

Deucheran Hill 2

Technical Appendix 8.3: Golden Eagle Topographical (GET) Model

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June 2026

Conclusion

1. The Golden Eagle Topographical (GET model) was used to estimate the amount of good golden eagle habitat that may be lost following the construction of a Proposed Development.
2. There is good evidence that the Proposed Development would not result in a significant loss of good golden eagle habitat available to range holding or dispersing golden eagles.
3. Also, it is unlikely that there would be a significant reduction in habitat use outside of the turbine exclusion zone resulting from a barrier effect created by the Proposed Development.

Background

4. The impact of the Proposed Development, 7 kilometres (km) northwest of Carradale in the Argyll West and Islands NHZ, is assessed using the GET model (Fielding *et al.*, 2020). Analyses are undertaken for a 14-turbine scheme provided by The Applicant.
5. Predicted habitat loss for range holding golden eagles, arising out of wind farm construction, was previously assessed using the Predicting Aquila Territories (PAT) model (McLeod *et al.*, 2002). Satellite tracking devices have been fitted to 134 range holding birds (Natural Research, unpublished data and Fielding *et al.*, 2024a) spread across Scotland and representing >20 % of all occupied ranges. The PAT model's home range boundary assumptions are unsupported in data from these 134 individuals, and the PAT model is unreliable, as recognised by NatureScot.
6. The GET model provides a robust method for estimating predicted habitat losses for dispersing young and range holding eagles. The GET model assigns a score between 1 and 10 to every 50 m pixel across Scotland. Habitat with a GET score of 6+ is a good indicator of potential golden eagle activity when present in large contiguous blocks. Habitat with a GET score of 5 or less is used infrequently. However, golden eagles also tend not to use land with a closed canopy forest cover, irrespective of the GET score. Since its development the GET model has been tested with a large amount of new, independent data, including from range holding birds, and the model has performed very well (See Appendix A in Fielding *et al.*, 2023).
7. Analyses of golden eagle satellite tracking records indicate that golden eagles rarely approach turbines (Whitfield and Fielding, 2017; Fielding *et al.*, 2022, 2021, 2023, 2024b). After turbines become operational, golden eagles effectively abandon inner turbine locations, and flight lines close to rotor blades are rare (Fielding *et al.*, 2021, 2024b). The main impact of a wind farm on golden eagles in Scotland is habitat loss with a small probability of a collision. Currently, there have been at least seven golden eagle collision deaths in Scotland spread over more than 10 years. The number of collisions will increase given recent increases in the numbers of turbines and golden eagles, but even if the collision mortality was double that recorded there would not have been a significant impact on the Scottish population.
8. Open habitat is land with no closed canopy forest cover and is at least 300 m from an existing or consented turbine. An appropriate baseline for an assessment of habitat loss for golden eagles is the current area of open GET habitat with a value of 6 or more. All subsequent measures of good golden eagle habitat refer to open country with a GET score of 6+.

9. Closed golden eagle habitat is land with extensive tree cover or within 500 m of a turbine tower. In these analyses tree cover was assessed using an 8 April 2025 Sentinel 2 image (T30UUG). A false colour composite image was constructed from the 10 m resolution bands 2, 3 and 4 while combining the 20 m resolution bands 2, 6 and 12 to enhance tree cover (Ottosen *et al.*, 2020).
10. There is no current NatureScot guidance on how to assess either the significance or the area of lost good golden eagle habitat arising from a wind farm development. Potential impact can be estimated by assuming all habitat within forests and close to wind turbines is lost. The loss can be compared with a regional figure to assess the significance level. It is also important to assess if the wind farm may act as barrier to golden eagle movements creating a greater loss than that inside the wind farm.
11. In the absence of formal guidance, the following approach is used to assess the area of good golden eagle habitat lost following construction and its possible significance.
 1. Define a turbine exclusion distance and buffer the turbines to this distance. All habitat within this buffer is assumed to be lost to golden eagles.
 2. Measure the amount of lost good eagle habitat within the turbine exclusion buffer.
 3. Assess the significance of this loss of habitat by comparing it to a region-specific threshold.
 4. Examine turbine positions, within the GET landscape, to assess which, if any, turbines may be particularly problematic for golden eagle movements.

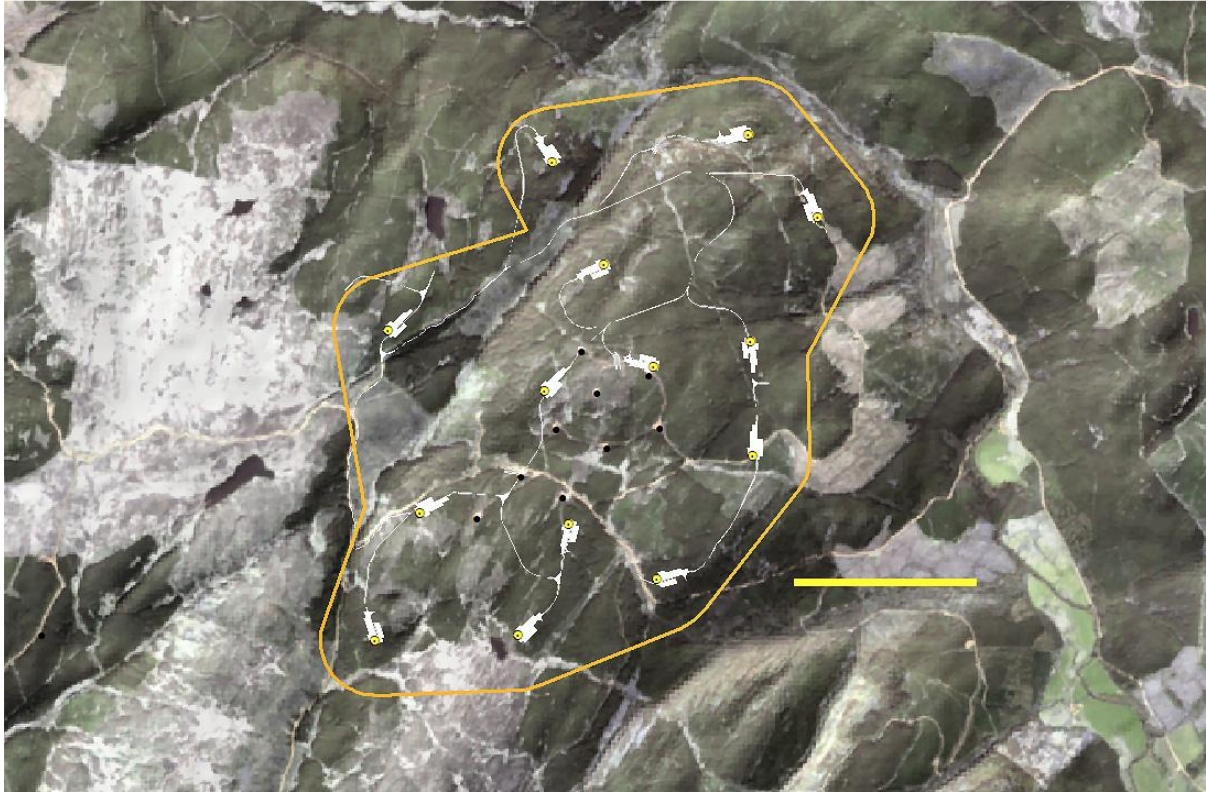
Exclusion Distance

12. Analyses in Fielding *et al.* (2021, 2022, 2023, 2024b) suggest that 500 m may be a conservative displacement distance¹, a smaller distance can be justified to assess potential habitat loss, particularly if it is combined with a turbine boundary rule. Turbine diameter was not a significant predictor of how close satellite tracked birds came to the turbines (Fielding *et al.*, 2022). However, displacement distances were not the same for all turbines, even for identical turbines in the same wind farm (Fielding *et al.*, 2022, 2023, 2024b).
13. Unfortunately, there is insufficient evidence, on causal relationships, to incorporate such variation into current analyses. Consequently, a displacement distance of 300 m from the proposed turbine towers is suggested. The displacement distance will be less for some turbines, particularly those in, or surrounded by, good eagle habitat. It will be greater for others².
14. Evidence from tagging data suggests that if turbines are not in a string (a line of turbines) the outer turbines act as a barrier to the wind farm's interior (Fielding *et al.*, 2021, 2022, 2024b) and therefore displacement should be assessed with respect to a buffer around the outer turbines. To do this a 300 m buffer was drawn around each turbine and an outline constructed as a concave polygon around the outer turbines such that no point inside the polygon is <300 m from a turbine (orange lines in Figure 1). All habitat within the concave polygon, even if >300 m from a turbine, is assumed to be lost to golden eagles once turbines are erected. Much of the golden eagle habitat (92.2 %), inside this exclusion zone, has already been lost to forest cover or turbines (see **Table 8.1** and **Figure 1**).

¹ 500 m was introduced into wind farm assessments to deal with location inaccuracy in VP surveys when translated into collision estimates.

² Note that a simple 500 m buffer is used to estimate existing losses to turbines because it is computationally easier when maintaining a database of lost habitat. It is a conservative estimate of the existing habitat loss.

Figure 1. 300 m wide Proposed Development golden eagle exclusion area (orange boundary). Yellow horizontal bar is 1 km. Background is an April 2025 Sentinel 2 image which shows much of the potential habitat is already lost to golden eagles to forest cover and the existing nine Deucheran Hill turbines (black dots). Contains Ordnance Survey data © Crown copyright and database right 2020.



The Current Extent of Good Eagle Habitat

15. Good GET habitat is extremely fragmented in Kintyre with no large patches of good GET habitat remaining, mainly as a consequence of extensive tree cover. Within 20 km of the Proposed Development most of the good habitat has been lost to tree cover and wind farms (**Figures 2 and 4**), with the exception of extensive good habitat in north Arran which is largely disconnected from the mainland habitat because of the distance over the Kilbrannan Sound.
16. There are 194 operational or consented turbines in 14 developments, within 20 km of the Proposed Development (**Figure 2**).
 - As this is a re-powering scheme, the nine existing Deucheran Hill turbines are inside the turbine eagle exclusion zone.
 - Ten operational Cour turbines and nine of the 10 consented, adjacent, High Constellation turbines are <5 km of the Proposed Development, plus 12 consented Clachaig Glen turbines.
 - There are 83 operational and consented turbines are within 5 - 10 km of the Proposed Development: the remaining High Constellation turbine; three operational Auchadaduie

turbines; the 65 operational turbines in the Beinn an Tuirc 1 (47) and 2 (18) schemes; one of Beinn an Tuirc 3 operational turbines; and the 13 operational Blary Hill turbines.

- There are 71 turbines in six developments between 10 and 20 km from the Proposed Development. There are 51 operational turbines in four schemes: Fraesdail (11); Tangy (22); Beinn an Tuirc 3 (14); and Gigha (4). The remaining 20 turbines are in two consented schemes: Airigh (7); and Eascairt (13).

Figure 2. Open GET landscape in the vicinity (20 km) of the Proposed Development. 300 m wide Proposed Development golden eagle exclusion area (orange boundary) with yellow turbine locations. Consented or operational turbines are shown as black circles. GET scores are on darkening scales for open land. Contains Ordnance Survey data © Crown copyright and database right 2020.

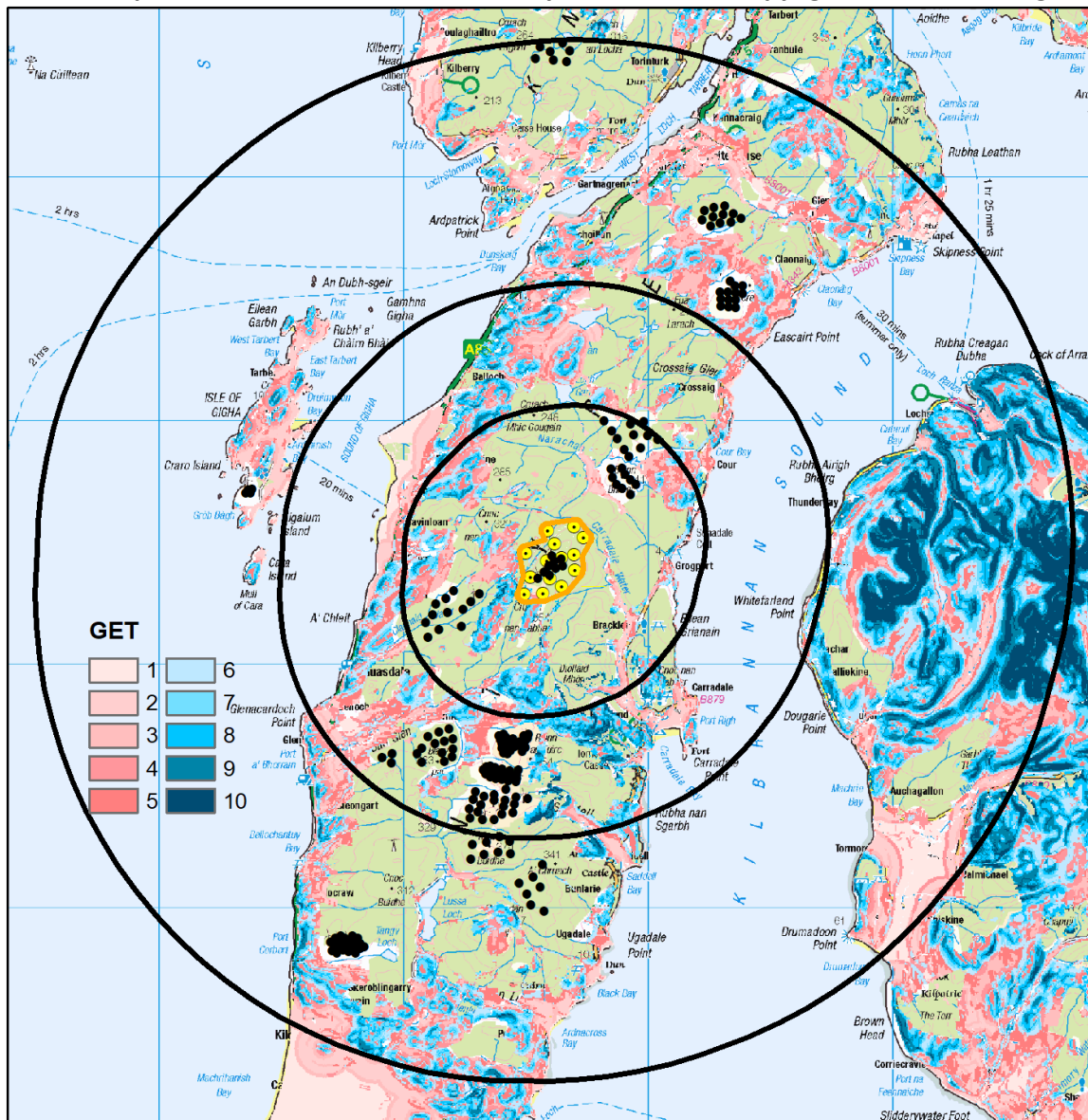
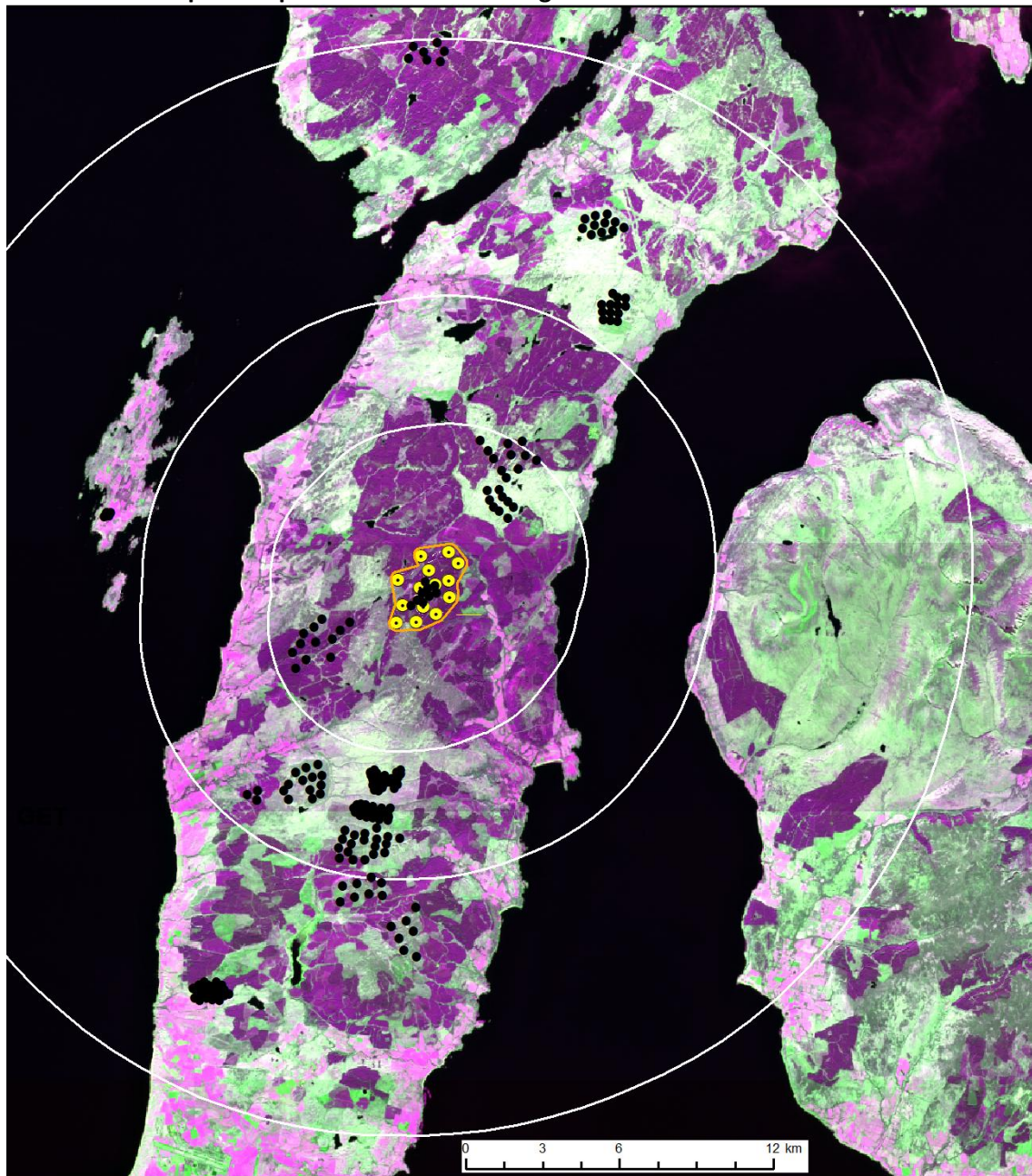


Figure 3 is a false colour composite image of the 20 m resolution Sentinel 2 bands 2, 6 and 12 (T30UUG, 8 April 2025)). It is easier to locate forest cover and other land covers in **Figure 3**. Using this image, and turbine buffers, the GET habitat was separated into the Open and Closed classes. **GET habitat loss is assessed only against the current extent of open habitat.**

Figure 3. Tree cover (forests are dark purple) in the vicinity (20 km) of the Proposed Development. 300 m wide Proposed Development golden eagle exclusion area (orange boundary) with yellow turbine locations. Consented or operational turbines are shown as black circles. Background is a false colour composite April 2025 Sentinel 2 image.



17. The extent of available habitat, against which losses can be assessed, was estimated in buffers of increasing distance (5, 10 and 20 km) from the Proposed Development (**Table 8.1**). Open habitat is the current area of open habitat while 'Full' is the habitat area assuming no habitat was lost to golden eagles as a result of forest cover or constructed and consented turbine buffers. The key figures in **Table 8.1** are the areas of open GET 6+ habitat within the three buffers.
18. The Proposed Development is in the Argyll West and Islands Natural Heritage Zone (NHZ 14). There is little good golden eagle habitat surrounding the Proposed Development (**Figure 2**). Outside of this zone, golden eagle habitat is further restricted by a combination of topography, forests and turbines although, even in the absence of these, the GET landscape is fragmented (**Figure 2**).
19. The areas of good eagle habitat (**Table 8.1**) are 1,843 (5 km); 5,328 (10 km); and 21,482 (20 km) ha (**Table 8.1**). The areas of good habitat already lost to golden eagles (Full Area – Open Area), through trees and constructed or consented wind farms, are: 4,713; 8,362 ha and 17,141 ha respectively (**Figures 2 and 4**). The percentages of GET 6+ already lost to trees and constructed or consented wind farms are 71.9 % (5 km), 61.1 % (10 km) and 44.4 % (20 km). The proportion open GET 6+ habitat is relatively constant with increasing distance from the Proposed Development (**Table 8.1, Figures 2 and 4**).

Table 8.1. Areas (hectares) of good golden eagle habitat at various distances from the Proposed Development turbines and within the turbine exclusion buffer (Within). Assessed area is the area against which the percentage of open GET 6+ habitat is calculated

GET	5 km		10 km		20 km		Within	
	Open	Full	Open	Full	Open	Full	Open	Full
Closed	8,658	47	16,210	215	34,512	483	2,634	0
1	9	32	366	467	1,528	1,841	-	0
2	157	372	945	1,477	3,445	5,022	-	0
3	488	1,766	1,244	3,691	3,557	8,030	2	18
4	416	1,224	978	2,487	3,061	6,532	65	275
5	691	2,265	2,210	5,239	6,234	13,134	26	385
6	539	1,856	1,584	3,979	4,998	10,390	26	586
7	651	2,185	1,758	4,365	5,686	11,255	54	824
8	443	1,537	1,247	3,212	4,586	8,365	29	499
9	173	765	586	1,670	3,292	5,266	17	226
10	38	214	153	465	2,921	3,347	3	43
Area	12,261		27,280		73,817		2,856	
Assessed area	3,603	12,215	11,070	27,050	39,306	73,183	222	2,856
GET 6+	1,843	6,556	5,328	13,690	21,482	38,623	129	2,178
% GET6+	51.2	53.7	48.1	50.6	54.7	52.8	58.1	76.3

Assess the Loss of Habitat with Respect to a Regional Figure and Range Areas

20. Historically, the Proposed Development is surrounded by four golden eagle ranges with four or five more on Arran. None of these golden eagle ranges has satellite tracked birds. Potential habitat loss to range holding birds is assessed by estimating the percentage loss of good eagle habitat within golden eagle home ranges using the GET model. The two historic surrounding range centres (G/KM2 and G/KM3) are unlikely, based on distance and the GET landscape, to make significant, if any, use of the land within the turbine exclusion buffer. However, there is an intermittently occupied new range sandwiched between the Deucheran Hill and Clachaig Glen wind farms which could potentially be impacted by the Proposed Development.

Figure 4. Open (top) and Full (bottom) GET landscape in the vicinity (20 km) of the Proposed Development. Consented or operational turbines are shown as black circles. GET scores are as in Figure 2 and centre. Contains Ordnance Survey data © Crown copyright and database right 2020.

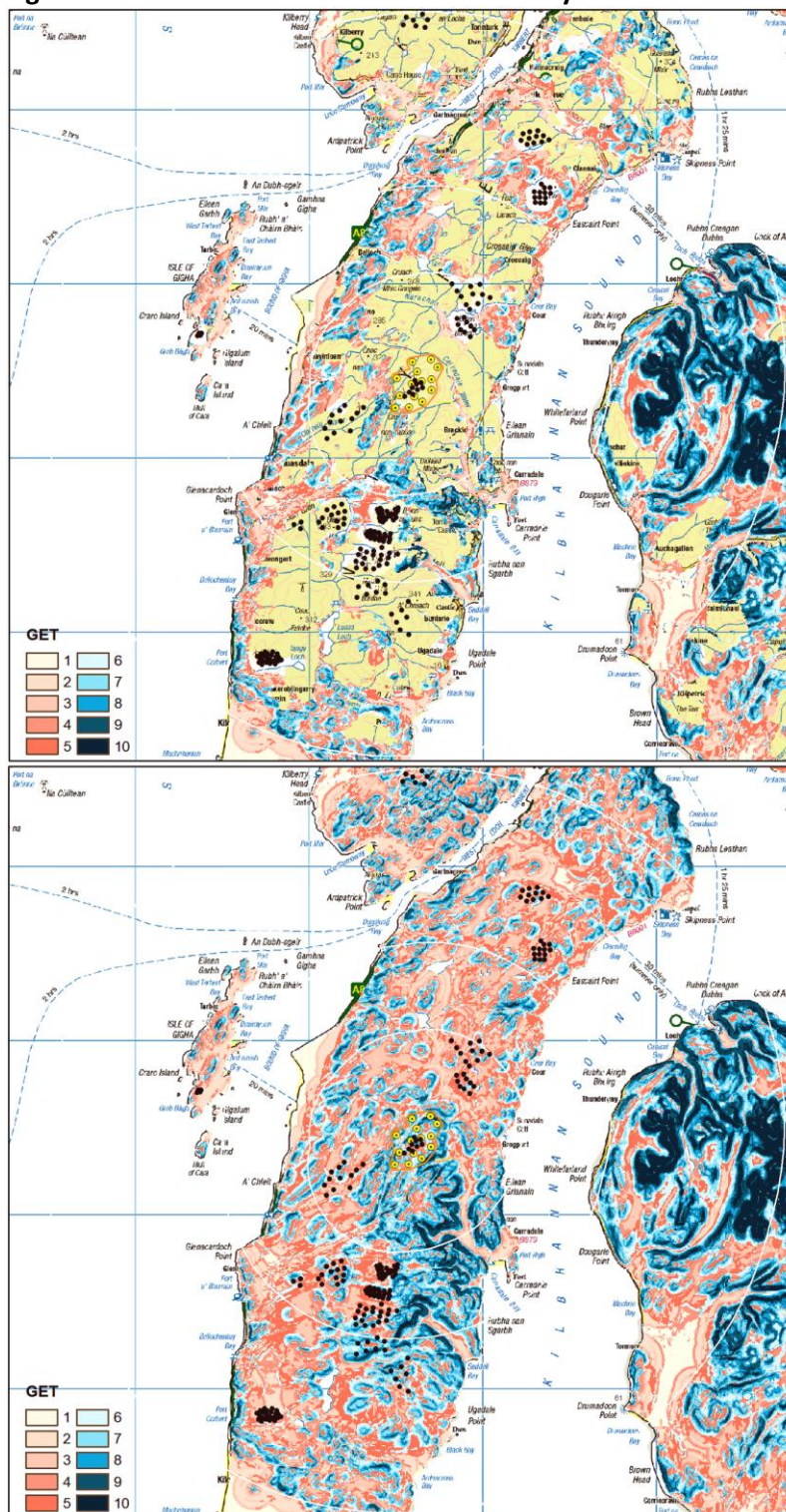
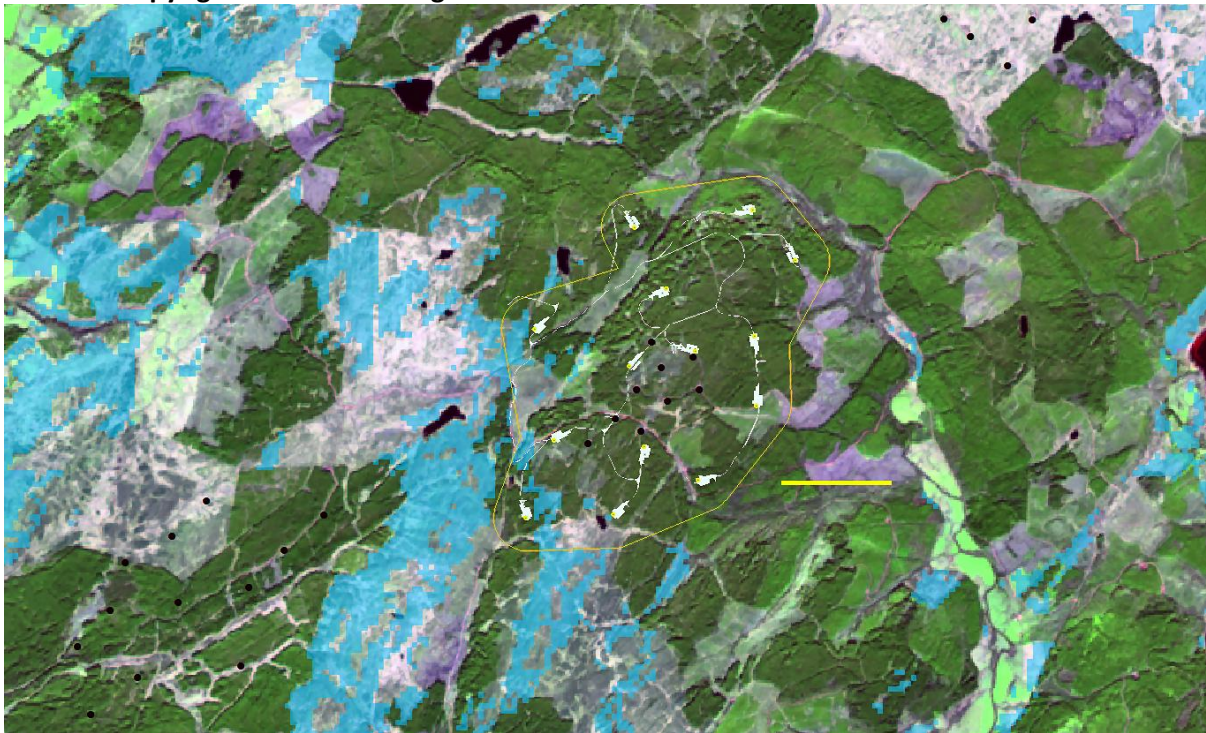


Figure 5. Open GET landscape with a GET score of 6 or more (blue shading), close to the Proposed Development (yellow bar is 1 km). Other operational turbines are shown as black circles. Background is a false colour composite April 2025 Sentinel 2 image. Contains Ordnance Survey data © Crown copyright and database right 2020.



21. The 300 m turbine exclusion zone is 2,856 ha, of which only 129 ha (4.5 %) is open GET 6+ habitat (**Table 8.1, Figure 5**). It is impossible to assess robustly if the Proposed Development will have a significant impact on current or future golden eagle ranges but average range size is a useful metric for assessing possible habitat loss (as in the PAT model). In the PAT model, home range size is defined by a 6 km Thiessen polygon but extensive evidence from satellite tagged adult golden eagles has shown this approach is unreliable and misleading in unpredictable ways. Unless range holders are satellite tagged, range boundaries are unknown for currently occupied ranges in Scotland and unknowable for theoretical future ranges. Nonetheless, given the current landscape of good eagle habitat, and the presence of wind farms and other golden eagles, it seems unlikely that the Proposed Development will overlap significantly with additional future home ranges.

22. Based on analyses of satellite tracked range holding birds (Natural Research, unpublished data and Fielding *et al.*, 2024a) the mean size for golden eagle ranges in this region was ~5,140 ha of open eagle habitat, based on 24 home ranges. The standard deviation for the area of GET 6+ habitat in an Argyll home range was large at 3,315 ha and it seems likely that this new, intermittently occupied range will be at the lower end of the area of GET 6+ habitat. In the following analyses a conservative 2,500 ha of GET 6+ habitat in this putative home range is assumed. Although an estimated habitat loss can be obtained using a reference golden eagle range area of 2,500 ha of open eagle habitat the actual range loss, *if any*, resulting from the Proposed Development depends how much of the turbine exclusion zone is within a home range boundary, how large the home range is and how important the area within the windfarm exclusion buffer is to the pair.
23. A theoretical range with 2,500 ha of open eagle habitat could lose 125 ha before reaching the PAT model's range loss threshold of 5 %. The estimated area of open eagle habitat within the Proposed Development is 129 ha (**Table 8.1**), resulting in a loss of 5.2 % of the putative home range's habitat and, because of existing forest cover, any losses would be on the range's periphery. On balance, the loss of good golden eagle habitat arising from the Proposed Development is unlikely to be large enough to threaten this putative golden eagle range. Note that any losses arising from the construction of the Clachaig Glen Wind Farm are already included in these calculations.
24. A qualitative impact assessment should also look at the Proposed Development in relation to the surrounding landscape and likely golden eagle movement patterns. Golden eagles have clear movement patterns along extensive contiguous GET 6+ areas, essentially following ridge lines. The intensity of movement is, to some extent, determined by the extent and connectivity of good eagle habitat (**Figure 6**). Connectivity can be disrupted by wind farms resulting in a larger loss of habitat than that within the turbine exclusion area if they form a barrier to good habitat beyond the turbines.
25. The Proposed Development has very little connected good eagle habitat and there is no good habitat east of the Proposed Development (**Figure 6**) and therefore there will be no new and significant access barriers to the surrounding good eagle habitat.

Figure 6. Open GET landscape with a GET score of 6 or more (blue shading), close to the Proposed Development (20 km buffer). Other operational and consented turbines are shown as black circles. Contains Ordnance Survey data © Crown copyright and database right 2020.



Expected Habitat Losses for Dispersing Birds

26. Wind farms can result in a loss of habitat used by dispersing golden eagles. Generally, dispersing golden eagles do not spend much time inside an occupied golden eagle ranges so if a wind farm is within an existing golden eagle home range any losses for dispersing young eagles should be small.
27. Assessing the impact on dispersing golden eagle habitat at, for example, the NHZ level will inevitably result in a trivial loss of habitat. For example, the 20 km buffer around the Proposed Development currently has ~21,000 ha of open eagle habitat (**Table 8.1**) and the exclusion zone around the Proposed Development would result in a 0.6 % loss of this open GET 6+ habitat (129 ha from 21,482 ha). Because dispersing golden eagles cover enormous areas, assessing loss at the scale of an individual's dispersal area would also lead to an inevitable trivial loss estimate.

28. Instead, habitat loss can be estimated regionally using a buffer (distance from the Proposed Development) appropriate for the region. Estimated percentage losses will be larger for small buffers and *vice versa*. A multiple of the estimated adult range size could be an appropriate guide to the buffer size, but this will not be a fixed planar area and the size of a buffer required to include a particular area of open eagle habitat depends on many factors but mainly topography, forestry and wind farms.
29. The upper limit for assessing the impact of a Proposed Development on dispersing golden eagle habitat could be the maximum loss calculated using EITHER a buffer with a maximum 10 km distance from the Proposed Development OR a smaller buffer distance such that the area of GET 6+ habitat within the buffer does not exceed five times a notional range area of 2,500 ha of GET 6+ habitat. Ten km is not a large distance for a golden eagle.
30. Inevitably these are arbitrary values but in relation to the size of a Proposed Development they should be biologically reasonable constraints. If the Proposed Development was in the centre of a very large expanse of suitable habitat, with little tree cover and no other wind farms, a 10 km buffer would contain large expanses of suitable habitat which has the effect of decreasing the proportional loss of good habitat with respect to the extent of good habitat within the wind farm.
31. The area of good eagle habitat within 10 km of the Proposed Development is ~5,328 ha (**Table 8.1**) which is much smaller than five times the notional range area ($5 \times 2,500 \text{ ha} = 12,500 \text{ ha}$), implying that habitat loss should be assessed against the 5,328 ha threshold. A loss of 129 ha from 5,328 ha is ~2.4 %, which is an insignificant loss.
32. The Proposed Development would not create an additional significant loss of good eagle habitat as the result of a barrier effect (**Figure 6**). There is, therefore, reasonable evidence that the Proposed Development would not result in a significant loss of good golden eagle habitat available to dispersing golden eagles.

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