# Corr Chnoc Wind Farm

# An analysis of potential golden eagle habitat loss using Satellite Tracking Data and the GET Model

Confidential report prepared for Galileo 04 Ltd

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## Summary of findings

1. The proposed Corr Chnoc Wind Farm (the Revised Proposed Development) is inside the Beinn Ghlas (G/LAW1) golden eagle range.

2. The potential impact of the Revised Proposed Development on golden eagles is assessed using extensive satellite tracking data.

3. There is considerable satellite tracking data for the recent female of the pair (tag 1157, February 2021 - August 2025). She was killed by another female who has taken her place in this range. Because of the quantity and duration of the tracking data a robust assessment can be made of the potential impact of the Revised Proposed Development.

4. It is assumed that all habitat inside a turbine exclusion zone would be lost to the golden eagles because of avoidance. This assumption is based on extensive analysis of tracking data across Scotland which has been published in four peer reviewed publications, including studies involving this range.

5. In addition to the habitat loss resulting from operational and consented turbines there is the potential for additional habitat loss from two schemes in planning. There are seven turbines in the Beinn Ghlas Repowering scheme (July 2025 application to Argyll & Bute Council) which would replace the existing 14 Beinn Ghlas turbines plus six turbines in the Cruach Clenamacrie (December 2024 S.36 Application) development.

6. Tag records are a more reliable indicator of habitat loss than the GET model as they are an empirical measure of habitat use by the birds.

7. There are 237,775 daytime records within the Home Range (HR) and 7,881 are within the Corr Chnoc turbine exclusion zone. The estimated range loss is therefore 3.3%.

8. There are an additional 2,376 records in the barrier zone west of the Revised Proposed Development, and so in total there are 10,257 records in an extended exclusion zone (7,881 + 2,376), which is 4.3% of the daytime tag records. Therefore, the estimated range loss from the Revised Proposed Development, plus a potential barrier zone, is 4.3%.

9. Turbine exclusion zones were also created for the proposed Beinn Ghlas Repowering and Cruach Clenamacrie developments. In combination there were 3,061 records in the new exclusion zones (Beinn Ghlas Repowering 1,726 records and Cruach Clenamacrie 1,335 records). In combination, the three proposed developments exclude 10,942 (3,061 + 7,881) records which is 4.6 % of the 237,895 (95%) HR points.

10. The number of records in the Beinn Ghlas Repowering new exclusion zone is relatively small because of the existing exclusion effect of the current turbines. Similarly, the number of records for Cruach Clenamacrie reflects its position overlapping, and extending beyond, the range boundary.

11. If the barrier zone, west of the Revised Proposed Development, is included with records in the three turbine exclusion zones this increases the number of records to 13,318 records (10,942 + 2,376) which is 5.6% of the 237,895 (95%) HR points.

12. A cumulative 5.6% loss of the range is very unlikely to result in range abandonment.

13. No additional habitat losses resulting from turbine barriers were included as the Cruach

Clenamacrie development overlaps the edge of the range and the Beinn Ghlas Repowered development is in the same location as the existing Beinn Ghlas turbines.

*14.* For comparative purposes, the potential impact is also assessed using the Golden Eagle Topographic (GET) model. The assessment based on empirical tracking data is much more reliable than the results from a general model.

*15.* The area around the Revised Proposed Development has fragmented good golden eagle habitat, as defined by the GET model.

*16.* The estimated range losses using the GET model were 7.5% (no barrier effect) and 14.6% with a barrier effect.

*17.* If the proposed Beinn Ghlas Repowering and Cruach Clenamacrie developments are included the estimated range losses using the GET model were 7.5% (no barrier effect) and 15.4% with a barrier effect.

*18.* Currently, because of the existence of the occupied range, there is unlikely to be a significant impact on habitat used by dispersing golden eagles.

There are eight sections to this report.

1. The Revised Proposed Development
2. Background to tag data and the GET model, and differences in the use of satellite tag data and the GET model to estimate the impact of wind farm on golden eagles.
3. Description of the satellite tag data and the derivation of home range boundaries.
4. Determining the size of habitat loss (turbine exclusion zone)
5. Estimates of impact of the proposed development using tag data.
6. As above but using the GET model.
7. Habitat loss for dispersing golden eagles.
8. Problems created by the absence of NatureScot (NS) guidance. In particular: how to use and interpret satellite tag and GET data; and how to estimate a HR boundary using satellite tracking data.

## 1. The Revised Proposed Development

The impact of the Revised Proposed Development south of Glen Lonan, in Argyll, is assessed using satellite tracking data provided by Natural Research and the Golden Eagle Topographic (GET) model (Fielding *et al*., 2020). Analyses are undertaken for an 11-turbine layout provided by Galileo 04 Ltd (T18 has been removed since submission on landscape and visual grounds after discussions with Argyll and Bute Council).

The Revised Proposed Development Boundary overlaps the G/LAW1, Beinn Ghlas, golden eagle home range.

As described below, it is normal to start with a baseline which assumes good golden eagle habitat is already lost to consented and operational turbines plus all commercial forestry. In these analyses the potential for additional habitat losses from two schemes in planning are also considered. There are seven turbines in the Beinn Ghlas Repowering scheme (July 2025 application to Argyll & Bute Council) which would replace the existing 14 Beinn Ghlas turbines although the overall footprints are quite similar. There are also six turbines in the Cruach Clenamacrie (December 2024 S.36 Application) development.

## 2. Background to tag data and the GET model

**This section explains why predictions made using satellite tag data should always take priority over those using the GET model. If sufficient satellite tag data are available the only role for a GET analysis is to enable comparisons with other schemes where satellite tag data were not available.**

The GET model (Fielding *et al.,* 2020) is a model which has been shown to be good at predicting the average behaviour of golden eagles with respect to their use of the topographic landscape (Fielding *et al.,* 2020, See Appendix A in Fielding *et al.,* 2023 for details of extensive testing). But it is a model and, as such, it serves a useful purpose in the absence of actual information about an individual's use of the landscape. However, no individual is average in every respect so it is to be expected that individuals will show some deviations from GET model's predictions of how an average individual would act. If detailed, and suitably comprehensive, data are available from a satellite tag the empirical results for that individual should always take precedence over the averaged predictions from a model, no matter how good the model is.

The analyses described below make use of extensive data to make predictions about how the construction of wind turbines will impact the G/LAW1 home range. Based on peer reviewed work it

is clear that the impact of wind farm developments will be negative for golden eagles, primarily through a loss of habitat. The question is how large will that negative impact be? This depends where the turbines are relative to the historic use of that location. Simplistically, if a bird rarely visits the intended turbine locations the impact will be less than if they regularly visit those locations.

No eagle uses the space inside its home range evenly. Topographically identical places may be visited with different probabilities which can only be identified from real data. Partly, this is due to the way golden eagles move across the landscape. They do not move at random, rather they follow major routes (see Figs. 1 & 2) and the effects arising from constructing a wind farm depend largely on where the turbines are placed relative to these major routes. Using the GET model it is possible, with experience, to make judgements about potential routes, which generally follow contiguous patches of high GET value pixels, but judgement is unlikely to be completely accurate.

The GET model uses topography to make predictions about the behaviour of an average individual and, in the same way that people can be above or below the average on a range of measures, it is difficult *a priori* to judge whether a particular part of a home range will be used more or less than predicted by the GET model, although familiarity with tag data from many individuals helps. As with all variables, in the absence of actual information, the best guess is the average which in this scenario is based on predictions by the GET model. When comparing predictions from the GET model with real data there will be differences, but those differences should be unbiased, meaning there should be no systematic over or under estimate of the use of a particular part of the range. Inevitably, if part of a range is used more than predicted by the GET model there must be other parts of the range which are used less than predicted.

The Beinn Ghlas home range is unusual in that it is the only home range, out of more than a hundred with tagged range holders, in which there is an operational wind farm in the center of the range and this wind farm pre-dates the range holders, i.e. the turbines were in place when the current range holders settled in the range. This is a different scenario from turbines being erected after birds have settled in a range. Analyses in Fielding *et al*. (2022) showed that although birds apparently make some use of the habitat around the Beinn Ghlas turbines in two-dimensional space they are, in reality, avoiding the turbines by flying over them. In the three-dimensional world of an eagle this represents a potential loss of habitat. Being in the centre of the range the existing Beinn Ghlas wind farm turbines should be considered as different from a new development on the edge of the range as the birds do not need to cross the new turbines to access another part of their range.

Finally, predictions from the GET model are binary with respect to the impact of turbines. The GET model predicts that habit will be used to varying degrees depending on the GET score but habitat close to turbines is predicted never to be used (this is expressed in the open and full GET models, see section 6). Using the GET model the impact of the existing Beinn Ghlas turbines is an absolute loss of all habitat close to the turbines, i.e. the pixels have a GET score of 0. The reality is inevitably more nuanced. First, an avoidance boundary around the turbines is not absolute at a fixed distance from turbines; rather it is a blurred boundary which depends, at least partly, on the relationship between topography close and distant from the turbines. For example, in Table 3 in Fielding *et* al (2023) the mean distance from a tag record to a Beinn Ghlas turbine, by a range holding bird, was 603 m but the confidence limits were 100 m to 996 m and Fig. 3 in Fielding *et al* (2024b) shows how birds approach some turbines more often than others. Inevitably these 'messy' details contribute to differences in impact assessments using real data and predictions from the GET model. There is less of a role for professional judgement on the magnitude of impact using tag data compared with the GET model. In both cases, the application of strict thresholds, which are based on a false logic, should be avoided.

**3. Description of the satellite tag data and the derivation of home range boundaries**

There is considerable tag data (tag 1157) from what was, until mid-April 2025, the female of the Beinn Ghlas pair. This female was tagged on 7th February 2021, whilst already a range holder. She was killed by another female [redacted] who immediately took over her nest and range in mid-April 2025. Prior to her death there were 370,779 tag records covering 1,522 days.

Because the Beinn Ghlas range has extensive tracking records a much more robust assessment of the Revised Proposed Development's potential impact can be undertaken than one relying on the GET model. Although 1157 has been replaced evidence from other ranges with replacement tagged birds has not resulted in significant changes in home range boundaries (unpublished analyses).

The 1157 range boundary was assessed using the method described in Fielding *et* al (2024a). This method uses day time records, and nighttime roost site records are excluded by filtering out all records between dusk and dawn. Tag 1157 had 256,210 day time records and Figs. 1 & 2 show the flight paths joining these points. Fig. 2, in particular, shows the nature of the well-used flight routes across the range.

***Figure 1****. Flights (thin blue lines) recorded from tag 1157 during the day time. The turbine exclusion zone (Section 4) is shown as an orange polygon. The range boundary is the black polygons. The Beinn Ghlas turbines are red circles. The image is a false colour composite of the 10 m resolution Sentinel 2 bands 2, 3 & 4 (April 2025). Contains Ordnance Survey data © Crown copyright and database right 2020.*



The estimated range boundaries are very reliant on the algorithm and data used (see Fig. 9). Fielding *et al.,* (2024a) showed how the amount of tag data and the size of the 'home range' varied by month with much more data in summer but also much smaller home ranges. There is more data in summer for two reasons. First the days are longer so birds will be active longer and, second, the rate of data transmission from modern tags depends on the tag's battery voltage. As tag batteries are solar charged, they generally have more charge in summer. It is for these reasons that the data were thinned to one record per 30 minutes. Because 'home range' sizes vary by month it is important to have a representative sample which Fielding *et al.,* (2024a) identified as at least 12 consecutive months. As the tracking data from 1157 span more than 12 months the current range limits should be reasonably robust (Fielding *et al.,* 2024a). The Beinn Ghlas male did not have data covering a long

enough period so it was not included in these analyses. However, Fielding *et al.,* (2024a) also showed that males and females in a pair have similar range use so restricting the analyses to the female should not create problems.

***Figure 2****. Flights (thin blue lines) recorded from tag 1157. The turbine exclusion zone is shown as an orange polygon. The range boundary is the black polygons.*



The method used here takes account of possible autocorrelation between sequential records. Home boundaries were estimated from isopleth contours extracted from the Utilisation Distribution (UD) of record locations at the 95% level (total home range extent). Home range isopleths have 95% confidence intervals but they were effectively identical, and indistinguishable when mapped. Consequently, the mean boundary is used. The planar area is the simplest measure of range size.

The Beinn Ghlas home range has a large, elongated main area plus three small satellite areas (Figs. 1 & 2). The area of the 95% Percent Volume Contour (PVC) home range is 5,552 ha and contains 237,895 of the 256,210 day time records. Habitat loss is assessed against the 237,895 records inside the 95% PVC.

## 4. Determining the size of habitat loss (turbine exclusion zone)

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). Therefore, the main impact of a wind farm 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[1], spread over the period 2015-2024. The collision rate may increase given recent increases in both the number of turbines and the number of golden eagles, particularly in the South of Scotland. Even if the collision mortality was double that recorded there would not be a significant impact on the Scottish population although there could be local impacts in some areas.

[1] https://www.nature.scot/doc/freedom-information-request-deaths-birds-prey-scotland-windfarms

Habitat loss for range holding golden eagles, arising out of wind farm construction, was assessed previously using the Predicting Aquila Territories (PAT) model (SNH, 2014). The PAT model was applicable only to range holding birds. The PAT model (McLeod *et al*., 2002) has five assumptions about expected habitat use:

1. Preference for proximity to ridge features.
2. Preference for areas close to the active nest site/territory centre, which degrades linearly with distance from the centre.
3. Territory boundaries can be modelled as Thiessen polygons which assign equidistant boundaries between neighbouring territory centres.
4. In the absence of a neighbouring territory centre within 12 km, the maximum ranging distance from the territory centre is 6 km, i.e. a circle with a planar area of 113.1 $km^2$.
5. Several land covers are avoided, notably closed canopy forestry and large water bodies.

Satellite tracking devices have been fitted to 59 range holding birds and a further 80 birds have settled in ranges after being tagged in the nest (Natural Research, unpublished data and Fielding *et al.,* 2024a). It is clear from these 139 individuals that assumptions 1 and 5 are valid but three assumptions (2, 3 & 4), related to territory boundaries, are unsupported by empirical data and the PAT model is unreliable and should no longer be used, as acknowledged by NatureScot (2022).

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. However, 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.

In the absence of NS guidance (section 8), the following approach is used to assess the area of good golden eagle habitat lost following wind farm construction and its possible significance:

- Define a turbine exclusion distance and buffer the proposed turbines to this distance. All habitat within this buffer is assumed to be lost to golden eagles.
- Measure the proportion of tag records, or the amount of good eagle habitat, within the turbine exclusion buffer.
- The proportion of lost habitat can be estimated simply with tag data as the % of home range records inside the turbine exclusion zone.
- In the absence of tag records or a home range boundary the significance of the habitat losses must be estimated by comparing the area lost to a region-specific threshold.
- Finally, examine turbine positions, with respect to tag records or within the GET landscape, to assess which, if any, turbines may be particularly problematic for golden eagle movements.

If satellite tracking data are unavailable, or inadequate, for determining the size of the home range it is necessary to estimate its size. Home range sizes vary by region and Fielding *et* al (2024a) give regional estimates. Clearly the assessment will be more robust if, as in this case, the home range size can be estimated with some certainty. However, whichever method is used to obtain the home range size it is still necessary to estimate how much habitat is lost. This is habitat within a turbine exclusion zone. Note that although range size can be estimated its boundaries cannot be estimated.

Turbine diameter was not a significant predictor of how close satellite tracked birds came to the turbines (Fielding *et al*., 2022) and displacement distances were not the same for all turbines, even for identical turbines in the same wind farm (Fielding *et al*., 2022, 2023, 2024b). Analyses in Fielding *et al*. (2021, 2022, 2023, 2024b) suggest that 500 m may be a conservative displacement distance,

and a smaller distance can be justified to assess potential habitat loss, particularly if it is combined with a turbine boundary rule. Unfortunately, there is insufficient evidence, on causal relationships, to incorporate such variation into current analyses.

An average displacement distance of 300 m from the proposed turbine towers is suggested. Actual displacement distances will be less for some turbines, particularly those in or surrounded by good eagle habitat. It will be greater for others (see Fig. 3 in Fielding *et al.,* 2024b)

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 Fig. 1). All habitat within the concave polygon (the turbine exclusion zone), even if >300 m from a turbine, is assumed to be lost to golden eagles once turbines are erected.

A small area of golden eagle habitat, inside the Corr Chnoc turbine exclusion zone, has already been lost to forest cover in the southwest corner (Fig. 3). The exclusion zone is 375 ha, comprising 357 ha of open habitat, of which 259 ha is good eagle habitat (using the GET model, Section 6).

A simple 500 m buffer is used to estimate losses to existing turbines because it is computationally easier when maintaining a national database of lost habitat. This produces a small overestimate of the existing habitat loss.

An impact assessment should also look at the Revised Proposed Development in relation to golden eagle movement patterns and the surrounding landscape. Golden eagles have clear movement patterns along extensive contiguous GET 6+ areas, essentially following ridge lines. The intensity of that movement is, to some extent, determined by the extent and connectivity of any good eagle habitat. Figs. 1 & 2 show that the female made use of habitat west of the turbine exclusion zone which could be an additional loss. Given the position and orientation of the turbines it is probable that the Revised Proposed Development could create a barrier to habitat west of the proposed turbines, shown as a hatched area in Fig. 4. This creates a potentially larger exclusion zone of an additional 325 ha.

***Figure 3***. *The Beinn Ghlas range boundaries (blue outline 95% Percent Volume Contour (PVC)). Also shown are the turbines (orange circles), the turbine exclusion zone (orange polygon) and the operational Beinn Ghlas turbines (black dots). The yellow line is 1 km. Background is an April 2025 Sentinel 2 image. Contains Ordnance Survey data © Crown copyright and database right 2020.*



As a repowered Beinn Ghlas wind farm occupies much of the same space as the existing turbines it is not easy to quantify the additional loss created by the repowered wind farm. The approach adopted here is pragmatic and conservative in that, the repowered wind farm is treated in the same way as a new development where there are no existing turbines. In reality this will inflate the impact of the repowered wind farm but there is no simple method by which the additional and current habitat losses can be disentangled.

***Figure 4****. The turbine exclusion zone (orange polygon) and the potential barrier zone (red hatched area). The range boundary is the black polygons.*



Finally, the 5% loss threshold used in the now defunct NS PAT guidance came out of assessments of the impact of afforestation on range loss in Argyll (see Whitfield *et al*., 2001 & 2007). First, the 5% loss threshold was intended as a qualitative and not an absolute threshold and, secondly, it was

based on evidence derived using the now discredited range boundary assumptions of the PAT model (see Section 6). There is little scientific evidence to support the application of a strict 5% loss threshold which unfortunately means more reliance on judgement and the value of that judgement must be related to experience of the person making those judgements.

## 5. Estimates of impact of the Revised Proposed Development using tag data

There are 237,775 daytime records within the 95% PVC range. Of these, 7,881 are within the turbine exclusion zone and can be used to estimate a range loss of 3.3%. This is below the 5% threshold.

Using daytime tag records, there are 2,376 records in the barrier zone beyond the turbines (Fig. 4). In total there are 10,257 records in an extended exclusion zone (7,881 within the turbine exclusion zone + 2,376 in the barrier zone), which is 4.3% of the daytime tag records. This remains below the 5% threshold.

In order to assess the additional losses from the proposed Beinn Ghlas Repowering and Cruach Clenamacrie developments a 300 m concave buffer was constructed for each using the same method as that used for the Revised Proposed Development. The number of day time home range records in each wind farm exclusion buffer was obtained. In combination there were 3,061 records in the new exclusion zones (Beinn Ghlas Repowering 1,726 records and Cruach Clenamacrie 1,335 records).

The number of records in the Beinn Ghlas Repowering exclusion zone is less than expected because of the existing exclusion effect of the current turbines. In combination, the three proposed developments exclude 10,982 (3,061 + 7,881) records which is 4.6 % of the 237,895 (95%) HR points.

If the barrier zone, west of the Revised Proposed Development, is included this increases to 13,318 records (10,982 + 2,376) which is 5.6% of the 237,895 (95%) HR points. A cumulative 5.6% loss of the range is extremely unlikely to result in range abandonment.

No additional habitat losses resulting from turbine barriers were included as the Cruach Clenamacrie development overlaps the edge of the range and the Beinn Ghlas Repowered development is in the same location as the existing Beinn Ghlas turbines.

## 6. Estimates of impact of the Revised Proposed Development using the GET model

Because the PAT model is unreliable and tag records are not available for all home ranges a new assessment method is needed for range holding birds which does not depend on tag data or the PAT model's assumptions. It would be useful if a broadly similar approach was available for dispersing young eagles. On the basis of peer-reviewed information the GET model is suitable for assessing potential losses for both range holding and dispersing birds.

The GET model assigns a habitat score between 1 and 10 to every 50m land pixel across Scotland[2]. 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) for details of extensive testing).

Habitat with a GET score of 6+ is a good indicator of potential golden eagle activity particularly when there are large contiguous blocks; habitat with a score of 5 or less is used infrequently.

The GET model is purely topographic and takes no account of land cover. Because it is known that golden eagles avoid turbines and tend not to use land with a closed canopy forest cover, irrespective

[2] A GET score of 0 means the pixel is not available. In the base model lochs have a GET score of 0.

of the GET score, it is necessary to assess the extent of available or open habitat, *at the time of the assessment*, as the appropriate baseline for an assessment of habitat loss using the GET model is the current area of open GET habitat with a value of 6 or more. Open habitat is land with no closed canopy forest cover and more than 500 m from an existing or consented turbine. All subsequent measures of good golden eagle habitat refer to open country habitat with a GET score of 6+.

The GET model is in the public domain but before it can be used to assess habitat loss it must be updated to reflect habitat that is unavailable within, for example, 20 km of the Revised Proposed Development. Habitat loss due to wind farms can be assessed by buffering operational and consented turbines by 500 m and setting the GET scores of the buffered pixels to 0. Losses due to commercial forest must also be incorporated but forest cover has to be mapped or obtained from other sources. For these analyses tree cover was assessed using an April 9th 2025 Sentinel 2 image (tile T30VUH). A false colour composite image was constructed from the 10m resolution bands 2, 3 and 4 while combining the 20m resolution bands 2, 6 and 12 enhanced tree cover (Ottosen *et al.*, 2020).

In this assessment two scenarios were assessed, with and without the Beinn Ghlas Repowering and Cruach Clenamacrie developments which are currently in planning.

Much of the landscape in which the Revised Proposed Development is located, at least within 10 km, is fragmented good golden eagle habitat (Fig. 5 & 5a). There is extensive good habitat to the northeast, around Loch Etive. In other places it is more fragmented and a large area of good habitat is currently unavailable because of forest cover and 51 existing, plus 17 consented, turbines that are within 20 km of the Revised Proposed Development. These reduce the extent of good golden eagle habitat although some land around turbines is also forested so is already assumed lost to forestry. The 51 existing turbines are in three wind farms: An Suidhe 17; Beinn Ghlas 14; Carraig Ghael 20; plus 17 consented turbines in the Blarghour (14 turbines) and Ladyfield (3 turbines) developments.

- The 14 Beinn Ghlas turbines are within 5 km of the Revised Proposed Development.
- The 20 Carraig Ghael turbines are within 5 - 10 km of the Revised Proposed Development.
- The remaining 34 turbines are between 10 and 20 km.

In addition to the consented turbines there is the potential for additional habitat loss from two schemes in planning. There are seven turbines in the Beinn Ghlas Repowering scheme (July 2025 application to Argyll & Bute Council) which would replace the existing 14 Beinn Ghlas turbines although the overall footprints are quite similar. There are also six turbines in the Cruach Clenamacrie (December 2024 S.36 Application) development (Fig. 5a).

***Figure 5****. Open GET landscape in the vicinity (10 & 20 km) of the Revised Proposed Development. Other consented or operational turbines are shown as black circles. GET scores are on darkening scale (lower left). Contains Ordnance Survey data © Crown copyright and database right 2020.*

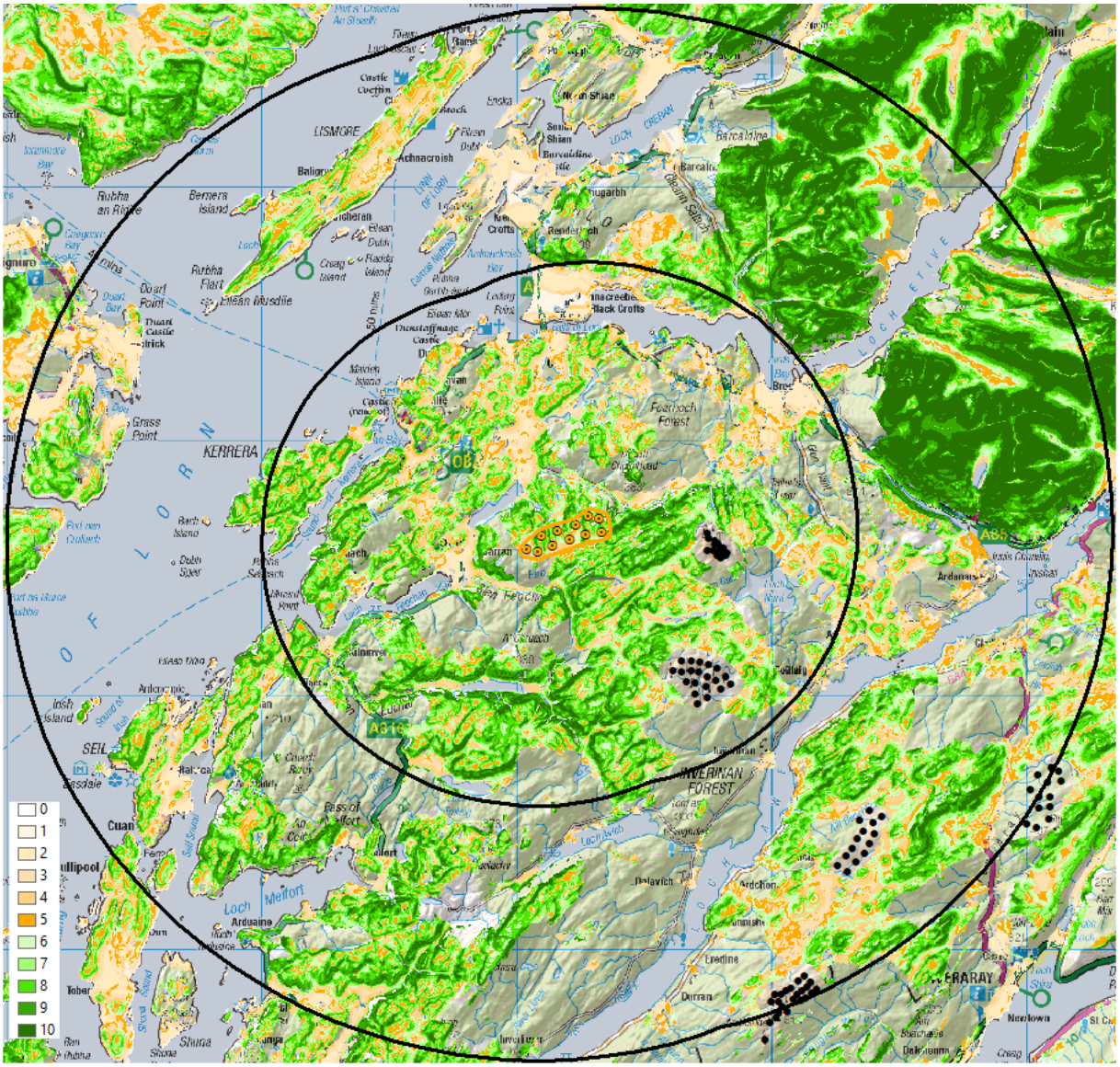

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KERRERA
SEIL
Cuan
Loch Melfort
Ardmaddy
Ardchattan
Connel
Barcaldine
Benderloch
Creagan
Ardanaiseig
Taynuilt
Bonawe
Achnacroish
Baligrundle
Berneray
Rubha an Ridire
Rubha Fiart
Eilean Musdile
Duart Point
Duart Castle
Grass Point
Maiden Island
Dubh Sgeir
Port nan Gharbh
Barr Island
Eilean Mor
Thomastfhuaigh Castle
Inish Island
Asgog Point
Ardencaple
Rail Caol
Bass of Mort
Arduaine
Shuna
Toberonochy
Ellanbeich
Balvicar
Easdale
Ullipool
Achnacreebeag
Black Crofts
Lochy Point
Creag Island
Flodda Island
Eilean Dubh
Eilean Dubh Mor
Fearnoch Forest
Inverinan Forest
Glen Lonan
Glen Nant
Glen Creran
Glen Salach
Glen Feochan
Glen Euchar
Glen Lora
Glen Ure
Glen Barr
Glen Shian
Glen Gabhail
Glen Kinglass
Glen Noe
Glen Ogle
Glen Dochart
Glen Lochy
Glen Orchy
Glen Strae
Glen Etive
Glen Fyne
Glen Aray
Glen Shira
Glen Croe
Glen Kinglas
Glen Douglas
Glen Falloch
Glen Lyon
Glen Tarbert
Glen Lochy
Glen Orchy
Glen Strae
Glen Etive
Glen Fyne
Glen Aray
Glen Shira
Glen Croe
Glen Kinglas
Glen Douglas
Glen Falloch
Glen Lyon
Glen Tarbert
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***Figure 5a***. *See Fig.5. The proposed Beinn Ghlas Repowering and Cruach Clenamacrie developments (red circles) have reduced the extent of open habitat. Contains Ordnance Survey data © Crown copyright and database right 2020.*

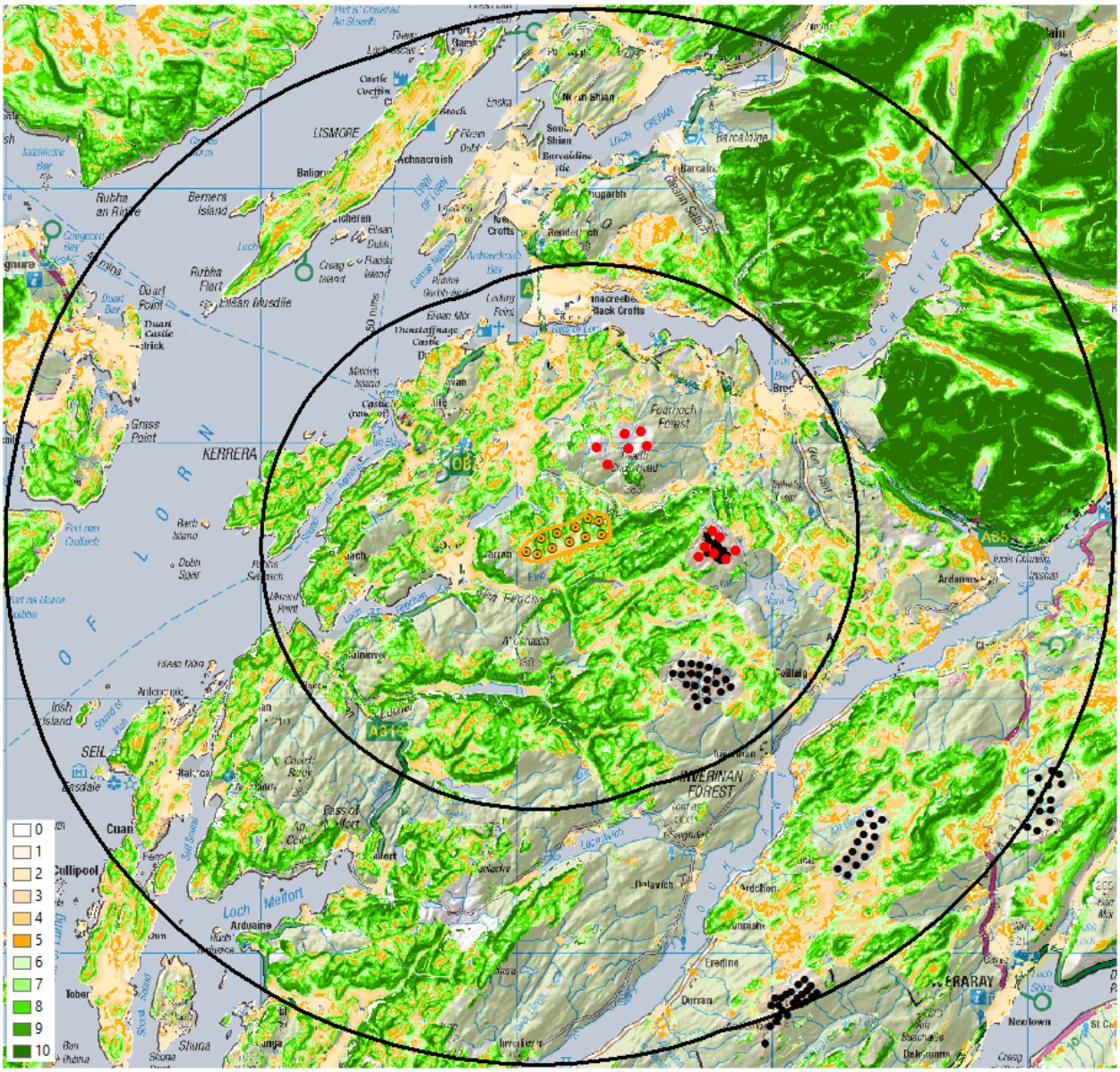
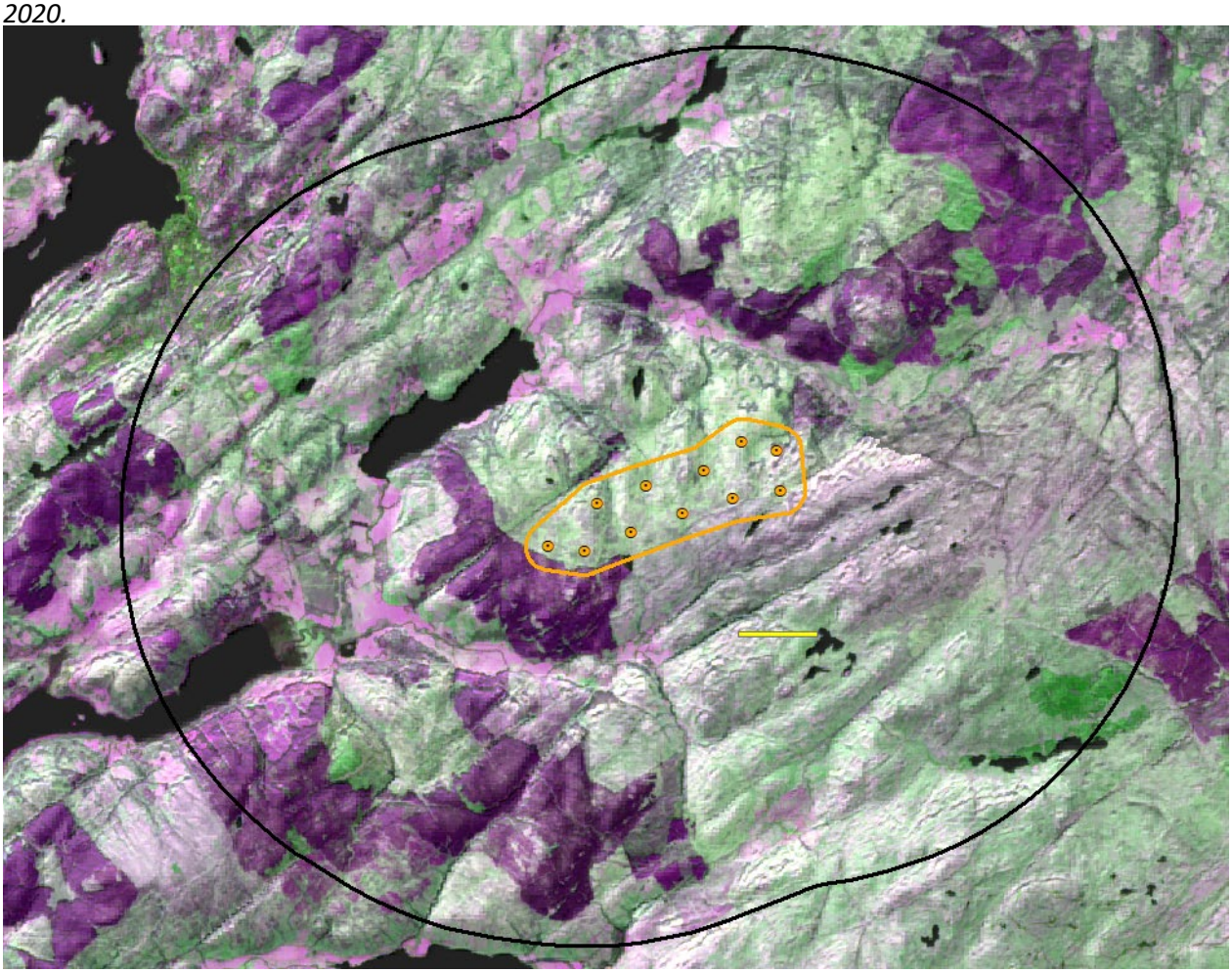



Fig. 6 is a false colour composite image of the 20 m resolution Sentinel 2 bands 2, 6 & 12. It is easier to locate forest cover and other land covers in Fig. 6. Using this image, and turbine buffers, the GET habitat was separated into the Open and Closed classes shown in Fig 7. GET habitat loss is assessed only against the current extent of open habitat.

The extent of available habitat, against which any losses can be assessed, was estimated in buffers of increasing distance (5, 10 and 20 km) from the turbines (Figs. 5 & 5a, Tables 1 & 1a) with and without the proposed Beinn Ghlas Repowering and Cruach Clenamacrie developments.

Extensive good golden eagle habitat in this region is mainly concentrated to the northeast (Figs. 5 & 5a), although there are three reasonably large patches including a patch where the Revised Proposed Development is placed.

*F**igure 6**. Tree cover (purple) in the vicinity of the Revised Proposed Development. Background is an April 2025 Sentinel 2 image. Contains Ordnance Survey data © Crown copyright and database right 2020.*



Tables 1 and 1a summarise the extent of good golden eagle habitat within different buffers from the outer turbines. Two figures are given in each table: **Open** is area of open habitat while **Full** includes habitat already lost to golden eagles, based on current forest cover plus constructed and consented turbine buffers (Fig. 5).

The key figures in Tables 1 & 1a are the areas of open GET 6+ habitat within the three buffers (Table 1 5,545, 14,767 and 45,590 ha respectively; Table 1a 5,287, 14,474 and 45,289 ha respectively). The open areas are smaller in Table 1a because of small additional habitat losses created by the proposed Beinn Ghlas Repowering and Cruach Clenamacrie developments.

The areas of GET 6+ already lost to golden eagles through trees and constructed or consented wind farms (Full – Open GET, 6+) are 2,885, 8,118 and 24,067 ha respectively in Table 1 and 3,143, 8,411 and 24,368 ha respectively in Table 1a (Figs. 5, 5a & 6).

The percentages of GET 6+ already lost to trees and constructed or consented wind farms are 34.2 % (5 km), 35.5 % (10 km) and 34.6 % (20 km) in Table 1 and 37.3 % (5 km), 36.8 % (10 km) and 35.0 % (20 km) in Table 1a.

The potential loss of habitat needs to be assessed with respect to a regional figure and golden eagle home range areas.

***Table 1**. Areas (hectares) of good golden eagle habitat at various distances from the Revised Proposed Development turbines and within the turbine exclusion buffer (Wind farm). Assessed area is the area against which the percentage of open GET 6+ habitat is calculated.*

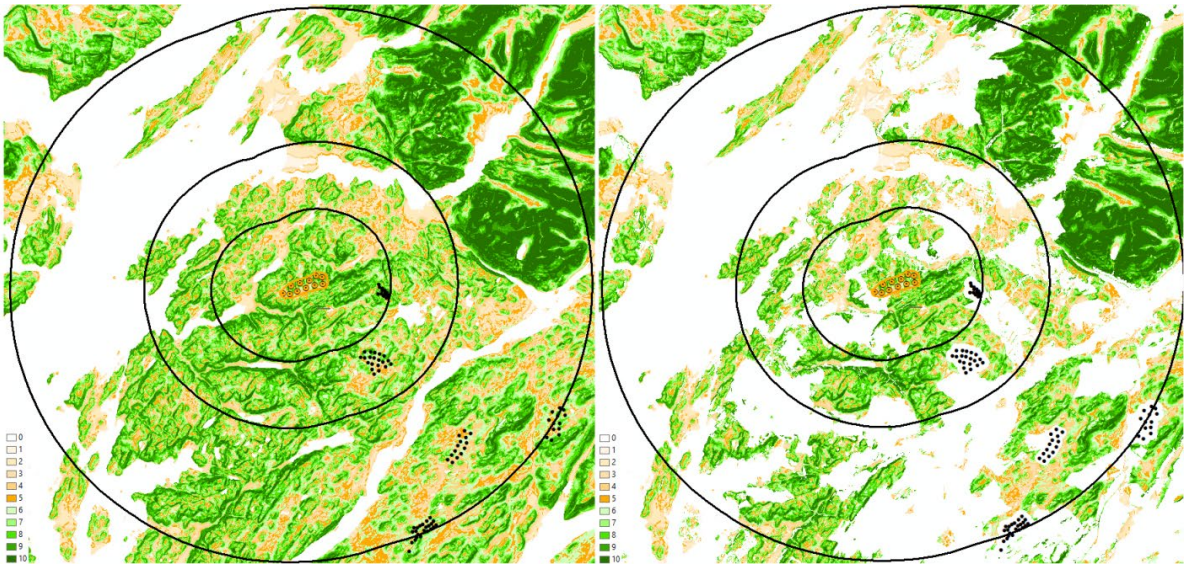
| | 5 km | | 10 km | | 20 km | | Wind farm | |
|---|---|---|---|---|---|---|---|---|
| GET | Open | Full | Open | Full | Open | Full | Open | Full |
| Closed | 3,982 | 241 | 12,252 | 864 | 41,256 | 5,164 | 18 | 0 |
| 1 | 8 | 9 | 261 | 292 | 979 | 1,182 | - | 0 |
| 2 | 262 | 345 | 1,065 | 1,345 | 3,097 | 4,336 | - | 0 |
| 3 | 386 | 490 | 1,262 | 1,754 | 3,510 | 5,564 | 4 | 5 |
| 4 | 712 | 941 | 2,099 | 2,968 | 4,845 | 7,707 | 52 | 54 |
| 5 | 787 | 1,219 | 2,504 | 4,083 | 6,700 | 12,220 | 43 | 45 |
| 6 | 836 | 1,243 | 2,411 | 3,839 | 6,616 | 11,666 | 51 | 55 |
| 7 | 1,605 | 2,418 | 4,318 | 6,819 | 10,479 | 17,461 | 85 | 87 |
| 8 | 1,549 | 2,342 | 4,038 | 6,220 | 10,536 | 16,501 | 70 | 72 |
| 9 | 1,132 | 1,805 | 2,942 | 4,546 | 9,555 | 14,156 | 42 | 46 |
| 10 | 424 | 624 | 1,058 | 1,461 | 8,404 | 9,874 | 11 | 12 |
| Area | 11,682 | | 34,210 | | 105,977 | | 375 | |
| Assessed area | 7,700 | 11,433 | 21,958 | 33,327 | 64,721 | 100,665 | 357 | 375 |
| GET6+ | 5,545 | 8,430 | 14,767 | 22,885 | 45,590 | 69,657 | 259 | 271 |
| %GET6+ | 72.0 | 73.7 | 67.3 | 68.7 | 70.4 | 69.2 | 72.4 | 72.4 |

***Table 1a**. See Table 1 but the extent of Open habitat assumes the proposed Beinn Ghlas Repowering and Cruach Clenamacrie developments have been constructed so the extent of Open habitat is reduced.*

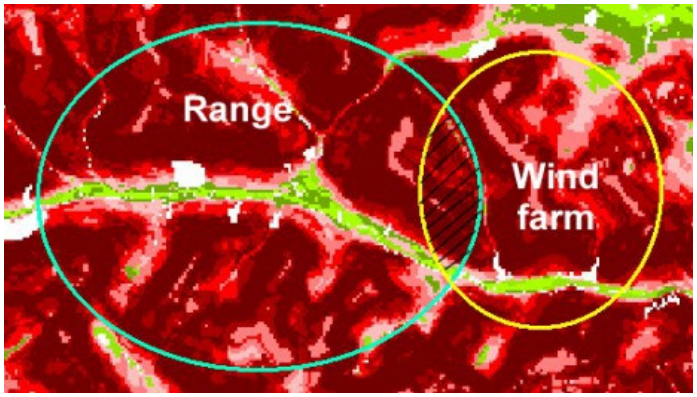
| | 5 km | | 10 km | | 20 km | | Wind farm | |
|---|---|---|---|---|---|---|---|---|
| GET | Open | Full | Open | Full | Open | Full | Open | Full |
| Closed | 4,349 | 241 | 12,685 | 864 | 41,712 | 5,164 | 18 | 0 |
| 1 | 8 | 9 | 261 | 292 | 976 | 1,182 | - | 0 |
| 2 | 262 | 345 | 1,064 | 1,345 | 3,094 | 4,336 | - | 0 |
| 3 | 371 | 490 | 1,243 | 1,754 | 3,488 | 5,564 | 4 | 5 |
| 4 | 675 | 941 | 2,048 | 2,968 | 4,791 | 7,707 | 52 | 54 |
| 5 | 730 | 1,219 | 2,434 | 4,083 | 6,627 | 12,220 | 43 | 45 |
| 6 | 774 | 1,243 | 2,336 | 3,839 | 6,539 | 11,666 | 51 | 55 |
| 7 | 1,523 | 2,418 | 4,224 | 6,819 | 10,381 | 17,461 | 85 | 87 |
| 8 | 1,485 | 2,342 | 3,967 | 6,220 | 10,465 | 16,501 | 70 | 72 |
| 9 | 1,090 | 1,805 | 2,897 | 4,546 | 9,510 | 14,156 | 42 | 46 |
| 10 | 416 | 624 | 1,050 | 1,461 | 8,396 | 9,874 | 11 | 12 |
| Area | 11,683 | | 34,210 | | 105,977 | | 375 | |
| Assessed area | 7,334 | 11,433 | 21,525 | 33,327 | 64,265 | 100,665 | 357 | 375 |
| GET6+ | 5,287 | 8,430 | 14,474 | 22,885 | 45,289 | 69,657 | 259 | 271 |
| %GET6+ | 72.1 | 73.7 | 67.2 | 68.7 | 70.5 | 69.2 | 72.4 | 72.4 |

In this assessment the size and shape of the home range is known because there are tag data. The area of the 95% PVC home range is 5,555 ha with 4,301 ha of open habitat of which 3,542 ha (80.2%) was good eagle habitat. If the habitat loss from the proposed Beinn Ghlas Repowering and Cruach Clenamacrie developments is included there was 3,268 ha (80.5%) of good eagle habitat.

***Figure 7**. The loss of open GET habitat within 20 km of the Revised Proposed Development (yellow circles). The full GET map is on the left and assumes no existing habitat loss. The open GET map (excluding the proposed Beinn Ghlas Repowering and Cruach Clenamacrie developments) is on the right. There are gaps in the Open habitat created by forests and existing wind farms (turbines are black circles). Contains Ordnance Survey data © Crown copyright and database right 2020.*



Box 1. Assessing range loss when a wind farm overlaps a range boundary




The overlap between the range and wind farm exclusion zone is hatched. If the extent of GET 6+ habitat within the range was 5,000 ha and the overlap contained 500 ha of GET 6+ the loss to the range would be 500/5,000 or 10%.

The turbine exclusion area is 375 ha, of which 259 ha is open GET 6+ habitat (Table 1, Fig. 8). The tag 1157 home range has 3,452 ha of open GET 6+ habitat out of a total home range area of 5,555 ha. This range has 'lost' ~1,020 ha of GET 6+ habitat to trees and the existing Beinn Ghlas wind farm. However, it should be noted that these losses were in place when this bird settled in the range so can, to some extent, be discounted.

The extent of good eagle habitat in the 1157 home range, overlapping the development boundary, is 259 ha which could be a 7.5% loss of GET 6+ habitat. This is just above the 5% unproven 'acceptable loss' threshold used in the PAT model.

Including the proposed Beinn Ghlas Repowering and Cruach Clenamacrie developments, the tag 1157 home range has a smaller area of 3,268 ha of open GET 6+ habitat with ~1,202 ha of GET 6+ habitat 'lost' to trees and turbines. The lost area has increased from 1,020 ha to 1,202 ha as a result of additional losses resulting from the inclusion of the proposed Beinn Ghlas Repowering and Cruach Clenamacrie developments.

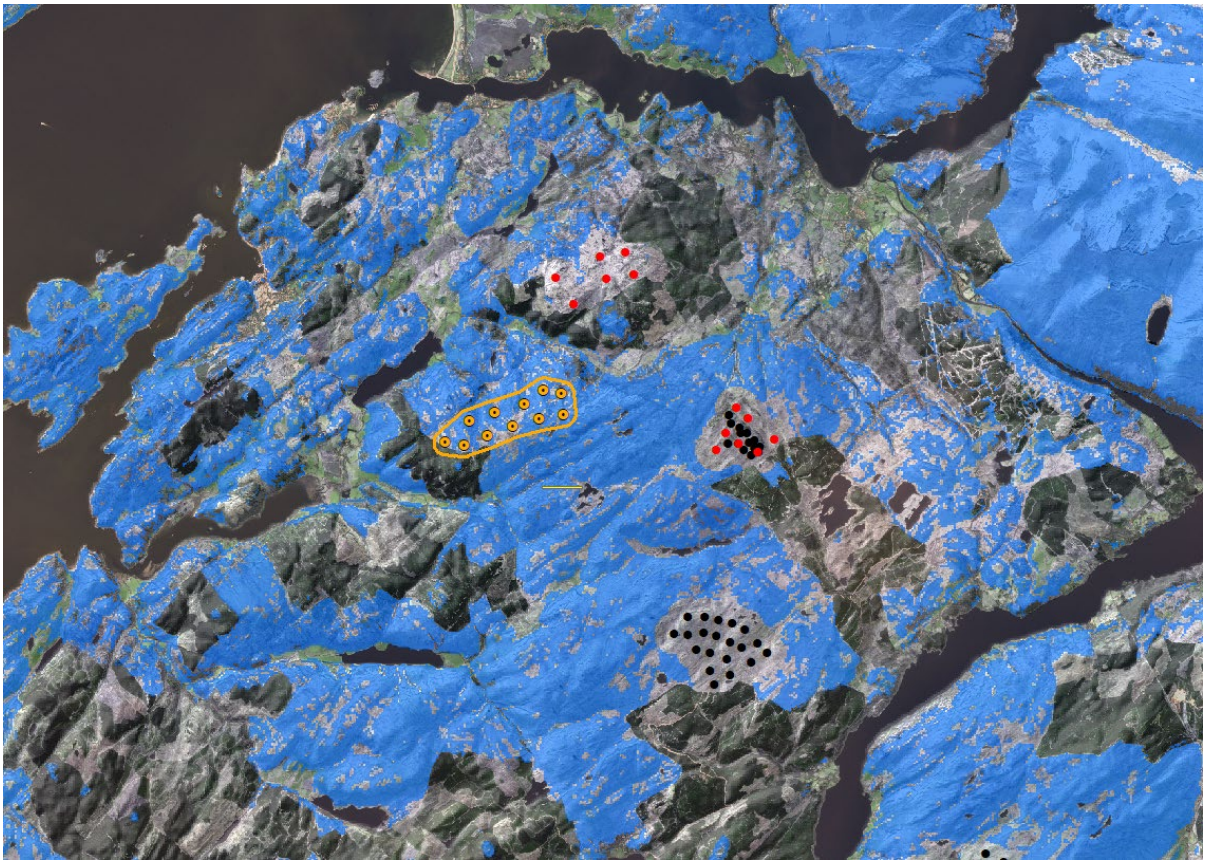
Including the proposed Beinn Ghlas Repowering and Cruach Clenamacrie developments, the extent of open GET 6+ is less so the percentage loss of 259 ha loss in the turbine exclusion zone would be a slightly larger 7.9% loss of GET 6+ habitat.

Loss estimates using tag data are lower than those based on the GET model. As explained in Section 2 this suggests that birds are not using the area within the development Boundary as expected if range use was spread equally across the range, which it rarely is. This becomes clearer when flight lines are examined (Figs. 1, 2 & 4).

If all of this additional habitat is lost from the range, because of the barrier effect (245 ha of open GET 6+), it would represent a 14.6% loss of good eagle habitat (504 ha of 3,452 ha), as measured by open GET habitat.

The loss is slightly higher at 15.4% (504 ha of 3,268 ha) if losses from the proposed Beinn Ghlas Repowering and Cruach Clenamacrie developments are included.

***Figure 8**. Good eagle habitat is shaded blue. The turbine exclusion zone is the orange polygon. Other turbines are shown as black dots except for the proposed Beinn Ghlas Repowering and Cruach Clenamacrie developments (red circles). The background image is a false colour composite of the 10 m resolution Sentinel 2 bands 2, 3 & 4 (acquired April 2025). Contains Ordnance Survey data © Crown copyright and database right 2020.*



## 7. Habitat loss for dispersing golden eagles

Wind farms can also result in a loss of habitat used by dispersing golden eagles. Generally, dispersing golden eagles stay outside of occupied golden eagle home ranges so if a wind farm is within an existing golden eagle home range, as in this case, losses for dispersing young eagles should be small because the range holding birds restrict use of their home range habitat by dispersing golden eagles.

There is relatively little tracking data from dispersing golden eagles in this part of Scotland so the GET model is used as a surrogate for the tracking data.

Assessing the impact on dispersing golden eagle habitat at, for example, the natural heritage zone level will inevitably result in a trivial loss of habitat. For example, the 20 km buffer around the Revised Proposed Development currently has more than 45,000 ha of open eagle habitat (Tables 1 & 1a) and the exclusion zone around the Revised Proposed Development would result in a very small ~0.5 % loss of this open GET 6+ habitat (239 ha from 45,590 ha). The loss remains at 0.5% if the additional losses from the proposed Beinn Ghlas Repowering and Cruach Clenamacrie developments are included (239 ha from 45,289 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.

Instead, habitat loss can be estimated regionally using a buffer (distance from the Revised Proposed Development) which is appropriate for the region; in which case the question becomes what buffer size is appropriate for this region?

Estimated percentage losses will be larger for small buffers and *vice versa*. The estimated home range size could be an appropriate lower limit for the buffer size. However, this is not 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.

Although the area of open GET 6+ habitat might be expected to scale in a non-linear manner with increasing buffer size (simple buffer area is non-linear with increasing buffer distances), the rate of increase in good eagle habitat is unpredictable. As shown in Table 1, in this region, but not elsewhere in Scotland, the percentage of open GET 6+ habitat is relatively constant with increasing buffer size.

The upper limit for assessing the impact of a Revised Proposed Development on dispersing golden eagle habitat could be EITHER a buffer with a maximum 10 km distance from the Revised 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 GET 6+ habitat.

Based on the satellite tracking data the range size is 2,935 ha  3,541 ha of open GET 6+ habitat.

The area of good eagle habitat within 10 km of the Revised Proposed Development is ~14,500 ha (Tables 1 & 1a) which is smaller, but similar, to five times the range area (5 x 3,541 ha = 17,705 ha), implying that habitat loss should be assessed against the 14,500 ha threshold. A loss of 239 ha from 14,500 ha is ~1.6%, which would normally be considered an insignificant loss. Including the barrier effect increases the loss to 504 ha from 14,500 ha, which is 3.5%.

Losses to dispersing golden eagles from a potential turbine barrier effect have not been calculated as, unlike the range holders, they could still get access to this area from other directions.

As most of this lost habitat is within the tag 1157 range the loss estimate must be an over estimate for dispersing birds and it is clear that the Revised Proposed Development would not result in a significant loss of good eagle habitat used by dispersing birds.

## 8. Problems created by the absence of NS guidance.

Comparisons between developments are greatly complicated by the absence of NS on several key issues. Guidance is needed on at least six topics.

1. How to use and interpret satellite tracking data.

2. How to estimate a home range boundary, primarily specifying an algorithm and how much data are needed and the pitfalls of not understanding how variations in the amount of data confound the home range boundary determinations. I have seen several examples of all three issues which ranged from poor to acceptable. Fig. 9 shows three home range boundaries for the G/LAW 4 home range obtained using different methods. Estimates of range loss will vary greatly depending which is used. The method used in this assessment results in the largest impact assessment: range losses (% home range records in the turbine exclusion zone) this method 4.6%; PAT Thiessen 3.3%; and all data range 3.2%. Note that specifying a kernel density method is not sufficient; the two blue and black outlined home ranges in Fig. 9 are both kernel density methods. Specific details for the implementation of a kernel density method are required.

***Figure 9****. Three home range boundaries for the G/LAW4 range. Red is the discredited PAT model's Thiessen (10,104 ha); black is a simple model based on the 95% utilization of all day time records (9,193 ha); pale blue uses the method described for this assessment (5,552 ha).*



3. How to construct a turbine exclusion zone.

4. The basics of the GET model and the difference between what is available and the base GET model.

5. How to assess the extent of lost habitat and how to interpret the significance of that loss.

6. How to identify and incorporate barrier effects.

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