Appendix 7-6 – Golden Eagle Topography Modelling Report

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A7.6.1 INTRODUCTION

This appendix presents the results of Golden Eagle topographical modelling for the Cloghercor Wind Farm project. This modelling used the Golden Eagle Topography model (GET model) developed by Fielding *et al.* (2020). All the modelling and reporting was carried out by Tom Gittings.

A7.6.2 THE GOLDEN EAGLE TOPOGRAPHY MODEL (GET MODEL)

The GET model is based on data from GPS-tagged dispersing juvenile Golden Eagles in Scotland. This data was analysed by Fielding *et al.* (2020) to assess the distribution of records in relation to altitude, slope and distance from ridge. For each of these parameters, they developed preference indices that expressed the relative occurrence of records in relation to the availability of classes of the parameter: e.g., the altitudinal records were divided into 20 m bands, so the preference index for the 0-20 m altitude class was the proportion of records in that class divided by the proportion of the available habitat in that class.

They then standardised the preference indices by dividing each preference index by the sum of the indices across all classes for the relevant parameter, and then multiplying by 1000. The resulting standardised preference indices (SPIs) sum to 1000 for each parameter, making the indices comparable between the three parameters (altitude, slope and distance from ridge).

They then summed the altitude, slope and distance to ridge SPIs for each 50 m pixel in Scotland. The resulting values were divided into ten quantiles and each pixels was given a score between 1 and 10 corresponding to the quantile that it fell in: e.g., the pixels that comprised the 10% of the dataset with the lowest summed SPIs were given a score of 1. These scores are the predicted use classes in the GET model, with an increasing frequency of predicted use from 1 (little predicted use) to 10 (high predicted use).

A7.6.3 METHODS

The GET model was used to assess the distribution of potentially suitable Golden Eagle topography in Donegal.

All the data analyses were carried out in R (R Core Team, 2020).

The Ordnance Survey Ireland *irl_osi_dtm1_Donegal.tif* raster dataset was used as the source of the topographical data. This raster dataset comprises 50 m pixels covering all the mainland area of Co. Donegal. It contains altitude values for each pixel. The *terrain* function in the *raster* package (Hijmans, 2021) was used to calculate slope values for each pixel. The R script in Appendix 2 of Fielding and Haworth (2014) was used to calculate distance from ridge for each pixel.

The altitude values were classified into 20 m classes, the slope values into 5° classes, and the distance to ridge values into 50 m classes. Table S2 in Fielding *et al.* (2020) was then used to assign SPI values for altitude, slope and distance to ridge to each pixel.

For altitude, two SPI values were assigned to each pixel: $SPI_{ALT-SCT}$ and SPI_{ALT-DL}. $SPI_{ALT-SCT}$ are the SPI values for Scotland as given by Fielding *et al.* (2020). However, Donegal has a much smaller altitudinal range than Scotland: the maximum altitude class the Donegal dataset was 620-640 m, compared to 1280 m+ in Fielding *et al.*'s dataset, and over 50% of the summed SPI values in the latter dataset are in altitude classes higher than 640 m. Therefore, the SPI values were calculated for the altitudinal range (0-640 m) in Donegal (SPI_{ALT-DL}) by dividing the preference index for each class by the sum of the preference indices across the 32 classes that comprise the 0-640 m altitudinal range.

The SPI values were summed for each pixel to obtain two summed SPI values: ΣSPI_{SCT} using the $SPI_{ALT-SCT}$ value for altitude, and ΣSPI_{ALT-DL} using the SPI_{DL} value for altitude. For ΣSPI_{SCT}, the quantile values in Fielding *et al.* (2020) were used to assign GET_{SCT} scores to each pixel (GET_{SCT}). For ΣSPI_{DL}, the distribution across pixels in the Donegal raster was used to generate ten quantiles, and the relevant quantile value was assigned to each pixel as its GET_{DL} score.

A7.6.4 RESULTS

The results of the analyses of the distribution of potentially suitable Golden Eagle topography using the GET model are shown in Figure A7.6.1 - Figure A7.6.3.

The analysis using the $SPI_{ALT-SCT}$ values, and the quantiles defined by Fielding *et al.* (2020) shows a more restricted distribution of topography with high GET scores (Figure A7.6.1), compared to the analysis using the SPI_{ALT-DL} values, and the quantiles of the distribution of summed species preference indices across all pixels in Donegal Figure A7.6.1). This reflects the more restricted altitudinal range in Donegal, which does not include the altitudes with the highest $SPI_{ALT-SCT}$ values (680-780 m). However, the overall patterns shown by the two analyses are similar.

The main concentrations of potentially suitable Golden Eagle topography in Donegal occur in the Blue Stack mountains, the Derryveagh mountains, the Slieve League peninsula, and the Malin Head Peninsula (Figure A7.6.1).

In the vicinity of the wind farm site, potentially suitable Golden Eagle topography mainly occurs along the southern/eastern side of the site and in the landscape to the south and east of the site (Figure A7.6.2). These maps illustrate how, while areas of high ground usually have high GET scores, some areas of lower ground can have high GET scores (due to their slope and ridge characteristics: e.g., the isolated hills to the north-west of Lettermacward have high GET scores, despite only reaching a maximum altitude of 172 m.

Figure A7.6.2 also shows how the model produces rings, which are due to the distance to ridge SPI values. These values generally decrease with increasing distance, but this decrease is not entirely consistent. In particular, there is a sharp increase in the SPI values for the 1050-1100 m, 1100-1150 m and 1150-1200 m distance classes, compared to the preceding classes, while all distances greater than 1200 m are given a very low SPI value. This means that rings of higher GET scores occur at distances of around 1000 m from ridges. These rings of higher GET scores are presumably artefacts of stochastic variation in the dataset used to derive the preference indices, as there does not seem to be any plausible reason why the eagles should show a strong increase in preference for topography at distances of 1050-1200 m from ridges, compared to distances a little smaller, or greater.

The GET score of 6 is considered to be a threshold where a score of 6 or greater represents preferred topography (Fielding *et al.*, 2022). Figure A7.6.3 shows the distribution of topography with GET scores of 6 or more in the wind farm site. These maps also show the 160 m and 210 m contours, which were used in the analyses of Golden Eagle flight activity for the Golden Eagle collision risk model (Appendix 7.7). The topography with the highest GET scores is mainly concentrated above the 210 m contour. However outlying areas of topography with high GET scores also occur below the 160 m contour. Between the 160 m and 210 m contour there is a large pocket of ground with low GET scores, corresponding to the valley between the high ground around Gafarretmoyle - Gafarreteor to the west and Craoghleheen to the east.

A7.6.5 DISCUSSION

The GET model, and similar approaches (e.g., Hanssen *et al.*, 2020), are topographical models. The model does not include biological habitat parameters, such as the presence of closed-canopy forests, or the availability of prey resources. Therefore, while the model indicates the suitability of topography for Golden Eagles, their occurrence patterns will also be influenced by habitat parameters that are not included in the model.

The GET model is based on analysis of the distribution of GPS-tagged dispersing juvenile Golden Eagles in Scotland (Fielding *et al.*, 2020). Therefore, it is necessary to consider how representative this model is for analyses of the potential distribution of suitable topography for breeding Golden Eagles in Ireland.

The model uses topographical features as surrogates for the distribution of orographic uplift (Fielding *et al.*, 2020). The effects of orographic uplift on Golden Eagle flight behaviour is presumably similar for adult and juvenile eagles. However, adult distribution patterns will also be influenced by nest site locations.

The effects of orographic uplift on Golden Eagle flight behaviour is also presumably similar in Scotland and Donegal. However, as discussed above, there are issues with applying the preference indices used to analyse the altitudinal distribution of eagles in Scotland, due to the much lower range of altitudes in Donegal. The adjustment that was made for calculating SPI_{ALT-DL} does not necessarily represent the preferences that eagles show in Donegal: it seems likely that eagles would show higher relative preferences for the altitudinal classes towards the upper limit of the available altitude range in Donegal, due to the absence of the even higher altitude classes that were more preferred in Scotland.

The “ring” artefact in the GET scores, which is produced by the SPI values for distance to ridge, indicates that the values for individual pixels should not be over-interpreted. Also, the model does not account for connectivity: for the same GET score it seems likely that pixels in isolated small clusters of pixels with high GET scores surrounded by large areas of lower GET scores will have lower Golden Eagle use, compared to pixels that are part of large aggregations of pixels with high GET scores.

Despite the above limitations, the GET models presented in this appendix are a useful method of assessing the overall distribution of potentially suitable Golden Eagle topography.

A7.6.6 REFERENCES

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Hanssen, F., May, R. & Nygård, T. (2020). High-resolution modelling of uplift landscapes can inform micrositing of wind turbines for soaring raptors. Environmental Management, 66, 319–332.

Hijmans, R.J. (2021). raster: Geographic Data Analysis and Modelling. R package version 3.5-11. https://CRAN.R-project.org/package=raster.

R Core Team (2020). R: A language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Austria. URL https://www.R-project.org/.

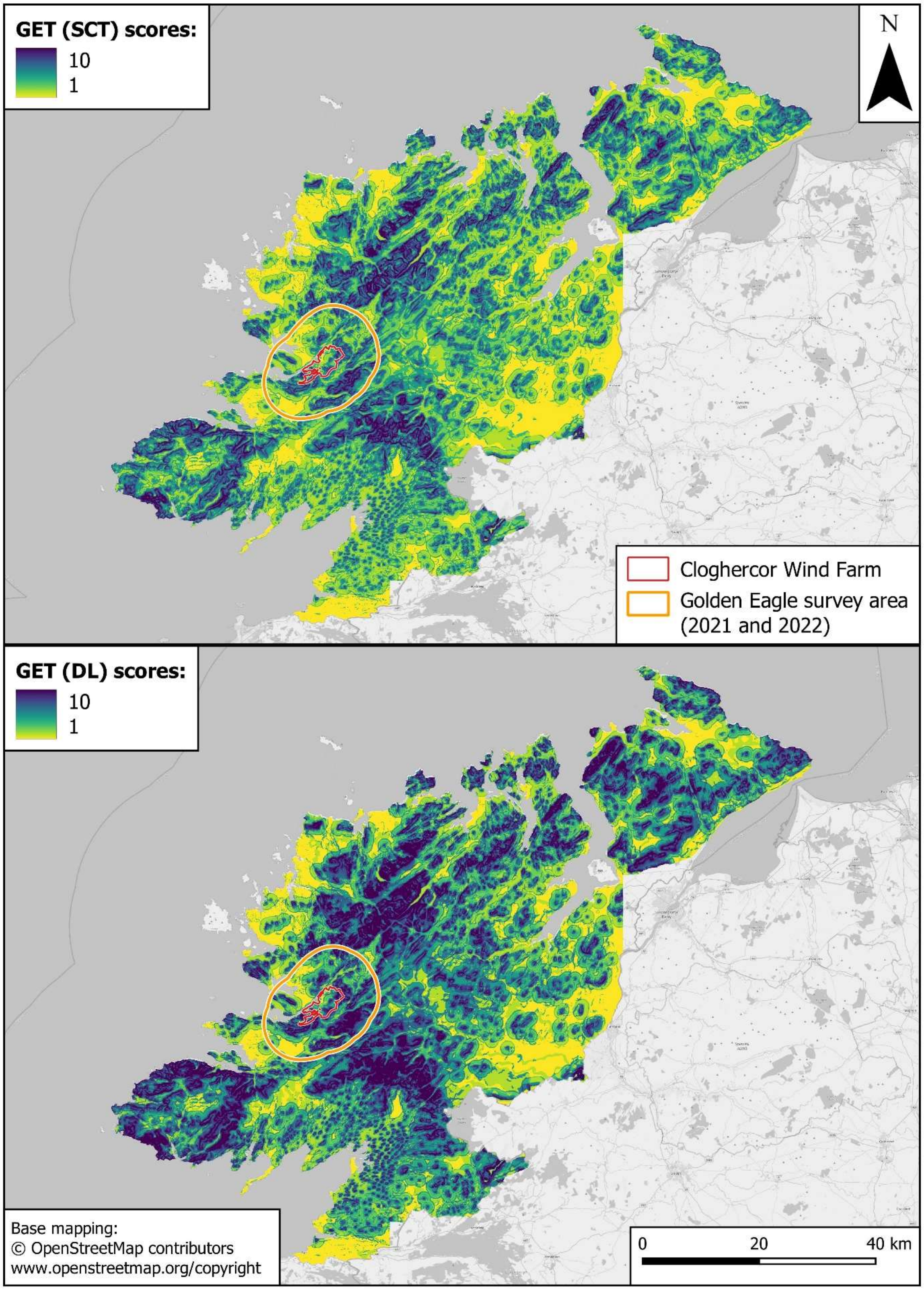

Figure A7.6.1 - Golden Eagle Topography (GET) modelling of Donegal.

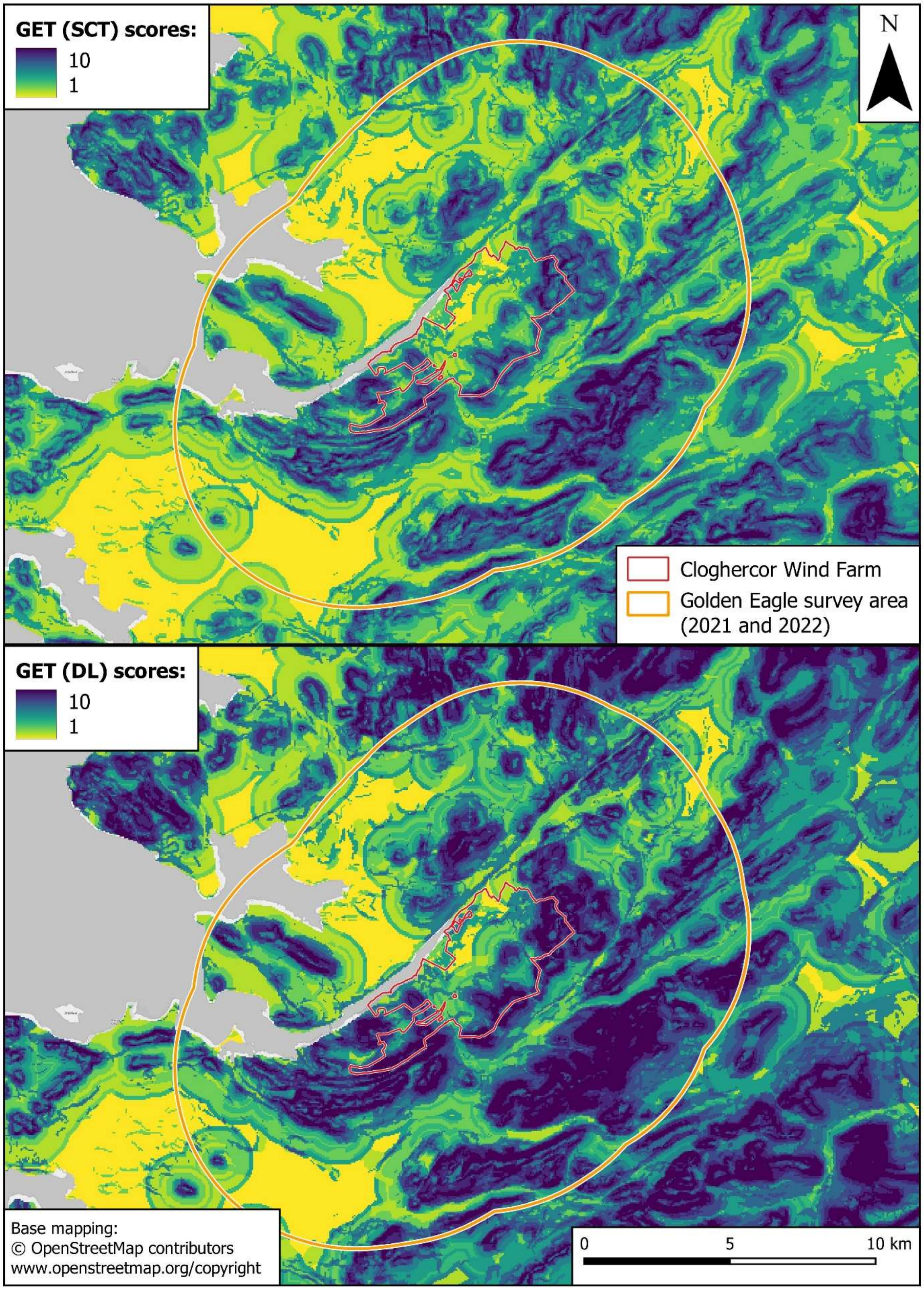

Figure A7.6.2 - Golden Eagle Topography (GET) modelling of the Golden Eagle survey area.

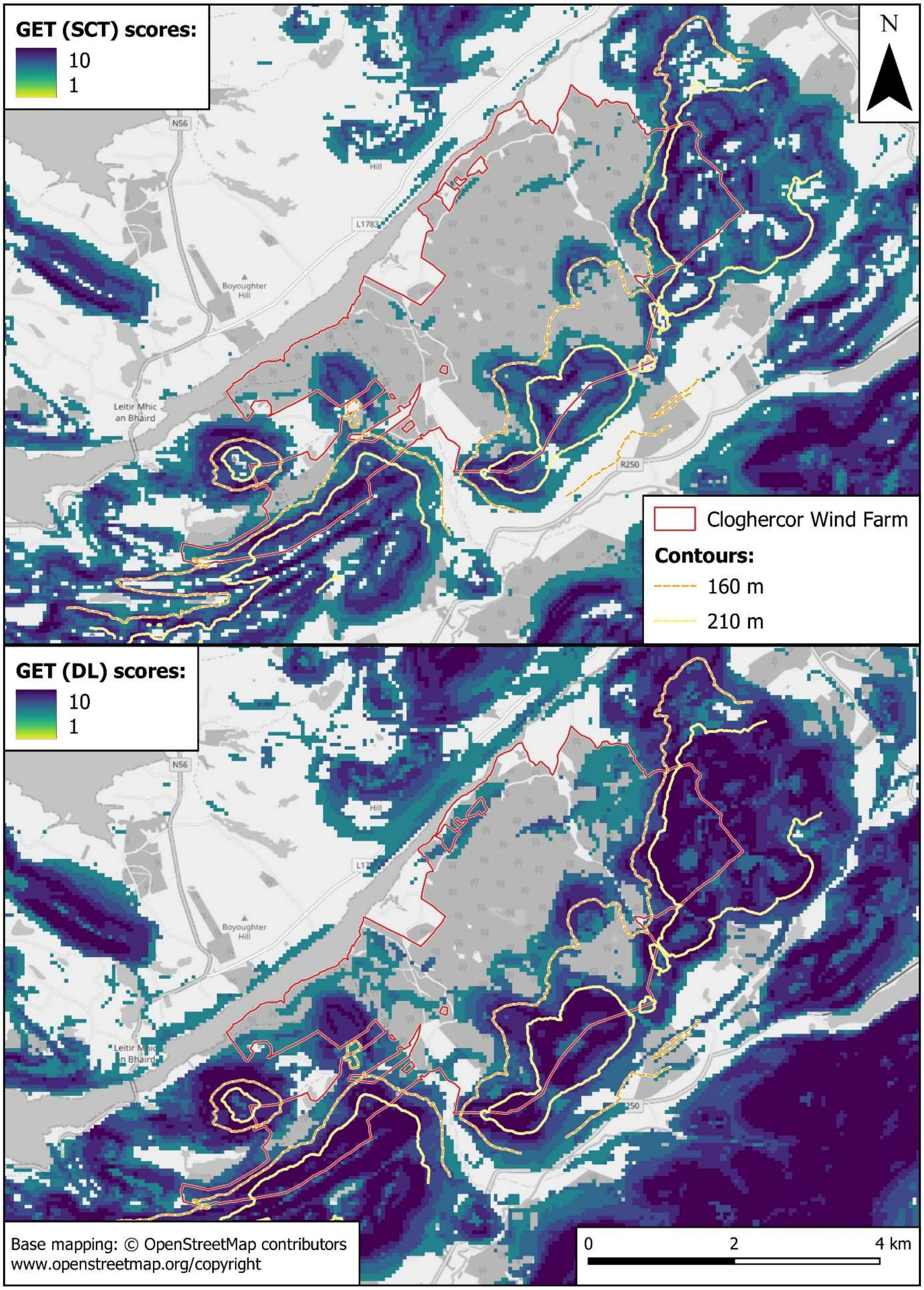

Figure A7.6.3 - Golden Eagle Topography (GET) modelling of the Cloghercor Wind Farm site, showing only scores ≥ 6.