surveys are needed for this type of detailed information. As mentioned above, the main outcome of the LCP-toolbox is its scoping ability. It is considered to be time- and cost-effective, and last but not least conflict reducing since affected stakeholders will participate in the dialog process.

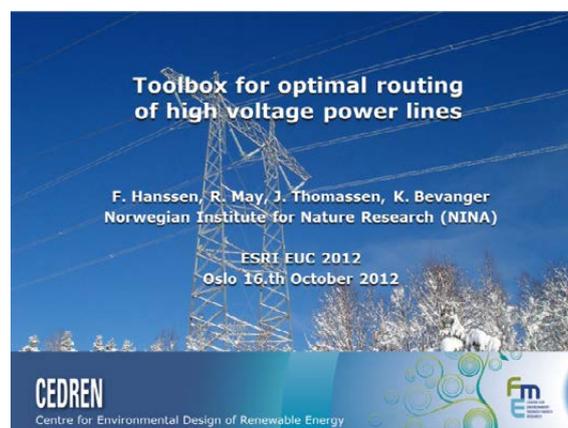
The toolbox and the validation exercise were presented at the first stakeholder dialog meeting in Stjørdal in April 2012. Participants from energy companies, grid owners, public sector, research institutions, consultants and NGOs were asked to validate the toolbox, its content, its criteria definitions and criteria values. Further on they were asked to define operational criteria for the toolbox (Thomassen et al. 2012 - [www.nina.no/archive/nina/PppBasePdf/rapport/2012/856.pdf](http://www.nina.no/archive/nina/PppBasePdf/rapport/2012/856.pdf)).

The stakeholders considered the toolbox to be a useful supplement in an early phase of planning/impact assessment. Some stakeholders pointed out that some land use interests (such as domestic reindeer herding and landscape aesthetics) are hard to quantify in a GIS. Stakeholders specified a list of criteria that should be refined and supplemented according to legal framework and best practices. The general response from the stakeholders was that the dialog process may improve the stakeholder engagement and ownership in the impact assessment process.

In November 2012 a second stakeholder dialog meeting was held in Stjørdal. The stakeholders were asked to specify preferred and critical criteria values to the list of operational criteria defined in April 2012. This exercise will be followed by an online stakeholder web survey to secure second opinions. Based on reported values degree of consensus will be measured for each criterion using summary statistics. Results from this second stakeholder dialog meeting will soon be made available as a technical online report.

Hopefully the project concept can evolve into new projects on micro siting of wind power plants. The mountain areas in Central Norway have great potential for wind power generation, and the County Council has invited NINA to develop a holistic knowledge platform to be used for optimal siting of wind power plants.

Throughout 2012 a significant effort has been made to disseminate the LCP-project concept and its outcomes at high level conferences in Portugal, USA and Norway. The project has also been presented in news articles on the homepages of [CEDREN](#) and [Digital Norway](#). A least two scientific papers based on the project findings will be finalised in 2013. The final deadline for the LCP Toolbox desktop version is December 31th 2013. The possibilities to fund a realization of an online version will be explored as well.



## 7 Birds and power line camouflaging

### Objectives

Assess the possibilities for increased collision hazard to birds by making the power line structures less visible for humans.

### 7.1 Description of 2012 activities and 2013 workplan

Knowledge on how camouflaging techniques (colouring and other surface treatment of overhead wires) affects birds are anecdotal. In this subproject available data on power line camouflaging techniques are reviewed.

The report – “*Power line camouflaging. Assessments of ecological and technical implications*”, (NINA Report 878) is nearly finalized. Due to the budget situation in CEDREN, it was decided to extent the project period four months into 2013, thus the final report will be available by the end of April 2013. By the end of 2013 we also aim to publish the findings in an international review journal.

## 8 Bird mortality mitigating effect of power line marking/modifications

### Objectives

Review available literature on technical modifying solutions and assess their effectiveness to mitigate bird collisions and electrocution.

### 8.1 Description of 2012 activities

A literature review of the effectiveness of reducing bird collision mortality by overhead wire marking is made, focusing the effectiveness of different devices being used, as well as the effectiveness of design modifications of utility structures to reduce electrocution hazard.

The report – “*Possibilities and constraints in reducing power line and electrocution induced mortality in birds*” (NINA Report 763) is nearly finalized. Due to the CEDREN budget situation, we decided to extent the project period four months into 2013, thus the final report will be available by the end of April 2013. By the end of 2013 we also aim to publish the findings in an international review journal.

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

### Objectives

- to determine the technical properties of conductor marking equipment
- to establish cost effective line design modifications to mitigate bird strikes or electrocution hazard
- to evaluate when and where underground (earth) cabling will be a technical and economic solution to mitigate bird strikes

- to consider actual insulating cover techniques on preferred poles associated with bird electrocution

## **9.1 Description of 2012 activities**

### **9.1.1 Marking**

A literature review of conductor marking equipment and an ageing test is carried out. The results will be analysed in 2013.

### **9.1.2 Design**

In order to reduce electrocution hazard for birds we wanted to modify the cross arm in overhead transmission line towers. A new type of perch is developed by NINA and SINTEF Energy AS working together with EI-tjenester AS, and it is combined with a perch discourager device on the top of the cross arm, preventing the birds from installing at hazardous places close to the phases or grounding. A perch and perch discourager device and the results of the test are presented in Ch. 10.

It is carried out an evaluation to clarify if the elevated perching structures could increase the rate of outages due to lightening strokes, and if the racks of sharp plastic spikes could increase the number electrical disturbances and mechanical failures due to possibly more ice and wet snow on the insulators and cross arm. The results are presented in note AN 12.12.27. The conclusions are:

It is not likely that an elevated perching structure will increase the rate of lightening strokes on the top of a 22kV-pole.

The combination of elevated perch and sharp plastic spikes will have minimal influence on the electrical disturbances when the cross arm and insulators are covered with clean or polluted ice and wet snow.

It is not likely that an potential increase in snow an ice load at the top of the cross arm will result in mechanical failures in wooden cross arms unless the cross arm has big pockets of decay.

### **9.1.3 Insulating**

A literature review of insulating cover techniques gives a review of Bird electrocution prevention insulation systems for 12-24 kV pin insulated overhead lines. AN 10.12.38.

Overhead lines in areas with sensitive populations of large birds raise demands for protection against bird electrocution (mortal current transfer through the bird bodies), particularly for threatened species like the eagle owl. For the decision making of what protection measures to apply, it is important to assess both their environmental benefits and the measures technical consequences. One of the popular retrofit protection methods is insulation of the aluminium conductors at pin insulated medium voltage overhead line poles.

However concerns regarding corrosion have been raised for such system for exposed marine locations at the Norwegian coast

In the present work we have performed accelerated corrosion tests on aluminium conductors using four different bird protection systems available on the market. The tests were performed in laboratory environment for marine corrosivity indices 4 and 8, and simulated time periods up to 24

years. The results show that the systems influence the degradation of the aluminium conductors, leading to life-time expectancy reductions between 12 and 22% for the investigated corrosivity indices.

The results are presented in an article called "Laboratory Corrosion Tests on Overhead Line Conductors with Bird Protection Systems".

### 9.1.4 Camouflaging

A literature review of the technical properties of conductor camouflaging techniques is carried out and the results are presented in note AN 10.12.106.

The assessed camouflaging techniques and their effect on conductors are based on performed ageing tests on camouflaging conductors. Conductors covered by enamel paint may cause crevice corrosion and galvanic corrosion in coastal areas.

By increasing the emission factor of the conductor the current carrying capacity may be increased with about 5%. The emissivity ( $\epsilon$ ) of a shiny conductor is approximately 0,09 and a coated conductor 0,9.

### 9.1.5 Cabling

Literature review of actual cable design; 10–72 kV (aerial/underground cable, UGC) is presented in note AN 12.12.01.

A survey of failure rates of underground cable (UGC) and overhead lines (OHTL) indicate that 132kV cables have the same failure rate per km as an OHTL. At low and medium voltage levels, cables have normally a lower failure rate per km.

The issues of costs are fundamental when it comes to comparing OHTL and UGC. The expenditure for an underground cable at the 22kV and 420kV level is respectively 2-3 times and 5-10 times an OHTL. Today we experience that earth cabling often may be an economical and technical solution to mitigate bird strikes for low and medium voltage levels.

The average unavailability of underground cables is 25 times an OHTL. The fault localisation is time-consuming if the utilities do not have available and skilled in house personnel to ensure effective maintenance on mixed lines.

Still it is a challenge to improve the mitigating properties of cable connectors to pole mounted transformers or the down lead to ground transformers. Still there are at least 20 000 pole mounted transformers that have to be redesigned in order to meet the safety requirements of the authorities within the first of January 2016. Many utilities will choose the cheapest solution and retain the pole mounted transformers and operate the fuses from the ground.

## 10 Eagle owl population impact of power-line induced mortality

### Objectives

Assess eagle owl mortality and population impact due to utility structures, identify high-hazard electrocution structures, and test effectiveness of design modifications of these.



**Figure 20.** *Adult eagle owl sitting on an elevated perch.* Photo: Karl-Otto Jacobsen.

### 10.1 Background and research methods

The Norwegian eagle owl population has experienced a steep decline since the 1950s. 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 (Directorate for Nature Management 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 power lines and eagle owl on Solværøyene in the municipality of Lurøy in 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 population of Lurøy municipality could probably consists of 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.). This makes the area suitable for e.g. mitigation experiments. For more details on the project background see Bevanger et al. (2009, 2010, 2011).

The project has cooperated 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:

- Use of GPS satellite telemetry to investigate to what extent the eagle owls use the power poles during hunting activities, and to find electrocuted eagle owls
- Collect feathers of eagle owls from the nests for DNA analysis to obtain a mortality estimate for adults
- Searches beneath all power lines and poles in the study area to find carcasses of eagle owls and other birds
- Investigate the population dynamics of the eagle owl population at Solvørøyene and how it is affected by power-line caused mortality.
- Testing of the efficiency of anti-perch devices and elevated perches on power poles
- Use of GPS satellite telemetry to determine the home-ranges and dispersal of eagle owls

## 10.2 Activities and findings

The eagle owl population improved the breeding success in the study area in 2012 compared to the previous three years. Out of nine potential territories in the study area, nine breeding attempts were recorded with 10 young fledged in six nest sites, compared to six breeding attempts and four young fledged in three nest sites in 2011. The vole population in 2012 was higher than the previous years, thus more young were produced. However, five of the young died before fledging (two most probably predated by white-tailed eagle), and some of the young were either too small or too large (i.e. able to fly) when they should be equipped with GPS satellite transmitters in July. Consequently only four juvenile eagle owls were equipped with transmitters in 2012 (**Figure 21**). One adult male (**Figure 24**) and one adult female were trapped and equipped with GPS satellite transmitters in June. The positions of all adult birds wearing transmitters in 2009-2012 are shown in **Figure 22**.

The home range size for the adult female #57268 increased from 0.28 km<sup>2</sup> minimum convex polygon (MCP) (0.11 km<sup>2</sup> using 95% kernel) in June to 9.35 km<sup>2</sup> MCP (20.1 km<sup>2</sup> at 95% kernel) in September (**Figure 23**). The position of the adult female #57268 gave signals until 21.10.2012. After that the solar cell probably did not provide enough power to transmit signals due to little daylight. The home range size for the adult male #107843 increased from 0.28 km<sup>2</sup> MCP in July to 0.83 km<sup>2</sup> in October.

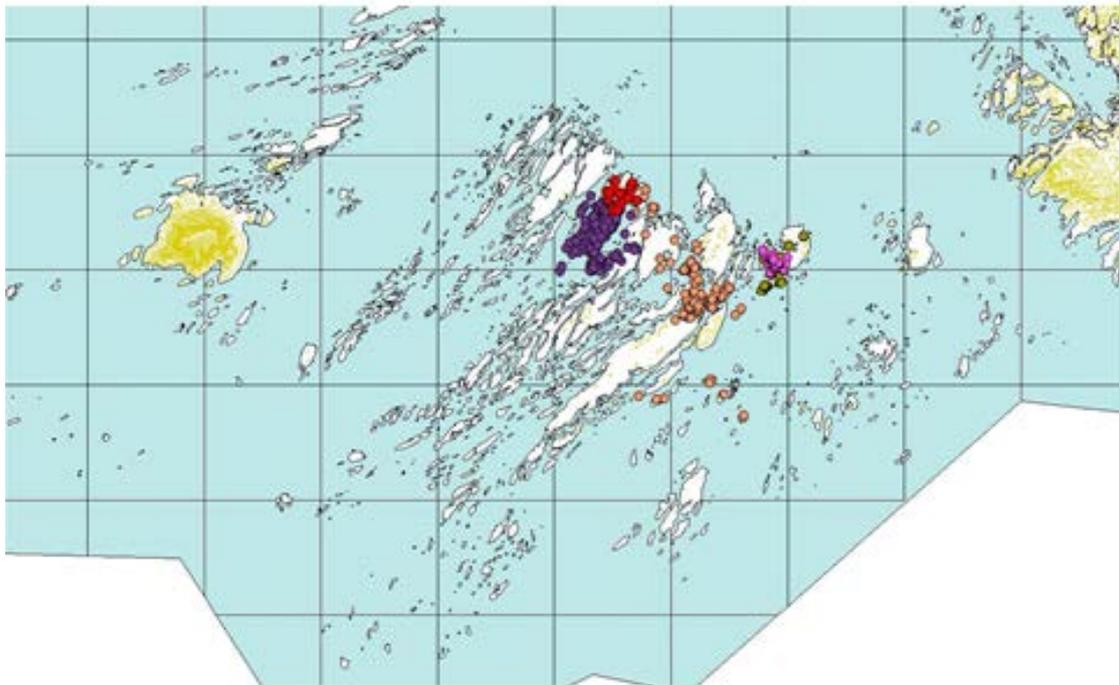
These home ranges were much smaller than those at Høg-Jæren/Dalane in Rogaland. In spring and summer a median value of 19.9 km<sup>2</sup> (variation 3.6–113.5 km<sup>2</sup>) for 16 birds based on 95% MCP was recorded. In autumn and winter the median value was 42.3 km<sup>2</sup> (variation 12.3–86.6 km<sup>2</sup>) based on 95% MCP (Oddane et al. 2012).

The results are more similar to the situation in Spain where mean home range sizes was recorded to 2.7 km<sup>2</sup> based on traditional VHF radio telemetry (estimation method unspecified; Delgado & Penteriani 2007). The high densities of eagle owls at Solvørøyene and in Spain are result of high prey availability. The movements of all juvenile eagle owls with radio transmitters (2009-2012) are shown in **Figure 25-27**. Only one of them has given positions into their second year so far, but the 2012 cohort seems to do better than the previous years'. Of the four juvenile birds marked in 2009, two died in July-August in the breeding area. The other two left the breeding ar-

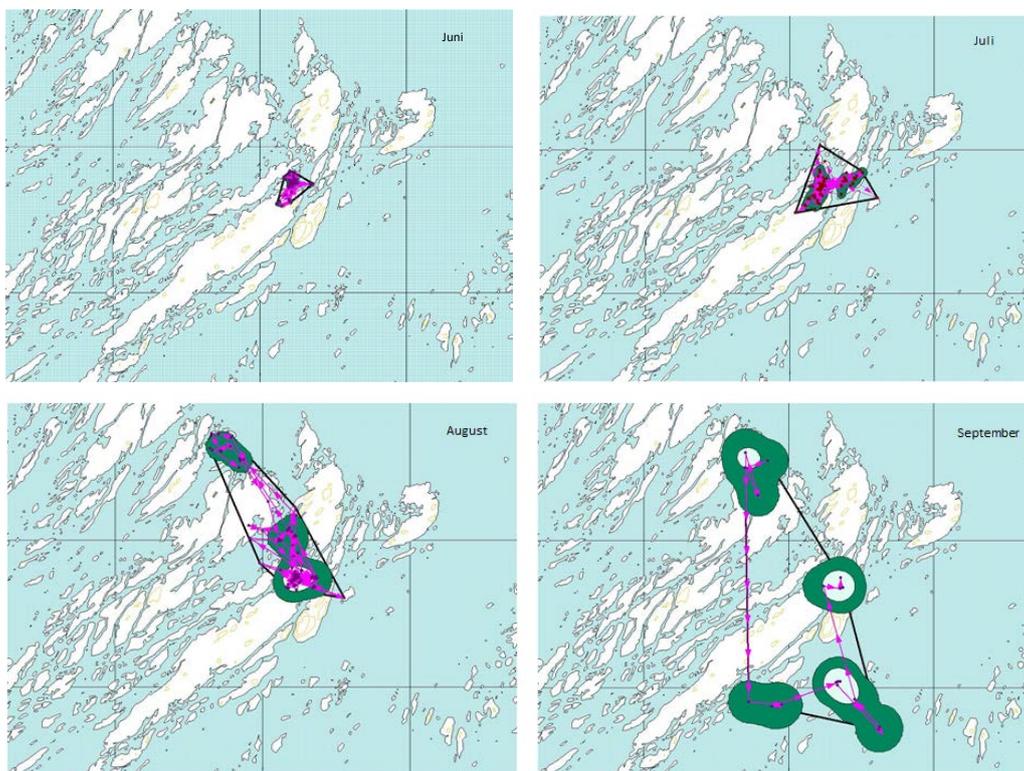
ea in September-October. Only one of them survived until November, when it had moved west to Lovund (red colour in **Figure 25**). It is yet unclear whether loss of signal means death or loss/failure of the transmitter.



**Figure 21.** Two young eagle owls #107842 and #115977 were equipped with GPS transmitters in 2012. Photo: Jan Ove Gjershaug.



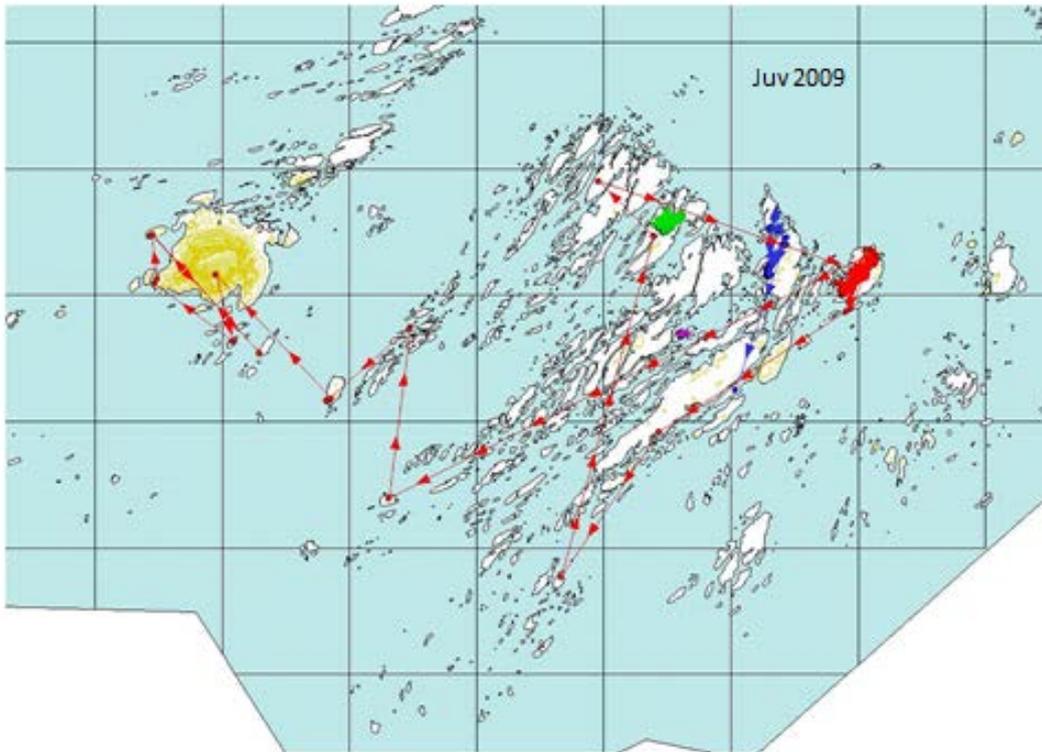
**Figure 22.** The GPS positions of all adult eagle owls wearing GPS satellite transmitters in 2009-2012. Red symbol = female #95336, violet symbol = male #107843, orange symbol = female #57268, pink symbol = female #95335 and green symbol = male #195335.



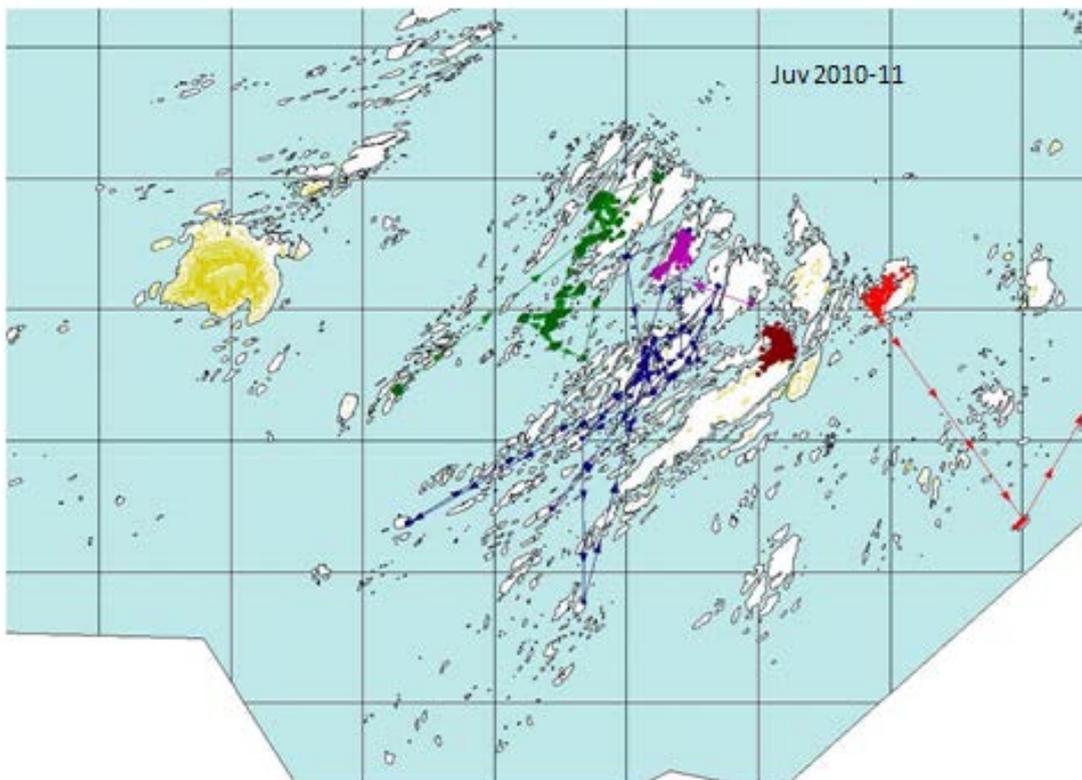
**Figure 23.** GPS positions of the adult female #57268 from 2012; June (upper left), July (upper right), August (lower left) and September (lower right). The minimum convex polygon is indicated by solid lines, the 95 % kernel probabilities by green areas and the 50 % probability areas by light blue. The movements between positions are indicated by purple arrows.



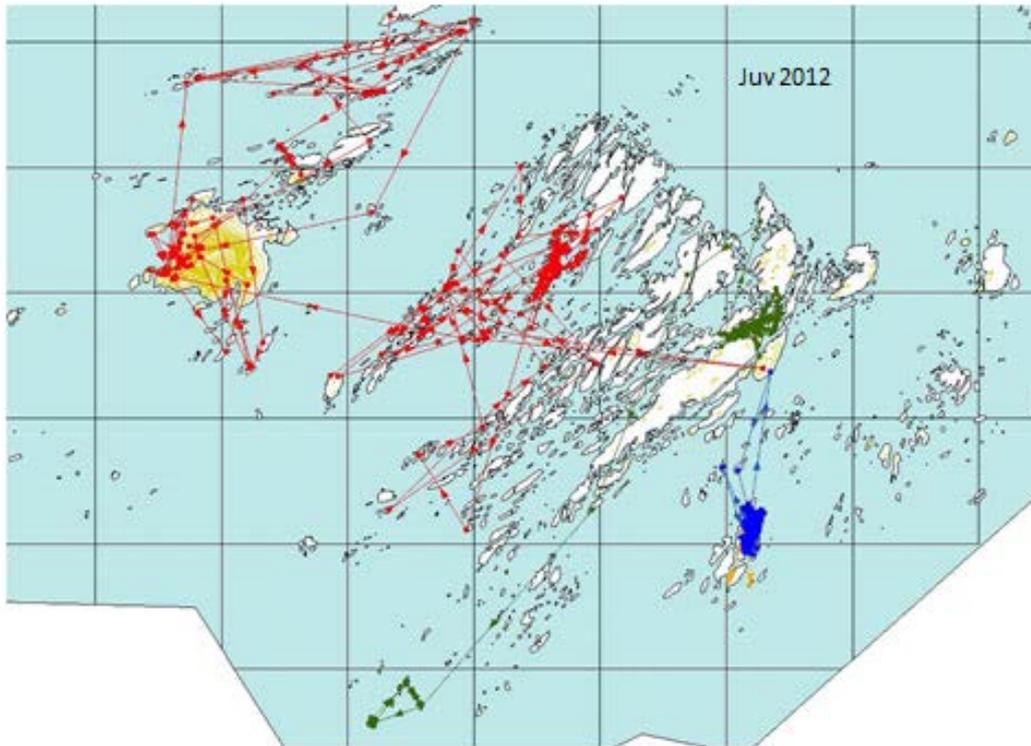
**Figure 24.** The adult male Eagle owl #107843 equipped with a GPS transmitter in 2012. Photo: Jan Ove Gjershaug.



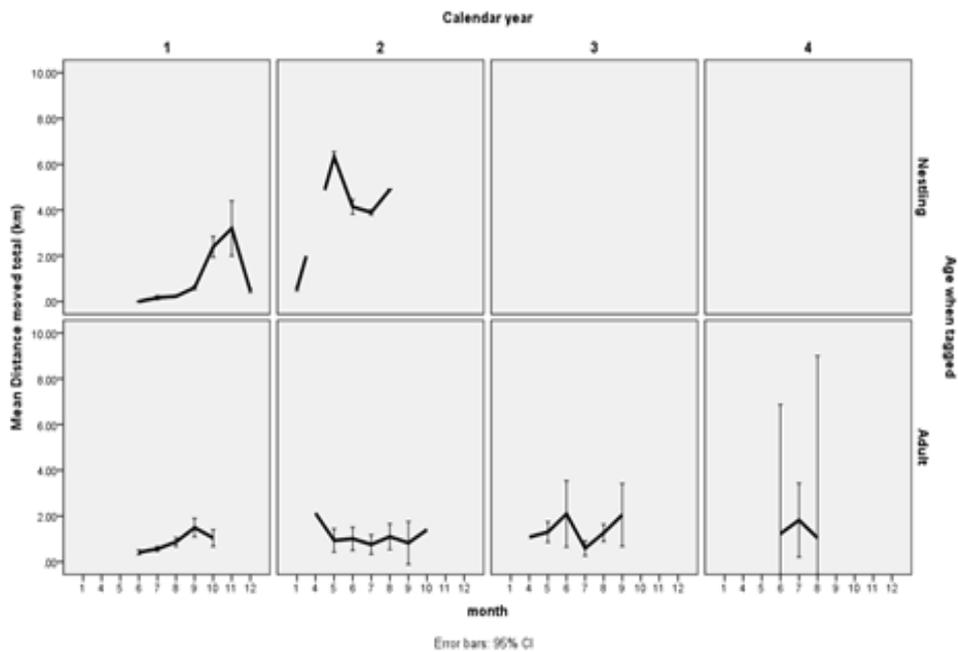
**Figure 25.** Movements of juvenile eagle owls in 2009. Different individuals indicated by different colours.



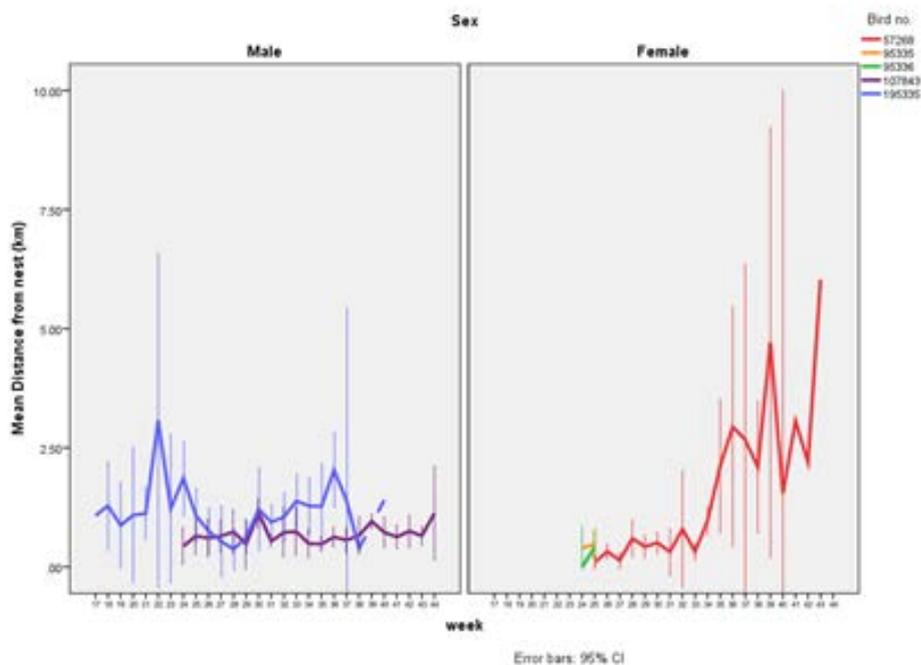
**Figure 26.** Movements of juvenile eagle owls with GPS transmitters in 2010-2011. Different individuals indicated by different colours.



**Figure 27.** Movements of all juvenile eagle owls with GPS transmitters in 2012. Different individuals indicated by different colours.



**Figure 28.** The mean distance moved from nest in relation to age by eagle owl.



**Figure 29.** Distance from nest in relation to time of the year in adult eagle owls.

The only juvenile bird marked in 2010 survived until October, when it disappeared south-east of its breeding area (red colour in **Figure 26**)

Of the four juvenile birds marked in 2011, one survived until October, still in its natal area (red colour in **Figure 26**). Its sibling survived until November (blue colour in **Figure 26**). One juvenile survived until January 2012, still in its natal area (brown colour in **Figure 26**). The last juvenile moved north-east and survived until August 2012 (green colour in **Figure 26**).

Of the five juvenile birds marked in 2012, one survived until August when it was probably killed by a white-tailed eagle in the breeding area (not shown on **Figure 27**). Its sibling has dispersed to the west of its natal area and was still alive in the end of November (red colour in **Figure 27**). This bird has moved around more than any other juvenile in this project. Two siblings are still near their natal areas (blue and yellow colour in **Figure 27**). The last bird of 2012 has moved to some very small islands south-west of its breeding area and stayed there for some time, but was still alive in November 2012 (green colour in **Figure 27**).

It is evident from **Figures 25-27** that there has been more dispersal of juveniles in the autumn 2012 than in any other of the previous years. This could be explained by the fact that 2012 apparently was a good vole year, and that the owlets are able to find food for themselves without the support from their parents. Dispersal out of their natal areas is a natural process, and is a common trait in most bird species.

The dispersal of eagle owls equipped with GPS satellite transmitters in relation to age is shown in **Figure 28**. Adult birds are more inclined to stay in the territory than juveniles, and will therefore show very small dispersal distances. The young bird that was followed into its second year moved around considerably. The one adult male we have followed during four years shows high site fidelity. Since only summer data is available, it is however impossible to tell anything about its behaviour during other seasons.

The distance from nest in relation to time of the year in adult eagle owls equipped with GPS satellite transmitters is shown in **Figure 29**. The movements of the adult female tagged in 2012 (cf. **Figure 23**) were much more extensive than was the case of the two adult males from 2009 and 2012. Two females tagged in 2009 removed their transmitters after less than one week, and therefore provided too little data.

Searches were carried out beneath all power lines and poles in the study area (**Figure 30**) to find carcasses of eagle owls and other birds. For overview of all the dead birds found beneath power lines/poles during the period 2008-2012 see **Table 3** and **Figure 30**. An overview of all carcasses and remains found beneath power lines/poles in the period 2008-2012 sorted by year and species/group is shown in **Table 4** and **5**.

The GPS positions of the adult female #57268 were used to estimate her use of power poles as perching places. Of 348 GPS plots, 88 (25.2%) were overlapping with power poles (**Figure 31**). In June and July this female and her mate were frequently observed perching on power poles in their territory (**Figure 32**).



**Figure 30.** Poles where carcasses have been recorded indicated by red flags (see also **Table 1**). Removed power line is indicated by green flags, and poles with elevated perches and anti-perch devices with green triangles.

**Table 3.** Bird carcasses and remains recorded beneath power lines/poles in 2008-2012.

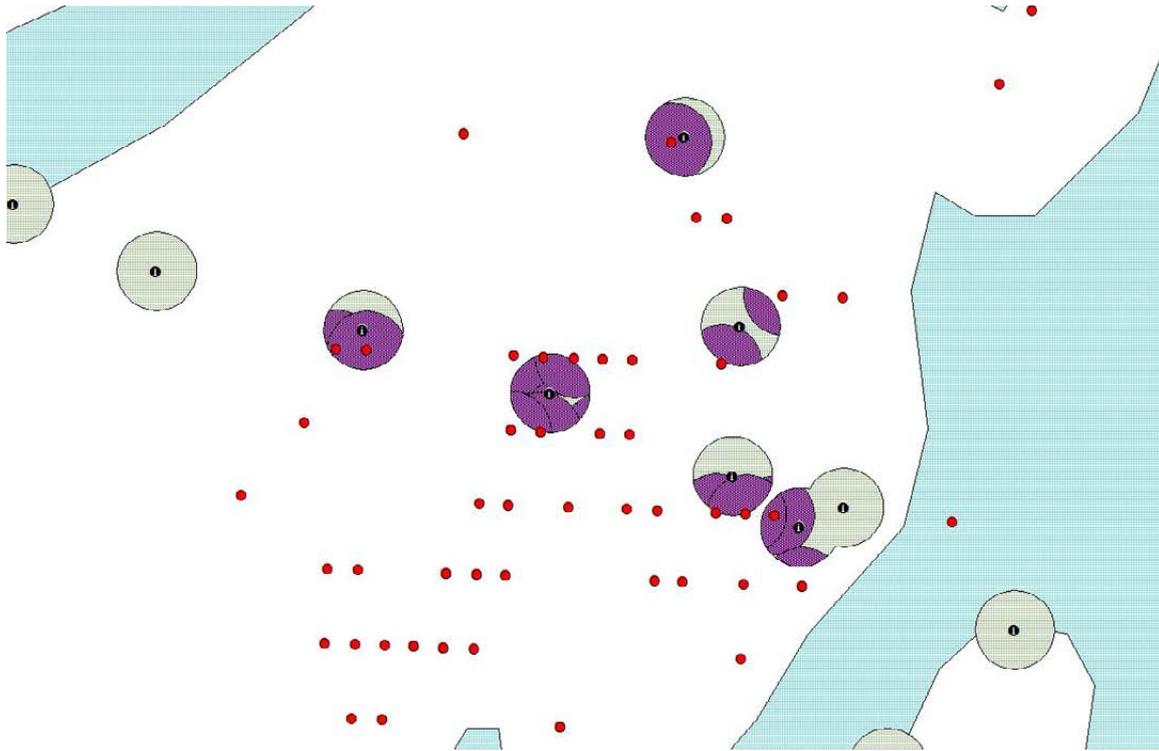
Type of poles	Pylon no.	2008	2009	2010	2011	2012
Power-line debranching	107			1 White-tailed eagle (adult)		1 Greylag goose (line)
Cable debranching	137		1 Black-backed gull			
Metal cross-arm	140			1 Greylag goose (line)		
Cable debranching	145	1 gull sp. (Black-backed/Herring gull.)	2 Hooded crow	1 Hooded Crow, 1 Raven, 1 gull sp.(Black-backed/Herring gull.)	2 Hooded crow	2 Hooded crows, 1 Greylag goose (line)
Pole-mounted transformer	149	1 Eagle owl (bones)				
Top insulator	164			1 White-tailed Eagle (juv.)		
Pole-mounted transformer	165	2 White-tailed eagle	1 White-tailed eagle (remains)			1 Hooded crow
Double top insulator	168	1 Greylag goose				
Double top-insulator	175		1 White-tailed eagle (old remains)			
Cable debranching	176	1 Eagle owl (from previous winter), 2 Hooded crow	1 White-tailed eagle (old remains)		3 Hooded crow, 1 Raven	
Double top-insulator	177	1 White-tailed eagle	1 Eagle owl (bones)	1 Eagle owl (from previous winter)		
Cable debranching	184	1 Eagle owl (bones)			1 Oyster-catcher	
Top-insulator	186			2 Hooded crow	1 Hooded crow, 1 Raven	
Pole mounted transformer	189			1 Hooded crow		1 White-tailed eagle, 1 Hooded crow
Cable debranching	213				1 Herring gull	
Cable debranching	690					1 Black-backed gull
Top insulator	694					1 Greylag goose (line)
Top insulator	111					1 White-tailed eagle (line)
Cable debranching	214					1 Herring gull

**Table 4.** All carcasses and remains recorded beneath power lines/poles in the period 2008-2012 sorted by year and species/group.

<b>Species</b>	<b>2008</b>	<b>2009</b>	<b>2010</b>	<b>2011</b>	<b>2012</b>	<b>Total</b>
Eagle owl	3	1	1			5
White-tailed eagle	3	3	2		2	10
Crow/Raven	2	2	4	8	4	20
Gulls	1	1	1	1	2	6
Greylag goose	1		1		3	5
Oystercatcher				1		1
<b>Sum per year</b>	<b>10</b>	<b>7</b>	<b>9</b>	<b>10</b>	<b>11</b>	<b>47</b>

**Table 5.** All carcasses and remains recorded beneath power lines/poles sorted by type of structures. The greylag geese and oystercatcher are probably killed by collision.

<b>Species</b>	<b>Cable debranching</b>	<b>Power line debranching</b>	<b>Metal crossarm</b>	<b>Pole-mounted transformer</b>	<b>Top insulator</b>	<b>Total</b>
Eagle owl	2			1	2	5
White-tailed eagle	1	1		4	4	10
Crow/Raven	8	6		2	4	20
Gulls	6					6
Greylag goose	1	1	1		2	5
Oystercatcher	1					1
<b>Sum</b>	<b>19</b>	<b>8</b>	<b>1</b>	<b>7</b>	<b>12</b>	<b>47</b>
<b>%</b>	<b>40,4</b>	<b>17,0</b>	<b>2,1</b>	<b>14,9</b>	<b>25,5</b>	<b>100</b>



**Figure 31.** Example of probable use of power poles by adult female #57268 in 2012. The light green circles have been drawn around the positions of the power poles with radius of 10 meter. Red dots are the GPS positions of the bird. Circle sectors in violet indicate the overlap between 10 m circles drawn around both a bird position and a pole. The error margin of a satellite transmitter is indicated to be up to 15 m (data given by the manufacturer, Microwave Telemetry, Inc.), own data indicate a standard deviation of ca. 10 m).



**Figure 32.** Female #57268 perching on one of the power poles in Figure 31. Photo: Jan Ove Gjershaug.

## 10.3 Mitigation measures

Rødøy-Lurøy Kraftverk AS carried out some mitigation measures on Solværøyan in 2012 as part of the implementation of the action plan for the eagle owl. The power line from pole 157 to 170 was removed. The power poles were also removed except pole 161, 164, 165 and 166, which were left as perching places for eagle owls. In addition elevated perches and anti-perch devices were installed on power poles 102, 103, 104, 105, 109, 146, 147, 148 and 149 (**Figure 31**). Several observations were made of eagle owls sitting on the elevated perches during the field work in June and July (**Figure 20**). Electrocutted birds have been found beneath three of these poles earlier (**Table 1**). There are still 12 poles where electrocuted birds have been recorded (**Table 3, Figure 30**) and several potentially dangerous poles, where retrofitting is needed. It is very important that the work is not done close to nesting places for eagle owls in the breeding season. In 2012 the work on Reløya was done in the spring (May), which resulted in breeding failure of an eagle owl nest close to one of the power poles.

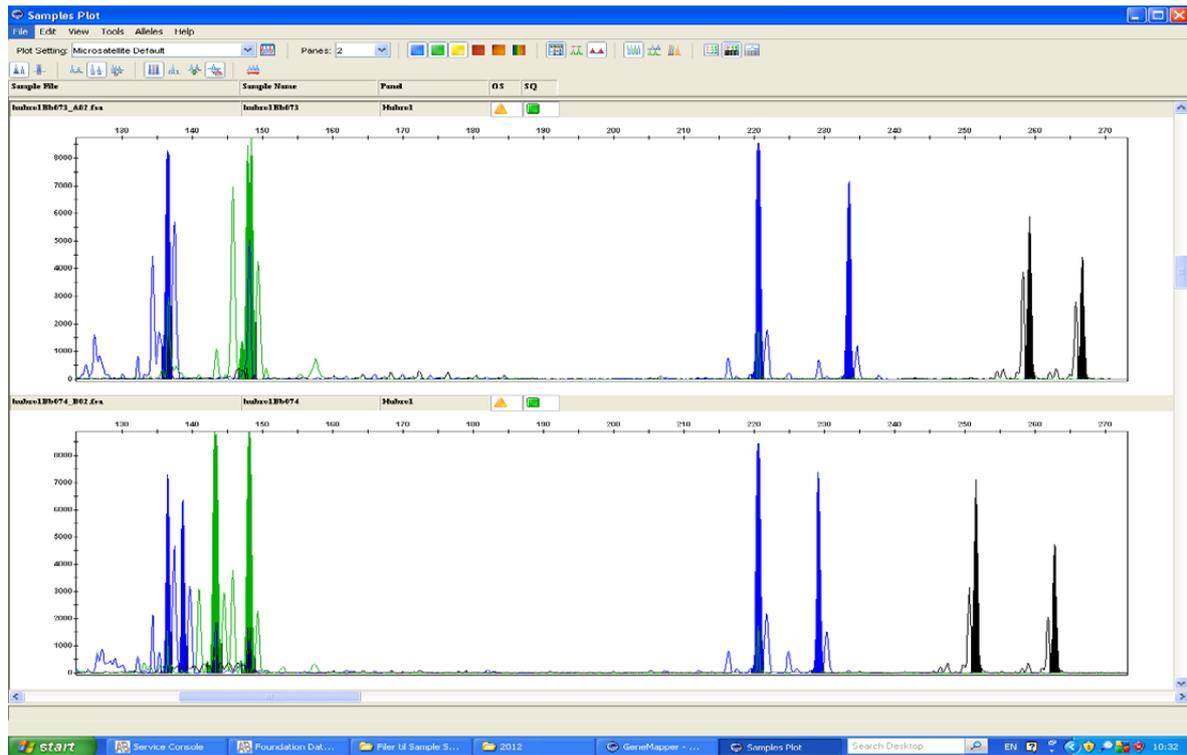
## 10.4 DNA analysis

Moulted eagle owl feathers have been collected at nesting sites with the purpose of estimating annual survival/mortality of individual birds through DNA-analysis. Feathers contain DNA which enables identification of individual eagle owls. Given that eagle owls are faithful to their breeding territories between years, a shift in an individual is interpreted as mortality.

A method to extract DNA from feathers has been tested and established. An automated system (Maxwell®16 Research System, Promega) following the manufacturer's protocol is used to extract DNA from the calamus of eagle owl feathers.

To establish a set of genetic markers that enables individual identification of eagle owls, eight novel microsatellite loci have been developed while four loci have been re-designed from previously developed eagle owl loci and two loci are cross-amplified from other owl species. To facilitate more efficient genotyping, three multiplex PCR sets have been developed (e.g. **Figure 33**). The panel of 14 polymorphic microsatellite loci provides a powerful marker set for individual identification of eagle owls.

A protocol to determine sex of individual eagle owls based on DNA has also been developed.



**Figure 33.** Electropherograms from one of the multiplex-PCRs developed for genotyping eagle owls. The shown multiplex-PCR consists of four polymorphic microsatellite markers. The upper and lower figure represent two different individuals and template DNA was extracted from moulted feathers.

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## 11.1 Publications

- Benjaminsen, J.T. & Refsnæs, S. 2012. Kabel eller Luftledning. AN12.12.01. SINTEF Energi AS, Trondheim.
- 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.
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- Thomassen, J., Hanssen, F., May, R. & Bevanger, K. 2012. Optipol Least Cost Path dialog - Rapport fra dialogseminar om tema, deltema og kriterier i Optipol-LCP versjon 1.0. NINA Report 856.

## 11.2 Lectures and conference participation

- Bartzke, G., May, R. Rolandsen, C., Solberg & Engen, S. 2012. Everything is relative - or what? How to calculate total step selection probabilities. IRSAE Summer school; Evenstad; 13-17 August.
- Bartzke, G., May, R. Rolandsen, C., Solberg, E., Stokke, S., Røskaft, E., Hedger, R. & Engen, S. 2012. Comparative effects of power lines and roads on moose (*Alces alces*) habitat selection. *Environmental Concerns In Rights-Of-Way Management. The Tenth Symposium.* Phoenix, AZ, USA, September 30-October 3.

- 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.
- Brøseth, H. & Bevanger, K. 2012. Black grouse and capercaillie population estimates by DNA identification. Environmental Concerns In Rights-Of-Way Management. The Tenth Symposium. Phoenix, AZ, USA, September 30-October 3.
- Gjershaug, J.O., Refsnæs, S. & Bevanger, K. 2012. Mitigation of eagle owl electrocution in Norway. Environmental Concerns In Rights-Of-Way Management. The Tenth Symposium. Phoenix, AZ, USA, September 30-October 3.
- Hanssen, F., Thomassen, J., May R. & Bevanger, K. 2012. A Least Cost Path toolbox for optimal routing of high voltage power lines. 32<sup>nd</sup> Annual Conference of the International Association for impact assessment. Energy Future. The Role of Impact Assessment; Porto, Portugal; 27 May – 1 June.
- Hanssen, F., Thomassen, J., May R. & Bevanger, K. 2012. Toolbox for optimal routing of high voltage power lines. ESRI European GIS User Conference. Oslo, Norway 18-20. October
- Hanssen, F., Thomassen, J., May R. & Bevanger, K. 2012. A Least-Cost-Path (LCP) toolbox for optimal routing of power lines. Environmental Concerns In Rights-Of-Way Management. The Tenth Symposium. Phoenix, AZ, USA, September 30-October 3.

### 11.3 Coverage in public media

- Nytt fra CEDREN nr. 3 – 2012. Finner optimal rute.
- Nytt fra CEDREN nr. 2 – 2012. Optimal trasévalg for kraftledninger.
- Bergens Tidende 17.10.2012. Denne sittepinnen reddar hubroliv.  
<http://www.bt.no/nyheter/lokalt/Denne-sittepinnen-reddar-hubroliv-2781999.html>
- NRK Nordland 29.11.2011. Denne sittepinnen skal hindre hubrogrilling.  
<http://nrk.no/nyheter/distrikt/nordland/1.7893792>
- Energibransjen.no. 18.10.2012. Sittepinne kan redde hubroen.  
<http://www.elektronett.no/default.asp?menu=2&id=2800>
- Rana Blad. 5.1.2012. Sittepinne redder hubro.  
<http://www.ranablad.no/nyheter/article5868708.ece>
- FM i Nordland. 3.1.2012. <http://www2.fylkesmannen.no/hoved.aspx?m=58293&amid=3555291>
- Regjeringen.no. 30.11.2011. Redder hubro fra grilling.  
<http://www.regjeringen.no/nb/dep/md/aktuelt/nyheter/2011/redder-hubro-fra-grilling.html?id=664927>
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- P4 30.11.2011. Ikke mer hubro-grilling. <http://www.p4.no/story.aspx?id=440954>
- BKK.no. 16.10.2012. Sittepinne kan redde hubroen.  
[http://www.bkk.no/om\\_oss/media/Nyheter\\_og\\_pressemeldinger/article36424.ece](http://www.bkk.no/om_oss/media/Nyheter_og_pressemeldinger/article36424.ece)

## Appendix 1. The OPTIPOL Annual Meeting 2012.



# Møteinvitasjon

## Brukermøte OPTIPOL 2012 – 19. november kl 0900-1600. Rica Hell hotell, Stjørdal

Som tidligere kommunisert samles vi til OPTIPOL brukermøte på Rica Hell hotell mandag 19. november. Som vanlig er intensjonen å presentere status for delprosjektene og diskutere veien videre. De fleste av OPTIPOLs aktiviteter avsluttes ved neste årsskifte, og et viktig spørsmål er om brukersiden har tanker om eventuell videreføring av noen av delprosjektene. Dette tar vi en runde på før vi avslutter møtet – senest kl 1600. Velkommen!

### Foreløpig program:

0900-0915	Velkommen (Kjetil Bevanger)
0915-1015	LCP. Hva har skjedd i 2012? (Frank Hanssen)
1015-1035	Kaffepause
1035-1100	Kraftledningsgater som viltbiotoper (Gundula Bartzke)
1100-1120	Kanteffekter og dyreliv i ryddebeltet langs kraftlinjer (Sigbjørn Stokke)
1120-1130	Nasjonal database for registrering av fugl drept. Status (Kjetil Bevanger)
1130-1215	Lunsj
1215-1245	Bestandsestimering og dødelighet hos storfugl og orrfugl i Ogdalen. Status. (Henrik Brøseth)
1245-1300	Forvaltningsplan for hubro. Status (Mia M. Husdal)
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
1420-1600	Nytteverdien av OPTIPOL for brukerne – er det problemstillinger vi bør arbeide videre med?

### Påmeldte:

#### NINA:

Gundula Bartzke  
Kjetil Bevanger  
Henrik Brøseth  
Jan Ove Gjershaug  
Frank Hanssen  
Karl Otto Jacobsen  
Roel May  
Roger Meås  
Torgeir Nygård  
Oddmund Rønning  
Sigbjørn Stokke  
Jørn Thomassen

#### SINTEF:

Steinar Refsnæs

#### DN:

Arild Espelien  
Snorre Stener

#### Statnett:

Johan Bjerke

#### NVE:

Håvar Røstad

#### FM Nordland:

Mia M. Husdal







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