

Skipulagsstofnun
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105 Reykjavík

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Efni: Svar við pósti Skipulagsstofnunar dags. 15. Maí 2025

Forsaga:

Þann 13. Desember 2024 barst Skipulagsstofnun til tals að verkefnastjórn 5. áfanga Rammaáætlunar hafði hafði tilgreint í niðurstöðum sínum að flug hafarna hefði mælst innan marka Vindorkugarðs í Garpsdal.

Þegar skýrslu um fuglarannsóknir yfir Garpsdal var lokið í Janúar 2023 höfðu engir fuglar greinst innan marka vindorkugarðsins.

Skipulagsstofnun bað því EM Orku um að skýra þennan mun.

Þann 13. Janúar 2025 sendir EM Orka Skipulagsstofnun öll gögn sem send höfðu verið til rammaáætlunar. Þessi gögn sendir Skipulagsstofnun síðan Náttúrufræðistofnun til yfirferðar.

Þann 15. Maí 2025 barst bréf með viðbrögðum NÍ sem EM Orka var beðin um að svara.

Til að bregðast við efni bréfsins ákváð EM Orka að leita sérfræðilíts eftirfarandi aðila:

- **Náttúrustofa Vestfjarða.**
NAVE setti staðsetningargögnin inn í áflugslíkan SNH og fann áflugsáhættu með uppfærðum áflugsstuðli NÍ.
- **John Murphy** - Vinnur hjá Malachy Walsh and Partners og skipulagði fuglarannsóknir á Garpsdalsfjalli.
John ritaði álit á því af hverju ernir sæktu í dali og gil nærri Garpsdalsfjalli.
- **Alan Fielding** - Meðal annars meðlimur í Sérfræðinganefnd vísindaráðgjafarnefndar SNH 2013-2021 (Scottish Natural Heritage Scientific Advisory Committee Experts Panel 2013-2021)
Alan smíðaði líkan fyrir búsvæðanotkun hafarna á Íslandi út frá staðsetningar gögnunum, svokallað Species Distribution Model (SDM) eða tegundardreifingarlíkan. Alan ritaði einnig álit um af hverju ernir sækja í dali og gil nærri Garpsdalsfjalli.
- **Dr. Matt Geary** - Dósent í náttúruverndarlíffræði og hegðun dýra við háskólann í Chester.
Matt greindi þær tæknilausnir sem eru í boði er varða sjálfvirka stöðvun á spöðum til að varna áflugi stærri fugla og notagildi þeirra.

1. Áflugshætta hafarna

Þann 9. október 2024 fékk EM Orka afhent öll staðsetningargögn frá NÍ fyrir árið 2023 til 1. september 2024. Þar með var EM Orka með í höndunum gögn allt frá upphafi mælinga 2019 til nýjustu gagna sem NÍ hafði í höndunum fyrir svæði sem spannar 40 km radíus frá Vindorkugarði í Garpsdal.

Til að fá rétta mynd af áhrifum á hafarni var umferð yfir fjallið sett inn í áflugslíkan SNH (Scottish National Heritage). Náttúrustofa Vestfjarða vann áflugshættumatið en í því mati var miðað við niðurstöður GPS gagna, þar segir m.a.:

“Niðurstöður benda til þess að á gagnasöfnunartímabilinu hafi fjórir ernir flogið yfir svæðið í fjögur aðskilin skipti. Af fjórum flugferðum yfir svæðið var árekstrarhættan lítil til miðlungs, þar sem heildarhættan að haförn yrði fyrir vindmyllu árekstri var 0,01 örn á ári. Öll flugin um svæðið hafa líklega verið innan hæðar vindmyllublaðs og voru farin utan vetrarmánaða. Af 39 merktum fuglum voru 177.787,9 km flug metnir, þar af 4,47 km innan svæðisins¹.” [1].

Niðurstöður GPS gagna gefa þannig til kynna að eitt áflug hafarnar við vindmyllu gæti átt sér stað á 100 ára fresti.

Umsögn Náttúrufræðistofnunar Íslands

Náttúrufræðistofnun Íslands segir að: „núverandi útreikningar á áflugshættu fyrir hafarni byggja einungis á GPS merktum örnunum og gera ekki ráð fyrir öðrum fuglum í stofninum. Til þess að áflugsmat nái yfir arnarstofninn í heild sinni telur Náttúrufræðistofnun nauðsynlegt að endurreikna áflugshættu út frá áætluðum fjölda hafarna á svæðinu. Þá væri áflugshætta fyrir hafarni búna GPS sendum (hér áætlað sem 1 fugl á 100 ára fresti) margfölduð með svokölluðum áflugsstuðli til að meta áflugshættu fyrir alla erni sem nýta sér svæðið, þ.e. allir ungfuglar í stofni sem og varpfuglar innan 10 km radíuss“.

Við mat á áflugshættu hafarna á tilteknu svæði þarf að meta áflugshættu fyrir fugla merkta GPS sendum (sendafuglar) og yfirfæra það á heildarfjölda fugla á svæðinu. Þegar áflugshætta fyrir sendafugla hefur verið áætluð þarf því að margfalda hana með áflugsstuðli sem er reiknaður út frá gögnum á hverju svæði fyrir sig. Íslenski hafarnastofninn telur um 90 varppör. Fuglarnir verða kynþroska og leita sér að óðali um 5 til 7 ára. Árgangar áður en þau verða hluti af varpstofni (pre-varpstofn) eru því um 5 til 7 til viðbótar við þekktan varpstofn (~90 pör). Þessir fuglar haga sér öðruvísi en varpfuglar, sem eru tryggir sínu óðali, og eru á miklu flakki um mest allt landið. Síðan 2019 hafa verið settir GPS-sendar á ófleyga arnarunga sem eru nú hluti af þessum hópi.

Við útreikninga á áflugsstuðli er fyrst reiknaður fjöldi ungfugla án sendis frá tímabilinu 2019 – 2024 sem eru á lífi út frá nýjustu gögnum og gert er ráð fyrir sömu lifun á sendafuglum og öðrum fuglum frá því tímabili:

$$\text{Lifandi ungfuglar}_{\text{án sendis}} = \left(\frac{\text{Sendafuglar}_{\text{lifandi}}}{\text{Sendafuglar}_{\text{heild}}} * \text{Ungfuglar}_{\text{án sendis}} \right)$$

¹ Náttúrustofa Vestfjarða - Árekstrarhættumat fyrir hafarni við vindorkugarð í Garpsdal.

Því næst reiknum við fjölda fugla á svæðinu sem samanstanda af sendafuglum, ungfuglum á sendis og varpfuglum (ef varpóðul eru innan 10 km). Hér gerum við ráð fyrir jafnri dreifingu sendafugla og annarra um landið, þ.e. að hlutfall sendafugla á svæðinu sé jafnt hlutfalli annarra fugla á svæðinu:

$$\text{Fjöldi fugla}_{\text{innan svæðis}} =$$

$$\left(\frac{\text{Sendafuglar}_{\text{innan svæðis}}}{\text{Sendafuglar}_{\text{heild}}} * \text{Lifandi ungfuglar}_{\text{án sendis}} \right) + \text{Sendafuglar}_{\text{innan svæðis}} + \text{Varpfuglar}$$

Áflugsstuðull fæst svo með því að margfalda áflugshættu fyrir sendafugla þannig að hún eigi við um alla fugla innan svæðis:

$$\text{Áflugsstuðull} = \frac{\text{Fjöldi fugla}_{\text{innan svæðis}}}{\text{Sendafuglar}_{\text{innan svæðis}}}$$

Þessi stuðull er svo notaður til að heimfæra áflugshættu fyrir sendafugla á alla fugla sem dvelja á fyrir fram skilgreindu svæði með eftirfarandi útreikningum:

$$\text{Áflug}_{\text{heild}} = \text{Áflug}_{\text{merktir}} * \text{Áflugsstuðull}$$

Náttúrufræðistofnun hefur tekið saman viðeigandi breytur fyrir Garpsdal til notkunar við ofangreinda útreikninga:

Sendafuglar lifandi = 35
Sendafuglar heild = 53
Ungfuglar án sendis = 199
Sendafuglar innan svæðis = 39²
Varpfuglar innan 10 km = 2

Útkoman er áflugsstuðull = 3,63

Viðbrögð EM Orku

Eins og fram kemur í umsögn Náttúrufræðistofnunar Íslands gerir stofnunin kröfu um að tekið verði tillit til alls arnarstofnsins við útreikning áflugsáhættu, en ekki einungis mældra GPS fluga.

² Fjöldi sendafugla sem hafði farið um svæðið þegar nýjustu gögn voru afhent framkvæmdaaðila. Miðað er við 40 km rás frá miðju framkvæmdasvæðis í Garpsdal. Athugið að þessa tölu þarf að leiðrétta í umhverfismatskýrslu.

Þegar margfaldað hefur verið með áflugsstuðli NÍ er hættu á áflugi hafarnar á vindmyllur í Garpsdal komin í mögulegt áflug á 28 ára fresti, sem svarar til 0,036 fugl/ári.

2. Mótvægisáðgerðir

Umsögn Náttúrufræðistofnunar Íslands

Stefnt er að því að mála neðsta hluta turna með dökkum lit til þess að lágmarka mögulegt áflug rjúpu. Náttúrufræðistofnun ítrekar einnig mikilvægi þess að notast verði við tækni sem stoppar spaða ef stór fugl kemur nærri, einkum í ljósi nýjustu gagna um ferðir hafarna.

Viðbrögð EM Orku

Óbeinar aðferðir felast í gera vindmyllusvæðið minna aðlaðandi fyrir tiltekna tegundir til að draga úr líkum á að fuglar noti svæðið yfirhöfuð.

Annars vegar er bein vistkerfis breyting í kringum túrbínurnar og hins vegar að fjarlægja strax hræ sem stærra fuglar myndu annars sækja í.

Breyting á vistkerfi er mjög mikið inngríp og myndi þar að auki ekki hafa mikil áhrif í Garpsdal. Hins vegar gæti vöktun á hræjum rjúpna á háanna tíma mögulega dregið úr ásækni fálka inn á svæðið.

Sem mótvægi við áflugi rjúpna mun neðsti hluti turnanna vera málaður svartur en aðrar aðferðir hafa borið árangur líkt og að mála einn spaða svartan. Niðurstöður benda til að slíkt geti minnkað áflug um 70%. [5]

Sjálfvirk stöðvun felur í sér að nýta annað hvort radar eða myndavélar til að nema fugla í grennd og stöðva spaðana sjálfvirkt.

Hugbúnaður kerfanna byggir á gervigreind en þar er einmitt hin lága tíðni fluga yfir fjallið orðið hamlandi.

„Oft þurfa þessir reiknirit mikið magn af þjálfunargögnum til að geta greint tegundir á áhrifaríkan hátt, helst á svipuðum stað með svipuðum umhverfisskilyrðum. Í ljósi þess hve fáir hvíthafarnir koma í nágrenni fyrirhugaðs svæðis gæti þetta tekið töluverðan tíma nema hægt sé að þjálfa gervigreindina á myndum af ratsjármerkjum annars staðar frá.“ [5]

Einnig er vert að athuga að skýjahula og þoka er algengari því hærra sem þú ferð og stendur Garpsdalsfjall í ca. 500 m hæð.

„Sýnileiki er hugsanlegt vandamál þegar kemur að kerfum sem vöktuð eru með myndavélum og eins gæti sólarstaða og veðurskilyrði haft áhrif.“ [5]

Kerfin sem eru í boði í dag er ætlað að minnka óásættanlega mikið dauðsfall sem er margfalt hærri en áætlaður fugladauði mun vera í Garpsdal.

³ Dr Matthew Geary - Potential technological solutions to reduce collision risk for White-tailed Eagles *Haliaeetus albicilla* at the proposed Garpsdalur windfarm

Engin rök eru fyrir því að brýn þörf sé fyrir slíka lausn. Í viðauka er samantekt á algengustu aðferðum sem nýttar eru við að minnka áflug. Byggt á þeim upplýsingum sem og á niðurstöðum útreikninga á áflugsáhættu þá tekur EM Orka ekki undir það að niðurstöður gefi til kynna að mikilvægt sé að íhuga tækni sem stoppar spaða til að draga úr áflugi. Slík tækni er ætluð fyrir verkefni með margfalt meiri áflugshættu en reiknuð er fyrir Garpsdal, eða jafnvel óásættanlegan fjölda staðfesta fugladauða.

EM Orka útilokar hins vegar ekki að nýta radar- eða myndavélalausnir sem byggja á gervigreind til að stöðva spaða, en miðað við áætlaða áflugsáhætta á 28 ára fresti er ekki tekið undir það að það sé mjög mikilvæg lausn. Það er einmitt hin lága tíðni flugs yfir svæðið sem hamlar fullri virkni lausnarinnar en ef hægt er að þjálfa hugbúnaðinn á stað þar sem tíðni sé mun hærri kæmi þessi lausn mögulega til greina.

Eins er ekki útilokað að mála einn spaða svartan þó er mikilvægt að ítreka að sjónræn áhrif af slíku gætu vegið mun þyngra en ávinningurinn.

EM Orka ítrekar hins vegar að áhrifaríkasta forvörnin er vel ígrundað svæðisval en það er einmitt ástæða þess að möguleg áflugsáhætta er á 28 ára fresti.

„Val á staðsetningu er einn mikilvægasti þátturinn í að draga úr áflugshættu. Svæði sem eru góð búsvæði fyrir tiltekna tegund eru líkleg til að laða að fleiri fuglahreyfingar sem eykur hættuna á áflugi.“ [5]

„Í Skotlandi voru svæði sem voru síður hentug fyrir gullörn ólíkleg til að laða að sér erni og í Þýskalandi var dánartíðni hafarnar við vindmyllugarða hærri á svæðum þar sem búsvæðin voru einnig góð. Heuck o.fl. notuðu svipaðar breytur, svo sem hæð yfir sjávarmáli og gögn um landþekju Corine, og í landfræðilíkani hafarnarins sem Alan Fielding framleiddi til að meta búsvæðishæfni fyrirhugaðs svæðis fyrir vindorkugarðinn í Garpsdal. Þetta líkan bendir til þess að hæfni á þessum stað sé mjög lítil og að staðarval hér sé þegar líklegt til að stuðla að því að draga úr áflugshættu.“ [5]

2.1 Forsendur fyrir svæðisvali

Þegar staðsetning ofan á Garpsdalsfjalli var valin var hegðunarmynstur og eðli hafarnarins haft í huga.

Búsvæði:

„Haförn lifir einkum á láglandi og aðallega við fjörur og firði norðvestanvert á landinu. ... Í þessum fjörðum og aðliggjandi túnnum og dölum verpa og nærast fuglar og fljúga um og veiða hentuga bráð. Flugleiðir sem sýndar eru í vöktuðum gervihnattafylgdum fuglum á árunum 2019 til 2024, eru aðallega af ókynþroska fuglum sem voru merktir á hreiðrinu sem ungfuglar. ... Svipaðar rannsóknir á flugslóðum ókynþroska hafnarna hafa farið fram í Finnlandi. [Þar] komust þeir einnig að því að GPS merktir ungfuglar hafa tilhneigingu til að halda sig við strandsvæði þar sem náttúrulegar fæðutækifæri eru aðgengileg allt árið, jafnvel á tímum mikillar snjókomu og frosts. ... Af þeim flugleiðum sem safnað hefur verið saman á 5 ára tímabili sem lýst er, sýna flugleiðir ókynþroska og nýlega fleygra arna sem dreifast í margar áttir á þessu svæði á Norðvesturlandi eins og búast má við. Þetta á við hvar sem þessi tegund finnst í hluta Evrópu

eða á Íslandi. Flugleiðirnar sýna fugla sem nýta sér dali til að fljúga í gegnum, til að komast í aðra firði þar sem fæða er helsta skotmarkið og hitta önnur afkvæmi varpandi arnar til að para sig við á komandi árum. Sumir fuglar kanna vatnasvæði á leiðinni til þessara annarra fjarða og þeir komast fljótt að því að margir af einangruðu stöðum efst á fjöllum og hásléttum veita ekki nægilega fæðu eða skjól til að halda uppi fullu lífi, ... Vegna þessa og eins og við er að búast er minni arnarvirkni skráð á hálendinu en á láglendi. ... Þetta hlýtur að takmarka varp- og veiðimöguleika fyrir haförn á Norðurlandi vestra við þessum hærri hæðum.“ [2]

Fæða og fæðuhættir:

“Örninn veiðir sér til matar og er aðalbráðin fyll sem hann tekur á flugi, æðarfugl tekur hann á sjó og fiskur (hrognkelsi, laxfiskar) sem hann grípur við yfirborð. Lundi og máfar eru einnig teknir. Hann etur gjarnan hræ og rænin stundum æti frá öðrum fuglum.”

[<https://fuglavefur.is/birdinfo.php?val=2&id=52>]

Veður og hegðun:

„Haförnum líkar ekki við að fljúga í þoku eða á dögum þegar mikill vindur er eða lélegt skyggni. Stórir ernir eins og þessir eiga það til að sitja þétt á jörðinni við þessar aðstæður þar sem þeir geta ekki stjórnað sér mjög vel. Hafarnir eins og meirihluti þessarar fjölskyldu hafa einstaklega góða sjón með 20/20 sjón til að veiða bráð. Með slíkri sjón geta þeir auðveldlega borið kennsl á og leyft þeim að forðast túrbínublöð á hreyfingu með blikkandi viðvörunarljósi á vélarhúsi til að aðstoða fugla við að koma auga á vindmyllurnar við léleg birtuskilyrði, jafnvel unga óproskaða fugla.“ [2]

Lega landsins og aðstæður uppi á Garpsdalsfjalli gefa til kynna að það sé ekkert uppi á Garpsdalsfjalli sem trekkir erni að enda greindust engir ernir innan marka vindorkugarðsins, hvorki frá sjónhólmælingum né GPS mælingum, frá upphafi mælinga 2019 til loka árs 2022.

2.2 Búsvæðishæfislíkan

Til að skilja betur ástæður mismunar í notkun milli dala í grennd og fjallstoppsins var búsvæðishæfislíkan (Habitat suitability model) smíðað sem ber saman staðsetningargögn við DEM20m landupplýsingakort frá Landmælingum Íslands.

Breyturnar sem búsvæðishæfislíkanið tók til greina voru: Halli, stefna, fjarlægð frá strandlínu, hryfisstuðull Riley, hryggir og fjarlægð frá hryggjum og að lokum Corine landflokkun. Að lokum er öllum svæðum gefinn svokallaður preference index (PI) eða valvísir á skalanum 1 – 10.

Við greiningu gagnanna sést vel að ernir hafa mikla tilhneigingu til að sækja í vissar aðstæður.

- Ernir sýndu yfirgnæfandi ásókn í láglandi umfram svæði yfir sjávarmáli. Þrátt fyrir að stór hluti svæðisins liggi hátt yfir sjávarmáli er lítil sem engin ásókn í þau svæði.
- Ernir kusu að halda sig mjög nærri strandlínu. Gögnin voru takmörkuð við þá punkta sem mældust yfir landi en ekki sjó þannig að fjarlægðir í ofangreindri töflu sýna hversu óviljugir fuglarnir eru til að ferðast inn í land frá strandlínu. Yfirlitskort sýna að ernirnir sækja mjög mikið út á haf nærri strandlínu.
- Ernir kjósa einnig að halda sig fjarri hryggjum og fjallsbrúnum.
- Þrátt fyrir að yfirgnæfandi hluti landsvæðisins séu heiðar þá sækja ernir umfram allt í leirur en forðast lítt gróin svæði.

Búsvæðishæfislíkanið er að lokum búið þannig til að landakorti er skipt niður í 1x1 metra möskva.

Þegar hver möskvi er litaður eftir því PI gildi sem honum var úthlutað kemur í ljós kort sem sýnir hvar kjörsvæði arna er að finna.

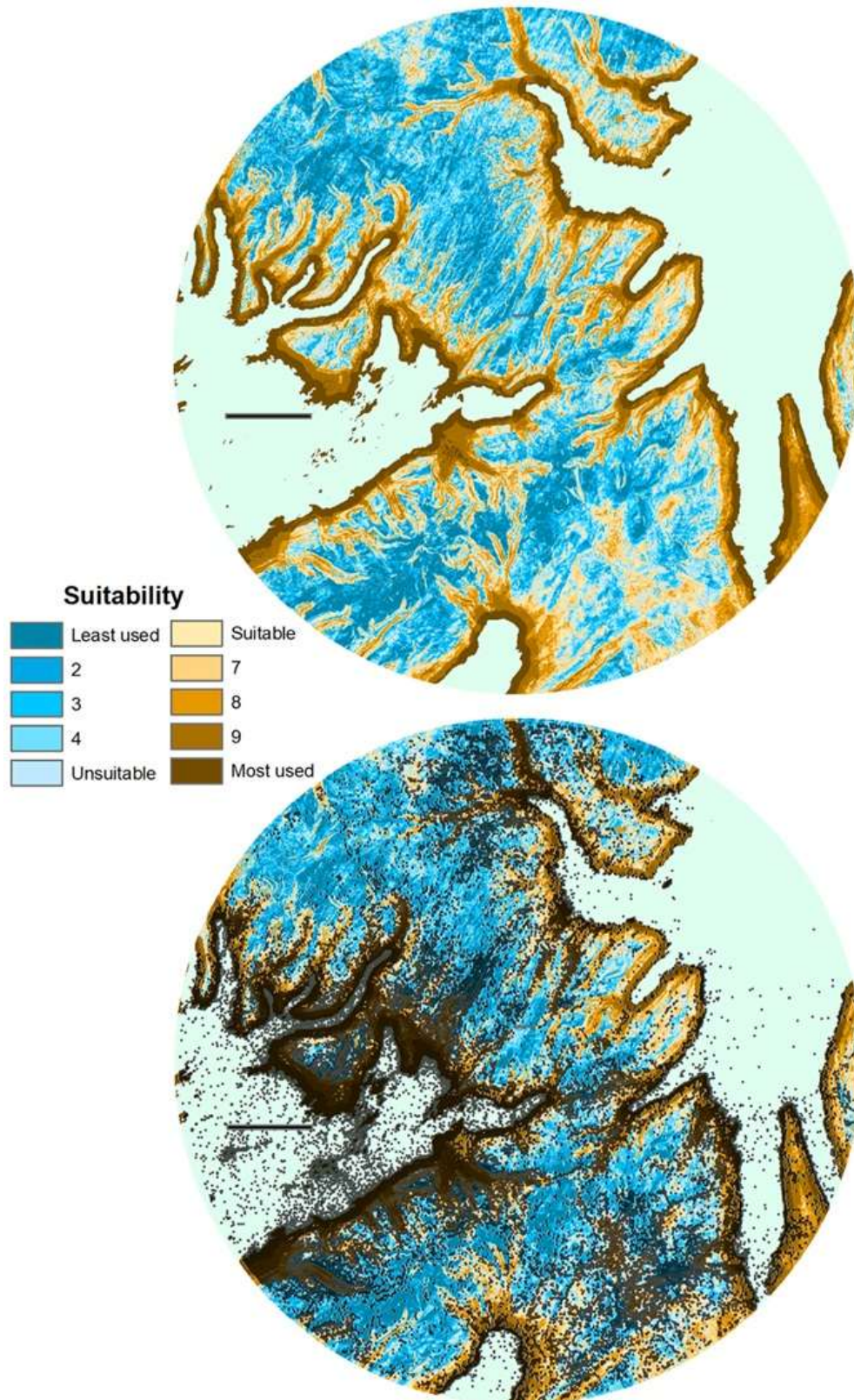


Figure 1: Viðauki[3] - Figure 15. Distribution of the 10 SPI quantiles (above) plus with all satellite tracking records.

Niðurstöður koma ekki á óvart þegar tillit er tekið til fæðuvals hafarna.

„Á sumrin veiða fullorðnir fuglar fisk, unga gæsir og aðra algenga villifugla og hvers kyns dauða sela- eða sjávarhvalahræ sem skoluðust upp meðfram ströndinni. Á fartímabili þegar bleikgæsir eða grágæsir, sem rækta á staðnum, safnast saman í sameiginlegum fjölskylduhópum á hefðbundnum ökrum víðsvegar um dalina, sem leiða af þessum fjörðum, sem gerir það að verkum að ernir geta tínt gæsir, sérstaklega að heimsækja hágæsir á leið frá varpstöðvum á Grænlandi til yfirvetrarsvæða í Bretlandi og Írlandi. Ernir geta einnig tínt krabbadýr og lindýr meðfram strandlengjum á tímum lítillar fugla eða spendýra, önnur ástæða þess að fuglar halda sig aðallega við strandsvæði á sumrin, en sérstaklega á veturna þar sem íslausar strendur veita ránfuglum og örnum fæði.“ [2]

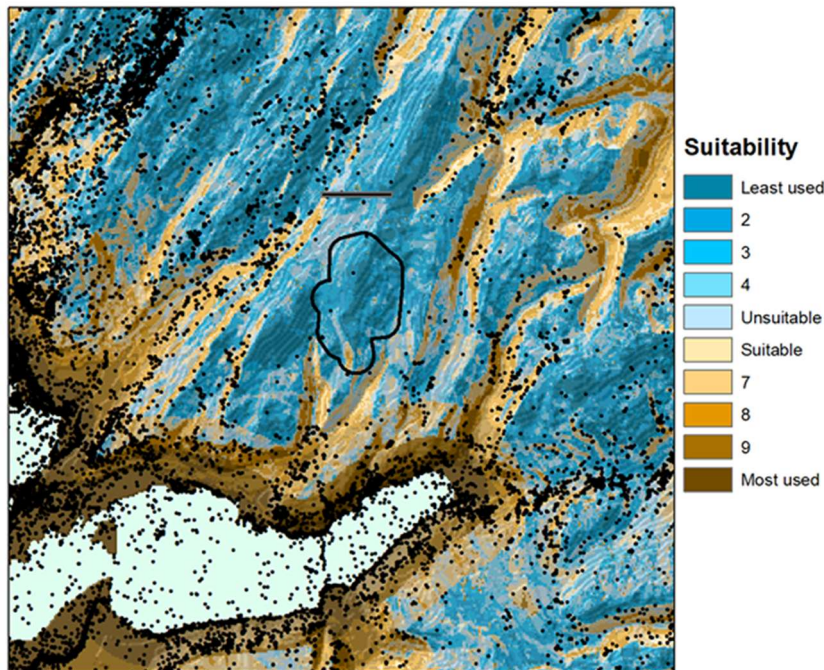


Figure 2: Viðauki[3] - Figure 17. 500 m turbine buffer in relation to the WET landscape with tag records.

Af einhverri ástæðu virðast hafarnir á Íslandi forðast fjallstoppa og ef þeir þurfa að fljúga frá ströndinni gera þeir það um dali sem er bersýnilegt þegar bæði búsvæðishæfislíkan af landsvæði og hitamynd af umferð eru skoðuð.

“There are significant White-tailed Eagle movements close to Garpsdalur mountain but the fact that the main routes are through valleys, and Garpsdalur windfarm is on a mountain/ridge, immediately reduces the potential for a collision.” [4]

Sú umferð sem liggur nærri Garpsdalsfjalli er eðlileg. Staðsetning vindorkugarðsins uppi á fjalli dregur þannig úr hættu á áflugi hafarna.

3. Vöktun

Umsögn NÍ

Verði úr framkvæmdinni er mikilvægt að sett verði upp markviss vöktunaráætlun fyrir fugla og gróðurfar á rekstrartíma í samráði við sérfræðinga. Vindorkugarðar myndu teljast til algjörRAR nýlundu í íslensku umhverfi og það eru ýmsir óvissuþættir sem þarfnast rannsókna. Hafa ber í huga að miklar skekkjur geta fylgt rannsóknum á áflugi sem byggja á hræleit í kringum mannvirkin og þarf að leitast við að lágmarka þær skekkjur.

Viðbrögð EM Orku

Eins og kynnt var fyrir NÍ í nóvember 2019 mun vöktun fylgja BACI meginreglunni (Before – After – Control – Impact).

Fyrir framkvæmdir mun EM Orka framkvæma grunnástandskönnun (baseline) til að staðfesta að engar breytingar hafi orðið á þeim aðstæðum sem mældar voru.

Meðan á framkvæmdum stendur framkvæmir sérskipaður umhverfisfulltrúi á staðnum ítrekað? umhverfisvöktunarmat.

Á rekstrarstigi mun EM Orka halda áfram með ástandskannanir. Skilvirkast er að framkvæma þær yfir 5 ára tímabil til að meta áhrif og staðfesta niðurstöður framkvæmda og forframkvæmda. Niðurstöðum verður ávallt deilt með öllum hagaðilum.

Eftirlit með búsvæðum

Vöktun búsvæða verður framkvæmd með fastpunktaljósmyndun á völdum úrtakssvæðum.

Vöktunaráætlunin nær til framkvæmdatíma og til viðbótar (að lágmarki) ár 1, 2, 3, 5, 7, 10, 15, 20, 25 og 30 eftir að byggingartíma lýkur. Grunnkannanir (Baseline surveys) eru til fyrir allt svæðið og þeim verður bætt við staðfestingarkannanir sem lokið er á byggingarstigi.

Vöktun á fyrstu árum aðgerðastigsins verður sérstaklega mikilvæg til að meta árangur stjórnunaraðgerða og ná hagstæðri náttúruverndarstöðu. Ef aðgerðir eru ekki taldar skila árangri hvað varðar markmið um hagstæða náttúruverndarstöðu þarf að grípa til úrbóta.

Eftirlit með fuglum fyrir framkvæmdir

Varp-mælingar fyrir byggingu munu fara fram á hentugum búsvæðum fyrir lykiltegundir til að ákvarða varpstöðu, sem gæti orðið fyrir truflun á framkvæmdastigi.

Eftirlit með fuglum eftir framkvæmdir

Vöktunaráætlun eftir framkvæmdir mun fela í sér hræleit til að fylgjast með áflugstíðni, VP-kannanir til að aðstoða við túlkun niðurstaða hræleitanna og ýmsar kannanir til að meta áhrif tilfærslu. Hönnun vöktunaráætlunarinnar verður byggð á leiðbeiningum SNH um aðferðir við vöktun fuglastofna í vindorkuverum á landi (SNH, 2009).

Útsýnisstaðakannanirnar eða VP-kannanir munu fara fram samhliða hræleitunum.

Aðrar kannanir munu fara fram með hæfilegu millibili til að ná yfir byggingar- og rekstrartímabil (t.d. ár 1, 2, 3, 5, 10 og 15).

4. Fálkar og rjúpur

Umsögn NÍ

Einnig skal bent á að fækkun í stofni fálka hefur verið mjög mikil seinustu ár. Vegna þessa er fálkinn nú listaður sem tegund í hættu (EN) á uppfærðum válista fyrir fugla.

Í ljósi þessarar miklu fækkunar fálka og þeirrar staðreyndar að vindmyllur geta orðið fálkum að grandí, þá hvetur Náttúrufræðistofnun til þess að hugað verði betur að hlutskipti fálka við mat á umhverfisáhrifum vindorkuvera. Með þessu er átt við að rannsakað verði hversu mörg fálkaóðul eru innan áhrifsvæða fyrirhugaðra vindorkuvera og að ábúð á þessum óðulum verði metin og vöktuð til lengri tíma verði vindorkugarður reistur. Jafnframt telur Náttúrufræðistofnun mikilvægt að rannsaka ferðir fálka og fæðuöflunarsvæði þeirra og hvernig þeir nýta loftrýmið á sínum ferðalögum. Miðað við fyrirbyggjandi þekkingu, þá sækja fálkar reglulega allt upp í 30 til 40 km frá óðali eftir bráð til að bera heim í hreiður.

Viðbrögð EM Orku

Áhrif á fálka eru rannsökuð í umhverfismati sem hluti af flugferla rannsókn Náttúrufræðistofu Austurlands. Áætluð áflugstíðni fálka er á bilinu 0,003 (\pm 0,001) – 0,014 (\pm 0,004) áflug á ári. Þetta samsvarar því að fálki geti orðið fyrir spaða á 72 ára fresti.

Það er ekkert sem gefur til kynna að vindorkugarðurinn muni hafa neikvæð áhrif á fálkastofninn né að fara þurfi í frekari rannsóknir.

Til að minnka áflug rjúpna mun neðsti hluti turnsins verða málaður svartur. Það hefur sýnt sig að þetta geti minnkað rjúpna áflug um 48%. (<https://pubmed.ncbi.nlm.nih.gov/32607182/>)

Þar að auki verður sem hluti af BACI vöktun hræathuganir sérstaklega auknar í október þegar mest er af rjúpu. Það mun draga enn úr hættu á áflugi fálka.

5. Næturflog

Umsögn NÍ

Hér er vísað í fróðlega samantektarskýrslu á rannsóknum á áhrifum vindorkuvera á fugla og leðurblökur. Hins vegar á tilvitnunin hér fyrir ofan við um rannsókn á farhegðun sjófugla (einkum æðarfugls) og áhrifum vindmylla á hafi þar á og því eiga niðurstöður hennar augljóslega ekki við hér.

Líkt og fram kemur í ofangreindri skýrslu, eru margir þættir sem hafa áhrif á áflugshættu, s.s. um hvaða tegund er að ræða, veðurfar og staðsetning vindmylla. Þá hafa ratsjarmælingar hérlandis í tengslum við önnur fyrirhuguð vindorkuver sýnt að það getur verið mikil umferð að nóttu til á fartíma.

Viðbrögð EM Orku

Í skýrslu Náttúrustofu Austurlands “Fuglalíf á Hrauni við Garpsdal og nærsvæðum Rannsóknir vegna fyrirhugaðs vindmyllugarðs” segir:

“Væntanleg áflugstíðni var reiknuð út frá áflugsáhættu, mældrar umferðar fugla um svæðið, væntanlegrar forðunar og virknitíma vindmylla, fyrir 8 áherslutegundir. Vegna óvissuþátta var líkanið keyrt fyrir mismunandi forsendur hvað varðar umferð að næturlagi (25 og 100%) og útmörk sjónsviðs (1 og 2 km).”

Við útreikning á áflugshættu var gert ráð fyrir sömu virkni og var að degi til við útreikning áflugshættu allra tegunda.

6. Vantar tilvísun í grein

Umsögn NÍ

“Hér vantar tilvísun í heimild en varast ber að yfirfæra niðurstöður erlendra rannsókna yfir á aðstæður hér á landi þar sem ýmsir staðbundnir þættir sem geta haft áhrif á hættu á áflugi. Þá kemur ekki fram hvort þarna hafi eingöngu verið um að ræða varpfugla eða líka ungfugla.”

Viðbrögð EM Orku

Umrædd heimild sem gleymdist að tilgreina var doktors ritgerð Espen Lie Dahl frá Norwegian University of Science and Technology:

<https://ntnuopen.ntnu.no/ntnu-xmlui/handle/11250/245556>

Hér er tilvitnun í ritgerðina í viðtali við Espen:

<https://norwegianscitechnews.com/2014/11/five-kilometres-between-life-and-death/>

Rannsóknin náði til bæði varp og ungfugla en studdist ekki við GPS gögn eins og NÍ rannsakar.

Niðurstöður gefa til kynna lífvænleika fugla miðað við fjarlægð hreiðurs frá vindmyllu en þá er vert að skoða afstöðu framfæmdarsvæðis frá nálægasta hreiðri.

„Nálægasta arnarhreiður við hið fyrirhugaða vindorkuver er í um það bil 7,6 km fjarlægð. Þetta er nægjanleg fjarlægð til að trufla ekki varpörn í Gilsfirði og víðar.“ [2]

„Þessi fjarlægð er átta sinnum stærri en stærsta svigrúm sem Goodship and Furnace (2022) mælir með í Skotlandi.“ [4]

Einnig verður að taka til greina að meira en 500 metra hæðarmunur er á milli vindorkugarðsins og hreiðursins.

7. Birting flugferla í skýrslu NAVE.

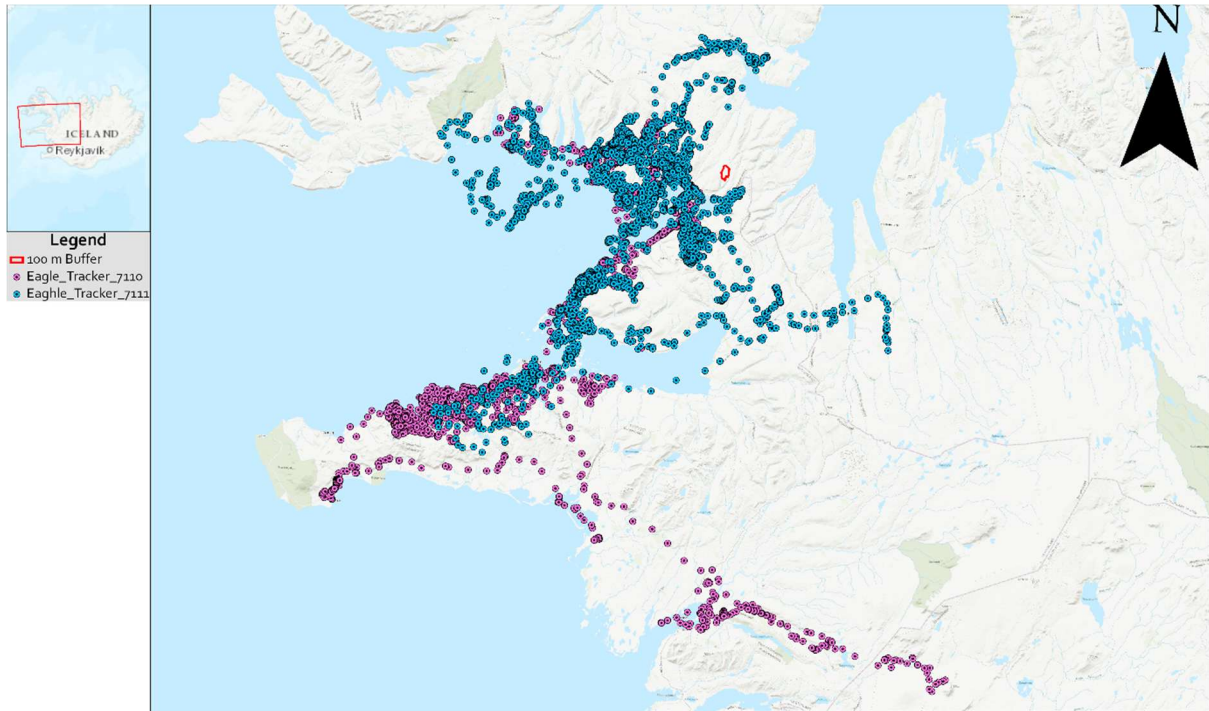
Umsögn NÍ

Náttúrufræðistofnun gerir athugasemd við birtingu korts með flugferlum.

Viðbrögð EM Orku

Á þeirri mynd sem NÍ gerir athugasemd við er flug 39 fugla yfir 6 ára tímabil en NÍ gerir athugasemd um að auðveldlega sé hægt að greina óðöl hafarna út frá myndinni.

Þann 28. júlí 2020 gaf Kristinn Haukur Skarphéðinsson leyfi fyrir eftirfarandi mynd til birtingar í umhverfismatsskýrslu á grundvelli þess að ekki væri hægt að greina hreiðurstæði út frá dreifingu gagna. Þessi mynd sýndi eingöngu flug tveggja fugla yfir eins árs tímabil.



Garpsdalur Wind Farm - Eagle Tracker (7110 & 7111)

EM Orka gengst við kröfu NÍ og umrædd mynd mun eingöngu sýna staðsetningar en ekki ferla í uppfærðri skýrslu NAVE.

8. Samantekt

- Náttúrufræðistofnun gaf upp leiðréttingarstuðul við fyrri áflugsniðurstöður sem myndi þar með taka tillit til allra arna á Íslandi.

Þegar leiðréttingarstuðullinn hefur verið tekin til greina þá er áflugsáhætta hafarna 0,036 fugl/ári fyrir Vindmyllugarð í Garpsdal.

- Náttúrufræðistofnun ítrekaði mikilvægi tækni sem stöðvar spaðana til að koma í veg fyrir áflug.

EM Orka leggur áherslu á að áflugsáhætta, jafnvel með leiðréttingarstuðlinum, sé undir áætlað eitt áflugi á líftíma vindmyllugarðsins.

Svæðisval til að minnka áflug er mun áhrifaríkara en tæknilausnir til að stöðva spaða þegar á reynir. Niðurstöður búsvæðislíkans benda til að forsendur sem urðu til þess að Garpsdalur varð fyrir valinu séu réttar.

EM Orka mun íhuga að mála einn spaða svartann, en áætluð áflugsáhætta eins fugls á 28 ára fresti réttlætir ekki frekari íhlutun.

- Náttúrufræðistofnun ítrekaði mikilvægi eftirlits með framkvæmdum og rekstri.
Þetta er í samræmi við áætlun EM Orku um eftirlit byggt á BACI meginreglunni (Before – After – Control – Impact) eins og hún var kynnt fyrir Náttúrufræðistofnun árið 2019.

- Náttúrufræðistofnun hvetur til þess að almennt verði hugað betur að hlutskiptum fálka í umhverfismötum vindorkuvera.

Þetta hefur þegar verið gert í fuglarannsóknarskýrslu og niðurstaðan er áflugshætta upp á 0,014 (\pm 0,004) fálkaáflug á ári fyrir allan vindmyllugarðinn.

- Náttúrufræðistofnun bendir EM Orku á að rannsóknir gefi til kynna að flug fugla gæti verið jafn mikið að nóttu sem að degi til.

Áflugshættulíkanið gerir nú þegar ráð fyrir að flug að nóttu séu jöfn því sem sést að degi til. Það er því ekki þörf á að taka þetta frekar til greina.

- Náttúrufræðistofnun óskaði eftirtilvísun í heimild.
Úr því hefur verið bætt.

- Náttúrufræðistofnun óskaði eftir að kort með flugleiðum yrði fjarlægt úr fyrri skýrslu NAVE vegna hættu á að hægt yrði að greina staðsetningu hreiðra.

Úr því hefur verið bætt.

9. Viðaukar

- [1] Náttúrustofa Vestfjarða - Árekstraráhættumat fyrir haferni við vindorkugarði í Garpsdal.
- [2] John Murphy - White-tailed eagle movements in the Garpsdalur Region of North-west Iceland
- [3] Alan Fielding - Developing a model of habitat use by White-tailed eagles in Iceland
- [4] Alan Fielding - Expert opinion on the likely impact of a proposed wind farm at Garpsdalur on White-tailed Eagles
- [5] Dr Matthew Geary - Potential technological solutions to reduce collision risk for White-tailed Eagles *Haliaeetus albicilla* at the proposed Garpsdalur windfarm

Ríkarður Örn Ragnarsson
Verkefnastjóri yfir Vindorkugarði í Garpsdal.

Viðauki 1

Náttúrustofa Vestfjarða

Árekstraráhættumat fyrir haferni við vindorkugarð í Garpsdal

Em orka

Suðurvangur 19a

Hafnarfjörður

Bt. Ríharður Örn Ragnarsson

Bolungarvík, 24.10.2025.

Árekstrarhættumat fyrir hafneri við 1. áfanga vindorkuvers við Garpsdal, viðbótargögn

Þetta minnisblað er að beiðni EM Orku þar sem Náttúrustofa Vestfjarða hefur verið beðin um að nota hreyfigögn til að kanna hættu á árekstri haförnsins (*Haliaeetus albicilla*) við vindmyllur í 1. áfanga fyrirhugaðs Garpsdalslundar.

Eftirfarandi skýrsla byggir á ferðagögnum sem söfnuð voru á tímabilinu september 2021 til ágúst 2024 úr GPS mælitækjum sem Kristinn Hauki Skarphéðinsson og samstarfsfólk hans við Náttúrufræðistofnun komu fyrir á 39 haförnum. Einstaklingarnir sem merktir eru eru hluti af stofn 180 einstaklinga sem nýta búsvæði milli Faxflóa og Húnaflóa. Mælingarnar veita upplýsingar um tíma, staðsetningu, hraða, stefnu, loftþrýsting, hitastig, fjölda gervihnattatenginga, vegalengd frá síðustu mælingu og hæð sem skráð er við hverja stefnubreytingu sem GPS greinir.

Niðurstöður benda til þess að á gagnasöfnunartímabilinu hafi fjórir ernir flogið yfir svæðið í fjögur aðskilin skipti. Af fjórum flugferðum yfir svæðið var árekstrarhættan lítil til miðlungs, þar sem heildarhættan að haförn yrði fyrir vindmyllu árekstri var 0,01 örn á ári. Öll flugin um svæðið hafa líklega verið innan hæðar vindmyllublaðs og voru farin utan vetrarmánaða.

Árekstrarhætta sem mynduð er út frá þessum gögnum hefur síðan verið sett inn í jöfnu sem Náttúrufræðistofnun lagði til, sem gerir kleift að taka með í reikninginn ómerkta og unga einstaklinga með árekstrarstuðlinum 3,63.

Að lokum má segja að hættan á að vindmylla rekist á erni á þessum stað sé 0,036 ernir á ári, sem er besta matið miðað við þau gögn sem fyrirbyggjandi eru. Þetta má jafngilda 3,6% líkum á hverju ári, sem síðan má margfalda með fjölda ára sem vindmyllugarðurinn kann að vera í rekstri.

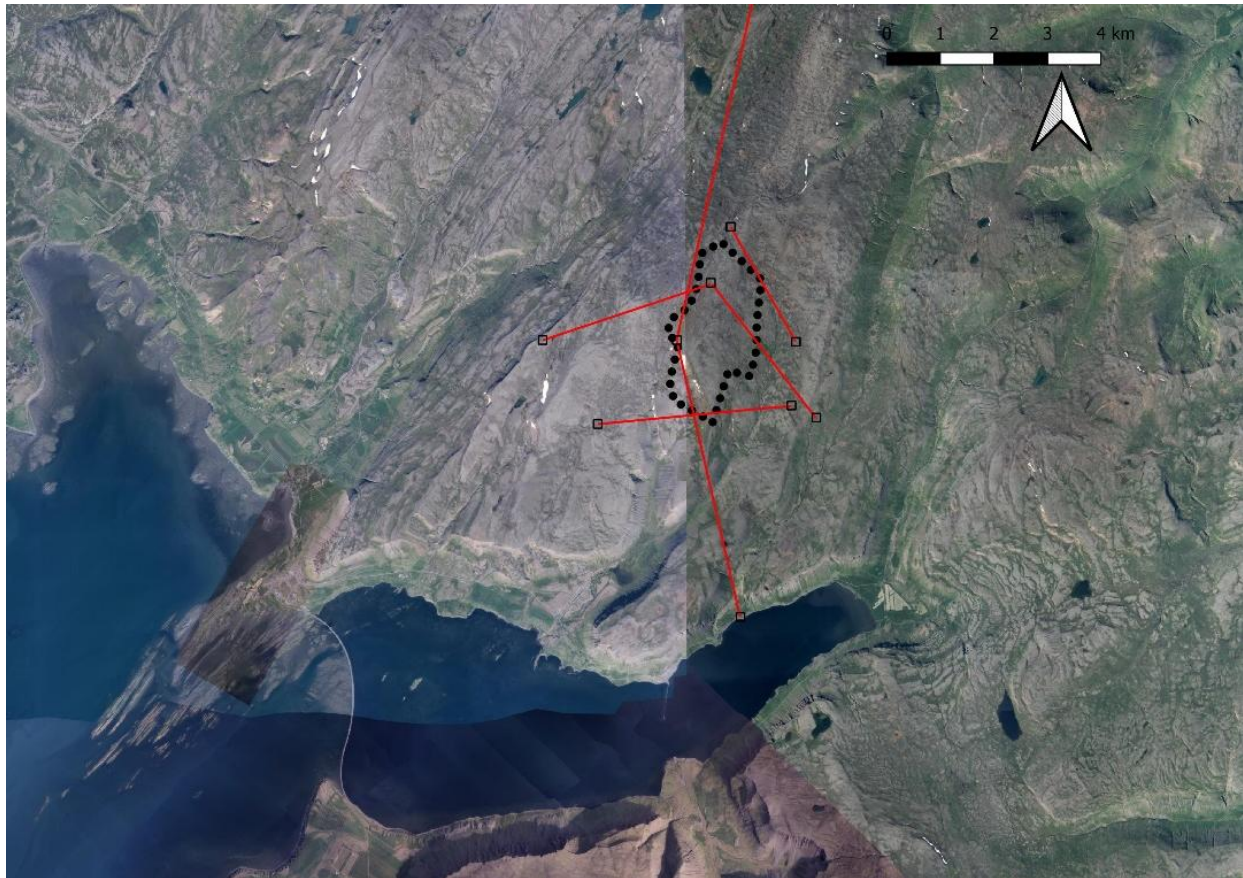
Aðferðir

Til að búa til höggáhættumat voru gögn um flughæð, stefnu og hraða tekin úr gagnapunktum næst staðnum og sett í Band Collision Risk Model (Band, 2024). Um er að ræða 2 hluta útreikning

sem er hannaður til að mæla hættuna á áhrifum á fugla sem fljúga í gegnum fyrirhugað vindorkuver. Handvirkar athuganir með sjónarhornskönnunum eða sniðtalningum eru staðlaðar aðferðir við gagnaöflun í þessu líkani en einnig er hægt er framkvæma þennan útreikning með GPS gögnum. Nafn, auðkenni merkisins og greiningartíma má sjá í töflu eitt, flugleiðirnar má sjá á mynd 1.

Tafla 1: Gagnapunktur notaðir við áflugsáhættumat á merktra erna sem hafa flogið yfir fyrirhugaðan vindorkugarð.

Tími	Örn	Merki nr.
14/06/2023 15:00	Gleri	7311
08/05/2024 14:30	Krskur	7111
30/06/2024 11:01	Ernir	3976
16/07/2024 19:05	Garpur	7308



Mynd 1: Flug hafarnanna 4. yfir svæðið.

Fyrsta skrefið felur í sér útreikning á áreksturshættu fyrir einstakar ferðir um svæðið, en þar er tekið er tillit til upplýsinga um fyrirhugaðan vindgarð, stærð og hraða fuglsins og hvort hann hafi verið að blakta eða svífa (hvort fuglinn er að blakta eða ekki hefur áhrif á þversnið fuglsins í gegnum snúningssvæðið, sem hefur einnig áhrif á líkur hans á að verða fyrir höggi). Einnig er innifalinn tímalengd vöktunar á svæðinu sem Náttúrustofa Norðausturlands stóð fyrir á árunum

2019 til 2021 (Hálfán H Helgason, 2023). Lengd vöktunartíma þeirra og lengd flug merktar arna yfir svæðinu var sameinuð og notuð sem breyta fyrir "lengd vöktunar á staðnum" í formúlunni.

Gögn um vindátt og hraða voru fengin frá Veðurstofustöð á Gillastaðamelum og sameinuð flugleiðum arnanna til að finna aðflugsstefnu að vindmyllunum. Vegna þess að við getum ekki sagt til um hvort fuglinn var að blakta eða svífa reiknum við bæði gildin hér. Formúlan fyrir útreikning á hversu margir ernir eru líklegir til að fluga yfir svæðið á hverju ári er eins og hér segir:

$$N_{transects} = (Tobs/Tmon * Avis) * Prisk * Arisk * Tactive * (Vr/Vw) / Ttransit$$

Seinni hluti útreikningsins tekur niðurstöðu áreksturshættu fyrir hvert flug til að gera mat á því hversu margir fuglar gætu orðið fyrir á ári. Það tekur tillit til þess hversu margir fuglar eru líklegir til að fljúga í gegnum snúningssvæðið á hverju ári og líkurnar á því að fugli takist ekki að forðast hættu. Formúlan fyrir heildarhættu á árekstrum fugla er sýnd hér að neðan:

$$\text{Number of birds colliding per annum} = \text{number flying through rotor area} * \text{probability of bird being hit by rotor}$$

Fjöldi fugla sem flugu í gegnum snúningssvæðið var reiknaður með upplýsingum frá GPS mælingargögnum. Til að ákvarða fjölda ferða um svæðið var lengd vöktunar borin saman við þann tíma sem fuglarnir dvöldu á staðnum, auk þess sem búast mætti við að fuglarnir væru til staðar. Hlutfall flugferða innan lóðrétta hættusvæðisins og flughraði var einnig tekið til greina við þennan útreikning.

Líkurnar á því að fugl verði fyrir snúningsblaði eru reiknaðar út í lokahluta greiningarinnar. Þessar líkur eru byggðar á May R (2011) þar sem lagt er til, byggt á gervihnattafjarmælingum, að 95% erna muni forðast hættusvæðið. Formúlan fyrir þennan útreikning er sem hér segir:

$$\text{Avoidance Rate} = 1 - \text{actual collisions} / (\text{number of birds flying through the rotor swept zone} * \text{hit probability})$$

Niðurstöður

GPS mælingar benda til þess að 4 einstaklingar hafi flogið yfir svæðið í fjögur aðskilin skipti (tafla 2). Niðurstöður útreiknings á árekstrarlíkum benda til þess að þessir einstaklingar hafi verið með áreksturshættu á bilinu 0,066 til 0,203 á svífi og áreksturshættu á bilinu 0,07-0,203 á flakki, sem bendir til þess að í þessum flugferðum hafi líkur á árekstri verið 6-20%.

Tafla 2: Árekstrarhætta leiðir til tilvika þar sem ernir flugu um svæðið. Þessi gildi gefa til kynna áhættuna fyrir einstaklinga í skráðu flugi.

Örn	Árekstrarhætta við svífflug	Árekstrarhætta við blökun
Gleri	0.145	0.138
Krskur	0.203	0.203
Ernir	0.066	0.07
Garpur	0.116	0.117

Niðurstöður áhættumats benda til þess að líklegt sé að 0,01 erni verði fyrir höggi á hverju ári (tafla 3). Hins vegar verður að hafa í huga að útreikningar á áhrifaáhættu (árekstrum á ári) sem settir eru fram hér að ofan taka ekki tillit til gagna frá ómerktum einstaklingum (141 af 180) og að gögn frá aðeins 4 af 39 merktum einstaklingum eru með í þessari greiningu.

Tafla 3: Niðurstöður áhættumats á áhrifum

	Við sviffflug	Við blökun
Árekstrarhætta (Collisions per annum)	0.0100445771	0.0100066731

Umræða

Áhættumat er tæki til að lýsa áhættunni sem stafar af fuglum á tilteknum stað. Þetta þýðir að búsvæðanotkun og hegðun fuglanna á lífsleiðinni er ekki hluti af útreikningnum. Það er krefjandi að spá fyrir um hættuna fyrir ómerkta fugla, þó þeir deili búsvæðum er ekki vitað hvort allir eða einhverjir séu nokkurn tíma á svæðinu. Hins vegar eru 21,6% stofnsins merktir og 10,2% merkta stofnsins flugu yfir svæðið á tímabilinu september 2021 til ágúst 2024. Þ.a.l., gætu mögulega 18.46 merktir og ómerktir ernir hugsanlega flogið yfir svæðið á 3 ára tímabili, eða 6 flug á ári.

Farleiðir erna eru sýnd á mynd 2. Þar sést að fuglarnir eru greinilega að nota dalina sitt hvoru megin við athafnarsvæðið til að ferðast á milli Breiðafjarðar og Steingrímsfjarðar. Tilvikin þar sem fuglarnir koma inn á svæðið gætu mögulega verið vegna þess að þeir skipta frá einni flugleið til annarrar, kannski eftir vindátt.

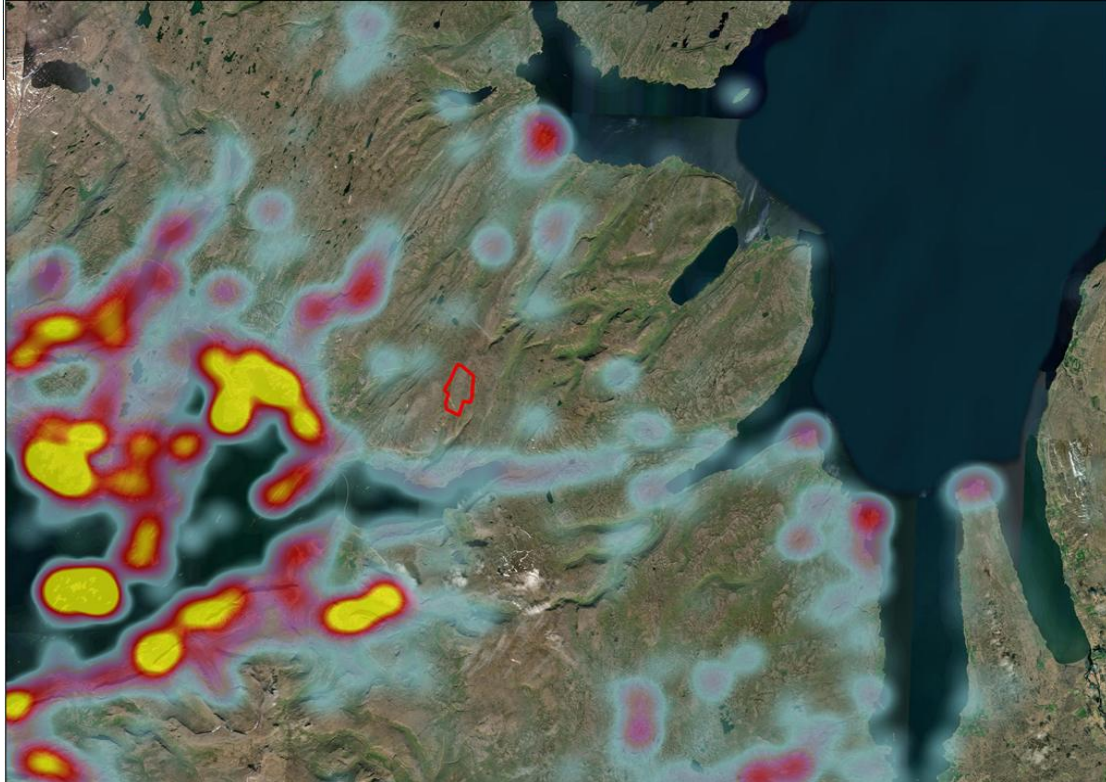
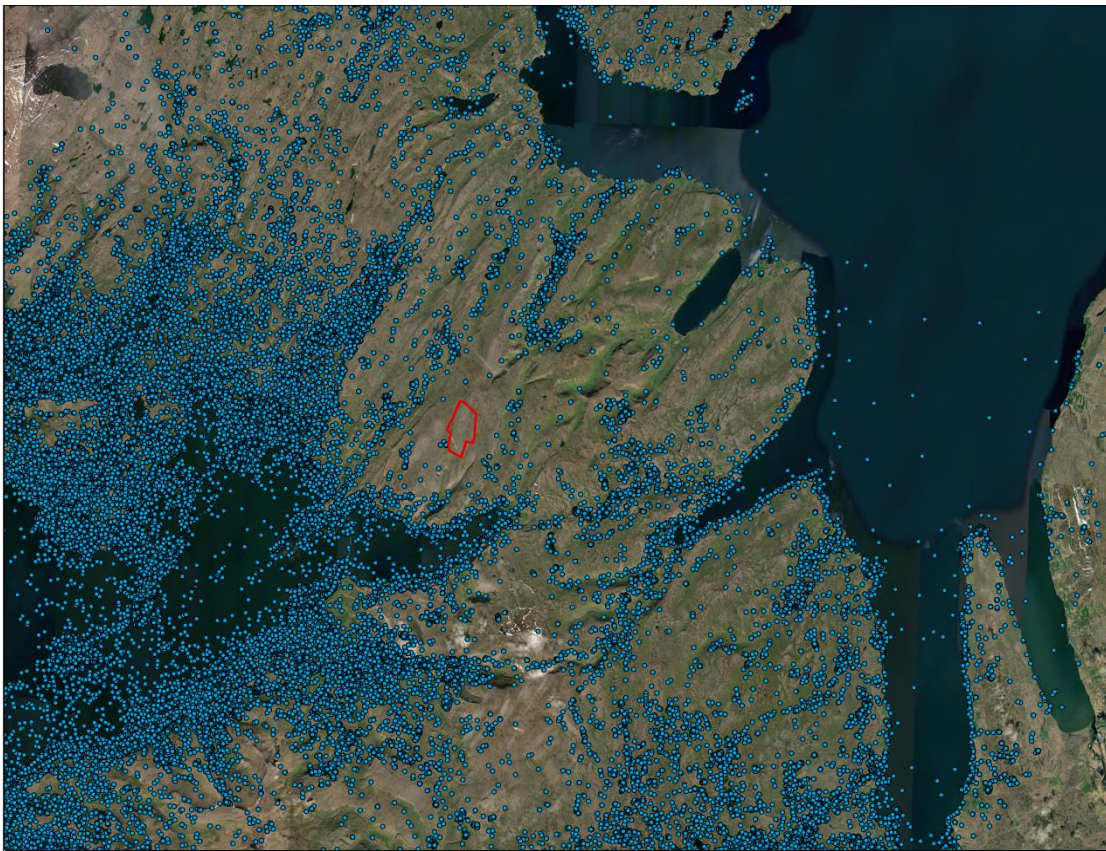
Í fyrsta stigi útreikningsins var reiknuð árekstrarhætta fyrir svæðið. Þetta lýsti aðeins skráðum tilvikum þar sem ernirnir flugu um svæðið. Seinni hluti útreikningsins tekur þessa tölu og reiknar þær upp í áætlaða umferð yfir heilt ár af skráðum athugunum. Til að skilgreina áætlaða umferð þarf að mæla tímann sem merktir ernir fluga í gegnum svæðið og þann tíma sem athugendur hafa eytt á staðnum í leit að fuglum. Þetta þýðir að þrátt fyrir að fylgst var með flugleið 39 arna samfellt í nokkur ár, var aðeins hægt að nota tímann sem ernirnir eyddu á staðnum í þetta áhættumat.

Eins og lýst er í grein frá May 2011, er geta hafarna til að forðast árekstri háð fjölda þátta, þar á meðal snúningshraða vindmillanna. May (2011) bendir á að jafnvel þegar vindmillur eru kyrrstæðar ná högglíkurnar aldrei núlli, heldur haldast undir 20% með snúningshraða yfir 1 snúning á 3. sekúndu fresti (May R, 2011).

Niðurstöður áhættumats sýna að líkurnar á því að fugl komist inn á svæðið og verði síðan fyrir vindmyllublaði eru tiltölulega litlar. Niðurstöður eins og 0,01 fugl á ári eru þó ekki samlagðar, þ.e. að það má endilega búast við því að 10% líkur á áratug og 100% líkur innan aldar fugl yrði drepinn ($0,01 \cdot 10 = 0,1$ og $0,01 \cdot 100 = 1$).

Niðurstöður benda hins vegar til þess að þetta sé ekki svæði sem fuglarnir nota oft, eins og sjá má á mynd 2.

Hitakortið byggir á sömu hreyfigögnum og hráu GPS-gögnin sem sýnd eru á mynd 2, en með hitakorti er betur hægt að sjá þau búsvæði sem oftast eru notuð. Eins og sést á myndinni eru eyjar og strandsvæði Breiðafjarðar oftast nýtt, ásamt nokkrum dölum.



Mynd 2: Flugleiðir merкта erna innan 40 km rafiuss fyrir ofan, hitakort að neðan sýnir sömu gögn.

Viðbót: Áflugsstuðull

Útreikningur á heildaráhættu er mögulegur með jöfnu frá Náttúrufræðistofnun (Borgný Katrínardóttir, 2025). Þessi jafna notar fjölda merktra fugla og þekkingu á fjölda fullorðinna og ungfugla á svæðinu. Jafnan sem notuð er er sýnd hér að neðan:

$$\text{Áflug}_{\text{heild}} = \text{Áflug}_{\text{merktir}} * \text{Áflugsstuðull}$$

Þar sem áflugsstuðull er reiknaður með:

$$\text{Áflugsstuðull} = \frac{\text{Fjöldi fugla}_{\text{innan svæðis}}}{\text{Sendafuglar}_{\text{innan svæðis}}}$$

Fjöldi fugla sem talið er að séu á svæðinu er reiknaður út með jöfnunni:

$$\text{Fjöldi fugla}_{\text{innan svæðis}} =$$

$$\left(\frac{\text{Sendafuglar}_{\text{innan svæðis}}}{\text{Sendafuglar}_{\text{heild}}} * \text{Lifandi ungfuglar}_{\text{án sendis}} \right) + \text{Sendafuglar}_{\text{innan svæðis}} + \text{Varpfuglar}$$

Og fjöldi lifandi en ómerktra ungfugla er reiknaður út með jöfnunni:

$$\text{Lifandi ungfuglar}_{\text{án sendis}} = \left(\frac{\text{Sendafuglar}_{\text{lifandi}}}{\text{Sendafuglar}_{\text{heild}}} * \text{Ungfuglar}_{\text{án sendis}} \right)$$

Til að fylgja þessari aðferðafræði eru hugtök og gildi sett fram í töflunni hér að neðan:

Tafla 4: Hugtök og gildi sem notuð eru til að reikna út raunverulega árekstrarhættu allra arna á svæðinu.

Hugtök	Gildi
Sendafuglar lifandi	35
Sendafuglar heild	53
Ungfuglar án sendi	199
Sendafuglar innan svæðis	39

Lifandi ungfuglar án sendis	131.4150943396226
Fjöldi fugla innan svæðis	141.7016732
Áflugsstuðull	3.633376236

Með þeim gögnum sem eru tiltæk er árekstrarstuðullinn gefinn upp sem 3,63. Þegar árekstrarhætta er margfölduð með þessu eru niðurstöðurnar fyrir leiðréttu árekstrarhættu eftirfarandi:

Tafla 5: Árekstrarhætta fyrir alla erni á svæðinu.

Árekstrarhætta arnarstofn	Við sviðflug	Við blökun
Áflug heild (Collisions per annum)	0.0364957277358098	0.0363580082429605

Notkun árekstrarhættugilda

Þetta nýja áhættugildi fyrir alla erni á norðvesturhluta svæðisins jafngildir 3,6% líkum á að einstaklingur verði fyrir vindmylluspaða innan svæðisins á hverju einasta ári. Í öðrum löndum hefur áhætta fyrir eitt ár ekki verið nægjanleg til að meta áhættuna, heldur er áhættan metin yfir allan líftíma vindmyllugarðsins. Þetta má tákna með því að margfalda áhættuna fyrir áhrif með fjölda ára sem vindmyllugarðurinn kann að vera virkur (Malachy Walsh, 2020; Galetch Energy Services, 2021). Í þessu tilviki má tákna gildið okkar sem 18% líkur á 5 ára rekstri, 36% líkur innan 10 ára, 90% líkur innan 25 ára rekstri eða 109% líkur á árekstri við vindmyllu innan 30 ára. Að lokum má segja að líkurnar á að örn verði fyrir árekstri við vindmyllu á hverju ári séu litlar, en á öllum líftíma vindmyllugarðsins má búast við að einn örn rekist á vindmyllu.

Heimildir

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Viðauki 2

John Murphy

White-tailed Eagle movements in the Garpsdalur Region of
North-west Iceland

White-tailed Eagle movements in the Garpsdalur Region of North-west Iceland

John N Murphy

Lead Ornithologist with the EMpower, Garpsdalur Wind Farm Project & Senior Ornithologist & Manager of Irish Ornithological Survey Group (IOSG).

In a further information request, with regard to documented movements of White-tailed Eagles *Haliaeetus albicilla* in the Gilsfjörður, and the surrounding region for the proposed Garpsdalur Wind Farm site location.

In order to satisfy the two main concerns as outlined in the further information request;

1. The air traffic of GPS tracked White-tailed eagles *Haliaeetus albicilla* and movements close to and over the proposed Garpsdalur Wind Farm (four individual birds on the site).
2. Dense eagle nest sites nearby and considerable eagle traffic along the edges of Garpsdalsfjall Mountain.

The presence of a poorly sited wind farm can raise concerns for wildlife, including birds of prey. This was one of the issues considered in advance of positioning this project in the Garpsdalsfjall Mountain range. As a highly experienced bird surveyor of hundreds of wind farm projects and with over 45 years of ornithological studies carried out since the mid 1970's, I was requested to advise and look at setting up bird studies in this location for the proposed Wind Farm project by EM Orka.

At the outset and in the original setup of these surveys (using the Scottish Natural Heritage 2017 methodology), In order to get a better picture and understanding of bird activities, I proposed that we not only cover the avifauna on the original site, but we also considered and did our best to understand bird community activity throughout this region. This included the White-tailed Eagle *Haliaeetus albicilla* and other common bird species found in this localised area of northwest Iceland.

Areas covered to gather this additional information included Gilsfjörður (Vestfjarðavegur, Tröllatunguvegur, Djúpvegur to Hólmavík) Innstrandavegur road to the north and Strandabyggð (where the Black Guillies nest) and Króksfjarðarnes.

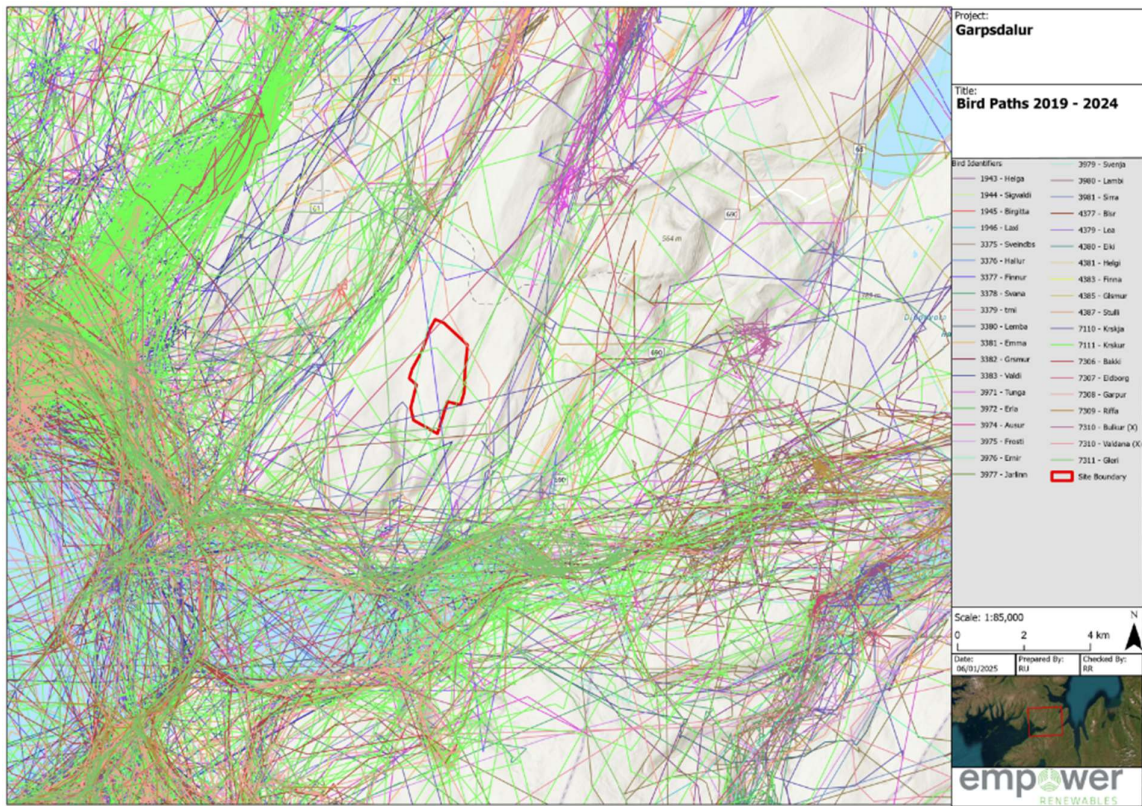
In an attempt to answer the above complex request on the movements of WTEs in this region, the following is my interpretation of why birds are using the current recorded flight paths as seen in the GPS location data;

Icelandic White-tailed Eagles *Haliaeetus albicilla* live mainly in the lowlands and mainly around shorelines and fjords in the north west of the country. Here there are up to 90 pairs nesting on suitable low lying island within these fjords, where the majority of their food source is more readily available throughout the year. In these fjords and adjacent fields and valleys, birds nest and feed, and fly around hunting suitable food prey. Flight paths depicted in the monitored satellite tracked birds between the years of 2019 to 2024, are mainly of immature birds that were tagged on the nest as pulli. The following information is my assessment of what the flight paths of the satellite tagged eagles, are potentially doing once they dispersed from the nest sites. Some of these flight paths are locations where adults also hunt their prey, to provide food for their juveniles, whether they are still on the nest, or sitting around in locations on lowland fields and outcrops awaiting food drops. We studied the flight paths of 39 individually tagged birds that traversed this region within a 40km radius and hundreds of kilometres of movements surrounding the proposed Wind Farm project on the plateau at Garpsdalsfjall Mountain.

Similar studies of flight paths of immature White-tailed Eagles *Haliaeetus albicilla* have taken place in Finland (<https://pmc.ncbi.nlm.nih.gov/articles/PMC5055479/>). Here they also found that satellite tagged juveniles tend to stick to coastal regions where natural food sources are readily available throughout the year, even in times of heavy snowfall and freezing conditions. This is a very similar picture in north-west Iceland where in

recent times global weather patterns have changed and freezing seas are less likely nowadays than they were in past times.

In summer, adult birds would take fish, young juvenile geese and other common wildfowl and any dead seal or marine cetacean carcasses washed up along the shore. During times of migration periods when Pink-footed Geese *Anser brachyrhynchus* or locally breeding Greylag Geese *Anser anser* gather in communal family flocks in traditional fields throughout the valleys, leading off these fjords, making it suitable for White-tailed Eagles *Haliaeetus albicilla* to pick off geese, especially visiting Barnacle Geese *Branta leucopsis* heading from breeding grounds in Greenland to overwintering grounds in Britain & Ireland. White-tailed Eagles *Haliaeetus albicilla* can also pick crustaceans and mollusc along shorelines in times of low bird or mammal presence, another reason why birds stick mainly to coastal locations in summer, but especially in winter where ice free shores provide feeding for prey species and eagles.



From the flight paths gathered over the 5 year period outlined, flight paths do depict immature and recently fledged eagles dispersing in many directions in this region of north-west Iceland, as would be expected. This is the case wherever this species is found in parts of Europe or Iceland. The flight paths show birds utilising valleys to fly through, to reach other fjords where food is the main target and meeting other offspring of nesting eagles to pair off with in future years. Some birds do explore bodies of water en-route to these other fjords and they soon find that many of the isolated locations at the tops of mountains and plateaus, do not provide enough food or shelter to sustain their full time existence, especially in winter months, where I'm sure a certain percentage of birds must perish naturally.

Likewise in late summer, when young eagles frequenting some of the lakes in upland regions of this mountain range after fledging, natural food source like wildfowl and fish can often be lower in quantities, to that of lowland habitats surrounding the plateaus and mountain tops. Rivers flowing through these mountains to the north and south of the proposed wind farm hold Brown Trout *Salmo trutta* and Atlantic Salmon *Salmo salar* or

Salmon Par, which White-tailed Eagles *Haliaeetus albicilla* may occasionally catch while travelling these systems. Most of the prey and small fish are probably eaten by Goosanders and other fish loving ducks, or small hatching ducklings by foraging Lesser Black-backed Gulls *Larus fuscus* or Grey Herons *Andrea cinerea*. The higher lakes would support native fish such as Arctic Char *Salvelinus alpinus* which are a deep water species and probably eaten by Red-throated Diver *Gavia stellata* Great Northern Divers *Gavia immer* and grebes, which breed in such isolated lakes. Successful hunting for eagles may be much more difficult at these altitudes, but the lower down plains provide a greater supply and mix of food source. Due to this and as would be expected, there is less eagle activity recorded in the highlands to that of the lowlands.

Icelandic mountain tops and lakes are bereft of trees unlike many areas of Fenno-Scandinavia and Britain or Ireland. Lack of tree line around shorelines of these Fjords and lakeside, are more readily available in northern and Western Europe. This must limit nesting and hunting options for sea eagles in north-west Iceland at these higher altitudes. Very few of the lakes have islands large enough to sustain breeding pairs of eagles, another reason why we see much more flight path activity in the seashore fjords and bays.

White-tailed Eagles *Haliaeetus albicilla* don't like to fly in fog or days when there are high winds or poor visibility. Large eagles like this tend to sit tight on the ground during these conditions as they cannot manoeuvre very well. White-tailed Eagles *Haliaeetus albicilla* like the majority of this family have extremely good eyesight with 20/20 vision for catching prey. With such vision they can easily identify and allow them to avoid moving turbine blades with flashing beckons to assist in birds spotting them in poor light conditions, even young immature birds. I oversee a large Wind Farm site in the west of Ireland with over 60 turbines, where post construction monitoring is carried out to see do White-Tailed Eagles *Haliaeetus albicilla* collide with large turbines. On this site we have a pair of White-tailed Eagles *Haliaeetus albicilla* nesting on the western fringes of the wind farm that in a nest, on the island, within a small lake (approximately 3km away). The young birds that fledge this nest regularly fly in and out of the wind farm. They often sit on rocks under the turbines and completely and successfully avoid the blades. There was never a collision on this site of eagles in a landscape similar to parts of north-west Iceland, but with greater mature tree line which they fly between. The nearest White-tailed Eagle *Haliaeetus albicilla* nest site to our proposed wind farm is approximately 7.6km away. This is sufficient distance as to not disturb any breeding eagles in Gilsfjörður and beyond.

As outlined in the beginning of this report, only four individuals came within or close to the site boundary in two seasons of avifauna monitoring at the proposed Garspdalur Wind Farm Project Phase 1. This is a tiny per cent of the overall population breeding on the island of Iceland and wind turbines on the top of this mountain should not have any adverse effect on the overall White-tailed Eagle *Haliaeetus albicilla* population, whether breeding or foraging for food. My conclusion is that the site at Garspdalur would be the best location in this region to construct such a green Energy project.

Viðauki 3

Alan Fielding

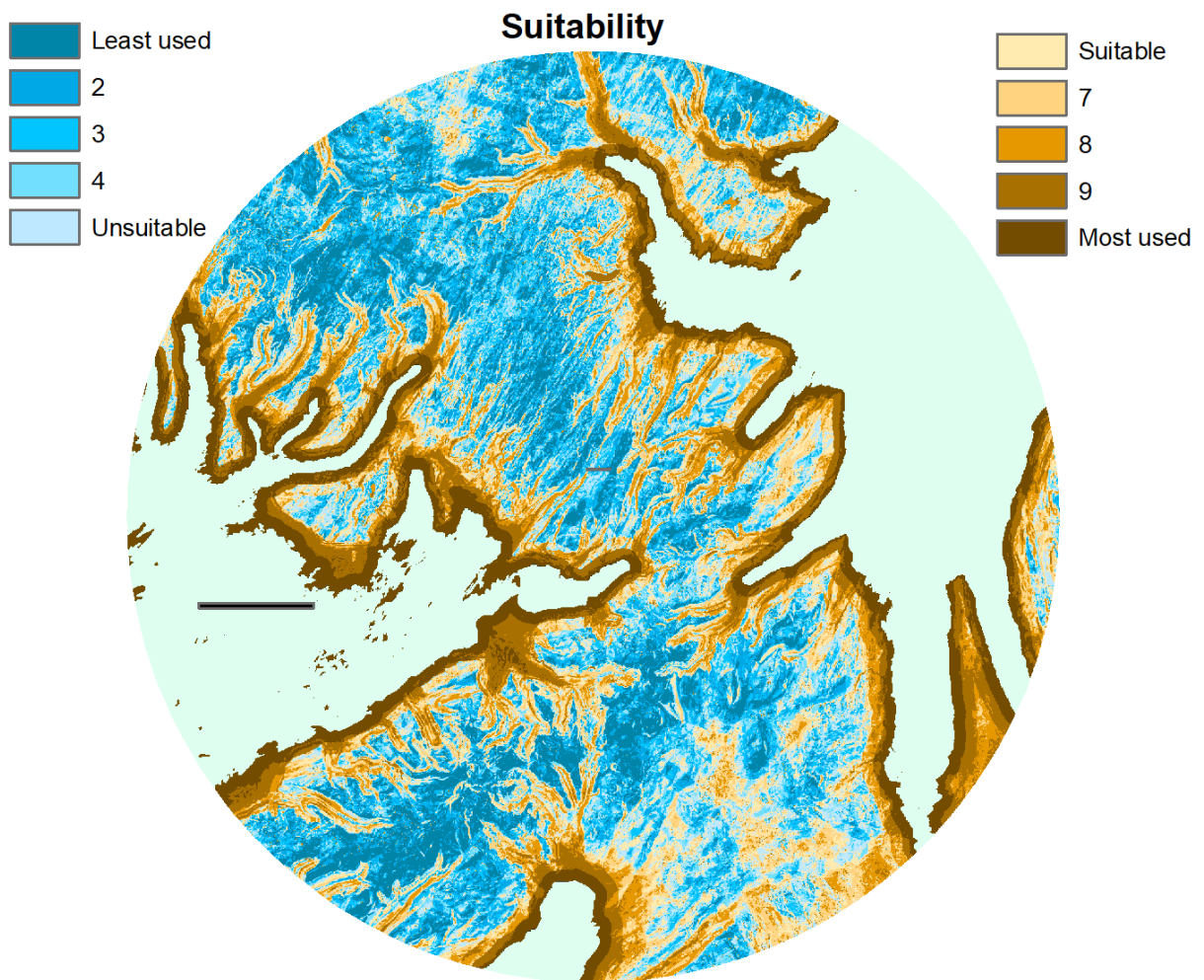
Developing a model of habitat use by White-tailed eagles in
Iceland

Developing a model of habitat use by White-tailed eagles in Iceland

Alan Fielding

February 2025

The habitat suitability model (White-tailed eagle Topographic (WET) Model)



Model background

A species distribution model (SDM) was developed to identify regions in NW Iceland that may be attractive to white-tailed eagles. A successful model could be used to identify locations that are unlikely to be used by white-tailed eagles and form the basis for an environment impact assessment of a proposed development.

The Species Distribution Model (SDM)

SDMs belong to a class of models called classifiers. Deciding which of the many classifier algorithms to use is not a simple choice. There is no 'best' classifier and classifier performance varies with the classification problem (Fielding, 2006). Fielding (2006) suggested that an ideal SDM would be accurate (correctly predicts where a species can be found or is absent) and has utility (results can be translated into actions).

SDMs are developed using a training data set (a subset of satellite tracking data in this SDM). The role of the training data is not to produce a SDM capable of producing exact representations of the training data, but rather to build a general model of the relationship between locations used by white-tailed eagles and the predictors. The ability to generalise is influenced by the SDM's complexity because, in general, SDMs with too few, *or* too many, predictors may perform poorly with new data. This means a SDM's complexity must be optimised. This is a difficult trade-off which needs to take account of the SDM's **bias and variance**.

It is a trivial task to produce a model which correctly predicts the locations of all tag records by assuming everywhere is suitable. Clearly such a model has no utility so the task is to produce a model which makes correct predictions for most (~90%) tag records but not at the expense of overpredicting the extent of suitable habitat. There is unlikely to be a SDM which is 100% accurate with training data without over-predicting areas likely to be used.

Bias measures the SDM's accuracy, i.e. closeness of predictions to reality. Low bias = high accuracy which is a very desirable property. *Variance* measures precision or repeatability. If variance is high, accuracy will change markedly between different training sets, for example two SDMs developed using the same predictors, but with data from different tags, could make very different spatial predictions. It is difficult to have confidence in a SDM with high variance because current accuracy may not be repeated with different data. Consequently, a SDM with low variance is desirable. Unfortunately, simultaneous low bias and low variance is impossible because of a trade-off such that one increases as the other declines. Low bias depends on an ability to adapt to differences in training sets, which is only possible with many predictors. Unfortunately, a classifier with many predictors is likely to have high variance. This trade-off is reflected in the different relationships between training and testing error rates and increasing classifier complexity. As complexity increases, training data errors decline to a minimum. Although errors in test data show an initial, parallel, decline with increasing SDM complexity the errors begin to increase as the SDM passes its optimum complexity. This trend has to be incorporated into a SDM's design to avoid developing models that are sub-optimal with new data. In general terms, a simpler model, that does not aim for 100% accuracy for the training data, is likely to result in a better bias-variance trade-off.

The approach

Two very different SDMs were investigated: Point Process Modelling (PPM, Renner *et al.* 2015) and Selection Index (SI) modelling. Both have been used successfully in modelling raptor distributions. The PPM was dropped at an early stage. Although a PPM model was used by AF and others to successfully model hen harrier distributions on the Isle of Mull (Geary *et al.*, 2018) subsequent

attempts to use the same method in other parts of Scotland were unsuccessful (unpublished analyses undertaken for the Joint Forests and Raptors Working Group). Recent changes to the software needed to develop a PPM made it unreliable and time consuming.

Selection Index modelling

The second approach uses a simple SI model based on the method used to model golden eagle habitat from topography (Fielding *et al.*, 2020). Since its development the Golden Eagle Topographic (GET) model has been tested with new, independent data, including from range holding birds, and the model has performed very well (See Appendix A in Fielding *et al.* 2023). NatureScot now advise that “from now on, in cases where modelling is necessary for the assessment of the impacts of forestry or wind farm proposals on golden eagles, GET model assessment is recommended to support Environmental Impact Assessment Reports”¹.

Whilst a reliance on ridges, as seen in the GET model, is less likely it is improbable that a large bird, such as the white-tailed eagle, would move around independently of topography. Consequently, a topographic model was developed – the White-tailed Eagle Topographic (WET) model.

The WET model uses a simple SI resource selection function approach (Manly *et al.* 2002). In the context of these models, it is more appropriate to refer to preference indices (PI) rather than SI (Beyer *et al.* 2010). Abundance, rather than accessibility, was used as a measure of availability (Hall *et al.* 1997). A PI does not explain the underlying habitat selection process but it highlights differences between suitable and unsuitable habitat.

A PI is the proportion of all tag records divided by the proportion of all available habitat in the landscape associated with a particular habitat predictor value. For example, 6.7% of the landscape has an altitude between 1 and 20 m but 54.3% of tag records were on a pixel with this altitude. The PI for an altitude between 1 and 20 m is, therefore, 8.07 (0.5431/0.0673). A PI of one indicates use that is directly proportional to availability whilst divergence from 1 indicates under (PI <1) or over-use (PI >1). A PI of 8.07 is strong evidence of over-use, a strong ‘preference’ for land at this low altitude.

A problem with a PI is its dependence on how available habitat is defined, different definitions affect the divisor (Beyer *et al.* 2010, Paton and Matthiopoulos, 2016). The definition of ‘available habitat’ used here approximates to Johnson’s (1980) third scale of availability of habitat use and was based on the 40 km wide bounding buffer surrounding the location of the proposed wind farm. Available habitat for white-tailed eagles was all land within this buffer. Some records were over the sea but for the purposes of this model they were not used.

PIs were standardised (SPI) by dividing each PI by the sum of that predictor’s PIs. Standardisation ensures that PIs sum to one. An SPI, rather than a PI, simplifies interpretation: for example, an SPI of 0.3 indicates that a habitat feature is three times more likely to be used than one with an SPI of 0.1. In a final step, to simplify subsequent GIS operations, SPIs were multiplied by 1,000 and retained as integer values. SPI calculated for seven predictors, stored as raster images with 50 m pixels.

Model Data and Predictors

All GIS Operations were undertaken using QGIS Desktop 3.38 software and various spatial libraries, particularly terra (1.7-83), in the R statistical program (R version 4.4.2).

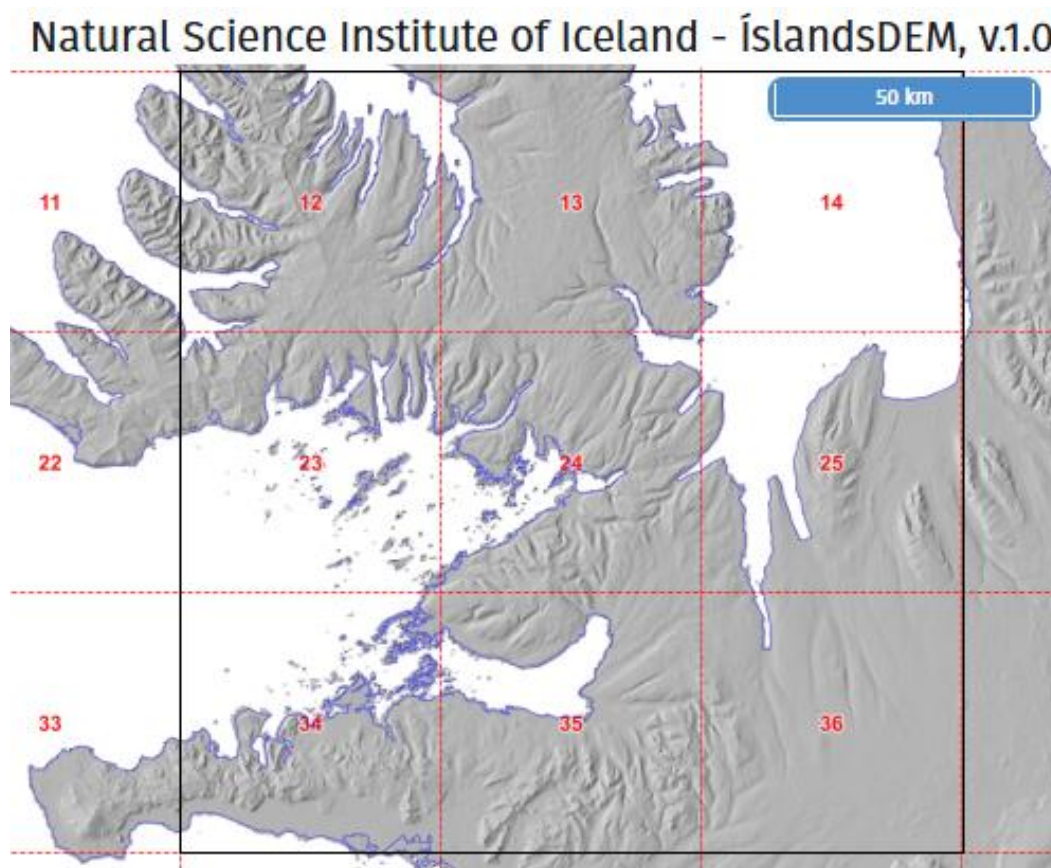
¹ <https://www.nature.scot/doc/naturescot-statement-modelling-support-assessment-forestry-and-wind-farm-impacts-golden-eagles>

Satellite tag data were provided in a 40 km buffer centred on a proposed wind farm. Consequently, all predictors were clipped to the same 40 km buffer.

The WET model is mainly a topographic model based on Digital Elevation Model (DEM) data. DEM data were available at various spatial resolutions. A 50 m pixel model was considered appropriate for these data for computational and spatial accuracy reasons. The other dataset was a 2012 Corine Landcover map which was converted from a vector to a raster image with 50 m pixels.

50 m DEM data were downloaded as nine 50 km tiles from the Náttúrufræðistofnun website. The tile numbers were: 12; 13; 14; 23; 24; 25; 34; 35; 36 (Fig. 1). The data projection was ISN2016 (epsg: 8088). The nine tiles were mosaiced into a single tile which formed the basis for all modelling and six raster data sets were derived from the raw DEM data.

Figure 1. The nine 50m DEM tiles used in the modelling (<https://atlas.lmi.is/mapview/?application=DEM>) These data are free for public use under the International CC BY 4.0 licence.



Corine data were downloaded (<https://www.lmi.is/is/landupplýsingar/gagnagrunnar/nidurhal>) for the whole of Iceland. The vector data were cropped to the 40 km tag buffer and converted to a raster image with a 50 m pixel resolution.

The Predictors

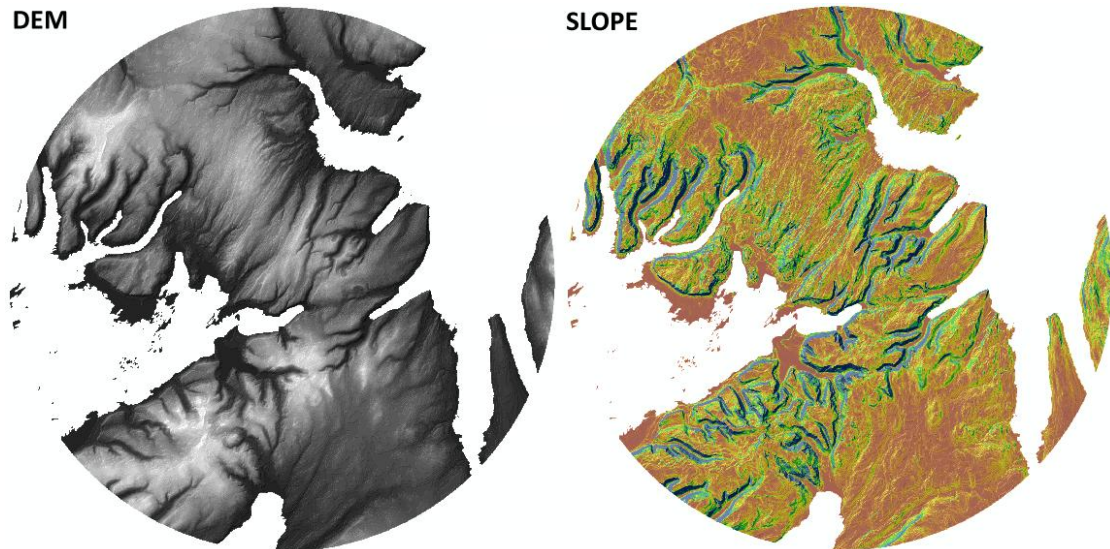
DEM20m

Altitude was placed in 20 m height bands (1-20 m, 21-40 m, etc). Binning the data into 46 20 m classes simplifies the preference analyses, compared with the original 920 1 m values (Fig. 2). Altitude above 500 m was placed in a single 500+ m class.

Slope

Slope was estimated using the QGIS terrain analysis function and binned into 5° classes (0 - 4°, 5 - 9°, etc) (Fig. 2).

Figure 2. left: DEM and right: Slope in the 40 km radius wind farm buffer.



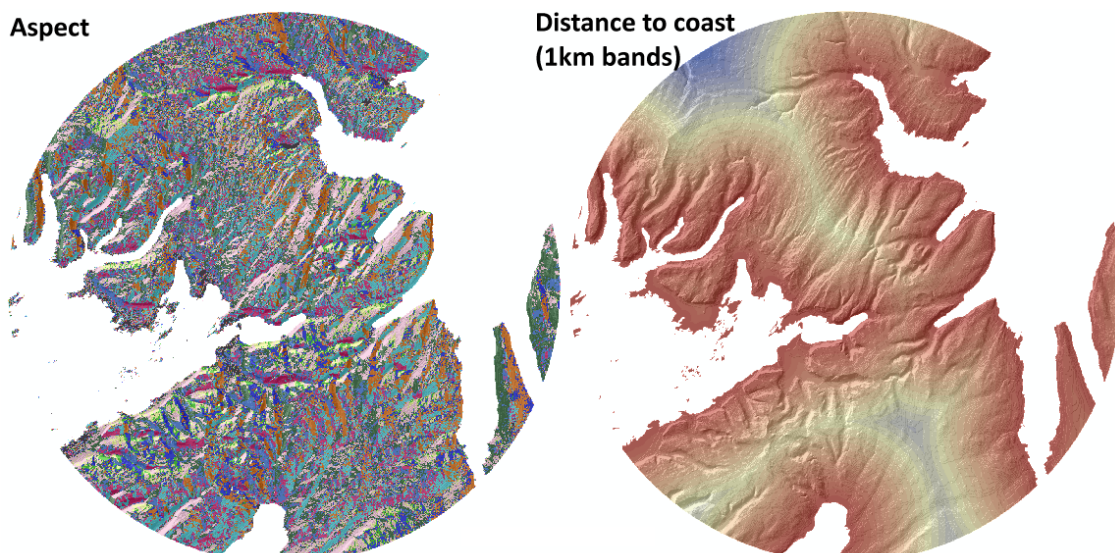
Aspect

Aspect was estimated in 10 directional zones using QGIS terrain functions: 1 flat; 2 N; 3 NE; 4 E; 5 SE; 6 S; 7 SW; 8 W; 9 NW; and 10 N (Fig. 3).

Distance to the coast

A binary image (land/sea) was created from the DEM and distance to the sea was estimated using the QGIS Raster Proximity function. Distances were binned into 1km bands (Fig. 3).

Figure 3. left: Aspect and right: Distance to the coast.

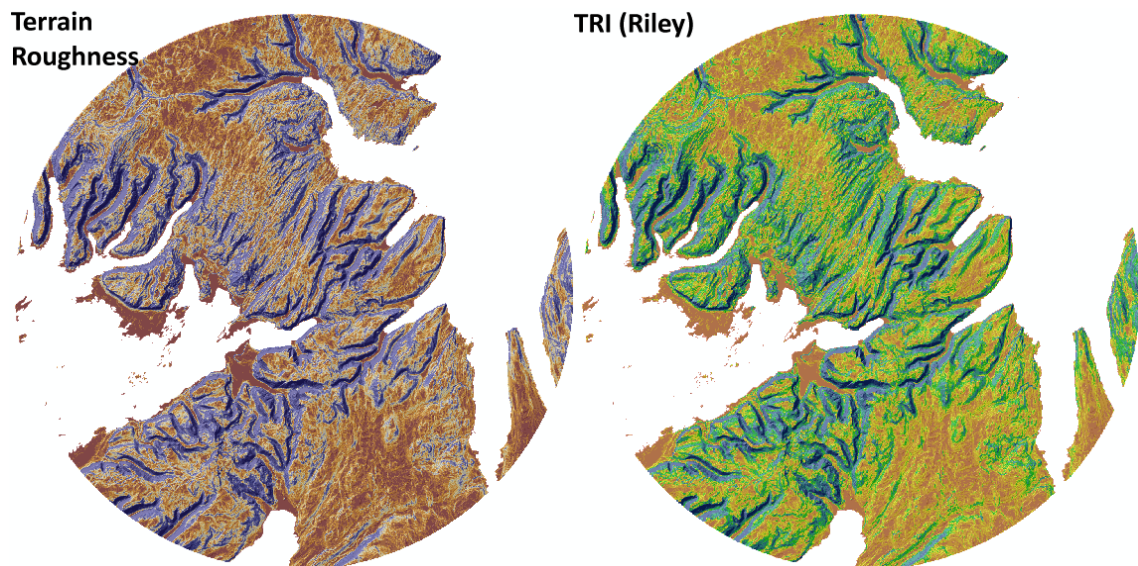


Riley's Terrain Roughness Index (Riley)

Surface roughness (terrain evenness) was estimated using the terrain function in the R terra package (Fig. 4). Three measures were considered: Roughness, Topographic Preference Index and Riley's Terrain Roughness Index (TRI, Riley *et al.*, 1999). Only the TRI, was retained. TRI measures topographic variation as the elevation difference between a central grid cell and its surrounding cells.

The scale is from low values (even ground) to higher values (rugged). Suggested categories are: 0-80, level; 81-116, nearly level; 117-161, slightly rugged surface; 162-239, intermediately rugged surface; 240-497, moderately rugged; 498-958, highly rugged surface and > 959, extremely rugged surface. The range of values in these data were 0 to 187 and for the purposes of these analyses the TRI values were placed in 10 quantiles (same number of pixels per quantile). The 0 values are around the coast where the algorithm did not calculate a value. These are retained as white-tailed eagles are often associated with the coast. This means that the 10-point quantile scale became an 11-point scale.

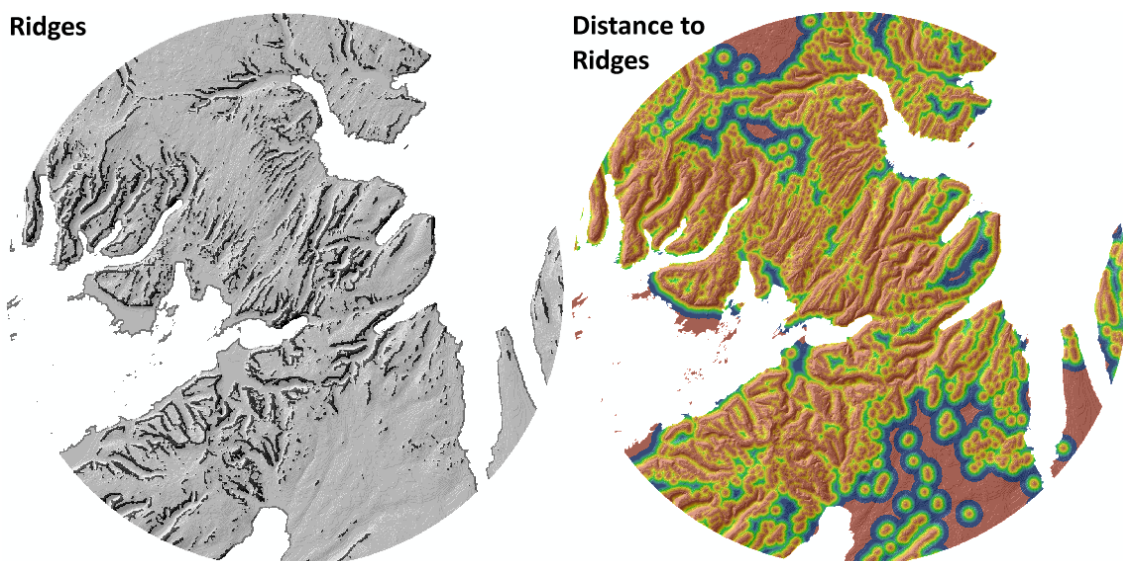
Figure 4 left: Terrain roughness (not used) and right: Riley's Terrain Roughness Index



Ridges and distance to a ridge

Ridges were identified using R code developed for the GET model (available in the Supplementary table S1 in Fielding *et al.*, 2020). In summary, a threshold (height in m) is set for the detection of ridges. This threshold is used in a comparison of the altitude of a putative ridge pixel against a mean calculated from filters running in four cardinal directions (N-S, E-W, NE-SW and NW-SE). The selected threshold is 54 m (26 m either side of the target pixel + 2 m). This threshold produces a ridge map which matches the terrain as judged from contour maps. Distance to a ridge is a continuous value so these were binned into 50 m distance classes, as in the GET model (Fig. 5).

Figure 5. left: Ridges and right: Distance to a ridge

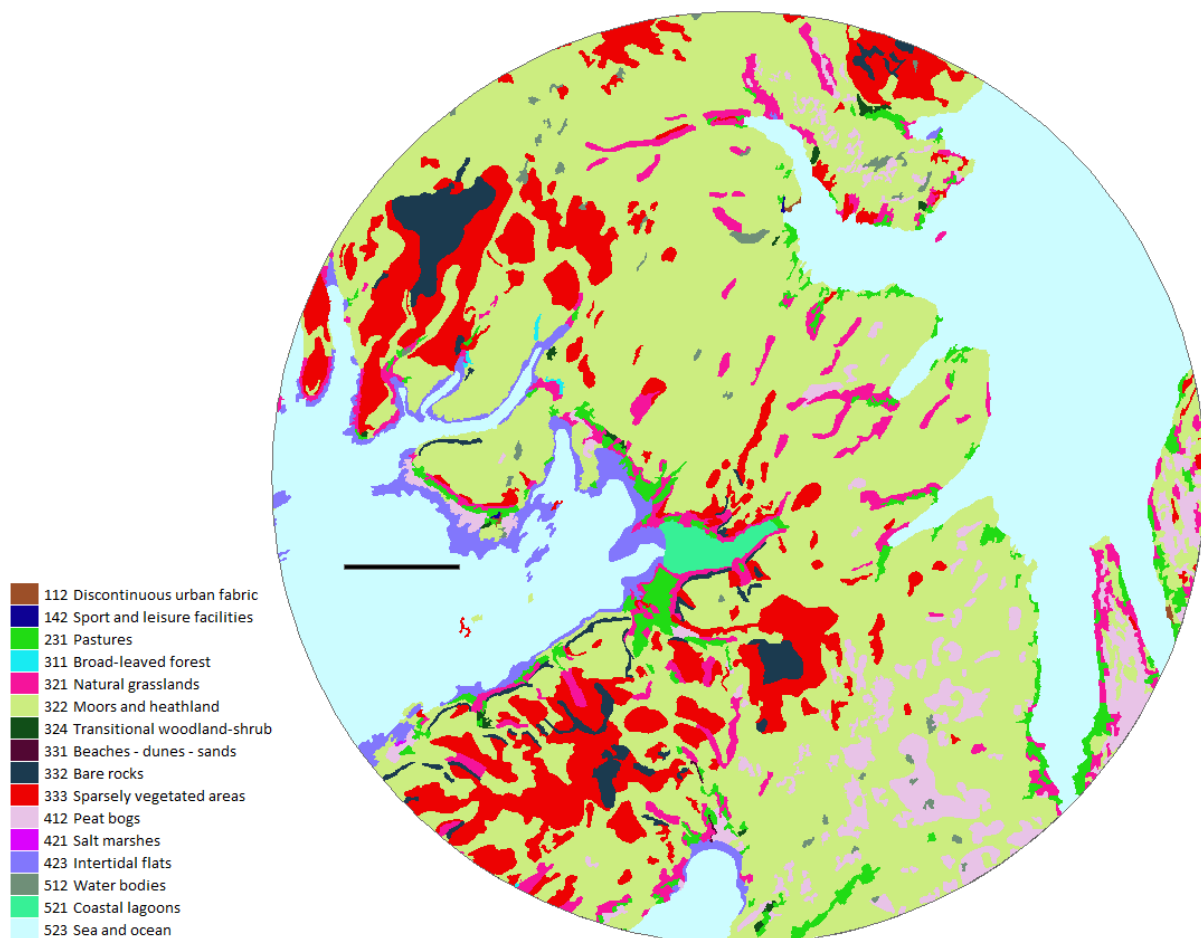


Corine Land Cover (CLC)

Corine Land Cover (CLC) provides consistent information on land cover and land cover changes across Europe, based on photointerpretation of satellite images by national teams of participating countries. There are 44 landcover classes in the hierarchical three level Corine nomenclature with a minimum mapping unit (MMU) of 25 ha.

Only 15 landcover classes are present in the 40 km tag buffer (codename - cover type): 112- Discontinuous urban fabric; 142-Sport and leisure facilities; 231-Pastures; 311-Broad-leaved forest; 321-Natural grasslands; 322-Moors and heathland; 324 Transitional woodland-shrub; 331-Beaches - dunes - sands; 332-Bare rocks; 333-Sparsely vegetated areas; 412-Peat bogs; 421-Salt marshes; 423-Intertidal flats; 512-Water bodies; 521-Coastal lagoons. The sea (code 523) is also present but as this is a primarily a topographic model it was not included (Fig. 6).

Figure 6. Corine land cover classes



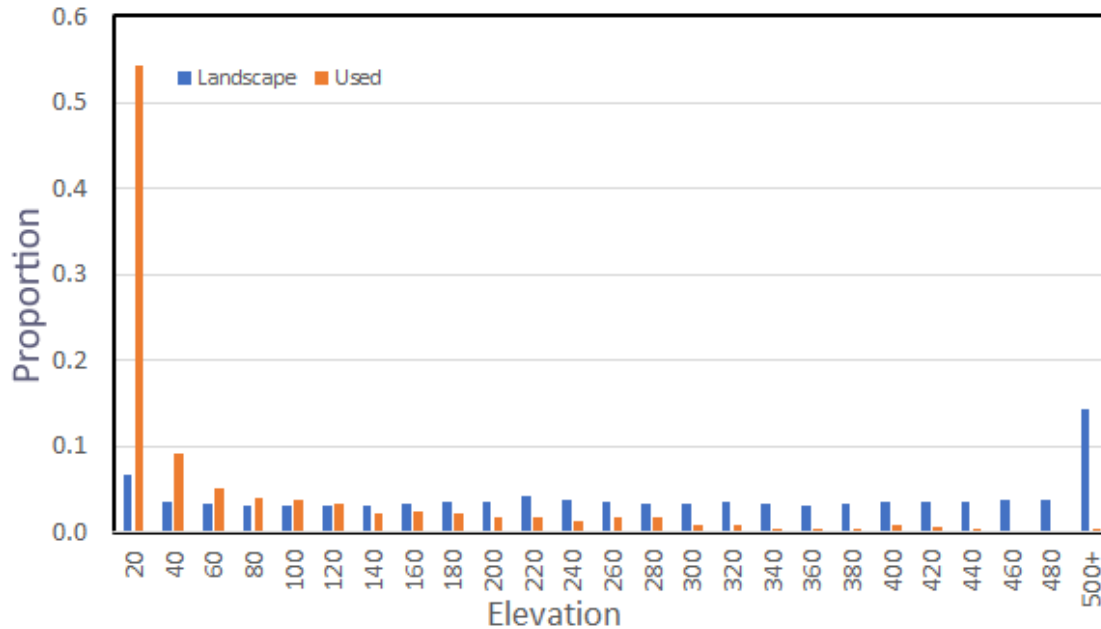
Preference Indices and Predictor Use

Data used to calculate the PIs are in Appendix 1.

Altitude

There was a very marked preference for land below 100 m (Fig. 7).

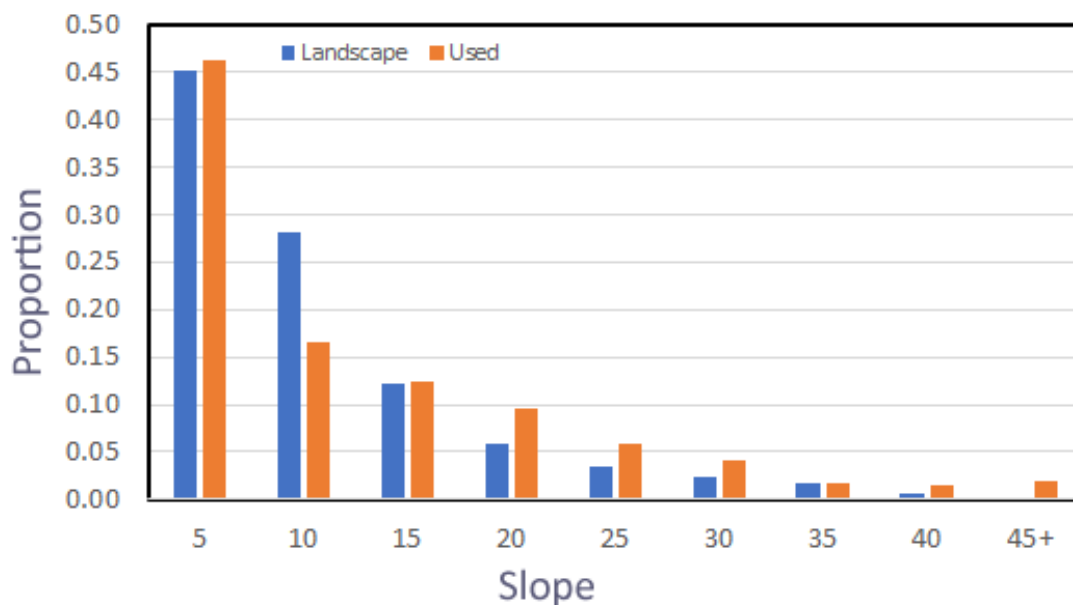
Figure 7. Proportions of habitat in 20 m altitude bands in the landscape and the proportion of satellite tracked white-tailed eagle records.



Slope

There were no large differences between what is available in the landscape and what was used (Fig. 8). There was some evidence of slight underuse of slopes between 5 and 10° and a moderate preference for slopes between 16 and 30°.

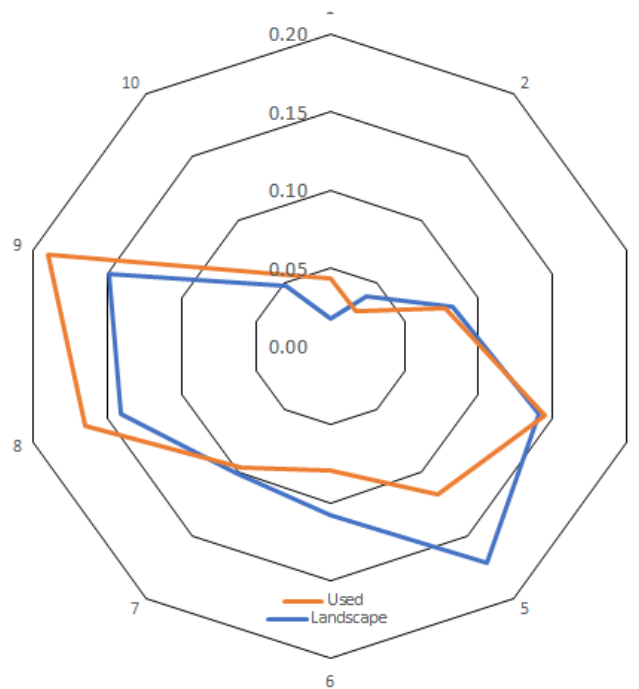
Figure 8. Proportions of habitat in 5° slope bands in the landscape and the proportion of satellite tracked white-tailed eagle records.



Aspect

As with slope, there were no large differences between what was available in the landscape and what was used (Fig. 9). Most PI values are close to 1. Only land with no aspect (flat) has a PI that deviates significantly from 1, its value is 2.4 but only 1.8% of the landscape is flat.

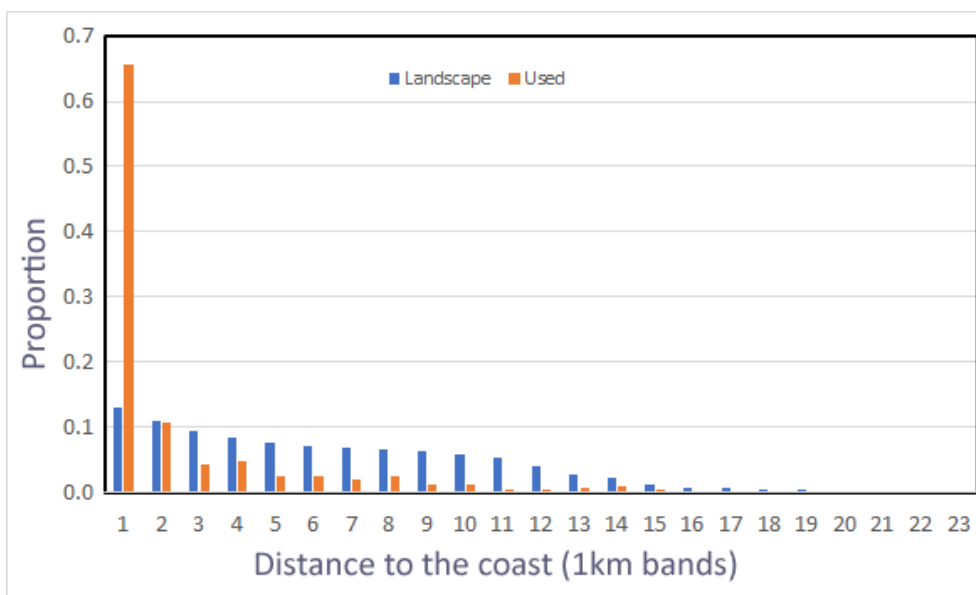
Figure 9. Proportions of habitat with different aspects in the landscape and the proportion of satellite tracked white-tailed eagle records.



Distance to the coast

Unsurprisingly the proportion land decreases with increasing distance to the coast but the overwhelming majority of white-tailed eagle tag records are within 1 km of the coast. After 2 km there are fewer records than expected from the area (Fig. 10).

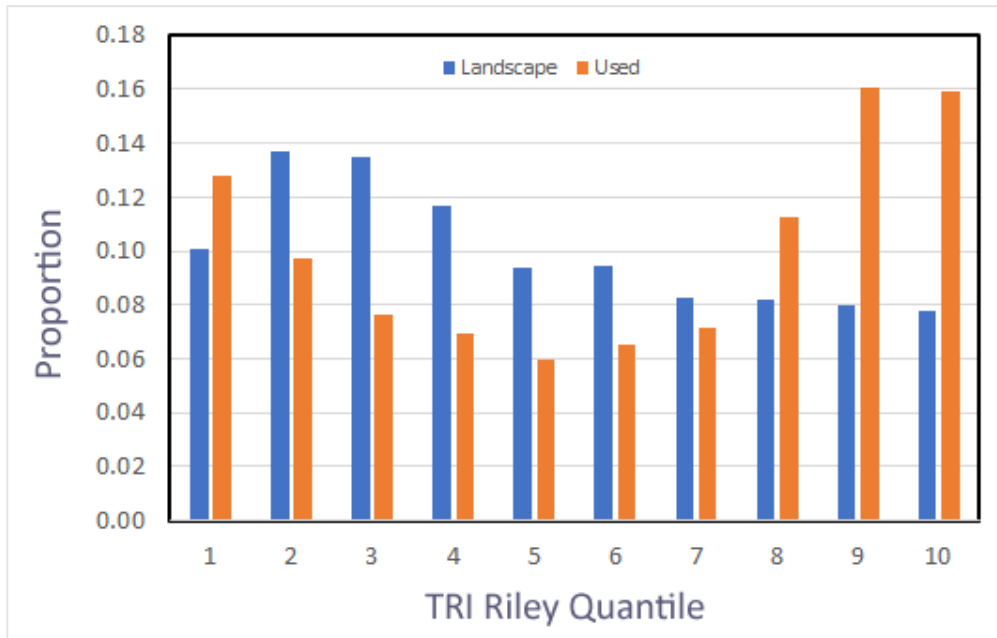
Figure 10. Proportions of habitat in 1 km wide bands from the coast in the landscape and the proportion of satellite tracked white-tailed eagle records.



Riley's Terrain Roughness Index

Riley's Terrain Roughness Index was binned into 10 quantiles. There are some large differences between what was used and what was available with a marked preference for quantiles 8 to 10 and underuse of quantiles 2 to 7 (Fig. 11).

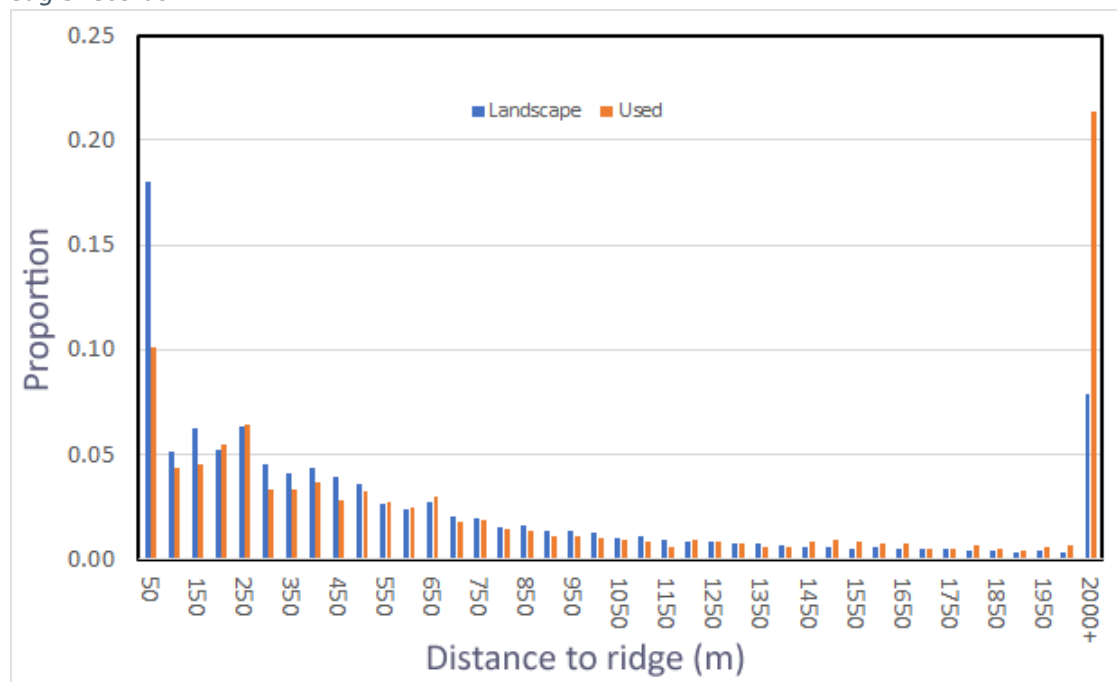
Figure 11. Proportions of the TRI Riley quantiles and the proportion of satellite tracked white-tailed eagle records.



Distance to a ridge

White-tailed eagles tended to avoid ridges and the greatest difference in proportions was at distances >2,000 m where there is strong evidence of over-use (Fig. 12).

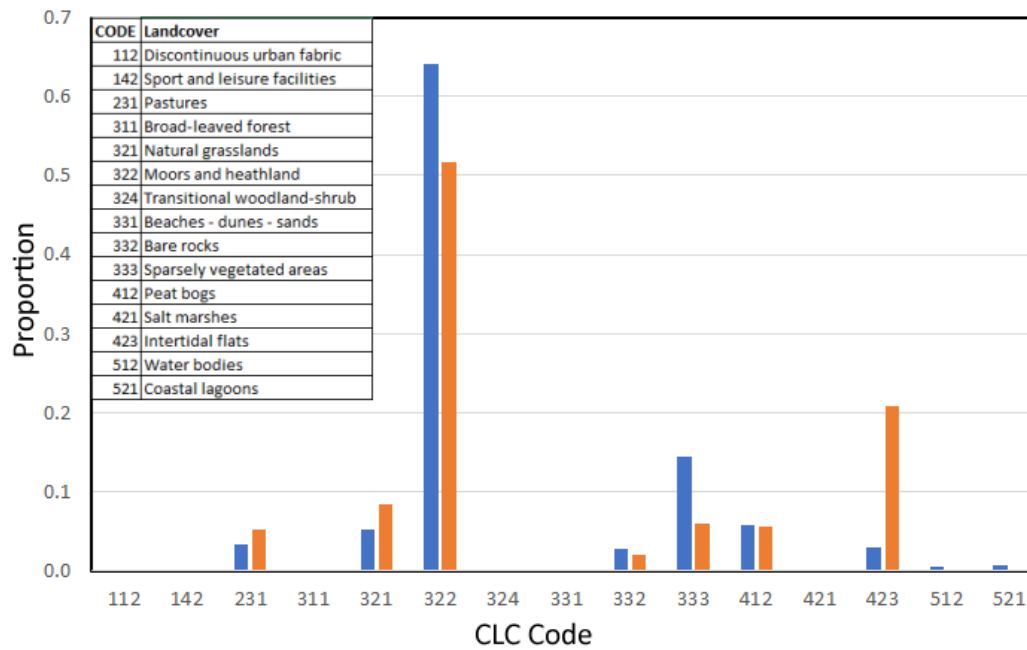
Figure 12. Proportions of distances to ridges (m) and the proportion of satellite tracked white-tailed eagle records.



Corine Land Cover (CLC)

The Corine landcover, in this region, is made up of seven main classes, dominated by Moors and Heathland which comprises 64% of the cover (Fig. 13). Bare rocks is the next largest landcover. The remaining five are Pastures; Natural Grasslands; Sparsely Vegetated Areas; Peat Bogs and Intertidal flats. White-tailed eagles only showed a preference for Pastures; Natural Grasslands and, most significantly, Intertidal flats.

Figure 13. Proportions of the Corine Landcover classes and the proportion of satellite tracked white-tailed eagle records.



Satellite tracking data

Satellite tracking data, within a 40 km radius buffer, were provided in gdb format with both point and line data. There were 979,841 records from 37 tags. The point data were extracted to shapefiles, one per tag, and re-projected into the ISN2016 projection. Table 1 summarises the tag data.

Table 1. Tag identification, number of records, first and last record dates, number of unique days with records.

tag_ident	records	1st record	last record	Days
7110	61,482	17/01/2020 12:00	01/05/2024 13:25	1,566
7111	97,985	28/01/2020 12:00	01/09/2024 16:00	1,678
7306	37,936	14/04/2020 12:10	25/04/2024 17:20	1,472
7307	87,402	24/04/2020 17:30	03/06/2024 14:15	1,501
7308	131,072	16/12/2020 00:00	14/08/2024 13:55	1,337
7309	24,340	07/02/2020 18:00	02/05/2024 19:45	1,546
7310	4,600	01/04/2020 10:00	27/07/2021 23:55	482
7311	72,446	24/10/2019 00:00	02/08/2024 21:05	1,744
201943	10,803	12/02/2021 06:52	01/09/2024 23:45	1,297
201944	27,579	11/09/2021 17:07	25/08/2024 15:28	1,079
201945	50,575	28/02/2021 14:37	29/07/2024 18:47	1,247
201946	13,214	24/03/2021 14:10	08/05/2024 13:13	1,141
213375	56,915	13/03/2022 16:55	01/09/2024 23:51	903
213376	54,139	24/10/2021 01:51	07/08/2024 10:49	1,018
213377	62,926	09/11/2021 00:11	01/09/2024 16:42	1,027
213378	14,611	25/04/2022 14:06	03/08/2023 00:35	465
213379	20,601	16/04/2022 08:09	01/09/2024 23:36	869
213380	15,624	06/02/2023 13:53	22/10/2023 19:34	258
213381	5,587	21/01/2022 13:08	26/08/2024 15:51	948
213382	4,647	02/11/2021 02:15	01/09/2024 10:49	1,034
213383	33,274	18/02/2022 22:22	15/04/2023 13:41	421
223971	15,786	18/04/2023 13:37	01/09/2024 23:48	502
223972	14,546	02/03/2023 15:32	17/08/2024 11:13	534
223974	550	29/12/2023 14:52	03/06/2024 05:55	157
223975	29,613	12/04/2023 15:29	01/09/2024 23:47	508
223976	2,566	27/04/2023 18:40	30/06/2024 15:01	430
223977	1,351	30/11/2022 12:43	23/07/2024 12:45	601
223979	6,246	04/04/2023 13:45	28/05/2024 18:47	420
223980	1,185	02/12/2022 12:40	07/08/2024 04:11	614
223981	900	27/03/2023 09:35	19/04/2024 15:03	389
234377	2,818	01/05/2024 14:41	01/09/2024 23:43	123
234379	3,163	20/02/2024 11:04	01/09/2024 10:09	194
234380	7,711	09/10/2023 16:36	01/09/2024 23:39	328
234381	419	02/02/2024 16:12	12/08/2024 14:08	192
234383	2,693	13/12/2023 15:05	01/09/2024 23:37	263
234385	2,496	01/01/2024 04:05	20/04/2024 18:04	110
234387	40	26/12/2023 13:35	22/04/2024 04:36	118

The tag data were split into model training and testing data to give an approximate 66/33% training/testing ratio. The tags used for training were: 7110; 7306; 7308; 7309; 7311; 201945; 213375; 213377; 213379; 213380; 213383; 223971; 223975; 223976; 223979; 234377; 234380; 234383; 234385 (19 tags). This is a split of 637,120 training records and 342,721 testing records.

However, the time interval between some records was very small, potentially creating spatial autocorrelation problems. In order to reduce this potential problem, the training and test data were sampled so that records were separated by at least 30 minutes. The technique for doing this is explained in Fielding *et al.*, (2024). Additionally, as this is a topographic model, all records over the sea were excluded. This process also helped to reduce the magnitude of differences in the number of records between tags. There were 33,086 training records (Table 2) and 20,544 test records.

Table 2 Number of training records per tag

Tag	Records			Tag	Records		
	Training	All	%		Training	All	%
7110	4516	61,482	7.3	213383	424	33,274	1.3
7306	287	37,936	0.8	223971	108	15,786	0.7
7308	1427	131,072	1.1	223975	544	29,613	1.8
7309	301	24,340	1.2	223976	57	2,566	2.2
7311	287	72,446	0.4	223979	285	6,246	4.6
201945	9376	50,575	18.5	234377	19	2,818	0.7
213375	7450	56,915	13.1	234380	1560	7,711	20.2
213377	3076	62,926	4.9	234383	28	2,693	1.0
213379	2166	20,601	10.5	234385	1029	2,496	41.2
213380	146	15,624	0.9	All	33,086	637,120	5.2

The Model

Seven SPI raster images were summed (aspect, slope, dem, coast distance, ridge distance, TRI and CLC). There were 1,680 unique sums ranging from 156 to 2,225. The distribution was multimodal with the majority having low sums below 560 (Fig. 14). The final model was produced by binning the raw SPI sums (Fig. 14) into 10 quantile classes (~145,000 pixels per quantile). Fig. 15 shows the distribution of the quantiles and all tag records.

Figure 14. Frequency distribution of the raw sums of seven SPI raster images.

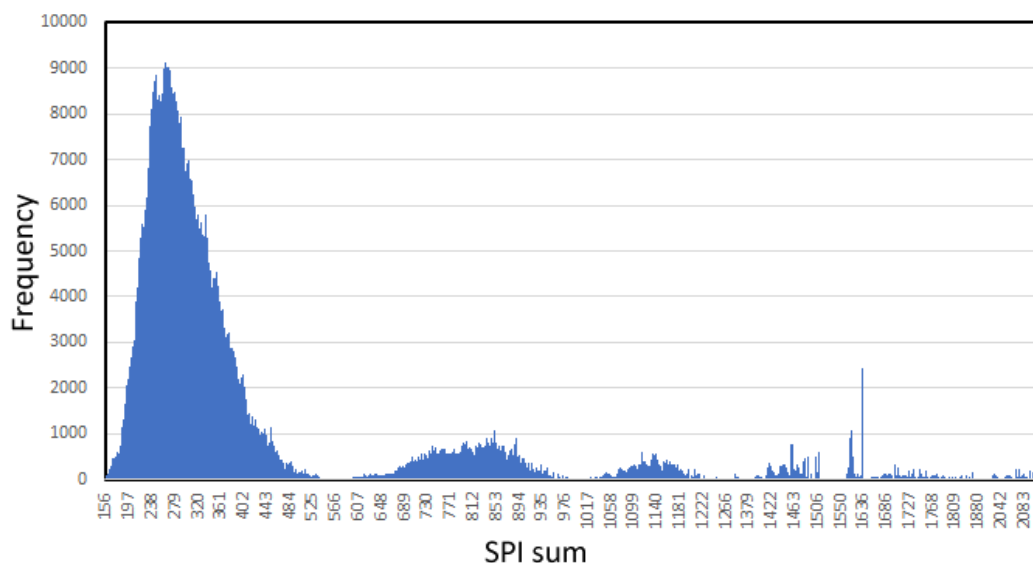
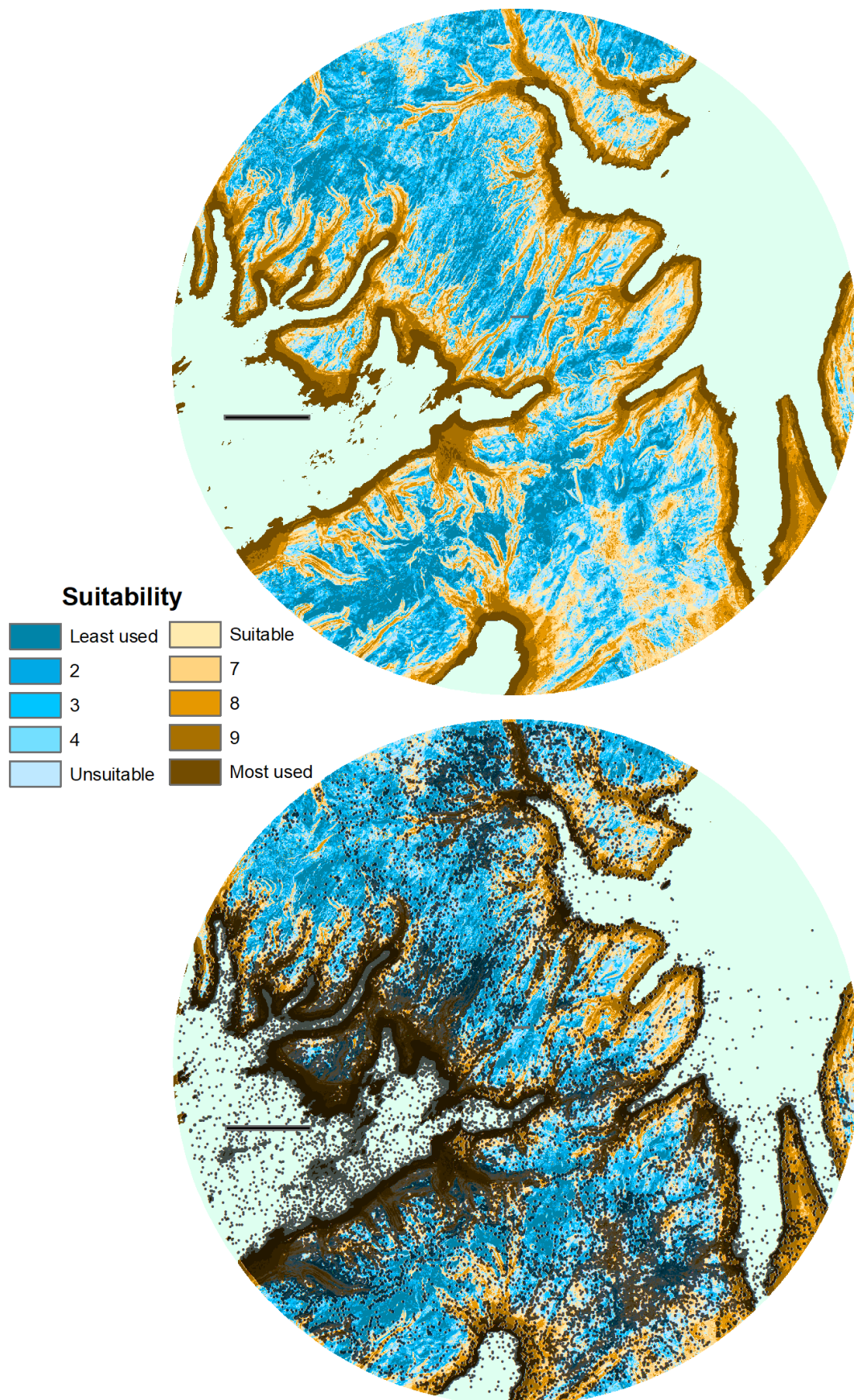


Figure 15. Distribution of the 10 SPI quantiles (above) plus with all satellite tracking records. The black bar is 10km.



Tag records are not spread evenly through the 10 SPI sum quantile classes. Unsurprisingly, they are seen less frequently in the lower values as these are derived from smaller SPI sums indicating under-use of a habitat feature. The proportion of landscape in each SPI quantile is approximately 0.1, as expected for a 10-class quantile scale. The proportions of tag records are much less than the landscape proportion until a value of 9 (Fig. 16 and Table 3).

There are only small differences between the train and test data indicating that the model has some general utility for predicting where white-tailed eagles are likely to fly in this part of Iceland.

Figure 16. Proportions of the landscape and tag records in each SPI Quantile class.

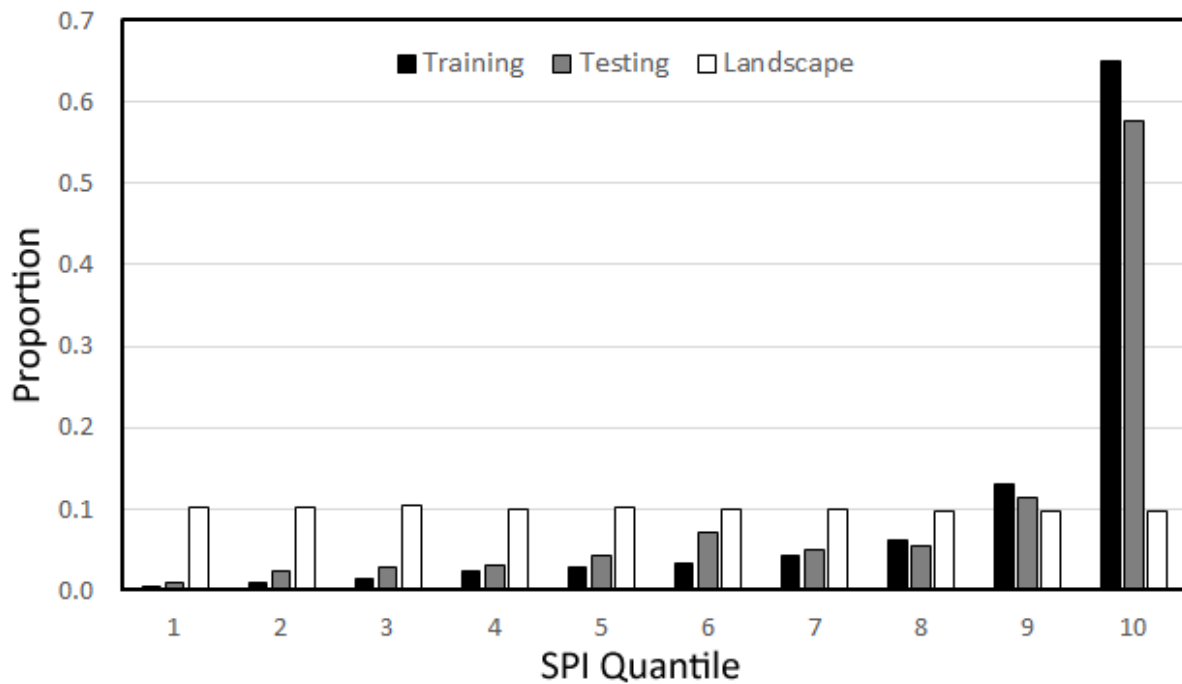


Table 3. Model results: number of records (n); proportion of records (p); and cumulative proportion of tag records (cumulative) for the training, testing and all tag records in each SPI Quantile class.

SPI Q10	Training records			Testing records			All records		
	n	p	cumulative	n	p	cumulative	n	p	cumulative
1	142	0.004	0.004	211	0.010	0.010	7,900	0.009	0.009
2	311	0.009	0.014	485	0.024	0.034	13,849	0.016	0.024
3	445	0.013	0.027	560	0.027	0.061	19,850	0.022	0.047
4	780	0.024	0.051	615	0.030	0.091	23,004	0.026	0.073
5	976	0.029	0.080	870	0.042	0.133	31,541	0.036	0.108
6	1,112	0.034	0.114	1,470	0.072	0.205	41,794	0.047	0.155
7	1,417	0.043	0.157	1,030	0.050	0.255	53,292	0.060	0.215
8	2,072	0.063	0.219	1,127	0.055	0.310	69,459	0.078	0.294
9	4,299	0.130	0.349	2,331	0.113	0.423	140,991	0.159	0.452
10	21,532	0.651	1.000	11,844	0.577	1.000	486,504	0.548	1.000

The GET model (Fielding *et al.*, 2020) also has a 10-point quantile scale and a threshold of 6 is used to separate good from poor golden eagle habitat. Habitat with a GET score in the 1 - 5 is considered to be poor golden eagle habitat while habitat with a score of 6 – 10 is considered to be good golden eagle habitat. If the same threshold is applied for the WET model the proportions of tag records in the 6+ class are: 0.92 for the training records, 0.87 for the testing records and 0.89 for all records (Table 3).

If a larger threshold of 9+ is used the proportions are 0.78, 0.69 and 0.71; suggesting that the model is performing better with the training data. However, even with the smaller 0.69 of test records this is still predicting that 69% of tag records will be seen in only 20% of the landscape and is, therefore, useful for identifying areas that could be problematic for white-tailed eagles if a wind farm was constructed there.

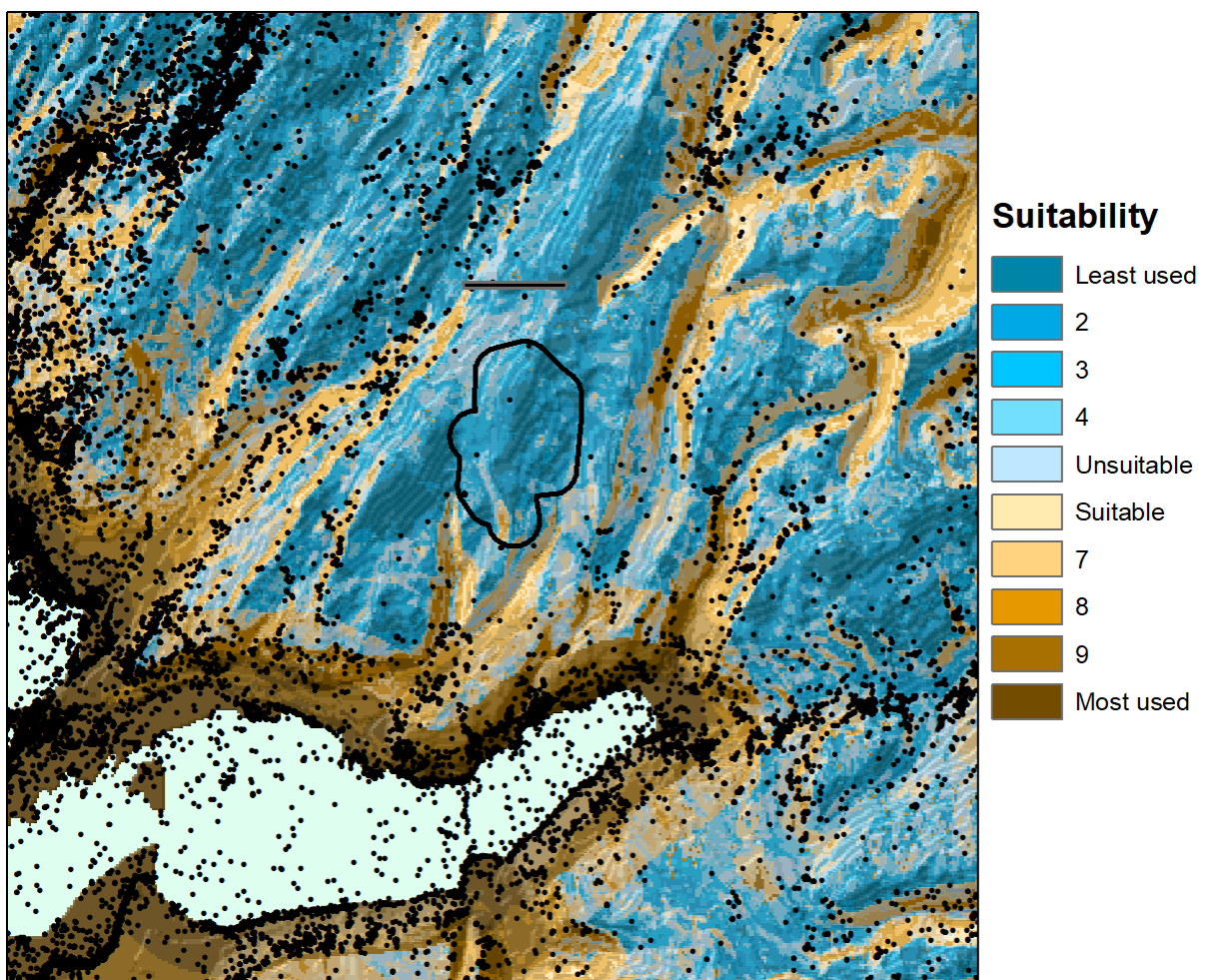
It is recommended that the same 6+ threshold is used for the WET model as the GET model as this will correctly predict 90% of tag locations whilst being restricted to 50% of the landscape.

An assessment of the proposed development

Normally, when using the GET model to assess the potential impact of a wind farm there would be two parts to the assessment. The first part, related to habitat loss, is less relevant to white-tailed eagles as they do not appear to show the same level of turbine avoidance seen in golden eagles. The second part is more relevant and involves a qualitative assessment of the position of a proposed development in the GET landscape.

Fig. 17 shows a 500 m buffer around the proposed layout. Brown shading is indicative of good white-tailed eagle habitat whereas the darkening blue scale highlights increasingly unused habitat. The proposed development is in a block of unsuitable habitat and is, therefore, unlikely to see very much activity from white-tailed eagles and it would be unlikely to create a significant collision or habitat loss problem.

Figure 17. 500 m turbine buffer in relation to the WET landscape with tag records..



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Appendix 1

The landscape column is the proportion of the land area in that class. The Used proportion is the proportion of tag training records in that class. PI is the preference index calculated as the used proportion / landscape proportion. The SPI is the standardised PI (PI/sums of the PIs)

Altitude

Altitude	Landscape	Used	PI	SPI
20	0.067	0.543	8.065	374
40	0.035	0.092	2.635	122
60	0.034	0.052	1.521	71
80	0.031	0.041	1.307	61
100	0.031	0.039	1.257	58
120	0.031	0.033	1.055	49
140	0.032	0.022	0.690	32
160	0.034	0.023	0.683	32
180	0.036	0.022	0.621	29
200	0.036	0.018	0.496	23
220	0.041	0.017	0.408	19
240	0.038	0.012	0.316	15
260	0.035	0.017	0.482	22
280	0.033	0.018	0.536	25
300	0.033	0.008	0.244	11
320	0.034	0.007	0.215	10
340	0.032	0.004	0.131	6
360	0.031	0.005	0.154	7
380	0.032	0.003	0.089	4
400	0.035	0.009	0.250	12
420	0.035	0.006	0.175	8
440	0.035	0.004	0.121	6
460	0.037	0.002	0.053	2
480	0.037	0.002	0.045	2
500+	0.143	0.003	0.019	1

Slope

Slope	Landscape	Used	PI	PPI
5	0.451	0.461	1.022	58
10	0.281	0.165	0.586	33
15	0.122	0.124	1.017	58
20	0.060	0.096	1.620	92
25	0.035	0.060	1.682	96
30	0.024	0.041	1.694	96
35	0.016	0.018	1.117	63
40	0.007	0.016	2.182	124
45+	0.003	0.019	6.682	380

Aspect

Aspect	Landscape	Used	PI	PPI
flat	0.018	0.043	2.411	217
N	0.039	0.028	0.723	65
NE	0.083	0.078	0.941	85
E	0.141	0.144	1.024	92
SE	0.171	0.117	0.681	61
S	0.109	0.08	0.736	66
SW	0.101	0.096	0.953	86
W	0.141	0.165	1.172	105
NW	0.149	0.19	1.279	115
N	0.048	0.058	1.196	108

Distance to the coast

Coast	distance1km band	Landscape	Used	PI	PPI
	1	0.130	0.658	5.059	496
	2	0.109	0.108	0.988	97
	3	0.094	0.042	0.448	44
	4	0.085	0.047	0.562	55
	5	0.077	0.026	0.337	33
	6	0.070	0.024	0.337	33
	7	0.067	0.018	0.273	27
	8	0.065	0.023	0.359	35
	9	0.063	0.011	0.169	17
	10	0.059	0.012	0.205	20
	11	0.053	0.005	0.096	9
	12	0.039	0.005	0.128	13
	13	0.028	0.006	0.196	19
	14	0.022	0.010	0.457	45
	15	0.012	0.004	0.339	33
	16	0.007	0.000	0.031	3
	17	0.006	0.000	0.021	2
	18	0.005	0.000	0.026	3
	19	0.004	0.000	0.130	13
	20	0.003	0.000	0.044	4
	21	0.002	0.000	0.000	0
	22	0.001	0.000	0.000	0
	23	0.000	0.000	0.000	0

Riley's Terrain Roughness Index Quantile

RileyTRI 10	Landscape	Used	SI	SSI
1	0.101	0.128	1.269	118
2	0.137	0.097	0.712	66
3	0.135	0.077	0.568	53
4	0.117	0.070	0.597	56
5	0.094	0.060	0.636	59
6	0.094	0.065	0.690	64
7	0.083	0.072	0.868	81
8	0.082	0.113	1.369	127
9	0.080	0.160	2.012	187
10	0.078	0.159	2.037	189

Distance to a ridge

Distance to a ridge	Landscape	Used	SI	SSI
50	0.180	0.101	0.560	12
100	0.051	0.043	0.848	19
150	0.062	0.045	0.724	16
200	0.052	0.055	1.047	23
250	0.063	0.064	1.017	23
300	0.045	0.033	0.732	16
350	0.041	0.033	0.812	18
400	0.043	0.036	0.835	19
450	0.039	0.028	0.713	16
500	0.035	0.033	0.924	21
550	0.027	0.027	1.005	22
600	0.024	0.024	1.019	23
650	0.027	0.030	1.104	25
700	0.021	0.018	0.853	19
750	0.020	0.019	0.941	21
800	0.015	0.015	0.958	21
850	0.016	0.013	0.831	19
900	0.013	0.011	0.818	18
950	0.013	0.011	0.863	19
1000	0.012	0.010	0.816	18
1050	0.010	0.009	0.937	21
1100	0.011	0.009	0.793	18
1150	0.009	0.006	0.676	15
1200	0.008	0.009	1.142	25
1250	0.009	0.008	0.978	22
1300	0.007	0.007	1.024	23
1350	0.007	0.005	0.760	17
1400	0.006	0.006	0.979	22
1450	0.006	0.008	1.344	30
1500	0.006	0.009	1.626	36

Distance to a ridge	Landscape	Used	SI	SSI
1550	0.005	0.008	1.611	36
1600	0.005	0.008	1.478	33
1650	0.005	0.008	1.669	37
1700	0.005	0.004	0.951	21
1750	0.005	0.005	1.127	25
1800	0.004	0.007	1.815	40
1850	0.004	0.005	1.235	28
1900	0.003	0.004	1.264	28
1950	0.004	0.005	1.398	31
2000	0.003	0.006	1.900	42
2000+	0.079	0.213	2.703	60

Corine Landcover (excluding sea)

CODE	Landcover	Landscape	Used	SI	SSI
112	Discontinuous urban fabric	0.0004	0.0000	0.000	0
142	Sport and leisure facilities	0.0002	0.0000	0.000	0
231	Pastures	0.0333	0.0520	1.562	81
311	Broad-leaved forest	0.0006	0.0004	0.746	38
321	Natural grasslands	0.0529	0.0844	1.596	82
322	Moors and heathland	0.6413	0.5165	0.805	42
324	Transitional woodland-shrub	0.0021	0.0010	0.476	25
331	Beaches - dunes - sands	0.0002	0.0000	0.158	8
332	Bare rocks	0.0270	0.0209	0.775	40
333	Sparsely vegetated areas	0.1435	0.0589	0.411	21
412	Peat bogs	0.0570	0.0565	0.992	51
421	Salt marshes	0.0001	0.0004	4.587	236
423	Intertidal flats	0.0293	0.2078	7.096	366
512	Water bodies	0.0051	0.0005	0.096	5
521	Coastal lagoons	0.0072	0.0007	0.096	5

Viðauki 4

Alan Fielding

Expert opinion on the likely impact of a proposed wind farm at
Garpsdalur on White-tailed Eagles

Expert opinion on the likely impact of a proposed wind farm at Garpsdalur on White-tailed Eagles

Alan Fielding BSc (Hons), MSc, PhD, FHEA, FLS

My Conclusion

The development of Garpsdalur windfarm, near to the population of breeding White-tailed Eagles in the Breiðafjörður's fjord, would not have a measurable impact on breeding and dispersing individuals from the local population.

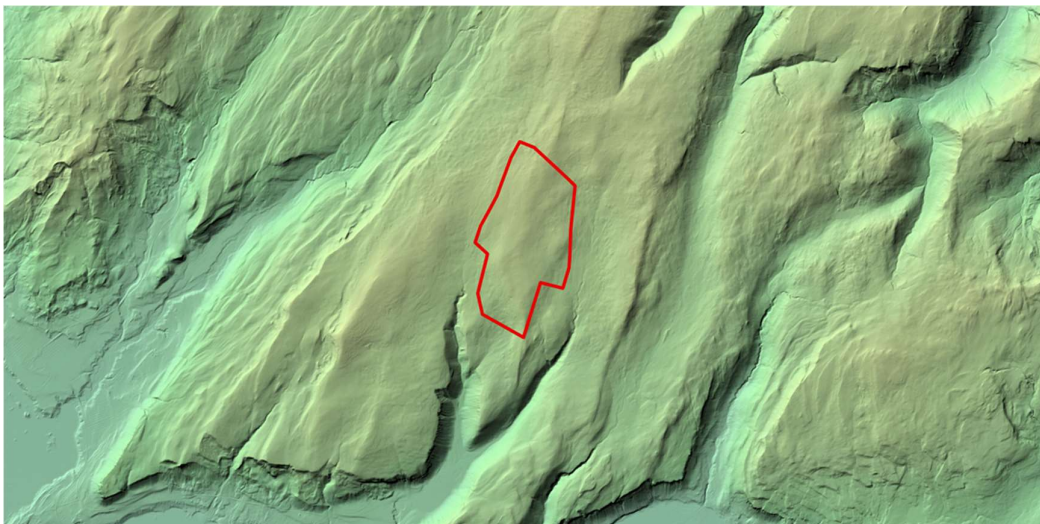
Evidence supporting my conclusion

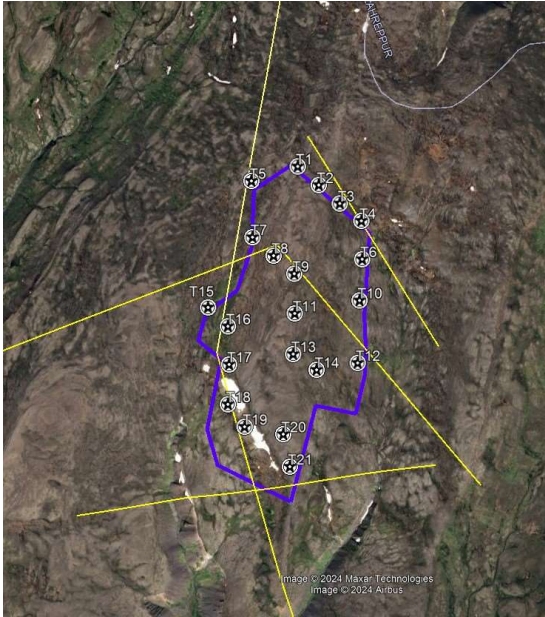
I have extensive experience analysing eagle satellite tracking data. I am the curator for more than 12 million records from ~350 Golden Eagles and White-tailed Eagles in Scotland. I have published extensively on what satellite tracking tells us about how Golden Eagles interact with turbines and their general biology. I also have considerable experience of modelling White-tailed Eagle populations for both wind farm impact assessments and reintroduction programmes.

We developed a very successful model (Golden Eagle Topographic model, GET), using satellite tracking data. The GET model predicts how Golden Eagles use topography (Fielding *et al* 2020). This model is now used to guide both wind farm and tree planting schemes in Scotland and is part of the NatureScot guidance to developers and foresters. The same techniques could be applied to White-tailed Eagles and the data collected in the region around the Breiðafjörður's fjord provides an ideal opportunity to develop a similar model which could be useful for guiding potential development sites and helping to avoid placing turbines in inappropriate locations.

It is apparent from the GET model that Golden Eagles use topography to move across the landscape and turbines even a few hundred meters from the preferred topography are unlikely to pose a risk to Golden Eagles. Visual inspection of the White-tailed Eagle flight lines in the region around the Breiðafjörður's fjord suggest that White-tailed Eagles also use topography to move around the landscape but their preferred routes are almost the opposite of those used by Golden Eagles.

There are significant White-tailed Eagle movements close to Garpsdalur mountain but the fact that the main routes are through valleys, and Garpsdalur windfarm is on a mountain/ridge, immediately reduces the potential for a collision.





There are only four flight lines passing over Garpsdalur windfarm boundary and there is little certainty that at least two passed through the wind farm given the time and distance differences between the start and end points of the flights.

Even when a White-tailed Eagle flies through a wind farm a collision is not inevitable. A particular set of circumstances are required before a collision occurs and, in Scotland, current guidance suggests that only 5 out of every 100 flights through a turbine's swept radius (a much smaller definition than the wind farm boundary) would result in a collision.

Heatmaps, based on extensive satellite tracking of dispersing White-tailed Eagles were provided to me (see Appendix – Heatmaps 2020 to 2024). It is

only possible to draw broad conclusions from the heatmaps as I have no information on the number of birds, their ages, whether they had not yet left their natal range or were they in a dispersal phase? Also, it matters if they are moving or roosting at the time of the record and, importantly, are they during daylight (night time roosting records produce clusters of records)? Nonetheless, three broad conclusions can be drawn from the heatmaps.

1. The tag records of these non-breeding birds are very much associated with Breiðafjörður's fjord and there appears to be little activity, by these tracked birds, on the east coast.
2. There are many areas, including the site of the wind farm, which are not used.
3. It is reasonable to assume that the site of the wind farm, and similar topography, are not important areas for non-breeding White-Tailed eagles.

Adult White-tailed Eagles generally remain in their territories during the nonbreeding season, whereas immature birds can roam widely. Despite roaming widely the type of terrain between the valleys does not appear to be attractive, as evidenced by the very small number of tracks over a long period from many tracked individuals.

The extremely low level of dispersing White-tailed Eagle flight activity around Garpsdalur windfarm results in an estimated annual number of collisions of 0.01 or one death every 100 years. Such a small additional level of mortality cannot have any impact on the viability of the local White-tailed Eagle population. The already tiny population-level impact is reduced even further if the collision victim is a dispersing young bird rather than a member of a breeding pair. This is evident from the elasticity of the dispersing bird survival rate in population models. The impact of additional deaths would be more significant if it was a member of a potentially breeding pair (although at a rate of one death every 100 years even that effect would still be undetectable).

The NatureScot guidance for avoiding disturbance to White-tailed Eagles is from Goodship and Furnace (2022)¹. *"In the UK, white-tailed eagle has the potential to be disturbed on breeding grounds as well as at communal roosting areas and foraging grounds during the nonbreeding season; this species is most likely to be disturbed pre- and during egg laying early in the breeding season.*

¹ Goodship, N.M. and Furness, R.W. 2022. *Disturbance Distances Review: An updated literature review of disturbance distances of selected bird species*. NatureScot Research Report 1283, Edinburgh, Scotland.

*Depending on the level of habituation to disturbance, a **buffer zone of 500-1000m is suggested to protect nesting white-tailed eagles** and a buffer zone of 250- 500m is suggested to protect roosting and foraging birds during the nonbreeding season from pedestrian disturbance. Buffer zones at the lower end of these ranges may be sufficient to protect individuals that have some habituation to human presence."*

The closest nest sites in the Breiðafjörður's fjord are at least 8 km from the proposed wind farm. This distance is eight times larger than the largest buffer distance recommended by Goodship and Furnace (2022) in Scotland. Fulmar colonies in the Western Isles of Scotland appear to be unaffected by predation by breeding White-tailed Eagles if the nest is >5 km from the colony (Reid, *pers comm*).

Therefore, there is no evidence that a Garpsdalur wind farm would have any impact on the breeding pairs in the Breiðafjörður's fjord

Brief summary of experience

Academic history and professional recognition

- University of Liverpool: BSc (Hons) and PhD.
- University of York; MSc Biological Computation.
- Leverhulme Personal Research Fellow 2000-2001
- University Senior Learning and Teaching Fellow 2001-2010 (Retired)
- Fellow of the Linnean Society of London
- Fellow of the Higher Education Academy
- Member of Scottish Natural Heritage Scientific Advisory Committee Experts Panel (2012-2021)
- Expert advisor to Irish Golden Eagle Trust with respect to the four raptor reintroductions: golden eagle; white-tailed eagle, red kite and osprey
- Expert advisor to a study of the impacts of wind farms on hen harriers in Ireland (2013-2017).
- South of Scotland Golden Eagle Project - member of Scientific Advisory Panel (2018-current)
- Member of the Forests and raptors joint working group (2018-current)
- Advisor to NatureScot on updating golden eagles and wind farms advice (current)

Books

1. Fielding, A. H. 1984. *Computing for Biologists*. 190pp, Addison-Wesley, Wokingham.
2. Fielding, A. H. 1999. (editor) *Ecological Applications of Machine Learning Methods*. 261pp. Kluwer Academic, Boston, MA.
3. Fielding, A. H. and Haworth, P. F. 1999. *Upland Habitats*. 141pp. Routledge, London.
4. Thompson, D. B. A., Redpath, S., Fielding, A. H., Marquiss, M. and Galbraith, C. A. (eds). 2003. *Birds of prey in a changing environment*. 550 pp, The Stationery Office, Edinburgh.
5. Fielding, A. H. 2006. *Cluster and classification techniques in the BioSciences*. Cambridge University Press, Cambridge.

Selected chapters in books

1. Bibby, C., Marsden, S. and Fielding, A. H. 1999. Bird-habitat studies. pp 99-114 in C. Bibby, M. Jones and S. Marsden (eds) *Expedition Field Techniques: Bird Surveys*. Expedition Advisory Centre, Royal Geographical Society, London.
2. Fielding, A. H. 1999. How should accuracy be measured? pp. 209-223 in A. Fielding (ed) *Ecological Applications of Machine Learning Methods*. Kluwer Academic, Boston, MA.
3. Fielding, A. H. 1999. A review of machine learning methods. pp 1-37 in A. Fielding (ed) *Ecological Applications of Machine Learning Methods*. Kluwer Academic, Boston, MA.
4. Fielding, A. H. 2002. What are the appropriate characteristics of an accuracy measure? pp 271-280 in J. M. Scott, P. J. Heglund, M. Morrison, J. B. Haufler, M. G. Raphael, W. B. Wall, and F. Samson (eds) *Predicting Plant and Animal Occurrences: Issues of Scale and Accuracy*, Island Press.
5. Fielding, A.H., Whitfield, D. P., McLeod, D. R. A., McGrady, M. and Haworth, P. F. 2003. Modelling the impact of land use changes on golden eagles *Aquila chrysaetos*. pp 323 - 340 in Thompson, D. B. A., Redpath, S., Fielding, A. H., Marquiss, M. and Galbraith, C. A. (eds). *Birds of prey in a changing environment*. The Stationery Office, Edinburgh.
6. Fielding, A. H., Morgan, D., Haworth, P. F., Whitfield, D. P. and Thompson, D. B. A. 2003. The impact of golden eagles on other raptors. pp 221-244 in Thompson, D. B. A., Redpath, S., Fielding, A. H., Marquiss, M. and Galbraith, C. A. (eds). *Birds of prey in a changing environment*. The Stationery Office, Edinburgh.

7. Watson, J, Fielding, A.H., Whitfield, D.P., Broad, R.A., Haworth, P., Nellist, K., Crane, K. & Macdonald, E.J. 2003. Golden eagle breeding performance in relation to climate in western Scotland during the period 1981-2000. pp 149-161 in: Thompson, D.B.A., Redpath, S., Fielding, A.H., Marquiss, M. & Galbraith, C.A. (eds.). *Birds of Prey in a Changing Environment*. The Stationery Office, Edinburgh, UK.
8. Benn, S., Fielding, A.H. & Whitfield, D.P. 2024. Golden Eagles in Scotland. pp 265-281 in: Rodriguez, J.B. & Ellis, D.H. (eds) *The Golden Eagle Around the World A Monograph on a Holarctic Raptor*. Hancock House Publishers, Surry, BC, Canada

Selected Government Reports

1. Whitfield, D. P., Fielding, A. H., McLeod, D. R. A. and Haworth, P. F. 2006. *A conservation framework for the golden eagle: implications for the conservation and management of golden eagles in Scotland*. SNH report number 193.
2. Whitfield, D. P., Fielding, A. H., McLeod, D. R. A., Haworth, P. F. and Watson, J. 2006. A conservation framework for the golden eagle in Scotland: refining condition targets and assessment of constraint influences. *Biological Conservation*, 130(4): 465-480.
3. Fielding, A., Haworth, P., Whitfield, P., McLeod, D. & Riley, H. 2011. *A Conservation Framework for Hen Harriers in the United Kingdom*. JNCC Report 441. Joint Nature Conservation Committee, Peterborough
4. Grainger, M., Fielding, A & Whittingham, M. 2015. Desk based review of the methods used to assess the effects of wind farms on different bird species. SWBSG Commissioned report number 1501. 29pp.
5. Dunn, J.C., Zwart, M.C., Kerr, S., Fielding, A.H. & Whittingham, M.J. 2015. Desk based evaluation of wind farms and habitat management in Scotland. SWBSG Commissioned report number 1503. 52 pp.
6. Roos, S., Dobson, A., Noble, D., Haworth, P., Fielding, A., Carrington-Cotton, A., Etheridge, B. & Wernham, C. 2015. Raptors in Scotland - a methodology for developing trends and indicators. Scottish Natural Heritage Commissioned Report No. 542
7. Whitfield, D.P. and Fielding, A.H. 2017. Analyses of the fates of satellite tracked golden eagles in Scotland. Scottish Natural Heritage Commissioned Report No. 982. This report was instrumental in bringing about a novel law, the Wildlife Management and Muirburn (Scotland) Act 2024 (<https://www.legislation.gov.uk/asp/2024/4>).

Recent peer-reviewed scientific papers

1. Fielding, A. H., Haworth, P. F., Anderson, D., Benn, S., Dennis, R., Weston, E. and Whitfield, D. P. 2020. A simple topographical model to predict Golden Eagle *Aquila chrysaetos* space use during dispersal. *Ibis* 162(2), 400-415.
2. Fielding, A.H., Anderson, D., Benn, S., Dennis, R., Geary, M., Weston, E. and Whitfield, D. P. 2021. Non-territorial GPS-tagged golden eagles *Aquila chrysaetos* at two Scottish wind farms: macro-avoidance influenced by preferred habitat distribution, wind speed and blade motion status. *PLoS One*.
3. Fielding, A. H., Anderson, D., Benn, S., Dennis, R., Geary, M., Weston, E. and Whitfield, D. P. 2022. Responses of dispersing GPS-tagged Golden Eagles (*Aquila chrysaetos*) to multiple wind farms across Scotland. *Ibis* 164(1), 102-117.
4. Whitfield D. P., Fielding, A. H., Anderson, D., Benn, S., Dennis, R., Grant, J. & Weston, E. D. 2022. Age of First Territory Settlement of Golden Eagles *Aquila chrysaetos* in a Variable Competitive Landscape. *Frontiers in Ecology and Evolution*, 10, DOI=10.3389/fevo.2022.743598.

5. Fielding, A. H., Anderson, D., Benn, S., Reid, R., Tingay, R., Weston, E. D. and Whitfield, D. P. 2023. Substantial Variation in Prospecting Behaviour of Young Golden Eagles *Aquila chrysaetos* Defies Expectations from Potential Predictors. *Diversity* 15, no. 4: 506. <https://doi.org/10.3390/d15040506>
6. Fielding, A.H., Anderson, D., Benn, S. Taylor, J., Tingay, R., Weston, E.D. and Whitfield, D.P. 2023. Responses of GPS-Tagged Territorial Golden Eagles *Aquila chrysaetos* to Wind Turbines in Scotland. *Diversity*, 15, 917. <https://doi.org/10.3390/d15080917>
7. Whitfield, D. P., Fielding, A. H., Anderson, D., Benn, S., Reid, R., Tingay, R. and Weston, E. D. 2024. Sex difference in natal dispersal distances of Golden Eagles *Aquila chrysaetos* in Scotland. *Ibis*, 166,146-155. <https://doi.org/10.1111/ibi.13225>
8. Fielding, A. H., Anderson, D., Benn, S., Taylor, J., Tingay, R., Weston, E. D. and Whitfield, D. P. 2024. Approach Distances of Scottish Golden Eagles *Aquila chrysaetos* to Wind Turbines according to Blade Motion Status, Wind Speed, and Preferred Habitat. *Diversity*, 16(1), 71; <https://doi.org/10.3390/d16010071>
9. Whitfield, D. Philip, Alan H. Fielding, David Anderson, Stuart Benn, Robin Reid, Ruth Tingay, and Ewan D. Weston. 2024. Seasonal Variation in First Territory Settlement of Dispersing Golden Eagles: An Innate Behaviour? *Diversity* 16, no. 2: 82. <https://doi.org/10.3390/d16020082>
10. Fielding, A.H.; Anderson, D.; Barlow, C.; Benn, S.; Reid, R.; Tingay, R.; Weston, E.D.; Whitfield, D.P. 2024. Golden Eagle Populations, Movements, and Landscape Barriers: Insights from Scotland. *Diversity*, 16, 195. <https://doi.org/10.3390/d16040195>
11. Fielding, Alan H., David Anderson, Catherine Barlow, Stuart Benn, Charlotte J. Chandler, Robin Reid, Ruth Tingay, Ewan D. Weston, and D. Philip Whitfield. 2024. The Characteristics and Variation of the Golden Eagle *Aquila chrysaetos* Home Range *Diversity* 16, no. 9: 523. <https://doi.org/10.3390/d16090523>

Consultancy

I have worked on many (>80) wind farm schemes almost exclusively with Haworth Conservation Ltd until Paul's death in 2018. Subsequently, I continued working as an independent consultant; analyzing data, calculating collision losses, advising on mitigation. I have also acted as an advisor to many wind energy proposals and have produced population and GET habitat loss models for local and cumulative impacts. I have very considerable experience of significant wind farm monitoring programmes (Edinbane, Clyde, Farr, Dumnaglass and Stronelaig).

I also provide advice to NatureScot (previously Scottish Natural Heritage, SNH) on matters related to wind farm environmental impact assessment either through commissioned reports or as a reviewer of other commissioned reports in my previous role as a member of the NatureScot scientific experts panel. I have delivered invited presentations on various aspects of environmental impact assessment at NS workshops. I acted as advisor to SNH during a planning inquiry relating to the potential impact of the proposed Stacain wind farm on Golden Eagles in an SPA.

Since 2017 I have been a member of the project team delivering an innovative approach to Golden Eagle conservation funded by SSE. It has already achieved its aims of increasing the size of the local Golden Eagle population but has also been influential in changing the local planning authority's (Highland Council) approach to wind farm planning permissions and has grown to include an education stream in addition to the research stream. Highland Council, NS and RSPB are also members of the project's management board. Currently, with Dr P. Whitfield (Natural Research Ltd), I am developing guidance for NS on reducing the impacts of wind farms and forest schemes on Golden Eagles. Once finalized, all wind farm developers will have to follow the guidelines if they are to obtain

permission for a wind farm or forest planting in regions occupied by Golden Eagles. This will replace current guidance on using the PAT model which we developed in 2002².

At the request of SNH, Paul Haworth and myself wrote an assessment of the potential for an expanded Golden Eagle population in the South of Scotland. Subsequently this resulted in the successful ongoing translocation programme. I am a member of the scientific advisory panel and regularly provide advice to the project.

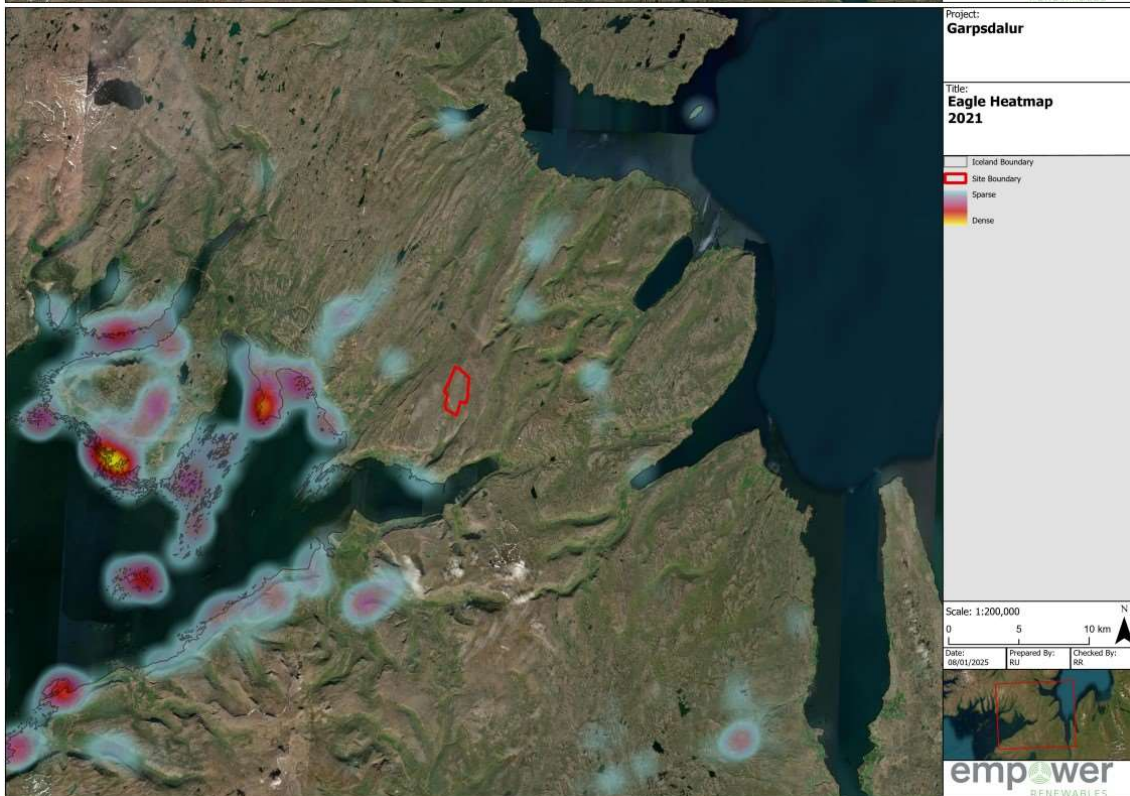
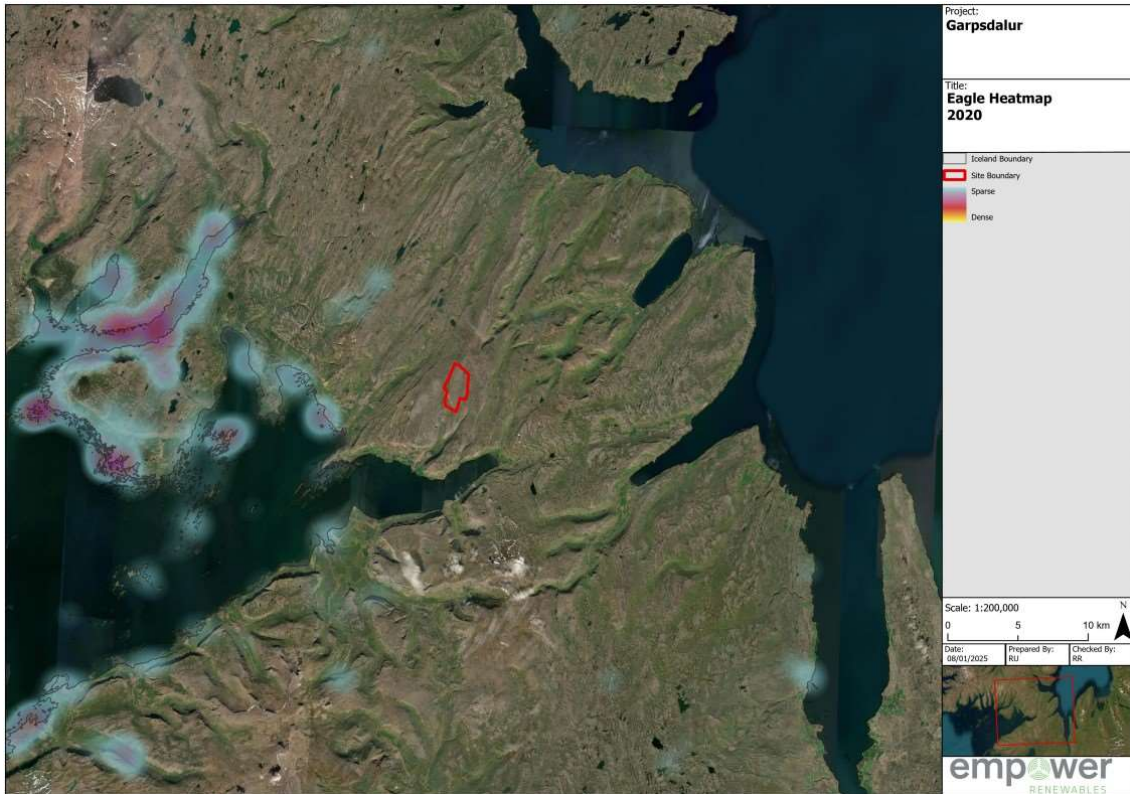
Phil Whitfield and myself completed a review, at the request of Scottish Government, of the evidence for the impact of illegal persecution of Golden Eagles in Scotland. This resulted in the grouse moor licensing legislation that has now become part of Scottish law.

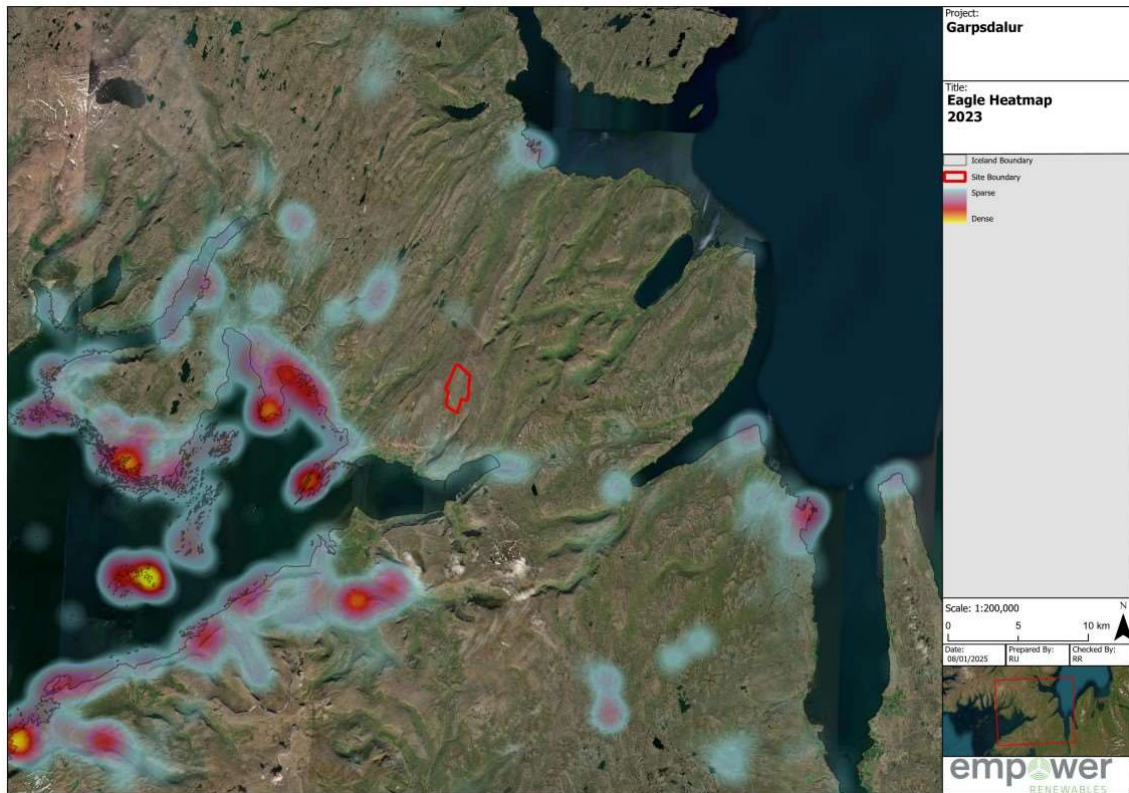
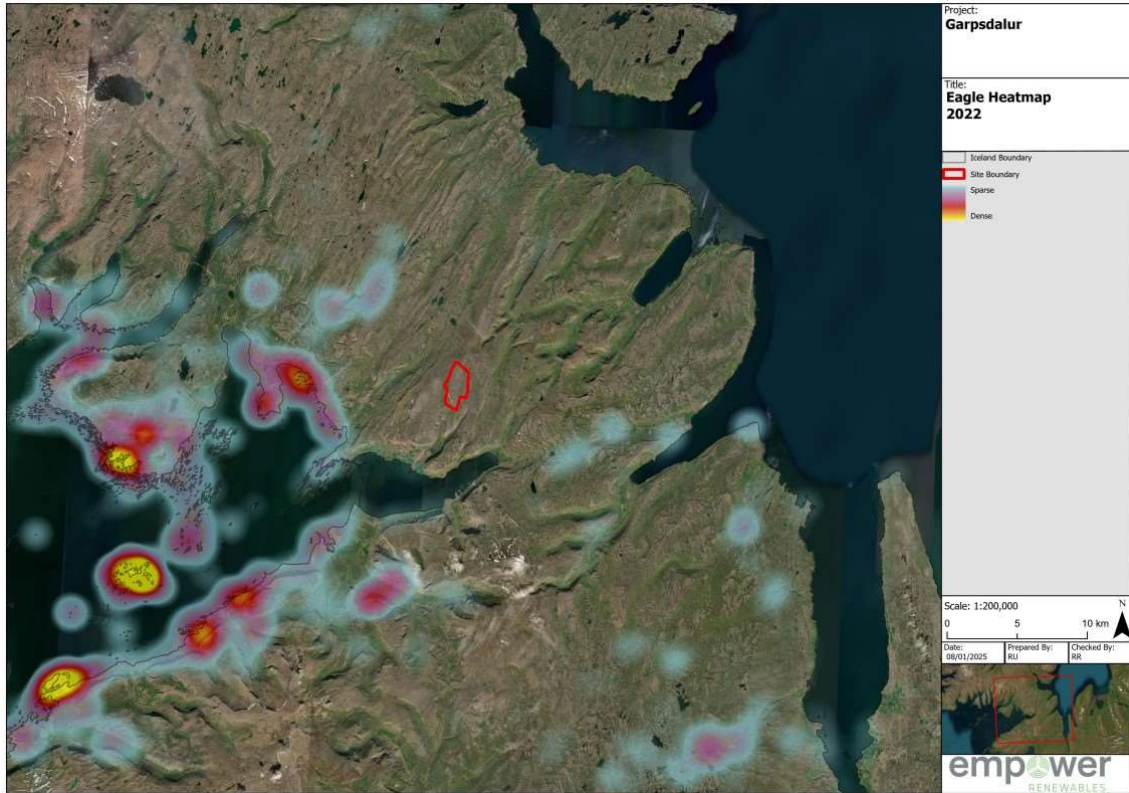
I am a founder member of the Golden Eagle and White-tailed Eagle Satellite Tagging groups (Natural Research, Wildland Ltd, Forest Enterprise Scotland, RSPB, SSE, Chris Packham, RPUK, Roy Dennis Foundation) and I collate data from all of the tags (>350) for use in ongoing research projects.

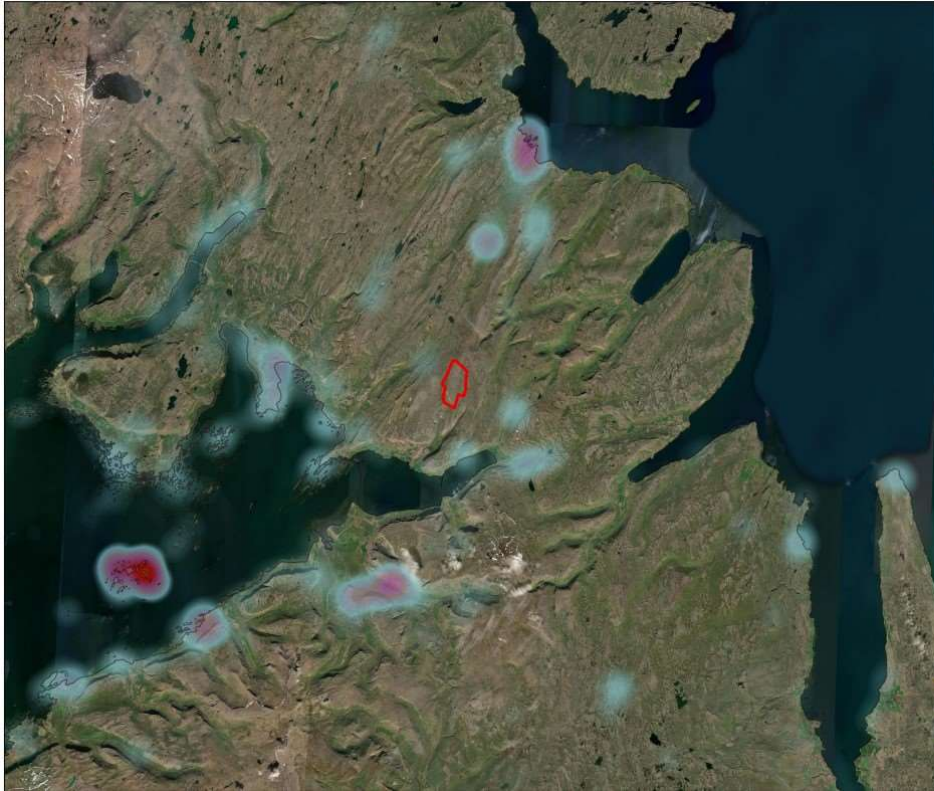
I am currently providing advice to the Cairngorm National Park to inform their future policy on raptor conservation and Forestry England (plus Natural England and DEFRA) on raptor conservation issues in England.

² <https://www.nature.scot/doc/naturescot-statement-modelling-support-assessment-forestry-and-wind-farm-impacts-golden-eagles>

Appendix – Heatmaps 2020 to 2024

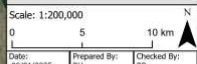
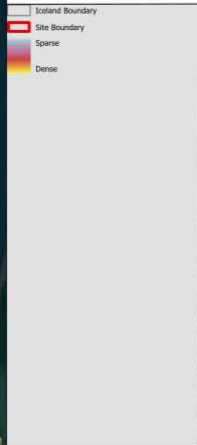






Project:
Garpsdalur

Title:
**Eagle Heatmap
2024**



Date:	Prepared By:	Checked By:
08/01/2025	KU	RR



Viðauki 5

Dr. Matthew Geary

Potential technological solutions to reduce collision risk for
White-tailed Eagles *Haliaeetus albicilla* at the proposed
Garpsdalur windfarm

Potential technological solutions to reduce collision risk for White-tailed Eagles *Haliaeetus albicilla* at the proposed Garpsdalur windfarm

Dr Matthew Geary

The proposed windfarm at Garpsdalur has been assessed in terms of habitat suitability and collision risk for White-tailed Eagles *Haliaeetus albicilla*, largely informed by the movements of the satellite tagged portion of the Icelandic population. The proposed windfarm would be at a high elevation site more than 7 km away from the nearest nesting birds. A collision risk assessment calculated the annual probability of a tagged bird colliding with the turbines to be 0.01. Scaling up to the whole Icelandic population, an estimate of collision risk is then a probability of 0,0357 which would translate to 0.0017 birds per turbine per year.

In order to further explore the potential of limiting the potential impact of the proposed windfarm on Icelandic White-tailed Eagles, I present a review of the potential mitigation approaches currently proposed or in use to minimise collisions between wind energy projects and large-bodied birds. The reports and scientific papers reviewed are based in a variety of locations with differing, often very high, risks of bird collisions. May et al. (2012) consider 11 White-tailed Eagles killed per year to be a small number compared to reported mortality of other species at wind energy facilities globally. Where appropriate I have tried to use the context above regarding the proposed windfarm at Garpsdalur to explain relevant factors which might be considered there.

The risk of collisions can be influenced by site-level factors, the position of individual turbines and the ecology and behaviour of the birds themselves (Marques et al., 2014). Indeed, these variables are likely to interact synergistically in many cases (Heuck et al., 2019). These factors can also inform the suitability of potential mitigation measures.

Site selection is one of the most important factors in reducing collision risk (Marques et al., 2014). Areas which are in good habitat for a particular species are likely to attract more bird movements which increases the risk of collision (Heuck et al., 2019). In Scotland, areas which were less suitable for Golden Eagle *Aquila chrysaetos* were less likely to attract Eagle movements (Fielding et al., 2024) and in Germany White-tailed Eagle mortality at windfarms was higher in areas where the habitat was also good (Heuck et al., 2019). Heuck et al. (2019) used similar variables, such as elevations and Corine Land Cover data, to the White-tailed Eagle Topographic model produced by Fielding (2025) to assess the habitat suitability of the proposed site for the Garpsdalur windfarm. This model suggests that the habitat suitability at the Garpsdalur Project site is very low and that site selection here is already likely to contribute to reducing collision risk. Several of the technological solutions developed below are essentially responses to windfarms which have demonstrated unacceptably high risks to bird populations post-construction and more effective site-selection may have had a stronger impact than post-construction mitigation.

Bird behaviour is also a strong factor influencing collision risk. Large, soaring species can be at risk from turbines because their flight style, use of thermals and relatively low manoeuvrability makes them more susceptible to and less effective at avoiding collisions (Marques et al., 2014). Migratory birds which may travel long distances (Critchley et al., 2025) or congregate in large numbers in

staging areas along a migratory route (Ferrer et al., 2011) may also have increased collision risk. For raptors, young birds are often more likely to travel widely compared to more strongly territorial adults (García-Macía et al., 2023; McCaslin et al., 2020; Weston et al., 2013) and this can increase their risk of collision with wind energy facilities. However, research from Germany on White-tailed eagles suggests that this may not always be true for this species (Heuck et al., 2020). More concerning for White-tailed Eagles is perhaps their lack of behaviour response to turbines (Dahl et al., 2013) which can be actively avoided by other species (Fielding et al., 2021), making site selection, for locations seldom used by White-tailed eagles, all the more important.

Approaches to reduce collision risk

Passive approaches

Passive approaches to reducing collisions between birds and windfarm sites effectively fall into two categories. The first are management actions which make the windfarm site less attractive to particular species to reduce the chance of birds using the site at all. An example of this is habitat management below turbines in a Portuguese windfarm to reduce the suitability of the site for hunting lesser kestrels *Falco naumanni* (Pescador et al., 2019). As the proposed site at Garpsdalur is currently seldom used by White-tailed Eagle, it is unlikely that these approaches would be suitable at this site. However, another recommendation for management is the swift removal of carcasses to avoid attracting scavenging birds which may be more appropriate if the site has the potential for collisions with other large bodied bird species such as geese.

Recently, May et al. (2020) demonstrated that making the turbines themselves more visible to birds could reduce collisions and resulting mortality. They found that painting one blade black resulted in 70% fewer White-tailed Eagle collisions than unpainted turbines at the same site. By painting only one of the three blades black the effect of motion smear may be reduced and allow birds to see the moving turbines more effectively (Hodos, 2003). Although the evidence in May et al. (2020) is compelling, it occurred over a short time period, in only one location and the authors themselves, recommend further investigation into the efficacy of this method. May (2023) reports that the approach has now been applied at wind energy facilities in the Netherlands, Spain and the USA. There is also some concern that, whilst having biodiversity benefits, this approach may be less acceptable to the public as the turbines may have a more pronounced detrimental effect on views. As the approach is relatively new, it's hard to assess this concern, however, the results on an MSc Thesis from the University of Groningen using a sample of 467 people found that having one black blade did not change the acceptability of windfarms to the public and when the approach was combined with information about the potentially positive benefits for biodiversity, their acceptability increased compared to standard turbines (Höfer, 2023).

Shutdown on Demand

The alternative to passive approaches, attempting to reduce collision risk by reducing the likelihood of collision overall, is to adapt active measures to prevent collisions. This involves stopping turbines in response to increased risks of collision – shutdown on demand – and is considered to be one of the most effective mitigation methods (Marques et al., 2014). Two approaches to shut down on

demand are discussed in the literature – predictive and responsive approaches (Birdlife International, 2015). Predictive approaches are most suitable where increased risks of collision are seasonal or the result in changing environmental conditions (Smallie et al., 2024). In these cases, wind energy production is halted during the period of high risk to prevent collisions (Birdlife International, 2015). The downside to this approach is that bird moments may not increase in line with predictions and result in shutdowns where the potential increased risk was not realised. They are also likely to involve most or all of the turbines at a facility and so reduce energy production significantly. This approach is unlikely to be useful at Garpsdalur because there is no evidence that collision risk is linked to seasonal factors or environmental conditions.

Responsive shutdown on demand approaches is more selective and involves the detection of specific collision risks shutting down a small number of, or potentially single, turbines in response (Smallie et al., 2024). Risk of collision across turbines even within the same site is not equal (de Lucas et al., 2012) and this approach allows the response to increased risk to be more selective in terms of shutdown. These approaches require detection of birds approaching turbines to be quickly communicated and shutdowns to happen rapidly as a result. The detection of birds can be automated and several systems for the automatic detection of birds are currently in operation (Smallie et al., 2024). Similarly, the shutdown of turbines can be built into control systems so shutdown happens without human input (Birdlife International, 2015).

Automated detection methods include cameras and radar, both of which can be effective for diurnal birds (Marques et al., 2014). Radar methods can cover wider areas but are more suited to open landscapes as topography can interfere with the signal (Birdlife International, 2015). Most radar systems operate over a wider area whereas camera-based methods tend to be focused on individual turbines, however, radar methods which focus on individual turbines have also been proposed, primarily for detecting bats and smaller birds (Moll et al., 2020). The majority of automated systems have the option of also automating the shutdown but they could potentially alert an operator in the same way as described above in the observer-based approaches (Birdlife International, 2015).

Several commercially available camera systems are mentioned in the literature including:

- DTBird (www.dtbird.com),
- Identiflight (<https://www.identiflight.com>),
- Safewind(<https://www.biodiv-wind.com/safewind/>),
- Bird Protection System (<https://bioseco.com/>) and
- nvBird (<https://www.internet-idee.net/en/nvbird.php>).

Of these DTBird appears to be the most widespread; it is currently in use in more than 90 locations in 16 countries (Smith et al., 2025). DTBird is a monoscopic camera system using four cameras mounted on individual turbines (May et al., 2012). It uses an artificial intelligence algorithm to detect moving birds and then estimates their proximity to the turbine by the number of pixels they cover (Smith et al., 2025). DTBird used pre-programmed distances to determine risk categories and combines audio deterrents with shutdown on demand (Birdlife International, 2015). When birds move within the first distance threshold an audio deterrent is sounded, if birds continue to approach the turbine this is followed by a second audio deterrent followed by turbine shutdown (Smith et al.,

2025). DTBird has been shown to reduce Golden Eagle collision risk by up to 50% at the Manzana Windpower Plant (reported in Smallie et al., 2024). Smith et al. (2025) used Unmanned Aerial Vehicles (UAVs) to test DTBird's detection capabilities at a windfarm in the USA. DTBird was able to detect 62% of their test flights but found low and close or high and close passes particularly difficult to detect. An evaluation of this system at the Smøla windfarm with DTBird mounted on two turbines compared DTBird detection to known bird movements from satellite tagged individuals and information from a MERLIN radar system (May et al., 2012). This study found that DTBird had a low false positive rate with a mean of only 1.2 false positives a day and suggests that the cameras detected 76% and 96% of flights on the two turbines. White-tailed eagles were detected at 200 – 300m from turbines and the camera detections overlapped strongly with radar detections.

Monoscopic systems such as DTBird use only one camera and therefore cannot estimate depth (i.e. distance from the camera) within an image (Gradolewski et al., 2021). Stereoscopic systems use multiple cameras in order to do this and so are likely to be more accurate at assessing proximity to turbines (Smallie et al., 2024). Gradolewski et al. (2021) propose a system called Bird Protection System (BPS) which they also test in Poland, demonstrating its ability to detect red kites and UAVs. In comparison with observations by ornithologists, BPS only missed 9 of 105 birds recorded flying close to the site and only one of these was within 200m of a turbine. BPS has later been evaluated elsewhere in Poland and in Switzerland, again showing high rates of detection for raptors but also potential blindspots depending on the angle of cameras (reported in Smallie et al., 2024).

The most widespread, and widely evaluated stereoscopic system is Identiflight (<https://www.identiflight.com/>). In Wyoming, USA, McClure et al. (2021) suggested that Identiflight combined with an automatic shutdown system showed a 63% reduction in fatalities of Golden Eagle and Bald Eagle *Haliaeetus leucocephalus* compared to before its installation and an 82% reduction compared to a nearby control. At the treatment site, they found 33 eagle carcasses over a five year period before Identiflight was deployed and only three during the following year while it was used. After controlling for carcass detection, this corresponds to approximately 7.5 birds killed per year before deployment and only 2.5 afterwards (McClure et al. 2021). This result was disputed by Huso & Dalthorp (2023) but reanalysis by McClure et al. (2023) and the large reduction in collision risk confirmed by analysis of a larger dataset in McClure et al. (2022) suggest that Identiflight is effective. Duerr et al. (2023) tested the detection ability of Identiflight using UAVs and found the system to correctly identify 77% of eagle flights and 85% of non-eagles. However, they also had high false positive rates for eagles caused by Common Ravens *Corvus corax* resulting in false curtailments of the wind turbines. Two additional reports assess the impact of the Identiflight system showing a 75% protection efficacy for Red Kites in Germany and 90% correct classification of eagle flights at Cattle Hill Windfarm, Australia (reported in Smallie et al., 2024). The result from Cattle Hill Windfarm identifies a potential issue in that obstruction of the camera systems by vegetation was thought to have contributed to the deaths of several Wedge-tailed Eagles *Aquila audax* which were not detected by the system. Visibility is a potential issue with all camera-based systems and could be affected by sun position (Smith et al., 2025) and weather conditions (May et al., 2012).

Radar-based systems are used widely for bird detection at airports (Phillips et al., 2018) and offshore windfarms (Fijn et al., 2015). Again, several systems are available including:

- MERLIN (<https://detect-inc.com/bird-control-radar-systems/>),
- Echotrack (<https://echotrack.com/technology.html>),
- Robin Radar (<https://www.robinradar.com/>) and
- Birdtrack (<https://birdtrackradar.com/>).

Of these, the most commonly mentioned in the literature is the MERLIN radar system made by Detect Inc which was at use in over 100 facilities worldwide in 2015 (Birdlife International, 2015). This has also been used at the Smøla windfarm where it had good overlap with the DTBird system in terms of detection and was shown to be able to detect White-tailed Eagle at up to 2.5 km from the site (May et al., 2012). MERLIN uses ‘T bar’ antennas to detect bird species and identifies them using specially designed data extractor algorithm, allowing continual detection of birds flying close to wind energy facilities (May et al. 2012). MERLIN has been shown to be effective in detecting birds, but as with other radar technology, is much less effective, and potentially non-operational, in weather conditions such as heavy rain and fog (Aishwarya et al. 2016). One downside to radar systems has been the lack of ability to identify birds, or groups of birds, but advances in this area using AI algorithms have improved this (Smallie et al., 2024). However, the use of AI algorithms in identification in the case of the proposed windfarm at Garpsdalur may present an additional issue whether in a camera or radar-based system. Often, these algorithms need large amounts of training data to be able to effectively identify species, ideally at a similar location with similar environmental conditions (Wäldchen & Mäder, 2018). Given the small numbers of White-tailed Eagles coming into the vicinity of the proposed site, this may take a considerable amount of time unless the AI can be trained on images of radar signatures from elsewhere.

In conclusion, there are a number of approaches which have been shown to be effective in reducing bird mortality at wind energy sites. However, in the majority of cases, these methods were employed because of very high levels of bird mortality. Indeed, it is important to note that the majority of examples, referred to here were post-construction mitigation measures to reduce mortality which had been shown through monitoring to be unacceptably high. In comparison to these situations, the predicted mortality at Garpsdalur is extremely low. In several situations, automated technologies resulted in frequent false-positives which shutdown energy production. With high collision risk sites, this trade off, and the subsequent lost energy production was acceptable. Indeed, the estimated loss of energy production was relatively small compared to annual output. Nevertheless, in a situation where expected risk of collisions is much lower, this trade-off would have to be evaluated. Automated shutdown on demand systems has been demonstrated to be effective for White-tailed Eagles in Norway and other large eagle species elsewhere in the world. They are likely to have large initial costs associated with them but ongoing costs are then likely to be lower than using an observer-based system. Ultimately the decision on the approach taken should be informed by consideration of how low collision risk has to be in order to be acceptable. This report includes a number of systems, both active and passive, which could reduce the risk by up to 90% all of which could potentially be considered for use at Garpsdalur if required, or indeed adopted at a later date if the need was demonstrated through post-construction monitoring.

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