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Birds vs. wind power – significant bird impacts of wind turbines in Finnish environmental impact assessment reports

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Tiivistelmä - Referat - Abstract

Tutkielman tavoitteena oli tunnistaa, mitkä linnustovaikutustyypit luokitellaan merkittäviksi suomalaisissa tuulivoimaa koskevissa ympäristövaikutusten arviointiraporteissa. Tuulivoimaloiden määrän lisääminen vaikuttaa lintuihin suoraan ja epäsuorasti, mikä voi osaltaan vähentää lintujen monimuotoisuutta. Biodiversiteettikatoa ei tulisi unohtaa ilmastonmuutoksen hillitsemisponnistelujen keskellä. Ympäristövaikutusten arviointi on työkalu, jolla hankkeen kielteisiä ympäristövaikutuksia voidaan tunnistaa ja vähentää. Se sisältää myös linnustovaikutusten arvioinnin. Kaikki merkittäviä linnustovaikutuksia sisältäneet tuulivoimaan liittyvät YVA-selostukset kerättiin Suomen ympäristöhallinnon yhteisiltä verkkosivuilta ja analysoitiin laadullista sisällönanalyysia käyttäen. Nämä 18 tapausta jaoteltiin kirjallisuudesta löytyneiden vaikutustyyppien (törmäykset, häiriöstä johtuva siirtyminen, estevaikutus ja elinympäristön muutos) mukaan.

Vaikka kaikkia neljää vaikutustyyppiä pidettiin merkittävinä aineistossa, yleisin tyyppi oli törmäykset. Eri vaikutustyyppien merkittävyyksistä on olemassa hyvin vähän vertailukelpoista tutkimustietoa. Törmäykset olivat kuitenkin tutkituin vaikutus aiemmassa kirjallisuudessa, mikä voi osaltaan vaikuttaa myös sen yleisyyteen merkittävyyden arvioinnissa. Tulokset olivat suurilta osin linjassa aikaisemman kirjallisuuden kanssa, sillä petolintujen arvioitiin kohtaavan merkittäviä vaikutuksia useammin muihin lintulahkoihin verrattuna. Ne ovatkin useiden tutkimusten mukaan alttiimpia tuulivoimaloiden vaikutuksille. Merkittävyyden syyt tapausten välillä olivat melko samanlaisia merkittävyyden arvioinnin monitulkintaisuudesta huolimatta. Niissä tapauksissa, joissa merkittävyyden syy kerrottiin, lajin suojelun taso oli yleisin. Tutkielman tulokset tukevat myös aiemmin esitettyä väitettä siitä, kuinka vaikutustyypit, vaikutuksen kohteet ja merkittävyys vaihtelevat sijainnin mukaan.

Tutkielman tuloksista voidaan päätellä, että tutkimustietoa hyödynnetään ainakin osittain merkittävyysarvioinneissa. Tuloksista on hyötyä tulevassa tutkimuksessa, YVA-käytäntöjen kehittämisessä ja linnustonsuojelun tehostamisessa. Merkittävien vaikutusten tarkasteleminen on olennaista myös jatkossa, koska merkittävyyden arviointi ei ole yksiselitteistä.

Avainsanat - Nyckelord
Ympäristövaikutusten arviointi, linnut, tuulivoima, merkittävyyden arviointi

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Tiivistelmä - Referat – Abstract

The aim of this study was to identify which bird impact types are considered significant in practice in Finnish environmental assessment reports regarding wind power. Increasing numbers of wind turbines can impact birds directly and indirectly, which could contribute to the loss of bird diversity. Amid climate change mitigation attempts, biodiversity loss should not be overlooked. Environmental impact assessment is an example of a policy tool for identifying and reducing the negative environmental effects of a project, including bird impacts. All wind power-related EIA reports with significant bird impacts were collected from the joint website of Finland's environmental administration and analyzed with the help of qualitative content analysis. The 18 cases were divided according to the types of impacts found in the literature.

Although all four impact types including collisions, displacement due to disturbance, barrier effect, and habitat change were considered significant in the EIAs, collisions were the most frequent. Very little comparable data about the significance of different impact types were found. However, collisions were the most researched impact type, which could have also contributed to the evaluation of its significance. The results corresponded to previous literature for the most part as Accipitriformes (diurnal birds of prey excluding falcons), according to several studies, are more vulnerable to the impacts of wind turbines. They were estimated to face significant impacts more often compared to other bird orders present in the materials. The reasonings between the cases were quite similar, despite the ambiguity of the significance assessment. In the cases where the reason for significance was stated, the level of protection of the species was the most common. The results also support the argument about how the impact type, the object of the impact, and the significance of an impact vary depending on the locations.

The findings of this thesis suggest that scientific data is used at least partially in significance assessments. The results are useful in future research, developing EIA practices, and enhancing bird protection. Looking at significant impacts is relevant also in the future as the assessment of significance is not uncomplicated.

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Abbreviations

CO_2	Carbon dioxide
D	Annex 1 species of the Birds Directive
EIA	Environmental impact assessment
EU	European Union
IUCN	The International Union for Conservation of Nature
MW	Megawatt

The conservation statuses are obtained from the Red List of Finnish Species (Lehikoinen et al., 2019) which is based on the criteria and categories created by The International Union for Conservation of Nature (IUCN). In this study, I am using the most recent assessment from 2019, but I am also considering the 2015 status of a species if it has changed. For example, the status of the White-tailed eagle in 2015 was VU but in 2019 LC, therefore it is marked as (VU 2015). The categories and their abbreviations are listed below:

NE	Not Evaluated
DD	Data Deficient
LC	Least Concern
NT	Near Threatened
VU	Vulnerable
EN	Endangered
CR	Critically endangered
EW	Extinct in the Wilds
EX	Extinct

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1 Introduction

In this thesis, I am analyzing the bird sections of Finnish wind power-related environmental impact assessment (later EIA) reports to find out what kind of impacts are considered significant. The aim of this study is to create knowledge about the significant impacts in practice, which is useful for future research, developing EIA practices, and enhancing bird protection, not to oppose wind power. It is relevant to focus on significant impacts as certain ambiguities are included in the assessment of significance.

As we are going through a time when energy transition is truly needed due to climate change and the energy crisis, building more renewable energy like wind power is becoming increasingly important. Generating energy by wind turbines causes considerably fewer CO_2 emissions, which is vital in climate change mitigation. Energy production by wind power has increased rapidly in Finland. Installed cumulative wind power capacity exceeded 4 000 MW in 2022 meaning that the capacity has doubled in five and increased eightfold in ten years (Finnish Wind Power Association, 2022a; Stenberg & Holttinen, 2010). The size, individual power, and number of turbines have also increased over the years (Finnish Wind Power Association, 2022a). The trend is similar around the world as the World Wind Capacity has more than tripled in the past ten years (WWEA, 2013; WWEA, 2022).

However, another planetary boundary, biodiversity loss, should not be overlooked as it can have far-reaching consequences for the whole Earth system (Steffen et al., 2015). Planetary boundaries are values that define a safe operating space for humanity in the biological and physical systems of planet Earth (Rockström et al., 2009). These limits characterize the permanent conditions that humanity must respect to avoid catastrophic environmental changes (Rockström et al., 2009). By 2022 humanity has crossed three boundaries including climate change, loss of biosphere integrity (biodiversity), novel entities, biogeochemical flows, land-systems change, and green water (Persson et al., 2022, Wang-Erlandsson, 2022). My topic is an example of how planetary boundaries can be interconnected; solving one environmental issue can exacerbate another.

Wind power impacts birds through collisions, displacement due to disturbance, habitat change, and barrier effect (Drewitt & Langston, 2006). Although predation by cats and collisions with buildings are more prevalent anthropogenic causes of bird mortality than wind turbines (Loss et al., 2015), the biodiversity of birds is at risk everywhere, so all possible causes of extra mortality should be researched and noted (Al Zohbi et al., 2015). The global loss of bird diversity can also be seen in Finland where 35 % of bird species are endangered (Lehikoinen et al., 2019). In addition, 38 bird species in Finland are our national responsibility species (Rassi et al., 2001) and there are 411 Finnish important bird areas (FINIBA) and 100 Important Bird and Biodiversity Areas (IBA) (Leivo et al., 2002; BirdLife Finland, 2023). Protection measures and assessment of negative impacts are certainly needed if biodiversity loss is to be stopped.

Environmental impact assessment is an example of a policy tool that can be used to reduce a project's negative biodiversity effects. In Finland, EIA is regulated by The Act on Environmental Impact Assessment Procedure 252/2017 (later EIA law) and Decree on Environmental Impact Assessment Procedure 277/2017 which are based on an EU directive. The purpose of the environmental impact assessment procedure is to assess the environmental impacts of projects to support planning and decision-making (Jantunen & Hokkanen, 2010). Its objectives include for example preventing adverse environmental effects and increasing public participation in decision-making (Jantunen & Hokkanen, 2010). According to the EIA law (252/2017), EIA is a required procedure in wind power projects when the number of turbines is at least 10 or the total capacity of the wind power plant is at least 45 MW.

EIA reports must include information about the possibly significant environmental impacts of a project (EIA law 252/2017). Guidelines about the significance assessment exist but a lot of responsibility is given to the consultants who construct the EIA report and use their consideration in determining the significance (e.g., Ministry of the Environment, 2016; Ehrlich & Ross, 2015). Significance assessment can therefore be seen as value-laden and subjective (Fonseca et al., 2020). These matters could affect the reliability of the document which is why it is important to create knowledge about what significance means in practice.

The discussion around birds and wind power has been colorful. Exaggerated bird mortality and exploding bats have been used as excuses by people who oppose wind power and renewable energy in general (e.g., The Guardian, 2019; Suomen Uutiset, 2016). However, serious concerns about wind power and the assessment of its impacts on birds have been raised, for example by a nature conservation organization BirdLife Finland. BirdLife Finland (2022) states that the location is key in building new wind power plants. They also criticize the ways the surveys and assessments are conducted as there are no legally binding, obligatory guidelines or limit values for assessments in Finland which would guarantee the objectivity, comparability, and application of the precautionary principle (BirdLife Finland, 2022). Along with its member organizations, BirdLife Finland writes statements about wind power projects during their planning phases. Their expertise should be valued when making decisions about new wind power projects.

The theoretical basis of this thesis consists of literature on the impact types of wind power faced by birds as well as literature on significance assessment. Data from EIA reports are analyzed with a concept-guided qualitative content analysis method. This thesis aims to answer the following research questions:

1) What kind of impacts on birds are considered significant in Finnish wind power EIAs?
2) Are some impact types considered significant more often than others?
3) Are some bird orders assessed to face significant impacts more often than others?

Firstly, in chapter two, I will introduce the theoretical background of the thesis. The four impact types of wind turbines on birds are presented, followed by a section about significance assessment and its challenges. In chapter three I will present the materials and methods used in this thesis. The results of the analysis are displayed in chapter four followed by chapter five where the results are discussed and connected to the theoretical background. Chapter five also includes the assessment of the analysis and suggestions for the future. Lastly, I will summarize the thesis in chapter six.

2 Literature review

This chapter includes a brief overview of the existing literature on wind power turbines' impacts on birds as well as the significance assessment and its challenges. Mostly research papers but also earlier reviews about bird impacts of wind power are utilized to find out what is characteristic of each impact type; for example, how common and significant different impact types are, which species are most vulnerable to impacts, and how impacts could be mitigated. Also, the definitions of significance, its assessment, and problems recognized by literature are introduced.

MOT Oxford Dictionary of English (2023) defines environmental impact as "1. The effect of a change in the physical environment on an organism (now rare). 2. The effect of a man-made activity, change, or development on the natural environment; frequently attributive, as "environmental impact assessment", "environmental impact statement", etc.". The Finnish EIA law (252/2017) gives a more detailed definition and mentions birds as one of the objects of environmental impacts: "1) *environmental impact* means the direct and indirect impacts in Finland and outside its territory of a project or activity on…b) the land, soil, water, air, climate, flora, organisms, and biodiversity, in particular the species and habitats protected by Council Directive 92/43/EEC on the conservation of natural habitats and of wild fauna and flora and by Directive 2009/147/EC of the European Parliament and of the Council on the conservation of wild birds."

The impacts of wind power on birds have been studied all over the world. They are usually divided into four categories which are collisions, displacement due to disturbance, barrier effect, and habitat change (Drewitt & Langston, 2006). In addition to wind turbines, new power lines required for the transportation of electricity can cause impacts on birds but in this study, I will be focusing on the impacts of turbines. As collisions are the only impact directly killing birds, it could easily be seen by some as the most severe and common of the four types. However, it is difficult to assess which impact has the most significant effect on birds as indirect impacts can be trickier to measure. Indirect impacts have been assessed to have a bigger impact on bird populations in many cases in comparison with collisions, but their role has not been researched enough to draw conclusions and generalize (Rydell, 2012).

All in all, the literature recognizes that wind power impacts on birds are mainly not significant, but assessments are important because there are differences in how some species in certain locations experience impacts. Absolute and universal quantitative knowledge about impacts is impossible to create.

2.1 Collisions

Collisions are perhaps the most researched effect of wind turbines on birds. The vulnerability to collisions varies between different bird species (Balotari-Chiebao et al., 2021). According to Balotari-Chiebao et al. (2021), soaring migratory birds like the Golden eagle, *Aquila chrysaetos* (VU), and White-tailed eagle, *Haliaeetus albicilla* (VU 2015) are among the most vulnerable species in Finland. Other species with a high fatality risk include little tern, *Sternula albifrons* (EN), lesser black-backed gull, *Larus fuscus* (EN) and Eurasian eagle-owl, *Bubo bubo* (EN) (Balotari-Chiebao et al., 2021). In addition to species, the number of collisions varies depending on the area, time of the year, and the size and placement of turbines (e.g., Loss et al., 2013; Miao et al., 2019; Everaert, 2014). For example, in Canada, the estimated collision fatality ranged from 0 to 26.9 birds per turbine per year when looking at 43 different wind farms (Zimmerling et al., 2013). In Europe the collisions per turbine range from 0 to 63 birds a year (Everaert, 2014).

The significance of collisions depends on the status of the species and in most cases, collisions have no significant effects on populations (Meller, 2017). It is stated that collisions with other things like windows, vehicles, and power lines are more significant in bird mortality (Calvert et al., 2013). However, assessing impacts is important because of the differences in areas and species.

Drewitt and Langston (2008) criticize the way collision research is carried out; they argue that most of the studies reflect more the observation effort than actual collisions since they are conducted by project developers or others who have a vested interest in the matter. Huso et al. (2015) also point out that there may be a motivation to develop poor monitoring programs if the absence of dead birds is perceived as proof that wind turbines have no adverse effects.

The most effective way of preventing collisions is the careful placement of turbines but mitigation after construction can also be useful in some cases (May et al., 2015). Some mitigation means are more suitable for certain species which is why biomechanical, audible, and optical mitigation tools exist (May et al., 2015). For example, in a study conducted in Norway painting one of the turbine blades black reduced the collisions by 70 % and had the biggest impact in reducing raptor mortality (May et al., 2020). Mitigation could be a good addition to impact assessment especially because assessments cannot predict the impacts with 100 % accuracy. After-construction monitoring is therefore a very important part of reducing collision impacts (May et al., 2015).

2.2 Displacement due to disturbance

Displacement due to disturbance (later disturbance) can happen in the construction or operating stage of a wind power plant (Drewitt & Langston, 2006). This impact is mostly relevant for breeding birds, but different species have different responses to it (Drewitt & Langston, 2006). The densities of for example snipe, *Gallinago gallinago* and curlew, *Numenius arquata* declined during construction and did not recover whereas the density of red grouse, *Lagopus lagopus* recovered (Pearce-Higgins et al., 2012). Breeding raptors are among the species that seem to react negatively to disturbance too (Farfán et al., 2009). The closer the turbines are, the more they affect breeding bird abundance (Miao et al., 2019). Miao et al. (2019) suggest that a 1,600 m buffer zone should be created around wind turbines in important bird areas. Rydell et al. (2012) on the other hand suggest that the disturbance effect only reaches 100–200 meters from the turbine. The safe distance and the significance of the impact depend of course on the species, season, and area (Meller, 2017).

2.3 Barrier effect

The studies found on the barrier effect focus mostly on offshore wind turbines which will not be considered in this study. The barrier effect can be defined as a disturbance to migration and movement, affecting the connectivity of areas (May et al., 2021). In a summary of observations about barrier effects, a clear majority, 62 %, indicated that barrier effects took place (Hötker et al., 2006). However, the significance of the barrier effect on birds cannot be determined from a quantity alone as it depends on the behavior of a species as well as the location and placement of turbines (Masden et al., 2009).

Some birds have learned to avoid turbines while flying, and the extra distance flown by migratory birds is usually insignificant to their energy budgets (Pettersson, 2005). In a study in North Ostrobothnia common cranes, *Grus grus*, flew through a wind power park to get to their feeding and resting areas without any issues (FCG Suunnittelu ja tekniikka Oy, 2017). However, Masden et al. (2009 & 2010) point out that although a single wind power plant might not influence migratory birds, the combined impact of multiple big wind power areas could affect the energy budget of birds significantly. Focusing on building wind power to suitable areas and leaving corridors for birds to pass the turbines safely could be ways to decrease the significance of barrier effects.

2.4 Habitat change

Construction of the wind farm's permanent infrastructure, including access roads and wind turbine bases, typically results in direct habitat loss (Garcia et al., 2015). The average land area lost or changed per turbine is around 1.23 ha, but the magnitude of habitat change depends on the size of the wind power park (Zimmerling et al., 2013). Habitat change does not only limit to cleared vegetation. Soaring migratory birds like to use the same areas that are suitable for wind energy production due to good wind conditions (Marques et al. 2020). Building wind turbines, therefore, causes habitat loss for them in the sky as they avoid the turbines (Marques et al., 2020).

Endangered or specialist species are more vulnerable to habitat loss compared to generalists and LC species (Beston et al., 2016). If the area is in a natural state and home to endangered species, the impact is more significant compared to an area heavily influenced by humans (Rydell et al., 2012). Although habitat loss is among the top reasons for biodiversity loss (e.g., IPBES, 2019), the habitat change caused by wind power is very minor compared to for example forestry (Rydell et al., 2012). The significance of habitat change, therefore, depends on the species and the area.

The species that are the most vulnerable to indirect effects (displacement due to disturbance, barrier effect, habitat change) in Finland include little tern, *Sternula albifrons*, Eurasian collared dove, *Streptopelia decaocto* (EN), spotted nutcracker, *Nucifraga caryocatactes*, northern goshawk, *Accipiter gentilis* (NT) and common buzzard, *Buteo buteo* (VU) (Balotari-Chiebao et al., 2021). Passerines seem to be less affected by wind farms (Farfán et al., 2009). Some populations may even increase after the construction (Garcia et al., 2015).

2.5 The significance of an impact

A conclusion about the full environmental impact of a project cannot be drawn from a list of impacts alone which is why the significance of an impact is an essential component of the EIA. MOT Oxford Dictionary of English (2023) defines the word significant as “Sufficiently great or important to be worthy of attention; noteworthy”. The definition itself indicates the ambiguity of the term and how values are needed to determine the significance of something.

The Finnish Ministry of the Environment (2016) has created a guideline document for assessing wind power-related bird impacts including a section about significance. The ecology of a species, population size, distribution and level of protection, impact type, strength, extent, timing, and duration of the impact, as well as the probability of an impact, should be considered when assessing the significance of an impact (Ministry of the Environment, 2016). Also, the combined effect with nearby wind power plants should be considered (Ministry of the Environment, 2016). They do not, however, go into detail in defining significance nor do they establish thresholds for significant impacts which is reasonable for policy documents as they should be applicable to numerous different cases.

A systematic tool for the assessment of impact significance, ARVI, was created in 2015. as a part of IMPERIA, a project mainly funded by the EU, Ministry of the Environment, Ministry of Agriculture and Forestry, and Finnish Environment Institute, intending to develop EIA (Marttunen et al., 2015). ARVI includes guidelines for assessing the significance of biodiversity impacts, but not for birds specifically. The main constituting factors of significance in ARVI are the sensitivity of the impacted object and the magnitude of change (Marttunen et al., 2015). Sensitivity is based on legislative guidance, societal significance, and susceptibility to change. Magnitude consists of intensity and direction, spatial extent, and temporal duration (Marttunen et al., 2015). Despite examples, ARVI still leaves the responsibility to the consultant in determining suitable criteria for the individual project based on its features. The use of ARVI is also not a requirement in EIAs.

The ambiguity of the significance of an impact has been noted in the EIA literature and tools and solutions have been created as seen in the previous paragraph. Nevertheless, the role of consultants is still considerable (Ehrlich & Ross, 2015). Because of the subjectivity included in the nature of significance assessment, the consultant or project developer can sometimes, for example, try to downplay the significance to advance the project (Briggs & Hudson, 2013). Another factor increasing the obscurity of significance assessment is the fact that it is not merely based on science but includes also societal values (Ehrlich & Ross, 2015). The public interest is at the heart of decision-making in EIA which means that consultants cannot be completely objective and are bound to make value-laden decisions (Fonseca et al., 2020). In an example by Ehrlich & Ross (2015), they point out that it matters who makes the decision about significance since for example, indigenous communities might value things differently compared to the non-indigenous population.

Other problems related to significance assessment include the lack of knowledge due to insufficient monitoring of impacts as well as deficiency in the understanding of ecological processes and bad background data (Briggs & Hudson, 2013). These issues can result in big differences in the quality of EIA reports (Lawrence, 2007) and put decision-making on an unsustainable track since EIA is an important informing document when deciding on the acceptability of a project (Duarte & Sánchez, 2020). It is important to critically examine what the significant impacts in practice are since it can create knowledge for further assessment of the feasibility of the EIA procedure in protecting the environment and in this case declining bird populations and biodiversity.

3 Materials and methods

3.1 Materials

In this paper, I am analyzing 18 Finnish EIA reports where the impacts of onshore wind power on birds are considered significant. I collected the data from ymparisto.fi which is a joint website of Finland's environmental administration. I used the search engine on the website to find all the wind power projects that had gone through the EIA procedure by the end of June 2022. I skimmed through the reports and picked all the ones with significant bird effects.

The 18 cases used in this study are from a ten-year period between 2011 and 2021 and the locations of the projects can be seen in Figure 1. In these cases, biologists from the same or another consultant company collected the data for the bird surveys, and the consultant companies composed the EIA report and determined the significance of the impacts. The EIA is done in the planning phase before the project gets a permit so that the environmental impacts can be weighed in the permit consideration.

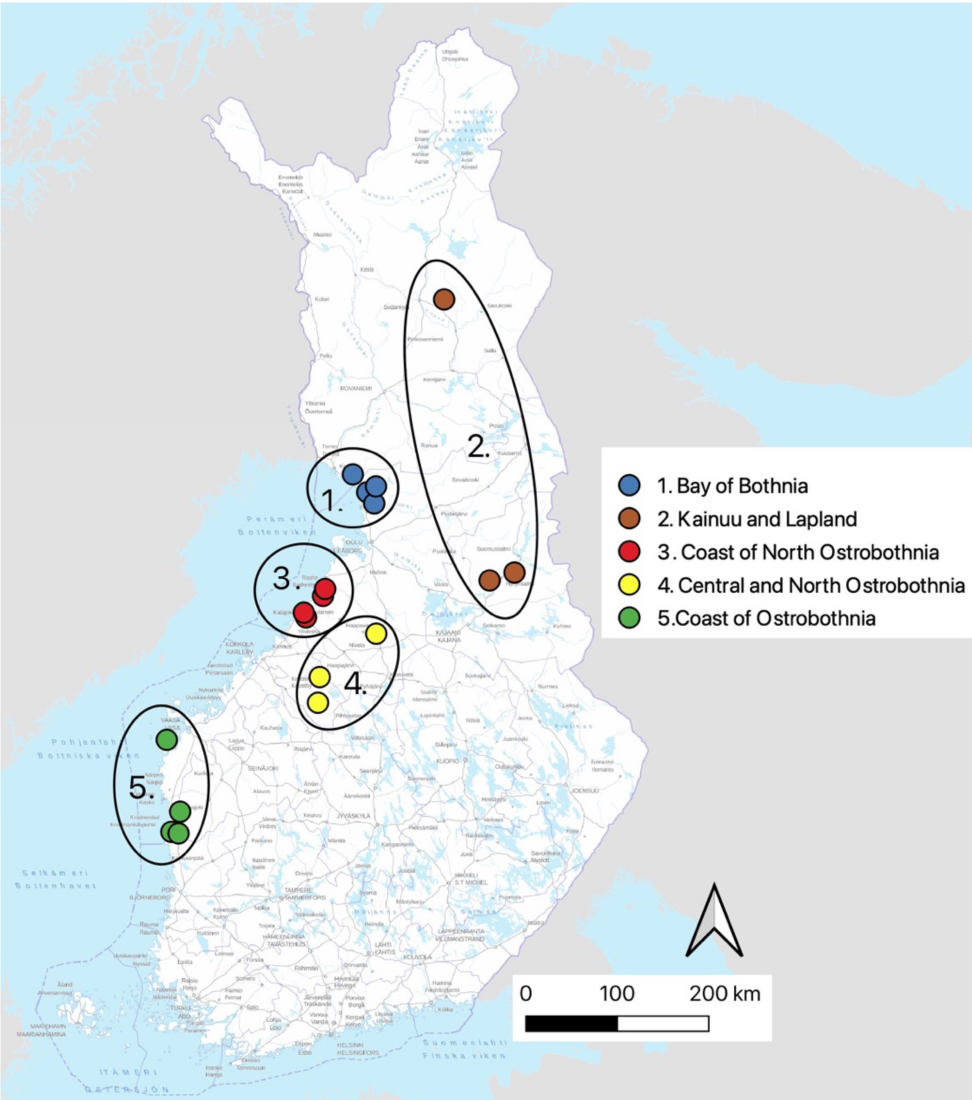

Figure 1 **Locations of the planned wind power projects.** (Background map: National Land Survey of Finland 11/2022)

The bird sections differ between consultant companies, but the composition is usually similar. First, they tell what kind of surveys need to be done, what is already known, and what methods are used. Then they present the results of the surveys; what kind of bird communities live and migrate through the areas. Also, the results of collision mortality modeling are presented. After that, impacts and their significance are discussed and sometimes justified with existing literature. The documents have a table of all impacts and their significance as well as comparisons between different options. Some of the options did not have significant impacts because of the differences between the location and the number of turbines. They are examples of the worst possible impacts of wind power on birds in Finland which is why they are relevant to this study.

Although EIA is just a tool in the preliminary phase of planning and changes to the plan can be made after it, I checked whether the projects had been executed as they are the only ones with significant bird impacts. I typed the name of the municipality into the Finnish Wind Power Association's (2022b) map service and checked if the project was finished or in the making. 13 of the 18 projects had been executed or will soon be executed: some with changes in the number and locations of turbines and some without any changes (Finnish Wind Power Association, 2022b). It is, however, good to keep in mind that the significance of other impacts also influences the execution of a project.

3.2 Methods

To analyze the EIA documents, I used the qualitative content analysis method. Content analysis is a method that can be used to systematically and objectively analyze documents that are in a text format. The goal is to form a condensed description of the phenomenon which connects the results to a wider context and previous studies. A basic principle of qualitative content analysis is that the material is chopped and coded into different categories that are connected to the research problem. After this, the material is classified, themed, or typed and finally structured into a new form. (Tuomi & Sarajärvi, 2018.)

Content analysis can be either material-driven, concept-driven, or concept-guided. The difference between them is how the analysis and classification are connected to the materials and theoretical framework. In concept-driven research, an existing theory and knowledge guide the way the materials are analyzed. The concept-driven analysis is deductive, and it is usually used in natural sciences. In a material-driven analysis on the other hand the materials are analyzed without any presumptions or theories and the goal is to create new knowledge inductively. However, the objectivity of this kind of research can be questioned since it is nearly impossible for the researcher's knowledge to not influence the research. (Tuomi & Sarajärvi, 2018.)

In this study, I am using the concept-guided approach where information is created abductively. Theories are mixed with the materials, which leaves room for interesting things to rise from the materials as well (Tuomi & Sarajärvi, 2018). The sooner the theory is connected to the materials, the more deductive the research is. This depends on the research and researcher (Tuomi & Sarajärvi, 2018). The concept-guided approach fits this study the best because I already had some knowledge about the different impact types but because the materials are new to me and I have not seen similar studies, it is good to have some flexibility in the analysis to see if something interesting comes up.

After selecting the documents, I read through the bird sections and the comparison tables at the end. I then created a table (Appendix 1) where I collected information about the project name, location, year, which of the four impacts were considered significant, and which species was the object of the impact as well as some notes from the EIA reports and their reasons for the significance. I also made a note of whether the object of the impact was a nesting or a migrating bird. I then abstracted the species category and grouped the cases based on the bird orders that were present. I also quantified the data and created a table (Table 1) to identify relationships between species groups and impact types. To find out whether the cases had any similarities I divided the wind power projects into five groups based on their location (see Figure 1). Each group has three or four projects.

Although the results have been quantified, numbers are used in a descriptive way rather than statistically. Numerical data helps to interpret the relationships between impact types and species. Quantitative methods are not suitable for the materials collected because the sample is not representative and large enough (Heikkilä, 2014). There is also no information in the literature about the distribution of variables in these kinds of cases which would be required in order to choose the right statistical tests (Heikkilä, 2014).

The goal of this study is not to make statistical generalizations but to describe a phenomenon, which makes qualitative methods more suitable (Heikkilä, 2014).

4 Results

In this chapter, I will present the results of the analysis. The results are divided into four sections based on the impact types that are derived from the literature. As mentioned in section 2.5, significant impact consists of the sensitivity of the impacted object and the magnitude of change. The word significant is therefore used here to describe the quality of an impact, and its meaningfulness. The word is commonly used in EIA literature and policies, and it is also a direct translation of the Finnish word used in the materials. Statistical significance will not be talked about without the word statistical.

All impact types mentioned in chapter 2 were considered significant in some of the 18 analyzed wind power EIAs. The impacts on the other hand were shared between six bird orders. As can be seen from Table 1, collisions as a significant impact were mentioned 13 times, displacement due to disturbance 9 times, barrier effect 7 times, and habitat change 5 times. Nesting Accipitriformes (diurnal birds of prey excluding falcons) as an object of significant impact was mentioned 15 times, migrating Accipitriformes 5 times and migrating Anseriformes (waterfowl) 4 times. Other orders faced impacts only on one or two occasions.

	Impact type				
Order	Collision	Disturbance	Barrier effect	Habitat change	Total
Nesting Accipitriformes	7	4	2	2	15
Nesting Anseriformes		1		1	2
Nesting Charadriiformes		1		1	2
Nesting Galliformes		1			1
Nesting Passeriformes		1			1
Migrating Accipitriformes	2		3		5
Migrating Anseriformes	3		1		4
Migrating Gruiformes	1		1		2
Unknown		1		1	2
Total	13	9	7	5	

Table 1 The bird orders and impact types. The numbers demonstrate how many cases had a certain order as an object of a significant impact. One case can have one or multiple different impacts on one or multiple orders. If one case has many species from the same order, they were combined and counted only once as the focus is on the impact type.
Accipitriformes = diurnal birds of prey excluding falcons
Anseriformes = waterfowl
Charadriiformes = shorebirds
Galliformes = gamefowl
Gruiformes = crane-like birds
Passeriformes = passerines

4.1 Collisions

The most frequently mentioned significant impact was collisions. Collisions were considered significant to both nesting and migrating Accipitriformes, migrating Anseriformes, and migrating Gruiformes (crane-like birds). The nesting species that were assessed to face significant impacts by collisions included the Golden eagle, *Aquila chrysaetos* (VU) and Osprey, *Pandion haliaetus* (D), in two cases, European honey buzzard, *Pernis apivorus* (EN), common buzzard, *Buteo buteo* (VU) and an endangered classified species in one case. The nesting information of a golden eagle is highly classified which is why I suspect it to be a classified species in this case. The Nature conservation group of Lapland (Lapin luonnonsuojelupiiri ry) also mentioned the golden eagle in their statement of the EIA report (ELY, 2014). The migrating species included rough-legged buzzard, *Buteo lagopus* (EN), white-tailed eagle, *Haliaeetus albicilla* (D), bean goose, *Anser fabalis* (VU/EN) [1], greylag goose, *Anser anser*, whooper swan, *Cygnus cygnus* (D), and common crane, *Grus grus*.

Collisions are numerically assessed with collision models. The number of individuals colliding is however not enough to make the impact significant. Among the most frequent justifications for the significance of a collision impact was the conservation status of a species (see Table 2) which means that the impact was seen to be more significant to endangered species. Another reason for the significance was the physical attributes of a species. Information found in literature was in some cases used to assess how vulnerable to impacts certain species are. For example, the reproduction of a golden eagle is very slow, and its large size is seen to be a disadvantage in dodging wind turbines. Important migration pathways also increased the significance of possible collision impacts.

[1] Subspecies taiga bean goose, *Anser fabalis fabalis* (VU), and tundra bean goose, *Anser fabalis rossicus* (EN)

Reason for significance	Number of times mentioned
Conservation status	7
Physical attributes and behavior	4
Location of a nest	3
The remarkable density of a species	1
The combined effect on an important migration route	4
The magnitude of habitat change	1
The magnitude of collisions	1
The magnitude of disturbance	1
Classified information	2

Table 2 The reasons for the significance of an impact. The numbers demonstrate how many cases mentioned a certain reason for the significance of an impact. One case can have one or multiple different reasons.

4.2 Displacement due to disturbance

Displacement due to disturbance was the second most frequent impact in the analyzed EIA reports. Only nesting birds including Accipitriformes, Anseriformes, Charadriiformes (shorebirds), Galliformes (gamefowl), and Passeriformes (passerines) were impacted by the disturbance. Also, one of the projects mentioned disturbance as a significant impact but did not differentiate species. Species significantly impacted included the white-tailed eagle, *Haliaeetus albicilla* (VU 2015), Golden eagle, *Aquila chrysaetos* (VU), European honey buzzard, *Pernis apivorus* (EN), common buzzard, *Buteo buteo* (VU), Osprey, *Pandion haliaetus* (D), northern goshawk, *Accipiter gentilis* (NT) and an endangered classified species (see 4.1). In addition to numerous Accipitriformes, western capercaillie, *Tetrao urogallus*, red-flanked bluetail, *Tarsiger cyanurus* (NT 2015), and waterfowl and shorebirds nesting in the wetland area of one of the projects were significantly impacted too.

A near location of the nest to the turbines or an area of the mating display were among the factors why displacement due to disturbance could be experienced. The significance of the impact was justified again by the conservation status of a species as well as by physical attributes including the inability of a species to stand disturbance (see Table 2).

In the case of red-flanked bluetail, the density of birds is the largest in Finland and Europe outside Russia which made the impact significant.

4.3 Barrier effect

The barrier effect was considered significant to seven bird orders in the analyzed cases including both nesting and migrating Accipitriformes as well as migrating Anseriformes and Gruiformes. The Golden eagle, *Aquila chrysaetos* (VU), the European honey buzzard, *Pernis apivorus* (EN), and an endangered classified species (see 4.1) were among the nesting Accipitriformes, whereas migrating Accipitriformes were not specified. Other migrating species included swans, geese, and other waterfowl as well as the common crane, *Grus grus*.

Important migration routes and especially the bottleneck for Accipitriformes' migration pathway made the barrier effects significant. Also, the proximity of other planned or constructed wind power plants increased the significance. As seen in Table 2, the combined effect on an important migration route was one of the most frequent reasons for significance. Large wind power areas create barriers that cause the migration routes to move. This could in some cases increase the energy consumption of birds making the impact significant. The conservation status of many of the Accipitriformes was used as a justification for the significance as well.

4.4 Habitat change

Habitat change was the least frequent impact in the analyzed EIA documents. It was still estimated to be significant for nesting birds including Accipitriformes, Anseriformes, and Charadriiformes. Also, one project did not differentiate between species but mentioned habitat change as a significant impact. Species significantly impacted included the Golden eagle, *Aquila chrysaetos* (VU) in two cases, European honey buzzard, *Pernis apivorus* (EN), and waterfowl and shorebirds nesting in the wetlands of one project area.

The conservation status of a species was the most frequent reason used to justify the significance of habitat change. Other reasons included species-specific information about their needs for the habitat. The magnitude of habitat change was also the reason for significance in one case (see Table 2). According to the literature used in assessing the significance of impacts, placing wind turbines near wetlands can have very severe effects on birds, which made habitat change impacts significant to certain species.

5 Discussion

In this chapter, I will first discuss the results of the thesis and connect them to previous literature. Secondly, I will consider other findings that emerged during the analysis. Lastly, the success of the analysis will be reflected and suggestions for future research will be discussed. The study aimed to discover 1) What kind of impacts on birds are considered significant in Finnish wind power EIAs? 2) Are some impact types considered significant more often than others? and 3) Are some bird orders assessed to face significant impacts more often than others?

5.1 Impact types and impacted bird orders

As seen in the previous chapter all four impact types were considered significant to birds in Finnish wind power EIAs. The most frequent impact type was collisions whereas both nesting and migrating Accipitriformes were the orders which faced significant impacts most frequently. There was also a difference in the types of impacts nesting and migrating birds faced. Disturbance and habitat change were more common to nesting birds whereas migrating birds were impacted by the barrier effect more often. Collisions were common for both. Nesting birds as a group faced significant impacts on more occasions compared to migrating birds.

Some of the results about impact types correspond to previous literature reviewed in chapter 2. For example, habitat change caused by wind power is not considered very significant in literature and it was the least frequent type in this study as well. The results, therefore, support the presumption that building wind power causes very minimal habitat change compared to other activities. As mentioned in chapter 2, it is no surprise that collisions were the number one impact type. They are easiest to assess which could contribute to their prevalence. In comparison, indirect impacts including displacement due to disturbance, barrier effect, and habitat change were altogether more frequent than

collisions which coincides with the literature as they can in some cases be more significant (Rydell et al., 2012). These results support the statement cited in chapter 2 that displacement due to disturbance is typical to only nesting birds. The barrier effect in turn was considered significant only 7 times which is few when considering how common it is according to literature. It is however good to keep in mind that, although some impacts might be more common according to literature, it does not mean they are more significant.
Since there is currently no available information on the impact type that has the greatest influence on birds, it is difficult to compare the results to the literature.

The results about impacted bird orders presented in the previous chapter also correspond in part to the existing literature reviewed in chapter 2. The abundance of Accipitriformes as the object of significant impacts in this study was no surprise as their vulnerability to both direct and indirect impacts of wind turbines is also highlighted in the literature. In addition, just one passerine was assessed to face significant impacts which also corresponds to the literature as passerines are very rarely affected negatively by wind turbines (Farfán et al., 2009, Garcia et al., 2015). Interestingly seagulls and terns were not among the species facing significant impacts even though some of them have conservation statuses and are among the most vulnerable birds when it comes to both direct and indirect impacts (Balotari-Chiebao et al., 2021). Other vulnerable species, including Eurasian eagle owl, *Bubo bubo* (EN), Eurasian collared dove, *Streptopelia decaocto* (EN) and spotted nutcracker, *Nucifraga caryocatactes* (Balotari-Chiebao et al., 2021) were also not assessed to face significant impacts which could either be caused by their absence in the areas or the criteria used for significance assessment. Eurasian collared dove and spotted nutcracker also have very limited nesting habitats in Finland (e.g., NatureGate, 2021a; NatureGate, 2021b) which could explain their absence. It is important, however, to keep in mind that vulnerability does not equal significance but is just one factor contributing to it as mentioned in chapter 2.

The most common reasons behind the significance of an impact were the conservation statuses, physical attributes, and behavior of species as well as the magnitude of the combined effect on important migration routes. For example, both conservation status and physical attributes affected Accipitriformes' vulnerability, which made them frequent objects of significant impact. Almost all the species assessed to face significant impacts had a special status. They were either classified as endangered, on the Birds Directive Annex 1 (D), or both. Birds Directive Annex 1 is a list of 194 bird species and sub-species that require Special Protection Areas (SPAs) by all Member States (2009/147/EC). Only two species, the common crane and greylag goose did not have a special status. However, this study did not demonstrate whether some species with status were left outside the significant impact category and what were the reasons. The reasons for significance correspond to those mentioned in the Ministry of Environment (2016) guidelines, presented in chapter 2.5, which include the ecology of a species, the level of protection, and the combined effect with nearby wind power plants. Interestingly, out of the two factors comprising significance (see Marttunen et al., 2015), the sensitivity of the impacted object was highlighted in most cases whereas the magnitude of change arose only in a few (see Table 2).

5.2 Location as a factor

The EIA reports with significant effects were evenly distributed over the years within the period under review. The projects were mainly located in clusters on the west coast with some exceptions (see Figure 1). In addition to the main results presented earlier, the location seemed to have interesting connections with the impact types and impacted bird orders. The impact types as well as impacted species varied a lot based on location. These results demonstrate BirdLife Finland's (2022) argument on how important location is when planning more wind power. Next, I am going to discuss how this study supports that argument.

Some areas had more cases with certain significant impact types. However, collisions were not characteristic of a certain area as they were considered significant on the coast as well as inland. Interestingly on the Coast of North Ostrobothnia (3), collisions were considered the only significant impact type. Displacement due to disturbance in turn was present in all the projects located on the coast of the Ostrobothnia area (5) whereas, in the other coastal areas, it was not considered to be significant. Out of all the habitat change impacts, ¾ occurred in the Central and North Ostrobothnia (4) region whereas, on the Bay of Bothnia (1), only the combined barrier effect of all the nearby wind power projects was considered significant in all but one case.

Some areas had more cases with certain impacted bird orders as well. On the Bay of Bothnia (1) only migrating birds, primarily Accipitriformes were impacted by the combined barrier effect. One case in the area considered collisions with the migrating rough-legged buzzard, *Buteo lagopus* (EN) to be significant. There were more cases with more significant impacts on nesting bird species in all the locations except for the Bay of Bothnia (1) and the Coast of North Ostrobothnia (3) due to important migration routes (Toivanen et al., 2014). On the coast of Ostrobothnia (5), Central and North Ostrobothnia (4), and in Kainuu and Lapland (2) only nesting birds were assessed to be facing significant impacts. These characteristics are in line with the literature which highlights the importance of location in determining the magnitude and significance of an impact.

5.3 Evaluation of the analysis

Although the goal of qualitative research is to enhance the understanding and produce useful knowledge of a phenomenon (Puusa et al., 2020), these results can be contextually generalized. This is because all Finnish wind power EIA reports with significant impacts were included in the study. However, as more wind power is planned and built rapidly in Finland, the number of EIAs increases quickly as well. This could influence the length of the period when these results can be considered valid. A larger generalization is not feasible as location and species seem to have such considerable roles when it comes to the impact type and its significance.

It is also good to keep in mind that this study only describes what consultants have considered significant so far. If the assessor had been a different person, some cases might have been classified as significant due to variations in the significance criteria. No conclusions about the execution of projects with significant bird impacts can be drawn either. Most of the cases had alternative options which were mostly assessed to have moderate impacts. This study only considered the alternative with significant impacts to create knowledge about what kind of impacts are considered significant in practice.

Despite preciseness and double-checking, there is a possibility that some details could have gone unnoticed due to the lengthy reports and differences in their structures. Also, manual coding always leaves room for human errors which can affect the reliability of research. It however allowed me to pick out all the features and synonyms which could have gone unnoticed in software analysis. The steps of the analysis were explained in detail which makes it possible to repeat the study and arrive at similar results. Although master's thesis is an independent project, reproducibility was also considered by discussing categories with the thesis supervisors.

There were differences in the qualities of the EIA reports, which could have influenced the analysis as well. Some of them did not specify between species while some used non-scientific names for the bird groups which I then had to deduce. In addition, the bird impacts in some cases were stated to be significant in the table at the end of the report where all possible impacts were just listed. No reasoning for significance could therefore be found in all cases. These shortcomings in the materials could have slightly affected the frequency of some species and reasons for significance.

Method selection was successful as previous literature about impact types created a suitable framework for the analysis and organization of the results. However, it also allowed me to explore and find categories from the materials. The concept-driven approach would have probably resulted in similar results about the impact types, but I would not have been able to categorize the results based on bird order without also looking at the materials. Creating a table with basic information about all 18 cases simplified the materials which made the analysis possible. Nonetheless, I still had to go back to the reports many times which was very time-consuming. This was due to the concept-guided method which allowed me to come up with interesting categories on the way. Also, not everything could be presented in such a dense form which required a lot of re-reading of the materials.

Research can never be purely objective as values impact what is studied and how the study is conducted (Tuomi & Sarajärvi, 2018). However, data collection and archiving as well as the presentation of results and discussion were done according to the Finnish National Board on Research Integrity (TENK) guidelines (see TENK, 2013). The study was conducted unhurriedly during a six-month period. The knowledge produced by other researchers was cited accordingly and no conflicts of interest were detected. The thesis, including its figures and tables, was made accessible to comply with the University of Helsinki Equality and Diversity Plan (see University of Helsinki, 2021). Because the materials used in this study are public and do not concern individual people no research permission was needed. No species are put at risk, nor will the research negatively affect the environment as no field experiments were conducted. Although some information about a classified species is discussed, no details about its nesting site are presented as it is only available to authorities. As stated earlier the goal of this study is not to oppose wind power and slow the mitigation of climate change, but to create knowledge that could support the mitigation of biodiversity loss.

5.4 Suggestions for future research

The results of this thesis could serve as base information if the quality and adequacy of significance assessment are evaluated in the future. They also allow criticism as they demonstrate how seriously bird impacts are taken if compared to other significant impacts assessed in EIAs. In addition, the results could be used as loose guidelines on what kind of impacts and species should be paid attention to in certain areas. However, as this study has shown, it is important to assess all impacts thoroughly because, for example, even a single vulnerable species can make the bird impacts of a certain project significant.

As the scope of a master’s thesis is quite limited, many interesting questions remain unanswered. To understand thoroughly the whole phenomenon of EIAs, their role in bird protection, their impact on decision-making, and the significance assessment, a lot more research is needed. It would be necessary to study whether the significance assessment is consistent. This would require a similar analysis of EIA reports with slightly and moderately negative bird impacts as well. Those results could then be compared with the ones acquired in this thesis. Only after that could bird-related improvements to the EIA process be proposed credibly. In future studies about significant impacts, it would be important to interview the consultants who conduct significance assessments. This would add information about the practicalities included in the process as well as how subjective or objective the assessment really is.

EU biodiversity strategy requires that European biodiversity starts to recover by 2030 and Finland has committed to it (European Commission, 2021). It would therefore be interesting to find out whether EIA is just a mandatory bureaucratic procedure or does it fill its purpose of preventing adverse environmental impacts including biodiversity loss. Mäkeläinen and Lehikoinen (2021) also call for further research on the aspects that influence project approval or rejection as addressing the impact of biodiversity values remains difficult in decision-making for EIA projects. As large numbers of nature surveys for EIAs are produced yearly, the results of those surveys could be used thoroughly for nature protection. This would be cost-effective if areas with high biodiversity could be protected as by-products of EIAs. It is not reasonable to save an area from wind power because of negative bird impacts and then not protect it from logging.

6 Conclusions

The aim of this master's thesis was to identify patterns in significant bird impacts of wind turbines in the practice. Based on a qualitative analysis of 18 Finnish wind power EIAs, it can be concluded that all four impact types including collisions, displacement due to disturbance, barrier effect, and habitat change are considered significant in some projects with collisions and Accipitriformes as object being the most frequent. The results indicate that the significance assessment of these cases is based on literature when it comes to bird orders. This shows that at least some consultants use scientific information as a justification for significance. They also consider collisions as the significant impact type most often although no comparable data about the significance of impact types exist.

I have argued throughout this work that significance is not easily defined and cannot be universally estimated. In particular, I demonstrated that significant impacts are very species and location-specific. Due to clear differences in the significance of impacts, impact types, and impacted species based on location, there must be a margin for the consultant's consideration in significance assessment. However, the process should be made more transparent by for example disclosing the criteria used.

Environmental impact assessment could be a useful tool in developing climate-friendly projects that do not deteriorate biodiversity. This thesis contributes to its development efforts by bringing light to one of the features of EIA. However, more research and other tools are definitely needed as biodiversity loss only keeps on accelerating.

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Appendices

Appendix 1.

Impact type	Object of impact	Bird order	Case	Municipality	Location	Year
Barrier effect	Accipitriformes; swans; geese; other waterfowl; common crane, Grus grus	Migrating Accipitriformes, Anseriformes, Gruiformes	Leipiö	Simo	1	2016
Barrier effect	Accipitriformes	Migrating Accipitriformes	Palokangas	Ii	1	2017
Barrier effect	Accipitriformes	Migrating Accipitriformes	Yli-Olhava	Ii	1	2020
Collision	Osprey, Pandion haliaetus (D)	Nesting Accipitriformes	Kivivaara	Suomussalmi, Hyrynsalmi	2	2013
Collision	Accipitriformes	Nesting Accipitriformes	Mustilankangas	Kalajoki	3	2012
Collision	Rough-legged buzzard, Buteo lagopus (EN)	Migrating Accipitriformes	Ollinkorpi	Ii	1	2021
Collision	Common crane, Grus grus; bean goose, Anser fabalis (VU/EN); white-tailed eagle, Haliaeetus albicilla (D)	Migrating Accipitriformes, Anseriformes, Gruiformes	Parhalahti	Pyhäjoki	3	2013
Collision	Bean goose, Anser fabalis (VU/EN); whooper swan, Cygnus cygnus (D)	Migrating Accipitriformes, Anseriformes	Raahen eteläiset	Raahe	3	2012
Collision	Bean goose, Anser fabalis (VU/EN); greylag goose, Anser anser; whooper swan, Cygnus cygnus (D)	Migrating Anseriformes	Tohkoja	Kalajoki	3	2012
Collision, disturbance	Common buzzard, Buteo buteo (VU); Osprey, Pandion haliaetus (D);	Nesting Accipitriformes	Västervik	Kristiinankaupunki	5	2013

	northern gos-hawk, Accipiter gentilis (NT)					
Collision, habitat change	Golden eagle, Aquila chrysae-tos (VU)	Nesting Accipitri-formes	Halsua	Halsua	4	2019
Collision, habitat change, dis-turbance, barrier effect	Golden eagle, Aquila chrysae-tos (VU); Euro-pean honey buz-zard, Pernis apivorus (EN)	Nesting Accipitri-formes	Toho-lampi	Toholampi, Lestijärvi	4	2016
Disturbance	White-tailed ea-gle, Haliaeetus albicilla (D)	Nesting Accipitri-formes	Bergö	Maalahti	5	2011
Disturbance	Red-flanked bluetail, Tarsi-ger cyanurus (NT 2015)	Nesting Passerifor-mes	Lumi-vaara	Hyrynsalmi	2	2014
Disturbance, barrier effect, collision	Endangered classified spe-cies	Nesting Accipitri-formes	Palkis-vaara	Sodankylä	2	2013
Disturbance, collision	Western caper-caillie, Tetrao urogallus; os-prey, Pandion haliaetus (D)	Nesting Gallifor-mes, acci-pitriformes	Mikon-keidas	Kristiinan-kaupunki	5	2014
Habitat change, dis-turbance	Wetland birds (water and shore birds)	Nesting Anserifor-mes, Cha-radriifor-mes	Piip-san-neva	Haapavesi	4	2020
Habitat change/ dis-turbance	unknown	unknown	Dags-mark	Kristiinan-kaupunki	5	2014