Farr windfarm: A review of displacement disturbance on golden plover arising from operational turbines - 2011 update.

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Summary

1. Previously, operational and construction impacts of the 40 turbine Farr windfarm on breeding golden plover were assessed over the period 2005 (pre-construction) to 2010 (operational).

2. Three hypotheses were tested: 1. No impact; 2. Immediate and permanent displacement of golden plover away from turbines; 3. Gradual but permanent displacement of golden plover away from turbines.

3. Data on territory centres and nest locations (when available) were analysed using first and second order spatial statistics.

4. There was no evidence from either the first or second order spatial statistics to support Hypothesis 2 or 3. There were no systematic or significant shifts in the mean centres of golden plover territory centres or any changes in the variability of territory coordinates.

5. There was no evidence that territory centres moved away from turbine locations.

6. In conclusion, there was no evidence for an immediate, or even delayed, displacement away from turbines. There is also no evidence for a systematic change in the pattern of golden plover territories.

7. As previously, golden plover territories were assigned to a 'windfarm' group if the territory centre was within a 500 m buffer drawn around the turbines. All others were assigned to a 'control' group.

8. In 2010 the number of wind farm territories declined from 20 in 2009 to 18 but this followed the most severe winter on record. There was a larger decline, 20 to 15, in the control group.

9. In 2011 the wind farm territories increased to 25 while the control group reduced from 15 to 14.

10. All of the previous analyses were repeated using new data from 2011 and the original conclusions were supported.

11. **In conclusion, there remains no evidence for a biologically significant decline in the number of golden plover breeding attempts at the Farr wind farm or in the spatial pattern of territories either with respect to each other or the turbines. Using current evidence the most parsimonious explanation of the observed results is scenario 1 – no biologically significant impact**.

Contents

1. Background

1.1 Farr Wind Farm was granted consent on the 5th October 2004 and construction began in April 2005. The last of 40 turbines was erected in March 2006, in advance of the 2006 golden plover breeding season. The consent had a number of conditions, including a requirement to undertake a breeding birds monitoring programme from the consent date (annually for three years from commissioning and subsequently at five year intervals, at 5, 10 and 15 years after the construction phase).

1.2 This is an update, using data from 2011, on the previous reports (Fielding and Haworth 2010, 2011) which reviewed data between 2005 and 2010.

1.3 The original analyses (Fielding and Haworth 2010) were predicated on three possible responses by golden plover to the windfarm construction and operation.

1. **No biologically significant impact**: under this scenario some minor annual variation in the number and distribution of golden plover territories is expected but no significant systematic impacts, related to the windfarm, would be apparent.
2. **Immediate and permanent displacement**: under this scenario it is expected that, immediately after construction, there would be a displacement of birds away from turbines, in the wind farm area, leading to a change in the spatial distribution of territories and a permanent reduction in the number of territories. The size of this reduction would be determined by the magnitude of the displacement distance. Following this impact there will still be some minor annual variation in the number and distribution of golden plover territories.
3. **Gradual and permanent displacement**: under this scenario it is expected that there would no immediate or large displacement of birds away from turbines but that displacement effects would accumulate over time if birds are site-faithful or habituated. As Ratcliffe (1976) noted, there are indications that individual pairs returning in successive years tend to nest closer to the site of the previous year than do new birds. Consequently, as the original occupants die, under this scenario, they would not be replaced within the displacement zone and after a few years, the distribution and abundance would resemble scenario two.

1.4 The conclusion of the analyses reported in Fielding and Haworth (2010, 2011) was that there was no evidence for a biologically significant decline in the number of golden plover breeding attempts at the Farr wind farm or in the spatial pattern of territories either with respect to each other or the turbines. Using current evidence the most parsimonious explanation of the observed results is scenario 1 – no biologically significant impact.

1.5 This report uses data from 2011 to test if the above conclusions are still valid.

2. Data

2.1 Data on locations of the golden plover territory centres and nest sites, during the 2011 breeding season, were extracted from the 2011 Farr Wind farm Breeding Wader Report (Rob Frith & Associates, 2011). The survey methodology is the accepted standard for censusing upland breeding waders and is the methodology currently recommended by both SNH (SNH 2005) and the RSPB (Gilbert *et al* 1998).

2.2 Territory distribution data were gathered from four survey periods (158 hours) between April 15th and June 26th 2011. An additional 135 hours was allocated to golden plover breeding observations and nest searching (Rob Frith & Associates, 2011).

3. Methods

3.1 Golden plover territories were split into control and windfarm groups depending on the distance between the territory centre and the nearest turbine. Any centre more than 500 m north of the upper row of turbines was assigned to the control group.

3.2 A variety of first and second order spatial statistics were used to describe patterns in golden plover territory centres and nest locations and to provide evidence for the magnitude of any disturbance or displacement effects. Statistics were calculated for all sites and, separately, for the wind farm and control sites. The majority of these analyses used Crimestat III (Levine, 2004).

3.3 Territory centre first order statistics

a) Minimum and maximum X and Y values.
b) Mean and median centre (arithmetic mean and median of the x and y coordinates).
c) Standard distance deviation (standard deviation of the distance of each point from the mean centre).

3.4 Territory centre second order statistics

a) Distance to the nearest turbine (minimum and maximum distances, mean distance, standard error of the distance, first quartile, median (second quartile) and third quartile. Distances were also calculated for the second, third fourth and fifth nearest turbines.
b) Area of a territory defined by a Thiessen polygon with a maximum radius of 500 m. (A maximum radius is needed to take account of unsurveyed regions and natural territory boundaries in the absence of neighbours. The area within a Thiessen polygon is closer to the point on which the polygon is centred than it is to any other point in the dataset.
c) Number of turbines within a territory Thiessen polygon (wind farm group only).

4. Results

4.1 Detailed results are presented in Appendix A.

4.2 In 2011 there were 39 territories, 25 in the wind farm group and 14 in the control group.

4.3 Six nest sites were identified. Five were identified during April when clutch sizes were determined. The sixth was found in May and contained egg fragments with an agitated female in close proximity.

4.4 The number of territories represents a 25% increase (20 to 25) within the windfarm and a 55% increase (9 to 14) in the control group since 2009.

4.5 As previously, there is no evidence from either the first or second order spatial statistics to support Scenario 2 or 3. For example, there have been no systematic or significant shifts in the mean centres of golden plover territory centres (Fig. 1). Similar results were obtained for control and wind farm territories.

4.6 There is also no evidence that territory centres have moved away from turbine locations (Table 1 and Figs 2a and 2b).

4.7 Over the seven years of recording the proportion of wind farm territory centres that were less than 200 m from the nearest turbine has increased at approximately 3% per year (Table 1, percentage within 200m = 2.86.year-5699.3, R^2 = 77.1%).

4.8 There is no evidence for a change in either the number or density (number per km^2) of turbines in the territory Thiessen polygons (Table 2).

4.9 Figures 3 – 9 show the position of territory centres and their Thiessen polygons in relation to the turbine locations and turbine 500 m buffer.

Table 1. Number of wind farm golden plover territory centres less than 200 m from the nearest turbine.

		Less than 200 m	
Year	Territories	n	%
2005	24	9	37.5
2006	27	11	40.7
2007	27	10	37.0
2008	27	13	48.1
2009	20	9	45.0
2010	18	10	55.0
2011	25	13	52.0

Figure 1. Mean x and y coordinates for wind farm and control golden plover territories for 2005-2011 (2005-red, 2006-orange, 2007-yellow, 2008-light blue, 2009-blue, 2010-dark blue, 2011 purple). The turbine 500 m buffer is shaded grey.

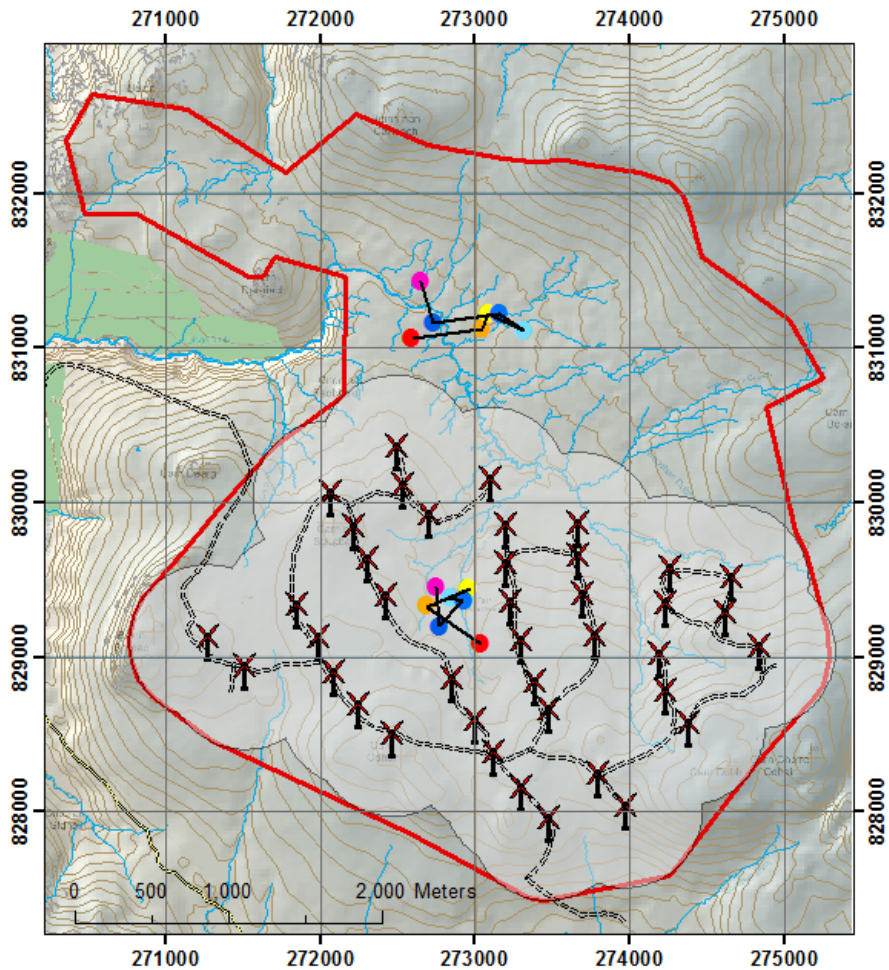


Table 2 Number of turbines, and turbine density, per territory Thiessen polygon.

	Turbines in Thiessen polygon									Turbines per km^2			
Year	0	1	2	3	4	5	1+	(% 1+)	n	Mean	SE	Median	Max
2005	3	10	6	5	0	0	21	87.5	24	4.1	0.57	3.7	8.4
2006	9	6	9	0	2	1	18	66.7	27	3.8	0.64	4.4	9.0
2007	8	7	8	3	1	0	19	70.4	27	3.6	0.60	3.4	10.3
2008	8	6	6	7	0	0	19	70.4	27	4.1	0.72	3.2	12.9
2009	3	6	6	4	0	1	17	85.0	20	3.8	0.52	4.0	8.6
2010	3	5	4	4	2	0	15	83.3	18	3.8	0.58	4.0	8.9
2011	4	10	5	1	4	0	20	80.0	25	4.4	0.67	3.7	7.6
All	34	40	39	23	5	2	129	75.9	170	3.9	0.28	3.6	12.9

Figure 2a Minimum distances from wind farm golden plover territory centres to the nearest turbine 2b Mean distances from wind farm golden plover territory centres to the nearest five turbines. Means are shown for each year.

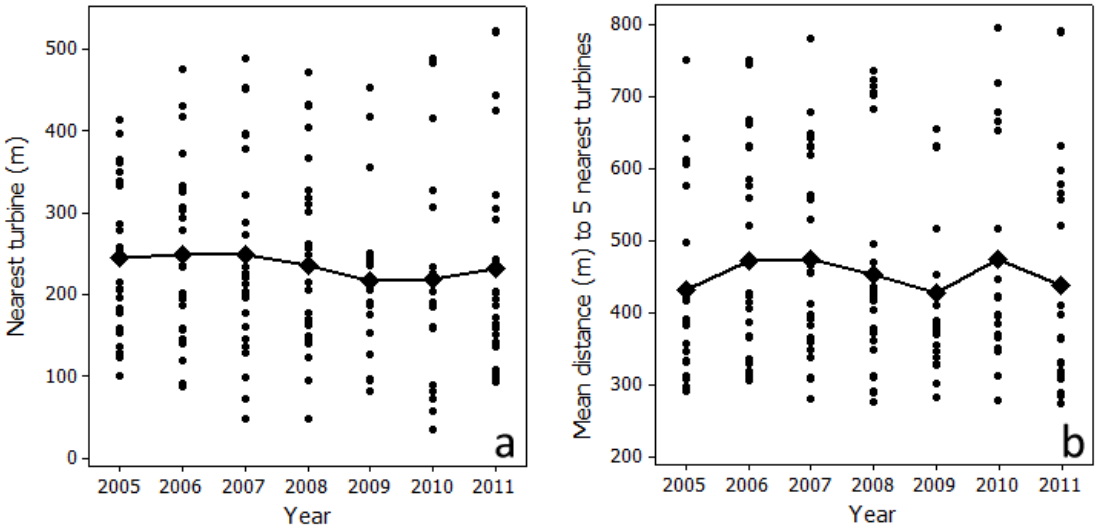


Figure 3. 2011 breeding season: Thiessen polygons, territory centres (+), plus turbines and 500 m buffer and windfarm red line boundary. Six nest sites are shown as green stars. The grid is 1 km. Contains Ordnance Survey data © Crown copyright and database.

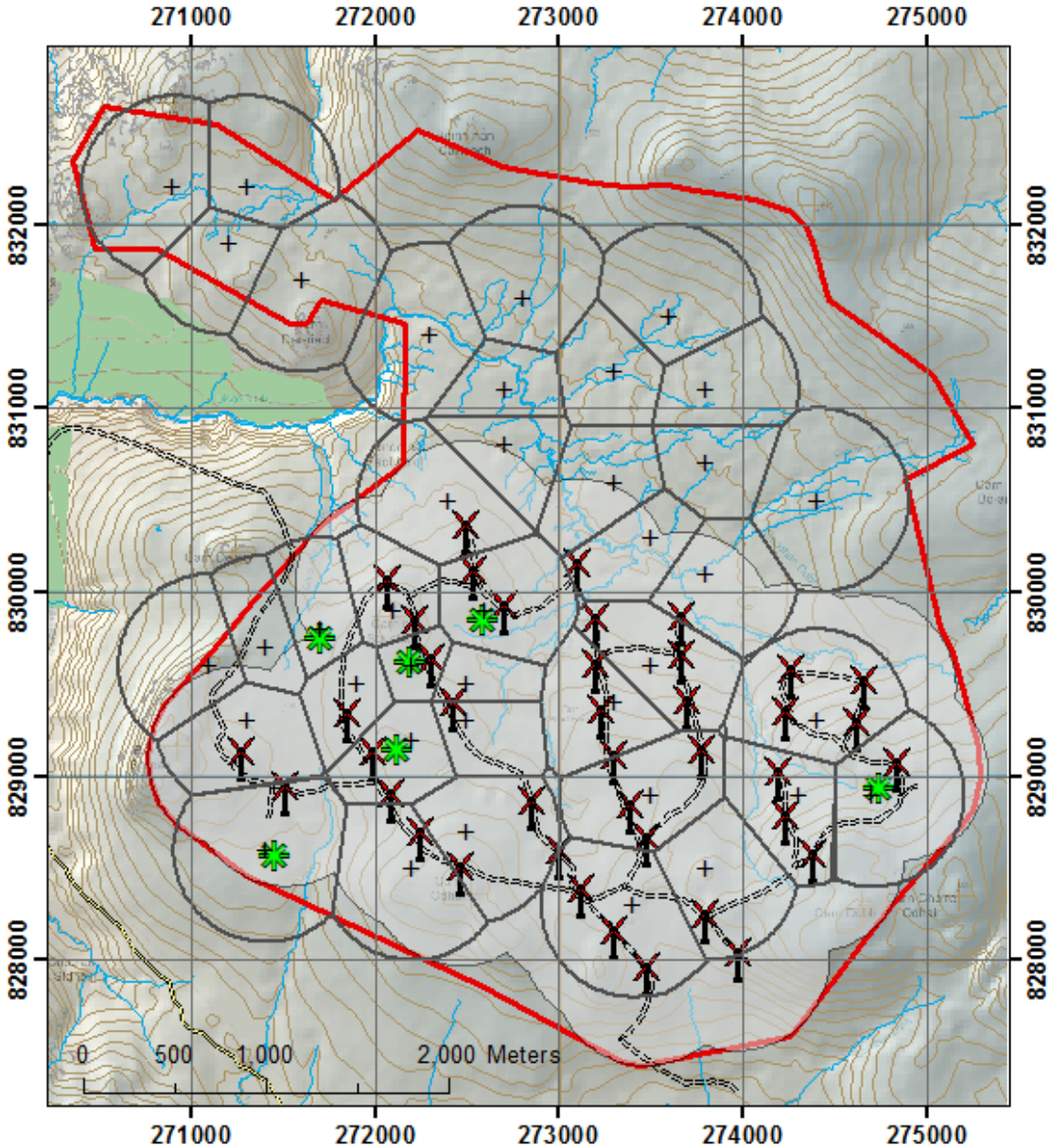


Figure 4. 2010 breeding season: Thiessen polygons, territory centres (+), plus turbines and 500 m buffer and windfarm red line boundary. The grid is 1 km. Contains Ordnance Survey data © Crown copyright and database.

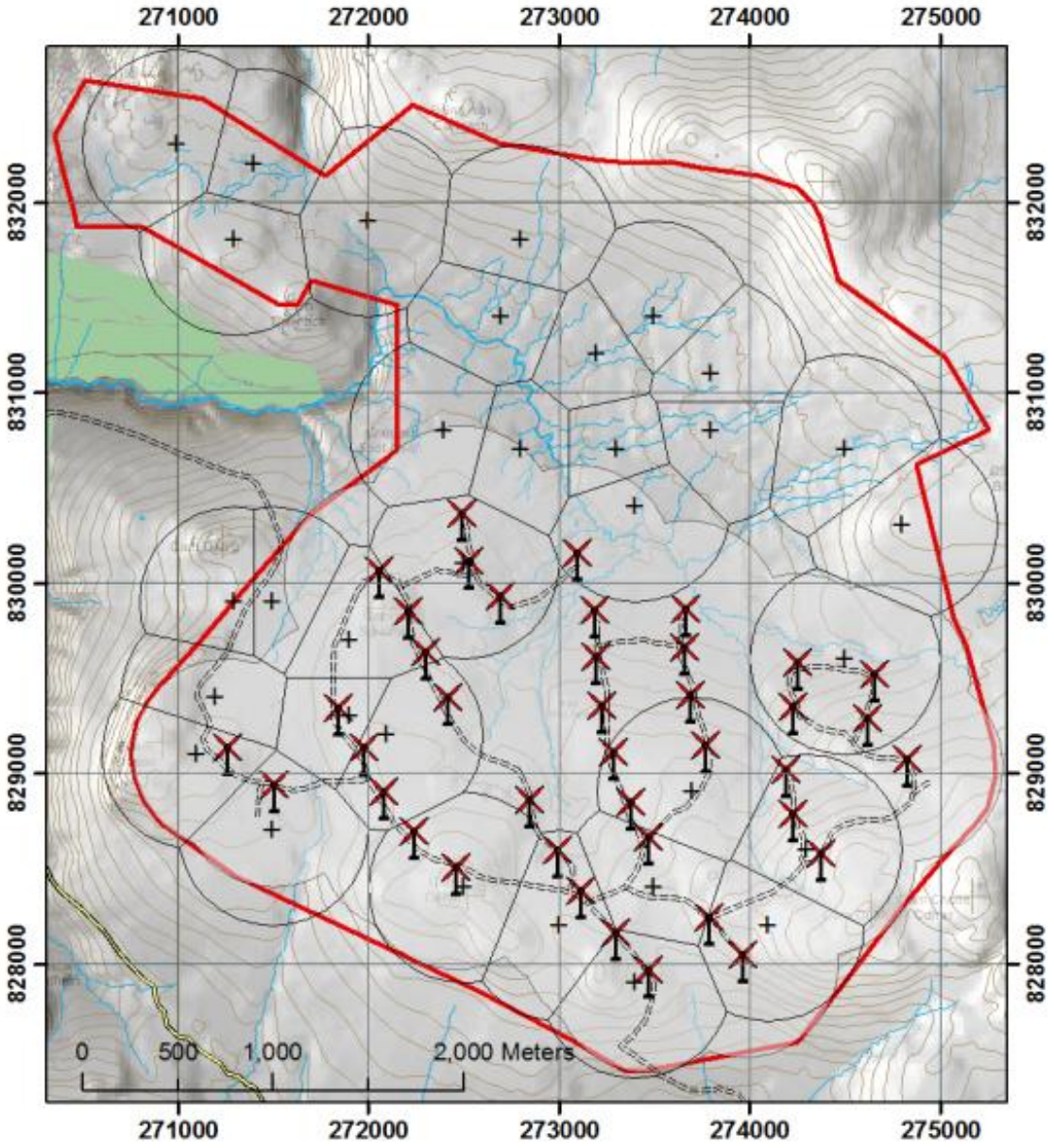


Figure 5. 2009 breeding season: Thiessen polygons, territory centres (+), plus turbines and 500 m buffer and windfarm red line boundary. The grid is 1 km. Contains Ordnance Survey data © Crown copyright and database.

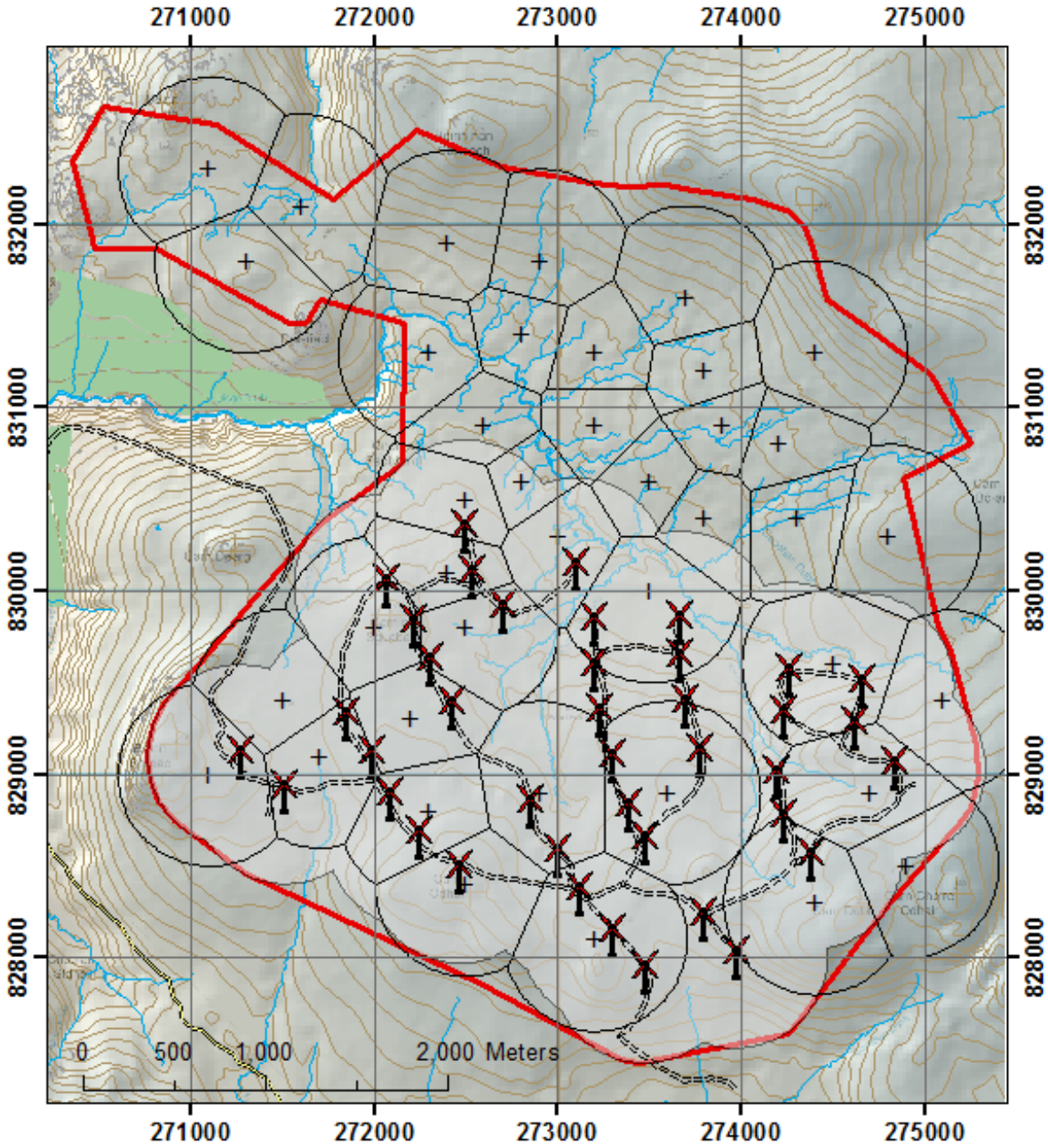


Figure 6. 2008 breeding season: Thiessen polygons, territory centres (+), plus turbines and 500 m buffer and windfarm red line boundary. Nest sites are shown as green stars. The grid is 1 km. Contains Ordnance Survey data © Crown copyright and database.

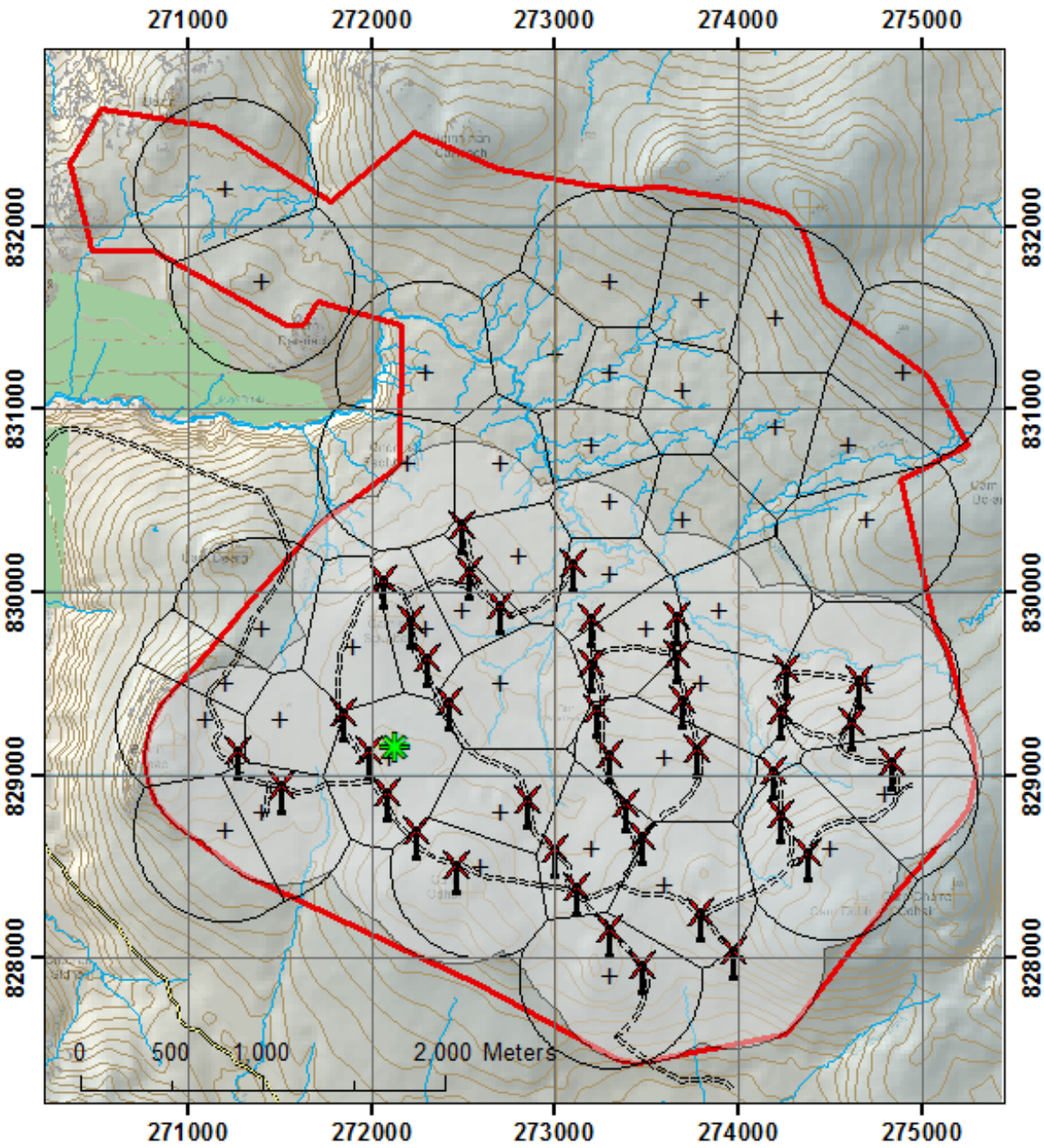


Figure 7. 2007 breeding season: Thiessen polygons, territory centres (+), plus turbines and 500 m buffer and windfarm red line boundary. The grid is 1 km. Contains Ordnance Survey data © Crown copyright and database.

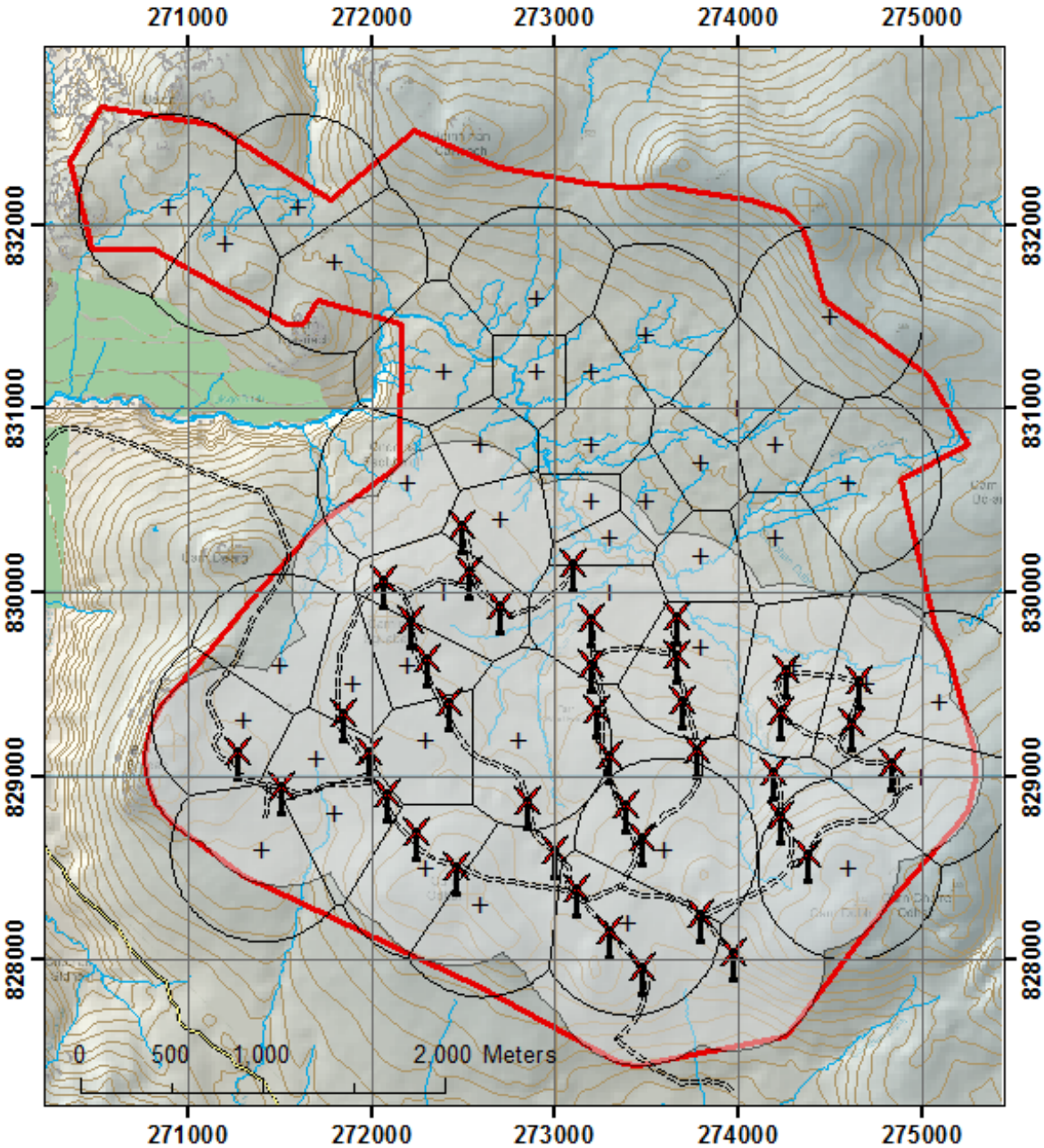


Figure 8. 2006 breeding season: Thiessen polygons, territory centres (+), plus turbines and 500 m buffer and windfarm red line boundary. Nest sites are shown as green stars. The grid is 1 km. Contains Ordnance Survey data © Crown copyright and database.

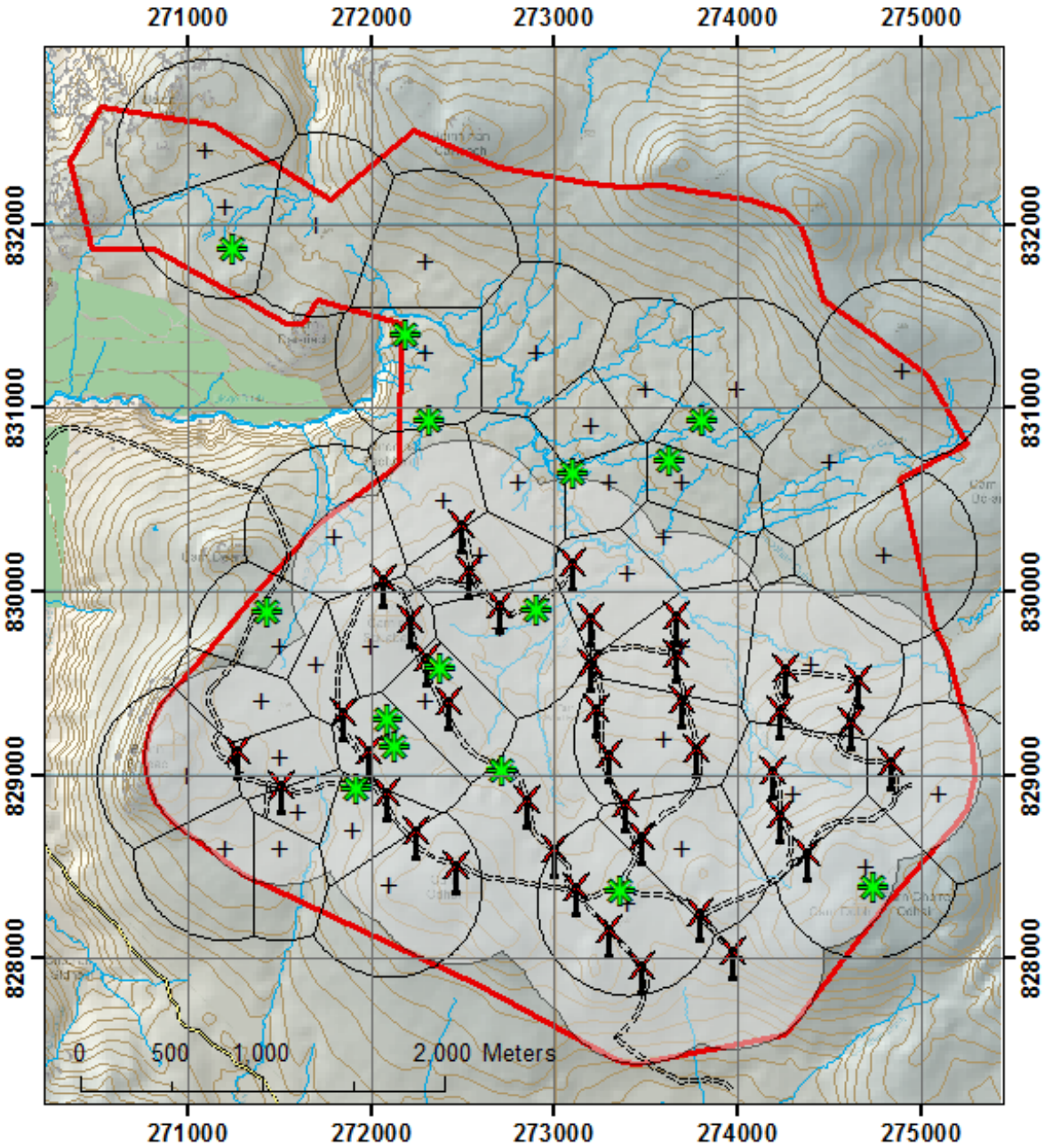
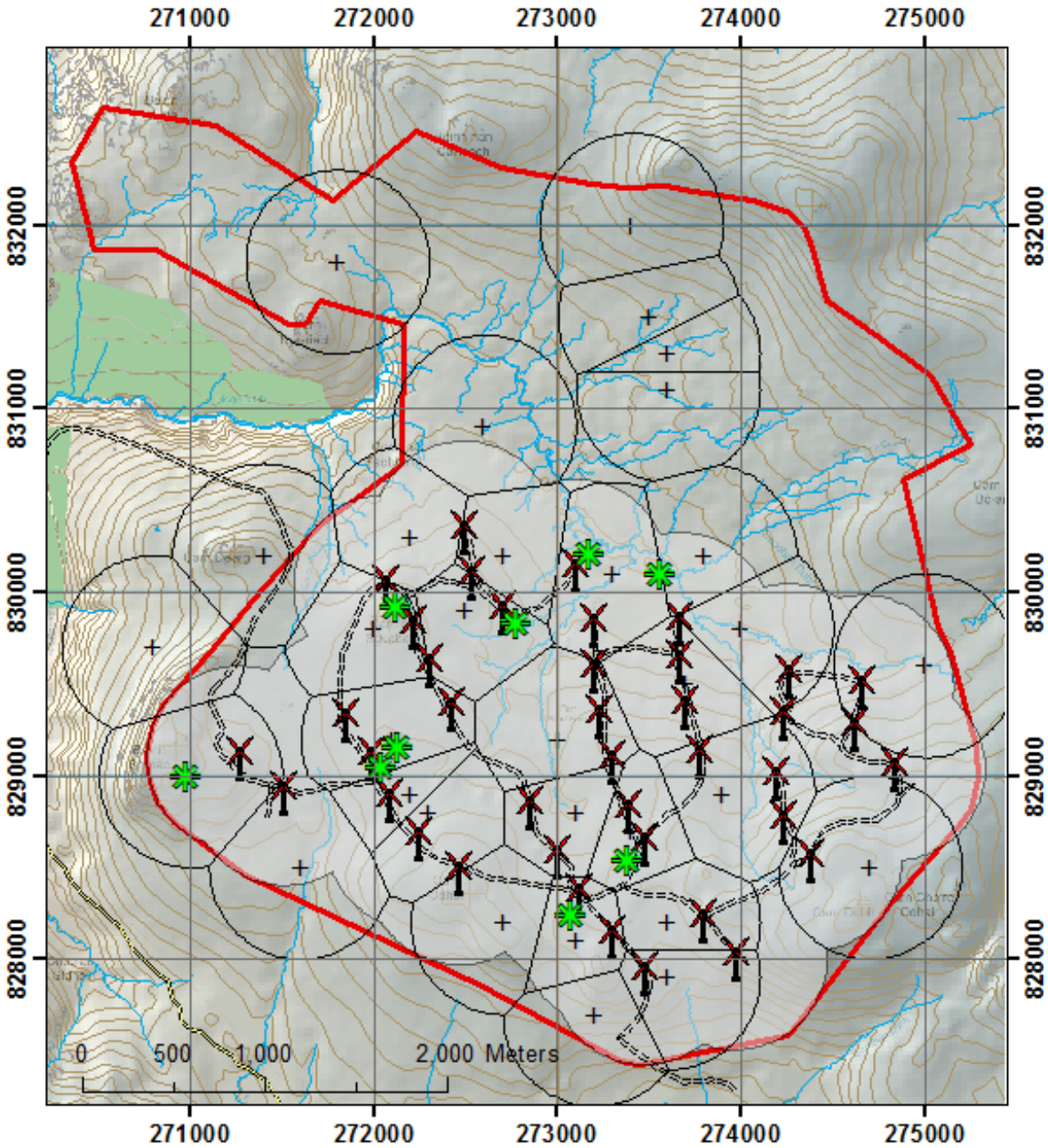


Figure 9. 2005 breeding season: Thiessen polygons, territory centres (+), plus turbines and 500 m buffer and windfarm red line boundary. Nest sites are shown as green stars. The grid is 1 km. Contains Ordnance Survey data © Crown copyright and database.



5. Discussion

5.1 This update uses data from 2011 to test if the conclusions listed in Fielding and Haworth (2011) are still valid. In total this represents six years of wind farm operation (2006-2011).

5.2 Under scenario 2 there would have been immediate displacement of golden plover away from the turbines. Pearce-Higgins *et al* (2009b) suggested a displacement distance of 200 m for this species. However, a more recent non-correlative study by Douglas *et al* (2011) supports the earlier conclusions of Fielding and Haworth (2010) since they found no significant difference in the change in abundance of golden plover between a wind farm and a control site, and no evidence that changes in its distribution were related to the wind farm infrastructure.

5.3 The number of turbines in a territory Thiessen polygon (Table 2) has remained relatively constant irrespective if it is measured as a count or a turbine density. In conclusion, there is still no evidence for an immediate, or even delayed, displacement away from turbines.

5.4 There is also no evidence for a systematic change in the pattern of golden plover territories and there is no evidence to support the predicted 200 m displacement distance for golden plover reported in Pearce-Higgins *et al* (2009b). Indeed, a larger proportion (52%) of wind farm territory centres are now within 200 m of turbine bases compared with the 38% in 2005 (Table 1).

5.5 Under scenario 3 there should be an annual decline in the number of golden plovers in the wind farm region at a rate that was a function of the annual adult survival rate. Although there was a decline in the number of territories in 2009 and 2010, 2011 saw an almost 40% increase in wind farm territories compared with 2010, while te control group decreased from 15 to 14.

5.6 It is unlikely that the wind farm is the direct cause of the 2010 decline since there were larger declines in the control group. There were no changes in habitat management in the previous 24 months (Rob Frith & Associates, 2010, 2011).

5.7 2010 had the lowest number of territories over the monitoring period but this followed one of the most severe winters in recent history. The UK mean temperature between December 2009 and February 2010 were 2.0 °C below the 1971-2000 average, making it the coldest winter since 1978/79 and in northern Scotland it was the coldest winter on record, with the highest number of frosts[1]. It is known that golden plover survival rates are affected by winter severity (e.g. Parr 1992 and Yalden and Pearce-Higgins 1997).

5.8 Given the severity of the preceding winter it would be surprising if there had been no decline in golden plover numbers. Indeed Fielding and Haworth (2010) made such a prediction before the 2010 data were collected (paragraph 5.2.4 "If it is true that golden plover survival rates are affected by winter severity it is possible, given the weather between December 2009 and February 2010, that there may be a significant reduction in occupancy in spring 2010."). The wind farm population seems to have recovered from this temporary decline.

[1] HTTP://WWW.METOFFICE.GOV.UK/CLIMATE/UK/2010/WINTER.HTML

5.9 Fielding and Haworth (2010) showed that, in the absence of recruitment, the wind farm population was expected to decline to seven pairs in 2011. The 2011 estimate of 25 pairs is more than treble this, and larger than the number (24) in 2005.

6. Conclusions

6.1 Hypothesis 2 was previously rejected since there was no evidence of an immediate change in golden plover distribution or abundance following the construction of the turbines prior to the 2006 breeding season. The addition of another year's monitoring data confirms the absence of any wind farm induced change in golden plover distribution or abundance.

6.2 The remaining hypotheses 1 and 3 can be separated if there is robust evidence of a decline in the number of golden plover following construction of the windfarm in advance of the 2006 breeding season. Between 2006 and 2009 there was no evidence for the predicted population decline within the wind farm. Even the apparent decline in 2010 was much smaller than that predicted by a habituation-philopatry hypothesis and the reduction is consistent with observed variation in local populations and the previous severe winter conditions. This is supported by the recovery to the 2005 population size in 2011.

6.3 Also, the evidence presented against Scenario 2 is relevant. In 2011, the sixth year of breeding with turbines present, there was no evidence for a change in the overall locations of golden plover territory centres and no evidence for an avoidance of turbines. This was true even when nest locations, rather than inferred territory centres, are used.

6.4 **In conclusion, there continues to be no evidence for a biologically significant decline in the number of golden plover breeding attempts at the Farr wind farm or in the spatial pattern of territories either with respect to each other or the turbines. Using current evidence the most parsimonious explanation of the observed results is scenario 1 – no biologically significant impact arising from the operation of this wind farm**.

6.5 **In the absence of any habitat management changes, it seems very unlikely that this wind farm will have any impact on the local golden plover population for the remainder of its active life. However, continuing monitoring will provide evidence to test this assumption.**

7. References

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Appendix A Spatial Statistics

A.1. Territory average centres

All territories		Minimum		Maximum		Simple		Median	
Year	n	x	y	x	y	x	y	x	y
2005	32	270800	827700	275000	832000	272919	829578	273100	829550
2006	43	271000	828300	275100	832400	272819	829998	272700	829800
2007	44	270900	828200	275100	832100	273005	830130	273050	830250
2008	43	271100	827900	274900	832200	273007	830026	273200	829900
2009	40	271100	828100	275100	832300	273078	830223	272950	830350
2010	33	271000	827900	274800	832300	272748	830091	272800	830100
2011	39	270900	828300	274700	832200	272715	830059	272600	832200
Min	32	270800	827700	274800	832000	272748	829578	272700	829550
Max	44	271100	828300	275100	832400	273078	830223	273200	832200
Control Territories									
2005	8	270800	829700	273600	832000	272588	831063	273000	831200
2006	16	271100	829700	274900	832400	273043	831119	273250	831100
2007	17	270900	830300	274600	832100	273082	831218	273200	831200
2008	16	271200	829800	274900	832200	273306	831113	273500	831200
2009	20	271100	830300	274800	832300	273147	831221	273200	831300
2010	15	271000	829900	274800	832300	272727	831160	272800	831200
2011	14	270900	830500	274400	832200	272642	831425	272600	831100
Min	8	270800	829900	273600	832000	272588	831063	272600	832200
Max	19	271200	830300	274900	832400	273306	831221	273500	832200
Wind farm territories									
2005	24	271000	827700	275000	830300	273029	829083	273100	828950
2006	27	271000	828300	275100	830600	272685	829333	272400	829200
2007	27	271300	828200	275100	830800	272956	829444	272700	829500
2008	27	271100	827900	274800	830700	272830	829381	272700	829500
2009	20	271100	828100	275100	830600	272920	829360	272650	829350
2010	18	271100	827900	274500	830800	272767	829200	272650	829150
2011	25	271100	828300	274700	830500	272748	829452	272500	830500
Min	18	271000	827700	274800	830300	272685	829083	272400	828950
Max	27	271300	828300	275100	830800	273029	829444	273100	830500

A.2. Areas (ha) of Thiessen polygons constructed around golden plover territory centres (mean, standard error, 1st quartile, median, second quartile, minimum, maximum, sample size, upper and lower 95% confidence limits).

Year	Mean	SE	Q1	Median	Q3	Min	Max	n	LCL	UCL
All territories										
2005	46.6	3.1	33.3	44.5	64.6	17.4	78.5	32	40.4	52.8
2006	37.5	2.4	22.4	39.2	51.4	11.1	68.4	43	32.7	42.3
2007	36.7	2.4	20.8	39.1	47.7	11.6	69.7	44	31.9	41.5
2008	38.3	2.1	26.7	33.6	48.1	16.9	64.8	43	34.0	42.6
2009	40.9	2.4	24.6	41.1	52.0	14.9	69.9	40	35.9	45.8
2010	44.4	2.3	33.4	45.0	55.1	20.8	72.9	33	39.8	49.0
2011	37.5	2.1	26.4	37.8	48.4	11.5	67.6	39	33.3	41.7
Control										
2005	55.8	6.8	38.6	64.3	67.4	21.1	78.5	8	40.1	71.6
2006	40.0	4.1	23.0	43.1	52.9	14.6	68.4	16	31.3	48.7
2007	35.5	4.1	19.5	37.1	49.6	12.8	69.7	17	26.9	44.1
2008	40.6	3.9	28.1	37.9	55.9	16.9	64.8	16	32.4	48.9
2009	37.1	3.3	23.2	36.9	50.0	16.5	58.5	20	30.2	44.0
2010	41.6	3.3	31.1	37.7	55.0	20.8	61.6	15	34.4	48.7
2011	39.6	3.4	28.3	37.5	49.9	22.8	64.2	14	32.3	46.9
Windfarm										
2005	43.5	3.2	32.6	41.4	48.3	17.4	78.5	24	36.9	50.2
2006	36.0	2.9	22.4	32.7	48.9	11.1	64.3	27	29.9	42.0
2007	37.4	3.0	22.6	39.1	46.4	11.6	68.9	27	31.3	43.6
2008	36.9	2.6	26.4	33.5	46.7	18.1	63.6	27	31.7	42.2
2009	44.6	3.5	32.7	41.7	59.5	14.9	69.9	20	37.3	51.9
2010	46.8	3.0	34.1	47.8	57.5	22.8	72.9	18	40.4	53.2
2011	36.4	2.7	25.4	37.8	44.0	11.5	67.6	25	30.8	42.0