Farr wind farm: A review of displacement disturbance on dunlin arising from operational turbines 2002-2015.

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Summary

1. Three disturbance hypotheses were tested using data collected using standard surveying techniques over the period 2002-2015.
2. Hypothesis 1. The wind farm has no negative impacts on breeding dunlin.
3. Hypothesis 2. There was immediate and permanent displacement of dunlin away from turbines.
4. Hypothesis 3. There was a gradual but permanent displacement of dunlin away from turbines.
5. Data on territory centres were analysed and no evidence was found to support Hypotheses 2 or 3.
6. There was no decline in the number of dunlin territories and no systematic or significant shifts in the mean centres of territory centres or any changes in the variability of territory coordinates.
7. There was no evidence that dunlin avoided the interior of the wind farm. There was no significant movement of Dunlin territory centres away from the nearest turbine.
8. In conclusion, there was no evidence for an immediate, or even delayed, displacement away from the wind farm.
9. There is also no evidence for a systematic change in the pattern of dunlin territories.
10. **In conclusion, there is no evidence for a biologically significant decline in the number of dunlin breeding attempts at the Farr wind farm or in the spatial pattern of their territories either with respect to each other or the turbines.**
11. **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 breeding season.

1.2 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).

1.3 This report uses data from 2002 - 2015 to examine the possible effects of the wind farm on the number and location of dunlin territories.

1.4 Previously, Fielding and Haworth (2010) discussed three possible responses by golden plover to wind farm construction and operation.

1. **No biologically significant impact**: under this scenario some minor annual variation in the number and distribution of territories is expected but no significant systematic impacts, related to the wind farm, 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. 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.

1.5 The conclusion of the analyses reported in Fielding and Haworth (2010, 2011, 2013) 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.

1.6 This report repeats some of the analyses used with golden plover and tests the same three hypotheses.

2. Data

2.1 Locations of dunlin territory centres were obtained from an Annex to the Farr Wind Farm Breeding Waders 2015 Report (Coyle, 2015). 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).

3. Methods

3.1 The wind farm is defined as the area enclosed by a 500 m radius buffer drawn around the turbines

3.2 Because the reference/control area was not searched each year these analyses are restricted to those territories with centres less than 500 m north of the upper row of turbines.

3.3 A variety of statistics are used to describe patterns in dunlin territory centres to provide evidence for the magnitude of any disturbance or displacement effects.

3.4 Territory centre statistics: minimum and maximum X and Y coordinates; mean centre.

3.5 Territory - turbine statistics: distance to the nearest turbine (minimum and maximum distances, mean distance, standard error of the distance, 95% Confidence limits.

4. Results

4.1 Detailed results are presented in Appendix A.

4.2 The number of territories in the wind farm has been reasonably constant and, with the exception of 2005 when there was construction activity, the number of territories within the wind farm area has never dropped below the pre-construction figures (Table 1).

4.3 As with the golden plover (Fielding and Haworth, 2015), there is no evidence from either set of statistics to support Scenarios 2 or 3. For example, there have been no systematic or significant shifts in the mean centres of dunlin territory centres (Fig. 1, 3-17).

4.4 There is no evidence that territory centres have moved away from the nearest turbine (Figs 2a and 2b). Indeed the mean distances to the nearest turbines in 2002 and 2015 were 257 and 260 m respectively. There has been no trend in the mean distance to the five nearest turbines and no change to the number of territories in the wind farm (Table 1).

4.5 Over the eight years of operation the proportion of territory centres that were less than 200 m from the nearest turbine has varied but with no trend (Table 1).

4.6 Figures 3 – 17 show the position of territory centres in relation to the turbine locations and turbine 200 m and 500 m buffer.

Table 1. Number of wind farm dunlin territories and the number of centres less than 200 m from the nearest turbine. Data in italics are from a period before all turbines were erected.

		Less than 200 m	
Year	Territories	n	%
2002	*7*	*1*	*14.3*
2003	*9*	*3*	*33.3*
2004	*9*	*6*	*66.7*
2005	*15*	*9*	*60.0*
2006	9	2	22.2
2007	10	4	40.0
2008	11	6	54.5
2009	12	4	33.3
2010	14	5	35.7
2011	12	2	16.7
2012	9	1	11.1
2013	11	4	36.4
2014	12	4	33.3
2015	12	6	50.0

Figure 1. Mean x and y coordinates for dunlin territories for 2002-2015. The 2002 centre is a filled circle, the 2015 location is a red star. The turbine locations are shown with 200 m and 500 m buffer shaded circular buffers. Contains Ordnance Survey data © Crown copyright and database.

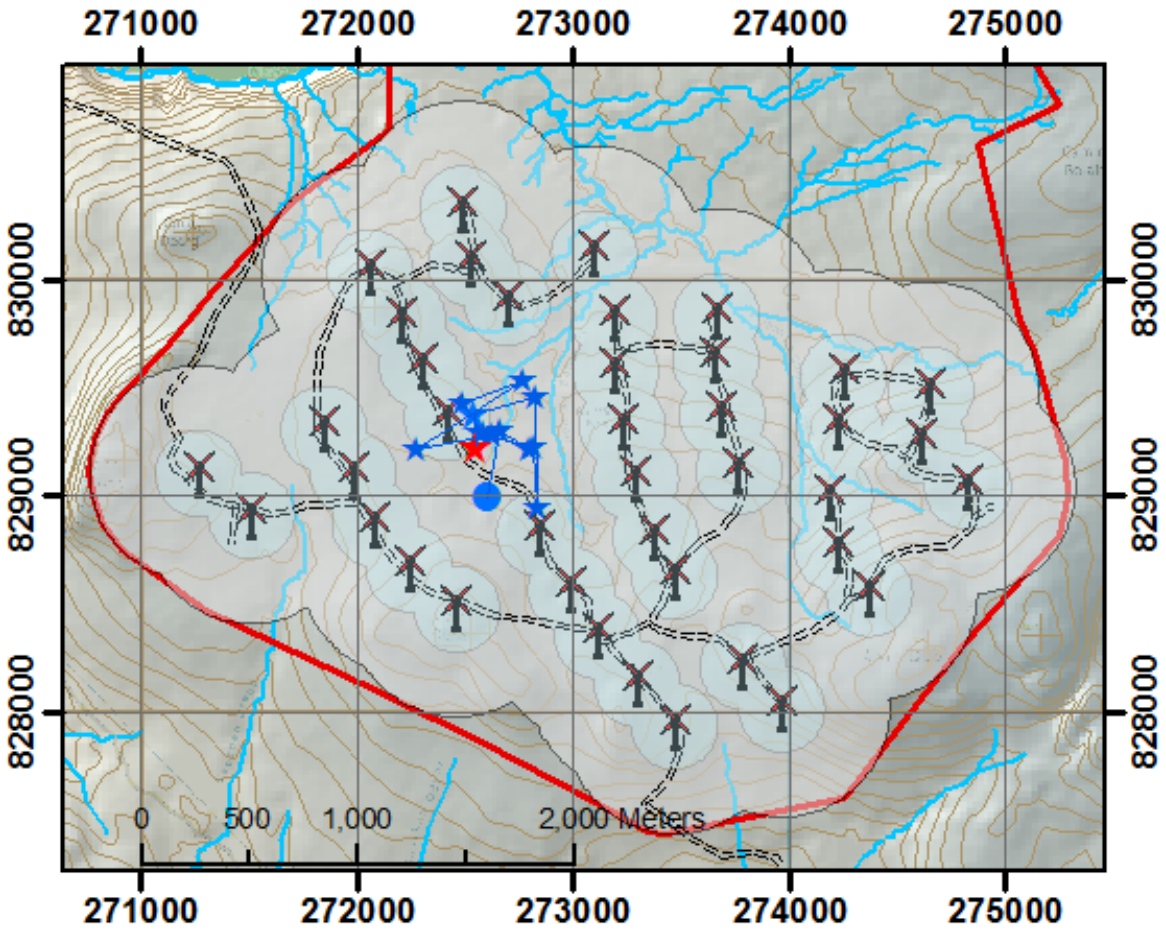
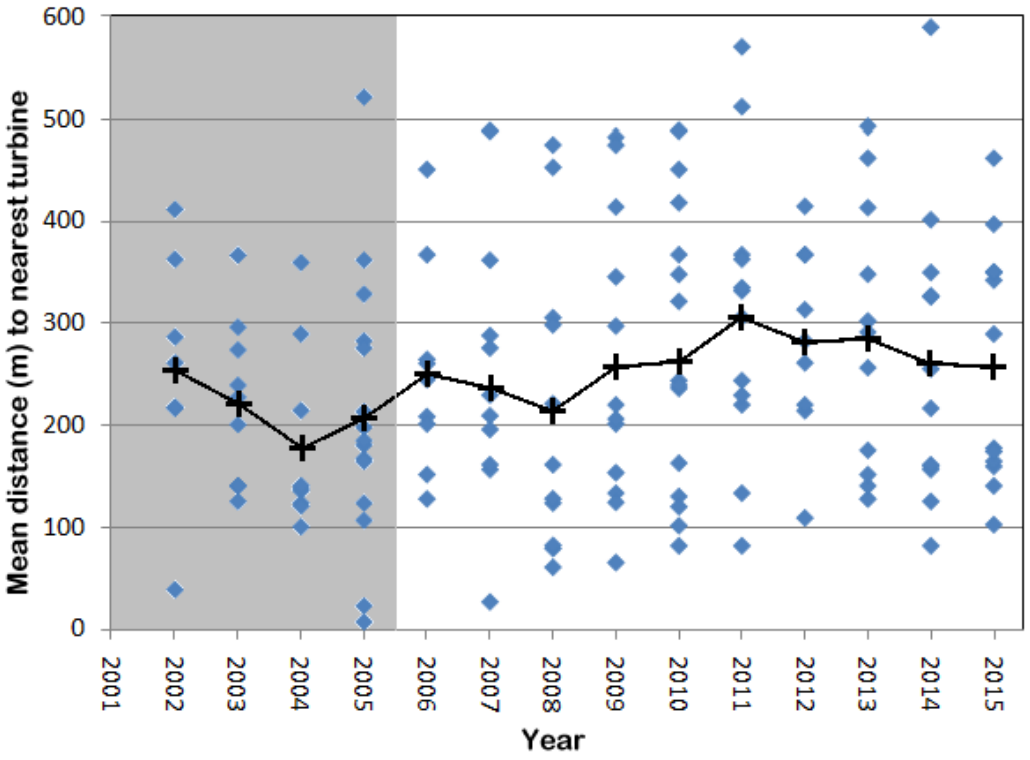


Figure 2a Minimum distances from wind farm dunlin territory centres to the nearest turbine. 2b Mean distances from wind farm dunlin territory centres to the nearest five turbines. Means are shown for each year. Shaded area is the period before all turbines were erected.



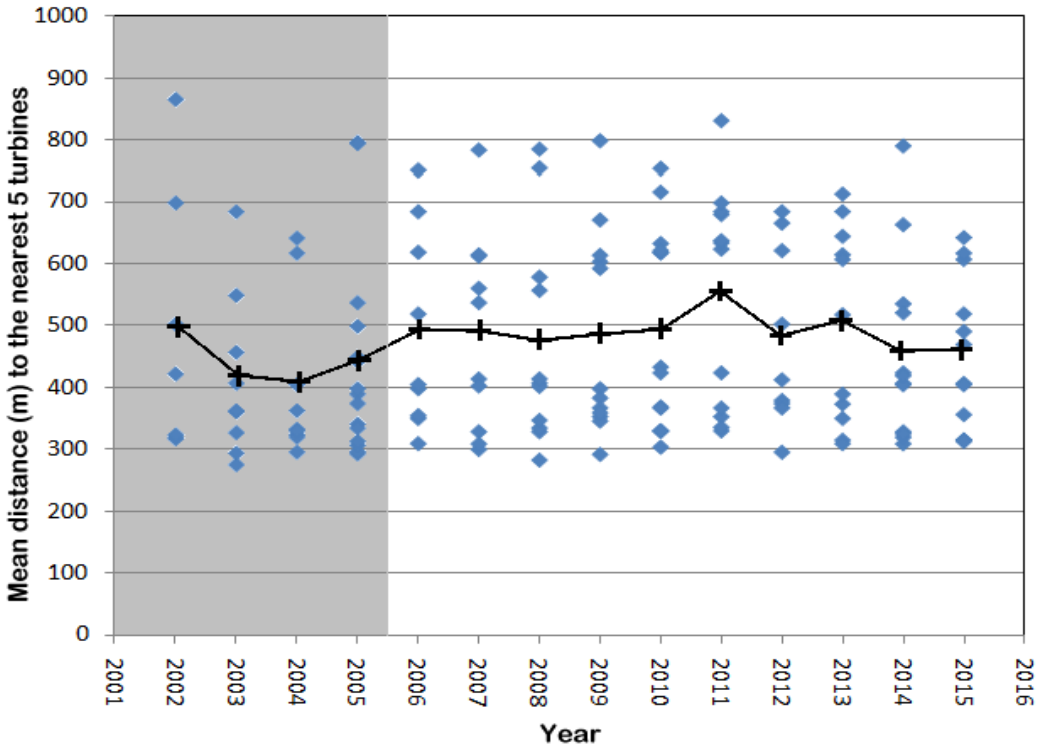


Figure 3. Pre- (+) and post- (filled circle) operational territory centres. Also shown are the turbines with 200 m and 500 m buffers and the wind farm red line boundary. The grid is 1 km. Contains Ordnance Survey data © Crown copyright and database.

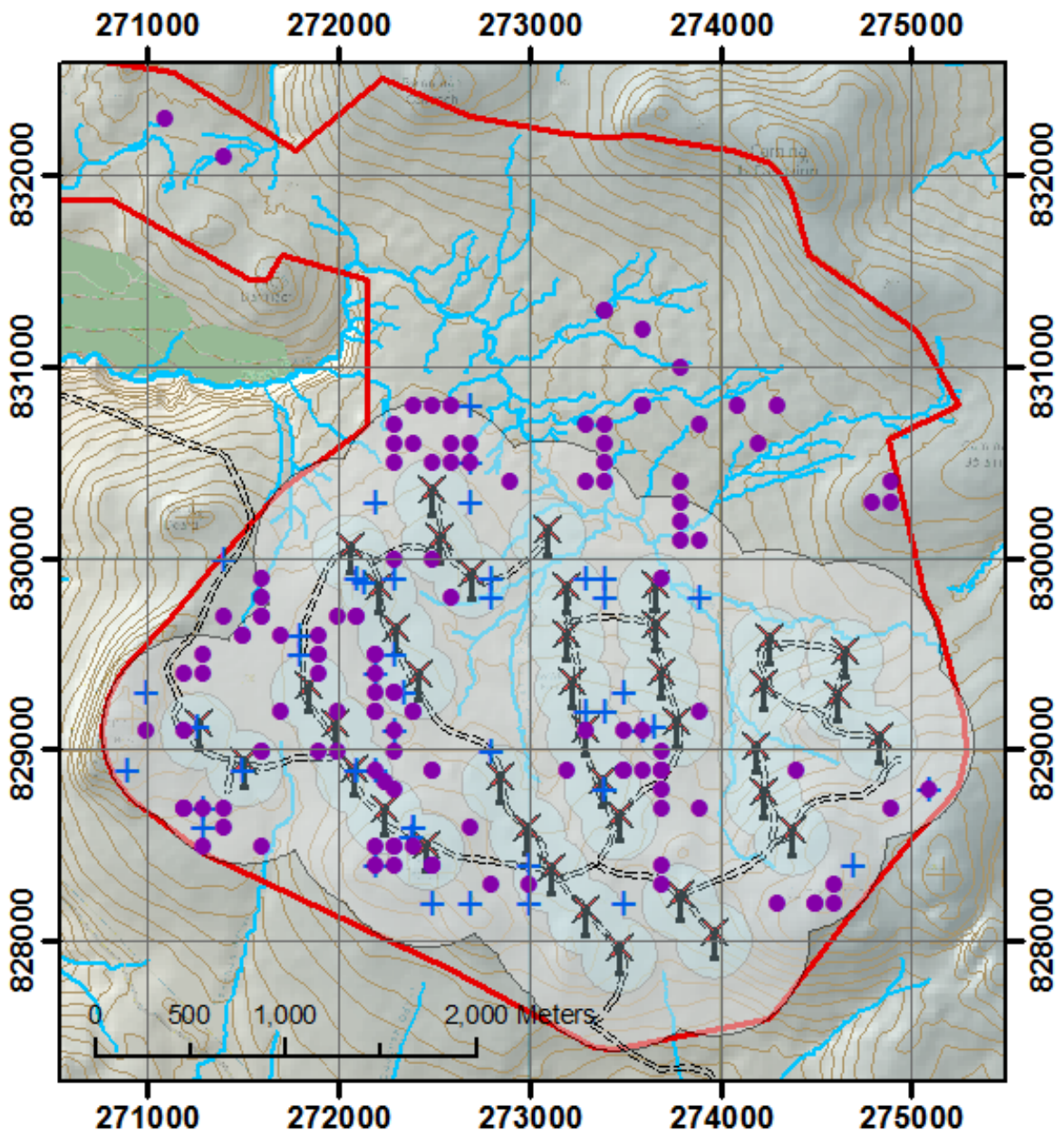


Figure 4. 2015 breeding season: Territory centres, plus turbines and 500 m buffer and wind farm red line boundary. The grid is 1 km. Contains Ordnance Survey data © Crown copyright and database.

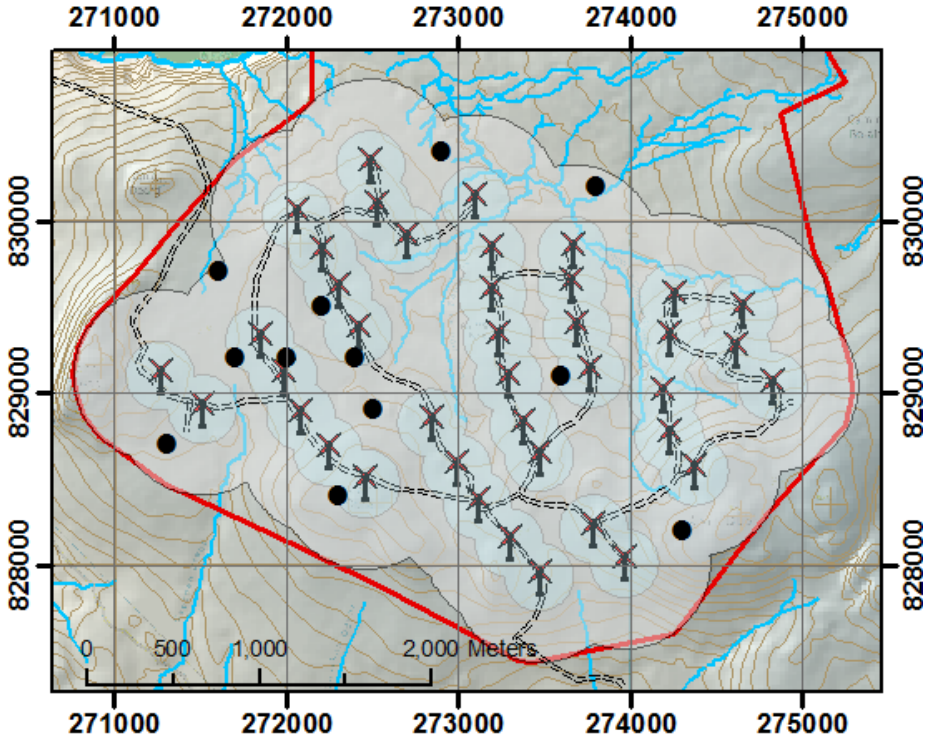


Figure 5. 2014 breeding season: Territory centres, plus turbines and 500 m buffer and wind farm red line boundary. The grid is 1 km. Contains Ordnance Survey data © Crown copyright and database.

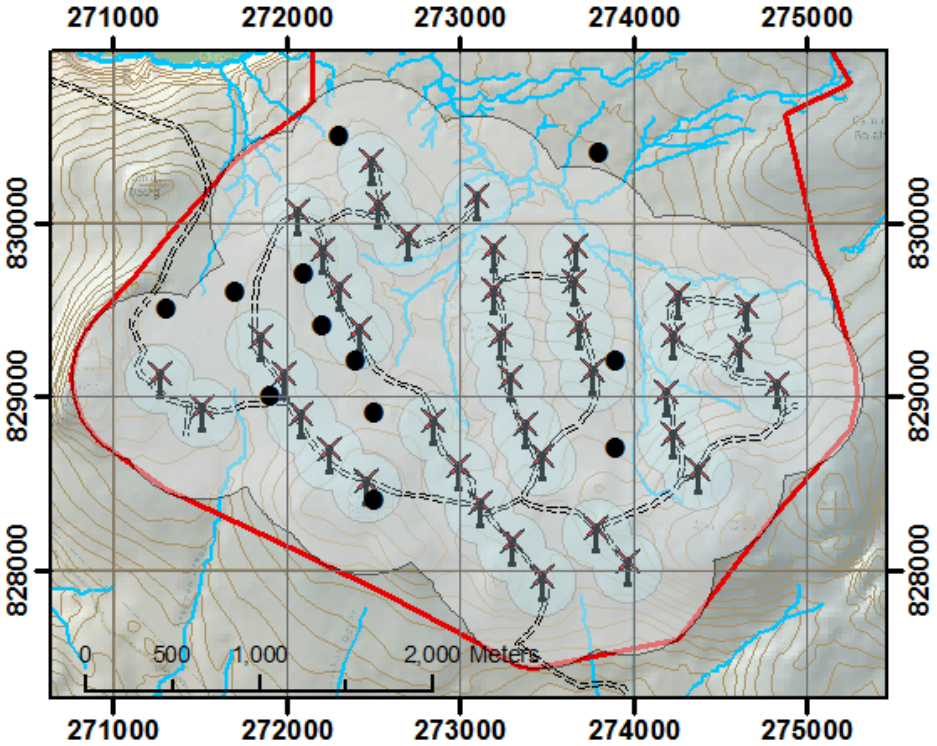


Figure 6. 2013 breeding season: Territory centres, plus turbines and 500 m buffer and wind farm red line boundary. The grid is 1 km. Contains Ordnance Survey data © Crown copyright and database.

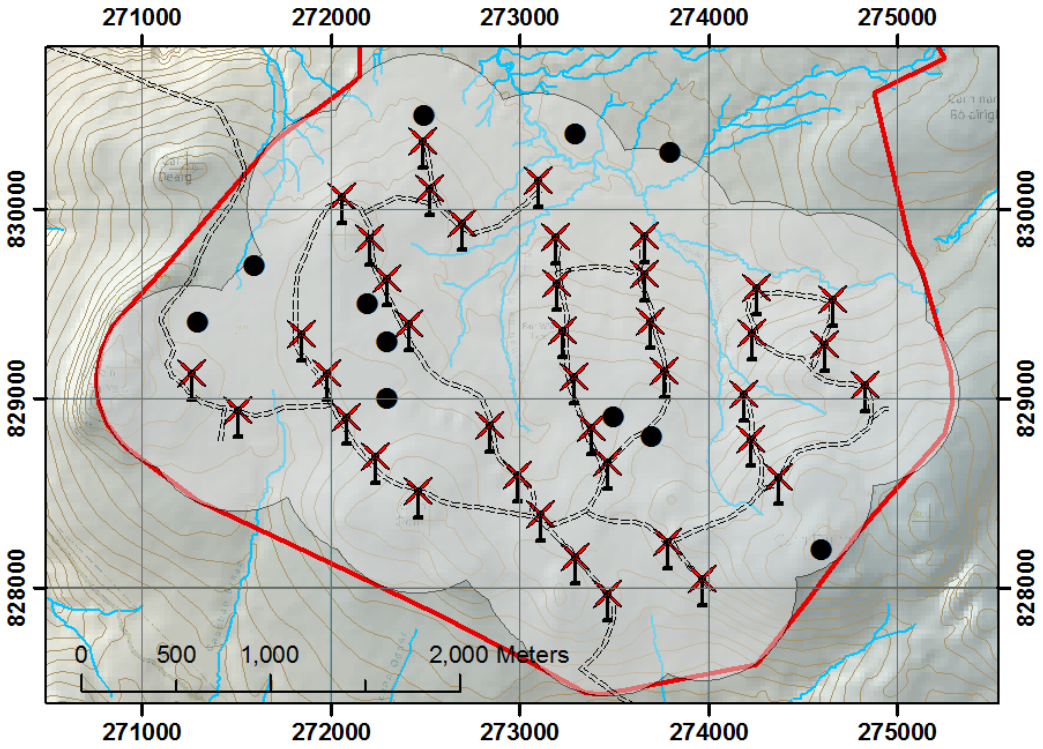


Figure 7. 2012 breeding season: Territory centres, plus turbines and 500 m buffer and wind farm red line boundary. The grid is 1 km. Contains Ordnance Survey data © Crown copyright and database.

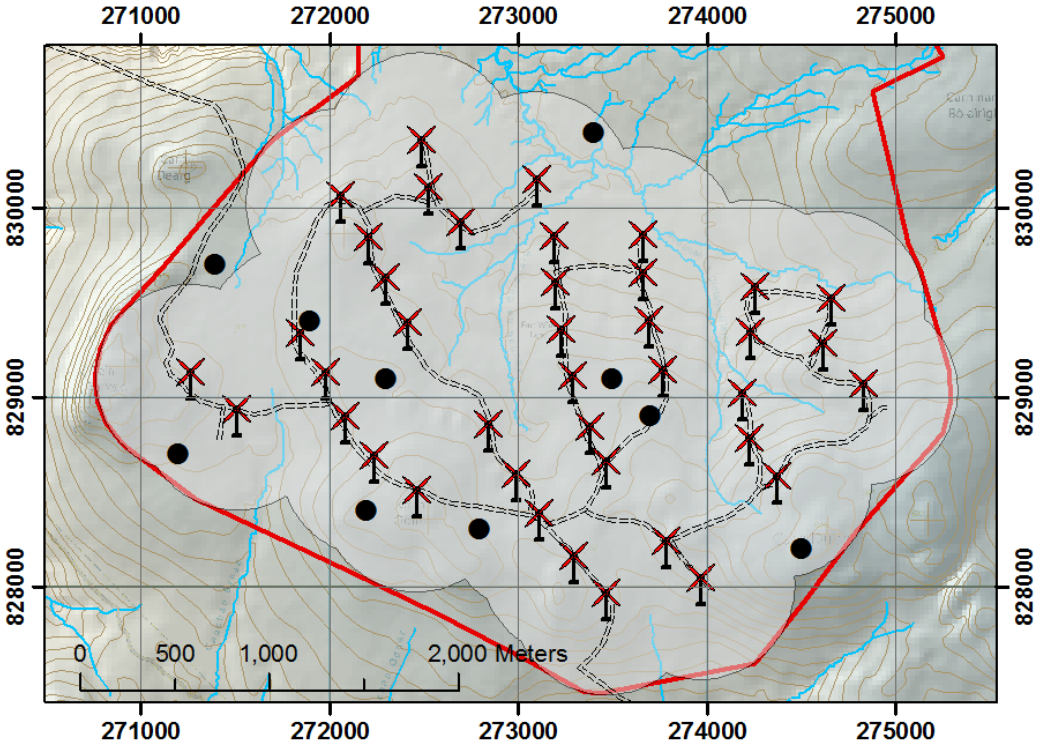


Figure 8. 2011 breeding season: Territory centres, plus turbines and 500 m buffer and wind farm red line boundary. The grid is 1 km. Contains Ordnance Survey data © Crown copyright and database.

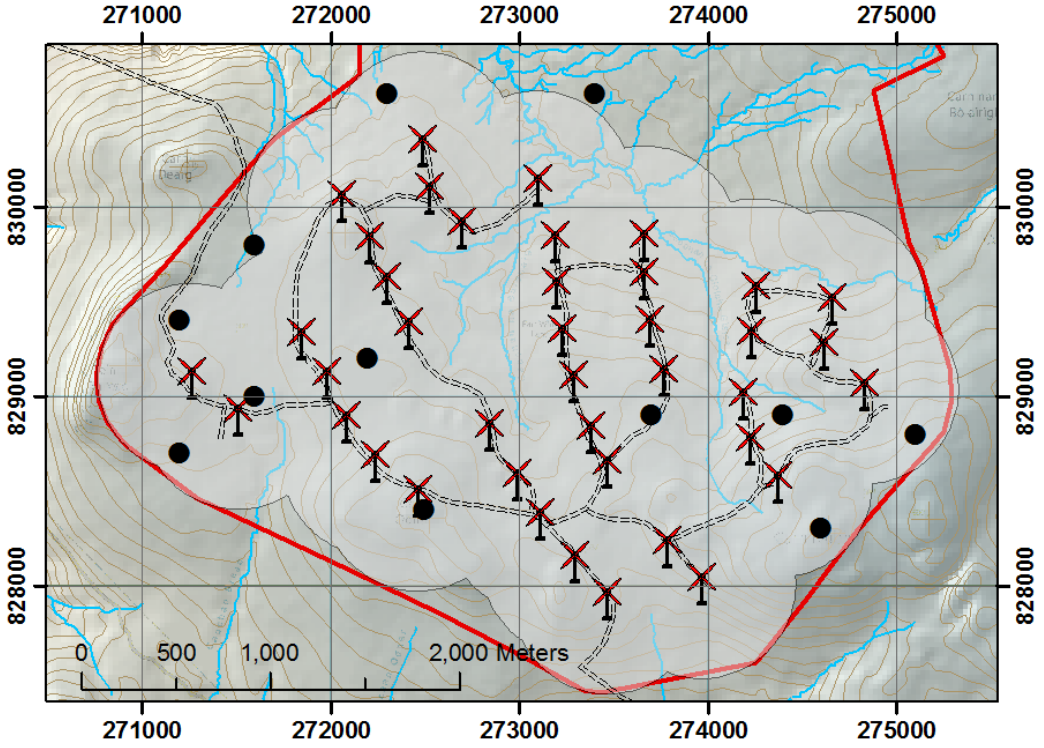


Figure 9. 2010 breeding season: Territory centres, plus turbines and 500 m buffer and wind farm red line boundary. The grid is 1 km. Contains Ordnance Survey data © Crown copyright and database.

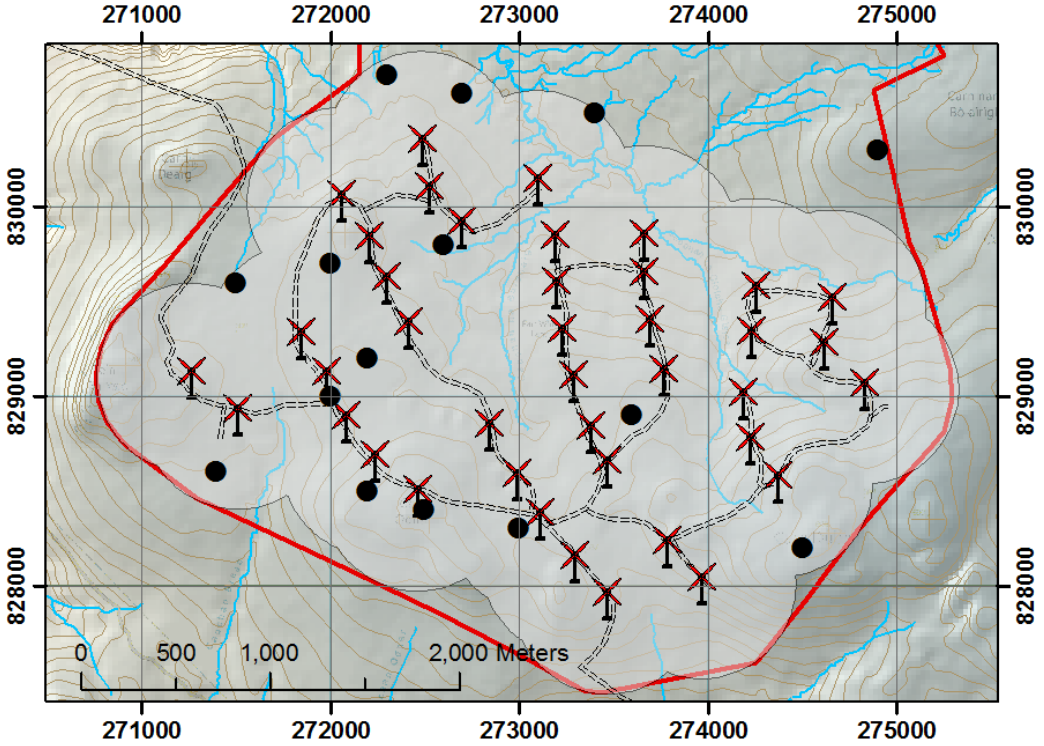


Figure 10. 2009 breeding season: Territory centres, plus turbines and 500 m buffer and wind farm red line boundary. The grid is 1 km. Contains Ordnance Survey data © Crown copyright and database.

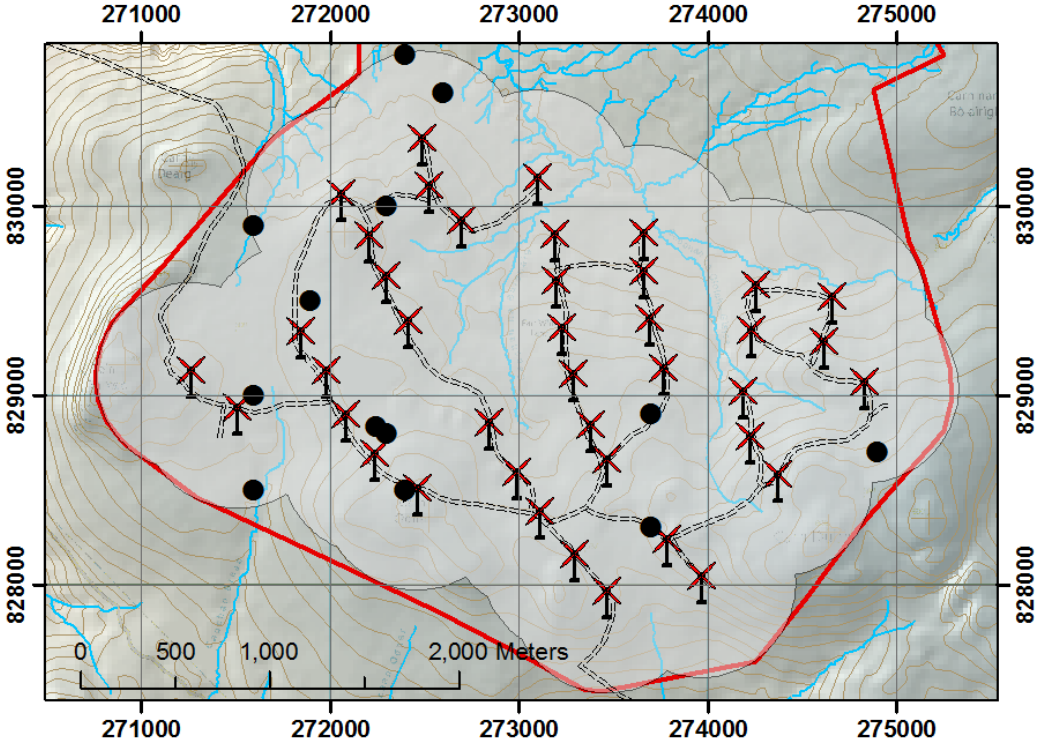


Figure 11. 2008 breeding season: Territory centres, plus turbines and 500 m buffer and wind farm red line boundary. The grid is 1 km. Contains Ordnance Survey data © Crown copyright and database.

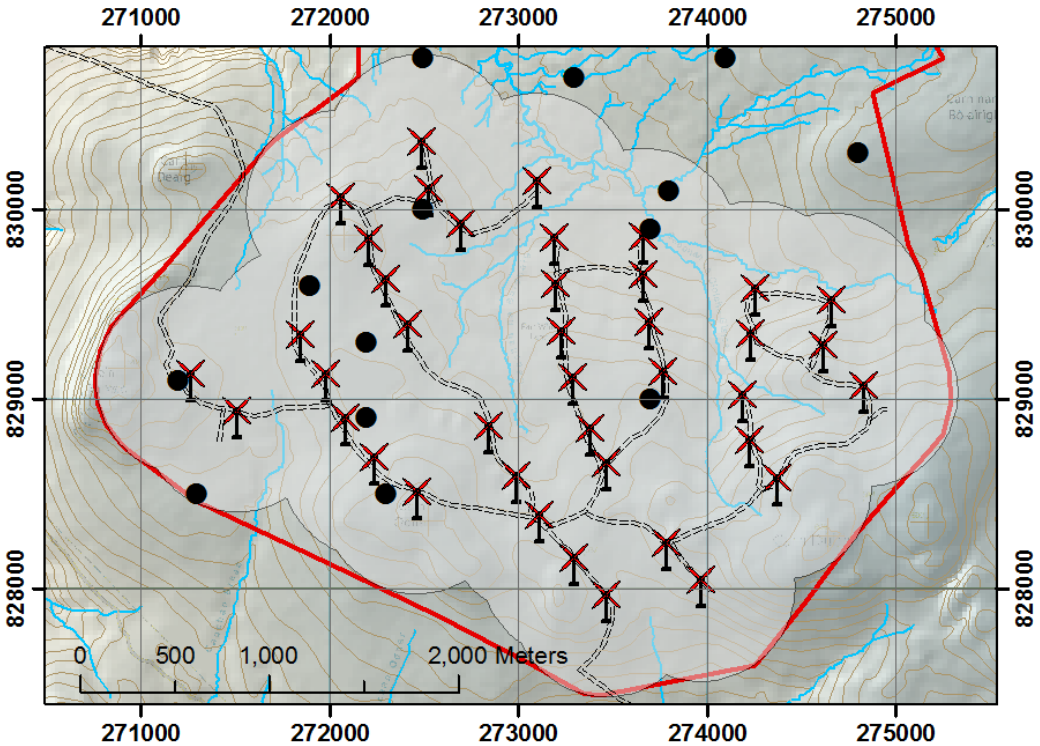


Figure 12. 2007 breeding season: Territory centres, plus turbines and 500 m buffer and wind farm red line boundary. The grid is 1 km. Contains Ordnance Survey data © Crown copyright and database.

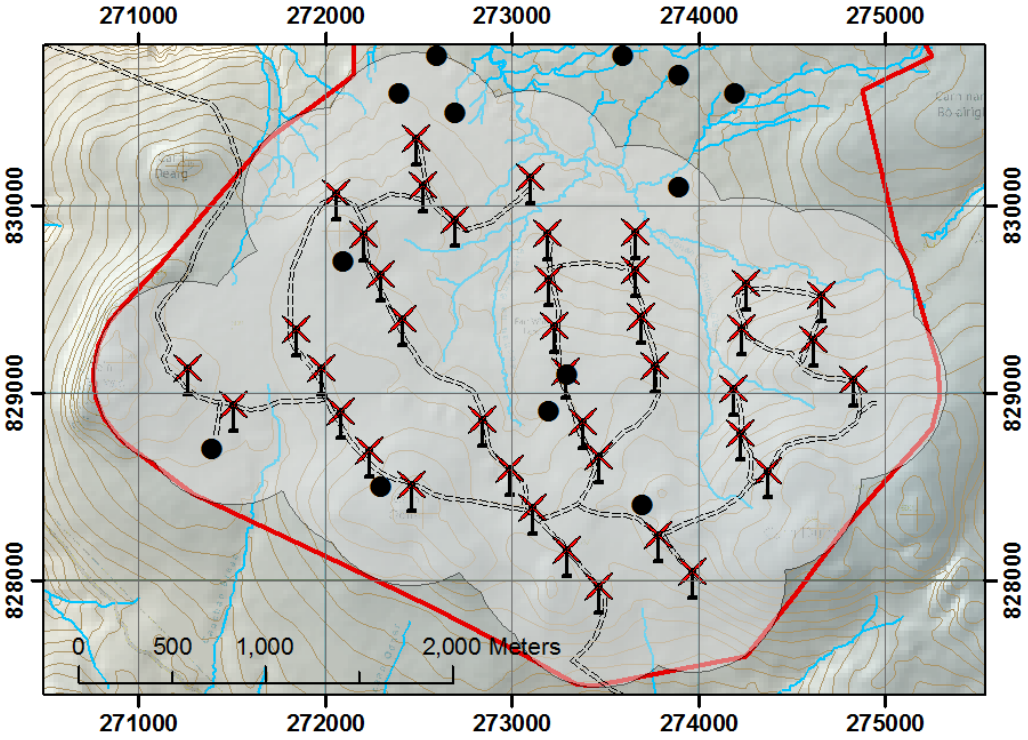


Figure 13. 2006 breeding season: Territory centres, plus turbines and 500 m buffer and wind farm red line boundary. The grid is 1 km. Contains Ordnance Survey data © Crown copyright and database.

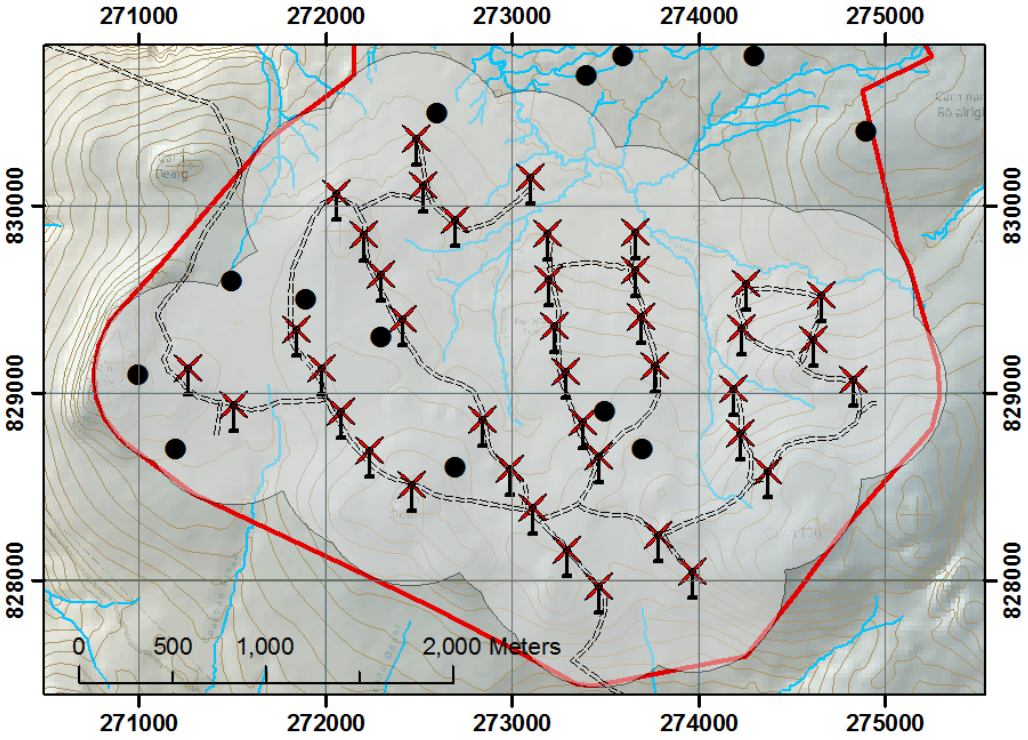


Figure 14. 2005 breeding season: Territory centres, plus turbines and 500 m buffer and wind farm red line boundary. The grid is 1 km. Contains Ordnance Survey data © Crown copyright and database.

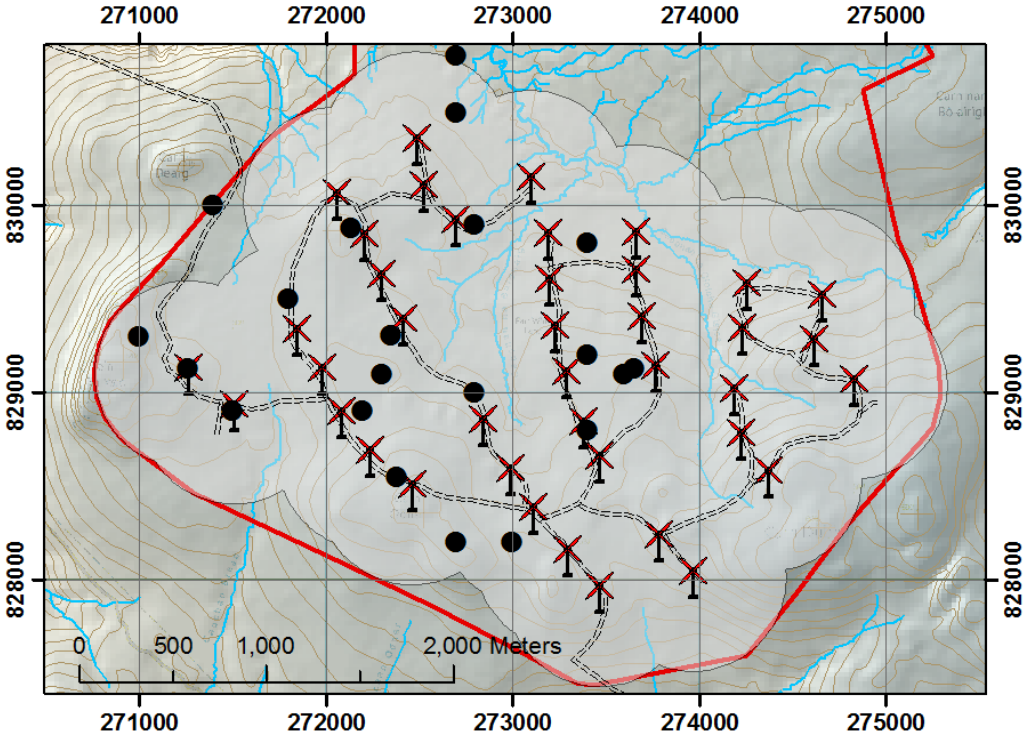


Figure 15. 2004 breeding season: Territory centres, plus turbines and 500 m buffer and wind farm red line boundary. The grid is 1 km. Contains Ordnance Survey data © Crown copyright and database.

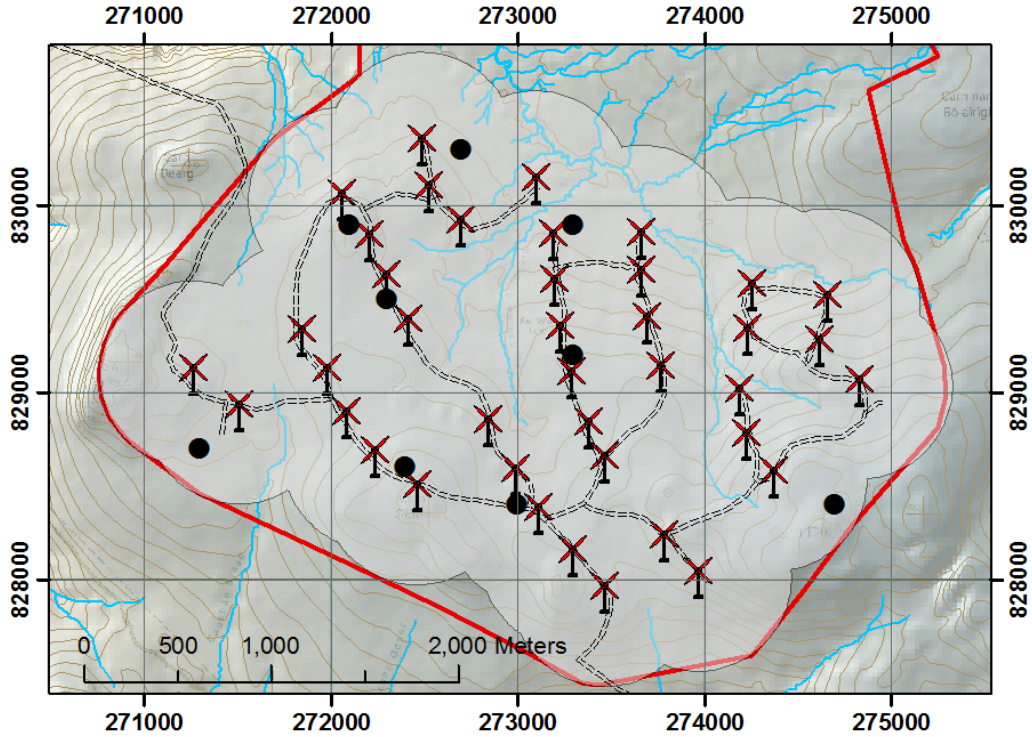


Figure 16. 2003 breeding season: Territory centres, plus turbines and 500 m buffer and wind farm red line boundary. The grid is 1 km. Contains Ordnance Survey data © Crown copyright and database.

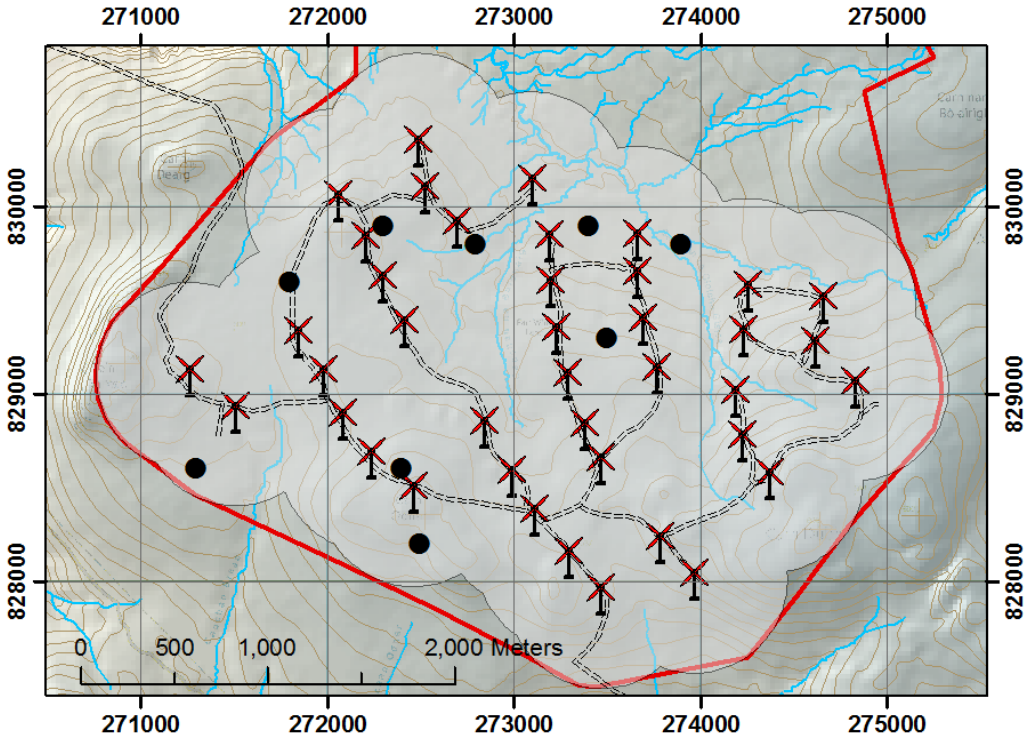
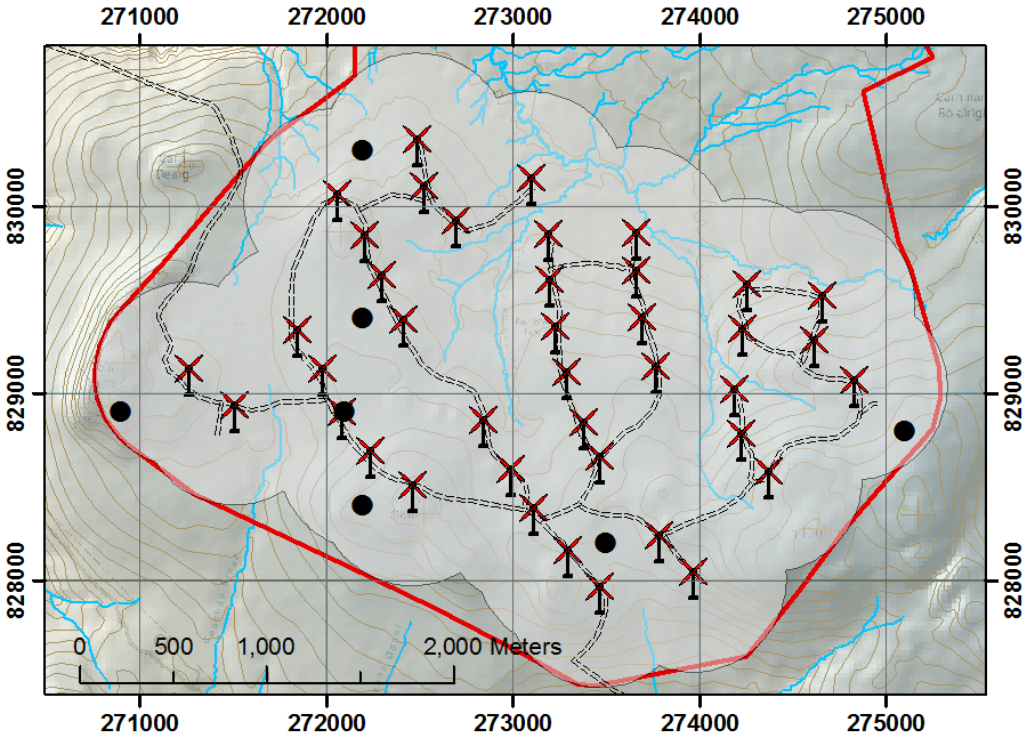


Figure 17. 2002 breeding season: Territory centres, plus turbines and 500 m buffer and wind farm red line boundary. The grid is 1 km. Contains Ordnance Survey data © Crown copyright and database.



5. Discussion

5.1 Under scenario 2 there would have been immediate displacement of dunlin away from the turbines. Eleven years of monitoring data confirms the absence of any wind farm induced change in dunlin distribution or abundance.

5.2 The Pearce-Higgins *et al.* (2009) study did not include dunlin but the later Pearce-Higgins *et al.* (2012) study did not find any evidence for an impact of wind farms on dunlin. Indeed, if there was any effect it appeared to be positive in that the average dunlin density was greater, although not significantly, during construction and operation than pre-construction (Fig. 1 in Pearce-Higgins *et al*., 2012).

5.3 At Farr, there was also no evidence for a systematic change in the pattern of dunlin territories or the proportion of wind farm territory centres within 200 m of turbine bases (Table 1).

5.4 The mean distances to the nearest turbines in 2002 and 2015 were 257 and 260 m respectively. There was also no trend in the mean distance to the five nearest turbines and no change to the number of territories in the wind farm (Table 1).

5.5 Under scenario 3 there should be an annual decline in the number of dunlin attempting to breed with the wind farm region at a rate that is a function of the annual adult survival rate. Although there was a decline in the number of territories in 2012 the number increased above the pre-construction figure in 2013 and has remained higher through 2014 and 2015.

5.6 There is no reason to suppose, particularly given the distribution of territory centres and nest sites, that the Farr wind farm has had any impact on the number and distribution of dunlin using the site.

6. Conclusions

6.1 **In conclusion, there is no evidence for a biologically significant decline in the number of dunlin attempting to breed at the Farr wind farm or in the spatial pattern of their territories either with respect to each other or the turbines.**

6.2 **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**.

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

7. References

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Appendix A Spatial Statistics

A.1. Wind farm mean territory centres

Year	Min X	Min Y	Max X	Max Y	Mean X	Mean Y
2002	270900	828200	275100	830300	272600	828986
2003	271300	828200	273900	829900	272656	829300
2004	271300	828400	274700	830300	272789	829211
2005	271000	828200	273600	830800	272620	829280
2006	271000	828600	273700	830500	272267	829211
2007	271400	828400	273900	830800	272760	829530
2008	271200	828500	273800	830800	272482	829427
2009	271600	828300	274900	830800	272583	829292
2010	271400	828200	274500	830700	272564	829286
2011	271200	828300	275100	830600	272817	829217
2012	271200	828200	274500	830400	272833	828944
2013	271300	828200	274600	830500	272827	829455
2014	271300	828400	273900	830500	272542	829375
2015	271300	828200	274300	830400	272550	829225
All	270900	828200	275100	830800	272635	829267

A.2. Number of dunlin territories and distances (m) from territory centres to the nearest turbine and the nearest five turbines. Min. Distance is the smallest distance from any territory centre to a turbine. Also shown are means, standard errors and the lower and upper 95% confidence limits.

			Nearest single turbine				Nearest five turbines			
Year	Territories	Min. Distance	Mean	SE	LCL	UCL	Mean	SE	LCL	UCL
2002	7	39.2	257.2	45.5	149.6	364.9	493.0	80.9	301.7	684.3
2003	9	125.9	224.1	27.0	163.0	285.2	413.5	44.1	313.7	513.3
2004	9	101.0	181.0	29.8	113.7	248.4	403.6	44.1	304.0	503.3
2005	15	7.6	209.9	34.0	137.3	282.5	437.9	41.9	348.5	527.3
2006	9	128.3	253.7	34.0	176.8	330.7	488.3	53.9	366.3	610.3
2007	10	27.2	240.0	39.7	151.5	328.5	486.7	50.8	373.6	599.8
2008	11	61.3	217.7	44.6	119.7	315.8	472.2	52.1	357.5	587.0
2009	12	65.9	260.6	40.8	171.6	349.5	481.9	47.4	378.7	585.2
2010	14	82.3	265.7	36.4	187.7	343.7	489.5	43.3	396.7	582.3
2011	12	82.3	308.4	40.6	220.0	396.9	550.4	50.6	440.0	660.7
2012	9	109.7	284.1	31.6	212.5	355.6	478.6	48.6	368.7	588.5
2013	11	128.3	288.1	39.5	201.2	375.0	502.3	47.4	398.0	606.7
2014	12	82.3	263.2	41.5	171.8	354.6	454.3	55.7	331.8	576.8
2015	12	103.1	259.9	34.4	184.2	335.6	455.3	53.2	338.3	572.3
All	152	7.6	249.6				475.8			