Tuuleparkide planeerimise praktikast Soomes –
Wind farm planning practices in Finland

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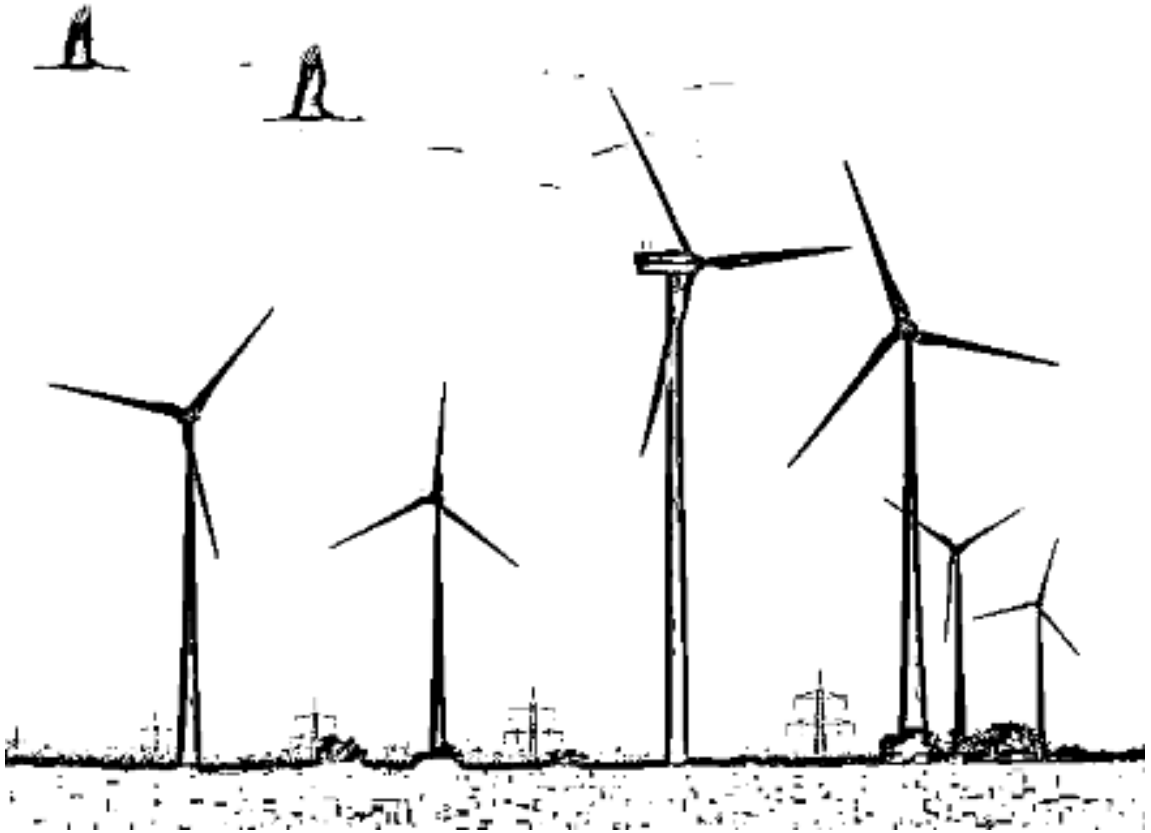
Mutual Impacts of Land-Based Wind Farms and Wildlife- conference | 16.-17.3.2026

Overview

- Wind power development in Finland
- Future plans and policy goals
- Public opinion
- Planning and permitting system
- Biodiversity considerations in wind energy planning
- Wildlife studies and mitigation measures
- Post-construction monitoring
- CASES reindeer, wild forest reindeer, wolf, golden eagle



Windpower in Finland

Wind Power Development in Finland

Finland's carbon neutrality goal:
By 2035

Reduction of fossil fuels and imported energy

Wind power has expanded rapidly during the last decade

* **Over 9433 MW** installed capacity by the end of 2025
* **2002** wind turbines
* By January 2026 there was over **56 000 megawats** (MW) worth of onshore wind power plans

~**25%** of Finland electricity production

Onshore Wind Power Projects in Finland 2025

Onshore wind power project stage	Projects	Capacity	Turbines
Identified projects	49	6542	833
Permitting/studies ongoing	301	45121	5299
Permitted	43	3672	574
Under construction	8	982	142
SUM	401	56317	6847

Source: Suomen uusiutuvat|Renewables Finland

Onshore Wind Power Projects – EIA status

EIA status	Projects	Capacity	Turbines
No EIA info given	38	1745	278
Not Required	32	952	148
Not started yet	52	9658	1174
EIA process ongoing	136	23960	2786
EIA approved	143	20004	2463
SUM	401	56317	6847

Source: Suomen uusiutuvat|Renewables Finland

Geographic Distribution of Wind Power

- Wind power is Not evenly distributed -

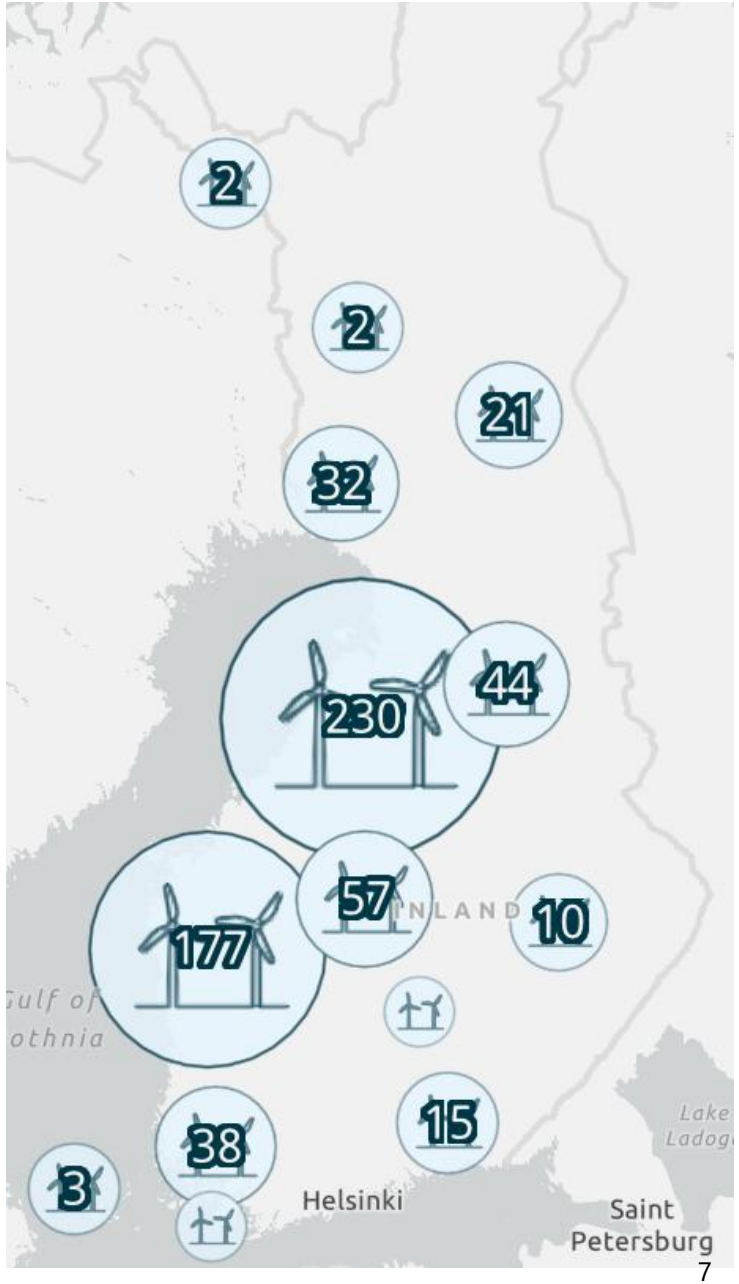
Wind power development is concentrated in:

- Northern Ostrobothnia
- Ostrobothnia
- Lapland
- Western coastal areas

- WHY?
  - Strong wind conditions
  - Low population density
  - Good grid connection possibilities

Why not eastern Finland?

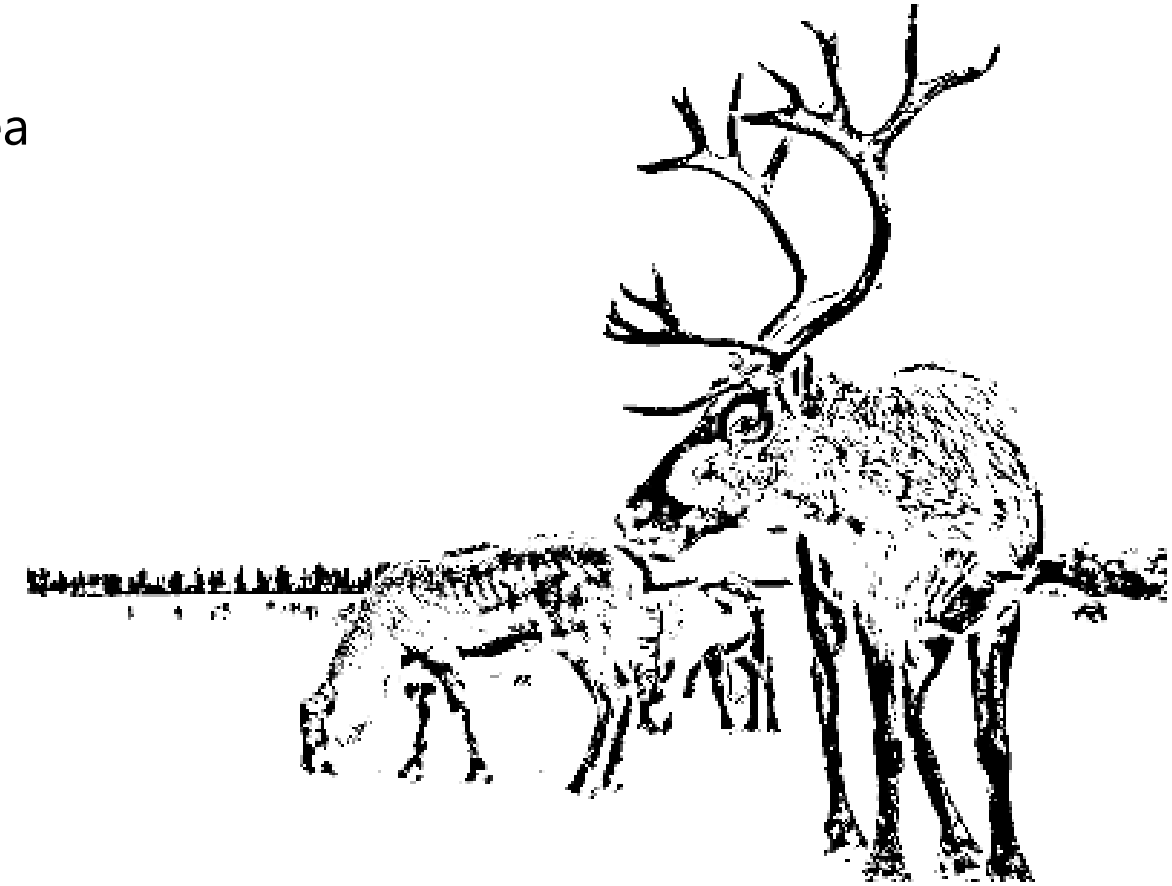
Military air-surveillance radars operated by the Finnish Defence Forces



Source: Suomen uusiutuvat|Renewables Finland

Future Development of Wind Energy

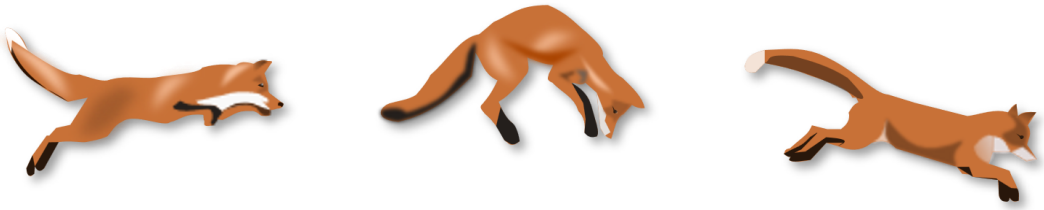
- Wind power capacity is expected to increa significantly
- Large new onshore projects
- Hybrid renewable parks (wind + solar)
- Energy storages?
- Estimates suggest capacity may reach:
  - 20-30 GW by the 2030s



Land Use Considerations

- Primarily located in forested areas
- Competes with multifuctional land use demands
- **Overlapping with important habitats for endangered species that require rugged areas further from human infrastructure**

Public opinion



- Public attitudes toward wind power are generally positive

National surveys show:

- Strong support for renewable energy
- Wind power widely accepted as part of climate policy

However there are concerns:

- Landscape impacts
- Noise and shadow flicker
- Biodiversity impacts
- Effects on tourism and recreation

Local acceptance varies significantly between regions – More acceptable farther from residential areas – But that creates another problem..

Planning Framework for Wind Power

Wind power planning occurs at three levels:

- National level
  - Climate and energy strategies
  - National land-use guidelines
- Regional level
  - Regional land-use plans identify suitable wind areas
- Municipal level
  - Local master plans allow construction of wind farms

Municipalities play a central role in project approval!

Environmental Impact Assessment - EIA

- Large wind farms require an Environmental Impact Assessment (EIA)
  - In Finland this process is called YVA
  - Usually EIA is required if projects size is 10 wind turbines or capacity 45 MW or more

Main objectives:

- Identify environmental impacts
- Support planning decisions
- Ensure transparency and public participation

EIA Process

1. EIA programme
    - Plan describing what impacts will be studied
    - Preliminary impact assessment
        - Environmental and ecological studies
2. EIA Report

- Impact assessments based on the information gathered in and after EIA programme

→ Public consultation in both phases

→ Authority evaluation in both phases

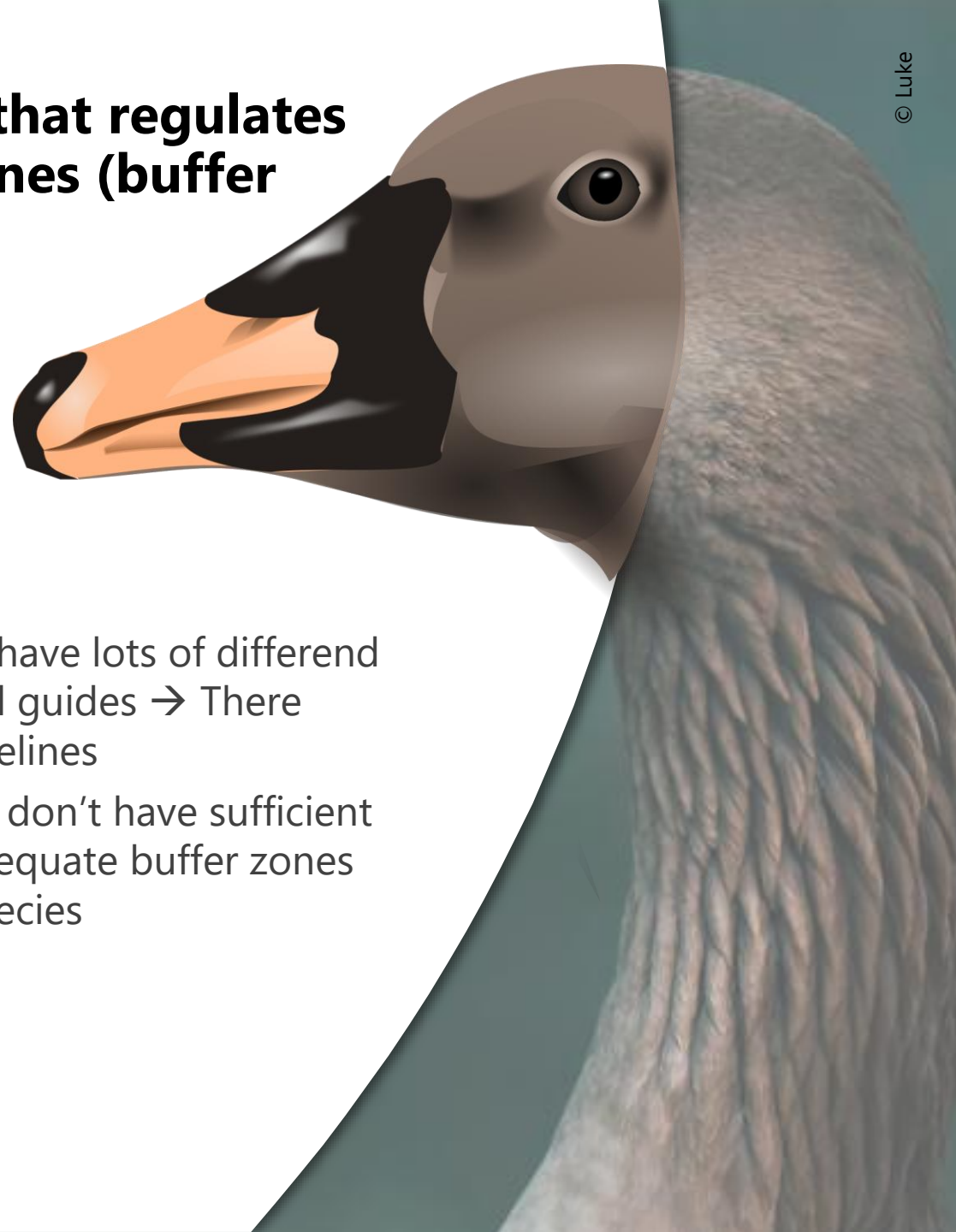
Are there national guidelines or legislation that regulates on how and where can you build wind turbines (buffer zones or excluded areas)?

- Land use and building act
- Environmental protection act
- Environmental impact assessment act
- Nature conservation act
- Forest act
- Electricity market act
- EU Nature and birds directive
- Etc.

Minimum distance between wind power and residental areas **1,25 km**

HOWEVER

- Even though we have lots of differend kinds of laws and guides → There aren't exact quidelines
- For example: We don't have sufficient knowledge in adequate buffer zones for significant species



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Biodiversity in Wind Power Planning

Biodiversity considerations focus especially on:

- Migrating birds
- Breeding birds
- Bats
- Flying squirrel (*Pteromus volans*)
- Protected habitats
- Natura 2000 areas
- Species listed in the EU habitat directive, especially large carnivores: wolf (*Canis lupus*), bear (*Ursus arctos*), lynx (*Lynx lynx*), wolverine (*Gulo gulo*) and wild forest reindeer (*Rangifer tarandus fennicus*)

Wildlife Studies During Planning

- Typical studies include
  - Bird studies
  - Breeding bird surveys
  - Migration monitoring
  - Collision risk assessment
  - Habitat surveys
    - Identification of protected/valuable habitats (ie. Wolf territories, wild forest reindeer habitats)

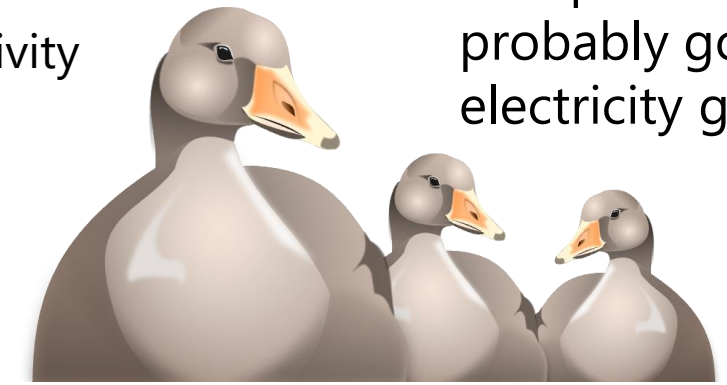
However…

there are still **significant gaps** in data!

- Both in completed species surveys and the methodology needed to make them adequate AND in how to take these species into account in planning in a way that would be sustainable

Mitigation Measures Often Proposed

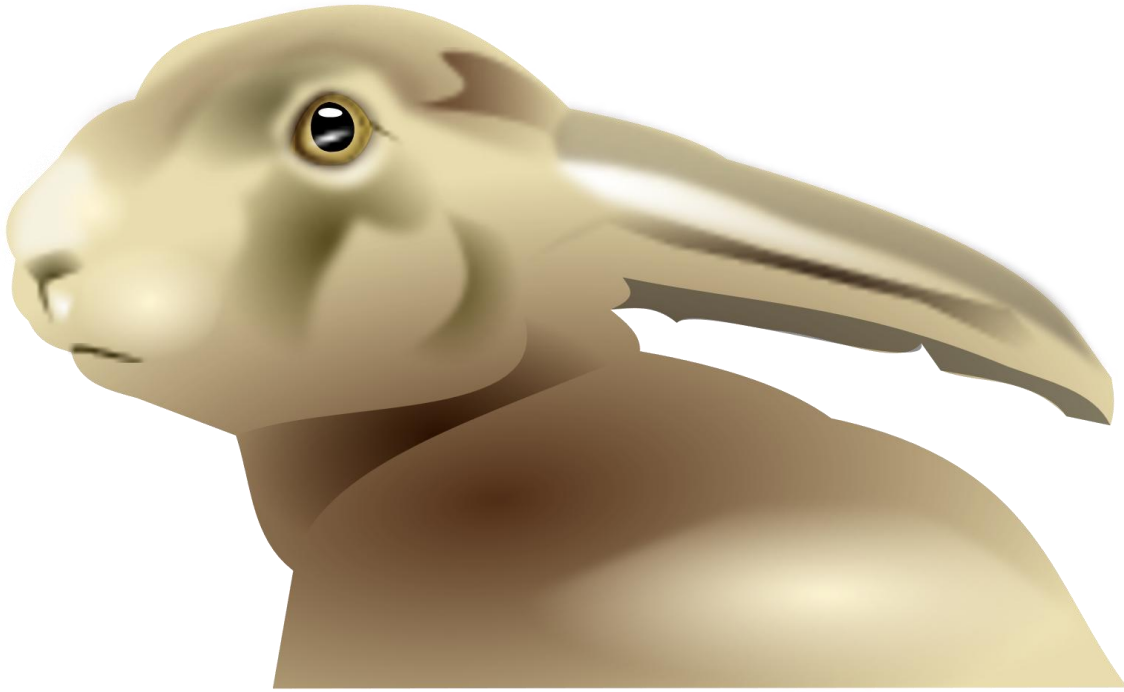
- Careful site selection
- Avoiding key habitats and migration routes
- Turbine placement
- Adjusting turbine locations within wind farms
- Operational mitigation
  - Temporary turbine shutdown during migration peaks
  - Curtailment during hig bat activity



- Painting the lower part of the wind turbine towers dark
- Using high-visibility / attention colours
- Scheduling construcion outside the nesting season
- Using buffer zones (like 500-800 meter buffer around capercaillie lek sites)
- Compensation measures (rarely, but we are probably going to have a case with Finnish electricity grid (backbone grid))

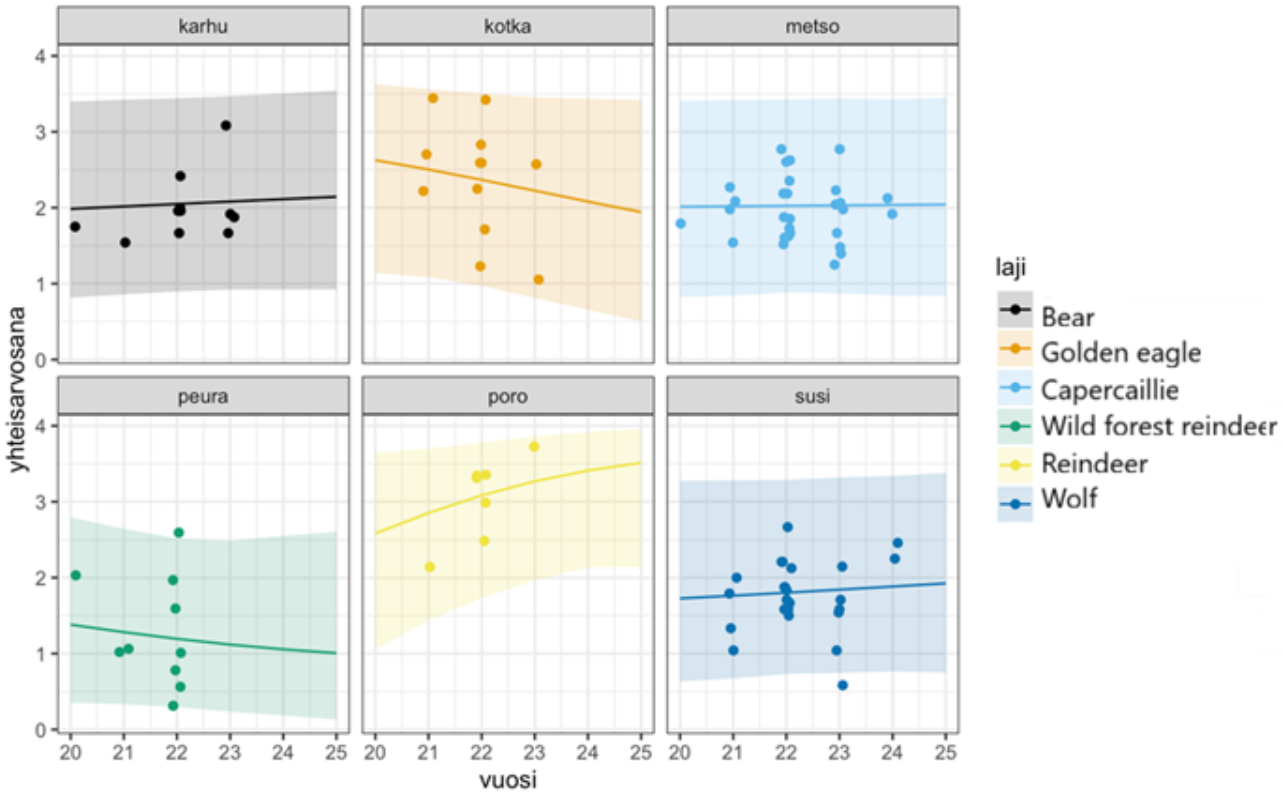
Emerging Challenges

- Increasing number of wind farms → Significant **cumulative ecological impacts**
- Planning frameworks may need to evolve as development accelerates
- More information and data needed



We Studied EIA-process – Report is almost ready

- Experts carried out 114 EIA assessments from total of 70 wind power plans/projects
- Species observed were: golden eagle, capercaillie, wild forest reindeer, reindeer, wolf and bear
- The study examined how baseline conditions, impact assessment, cumulative impact assessment, and the consideration of impacts were carried out in the EIA process
- The comprehensiveness and quality of the assessment for each component were scored on a scale from 0 to 4, where 0 = missing, 1 = poor, 2 = satisfactory, 3 = good, and 4 = very good



Ongoing Wind Power Research in Finland

WindLife 2023-2027

Occurrence of wildlife and habitat use near wind turbines

Joint project by the Natural Resources Institute Finland (Luke) and 14 wind power companies

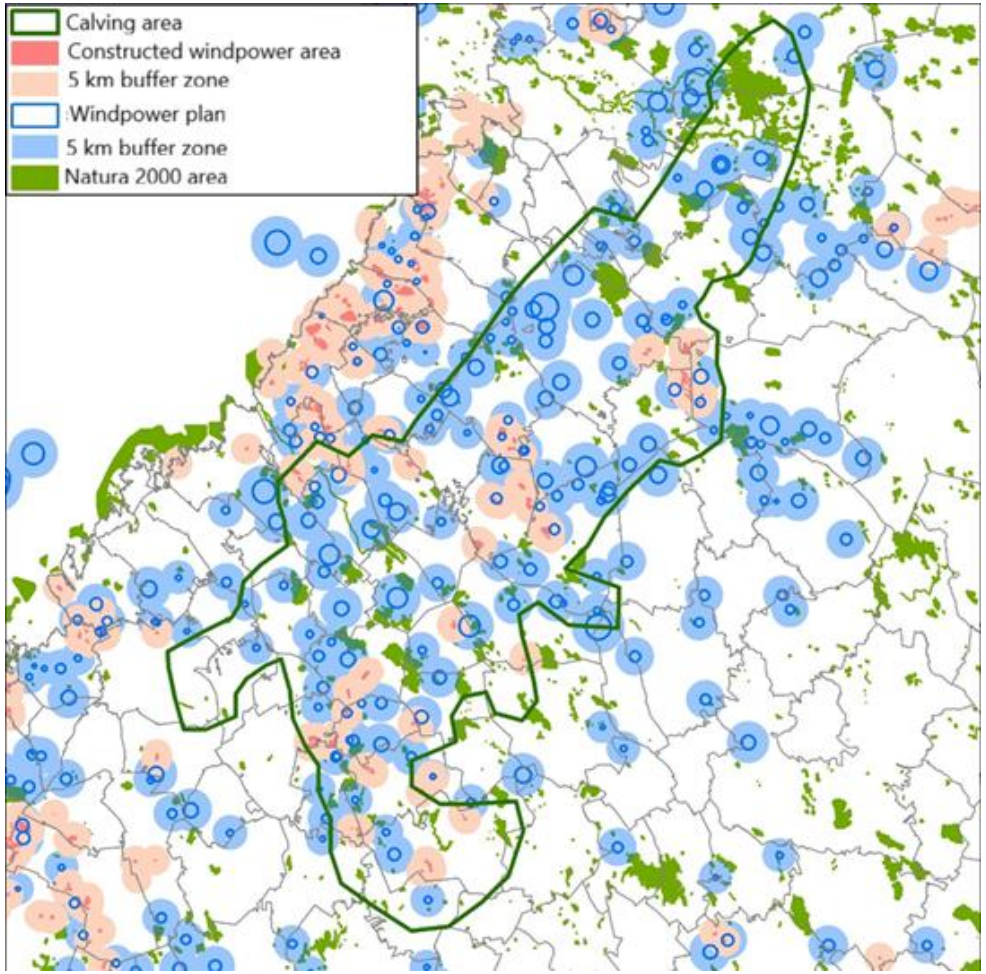
- Studies the impacts of wind power on EU directive species:
  - Wolf
  - Wild Forest reindeer
  - Golden eagle
- Examines effects on reindeer husbandry
  - Impacts on herding practices
  - Changes in costs of reindeer husbandry
- Surveys hunter’s views and experiences regarding
  - The impacts of wind power on hunting

CASE Wild Forest Reindeer

Rangifer tarandus fennicus

Extensive wind power development is planned in the habitat of the Suomenselkä wild forest reindeer population

- Currently, there are relatively few operational wind turbines in the calving area
- However, wind power is planned across almost the entire calving area
- Peer-reviewed scientific research is needed to support the sustainable planning and construction of wind power
- Currently we at Luke advice 5 km buffer zone from important wild forest reindeer areas (such as Natura 2000 areas) based on scientific research made elsewhere

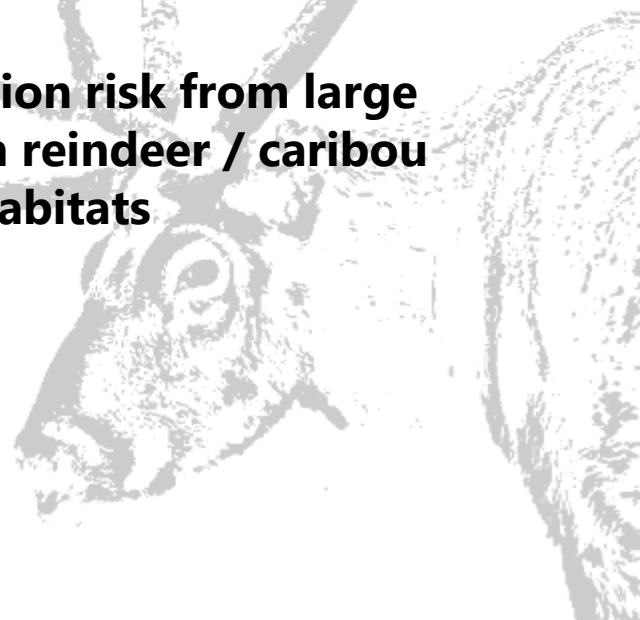


Responses of different reindeer subspecies to wind power and other human disturbances have been studied elsewhere

Tundra Reindeer / Reindeer (Rangifer tarandus tarandus) and North American Caribou (various R. tarandus subspecies)

- Avoid
  - wind turbines and related construction activities
  - Roads, power lines, industrial facilities
  - Humans moving in the landscape
- Affected behavious
  - Grazing areas
  - Migration between grazing areas
- Notes from research
  - A small number of studies have not found avoidance responses
  - Calving and care of young calves is the period of highest sensitivity to human impacts
  - Human impacts in the habitat reduce population viability

- **Indirect impacts** also arise from human activities and infrastucture
  - Linear structures in the environment (e.g. roads) can facilitate wolf predation, increasing **the risk of predation** on reindeer/caribou
- **Ecological interactions are also important in habitat selection**
  - **Avoiding the predation risk from large carnivores may push reindeer / caribou outside their ideal habitats**



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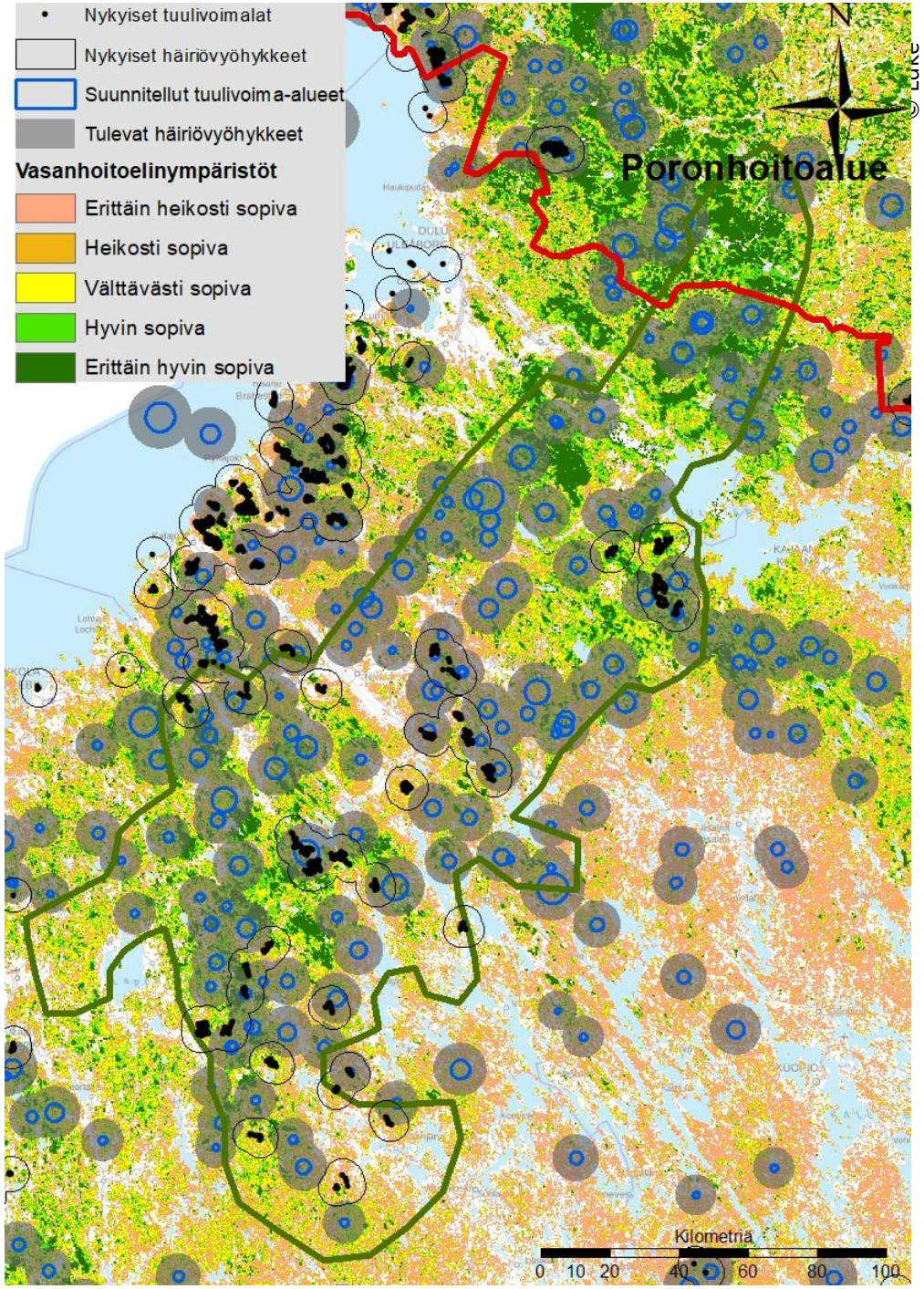
Findings from other regions or reindeer subspecies cannot directly be applied to wild forest reindeer

- Wild forest reindeer (*Rangifer tarandus fennicus*) is a distinct subspecies
  - No published research on responses to human activity
- Finnish conditions are unique
  - Topography
  - Landscape structures
  - Land use
  - Biological communities

Key research and information needs in Finland

- Calving and calf care are critical life cycle stages requiring more data
- Effects of wind farms on the location of calving sites
- Consequenses of wind turbines, associated infrastructure, and other human activies on movements between summer and winter pastures
- Opportunities for ecological compensation and habitat restoration?



Existing data gives us opportunity to study the impacts of wind power infrastucture and other human activities

- Extensive GPS tracking data available
  - 47 individuals with iridium GPS collars
  - 4 with Anicare GPS ear tags
- Assessment of wind farm impacts is currently limited by the low number of turbines in the study area, but data is continually increasing
- Limited use of the data in research so far
  - Habitat selection during calf care has been preliminarily analyzed in relation to available habitat types
  - The Goal is to identify factors that best explain habitat selection under baseline conditions, before wind power structures are present, so these factors can be considered when analyzing wind power disturbance effects

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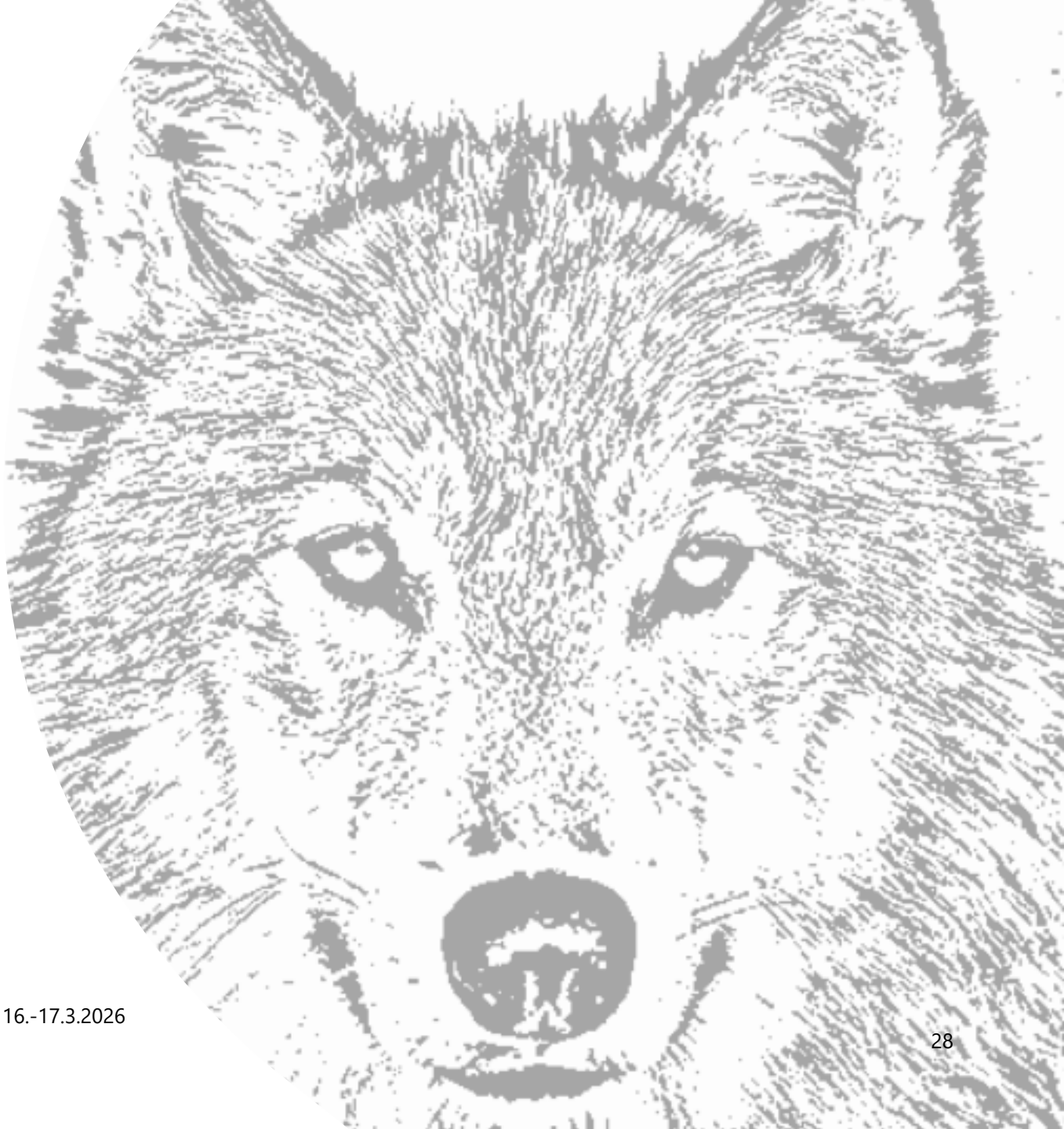
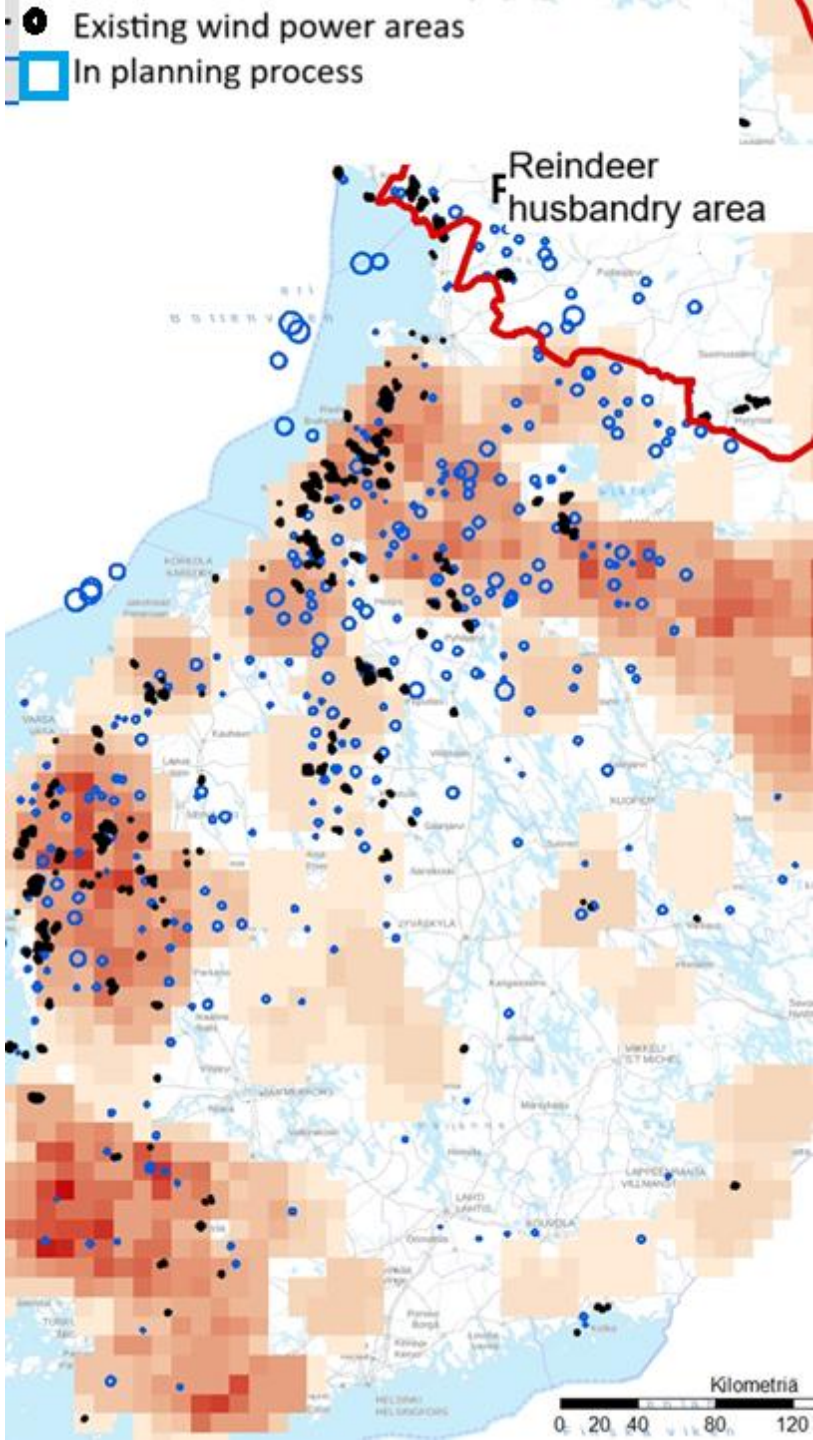
CASE Wolf

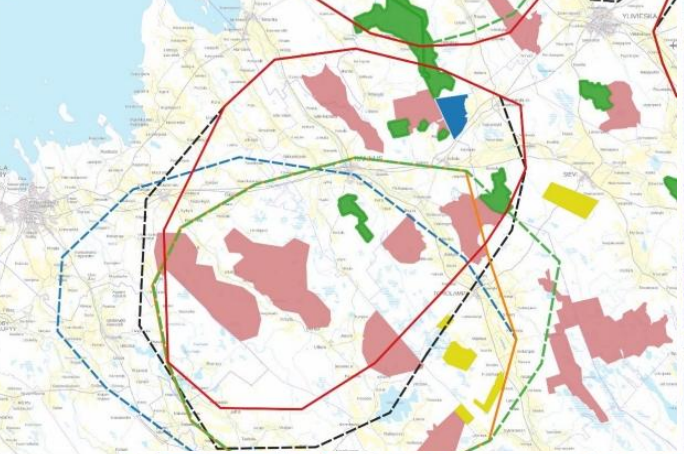
Canis lupus



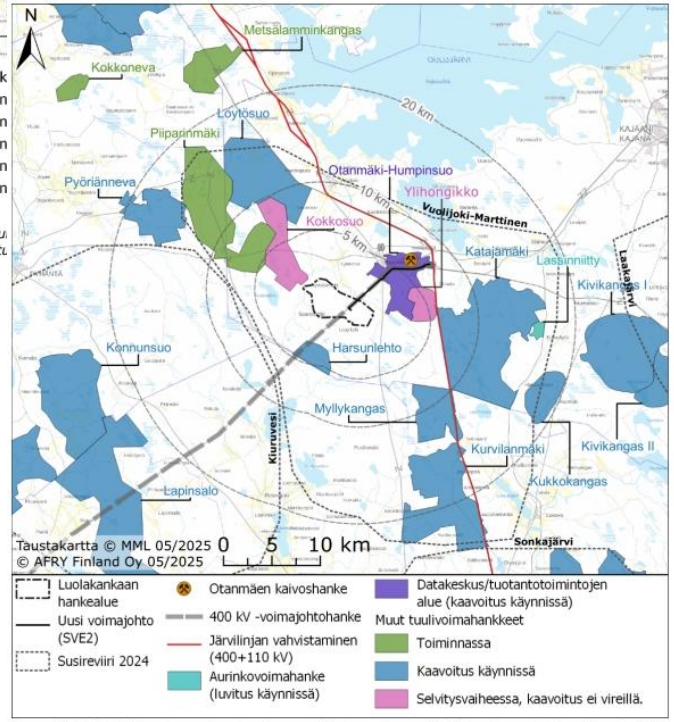
Wind Power and Wolf Territories

- Location of existing and planned wind power areas and the **wolf territory raster** (10 × 10 km, different shades of red), which illustrates the **overlap of wolf territories** according to wolf territory data from **2017–2024**.
- The darker the **10 × 10 km raster cell**, the greater the number of **overlapping wolf territories** during the above-mentioned years.

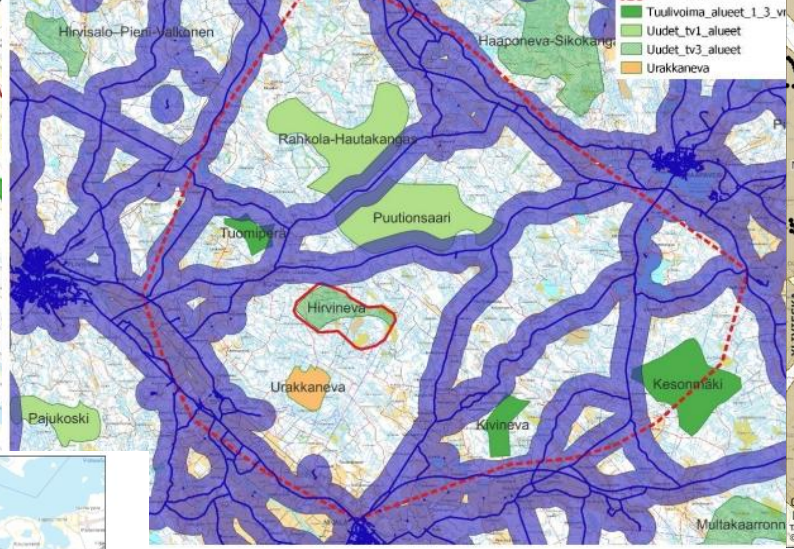


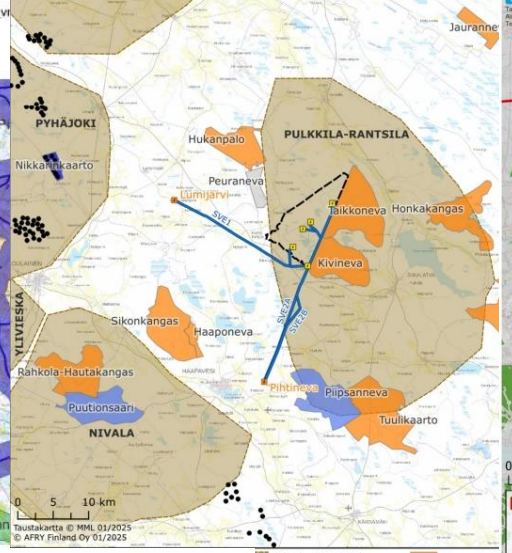


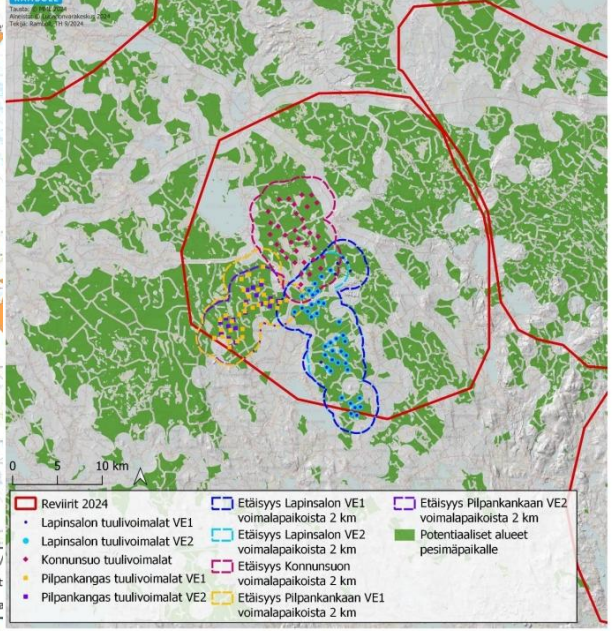
va 5-1 Muut tuu
nkealueen sijoittu

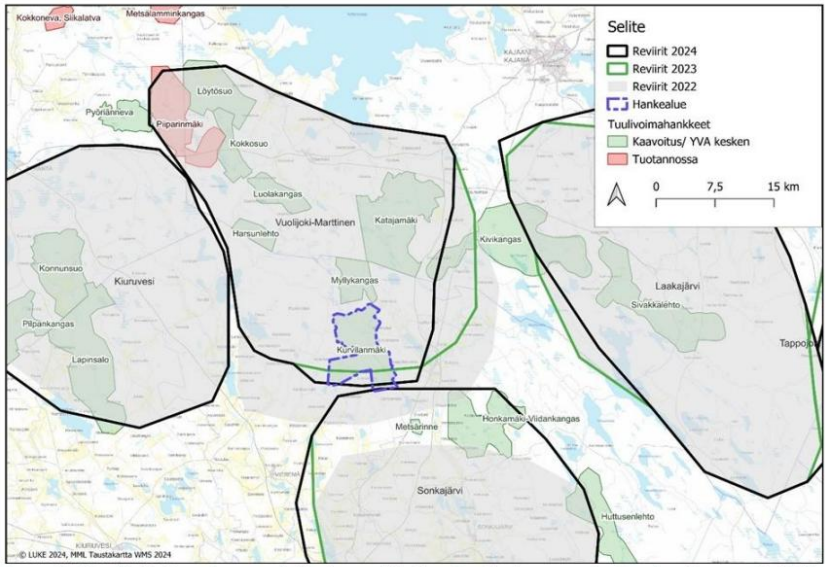


Kuva 5-2. Luolakankaan hankealueen läheisyyteen sijoittuvat muut hankkeet, joilla voi olla yhteisvaikutuksia alueen susireviirien näkökulmasta.

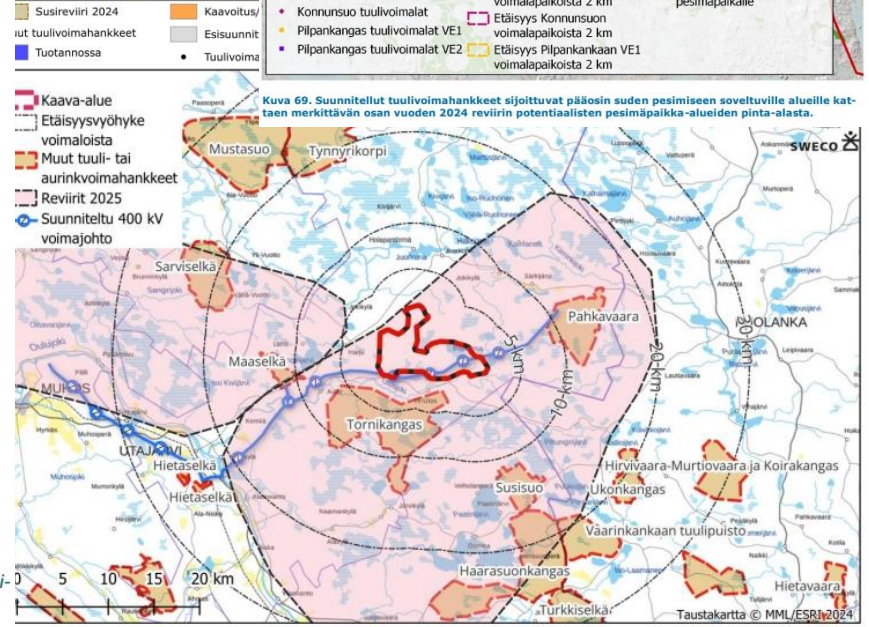








Kuva 16. Vuolijoki-Marttisen reviirille ja sen läheisyydessä olevat tuulivoimahankkeet paitsi Ylihongikon tuulivoima-alue.



Kuva 69. Suunnitellut tuulivoimahankkeet sijoittuvat pääosin suden pesimiseen soveltuville alueille kattaen merkittävän osan vuoden 2024 reviirin potentiaalisten pesimäpaikka-alueiden pinta-alasta.

Kuva 94. Pahkavaaran susireviiri 2025. Pahkavaaran susireviirin alueelle suunnitellut tuulivoimahankkeet sekä uuden suunnitellun voimajohdon (400 kV) sijainti Pahkavaaran susireviirillä.

Sources: Malakakankaan tuuli- ja aurinkovoimahanke sekä 110 kV:n voimajohto, susiselvitys | Vasaman tuulivoimahanke –selvitys | Leuvannevan susiselvitys | Ponteman Kaavaselostus | Lapinsalon YVA-selostus | Luolakankaan susiselvitys | Vaikutukset Vuolijoki-Marttisen susireviiriin, Kurvilanmäen tuulivoimapuisto

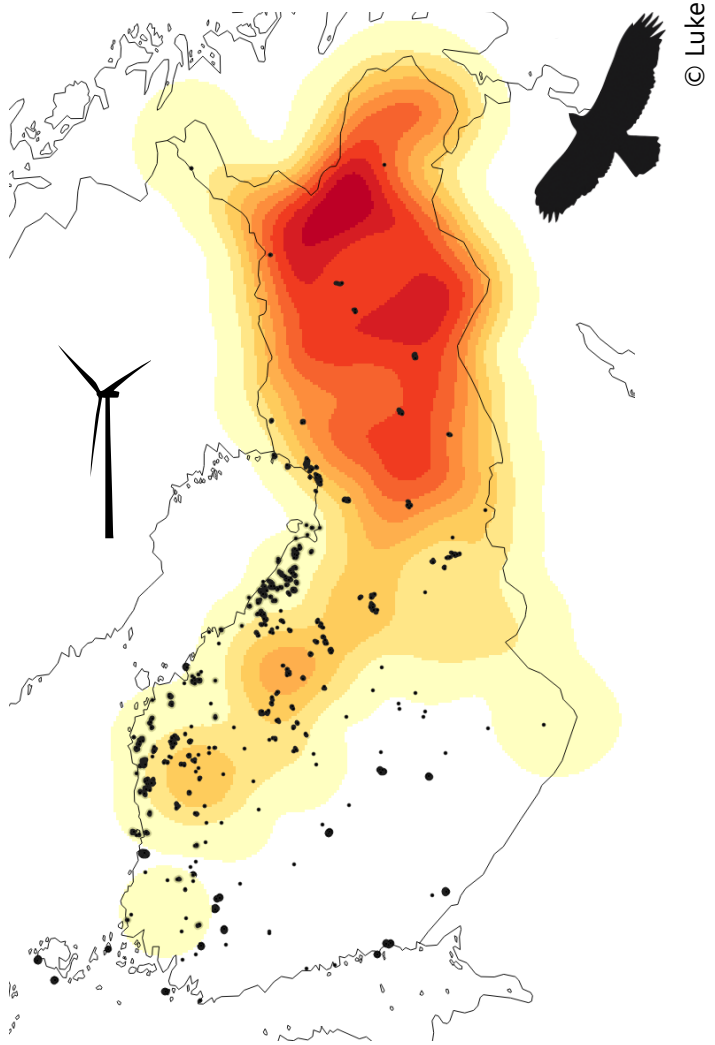
CASE Golden eagle

Aquila chrysaetos

Space use of Golden Eagles and the effect of wind turbines

- The Golden eagle population in Finland is densest in the north
- The eagles are highly territorial, and the territories do not overlap. The size of the territory has a radius of up to ~10 km, smaller where the population is dense.
- Wind power is being constructed also on eagle territories.
- For eagles, this poses both a direct collision risk, and potential habitat loss and a reduction of effective territory size

The aim of this project is to study how the construction of wind power affects territorial golden eagles and eaglets hatched on the territories.



Heat map of Golden eagle territories in Finland. Black dots show wind power plants.

Methods

- Golden eagles equipped with GPS-transmitters (27 adults, 16+ eaglets)
- Modeling the habitat use (preferences and avoidance of certain habitats)
- Wind power plant density included in habitat variables

Preliminary results (adults)

- Golden eagles **prefer** proximity to the nest, steep slopes, bog edges, sparse forests and old forests, and **avoid** neighbor territories, human settlements and lakes
- The golden eagles avoid dense wind power plant areas to some extent, but the avoidance is not total
- The eagles use wind-power areas more, if:
  - The turbines are close to the nest or an alternate nests
  - The turbines are placed in habitats that are favored by the eagles

Implications

🙂 Avoidance reduces collision risk

😟 risk higher if wind power in preferred habitats

😟 Habitat loss reduces the effective territory size

🤔 Problem in densely populated areas? Consequences for the breeding success and chick production?

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Thank you!

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