Cloiche Wind Farm EIA Report

Chapter 9 Technical Appendix:

9.2 Golden Eagle Topographical Model Report

April 2020

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1. INTRODUCTION

1.1 Purpose and Scope of this Document

1.1.1 This a technical appendix to Chapter 9 (Ornithology) of the Cloiche wind farm Environmental Impact Assessment (EIA) Report.

1.1.2 This appendix provides further background information on the Golden Eagle Topographical (GET) Model which has been used to inform the design of the Proposed Development and the impact assessment in relation to displacement effects on golden eagle.

1.2 The GET Model

1.2.1 The GET Model has been developed to provide a simple model of landscape use for golden eagle (Fielding *et al*. 2019). It is based on the understanding that terrestrial habitats that provide vertical energetic lift from orographic and anabatic winds are preferred by large soaring species such as golden eagles. Accordingly, ridges and/or rugged topography are common preferred features in habitat use by large raptors. The model has been developed and tested using thousands of GPS telemetry records from 92 tagged juvenile birds between 2007 and 2016 across upland Scotland. The model found that young golden eagles preferred, or used according to availability, slopes greater than 10°, at altitudes of ≥ 300 m, and within 300 m of a ridge.

2. METHODS

2.1 Introduction

2.1.1 In summary, the GET model involves three sets of data in grid format at 50 m resolution:

- Altitude (m)
- Slope (degrees)
- Distance to ridge (m)

2.1.2 Each 50 m grid pixel is assigned a SPI (standardised preference index) value for all three data sets. The SPI values are then summed and a final predicted use value (1-10) is assigned to each pixel, (1 indicating the lowest predicted use and 10 indicating the highest predicted use by golden eagle).

2.1.3 The following section provides further information on the methods for each stage of the GET process.

2.2 Data Processing

2.2.1 Topographic data for the site was obtained as a 50 m resolution grid Digital Terrain Model (DTM) from Ordnance Survey Open Data (OS Terrain® 50 in ASCII Grid format). Six 10 km x 10 km grid squares (NN49, NH40, NH41, NN59, NH50 and NH51) were spliced together in MapInfo Vertical Mapper (v3.1) to provide coverage for the proposed Cloiche site, surrounding turbines and proposed turbines, and the potential golden eagle territories of concern close to the site.

2.2.2 Using the 20 km x 30 km OS Terrain 50 DTM, slope was obtained by using the “Create Slope and Aspect” tool in MapInfo Vertical Mapper.

2.2.3 Using the OS Terrain 50 DTM, ridges were defined and then the distance to ridge calculated for each 50 m pixel using a script for open source R statistical software (Fielding & Haworth 2014, Fielding *et al*. 2019).

2.2.4 The three grids (altitude, slope and distance to ridge) were exported into text format and imported into Excel where each pixel was assigned an SPI value. The three SPI values (for altitude, slope and distance to ridge) were summed for each pixel. The pixel was then allocated a predicted use value between 1 and 10 (1 indicating little predicted use and 10 indicating high predicted use). The criteria for allocating SPI values and predicted use values are shown in Tables 1-4 in Appendix 9.2.1 and are taken from Fielding *et al.* 2019.

2.2.5 The final predicted use values were then exported from Excel, and imported as a new grid file into MapInfo Vertical Mapper to view. The predicted use grid was spot-checked and compared with a manual calculation of predicted use.

3. RESULTS

3.1.1 Figure 9.2.1 shows the golden eagle topography predicted use classes (classes 6 – 10) for the six modelled 10km squares along with a 500m wide buffer around the proposed and existing wind turbines.

3.1.2 The area categorised 6-10 for predicted golden eagle use is 307km^2 out of a total of 600km^2 within the 6 hectads modelled.

3.1.3 The area categorised 6-10 for predicted golden eagle within the proposed development turbine 500m buffer (layout as defined in December 2019) is 3.7km^2.

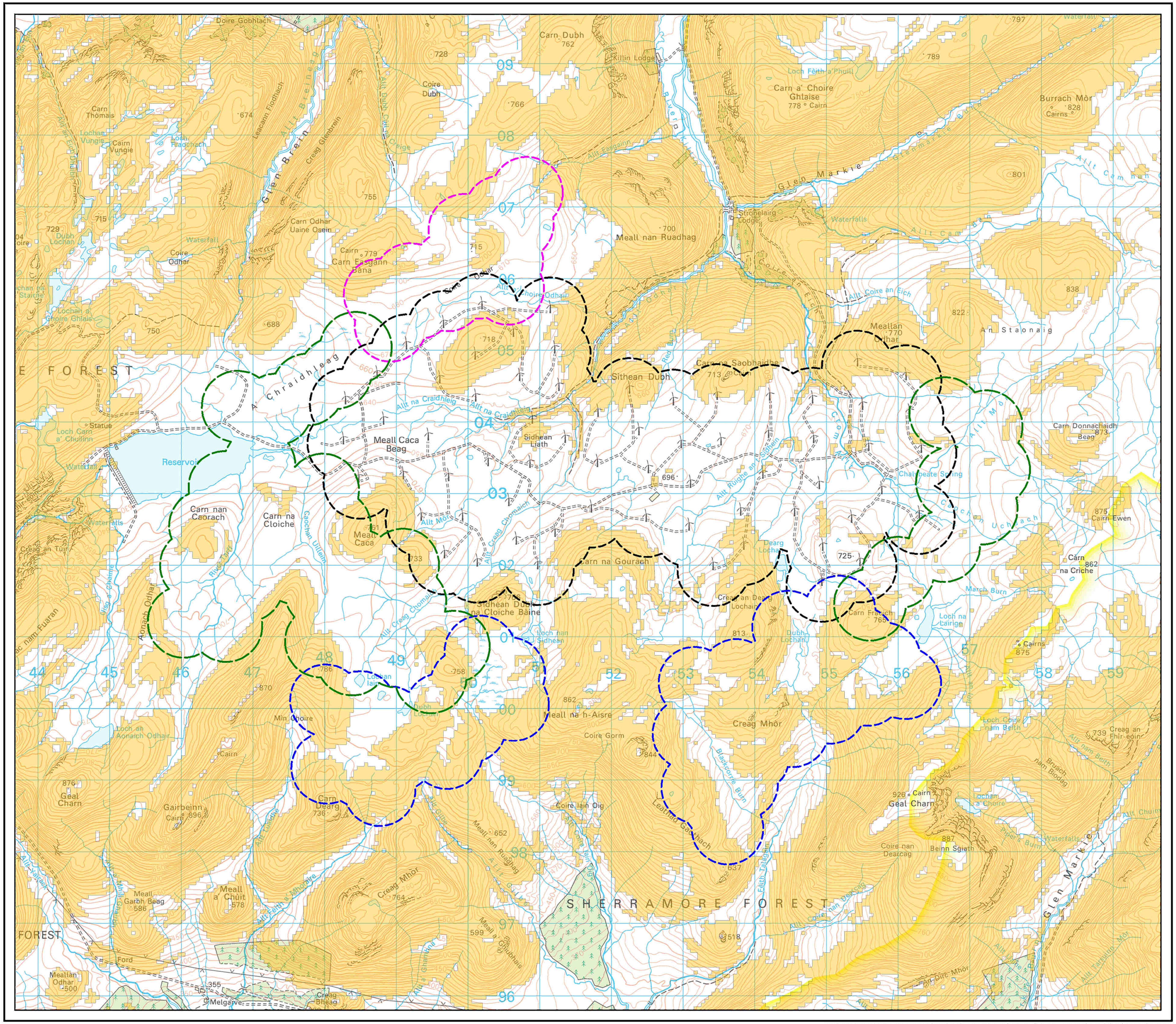
3.1.4 When the combined 500m buffers for the existing turbines at Stronelairg Wind Farm, and the turbines for the proposed development, Dell and Glenshero Wind Farms are considered together, the total area classed 6-10 for predicted golden eagle use within the 500m combined turbine buffer is 19.1km^2.

4. REFERENCES

Fielding, A.H. and Haworth, P.F. (2014). Golden eagles in the south of Scotland: an overview. Scottish Natural Heritage Commissioned Report No. 626.

Fielding, A.H., Haworth, P.F., Anderson, D., Benn, S., Dennis, R., Weston, E. and Whitfield, D.P. (2019). A simple topographical model to predict Golden Eagle *Aquila chrysaetos* space use during dispersal. International Journal of Avian Science.

FIGURES



sse Renewables

mbec environmental consulting

Key

- Cloiche 500m Proposed Turbine Buffer (Mar 2020)
- Stronelairg 500m Turbine Buffer
- Dell 500m Proposed Turbine Buffer
- Glenshero 500m Proposed Turbine Buffer

Golden Eagle Topography (GET) Model

- Predicted Use Values 6-10

Scale 1:50,000 @ A3

0 1.0 2.0 Km

N

Figure 9.2.1
Golden Eagle Topographic Model Results

Cloiche Wind Farm
EIA Report

APPENDICES

APPENDIX 9.2.1: Preference Indices (PI) and Standardised Preference Indices (SPI) for Slope, Altitude and Distance to Ridge

Tables 1, 2 and 3 provide PI and SPI values with lower and upper 95% confidence limits (LCL and UCL, respectively) for the three attributes which informed GET model: slope, altitude and distance to ridge (from Fielding *et al.* 2019, online supporting information). Table 4 shows the combined SPI values and final model predicted use values assigned to each pixel (1 indicating little predicted use and 10 indicating high predicted use (from Fielding *et al*. 2019[1]).

Table 1: Slope PI and SPI values

Slope (degrees)	LCL	PI	UCL	SPI
0-4	0.000	0.000	0.000	0
5-9	0.357	0.370	0.383	17
10-14	1.030	1.058	1.090	50
15-19	1.346	1.386	1.426	65
20-24	1.669	1.730	1.790	81
25-29	1.959	2.052	2.148	97
30-34	1.869	1.988	2.102	94
35-39	1.871	2.019	2.188	95
40-44	1.766	1.973	2.194	93
45-49	1.612	1.950	2.306	92
50-54	1.541	2.281	2.959	107
55-59	1.104	2.428	3.974	114
60-64	0.000	1.000	3.802	47
65-69	0.000	1.000	10.266	47
70-90	0.000	0.000	0.000	0

Table 2: Altitude PI and SPI values

Altitude (m)	LCL	PI	UCL	SPI
0-19				0
20-39	0.001	0.003	0.005	0
40-59	0.063	0.084	0.110	1
60-79	0.264	0.311	0.362	4
80-99	0.376	0.434	0.499	5
100-119	0.342	0.404	0.463	5
120-139	0.320	0.374	0.433	4
140-159	0.379	0.440	0.502	5
160-179	0.338	0.397	0.463	5

[1] Fielding, A.H., Haworth, P.F., Anderson, D., Benn, S., Dennis, R., Weston, E. and Whitfield, D.P. (2019). A simple topographical model to predict Golden Eagle Aquila chrysaetos space use during dispersal. International Journal of Avian Science.

Altitude (m)	LCL	PI	UCL	SPI
180-199	0.453	0.511	0.579	6
200-219	0.566	0.640	0.711	7
220-239	0.642	0.717	0.793	8
240-259	0.657	0.732	0.812	8
260-279	0.729	0.809	0.894	9
280-299	0.686	0.757	0.835	9
300-319	0.711	0.793	0.876	9
320-339	0.682	0.765	0.840	9
340-359	0.723	0.801	0.884	9
360-379	0.757	0.844	0.934	10
380-399	0.791	0.869	0.952	10
400-419	0.851	1.000	1.037	11
420-439	1.044	1.145	1.251	13
440-459	1.167	1.292	1.411	15
460-479	1.323	1.449	1.577	17
480-499	1.471	1.608	1.735	18
500-519	1.694	1.848	2.010	21
520-539	1.842	2.007	2.168	23
540-559	2.080	2.263	2.450	26
560-579	2.171	2.365	2.559	27
580-599	2.470	2.679	2.898	31
600-619	2.453	2.659	2.897	30
620-639	2.703	2.916	3.157	33
640-659	3.031	3.270	3.534	37
660-679	3.048	3.304	3.559	38
680-699	3.289	3.562	3.842	41
700-719	3.206	3.519	3.811	40
720-739	3.444	3.767	4.082	43
740-759	3.439	3.791	4.134	43
760-779	3.293	3.620	3.967	41
780-799	3.468	3.819	4.191	44
800-819	2.868	3.213	3.597	37
820-839	2.557	2.927	3.311	33
840-859	2.179	2.548	2.952	29
860-879	1.833	2.192	2.570	25
880-899	1.481	1.887	2.269	22
900-919	0.997	1.000	1.807	11
920-939	0.772	1.000	1.543	11

Altitude (m)	LCL	PI	UCL	SPI
940-959	0.539	1.000	1.324	11
960-979	0.221	0.553	0.941	6
980-999	0.274	0.547	0.958	6
1000-1019	0.173	0.432	0.865	5
1020-1039	0.000	0.328	0.656	4
1040-1059	0.000	0.283	0.708	3
1060-1079	0.000	0.333	0.834	4
1080-1099	0.000	0.196	0.587	2
1100-1119	0.000	0.248	0.994	3
1120-1139	0.000	0.299	0.896	3
1140-1159	0.000	1.000	1.163	11
1160-1179	0.000	1.000	1.486	11
1180-1199	0.000	1.000	1.300	11
1200-1219	0.000	0.000	0.000	0
1220-1239	0.000	1.000	1.541	11
1240-1259	0.000	1.000	1.507	11
1260-1279	0.000	1.000	1.750	11
>1280	0.000	0.000	0.000	0

Table 3: Distance to ridge PI and SPI values

Distance to ridge (m)	LCL	PI	UCL	SPI
0-50	1.459	1.490	1.521	65
51-100	1.714	1.794	1.874	78
101-150	1.506	1.573	1.637	68
151-200	1.284	1.354	1.422	59
201-250	1.128	1.195	1.255	52
251-300	0.966	1.000	1.113	43
301-350	0.841	0.920	0.991	40
351-400	0.795	0.871	0.943	38
401-450	0.739	0.809	0.886	35
451-500	0.682	0.763	0.841	33
501-550	0.639	0.726	0.821	32
551-600	0.611	0.713	0.816	31
601-650	0.631	0.737	0.832	32
651-700	0.669	0.786	0.909	34
701-750	0.673	0.785	0.903	34
751-800	0.593	0.738	0.874	32
801-850	0.592	0.723	0.861	31

Distance to ridge (m)	LCL	PI	UCL	SPI
851-900	0.553	0.694	0.853	30
901-950	0.552	0.695	0.848	30
951-1000	0.559	0.730	0.901	32
1001-1050	0.578	0.745	0.958	32
1051-1100	0.655	1.000	1.055	43
1101-1150	0.594	1.000	1.045	43
1151-1200	0.594	1.000	1.045	43
>1201	0.179	0.194	0.208	8

Table 4: Summed SPI values and final model value for pixels

Combined SPI Range	Final predicted use value
0.0-30.0	1
30.1-54.0	2
54.1-61.0	3
61.1-81.0	4
81.1-94.0	5
94.1-111.0	6
111.1-127.0	7
127.1-145.0	8
145.1-167.0	9
167.1-236.0	10

APPENDIX 9.2.2: 'R' ridge detection and distance to ridge code

The algorithm (from Fielding & Haworth 2014[2], and Fielding *et al.* 2019[3] online supporting information) uses the 50m resolution DTM (Digital Terrain Model) and examines the height of a central pixel with opposing test pixels. If the combined difference in altitude between the central pixel and the test pixels is greater than the user-supplied threshold the central pixel is a ridge. Four comparisons, horizontal, vertical and both diagonals are made, and the central pixel only needs to pass one threshold test to achieve ridge status.

This code is presented in two sections. The first identifies the ridges and the second calculates distances to the ridges.

Step 1: Identify ridges

```
#Ridge identification
#This code is intentionally verbose to ease understanding.
#It could be made much more efficient

library(raster)

#USER SUPPLIED VALUES
#The DEM as an ASC file.
#file paths need to be set to correct locations if files are to be saved and loaded
#set the working directory so that the full path is not needed again
#NOTE use / and not \ in file paths

setwd("C:/Users/Alan/Desktop/SScotland_Eagles/model/")

#dem_txt_file is the name of the DEM text file with no path but with file extension

dem_txt_file<-'demtest.txt'

#This is a text file that MUST have the asc extension, do not use .txt or .dat

ridgesave<-'tstridge.asc'

#Load the DEM into a raster layer called rdem

rdem <- raster(dem_txt_file)

#if an onscreen ridge map is required leave debug = T otherwise change it to F

debug<-T

#END OF USER SUPPLIED VALUES

# IDENTIFYING RIDGES
#First set a threshold value for the detection of ridges.
#This is used to compare the altitude of a putative ridge pixel against
#a mean calculated from a neighbourhood filter.
#Threshold is 26 m for 250 m (5 pixels) at 168 degrees
#(Tan 6 degrees = 0.1051, T=O/A so O = Tan A or 0.1051 x 250 m)
#But, there are two sides to a ridge so threshold is 54 (26+26 + 2)
#This setting seems to duplicate original PAT models
#and empirically this value creates #a visually acceptable representation of
#ridges when overlaid on to a 1:50,000 OS map.
```

[2] Fielding, A.H. and Haworth, P.F. (2014). Golden eagles in the south of Scotland: an overview. Scottish Natural Heritage Commissioned Report No. 626.

[3] Fielding, A.H., Haworth, P.F., Anderson, D., Benn, S., Dennis, R., Weston, E. and Whitfield, D.P. (2019). A simple topographical model to predict Golden Eagle Aquila chrysaetos space use during dispersal. International Journal of Avian Science.

```
threshold<-54

#Ridges are identified using the focal function from the raster package.
#first create two focal functions to sum the 5 cells to the left (west) and
#right (east) of the focal cell

leftrow<-matrix(0, nrow=3, ncol=11)
leftrow[2,1]<-1
rrow<-matrix(0, nrow=3, ncol=11)
rrow[2,11]<-1

# Combine the two filterings and see if the combined difference is > threshold

hf <- ((rdem-focal(rdem, w = leftrow)))+(rdem-focal(rdem, w = rrow))>threshold

#Now the verticals (North – South)

lcol<-matrix(0, nrow=11, ncol=3)
lcol[11,2]<-1
ucol<-matrix(0, nrow=11, ncol=3)
ucol[1,2]<-1

vf <- ((rdem-focal(rdem, w = lcol)))+(rdem-focal(rdem, w = ucol))>threshold

#Now the diagonals
#nw corner

nwd<-matrix(0, nrow=11, ncol=11)
nwd[1,1]<-1

#se corner

sed<-matrix(0, nrow=11, ncol=11)
sed[11,11]<-1

nwsedf <- ((rdem-focal(rdem, w = nwd)))+(rdem-focal(rdem, w = sed))>threshold

#sw corner

swd<-matrix(0, nrow=11, ncol=11)
swd[11,1]<-1

#ne corner

ned<-matrix(0, nrow=11, ncol=11)
ned[1,11]<-1

swnedf <- ((rdem-focal(rdem, w = ned)))+(rdem-focal(rdem, w = swd))>threshold

#a pixel is a ridge if one is detected vertically, horizontally or on a diagonal

ridge<-vf | hf | nwsedf | swnedf

#have a look at a plot of the ridges and save the file for importing into a GIS

if (debug) plot(ridge)
rfile <- writeRaster(ridge, filename=ridgesave, datatype='INT4S', overwrite=TRUE)
```

Step 2: Distance to ridge

```
#FIND DISTANCES FROM ALL PIXELS TO THE RIDGES
#These commands assume that a raster layer called ridge exists (i.e. is loaded)
#the ridge layer must have 1 for ridge pixels and 0 or NA for all other pixels
#It could be loaded from a saved .asc file
```

```
#If an onscreen ridge distance map is required leave debug = T
#otherwise change it to F

debug<-T

#The weighted distance map is saved as a text file in the working directory.
#This text file that MUST have the asc extension, do not use .txt or .dat

wtdist<-'wtdist.asc'

#Copy the ridge raster file and convert non-ridge values to NA
#The NA values are needed to enable distance calculations.
#The raster package distance function measures distances to non-NA values.
#The raster distance function measures distances to non-NA values.

rt2<-ridge
rt2[rt2<1] <- NA

#now do the distance calculation from ridges to all pixels.
#Note add 50 (PIXEL SIZE) otherwise there is an offset in the distances

rdist<-distance(rt2)+50

#have a look at the distances-to-ridges map

if (debug) plot(rdist)
rfile <- writeRaster(rdist, filename=wtdist, datatype='INT4S', overwrite=TRUE)
```