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Assessing the ecological effects of the Lista wind power park on vegetation and cervids.

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Abstract

Land-based wind power is considered one of the most applicable sources of renewable energy for the future. While cost effective, the knowledge of ecological consequences associated with construction and operation is limited. This thesis investigates how vegetation and cervid animals at Lista Wind Park were affected by its construction and operation.

Vegetation data in revegetated and control plots were compared over a twelve-year period and tested for variation in species richness, species diversity and foliar coverage. Dispersal of alien species, as a result of infrastructure construction, was also investigated.

Cervid habitat use was mapped one year before, during construction and several different years after the wind park was set into operation. This data was considered unreliable due to inconsistency in sampling circumstances and lack of calibration between observers, and not analysed further. Rather, inter-observer discrepancies in species identification were investigated.

Vegetation in revegetated plots seems to converge towards control plots after twelve years. Differences in species richness, species diversity and foliar cover are no longer significant. However, models fail to account possible variations due to climate. The construction of the wind park resulted in dispersal of alien species.

In general, experienced observers had trouble identifying species though photographs of feces, only being certain in ca. 50% of the cases. In cases where observers were certain, species ID was different compared to another observer in 19% of the cases.

More studies are needed to determine land-based wind powers ecological consequences, especially on cervids.

Acknowledgments

This thesis represents the completion of my master program at NMBU, and the topic was chosen due to my interests in restoration ecology.

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Norwegian University of Life Sciences

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Einar Lyche Lebesbye

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1 Introduction

Humanity is currently facing multiple major challenges, including the climate and biodiversity crises. Man-made emissions have caused a 1.1°C rise in global temperatures since 1850. This has resulted in rapid changes in the atmosphere, ocean, cryosphere, and biosphere, referred to as global warming. This increases the frequency of extreme weather events like marine heatwaves, drought, fires, and floods (Purvis et al., 2019). In turn, this results in habitat loss, reduced water and food security and is increasingly exacerbating the biodiversity crises (IPCC, 2023). From 1970 to 2018, we have seen an average decline in wildlife populations of 69% (WWF, 2022). Furthermore, per the IPBES Nature Rapport of 2019, one million out of the earth's estimated eight million species are currently facing the threat of extinction (Purvis et al., 2019). Humans are continuously converting larger areas to sustain a growing population. By now, 75% of the earth's land surface has been significantly altered by humans, and 66% of oceans are impacted by human activities (UNEP, 2023b).

Norway is no exception, and increasing urbanization and development come at nature's cost. An analysis of municipal area plans shows that 2166 km² is planned for future development; of residential areas (453 km²), recreational housing (987 km²), and commercial purposes (726 km²) (Simensen et al., 2023). This means developed areas will increase by 36% with current municipal area plans, reducing natural areas. In 2018, the Norwegian Environment Agency estimated that only 44% of Norway's landscape classified as pristine nature, while 11,5% remained with a wilderness character. Pristine nature (all categories) decreased by 7682 km² in the period 1988 – 2018 (*Table 1*). Construction of infrastructure surrounding wind and hydropower, as well as new powerlines, made up the majority of the reduction in pristine nature from 2013 to 2018 (Miljøstatus, 2023).

Table 1: Change in pristine nature across 30 years (Miljøstatus, 2022).

Category	Distance to major technical intervention	Change 1988-2018 in km²
Pristine nature with wilderness character	> 5 km	- 2018
Pristine nature zone 1	3-5 km	- 1451
Pristine nature zone 2	1-3 km	- 4213
Close to human interference	< 1km	+ 7682

The 2023 UNEP Gap report states that we are far from reaching the Paris Agreement's goals and are heading towards a global warming of 3 °C following current policies. As energy is the most prominent source of greenhouse gas emissions, the report calls for an accelerated transition to low-emission energy production (UNEP, 2023a). More than three-fourths of the world's energy consumption comes from fossil fuels (REN21, 2023), accounting for nearly 90% of the world's CO2 emissions (SEI et al., 2023). The problems at hand demand immediate, rapid, comprehensive, and sustained emission reductions to keep the human-induced temperature increase under 1.5 °C (IPCC, 2023). Though the need for change is worldwide, a particular responsibility rests on high-income countries, like Norway, as they possess a greater financial capacity. This is also the basis of negotiations in the "*United Nations Framework Convention on Climate Change (UNFCCC) principle of common but differentiated responsibilities and respective capabilities*" (UNEP, 2023a).

In Norway, most power production is renewable. However, not all production can be considered nature friendly, and Norway will need more renewable energy in years to come. A new rapport from the Norwegian Energy Commission forecasts the additional energy needs between 21 and 35 TWh by 2030. Some prognoses even go as high as 75 TWh, depending on establishing new industries (NOU 2023: 3). For reference: wind power production in Norway was 14,8 TWh in 2022, produced by 1388 turbines, covering 10% of total national power production (NVE, s.a., Statnett, 2023). In other words, Norway needs more energy, we need it fast, and we need it to be "green." As low-carbon technologies have become cheaper, wind and solar are now the world's most affordable sources of new power generation (UNEP, 2019). In Norway, wind power on land is considered the production technology with the lowest mean building costs (Energidepartementet, s.a.; Statkraft, s.a.).

Hence, wind power lies at the juncture between climate crises and biodiversity crises—part problem, part solution. While being the cheapest alternative to creating new green energy, it requires massive areas, which is also a restricted resource. Reports indicate that the governance of this resource is often neglected. A review of the knowledge base used for granting building permits for wind power plants reveals that impact assessments frequently fail to provide adequate insight into the potential impact on nature of the proposed build (Agder County Governer, 2019; Mdir, 2015). Methods and the quality of fieldwork vary greatly. In several cases, one rapport says it's *"..difficult to see how the academic quality of the investigations is reflected in the conclusions of the Norwegian Water Resources and Energy Directorate (NVE)"* (Mdir, 2015). This may also have been the case at Lista Wind Power Park (WPP), as the County Governor strongly advised NVE against granting concession, among other reasons, because the original impact assessment did not correspond to actual circumstances (Vest-Agder County Governer, 2005; Vest-Agder County Governer, 2006) (See appendix, attachment 4).

1.1 Revegetation

1.1.1 Nomenclature

In everyday language, terms describing variations of species introduced to an ecosystem in "newer" times are used interchangeably, diluting their respective implications. For the sake of this thesis, this must be clarified.

The Norwegian Biodiversity Information Centre (NBIS)'s definition of alien species is based on the Convention on Biological Diversity; "*a species, subspecies or lower taxon, introduced outside its natural past or present distribution…"(UNEP, 2002)* if "*…presents is due to human transport…*"(NBIS, 2023d). A species can be both national or/and regionally alien (NBIS, 2023d).

The term «invasive» describes a behavior characteristic that species may possess and is described as "*expanding its presence in a way that suppresses other species or destroys their habitat*" (Ratikainen, 2023). This characteristic is similar to, but must not be confused with, succession—a gradual, predictable, and directional change in species composition in a habitat (IBV, 2023). The main difference is the time aspect, and invasive behavior is most often associated with alien species.

In this thesis, the term **reference/native species** is used to describe species that have historically occurred in the environment and historically belong to the region. The term **introduced species** describes species alien to the region but not the country. The term **alien species** is used to describe species defined as alien species by NBIS in its broad sense (alien to Norway). This definition is only assigned to species introduced to the country after 1800 (NBIS, 2023c).

1.1.2 Revegetation techniques and convention

According to the 2019 IPBES report, human interference through changes in land use is the biggest threat to biodiversity (Purvis et al., 2019). As stated earlier, building wind parks could cause for significant decline in pristine nature (Miljøstatus, 2023). A considerable part of a this is the access roads. The roads associated with the construction of Lista WWP had a total length of 22 km, approximately 5,5 meters in width (Selboe, 2019). As road construction requires a relatively large area, it may lead to habitat loss and fragmentation for multiple species. In addition, the road might create a barrier for some species while creating a dispersal corridor and pathway for others. The magnitude of disturbance and change of habitat can be reduced by implementing the proper measures, like choosing the best route and revegetation method, and taking precautions not to introduce new species to the area (Skrindo & Mehlhoop, 2021).

Deciding which revegetation method should be used depends on technical, ecological, and financial restrictions as well as the objective of revegetation. Until the 1990's, aesthetics was the prioritized objective for most revegetation following road projects in Norway (Skrindo & Mehlhoop, 2021). Present guidelines cover a broader spectrum of objectives, e.g., reduce road constructions' negative effects on vegetation, prevent erosion, serve as wildlife corridors, etc. The preferred method for restoring natural vegetation is to remove the topsoil before establishment, store it temporarily, and then lay it on top of sub-layers when the road foundation is established (*Figure 1*). In this case, the seed bank and propagules in the topsoil will serve as basis for revegetation *(Norwegian Public Roads Administation, 2016)*. For the sake of this thesis, this method will be called topsoil-revegetation. Topsoil-revegetation is a method that has been known and used for decades but has been under-communicated (Skrindo & Halvorsen, 2008). The temporary removal of the topsoil layer often proves insufficient to conceal the full extent of the intervention, resulting in a lack of biologically active soil masses. This issue is frequently encountered in regions characterized by barren soil, such as those often designated for wind power installations (Kongsbakk, 2024).

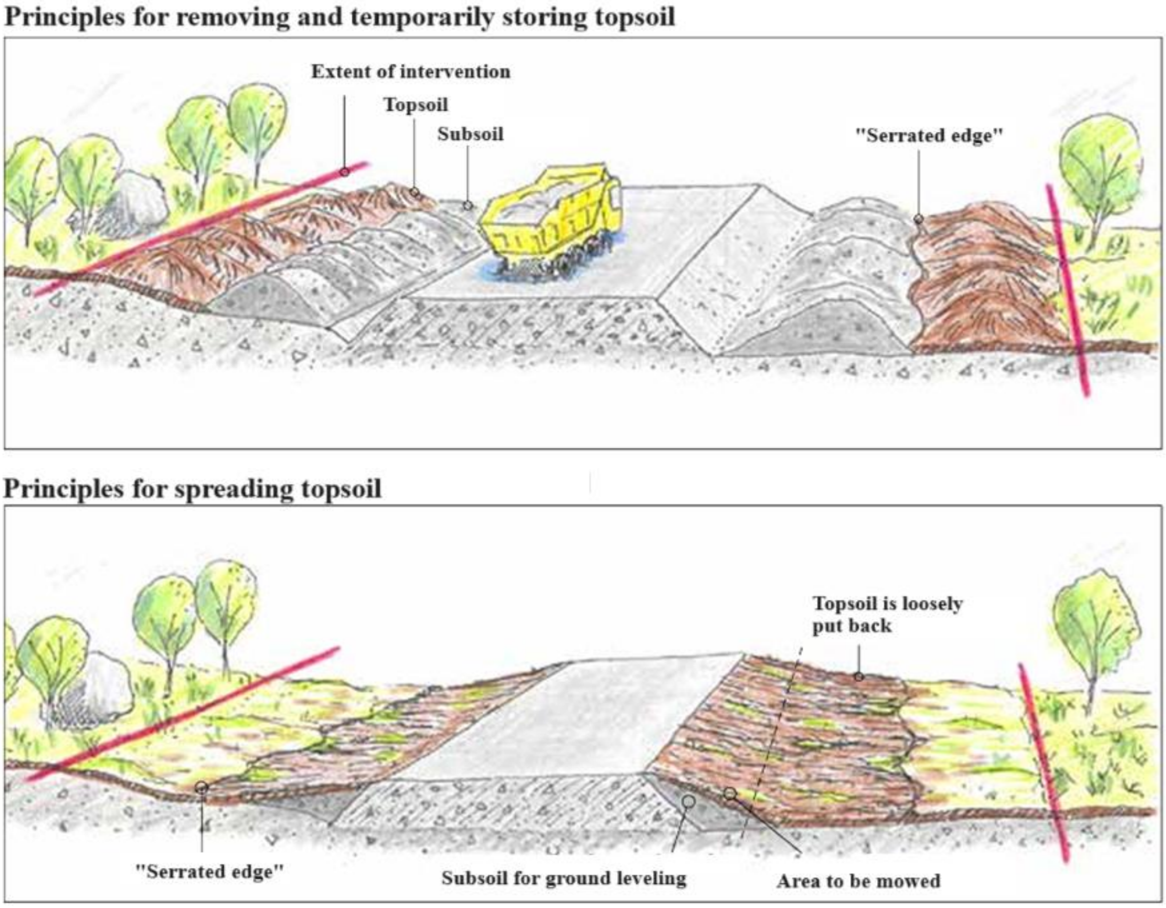

Figure 1: Principles for natural vegetation from topsoil. Topsoil is temporally stored along red line and then spread back without compression. The serrated edge is to ensure good contact and blend with surrounding vegetation. Illustrated by Elisabet Kongsbakk (Norwegian Public Roads Administation, 2016).

Norway's most common revegetation method is hydroseeding of commercial seed mixes (Norwegian Public Roads Administation, 2016). Hydroseeding is a method in which seed is mixed with water, fertilizer and organic matter, like wood fibers, and sprayed into the ground using pressure. This is also used in combination with topsoil-revegetation, often to restrict erosion, and was also done at Lista WPP. However, research regarding mechanisms of hydroseeding and commercial vs. local seed is not unanimous.

A long-term (25 years) revegetation study in Scotland (Bayfield, 1996) and a long-term (20-45 years) reclamation study in Iceland (Gretarsdottir et al., 2004) showed significantly greater vegetation cover in plots that had been seeded with commercial seeds than in control. In most cases, the commercial species acted as nurse plants that declined or disappeared after facilitating the colonization of native flora in treated areas. Nurse plants would capture wind-spread seeds, protect newly spouted plants from wind, and retain moisture. The native vegetation cover was significantly greater in plots seeded with commercial seeds than untreated plots. Both these studies were conducted in high wind-exposure areas, and the Icelandic soil was very barren and low in nitrogen (Bayfield, 1996; Gretarsdottir et al., 2004)

Studies in alpine environments showed significantly greater total vegetation cover in plots hydroseeded with commercial seeds. However, native vegetation cover was greater in unseeded plots, though not significantly. Species richness was significantly greater in unseeded plots after 21 years (Hagen et al., 2014). Other studies have also shown that the seeding of fast-growing commercial grasses interferes with the colonization of reference species, lowering species richness and diversity and altering species composition (Aradottir & Hagen, 2013; Rydgren et al., 2016). This has also been shown in hydroseed mixes of both commercial and reference species in the same blend (Matesanz & Valladares, 2007). Some studies have shown that a mix of locally selected species had a significantly greater vegetation cover than commercial species (Bochet et al., 2010; Tormo et al., 2007), but this alternative has been relatively expensive and unavailable.

Often, reducing erosion is the main objective of revegetation measures. While Bayfield et al. (1996) and Greatarsdottirs et al. (2004) studies suggest hydroseeding with commercial seed might prevent erosion, Bochet et al. (2010) and Tormo et al. (2007) found that locally selected species reduced erosion better than commercial species, but not significantly. Bochet et al. (2010) and Tormo et al. (2007) found commercial species did not act as nurse plants, as the vegetation cover they provided in the first year was inadequate. The initial cost of using locally selected species then was about 30 times more expensive than commercial. However, the study concludes that the actual cost was only double that of commercial seeds due to the geomorphological and ecological advantages of using local seeds. They also hypostasized that wood mulch and fertilizer in the hydroseed mix played an essential role in creating a high vegetation foliar cover (Bochet et al., 2010; Tormo et al., 2007). This is somewhat investigated in (Gudyniene et al., 2021), where native seeds were sown both alone by a traditional sowing machine and together with wood mulch, dye, surfactant, and fertilizer through hydroseeding. They found a positive, significant short-term effect on vegetation cover by hydroseeding and no significant difference in species richness (Gudyniene et al., 2021).

Auestad et al. (2015) compared hand sowing seeds collected from local flora and transplanted hay collected from local grasslands using hard or light raking, natural revegetation, and standard hydroseeding with commercial seed. Hydroseeding and transfer-hay with hard or light raking had the same effect on species richness in the first growth year. All treatments gave similar species richness the second growth year, except hand sowing with local seed. Hand sowing treatment surpassed others and remained higher throughout the study (Auestad et al., 2015)

In summary, studies have found that commercial seeds can either facilitate or hinder the regrowth of native plants. While conventionally, hydroseeding with commercial seeds is employed to control erosion, studies have demonstrated that local seed is significantly more effective. Moreover, hydroseeding as a seed dispersal method has been tested and shown to enhance vegetation cover, irrespective of seed type. Interestingly, similar results have been observed when using transplanted hay.

1.2 Alien species

Road construction involves the movement and management of soil and rock. How this work should be conducted, and limitations on the use of contaminated soil is regulated by law (Biodiversityact, 2009; Regulation on alien organisms, 2016). Contractors may also have internal guidelines to follow (Norwegian Public Roads Administation, 2016). In road projects, this handling is likely the most significant cause of the dispersal of alien species (Norwegian Public Roads Administation, 2016). At the same time, a survey of entrepreneurs in East and South-East Norway revealed that only a few of the queried businesses had knowledge of invasive species, and a significant portion of the companies were unfamiliar with the relevant laws on the subject. This survey was ordered by The Norwegian Environmental Agency some years after the construction of Lista WPP (Multiconsult, 2015).

Besides plants being spread by soil directly, increased accessibility of the area through access roads may increase the possibility of spread with humans or, e.g., dogs as vectors, seeds in animal feces or attached to fur/wool (*zookori*) (IBV, 2011). Roads are also known to act as corridors, in which seeds from wind-spread plants may travel “freely” without being stopped by vegetation or topography (Travers et al., 2021).

At Lista WPP, topsoil revegetation was partly used. However, there was not enough topsoil to cover all rock cuttings. Contractors gathered soil from a mire on the side of an access road, and spread this soil over cuttings (Flydal et al., 2012a). In addition, soil was gathered from a nearby farmland (Hallan, 2024).

1.3 Cervids

The knowledge foundation of how cervids are influenced by wind power is weak. For example, there are no peer-reviewed studies on how moose are influenced by wind power (Zimmermann et al., 2023). To the best of my knowledge, apart from the master theses of my predecessors, there exists only one study addressing the correlation of red deer habitat use, and one addressing roe deer stress levels, considering wind power. However, several studies investigate how wind power affects semi-domesticated reindeer (*Rangifer tarandus*).

Generally, we know wind power affects terrestrial animals in a few different ways. Wind power is quite area extensive, primarily due to the required network of access roads as mentioned above. First, this reduces habitat for wild animals. Second, this might also degrade or somehow influence the behavior of the animals in a larger part of the habitat, making animals avoid it. Construction of access roads increases availability in areas that historically had been relatively inaccessible to humans. Increased human activity is considered to be the most important negative effect on cervids (Helldin et al., 2012). Some studies have also reported avoidance corresponding with audio and visible disturbance from wind turbines in terrestrial animals (Barber et al., 2010; Łopucki et al., 2018; Skarin et al., 2018). However, studies have found disturbance, like road construction, creates edge vegetation profitable to ungulates like roe dear and red deer (Helldin et al., 2012; Saïd & Servanty, 2005). This would suggest increased use of habitat, as opposed to avoidance.

Several studies show adverse effects of wind power on birds and bats, both from death due to collisions, but also through habitat loss (Barrios & Rodriguez, 2004; Drewitt & Langston, 2006; Smallwood & Bell, 2020; Zimmerling et al., 2013). Avoidance of wind parks have been found for wolves (Ferrão da Costa et al., 2018) and hare (Łopucki et al., 2017). However, red fox show a natural, or even increased use of habitat after construction of wind parks (Łopucki et al., 2017; Sirén et al., 2017). For ground-dwelling species, there has been found significantly higher levels of stress hormones in badgers (Agnew et al., 2016) and common vole (Łopucki et al., 2018), but not in European hamster (Łopucki & Perzanowski, 2018) or striped field mouse associated with being in or near a wind park (Łopucki et al., 2018).

Several studies show roe deer avoidance of roads (Coulon et al., 2008; Hewison et al., 2001; Łopucki et al., 2017; Torres et al., 2011). Klich et al. (2020) found roe deer stress levels are enhanced in large (>1500 ha) wind farms (Klich et al., 2020). One study found that moose avoided forestry roads (Jiang et al., 2009), and another found that roads acted as a barrier (Bartzke et al., 2015). However, Torres et al (2011) found no preference in moose for/against areas with human disturbance (Torres et al., 2011). A study on Rocky Mountain Elk/Red deer showed that the construction and operation of wind turbines did not affect habitat use or nutrition (Walter et al., 2006). There is some debate if this is in fact the same species. Nomenclature differs between *Cervus canadensis* (Erxleben, 1777) and *Cervus elaphus* (Linnaeus, 1758) (CDFW, 2022). In semi-domesticated reindeer, scientists agree that wind power has a negative effect, but not on how and to what extent (Eftestøl et al., 2022). Some studies show no or minimal avoidance towards wind turbines (Colman et al., 2012; Colman et al., 2013; Colman et al., 2014; Tsegaye et al., 2017). Some studies have shown only small avoidance effects in construction phase of the wind power plant, with the effect decreasing after a couple of years (Colman et al., 2014). Other studies report significant and lasting avoidance of wind turbines (Colman et al., 2020; Skarin et al., 2018; Skarin et al., 2016; Supreme Court, 2021). Studies suggesting avoidance in terrestrial animals hypothesize this is due to continuous disturbance disrupting both audio (Barber et al., 2010; Łopucki et al., 2018) and visual detection of predators (Skarin et al., 2018; Skarin et al., 2016). Other studies suggest that avoidance of roads is connected to increased human activity due to new roads rather than the roads themselves (Colman et al., 2014; Coulon et al., 2008). The latter would mean avoidance would be greatest in the construction phase and then ease off, assuming that the roads do not lead to increased use of the area from the community.

1.4 Hypotheses

The need for fundamental research on the ecological consequences of wind power is very much present. This thesis will investigate how cervids and vegetation are affected by the establishment of a wind power park at Lista, in Southern Norway.

I hypothesize:

1. **a) The disturbed terrain (revegetated) will have a lower vegetation diversity than undisturbed terrain (control).**
   b) Introduced invasive species will, to some extent, have migrated into the undisturbed terrain. There will be a higher presence of introduced species in the disturbed terrain than in the undisturbed terrain.
   c) Construction of the wind park has contributed to the spread of alien species.

2. **a) Cervids avoid areas in close proximity (less than 100 m) to the access roads compared to before construction.**

   b) Moose is more sensitive towards the roads than roe deer and red deer.

   c) Avoidance was greater during construction phase than in operation phase.

2 Method

2.1 Study area

The Lista WPP lies southwest of Agder County in the south of Norway (*Figure 2*). Construction of the park started in 2011, and it was put into operation in December 2012. The developer was Fred. Olsen Renewables AS. The park is situated on the northern part of the Lista peninsula, and the turbines are scattered across hilly terrain, with the highest peak, Storfjellet, at 346 m.a.s.l.

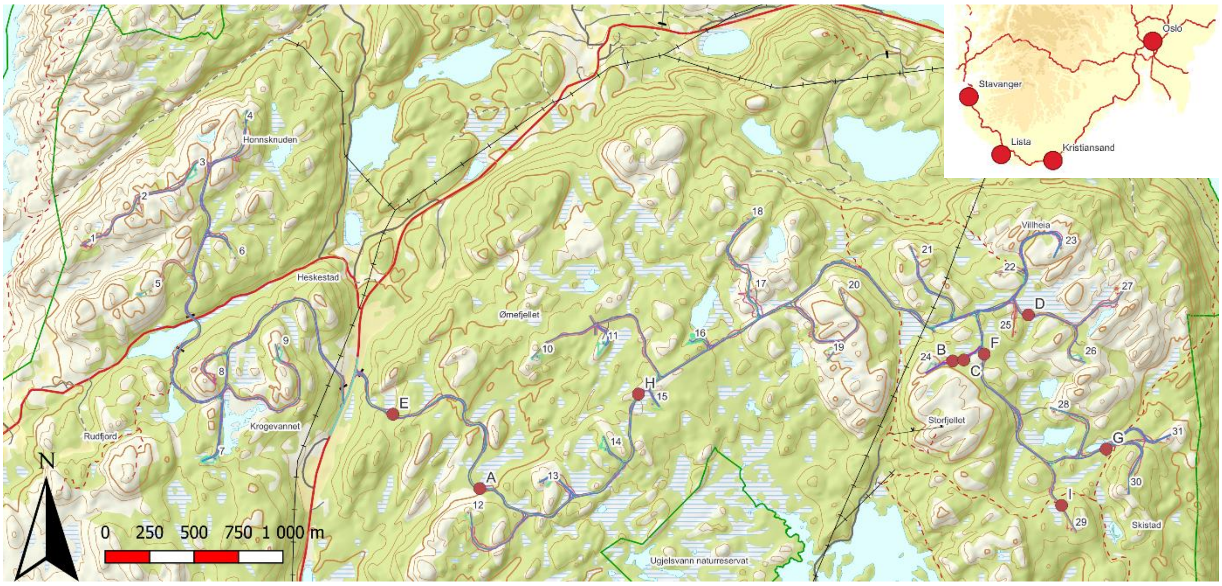

Figure 2: Map of study area with vegetation plots (A-I). Turbines represented by number-id. Access roads in grey (Kartverket, 2024).

The landscape consists of hills, some without vegetation at the hilltops, giving an impression of an alpine character despite not being that high above sea level. Several valleys go north-south, and some farms and agricultural land are in the surrounding landscape. The area is totally dominated by precambric bedrock, mainly granite and gneiss, creating an acidic topsoil and waterbeds. Climate in the region is suboceanic, namely the shift between west coast- and south coast- climate (Flydal et al., 2012b). The annual average temperature was 6,3-9,8 °C, and yearly precipitation was 783-1604 mm in the period 1991-2023 (Klimaservicesenter, s.a.). Cervid species in the area is moose (*Alces alces*), Red deer (*Cervus elaphus*) and Roe deer (*Capreolus capreolus*). The area is also used by grazing livestock; sheep (*Ovis aries*) and cattle (*Bos taurus*).

The park covers an area of 10 km² with an additional 22 km of approximately 5,5-meter-wide gravel roads (Selboe, 2019). In some sections, the roads are less than 5 m wide (Colman, 2024).

All areas where soil was added in connection to road construction were hydroseeded with a commercial seed mix *(Table 2)* first in 2012 and then again in 2013. The seed mix was approved by the NVE (Hallan, 2024). Naturrestaurering AS recommended Fred. Olsen Renewables not to hydroseeded park areas to ensure natural revegetation from local flora (reference species) – except for slopes particularly exposed to erosion (Colman, 2012). However, hydroseeding was imposed by the County Governor's Environmental Protection Department (Hallan, 2024). Hence, most of the areas were hydroseeded (Flydal et al., 2012a; Hallan, 2024) Landowners and the NVE's environmental inspection later believed this was unnecessary (Hallan, 2024).

Table 2: Content of seed mix used in hydroseeding (Hallan, 2024).

Species	Commercial name	Origin	Portion (%)
Festuca rubra (ssp. Communtata)	Olivia	Netherlands	25
Festuca rubra (ssp. Communtata)	Raisa	Netherlands	25
Festuca rubra (ssp. Rubra)	Leik	Norway	20
Festuca rubra (ssp. Rubra)	Frigg	Norway	20
Agrostis capillaris	Leikvin	Norway	5
Trifolium repens	Undrom	Sweden	5

2.2 Vegetation

The design for the vegetation study was developed by Léon and Høiland in 2013 (González-León, 2014) and corresponds to systematic sampling (Elzinga et al., 1998). Two transects were placed parallel to the road, one representing each treatment: revegetation and control (*Figure 3)*. Because cuttings and embankments are adapted to fit the landscape, intervention areas vary in width—hence, the distance from the road to the transects varies.

The nine sites (a-i) were within the wind park, all in the eastern part (*Figure 2*). Each site had four revegetated plots and four controls. In 2013 and 2015, only three sites were used, giving 24 plots. In 2019 and 2023, all nine sites were used, giving 72 plots. The survey was conducted using a 1x1m square, with string separating 25 smaller squares within, each making up 4% of

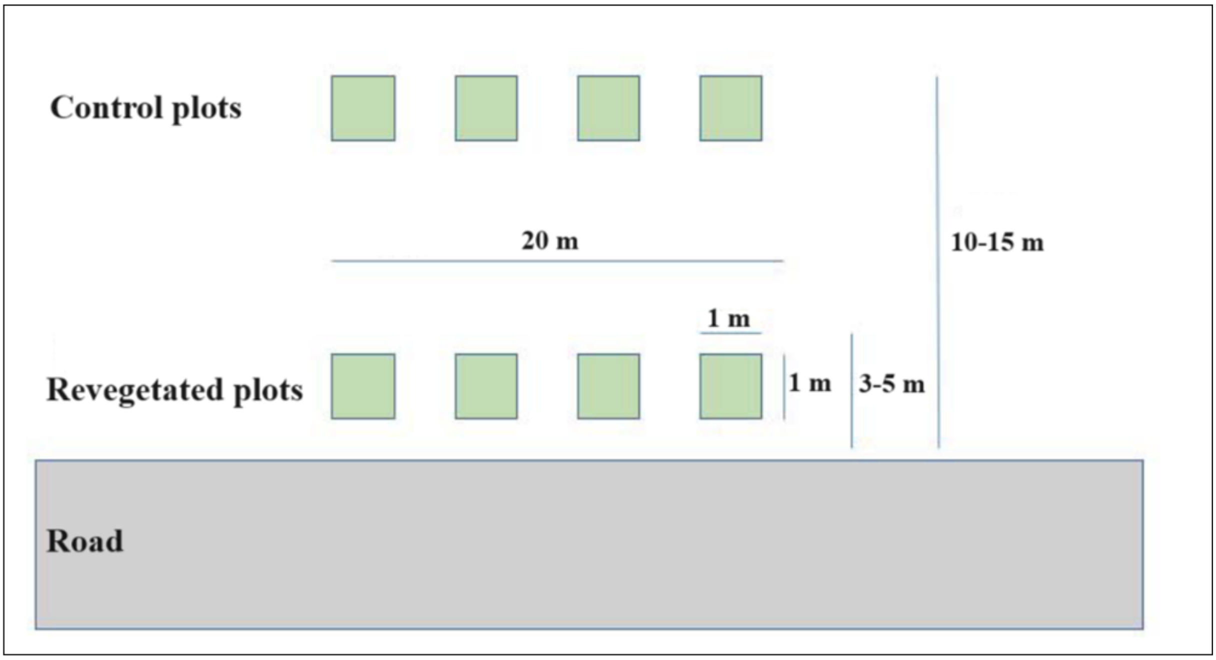

Figure 3: Transect design (Reksten, 2016).

the frame. In each plot, the foliar coverage for each occurring species was noted. Dead plants were not noted. Overhanging vegetation in the shrub layer was added. This means the total coverage in each plot could be >100%. This is the same method as Leon (2014), Reksten (2016), and Nygjordet (2020). Species were identified using *«Gyldendals store nordiske flora (2018), 3. edition by Lennart Stenberg & Bo Mossberg»* and uncertain observations were labeled and brought to botanist Klaus Høiland for identification.

2.3 Alien species

All alien species in vegetation plots were registered. The NBIS database was checked for registration of alien species in the project area before, during and after the construction. Fred. Olsen Renewables was also inquired about cases not registered in public databases.

2.4 Cervids

Cervid habitat use was sampled by counting fecal pellets along 34 predetermined transects placed in a north/sound and east/west grid system (*Figure 4*). This was designed and completed by Naturrestaurering AS and used in the preliminary examination in 2011 and following years.

Fecal pellet groups were recorded along the transects following a hand-held GPS (Garmin etrex 10) and separated by species. All fecal pellets within 1,5 meters to each side of the observers' feet were counted. The pre-designed transects varied in length, adding up to 15 km. They also varied in vegetation type, elevation, and distance from access roads and wind turbines. This is the same study design as my predecessors (Flydal et al., 2012b; González-León, 2014; Reksten, 2016; Selboe, 2019). I received no training before my fieldwork, which I completed alone. Instead, I was to photograph every scat so that uncertainties could be determined later. I identified species to the best of my ability in the field, and every scat was later crosschecked by

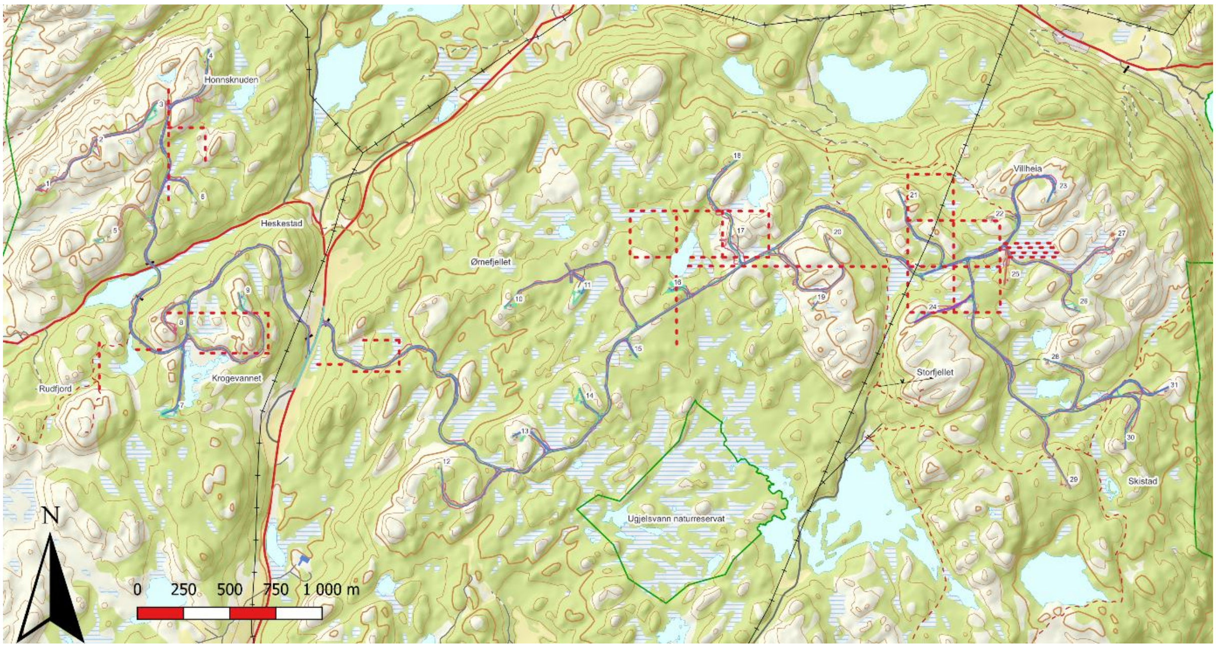

Figure 4: Scat transect lay-out. Thick red dotted line represent transects. Turbines are represented by number-id. Access roads in grey (Kartverket, 2024).

three experienced observers at NINA and Hjortesenteret separately (Hjorteviltsenteret, 2024; Tvete, 2023)

Initially, the plan was to compare my samples with data from preliminary investigations in 2011 and data collected from my predecessors. Distances from the scat to the nearest road and nearest turbine could be calculated in Qgis, and AIC models could be calculated to predict the likelihood of distribution for future scat for each of the study species. I could also have investigated the significance of vegetation type and year. However, I considered the quality of my data as too poor for analysis. Instead, I investigated the discrepancies in interpretations among observers cross-checking my observations. As a result, none of the hypotheses regarding cervids have been tested.

2.5 Statistical analysis

All statistical analyses were conducted using R 4.1.1 (R Core Team, 2021), using mainly the packages ‘vegan’(Oksanen et al., 2022), ‘tidyverse’(Wickham et al., 2019), and ‘ggplot2’(Wickham, 2016).

2.5.1 Vegetation

Field data collected in 2023 was organized in Excel version 2404 (Microsoft Corporation, 2024), together with previously registered data from León (2013), Reksten (2015), and Nyjordet (2019). Data from previous years were re-tested. However, in 2015, the study was extended from three plots (a-c) to nine plots (a-i). This extension was decided in the autumn, and plots d-i were sampled in October. For 2015, I only included data sampled in June (plots a-c). Data sampled in October 2015 (plot d-i) was discarded, but analysis of the complete dataset for this year (a-i) is included in appendix (*attachment 2*) to provide additional information.

Using the plant species foliar coverage data, the Shannon diversity index (H’) was calculated for each plot and pooled for each year using the ‘vegan’ package. Species richness was also calculated similarly for each plot and year.

$$H' = -\sum_{i=1}^{s} p_i \ln(p_i)$$

Where:
H’= the Shannon index value
p_i = the proportion of individuals found in the *i*th species
ln = the natural logarithm
s = the number of species found in the community.
The lowest possible value of H is zero. The higher a community’s H value, the greater the species diversity (Bowman & Hacker, 2021).

A linear interaction model was used to estimate the effect by year (with four levels: 2013, 2015, 2019 and 2023) and transect type (with two levels: control and revegetated) on plant species diversity (i.e., Shannon diversity index). A similar model was used to explain the variation in richness.

Reference species and introduced species are grouped separately. A linear interaction model was used to estimate foliar coverage in relation to control and revegetation and calculated the year for each group separately. In these models, area is used as a random factor to account for variations that area differences could cause.

A similar method to Nygjordet (2020) and Leon (2014) was followed. However, rather than restricting the analysis to species with foliar coverage ≥2%, all present species were considered. Additionally, the presence of introduced species was quantified, and changes over the years were investigated.

2.5.2 Cervids

Field data collected in 2023 was organized in Excel, together with previously registered data. No statistical analysis was performed.

2.5.3 Adequacy for models

All models have been tested for adequacy (see normal Q-Q plots in the appendix, attachment A). Models pertaining to species diversity, richness, and variation of foliar cover of reference species were found to be fairly adequate, demonstrating satisfactory performance. Few outliers were observed, which did not affect the model's performance much. However, the model for variation of foliar cover for introduced species was not normal, indicating poor performance. Thus, non-parametric statistics were used for this model, specifically using the Kruskal-Wallis test. Each transect (i.e., control and revegetated) was tested separately; see appendix (attachment A).

2.6 Maps

All maps were created in QGIS version 3.22.8-Białowieża (QGIS Development Team, 2009). Background map was provided by (Kartverket, 2024), and additional layers were constructed with data sampled in this project.

3 Results

3.1 Vegetation

Sampling conducted in 2023 found 31 different species across all surveyed plots, out of which 28 were native and three were introduced (*Table 3*). The number of unique species registered across control plots was 28, while the revegetated plots had 30 species. The pooled Shannon diversity index was greater in control plots than revegetated plots, 2.501 and 2.280 respectably.

Table 3: Summary of species richness, diversity, and cover from vegetation survey grouped by control or revegetated and year. The mean Shannon value is pooled for each year. Richness is the number of unique species in all plots of the same group. Cover numbers are means for each group in percent.

	Control				Revegetated			
	2013	**2015**	**2019**	**2023**	**2013**	**2015**	**2019**	**2023**
n	12	12	36	36	12	12	36	36
Richness (unique species)	28	30	43	28	9	17	44	30
Diversity (Shannon)	2.304	2.482	2.872	2.501	0.669	1.448	2.040	2.280
Cover introduced species (%)	<1	7	10	5	40	68	39	13
Cover reference species (%)	93	82	63	89	7	36	23	71
Total Cover (%)	93	89	73	93	47	104	62	84

3.1.1 Species richness

In 2013 and 2015 control had a higher number of unique species across all plots. In 2019 and 2023, revegetated was highest (*Table 3*). Looking at mean species richness, control plots had a higher value than revegetated plots in all years (*Figure 5*). This difference is significant in all years, except 2023. The difference between control and revegetated decreased each year.

Within control plots, species richness fluctuated between 2 and 16, but did not vary significantly among years, except for 2023 (*Figure 5; Table 4*). In 2023, however, species richness decreased significantly compared to other years.

Within revegetated plots, species richness fluctuated between 2 and 12. Compared to 2013, species richness increased significantly in the following years. However, it did not vary significantly from 2015 to 2023 (*Figure 5; Table 4*). Species richness decreased from 2019 to 2023, though not significantly.

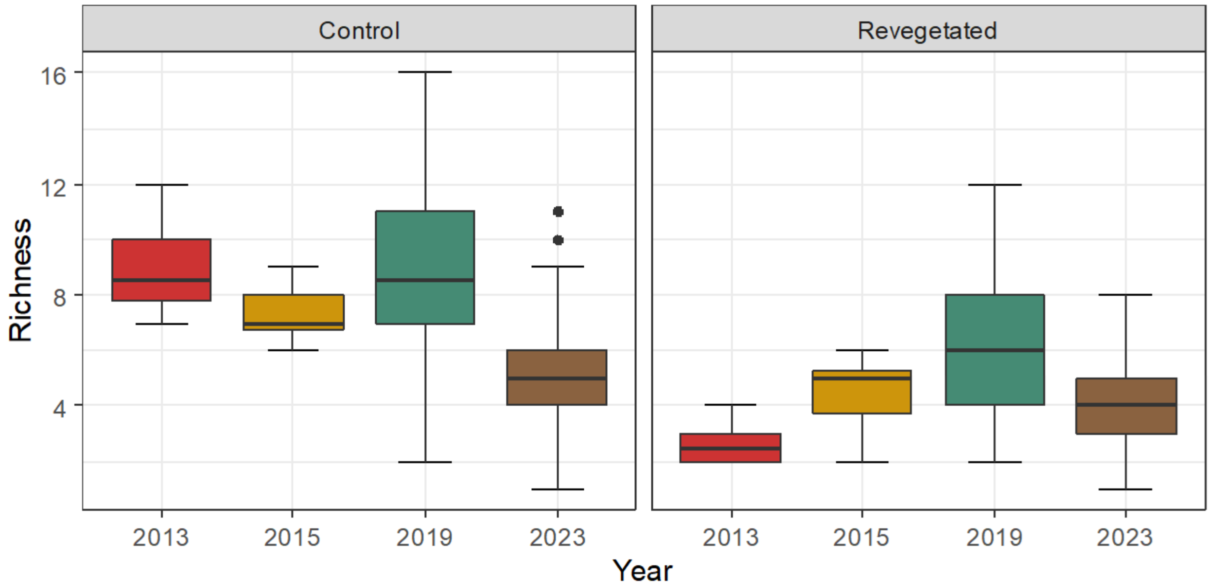

Figure 5: Mean species richness in relation to transect type across survey years.

Table4 4: Estimate of species richness in relation to transect type (revegetated or control) and year (2013, 2015, 2019, and 2023), analyzed with an interaction linear model. Control and 2013 were references for transect type and year categorical variables, respectively.

Effects	Estimate	SE	t-value	p-value
Intercept	8.917	0.645	13.82	< 0.001
Revegetated	-6.250	0.913	-6.85	< 0.001
2015	-1.583	0.913	-1.735	0.083
2019	-0.139	0.745	-0.186	0.852
2023	-3.500	0.745	-4.698	< 0.001
Revegetated x 2015	3.417	1.290	2.6477	0.008
Revegetated x 2019	3.389	1.054	3.2164	0.001
Revegetated x 2023	5.056	1.054	4.7982	< 0.001

3.1.2 Species diversity

In control plots, species diversity did not vary significantly between years, except for 2023, which showed a significant decrease compared to the previous survey years (Fig. 6; Table 5). In revegetated plots, diversity did not vary significantly between years, except for 2013, which had lower diversity compared to 2015 (Fig. 6; Table 5). Species diversity is significantly lower in revegetated plots compared to control plots in 2013 and 2015, but not in 2019 and 2023.

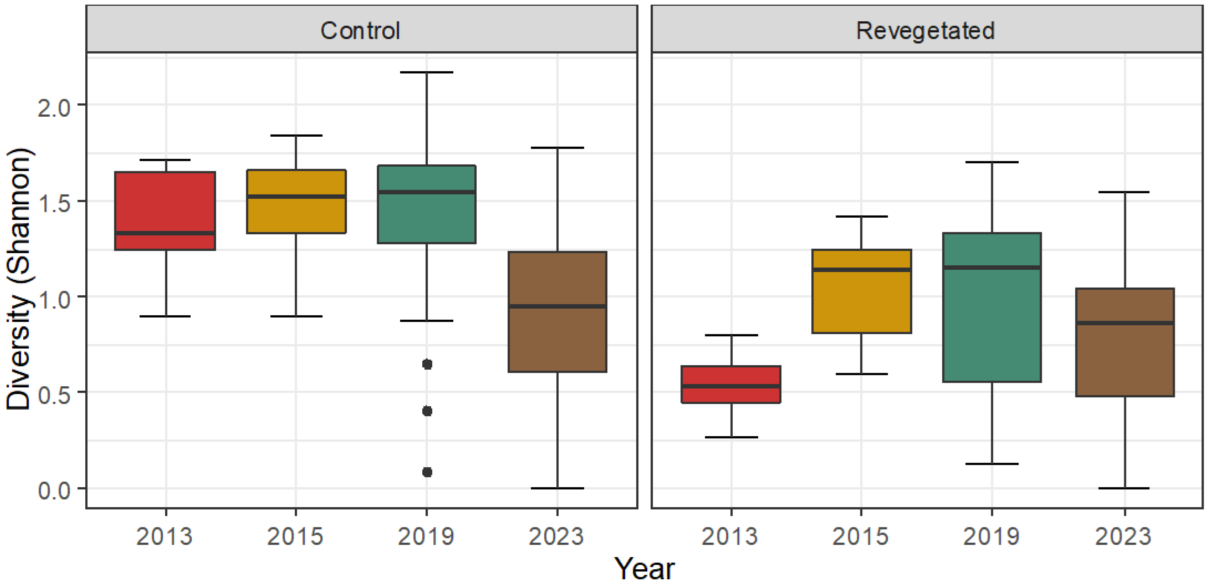

Figure 6: Species diversity (Shannon) in relation to transect type across survey years.

Table 5: Estimate of Shannon diversity in relation to transect type (revegetated or control) and year (2013, 2015, 2019, and 2023), analyzed with an interaction linear model. Control and 2013 were references for transect type and year categorical variables, respectively.

Effects	Estimate	SE	t-value	p-value
Intercept	1.366	0.115	11.894	< 0.001
Revegetated	-0.825	0.162	-5.080	< 0.001
2015	0.121	0.162	0.744	0.458
2019	0.079	0.133	0.594	0.553
2023	-0.410	0.133	-3.093	0.002
Revegetated x 2015	0.382	0.230	1.664	0.098
Revegetated x 2019	0.357	0.188	1.903	0.059
Revegetated x 2023	0.664	0.188	3.541	< 0.001

3.1.3 Coverage

In control plots, reference species are dominant all years (*Figure 7*). The introduced species were almost non-present in 2013 and increased in 2015 and 2019, while reference species coverage decreased. In 2023, introduced species decreased while reference species increased.

For the revegetated plots, total coverage in 2013 is considerably lower, summing to half that of control plots. Introduced species were most prominent in revegetated plots. Both introduced and reference species increase significantly from 2013 to 2015, and decrease significantly from 2015 to 2019. In 2023, reference species increased significantly, and introduced species decreased significantly, compared to 2019.

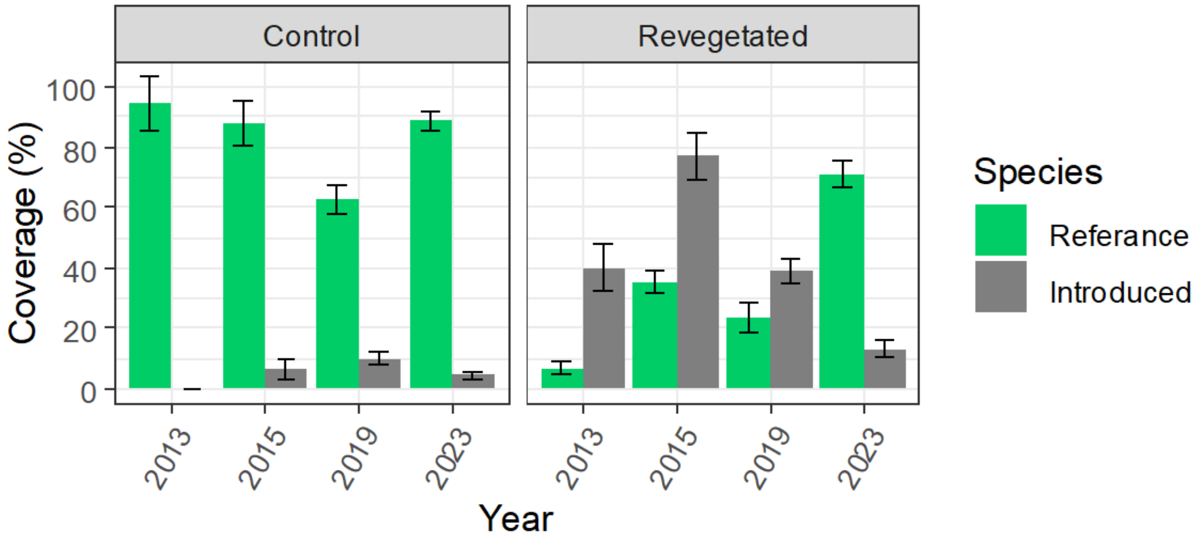

Figure 7: Coverage in percentage for reference and introduced plant species in relation to transect type across survey years.

3.2 Alien species

Sitka spruce (*Picea sitchensis)* and Lutz spruce (*Picea glauca x Picea sitchensis*) were found in vegetation plots. Sitka was also registered prior to construction, and so was white spruce (*Picea glauca*) (NBIS, 2023a). No other alien species were found in vegetation plots.

Narrow-leaved ragwort (*Senecio inaequidens*) was registered by turbine 29 in 2015 (NBIS, 2023b).

Inquiries with Fred. Olsen Renewables revealed Giant knotweed (*Fallopia sachalinensis*) was spread into the construction area using contaminated soil. This was later removed manually and using herbicides (Hallan, 2024)

All revegetated areas were hydroseeded with a seed mix containing 50% *F. Rubra (ssp. Communtata)* (*table 2*) which is defined as an alien subspecies (Hegre et al., 2023; NIBIO, s.a.-a).

3.3 Cervid

In 2023, 114 scats were counted in the transects, including scats known not to be cervid species (*Table 6*). Experienced observers viewing the photographed scat generally reported the task to be very challenging, some reporting it being much more challenging than they believed it would be.

Table 6: Observers categorization of scat. Highest number of observations per species in bold.

	Positive observation (%)	Moose (n)	Red Deer (n)	Roedeer (n)	Other (n)	Unknown/uncertain (n)
Observer 1	51	3	2	3	55	51
Observer 2	39	0	5	0	42	67
Observer 3	54	**16**	**20**	1	25	52
Field observer	37	5	12	**8**	17	72

In 19% of the cases, one observer would positively identify a scat as one species, while one or more other observers would positively identify the same scat as another species.

If we were to select the scat count for each species from the observer (including my field data) with the highest value for each cervid species, this would add up to 44 (*Figure 8*). This would be a significant decrease from 2019 and is significantly lower than all other years except 2013.

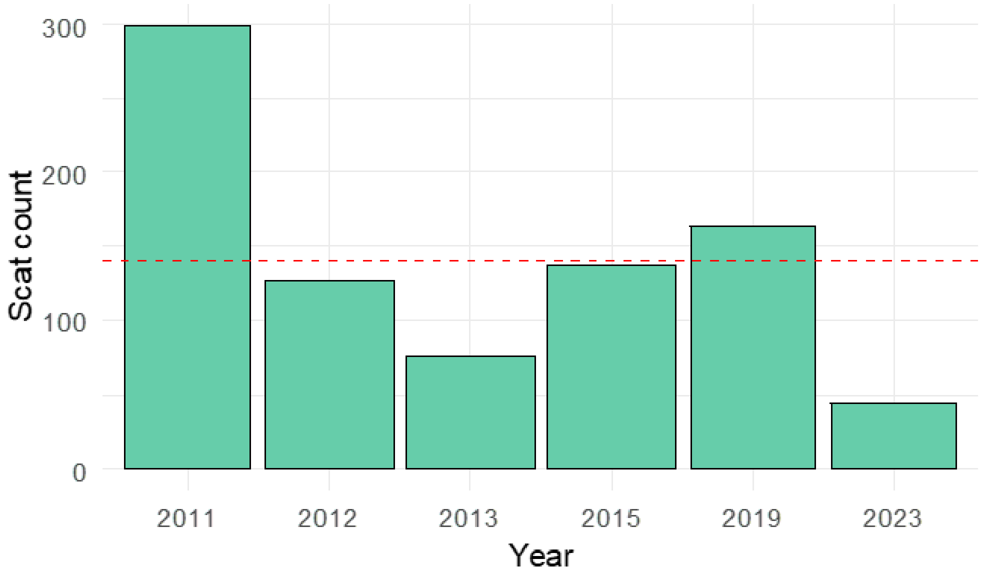

Figure 8: Number of cervid scats per year. The 2023 value is a "best-case" result; the value from the observer (including field) with the largest count for each cervid species is combined. Values other years is the sum of cervid scat used for statistical analysis in previous thesis. The red dotted line equals the mean for all years.

4 Discussion

4.1 Vegetation

4.1.1 Findings

Both Shannon diversity and mean richness was greater in control plots than in revegetated plots all years. However, the values in the two plot types were converging each year. This suggests the revegetated plots are becoming more similar to control plots, and that the disturbance effect of construction is diminishing each year. Also, a larger number of unique species was found across all revegetated plots than control plots. These findings all point to revegetated plots not having a lower vegetation diversity, rejecting the first hypothesis. The introduced species from the hydroseeded seed mix did in fact migrate into control plots. This confirms hyphotesis b. However, these species only covered a maximum mean of 10% and cannot be said to have expressed invasive properties (*Figure 7*). Figures from 2023 show introduced species are in decline in both plot types. This indicates a resilience towards the introduced species in the ecosystem. While the mechanisms behind ecosystem resilience are debated and not fully understood, resilience has been found to be positively correlated with species diversity (Tilman et al., 2006). Resilience will affect how quickly an ecosystem recovers after a major disturbance, like that at Lista. Rate of recovery has also been linked to the proportion of pioneer species present and post-disturbance climate stress (Hérault & Piponiot, 2018). A literature study of peer reviewed papers concerning restoration in riparian zones reported that there is a shortage of long-term monitoring programs following restoration efforts (González et al., 2015). In restoration projects in alpine spoil heaps in Norway, succession rates have been predicted through ordination (Rydgren et al., 2011). Rydgren et al (2011) predicts vegetation to be rather similar to vegetation pre-disturbance within 50 years after intervention, while stating this is an optimistic estimate. Compared to this, the rate of revegetation at Lista is far greater. However, this cannot be compared directly, as Lista is not in an alpine region and succession is likely to happen faster.

Findings must also be seen in light of the differences in disturbance between the two plot types. Generally, succession had progressed further in control plots than in revegetated plots. While revegetated plots mainly consisted of grasses and heather, control plots often presented trees and ferns. These dominated the control plots, decreasing light intensity to the understory. This might in part explain the lower number of unique species across all control plots.

4.1.2 Revegetation methods

In cases where it is desirable to maintain local flora, the Norwegian public road authorities consider topsoil-revegetation the best technique for revegetation (Norwegian Public Roads Administation, 2016). When erosion is an issue, this is often combined with hydroseeding commercial seeds, as vegetation stabilizes and binds topsoil (Norwegian Public Roads Administation, 2016) . Whether commercial seed is the best alternative is debatable. When the main objective is to control erosion, commercial species do not necessarily perform better than local seeds (Tormo et al., 2007). In cases where the main objective is to maintain reference flora while securing rapid revegetation, several studies suggest using locally harvested seed is best (Auestad et al., 2015; Bochet et al., 2010; Tormo et al., 2007). However, this has not been feasible due to availability and cost. The application of commercial seeds is a compromise - it secures rapid vegetation cover, while it is believed that the introduced species is too poorly adapted to the area and will diminish as local species outcompete them. Meanwhile, research on how well local species manage in these conditions diverges. Some studies show commercial species act as "nurse plants," retaining water, protecting seedlings from wind, and capturing wind-spread local seed – ultimately boosting local flora (Bayfield, 1996; Gretarsdottir et al., 2004). Others show no "nurse-plant"-effects, and ultimately negative effects on local flora (Aradottir & Hagen, 2013; Bochet et al., 2010; Hagen et al., 2014; Rydgren et al., 2016). At Lista, whether or not introduced species acted as nurse plants cannot be determined, as we have no control for this. This would have required a control area that was treated with top-soil revegetation, but not hydroseeded with commercial species.

Increasing demand and knowledge on the application of local seeds in the revegetation of both roadsides and more species-rich meadows have led to increased accessibility. The NIBIO branch at Landvik: *Norwegian Competence Center for Flower Meadows and Native Seeds* started to produce regionally adapted seeds of grasses and wildflowers for ecological restoration in 2008 and 2018, respectively. They conduct vegetation studies and propagate seed mixes adapted to different regions and soil types (NIBIO, s.a.-b). Retail prices on seed propagated for the Lista – region, suited for road revegetation, are about 2-4 times the price of commercial seed (Aamlid, 2024). Considering Botchet et al. (2010)'s cost analysis and the current competitive pricing of regionally adapted seeds, it's clear that the benefits of using them in future revegetation is eminent.

Results show that the sampled revegetated areas at Lista have regained their natural vegetation, with only a small and decreasing cover of introduced species. Whether or not hydroseeding of commercial species was the best solution is not easy to determine. However, it likely the seed mix used would not have been approved today (Aamlid, 2024). Since the WPP area would have been defined as an industrial development area, technically it would not have been illegal to disperse alien species as it normally would by the Biodiversity Act §30. However, today this might break with the duty of due diligence targeted by the Biodiversity Act. At the time, the chapter regarding alien species had not yet come into effect – this happened in 2014, after construction of Lista WPP (Biodiversityact, 2009).

Included in the WPP area is also a stretch of coastal heathland, now considered an endangered habitat (Hovstad et al., 2018), which was fragmented by construction. This is located at the southwest end of the park by turbines 7, 8, and 9 and was not fully registered until 2021 (Miljødirektoratet, s.a.) (*See figure 17 and 18 in appendix*, *attachment 3*).

4.1.3 Study design

Preliminary reports recommended using some areas that were not hydroseeded as references to surveil revegetation (Flydal et al., 2012a). However, none of these areas were used in vegetation studies later. This is regrettable, as a comparison might have shed light on the potential effects of seeding vs. natural revegetation.

In 2015, Reksten (2016) increased the number of vegetation plots from 24 to 72. This increases the precision and reliability of the dataset, in addition to giving greater statistical power for testing hypotheses and making the data more robust towards sources of error. However, sampling 24 plots in June and the remaining 48 plots in October, in my opinion, introduces a significant potential for error. Species develop at different paces depending on their phenology, even with the same climatic conditions. Quite a few species will have withered away by October, making them difficult to identify. Hence, comparing plots sampled under different circumstances according to the same rules does not make an accurate analysis. For this reason, I chose to exclude the data sampled in October from my dataset, enforcing all 72 plots as of 2019. Figures and tables based on all available plots for all years can be found in the appendix, attachment 2.

In retrospect, our models should also have included weather and climate effects. Studies have shown that climate is a crucial factor in revegetation measures both on a large scale and long-term (Dou et al., 2024; Harris et al., 2006; Huo et al., 2024; Sun et al., 2015; Wu et al., 2020), and on a small scale and short-term (Alday et al., 2009). We did not control for the effects of weather. This is an issue because changes in the data might actually be weather patterns masquerading as trends. For example, the trend in mean richness for revegetated plots suggests an increase in richness each year from 2013 to 2019 and then a decrease from 2019 to 2023. While in control plots, species richness is relatively consistent from 2013 to 2019 (although the variation in 2019 is extreme compared with other years), and then there was a decrease in 2023. This leaves the control and revegetated values for 2023 almost equal – suggesting that the two groups are getting more similar. However, this might be explained by ideal growing conditions in 2019 and drought conditions in 2023. Sampling of the plots was done between 30. June – 5. July for the years 2019 and 2023. In 2019, precipitation at Lista was at 116% and temperature +0,8 °C compared to mean conditions (mean of precipitation and temperature 1991-2020). June 2023 had precipitation of 48% and temperatures of +2,3 °C of the mean (Norsk Klimaservicesenter, s.a.). This suggests that conditions for vegetative growth in June 2019 were ideal, which might explain the increase in richness for both groups. In 2023, the conditions for vegetative growth were harsh, which may have contributed to a decrease in species richness for both groups – suggesting a trend in which they are getting more similar.

4.2 Alien species

Sitka spruce and white spruce were already registered in the area prior to construction. Lutz spruce was not, but is a hybrid of the two. Construction of the wind park may have influenced dispersal of seed though changed topography and hydrology, as well as redirection of wind hitting turbines, however, this influence might work both for and against dispersal and effects are most likely minimal. In comparison, construction of access roads might have had a significant impact on alien conifer populations. Both during and after construction, access roads have been utilized for logging. Forestry in these areas would not have been profitable without roads, and potential removal would have been without an economic incentive. Sitka spruce is known to have great negative impacts on biodiversity in coastal areas of Norway (Nielsen, 2023; Saure et al., 2013; Vandvik et al., 2023). In this way, if construction of access roads led to increased removal of Sitka spruce, it may have contributed to biodiversity in a positive way. However, logging is also a major potential source of seed dispersal as the seeds may be spread by forestry machines.

Narrow-leaved ragwort was not registered in the area prior to construction and the individual was 4,7 km away from the nearest observation (Kommunekart, s.a.; NBIS, 2023b). The plant is poisonous to grazing animals and can be fatal. It also transfers to the animal's milk and is carcinogenic to humans. The plant produces many seeds and is known to spread by wind along roads (Alm et al., 2023). It's likely that the plant either spread in this manner, in the soil during construction, or with a vehicle or human as vector. Though this is difficult to test, it's very likely that the spread of Narrow-leaved ragwort was a direct result of wind park construction.

Giant knotweed was unquestionably spread as a direct result of wind park construction (Hallan, 2024). The species is known to be especially difficult to remove, have a very high invasion risk and adverse ecological consequences (Skarpaas et al., 2023).

The introduction of alien species is undoubtedly a significant societal issue and is identified as one of the main drivers behind the biodiversity crisis (IPBES, 2023; Purvis et al., 2019). Wind power is typically developed in areas that are initially more or less unaffected by humans, and thus unaffected by alien species. Hence, wind power construction acts as a dispersal front for alien species into previously pristine nature.

4.3 Cervid

The initial method of identifying cervid scat in the field with limited prior experience yielded data with a very low level of confidence: only 37% of observations were identified with confidence, while 63% of observations were categorized as uncertain (*Table 6*).

The backup solution of using experienced observers to identify scats by photograph also provided low confidence. First, observers were only confident in 39 – 54% of the cases. Second, in cases they were confident in, they disagreed with at least one other observer in 19% of the cases. For example, one observer was certain of cattle, while another was certain of moose.

The best-case scenario for the number of observed scat from cervid species is 44 (*figure 8*). Distributed among three species, this would not have provided sufficient statistical power to predict anything.

4.3.1 Skepticism towards data

Habitat use calculated from strip transect method analysis has shown to correlate well in control studies with GPS (Persson, 2003). However, surveys based mainly on indirect observations, like scat surveys, have been criticized for various reasons (Cortázar-Chinarro et al., 2019). The main critique has centered around flawed species identification (Davison et al., 2002; Harrington et al., 2010), alongside a lack of validation against population abundance and the failure to consider imperfect detection (Rhodes et al., 2011).

Scat surveyes conducted by non-expert personnel have shown to yield sufficiently reliable data, given proper training and following the same protocol (Newman et al., 2003). However, my predecessors followed the initial method and were alone in field identification. As of 2013, observers were master students. There was no overlap besides an oral method description – no protocol of characteristics to check for. "*I believe this is species A*" is not very replicable without a standardized set of characteristics defining said species scat. The lack of pre-field calibration with previous observers accounts for an inconsistent method and poor inter-observer reliability, weakening the confidence of the dataset (Bateson, 2021; Cortázar-Chinarro et al., 2019). To establish a solid knowledge base for governance, studies should be conducted in a manner that provides high-resolution data suited for spatial usage analysis, such as GPS. If studies rely primarily on visual identification of scat, a subsample of observations could be crosschecked with DNA- analysis, to build a confusion matrix. Then one could use that information to support or weaken one's inferences from the study (Bischof, 2024).

The visibility of scats might also differ according to the season. The scat transects experiment was carried out in March/April 2011, May 2012, June 2013, July 2015, May 2019, and October 2023. This is not ideal, as different seasons may offer different extents of vegetation cover. Scat decomposes faster in higher temperatures and precipitation, and visibility negatively correlates with more abundant undergrowth (Persson, 2003). As with vegetation surveys, conducting experiments at consistent times annually is advisable to minimize random effects. Cervid scat is more consistent in winter, and identification would be much easier. In addition, livestock would not have been in the area, eliminating a major source of error. While snow cover would have made combining the scat with tracks possible, fresh snowfall or melting and freezing snow could cover the scat. Using the '*SeNorge*'- database, historical data from the last ten years suggest the ground in Lista would have had <25mm snow cover by March and bare ground by April (SeNorge, s.a.). Studies should have been conducted at the same annual time, ideally March/April.

Several of this year's observers expressed they belived they would be more certain had they been in the field themselves. However, experience from NIBIO has shown that differentiating scat by species in the field can be tricky, even for experienced observers. In 2009, Bioforsk (now NIBIO) identified species from scat using mitochondrial DNA (mtDNA). The samples were identified as brown bear (*Ursus arctos*) in the field and were to be identified and tested for relatedness as part of the national program for monitoring populations of large carnivores. They found that only 58% of the sampled scat from Norway was indeed from bears. A corresponding sampling from Sweden had 78% bear DNA (Eiken et al., 2010). In 2010, 68% of Norwegian samples were bears. (Tobiassen et al., 2011). They also tested samples for mtDNA from moose, badger (*Meles meles*), raccoon dog (*Nyctereutes procyonoides*), reindeer, fox (*Vulpes vulpes*), and sheep. Laboratory manager at NIBIO, Ida Fløydalen, states, "*From our experience, species identification done in the field cannot be granted high confidence, especially if the observer isn't regularly cross-checked by a lab. It's important to address uncertainty in these cases, as we often see deviations between observed species in the field and corresponding DNA.*" (Fløydalen, 2024). The divergence between field identification and mtDNA- identification in this example is severe – as the observers made mistakes between species with entirely different diets: carnivores, omnivores, and herbivores. In our case, discrepancies among observers were mostly between two herbivore species.

Furthermore, it may be challenging to differentiate wild game from domestic animals when they share the same grazing areas during the summer and have similar diets (Tvete, 2023). The shape and texture may vary depending on what the animal has eaten, its gender, and its overall condition. Often, when wild game and grazing domestic animals overlap or border in habitat usage, the scat is differentiated by the context it is found in rather than just the properties of the scat. For example, cattle scat is often found where the ground is trampled (Tvete, 2023; Wam, 2024). Several studies have shown moose and cattle habitat use seldom overlap (Herfindal et al., 2017), however scat found in the transition of these habitats may be difficult to differ.

Spatial extent of suitable habitats for wild herbivores can differ between years, suggesting that a multi-year control period may be necessary for establishing habitat use baseline (Muposhi et al., 2016).

4.3.2 Recommendations for future studies

1) To minimize sources of error, scat transect surveys should be conducted in early spring. The same time, each year.

2) For a comparative study, consistency in data sampling is critical. Before conducting such a study, the observer should receive adequate training and use a standardized protocol used by all observers of said study (Bateson, 2021; Cortázar-Chinarro et al., 2019).

3) A subsample of scat should be cross-checked with DNA to establish a confusion matrix.

4) In addition, pre-construction habitat use should be registered over a course of several years, as one year of control-data may not be representative.

5 Conclusion

Results of this thesis show species richness and diversity in revegetated areas is converging with reference areas, twelve years after disturbance. Introduced species are in recession, but still inhabit both control and revegetated areas. A limitation with this study is that weather data is not included in the analysis. The construction of Lista WPP directly resulted in spread of alien species, while its infrastructure has increased the potential for alien species invasion in the future. However, it also facilitated removal of Sikta spruce.

The method for testing changes in cervid habitat use had substantial weaknesses, making data unsuitable for analysis. Inquiry of this method revealed major discrepancies between experienced observers. This underlines the importance of calibration between observer and questions the reliability of studies based solely on scat observations without crosschecking for DNA.

A review of available literature indicates that we still know very little about how cervids are affected by wind power. With land-based wind power being one of the most relevant sources of green power for the future; large-scale, high-resolution studies should be conducted to investigate how cervids habitat use is affected. This knowledge is essential to avoid fueling the biodiversity crisis while addressing the climate crisis.

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7 Appendix

Attachment 1: Adequacy for models

Diversity model

Estimate of species richness in relation to transect type (revegetated or control) and year (2013, 2015, 2019 and 2023), analyzed with an interaction linear model. Control and 2013 were used as reference for transect type and year categorical variables, respectively.

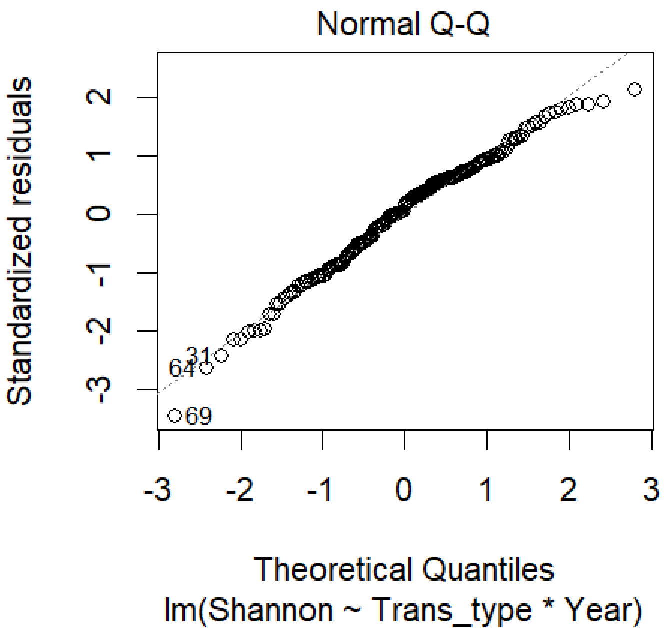

Figure 5: Normal Q-Q-plot for diversity model

Richness model

The estimate of species richness in relation to transect type (revegetated or control) and year (2013, 2015, 2019, and 2023), analyzed with an interaction linear model. Control and 2013 were references for transect type and year categorical variables, respectively.

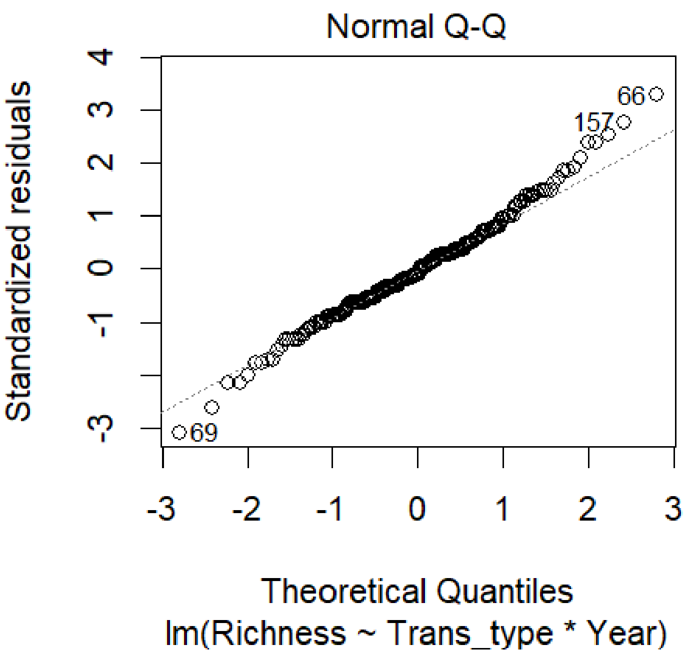

Figure 6: Normal Q-Q-plot for Richness model

Models for variations in foliar cover for referance and introduced species.

Reference species model

```
lm(formula = Referance ~ Trans_type * Year, data = mixed_data)

Residuals:
    Min      1Q  Median      3Q     Max 
-66.014 -15.076   0.868  12.323  89.819 

Coefficients:
                               Estimate Std. Error t value Pr(>|t|)    
(Intercept)                      94.250      7.268  12.969  < 2e-16 ***
Trans_typeRevegetated           -87.583     10.278  -8.522 5.57e-15 ***
Year2015                         -6.167     10.278  -0.600 0.549246    
Year2019                        -31.569      8.392  -3.762 0.000226 ***
Year2023                         -5.292      8.392  -0.631 0.529100    
Trans_typeRevegetated:Year2015   34.750     14.535   2.391 0.017822 *  
Trans_typeRevegetated:Year2019   48.333     11.868   4.073 6.90e-05 ***
Trans_typeRevegetated:Year2023   69.639     11.868   5.868 2.02e-08 ***
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Residual standard error: 25.18 on 184 degrees of freedom
Multiple R-squared:  0.5593,	Adjusted R-squared:  0.5425 
F-statistic: 33.35 on 7 and 184 DF,  p-value: < 2.2e-16
```

Interpretation: The variation in foliar coverage for reference species can be explained by the factor year in 2019 and Transtype for both factors. As well as the interaction between Transtype and the years 2019 and 2023. This model has been shown to be adequate through the Kruskal test.

The observations mostly fit along the regression line of this model. There are few outliers, but the model is fairly satisfactory.

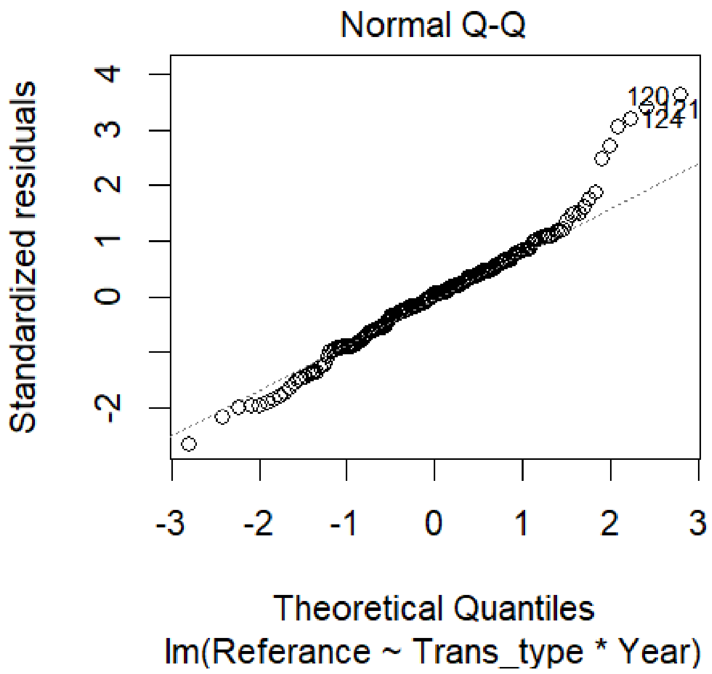

Figure 7: Normal Q-Q-plot for foliar coverage, referance species

Introduced species model

```
lm(formula = Introduced ~ Trans_type * Year, data = mixed_data)

Residuals:
    Min      1Q  Median      3Q     Max 
-52.167  -9.038  -3.382   5.229  71.667 

Coefficients:
                               Estimate Std. Error t value Pr(>|t|)    
(Intercept)                      0.1667     5.1613   0.032 0.974274    
Trans_typeRevegetated           40.0000     7.2991   5.480 1.38e-07 ***
Year2015                         6.4167     7.2991   0.879 0.380493    
Year2019                         9.8056     5.9597   1.645 0.101614    
Year2023                         4.3611     5.9597   0.732 0.465243    
Trans_typeRevegetated:Year2015  30.5833    10.3225   2.963 0.003452 ** 
Trans_typeRevegetated:Year2019 -11.1389     8.4283  -1.322 0.187941    
Trans_typeRevegetated:Year2023 -31.2917     8.4283  -3.713 0.000272 ***
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Residual standard error: 17.88 on 184 degrees of freedom
Multiple R-squared:  0.5689,	Adjusted R-squared:  0.5525 
F-statistic: 34.69 on 7 and 184 DF,  p-value: < 2.2e-16
```

Interpretation: The variation in foliar coverage for introduced species explained by year and transect type. There is a significant positive correlation between the higher introduced species' foliar coverage and Trans_type Revegetated. There is also a significant correlation with interaction between Revegetated and 2015 and 2023. +

This model does not fulfill model adequacy requirements. Therefore, we used a non-parametric test for the control and revegetated transects separately, as explained in the method.

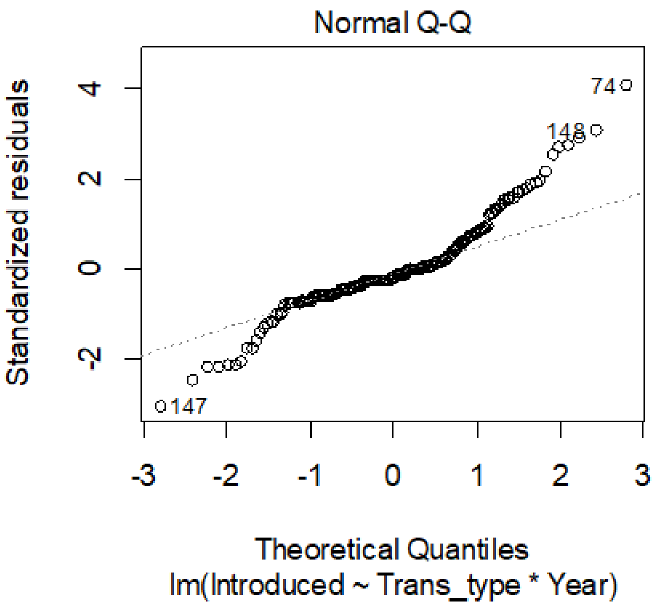

Figure 8: Normal Q-Q-plot for foliar coverage, introduced species.

```
data:  mixed_data_control$Introduced and mixed_data_control$Year

     2013   2015   2019
2015 0.0019 -      -
2019 0.0019 0.5547 -
2023 0.0426 0.1895 0.0501
```

Kruskual test for control

```
kruskal.test(Introduced~ Year, data =mixed_data_control)

        Kruskal-Wallis rank sum test

data:  Introduced by Year
Kruskal-Wallis chi-squared = 15.79, df = 3, p-value = 0.001252
```

Pairwise test result for the control:

```
     2013   2015   2019
2015 0.0019 -      -
2019 0.0019 0.5547 -
2023 0.0426 0.1895 0.0501
```

Kruskual test for revegetated:

```
kruskal.test(Introduced ~ Year, data =mixed_data_revegetated)

        Kruskal-Wallis rank sum test

data:  Introduced by Year
Kruskal-Wallis chi-squared = 41.504, df = 3, p-value = 5.111e-09
```

Pairwise test result for revegated:

```
data:  mixed_data_revegetated$Introduced and mixed_data_control$Year

     2013    2015    2019
2015 0.00505 -       -
2019 0.95252 0.00037 -
2023 0.00074 7.7e-06 1.9e-05
```

Attachment 2: Analysis when all samples (a-i) from 2015 are included.

Table 2: Key numbers from vegetation survey grouped by transect type and year. The mean Shannon value is pooled for each year. Cover numbers are means for each group in percent.

	Control				Revegetated			
	2013	**2015**	**2019**	**2023**	**2013**	**2015**	**2019**	**2023**
n	12	36	36	36	12	36	36	36
Richness	28	38	43	28	9	25	44	30
Shannon Diversity	2.254	2.712	2.872	2.501	0.669	1.968	2.040	2.280
Cover introduced species (%)	<1	7	10	5	40	68	39	13
Cover control species (%)	93	82	63	89	7	36	23	71
Total Cover (%)	93	89	73	93	47	104	62	84

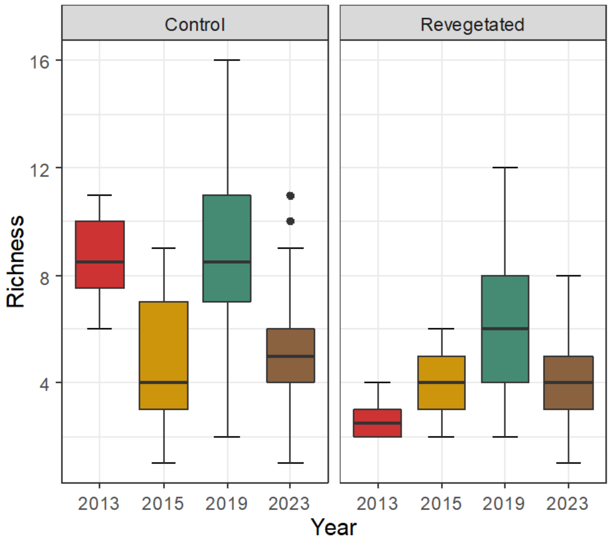

Figure 9: Richness grouped by year and transect type

Table 3: Species richness in light of transect type (Revegetated or control) and year (2013, 2015, 2019, and 2023). Analyzed with a linear model. Reference is the year 2013, and transect-type control

Effects	Estimate	SE	t-value	p-value
Intercept	8.917	0.633	14.082	<0.001
Revegetated	-6.250	0.896	-6.980	<0.001
2015	-4.167	0.731	-5.699	<0.001
2019	-0.139	0.731	-0.190	0.849
2023	-3.500	0.731	-4.787	<0.001
Revegetated x 2015	5.556	1.034	5.373	<0.001
Revegetated x 2019	3.389	1.034	3.278	0.001
Revegetated x 2023	5.056	1.034	4.889	<0.001

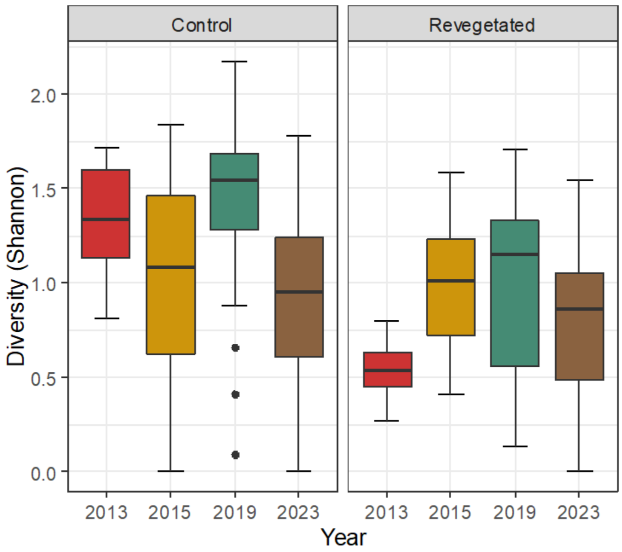

Figure 10: Diversity grouped by year and transect type

Table 4: Shannon diversity in light of transect type (Revegetated or control) and year (2013, 2015, 2019, and 2023). Analyzed with a linear model. Reference is the year 2013, and transect-type control

Effects	Estimate	SE	t-value	p-value
Intercept	1.366	0.1184	11.544	<0.001
Revegetated	-0.825	0.1367	-4.931	<0.001
2015	-0.306	0.1367	-2.239	0.026
2019	0.079	0.1367	0.577	0.565
2023	-0.410	0.1674	-3.002	0.003
Revegetated x 2015	0.746	0.1933	3.860	<0.001
Revegetated x 2019	0.357	0.1933	1.847	0.066
Revegetated x 2023	0.664	0.1933	3.436	<0.001

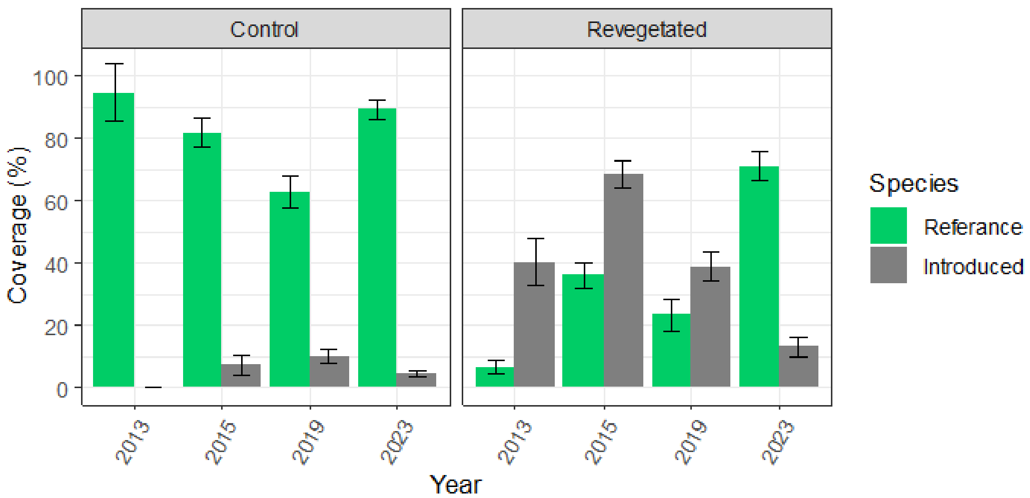

Figure 11: Coverplot with including all plots (a-i) for all years.

Attachment 3: Additional maps

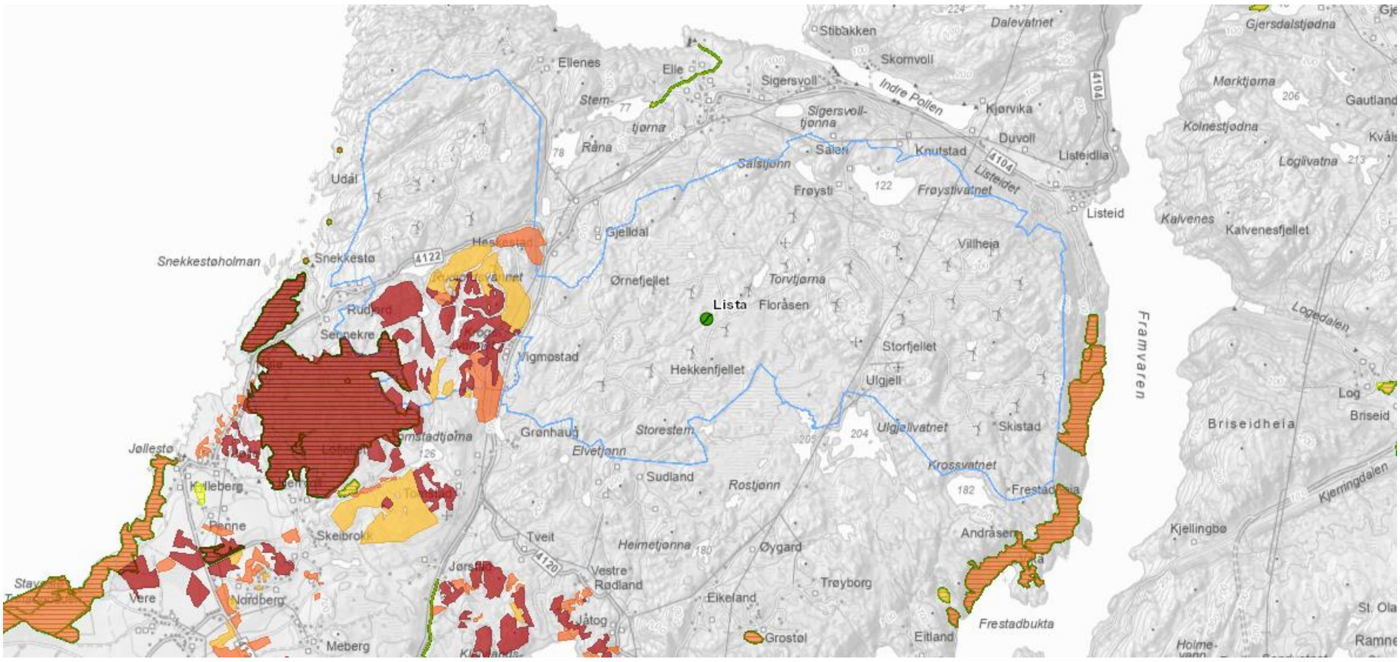

Figure 12: Map of consession area (blue line) and areas with nature considered valuable. Intermediate value is yellow, high value is orange, very high value is red.

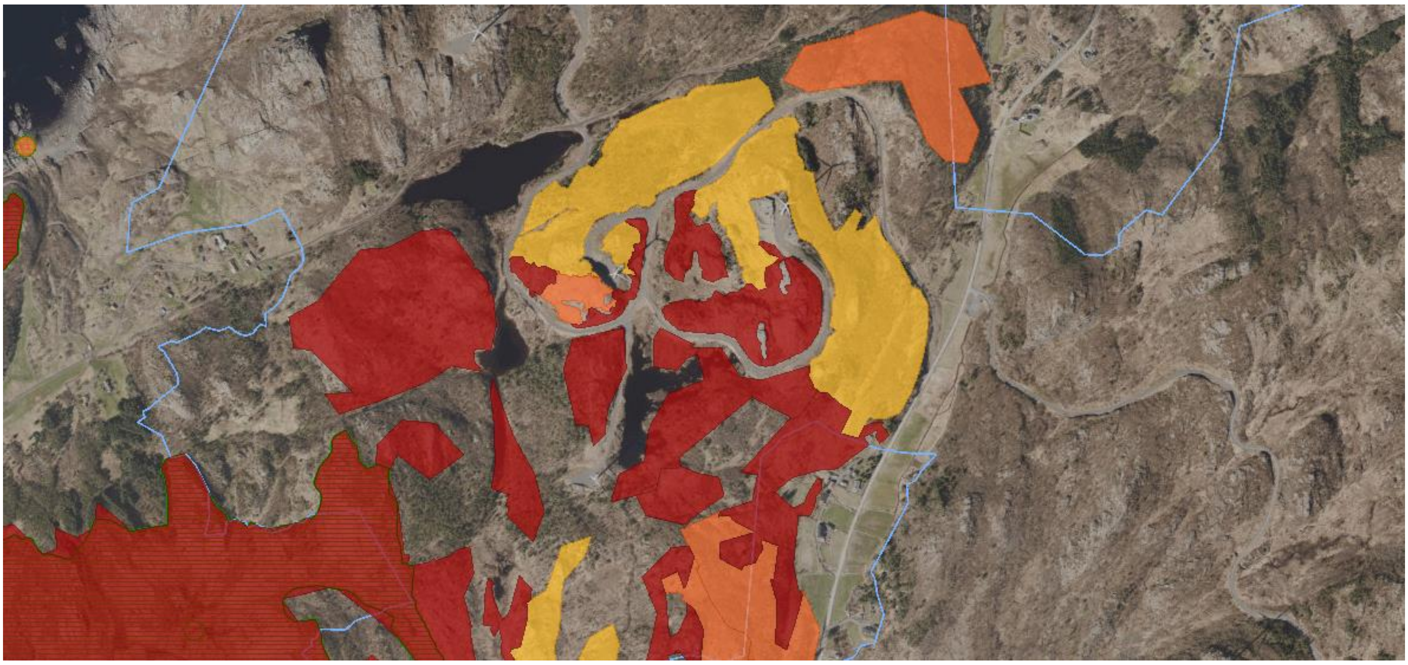

Figure 13: Arial photo of turbine 7,8 and 9. Areas with nature considered valuable. Intermediate value is yellow, high value is orange, very high value is red

Attachment 4: Statements from Vest-Agder county governor.

Fylkesmannen i Vest-Agder

Saksbehandler: Tor Kviljo
Tlf.: 38 17 66 78

Deres ref.: 25.05.2005 *Vår dato: 10.08.2005*
Vår ref.: 2003/8195 *Arkivkode: 563*

Norges vassdrags- og energidirektorat
Postboks 5091 - Majorstuen
0301 Oslo

Lista vindpark – høring av søknad og konsekvensutredning

Etter vurdering av foreliggende søknad om bygging av vindmøllepark på Lista, har Fylkesmannen kommet til at anlegget landskapsmessig vil komme i vesentlig konflikt med den helhet av internasjonalt og nasjonalt sjelden og verneverdig natur som Listahalvøya utgjør. Fylkesmannen frykter de negative virkninger vindparken kan få for fugletrekket, og registrerer at virkningene av støy fra vindmøllene vil redusere verdien av indre Lista som turområde så vel som for hytteeiere og beboere.

Fylkesmannen vil derfor sterkt fraråde Norges Vassdrags- og Energidirektorat å gi konsesjon til Norges Miljø Energi – Sør for bygging av Lista vindpark.

Ut fra en samlet vurdering av konsekvensutredningens behandling av viktige tema som landskapspåvirkning, støy og friluftsliv, er det Fylkesmannens vurdering at konsekvensutredningen ikke gir et korrekt bilde av utbyggingens virkninger på nasjonalt vernet og verneverdig natur-/kulturlandskap og friluftsområder.

Det vises til Norges Vassdrags- og Energidirektorats oversendelse av 25. mai d.å., vedlagt søkad og konsekvensutredning fra Norsk Miljø Energi Sør AS for Lista vindpark.

Sak:
Norsk Miljø Energi Sør AS, heretter kalt NMES, har søkt om tillatelse til å bygge vindpark på Listahalvøya. Søknaden omfatter et anlegg på inntil 32 møller og inntil 102 MW installert effekt. Med relevant møllestørrelse kan en anleggshøyde på 125 meter være aktuell (80m tårn + 90m rotor).

Fylkesmannens rolle:
I søknader om bygging av anlegg i medhold av energiloven, representerer Fylkesmannen ikke konsesjonsmyndighet, men statlig myndighet på regionalt nivå innenfor miljø, landbruk, sivilt beredskap m.m. I saker som berører vindmølleanlegg for energiproduksjon, vil miljørelaterte spørsmål være den dominerende delen av Fylkesmannens ansvar. Ikke minst vil dette gjelde på Lista, hvor omfanget av vernede landskap og naturtyper er blant det høyeste i landet. Fylkesmannen vil også påpeke at man gjentatte ganger har bedt statlige myndigheter ta skritt for å få til en helhetlig satsing m.h.p. vindmølleutbygging. Dette ut fra det forhold at

Besøksadr. Tordenskjoldsgate 65 E-post postmottak@fmva.no
Postadr. Serviceboks 513, 4605 Kristiansand Hjemmeside http://www.fylkesmannen.no/va
Telefon 38 17 66 00 Telefaks 38 17 60 13 Org.nr. NO974 762 994 Bankgiro 7694.05.01381

vindmøllene kan gi et positivt bidrag til energibalansen samtidig som de har til dels store negative virkninger på landskapsverdiene. Dette gjør at deler av Norskekysten vil være uegnet for denne typen utbygging grunnet andre interesser, eksempelvis landskaps- og naturverninteresser, mens man i andre deler av landet med sannsynlighet vil kunne gjennomføre utbygginger med sammenliknbar økonomiske gevinst, men med mindre skader på nasjonale naturverninteresser. Fylkesmannen ser således positivt på vindkraftutbygging når denne er gjennomført og lokalisert på en slik måte at skadevirkning på viktige allmenne interesser er på et akseptabelt nivå. Fylkesmannen ser Direktoratet for naturforvaltnings (DN) nystartede prosjekt: "*Sammenliknende konfliktvurdering av omsøkte vindkraftverk*" som tegn på at behovet for en slik helhetsvurdering nå følges opp. DN har anmodet om å få konfliktvurdert foreliggende utbyggingsplan på Lista som del av konfliktvurderingsprosjektet.

<u>Foreliggende planer:</u>
Det foreligger planer om å bygge i alt inntil 34 vindmøller på nordre del av Listahalvøya. Planområdet for anlegget utgjør 15 kvadratkilometer. Planområdet utgjøres av klipper og fjellområder med stort innslag av hedelandskap, mye spor etter eldre tiders bruk og derav stort innslag av fornminner, men meget små innslag av moderne tekniske inngrep.

<u>Planområdet og tilgrensende arealer i forhold til allmenne interesser:</u>

Listahalvøya utgjør i Norsk målestokk en unik helhet av verdifulle natur- og landskapstyper, og brukes blant annet som studieområde av universitet og høyskoler. Den store variasjon i nasjonalt verdifulle naturområder, kulturlandskap med høy tetthet av viktige kulturminner, internasjonalt verneverdige biotoper med mange truede og sårbare arter og regionalt viktige friluftsområder, gjør at Fylkesmannen vurderer landskapsverdiene på Listahalvøya som allmenne naturinteresser av internasjonal verdi. Bakgrunnen for en slik helhetsvurdering fremgår under.

I vest grenser planområdet mot Listastrendene landskapsvernområde. Med utpreget dramatisk natur med bratte klippeformasjoner og åpent hav som viktigste randelement, utgjør dette landskapet en vesentlig kontrast til rullesteinsstrendene i sør og sandstrendene i sørøst. Betydelige innslag av til dels godt bevarte kulturlandskap og bygningsmasser øker opplevelses- og verneverdien av det som en gang representerte den karrigste delen av Listakysten. Bebyggelsen og kulturlandskapet ved Vigan, Utdal og på Rudjord er viktige eksempler i denne sammenhengen. Disse er beliggende til dels i direkte nærhet til vestre del av planlagt anlegg. Snekkestø – havnen nedenfor Rudjord, er svært mye brukt turområde for utfart mot dette klippeområdet, herunder Vonnestien. Tilsvarende er skiltet tursti til Vigan og Varnes festning mye brukt turområder med meget stor opplevelsesverdi grunnet landskapets karakter. Planen viser vindmøller i umiddelbar tilknytning til heiområdene rundt disse stedene med de virkninger på opplevelsesverdien av fjellnatur som derav kan forventes.

Indre del av planlagt vindmøllepark dekker det særpregede men karrige hedelandskapet. Her er det mye spor av bosetting fra tidligere tider. Heiegårdene her oppe var blant de fattigste på Lista, og gårdene på Skistad ble tidlig forlatt ved utvandringen til Amerika. Heia og Andråsen ble fraflyttet senere, og Ulgjel, som er eneste av dem med veiforbindelse, var senest bebodd. Området er derfor preget av kulturhistoriske spor og er et mye brukt turområde, med merkede løyper og kart, med avgang fra Eitland (via Andråsen – Heia – Skistad – Trøyborg) og fra Ulgjel.

Framvaren er p.t. under verneplanarbeide som eneste foreslåtte marine verneområde i Vest-Agder. Fjorden har særlige verneverdier vannkjemisk sett, og har særpreget natur med innslag av landskapselementer som er uvanlige i de sørlandske fjorder – loddrette klippevegger, store rasvifter og et generelt mer dramatisk landskap enn det man er vant til. Listeid har kulturhistorisk betydning blant annet gjennom sin viktighet som ferdselsåre, herigjennom et båtdrag som har vært benyttet i over tusen år, og som er i drift også idag. Fjorden er i det alt vesentligste skånet for tekniske inngrep, og et verneverdig veianlegg (Bøensveien) og til dels historisk bebyggelse i Frestadvika og på Listeid utgjør noen av de få innslagene i et ellers intakt fjordlandskap. Bøensbakkane/Bøensveien er nasjonalt verneverdig og nylig rehabilitert vei-kulturminne som nyter stor popularitet som turområde og som i tillegg er valgt til kommunens kulturminne.

Listastrendene er i sin helhet* vernet som naturvernområde med varierende og til dels overlappende verneformål og utgjør et sammenhengende 30 kilometer langt verneområde. Landskapsvern, fuglefredningsområde og plantefredningsområde er alle i bruk på deler av strendene. Deler av området inngår i RAMSAR-område som internasjonalt vernet fugleområde.

I tillegg til Listastrendene er Rauna sjøfuglreservat, Nesheimvann, Kråkenesvann, Prestvannet, Straumen naturreservat, Listeid naturreservat, Ulgjel myrreservat, Havnehagen naturreservat m.m. vernet i medhold av naturvernloven. Det siste tilskuddet, Slevedalsvann naturreservat, ble vernet i 2005.

Kyststrekningen fra Lista fyr – Vest-Lista til Varnes og kysten inn til Listeid – Framvaren ble av Fylkesmannen i sin tid meldt inn som forslag til Natur-Arv område, dvs. internasjonalt verneverdig naturlandskap.

Verneverdiene og allerede etablerte naturreservat og landskapsverneområder understreker at Listahalvøya utgjør det mest verdifulle av alle naturområder som er å finne på Sørlandskysten. Det eksisterer så vidt vites heller ingen andre områder i Norge som har sammenliknbar tetthet og variasjon i nasjonalt til internasjonalt verneverdig natur og naturreservater. De ovennevnte naturvernområdene dekker også en stor gradient – fra Listastrendene landskapsvernområder med virkeområde fra 6 meters sjødyp, og opp til Ulgjel myrreservat (200m.o.h.) som er beliggende i kanten av vindmølleområdet oppe på fjellet. Ulgjelsvann er dessuten del av Nesheimvassdraget – varig vernet i Verneplan IV for vassdrag.

<u>I forhold til andre vindparkplaner:</u>
Fylkesmannen er gjennom foreliggende meldinger og søknader kjent med at det foreligger planer for flere andre vindparker i Vest-Agder. Det skal i denne sammenheng ikke underslås at Lista antakelig utgjør det området i Vest-Agder hvor konfliktene med allmenne interesser vil være størst. Det Fylkesmannen er gjort kjent med av andre planforslag og idèskisser tilsier at det foreligger grunnlag for vindparker i Vest-Agder med vesentlig lavere konfliktnivå enn det en vindpark på Listalandet vil utgjøre.

*Borhaug havn er eneste del av Listastrendene som ikke er vernet – i egenskap av fiskerihavn og industrirelatert område.

Vurdering av foreliggende konsekvensutredning:
Som det fremgår av foregående, så utgjør landskapsbildet et meget viktig grunnlag for Listaområdets verdi som nasjonalt viktig og vernet natur- og kulturlandskap. I vurdering av foreliggende vindmølleplaner er da også virkningene på landskapet helt sentralt i Fylkesmannens vurdering av konsekvensene av anlegget.
De enkelte delområder og verdivektinger:

Natur- og friluftsliv:
Vi registrerer at konsekvensutredningen fremstiller skadevirkningene av den omfattende mølleutbyggingen på indre del av Lista – på det høyereliggende hedeområdet, som ”*middels negativ*”. Fylkesmannen kan som statlig fagmyndighet ikke gi sin tilslutning til denne vurderingen. Landskapet er slik det fremstår i dag i det alt vesentlige forskånet for tyngre tekniske inngrep. Området er preget av varierte kulturhistoriske spor og er et mye brukt turområde. Ødegårdene på Skistad og gårdene på Ulgjel er beliggende i direkte tilknytning til møllene, Ødegårdene Heia og Andråsen ligger en kilometer til to unna nærmeste mølle. Alle gårdene og nærområdene til disse (typiske turmål) er derved i direkte eller sterkt påvirket sone for vindmøllene. Fylkesmannen vil påpeke at det vanskelig kan oppfattes som annet enn en *sterkt negativ endring* i dette landskapet når man etter en eventuell utbygging finner det åpne hedelandskapet massivt påvirket av et større antall 125 meter høye vindmøller.

At skadevirkningene av bygging av det omfattende nettet med drifts- og anleggsveier som behøves vurderes til *Liten negativ konsekvens* er tilsvarende noe Fylkesmannen må si seg sterkt uenig i. Verditapet fra det som i dag fremstår som et kulturhistorisk rikt hedelandskap avgrenset av heier og kystklipper uten tekniske inngrep av betydning, vil etter Fylkesmannens vurdering være omfattende og negativ.

Tilsvarende er det vanskelig å oppfatte hvordan konsekvensutredningen kan fremstille konsekvensene av vindmøllene på strekningen Jølle – Varnes som *ubetydelig/ingen*. I dette klippepregede landskapet - Listastrendene landskapsvernområde - vil møllene virke på sitt mest fremmedgjørende. Som utreder bør være kjent med, så er det fra høydragene i dette området at utsikten og naturopplevelsen er sterkest, og hvor virkningene av store vindmøller på fjellryggene i umiddelbar nærhet vil fremstå som sterkest og mest negativt. Bebyggelsen og kulturlandskapet ved Vigan, Utdal og på Rudjord er viktige eksempler i denne sammenhengen. Disse er beliggende til dels i direkte nærhet til vestre del av planlagt anlegg.

Snekkestø – havnen nedenfor Rudjord, er et svært mye brukt turområde for utfart mot dette klippeområdet, herunder Vonnestien. Tilsvarende er tilrettelagt og skiltet tursti til Vigan og Varnes festning mye brukt turområder med meget stor opplevelsesverdi grunnet landskapets karakter. Konsekvensutredningen har fastslått liten/ingen konsekvens for disse områdene. Dette er en konklusjon som bare gjelder om man forutsetter at besøkende og turgåere kun oppsøker selve punktene Vigan og Varnes festning, og ikke beveger seg ut i terrenget rundt disse. Som alle turgåere som har brukt Vest-Lista vil være kjent med, så bruker turgåere både gamle ferdselsstier og oppsøker kulturlandskap og høydrag. Herfra vil man oppleve direkte innsyn til de vindmøller som planlegges bygget på heiområdene på Vest-Lista – med de vesentlige og negative virkninger på opplevelsesverdien som derav følger. Ut fra dette er konsekvensutredningens vurdering av virkningen av utbyggingen for den kyststrekningen som liten/ingen konsekvens for friluftsliv, ikke i samsvar med vår vurdering.

Framvaren er foreslått som eneste marine verneområde i Vest-Agder. Fjorden har særpreget natur med innslag av landskapselementer som er uvanlige i de sørlandske fjorder – loddrette klippevegger, store rasvifter og et generelt mer dramatisk landskap enn det man er vant til. Fjorden er for det alt vesentlige fri for tekniske inngrep med unntak av bebyggelse i Frestadvika og på Listeid, og utgjør et storslagent landskapsrom. Bygging av vindmøller på fjellene på vestsiden av fjorden vil endre dette vesentlig. Dette fremgår også av bildene i KU 6.4 og 6.5, som klargjør at et større antall møller vil være synlig fra Bøensveien – nasjonalt vei-kulturminne og meget viktig turmål, så vel som fra fjorden. Fra Log, eneste veiforbindelse inn til fjordens sentrale østside – vil tilsvarende et stort antall møller bli synlige. Ut fra denne klargjøringen av vindmøllepåvirkning på Framvarenområdet synes det for Fylkesmannen lite beskrivende når konsekvensutredningen fastslår at utbyggingen har *lite negativ virkning* på Framvarenområdet for friluftsliv og ferdsel.

Det må også stilles et spørsmålstegn ved utreders vurdering av *uvesentligheten* av at Listalandet/flat-Lista endres fra et kulturlandskap med naturlige heier i bakgrunnen – til et kulturlandskap hvor bakenforliggende heier preges av en serie på 30 stykk 125 meter høye vindturbiner, jf. utredningens pkt. 6.1.5.

Støyforurensning fra møllene:
Anleggsarbeidene er i liten grad redegjort for, men det sier seg selv at bygging av et så stort antall meget tunge konstruksjoner på heidrag og inne i hedelandskapet, vil medføre en anleggsperiode med omfattende maskinstøy og tungtransport. Anleggsperioden er angitt til en varighet på ca. 1.5 år.

Ut over støyforurensning i anleggsperioden, en belastning som i vesentlig grad må forventes å forringe bruksverdien av de berørte naturområdene, så vil vindparken representere en kilde til kontinuerlig støy i et område hvor tekniske inngrep og støy i det alt vesentlige er fraværende. Erfaringer fra vindmøller annensteds i Vest-Agder, viser at støyen som genereres fra disse kan være til sjenanse ut over de avstander som ellers måle- og modelleringsverdier skulle tilsi. Vindskyggeeffekt – effekten av at fritidsbebyggelse og bolighus ligger slik skjermet i terrenget at det ikke er noen gevinst å hente fra bakgrunnsvindstøy – gjør at negative virkninger fra vindmøllene ikke skal neglisjeres. Fylkesmannen finner i denne sammenhengen at søkers beregninger som viser at i alt 63 bygninger kan få hørbar støy (35 – 40 dBA) eller støynivåer over 40 dBA ved fremherskende vindretning, som et urovekkende høyt tall. Når man legger til at de bebyggede områdene ofte sammenfaller med utgangspunkt for rekreasjon og turgåing, så betyr det at støybelastningen vil ha negative virkninger for naturopplevelsen i dette området så vel som for beboere og hytteeiere.

Virkninger på dyrelivet:
Listalandet utgjør viktig trekkorridor for sørtrekkende rovfugl så vel som andre grupper større fugl. Disse har som del av sin atferd å bruke betydelige landarealer både til samleområde mens de venter på gunstige overflygingsforhold, og som stigeområder for å benytte thermic/oppvinder for å skru seg opp til stor høyde før de slipper seg ut over havet. Stigeområdene kjennetegnes ved at det typisk er avgrensede arealer med mørk vegetasjon, dvs. arealer med tett barskog omgitt av annet, lysere landskap/vegetasjon. Her danner soloppvarmingen kraftige luftheiser som fuglene benytter. Dette finnes lite av slike barskogsområder på Flat-Lista, men derimot i stor grad i heidragene inn mot planlagt vindmøllepark. Tilsvarende områder og trekkmønster finner man forøvrig på Skagen (Danmark) som er samlepunkt for nordgående trekk, og Falsterbo (Sverige) som er samlepunkt for sørgående trekk i østlig korridor. Lista, Falsterbo og Skagen utgjør tre av de viktigste (flest passeringer – stort antall arter) trekkfuglområdene i Skandinavia. Ingen av disse områdene har pr. i dag vindmølleparker, men Skagen har noen ytterst få enkeltmøller av

gammel type og liten størrelse, ikke i noen grad sammenliknbare med omsøkte 2-3 MW/125 meter høye installasjoner. Erfaringene om hvordan rovfugl og andre større trekkfugl eventuelt vil forstyrres av en massiv oppbygget vindmøllepark slik det her søkes om er derfor sparsomme, men det er grunn til å frykte at møllene kan utgjøre et forstyrrende element i kraft av vindparkens omfang, størrelse og plassering så vel som i egenskap av barriere for inntrekket nordfra.

Avbøtende tiltak
Foreliggende forslag om avbøtende tiltak kan lokalt avhjelpe skadevirkningene ved at enkeltmøller tas ut av planen. Det er imidlertid ugjørlig å etablere vindmøller på denne delen av Lista uten betydelig skade på landskapsverdiene, så effekten av avbøtende tiltak vil være meget begrenset i forhold til de overordnede allmenne naturinteressene av nasjonal verdi som påvirkes negativt.

Fylkesmannens sammenfattende vurdering:
Ut fra ovennevnte vurderinger av foreliggende planer og basert på allerede eksisterende, dokumenterte og vel kjente nasjonale og internasjonale verneverdier på Listahalvøya, lokalt- og regionalt viktige tur- og friluftsområder, er det Fylkesmannens vurdering at Lista vindmøllepark ikke kan etableres uten at det er til vesentlig skade for store miljøverdier. Viktige områder hvor vindmølleparken vil medføre skade på allmenne interesser til natur – friluftsliv – kulturlandskap m.m. er:

- Vesentlig forringelse av verdien av det eksisterende landskapsvernområdet på Vest-Lista

- vesentlig reduksjon av friluftslivsverdi/opplevelsesverdi av kyststrekningen på Vest-Lista og viktige grender i dette området

- vesentlig reduksjon av rekreasjonsverdien av hedelandskapet sentralt på Lista som naturområde og kulturminnerikt landskap

- vesentlig reduksjon av det i dag teknisk meget lite påvirkede landskapsrommet i foreslått marint verneområde Framvaren og nasjonalt vei-kulturminne og turområde Bøensveien

- redusert verdi av Lista som en naturmessig helhet, i dag bestående av teknisk ubrutt natur- og kulturlandskap fra variert ytterste kystsone, via et mangfoldig kulturlandskap med et heiebelte som overgangssone mot klippe- og hedelandskapet nord og vest på Lista.

- Uavklarte men sannsynlige virkninger i forhold til Lista som særdeles viktig trekkområde for rovfugl og andre fuglearter.

- Støy både i forhold til friluftsområder, boligområder og hytteområder der hvor det i dag ikke finnes industriell bakgrunnsstøy av betydning

Konklusjon:
Fylkesmannen vil sterkt fraråde Norges Vassdrags- og Energidirektorat å gi konsesjon til NMES for bygging av omsøkte Lista Vindpark. Dette ut fra den betydelige skade på allmenne natur- og friluftsinteresser som anlegget vil medføre. Mindre justeringer m.h.p. mølleantall vil ikke formå å endre denne helhetsvurderingen.

Utbygging av vindmøllepark på Lista utgjør en energiutbygging som etter Fylkesmannens vurdering ikke står i forhold til det store offer som må gjøres på viktige miljøverdier.

Fylkesmannen anbefaler at foreliggende konsekvensutredning for Lista Vindpark ikke godkjennes. Dette ut fra KU's fastsetting av konsekvenser (KU tabell 6.1) for utbyggingens virkning på bl.a. vernede områder som Fylkesmannen anser for ikke å være i tråd med de faktiske forhold.

Ann-Kristin Olsen

Tom Egerhei
miljøverndirektør

Kopi til:
- Farsund kommune, Pb. 100, 4552 FARSUND
- Vest-Agder Fylkeskommune, NSK, avd., her
- Direktoratet for naturforvaltning, Tungasletta 2, 7485 TRONDHEIM

Fylkesmannen i Vest-Agder
Miljøvernavdelingen

Saksbehandler: Tor Kviljo | *Deres ref:. 06.08.2003* | *Vår ref.: 2003/8195* | *Vår dato: 08.10.2003* | *Arkivnr: 563*

Norges vassdrags- og energidirektorat
Postboks 5091 - Majorstuen
0301 Oslo

Melding om planlagt vindpark på Lista

Det vises til Deres brev av 6. august d.å., vedlagt melding av 4. juni s.å. om planlegging av Lista vindmøllepark.

Sak:
Norsk Miljø Energi Sør AS har oversendt melding og forslag om konsekvensutredningsprogram (KU) for en vindpark på 90 MW lokalisert på nordre og vestre del av Lista i Farsund kommune.

Innledende betraktninger:
Fylkesmannen er positiv til etablering av vindmølleparker til fordel for bærekraftig produksjon av fornybar energi. En grunnleggende forutsetning for en samfunnsmessig riktig vindmølleparketablering, må imidlertid være at de samlede ulempene av utbyggingen er vesentlig mindre enn fordelene ved tiltaket. Vesentlighetsbetingelsen dekker de svakheter vindenergi har i forhold til el-produksjon fra magasinbasert vannkraftverk. I forhold til sistnevnte vil vindkraftutbyggingen generelt ha høyere utbyggingskostnad kombinert med manglende magasineringsmuligheter og lav produksjon i ekstreme kuldeperioder (inversjonsperioder). En grundig gjennomført konsekvensutredning og søknadsfase bør imidlertid gi grunnlag for vekting av disse forholdene.

Behandling:
Meldingen behandles hos Fylkesmannen av miljøvernavdelingen. Det er foretatt intern høring i embetet av planen og KU-programmet.

Planområdet:
Planlagt vindmøllepark omfatter to felt på høydragene som preger nordre del av Listalandet. Vestre felt omfatter et frittliggende klippemassiv nord for Rudjord, østre og største felt et sammenhengende hei- og skogplatå sentralt på Nord-Lista. Det østre feltet er beliggende grensende inn til Vest-Lista landskapsvernområde, og inkluderer arealer som er en del av dette meget karakteristiske kystklippelandskapet. Østre felt grenser mot Ulgjel og Storefjell – høyereliggende skog og hedelandskap med enkelte gårder og mange spor etter tidligere tiders bruk. Begge områdene er i dag i naturtilstanden og i liten grad skadet av tekniske inngrep. Dette understrekes av at østre planområde dels overlapper og dels grenser mot de to siste gjenværende INON (inngrepsfrie Naturområder I Norge) områdene som er igjen på Lista-halvøya. INON-områdene er begge i kategori 2: områder mer enn 1 kilometer fra tyngre tekniske inngrep. Etablering av vindparkene vil ta ut hhv. vesentlig redusere disse to områdene siden avstand til tekniske inngrep blir dramatisk redusert.

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Dagens bruk:
Planområdene er i dag i særlig grad i bruk til friluftsliv og annen rekreasjon. Det vestre området er del av det mest dramatiske av Lista-naturen: klippekysten i vest. I vest er Snekkestø – Utdal området som viktig turområde, og i nord Varnes krigskulturminneområde og Vigan naturområde – begge mye besøkte og med stor opplevelsesverdi. Østre planområde grenser i sør mot Ulgjel – vernet vassdrag og mange rester av tidligere bosetting. Gjennom mangeårig vel-utbygget turstinett med inngang fra Eitland, Ulgjel, Trøyborg og Frøysti er dette høydraget i stor grad tatt i bruk som turområde. De gamle drifteveiene tilhørende ødegårdene Andråsen, Frestadheia og Skistad gir god adgang inn i hedelandskapet på indre Lista og derved inn mot og til planområde øst. Turstiene mot Frøysti dekkes av planområdet for østre vindmøllepark da dette i nord går helt bort til Frøysti gårdene.

Tiltakets påvirkningsområde:

Visuelt:
Meldingen angir at vindturbiner med tårnhøyde 80 meter og rotordiameter på 80 diameter for en samlet høyde på 120 meter, vil være naturlig installasjoner. Med 2,5 MW generatorer vil 36 turbiner være anslagsvis utbyggingstall for en vindpark på 90 MW. På grunn av at Listalandet stiger jevnt fra sør til nord, og grunnet at veier, bosetting og infrastruktur i hovedsak er lokalisert til søndre del av Lista, vil især vindturbinene i det vestre planområdet være meget godt synlig fra bebyggelse på Vest-Lista. Den spredte bosetningen som preger indre del av lista – hvor oppdeling av gårder har gitt opphav til små grender, gjør at en rekke smågrender vil komme en kilometer eller mindre fra vindparkområdene. Dette gjelder eksempelvis Vigmostad, Ellenes, Elle, Tomstad, Rudjord og Sennekre, Heskestad, Frøysti og Sigersvoll. For disse områdene kan – avhengig av vindturbinplassering m.m., det visuelle inntrykket fra vindmølleparken bli meget betydelig. Østre vindmøllepark vil forventelig bli et fremmedartet og godt synlig anlegg sett fra Framvaren. Framvaren er en naturskjønn og tilnærmet urørt fjord som gjennom straumen og kontakt mot Farsund er tilgjengelig og populær som turområde/båtutfartsområde også for mindre fritidsbåter. Framvaren er under planlegging som marint verneområde.

Støy:
I Lindesnes kommune har Fjeldskår vindmøllepark nylig vært underlagt konsesjons-behandling ihht. forurensningslovens bestemmelser om støy. Konsesjonsbehandlingen er foranlediget av at støyen fra vindturbinene her stedvis har vært betydelig mer merkbar enn forventet. Dette skyldes forventelig i stor grad at bebyggelsen har vært plassert i vindskygge, slik at kamuflerende vindsus ikke har oppstått. Støyen fra vindmøllene har derved blitt oppfattet langt sterkere enn det støyberegningene skulle tilsi.

Tilsvarene topografisk tilpasset bebyggelse gjør seg gjeldende også på det kuperte vest- og nordre Listalandet. Det er følgelig all grunn til å forvente at støyforhold vil måtte klarlegges ut fra at berørte eiendommer og områder befinner seg i vindskyggeområder. Det må derfor forventes at utredning av støyvirkningene vil gi resultater som vil bli svært viktig for vekting av om vindturbinene bør bygges eller ei.

Dagens bruk:
Planområdene er i dag i særlig grad i bruk til friluftsliv og annen rekreasjon. Det vestre området er del av det mest dramatiske av Lista-naturen: klippekysten i vest. I vest er Snekkestø – Utdal området som viktig turområde, og i nord Varnes krigskulturminneområde og Vigan naturområde – begge mye besøkte og med stor opplevelsesverdi. Østre planområde grenser i sør mot Ulgjel – vernet vassdrag og mange rester av tidligere bosetting. Gjennom mangeårig vel-utbygget turstinett med inngang fra Eitland, Ulgjel, Trøyborg og Frøysti er dette høydraget i stor grad tatt i bruk som turområde. De gamle drifteveiene tilhørende ødegårdene Andråsen, Frestadheia og Skistad gir god adgang inn i hedelandskapet på indre Lista og derved inn mot og til planområde øst. Turstiene mot Frøysti dekkes av planområdet for østre vindmøllepark da dette i nord går helt bort til Frøysti gårdene.

Tiltakets påvirkningsområde:

Visuelt:
Meldingen angir at vindturbiner med tårnhøyde 80 meter og rotordiameter på 80 diameter for en samlet høyde på 120 meter, vil være naturlig installasjoner. Med 2,5 MW generatorer vil 36 turbiner være anslagsvis utbyggingstall for en vindpark på 90 MW. På grunn av at Listalandet stiger jevnt fra sør til nord, og grunnet at veier, bosetting og infrastruktur i hovedsak er lokalisert til søndre del av Lista, vil især vindturbinene i det vestre planområdet være meget godt synlig fra bebyggelse på Vest-Lista. Den spredte bosetningen som preger indre del av lista – hvor oppdeling av gårder har gitt opphav til små grender, gjør at en rekke smågrender vil komme en kilometer eller mindre fra vindparkområdene. Dette gjelder eksempelvis Vigmostad, Ellenes, Elle, Tomstad, Rudjord og Sennekre, Heskestad, Frøysti og Sigersvoll. For disse områdene kan – avhengig av vindturbinplassering m.m., det visuelle inntrykket fra vindmølleparken bli meget betydelig. Østre vindmøllepark vil forventelig bli et fremmedartet og godt synlig anlegg sett fra Framvaren. Framvaren er en naturskjønn og tilnærmet urørt fjord som gjennom straumen og kontakt mot Farsund er tilgjengelig og populær som turområde/båtutfartsområde også for mindre fritidsbåter. Framvaren er under planlegging som marint verneområde.

Støy:
I Lindesnes kommune har Fjeldskår vindmøllepark nylig vært underlagt konsesjons-behandling ihht. forurensningslovens bestemmelser om støy. Konsesjonsbehandlingen er foranlediget av at støyen fra vindturbinene her stedvis har vært betydelig mer merkbar enn forventet. Dette skyldes forventelig i stor grad at bebyggelsen har vært plassert i vindskygge, slik at kamuflerende vindsus ikke har oppstått. Støyen fra vindmøllene har derved blitt oppfattet langt sterkere enn det støyberegningene skulle tilsi.

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Miljøvernavdelingen vil be om at det foretas målinger i felt ved relevant bebyggelse for å avklare om disse befinner seg i vindskyggeområde, og således om minimumsavstand til vindturbinene må økes. Erfaringer fra Fjeldskår vindmøllepark i Lindesnes så vel som nyere og større norske anlegg, bør legges til grunn. Effektene av særlige topografiske forhold, så som lydbildet fra eventuelle vindturbiner i vestre vindpark og på Ørnefjell i forhold til bebyggelse på Rudjord, Heskstad, Vigmostad, Gjelldal og Frøysti bør modelleres og redegjøres for spesielt.

7.3.10. Infrastruktur
KU må redegjøre for de reduksjoner av eksisterende INON-områder (Inngrepsfrie NaturOmråder I Norge) som utbyggingen, herunder veianlegg, kraftlinjer m.m., vil få.

7.3.11. Samfunnsmessige virkninger
Miljøvernavdelingen ber om at dette punktet vektes sterkere enn det konsekvensutredningsprogrammet tilkjennegir. Lista er det område i Vest-Agder som har størst omfang av og variasjon av arealer vernet i medhold av naturvernloven. Dette understreker de store allmenne naturinteresser Lista omfatter. De store naturverdiene gjør at Lista er mye og økende besøkt av øko-turister fra Norge og utlandet. Deler av de vernede områdene, herunder Vest-Lista landskapsvernområde og Nesheimvassdraget med Ulgjelvann og Ulgjel naturreservat - vernet vassdrag, har landskapsstyrke- og verdi som helt sentrale deler av vernegrunnlaget. Ut fra dette vil bygging av så store visuelt påvirkende anlegg som flere titalls 120 meter høye vindturbiner kunne gi negative påvirkninger på landskapet. Av hensyn til allmenne interesser til Lista-naturen vil det være nødvendig å komme frem til presise redegjørelser for virkningene av anleggene på verneområder og landskap og sekundært på egnethet for friluftsliv m.m. Miljøvernavdelingen mener visualiserings-materialet/3D presentasjon av dagens situasjon/landskap kontra utbygget situasjon bør høres hos relevante instanser som kan representere både nasjonale og internasjonale besøkende. Dette for å klarlegge om bygging av omsøkte anlegg vil kunne påvirke naturopplevelsen og derved allmennhetens opplevelse av Lista-naturen.

Det må dessuten redegjøres for hvilke følger utbyggingen vil ha for utøvelse av jord- og skogbruk, både i anleggs- og driftsfasen. Dette kan muligens fanges opp under KU-punkt 7.3.9. eller 7.3.11., men da dette ikke fremgår tydelig, ber miljøvernavdelingen om at det blir redegjort for virkningene på jord- og skogbruk spesielt.

Avsluttende bemerkninger:
Miljøvernavdelingen vil understreke viktigheten av å gjennomføre en bredest mulig høring av den planlagte vindmølleparken på Lista.

På Lista har etter hvert en økende turisme fundamentert på de betydelige områdene med nasjonalt og internasjonalt verneverdige naturforekomster supplert den alminnelige verdien Lista har som kystnært rekreasjonsområde. Ferie- og friluftslivsverdien av Listalandet gjør at de planlagte vindmølleparkene vil ha betydning for et større antall mennesker enn hva tilfellet er for tilsvarende befolkede arealer i mindre pressede deler av landet. Hittil er det ikke bygget noen vindmøllepark av sammenliknbart omfang langs sørlandskysten, og det vil derfor etter miljøvernavdelingens vurdering være riktig å legge opp til en noe mer omfattende høring og velutarbeidet visualisering for å dekke informasjons- og høringsbehovet i tilstrekkelig grad.

Ikke minst er dette viktig for å avklare virkningene ut fra det perspektiv at vindmølleparkene planlegges bygd i nærheten av allerede vernede kystområder som gjennom vern etter naturvernloven er identifisert som arealer av nasjonal verdi.

Med hilsen

Erling Vindenes (e.f.)	Tor Kviljo
Direktør miljøvernsaker	1. konsulent

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- Samarbeidsrådet for naturvernsaker, SRN, v/Jan Olav Nybo, Pb. 7, 0101 OSLO
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Med hilsen

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