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Supplementary material

Appendix 1. Summary about the implications of potential type I and II errors, based on Fieberg and Börger (2012).

In our study, we wanted to assess which habitats are used by nightjars to forage or breed and which are not. Therefore we estimated home range size by calculating fixed kernels, which is a type of a kernel density estimator (KDE). Traditional statistical home range estimators, such as KDEs, often do not include areas known to be used by animals or include areas known not to be used (White and Garrott 1990, Getz and Wilmers 2004, Getz et al. 2007). These errors are also known as type I and type II errors, respectively.

In case of KDE, home range estimates obtained from the 95% kernel often decrease with sample size (Belant and Follmann 2002, Barg et al. 2005, Fieberg 2007) causing home ranges to fragment into multiple, small polygons. Estimates of large datasets, thus, have the tendency to leave out traveling corridors, resulting in type I errors. Whereas small datasets are typically sensitive to type II errors (due to over smoothing) (Fieberg and Börger 2012).

In our case, we used a fixed multiplier of 0.4 to limit the number of multi-modal home ranges or inclusion of large unused areas. Thus, this reduced the risk of making type II errors which in other cases would incorrectly define habitats that were used to travel as breeding/foraging areas (Fieberg 2007). This resulted in a clear demarcation of habitats used by nightjars to breed or forage.

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Belant, J. L. and Follmann, E. H. 2002. Sampling Considerations for American Black and Brown Bear Home Range and Habitat Use. - Ursus 13: 299–315.

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Fieberg, J. and Börger, L. 2012. Could you please phrase “home range” as a question? - J. Mammal. 93: 890–902.

Getz, W. M. and Wilmers, C. C. 2004. A local nearest neighbor convex-hull construction of home ranges and utilization distribution. - Ecography (Cop.). 27: 1–17.

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Appendix 2. Habitat ranking

Table A1 (habitat ranking). Ranking of habitats in 50% kernels (orange) and 95% kernels (black) as calculated by compositional analysis. Ranking 50% kernels = Pine forest (young)>Pine forest (old), high undergrowth)>Wide track>Dune>Pine forest (old) with low undergrowth)>Clearcuts>Dry heathland>Oak stands>>>Swamp>Agricultural land>Natural water>>>Clearcuts with broom>Wet heathland>River valley>Mixed pine forest>Clearcut with rejuvenation>Recreational area>Grassland>Urbanization>Farmland. Ranking 95% kernels = Pine forest (young)>Pine forest (old), with high undergrowth>Wide track>Dry heathland>Grassland>Recreational area>Pine forest (old), with low undergrowth>Oak stands>Clearcuts>Dune>River valleyl>Urbanization=Clearcut with rejuvenation>Wet heathland=Agricultural area>Clearcuts with broom>Natural water>Farmland>Swamp>Mixed pine forest;). See 1able 1 for habitat abbreviations. (“+” or “-“ = higher or lower ranking, “+++” or “---“ = significant higher or lower ranking, “=” = equally used).

	Natural Water	Farmland	Dry Heathland	Wet Heathland	Inland dune	Agricultural land	Grassland	Wide track	Clearcuts with broom	Swamp	Mixed pine forest	Pine forest (young)	Pine forest (old), low undergrowth	Pine forest (old), high undergrowth	Oak stand	Clearcut	Clearcut with rejuvenation	Recreational area	Urbanization	River valley	Rank 95%
Natural Water		+++	---	+	---	-	+	---	+	-	+++	---	---	---	-	---	+++	+++	+++	+	3
Farmland	-		---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	-	---	2
Dry Heathland	+++	+++		+++	-	+++	+++	- (---)	+++	+++	+++	---	-	-	+	-	+++	+++	+++	+++	16
Wet Heathland	+	+	---		---	-	+	---	---	---	+	---	---	---	---	---	+	+	+	+	6
Inland dune	+++	+++	-	+++		+++	+++	-	+++	+++	+++	---	+	-	+	+	+++	+++	+++	+++	10
Agricultural land	+	+ (+++)	---	-	-		+	---	+	-	+	---	---	---	-	---	+	+	+++	+	5

Grassland	+++	+++	-	+++	+	+++		---	-	---	-	---	---	---	---	---	-	-	+	-	15
Wide track	+++	+++	+	+++	+	+++	+		+++	+++	+++	-	+	-	+++	+	+++	+++	+++	+++	17
Clearcuts with broom	+	+	---	-	---	-	---	---		-	+++	---	---	---	-	---	+	+	+++	+	4
Swamp	-	-	---	-	---	-	---	---	-		+++	---	---	---	---	---	+++	+++	+++	+++	1
Mixed pine forest	-	---	---	---	---	---	---	---	---	-		---	---	---	---	---	+	+	+	-	0
Pine forest (young)	+++	+++	+	+++	+++	+++	+++	+	+++	+++	+++		+++ (+)	+	+++	+++	+++	+++	+++	+++	19
Pine forest (old), low undergrowth	+++	+++	-	+	+	+++	-	-	+++	+++	+++	---		-	+	+	+++	+++	+++	+++	13
Pine forest (old), high undergrowth	+++	+++	+	+++	+++	+++	+	+	+++	+++	+++	-	+++		+++	+++	+++	+++	+++	+++	18
Oak stand	+++	+++	-	+++	+	+	-	-	+++	+++	+++	---	-	---		-	+++	+++	+++	+++	12
Clearcut	+	+++	-	+	+	+	-	-	+	+++	+++	---	-	---	-		+++	+++	+++	+++	11
Clearcut with rejuvenation	+	+	---	+	-	+	---	---	+	+++	+++	---	-	---	-	-		+	+	-	7
Recreational area	+++	+++	-	+++	+	+	-	-	+++	+++	+++	---	+	-	+	+	+++		+	-	14
Urbanization	+	+	---	+	-	-	---	---	+	+++	+++	---	---	---	-	-	+	---		-	8
River valley	+	+	---	+	-	+	---	-	+	+++	+++	---	-	---	-	-	+	---	+		9
Rank 50%	9	0	13	7	16	10	2	17	8	11	5	19	15	18	12	14	4	3	1	6	

Appendix 3. Observation estimates.

In order to improve the accuracy of telemetry observations, we elaborately tested the error of the tags on 1) tags that were not attached to birds (within different habitats), 2) stationary birds (breeding and singing) and 3) on stationary birds at known foraging locations. At the start of every field season, we tested the accuracy of position estimates with stationary tags, not attached to birds. We measured the accuracy of tags in open and closed habitats. The same two observers performed this test at the start of every field season. We calculated the error margin (45±32m) of (all) stationary tags that were located at a distance of 500m with forests or open areas in between the tag and observer. This error margin was determined by following the "one person" procedure, described in the Methods-section. The Table "Accuracy of telemetry" shows raw data, collected during five field seasons.

Furthermore, nightjars can forage following different strategies, such as sit-and-wait (similar to described by (Camacho 2013)) and on-the-wing. Using infrared binoculars, we observed that nightjars mainly forage following the sit-and-wait method when located in foraging habitat. Consequently, we decided that birds were stationary when foraging.

If observation-lines did not line up, we chose the centre point between the crossing lines as an estimate of the bird's location. When location estimates were located at the boundary of habitats, they were placed at the side of foraging habitat. Based on observations of foraging nightjars, we felt confident to do this because these birds usually forage within suitable habitats, or at the boundaries of these habitats.

To clarify further, we studied habitat selection by comparing available habitat with kernel placement, following standard procedures (Aebischer et al. 1993). Home range kernels were derived from location estimates and estimated using a fixed multiplier to limit the number of multimodal home ranges or the inclusion of large unused areas which otherwise would incorrectly define as habitats that were actually used to travel, as breeding/foraging areas. Home ranges thus are estimates, built to approximate the field-situation based upon visual inspection. According to the procedures we followed, we believe that the (average) 190ha home-ranges are such an approximation of the field-situation and account for the 45m errors (see figure below).

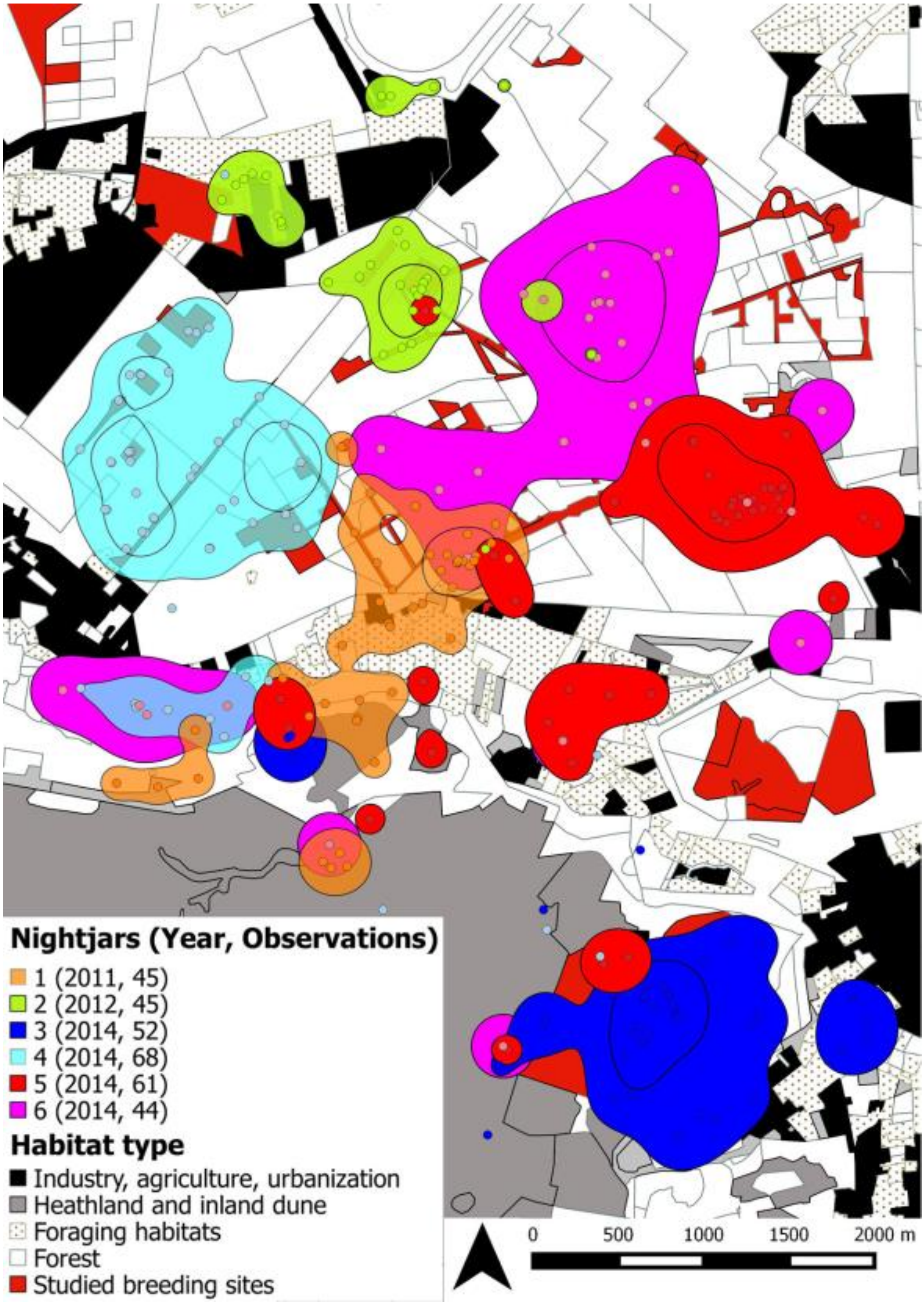

Figure A1. Home range of six individuals, including telemetry observations. Each colour represents the home range of one individual, with 50% kernels as the inner circles and 95% kernels as the outer circles. Points represent telemetry observations.

Table A2 (Accuracy of telemetry). Error measurements (in meters, distance between measured and observed location) collected during 5 years in two habitat types (Open and Forest). Averages and standard deviations are shown below.

	2010	2010	2011	2011	2012	2012	2013	2013	2014	2014
Observation	Open	Forest	Open	Forest	Open	Forest	Open	Forest	Open	Forest
1	7	26	42	34	13	45	11	86	10	91
2	10	62	29	18	30	61	28	79	26	89
3	23	103	26	65	47	80	14	81	21	92
4	20	61	32	85	30	70	19	46	40	87
5	41	86	9	7	35	55	21	49	14	113
6	7	55	3	62	37	46	1	97	44	97
7	10	16	29	52	18	91	30	98	48	60
8	25	49	15	37	19	63	16	61	41	117
9	2	33	6	21	82	24	9	58	15	55
10	27	52	45	49	29	80	16	80	17	83
11	19	34	8	70	34	48	19	105	27	93
12	2	81	39	59	72	115	28	75	18	93
13	18	44	1	68	35	19	17	88	3	70
14	16	110	1	27	58	67	32	123	1	107
15	34	70	21	25	48	96	18	83	4	72
16	25	80	31	7	46	63	23	66	9	77
17	43	37	15	31	41	39	11	77	4	81
18	54	43	34	10	49	25	25	73	36	60
19	54	55	40	79	66	91	26	28	10	83
20	39	62	46	61	20	58	11	61	7	101
21	64	80	12	64	19	35	29	73	7	46
22	60	75	18	62	32	159	18	31	7	111
23	39	6	6	44	32	149	22	53	3	68
24	47	92	9	52	49	72	6	64	22	95
25	46	30	41	36	25	30	28	39	5	107
26	17	17	12	75	20	62	24	35	22	40
27	62	32	10	23	27	99	24	109	19	88
28	43	87	11	11	34	75	18	93	8	92
29	27	134	11	59	13	2	26	77	19	82
30	38	116	10	12	13	152	26	100	22	82
31	7	64	18	50	15	96	43	45	33	101
32	21	68	39	23	42	33	28	82	24	85
33	43	66	6	109	8	85	14	58	7	74
34	44	71	21	9	23	18	23	66	15	84
35	58	17	22	85	4	92	9	80	15	81
36	1	89	39	57	34	62	24	37	5	101
37	12	104	59	8	9	102	2	80	12	91
38	21	64	31	96	11	87	36	57	13	67

39	38	70	3	48	40	119	25	103	22	68
40	31	111	2	23	8	68	27	78	15	104
41	23	39	9	16	5	29	32	72	16	67
42	54	73	36	86	48	117	15	116	24	97
43	45	102	27	44	12	56	1	67	10	74
44	41	1	38	17	40	39	10	103	20	71
45	6	59	47	12	53	152	21	92	10	90
46	38	64	4	52	48	82	15	56	5	89
47	22	36	32	8	18	28	25	91	6	75
48	51	72	46	0	3	62	15	100	1	65
49	16	111	23	19	25	158	6	116	11	66
50	24	127	0	43	50	23	7	100	50	74
51	42	4	45	42	6	97	23	64	7	56
52	45	88	17	66	46	72	15	37	5	87
53	38	53	59	6	28	28	26	84	23	86
54	33	99	0	71	11	25	28	108	1	68
55	15	32	2	107	33	39	28	71	24	80
56	10	38	1	35	22	78	41	84	30	91
57	41	34	13	68	58	126	17	62	19	65
58	23	40	5	11	0	149	24	66	4	66
59	26	59	9	34	16	110	31	50	48	87
60	40	38	44	97	2	101	20	70	2	58
61	7	87	12	37	40	89	28	96	30	91
62	25	52	31	29	21	35	38	67	19	82
63	32	33	19	10	38	63	33	132	9	86
64	21	68	19	50	32	89	29	50	7	88
65	6	54	27	67	39	88	18	30	4	96
66	31	64	14	40	1	66	22	51	13	112
67	18	89	32	58	1	126	17	70	28	56
68	23	51	9	28	6	58	16	98	1	99
69	60	78	52	8	1	62	23	41	2	71
70	34	69	30	80	46	121	26	74	11	64
71	30	100	39	62	16	42	9	101	2	55
72	54	27	14	15	11	107	36	86	6	81
73	19	46	9	52	84	126	16	50	24	69
74	25	99	17	8	54	92	34	129	27	85
75	55	70	30	60	34	85	22	86	14	90
76			43	7	67	53	20	74	36	91
77			12	61	35	73	20	43	26	57
78			5	38	32	34	32	64	37	59
79			30	35	39	118	2	78	30	61
80			12		37	64	35	111	11	75
81			54		16	77	17	70	25	72
82					24	24	18	78	8	50
83					22	51	15	91	25	82

84					24	16	36	53	13	87
85					1	72	19	72	14	92
86					51	8	30	34	1	65
87					41	33	13	85	22	101
88					28	39	28	78	25	96
89					13	46	20	85	29	75
90					23	23	17	11	11	101
91					37	71	1	102	11	84
92					19	79	24	47	22	74
93					3	85	1	47	35	111
94					24	45	19	56	13	72
95					54	8	12	40	20	92
96					34	35	17	67	30	107
97					14	41	15	64	9	101
98					38	27	30	116	22	82
99					7	49	14	102	23	46
100					9	79	19	57	37	90
101					39	50	10	33	7	67
102					32	22	27	63	15	91
103					24	49	8	72	4	115
104					6	66	24	74	23	67
105					23	43	16	105	0	75
106					2	99	29	100	22	94
107					18	79	37	47	17	83
108					33	31	33	38	21	79
109					40	25	22	61	2	61
110					55	47	13	38	1	67
111					38	47	38	122	24	81
112					6	2	18	75	21	98
113					19	8	31	49	18	81
114					23	20	9	47	31	71
115					8	6	25	42	13	43
116					50	66	18	56	4	100
117					13	80	23	99	26	79
118					16	3	14	62	12	95
119					8	80	18	83	0	89
120					22	3	25	89	13	112
121					12	102	7	44	37	79
122					9	75	49	93	6	70
123					11	75	16	86	48	80
124					41	81	43	60	37	39
125					29	48	17	116	61	107
126					27		22	36	28	106
127					12		23	50	0	87
128					4		40	69	34	83

129					10		35	76	26	101
130					0		13	69	1	71
131					58		34	79	6	67
132					5		27	110	35	91
133					43		15	36	12	79
134					11		31	76	19	97
135					6		10	60	33	79
136					18		30	41	13	72
137					23		25	90	28	123
138							48	73	31	79
139							20	102	3	66
140							8	55	15	112
141							45	79	24	80
142							23	35	4	113
143							14	94	2	104
144							30	53	6	102
145							17	46	12	83
146							33	92	27	81
147							34	31	19	85
148							8	51	15	63
149							25	102	41	90
150							1	69	20	110
151							5	34	6	49
152							13	72	21	80
153							28	33	54	72
154							17	18	30	77
155							7	64	31	79
156							14	63	7	86
157							31	55	20	75
158							22	37	34	83
159							18	46	19	76
160							28	53	35	83
161							7	86	12	70
162							28	68	14	67
163							23	80	28	
164							29	35	27	
165							12	57	36	
166							10	87	4	
167							23	53	19	
168							27	33	4	
169								81	22	
170								97	30	
171								47	17	
172								91	50	
173								69	26	

174								83	29	
175								96	24	
176								90	36	
177								29	15	
178								125	1	
179								19	35	
180								100	10	
181								74	25	
182								129	37	
183								72	9	
184								36	16	
185								78	22	
186								49	4	
187								39	6	
188								65	1	
189								73	16	
190								84		
191								87		
192								79		
193										

Year	**2010**	**2010**	**2011**	**2011**	**2012**	**2012**	**2013**	**2013**	**2014**	**2014**	**Total**
Habitat	**Open**	**Forest**	**Open**	**Forest**	**Open**	**Forest**	**Open**	**Forest**	**Open**	**Forest**	**Total**
Average	30.2	62.8	22.5	42.9	27.0	64.9	21.4	70.6	18.4	82.0	45.2
Stdev.	16.5	29.8	15.9	27.1	18.1	36.7	9.9	25.0	12.7	16.8	32.3

References

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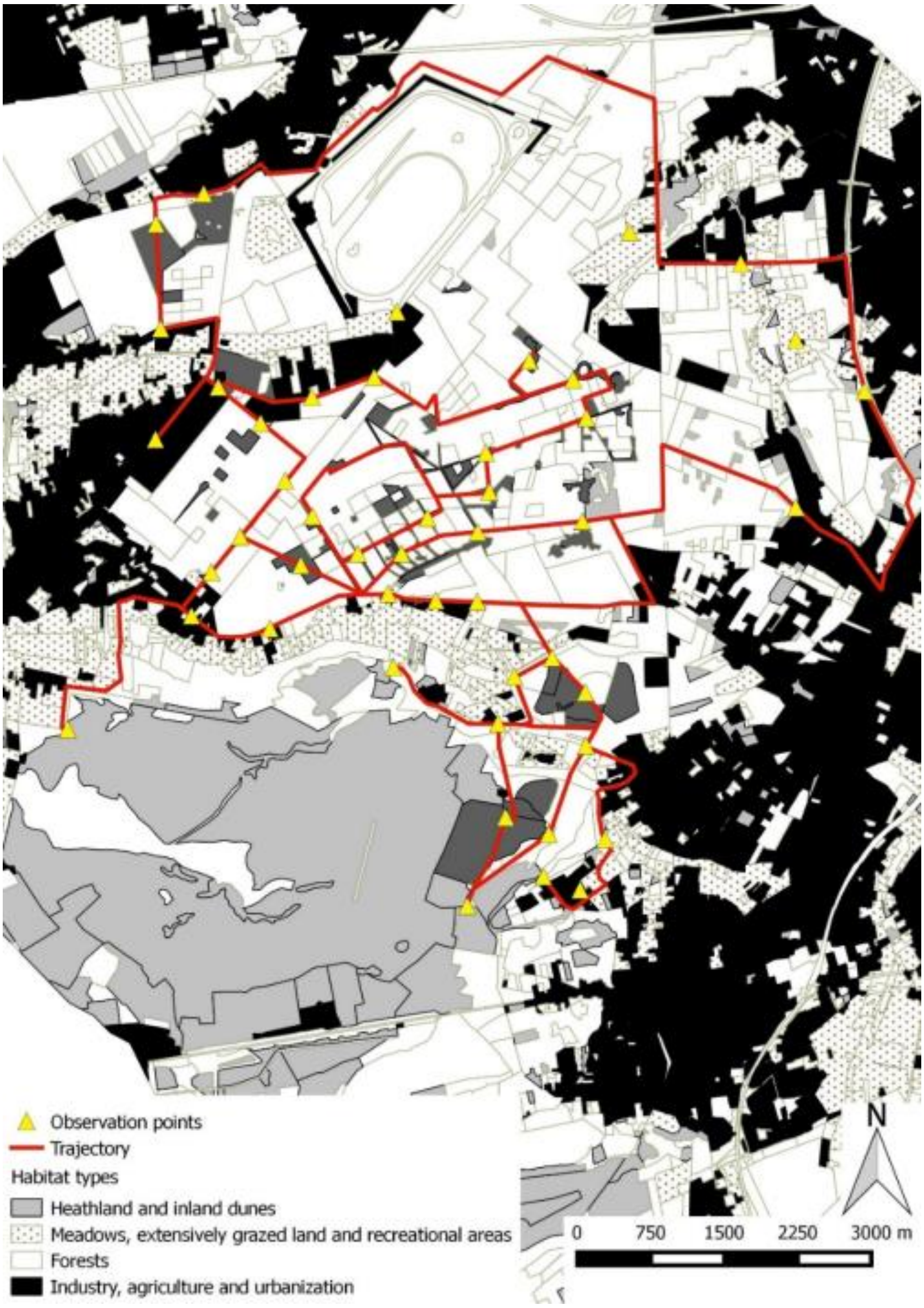
Appendix 4. Observation Route

Figure A2 (observation route). The monitoring route contains 47 monitoring points. On each point (yellow triangles) the presence of tagged birds was checked for four minutes. The time interval between consecutive locations was 4-7 minutes.



Appendix 5. Radio tracked birds

Table A3 (radio tracked birds). Information on the birds that were tracked during our study. ID = serial number, Ring = ring number, Sex: M = male, F = Female, Fixes = number of observations, Foraging distance Mean = mean foraging distance (meters), Foraging distance Mas = maximal foraging distance (meters), Homerange 50% = home range size 50% kernel, Homerange 95% = home range size 95% kernel.

ID	Ring	Sex	Year	Fixes	Foraging distance Mean	Foraging distance Max	Homerange 50%	Homerange 95%
1	20z70973	M	2010	105	511.32	2968.23	29.29	165.83
2	21z03141	M	2010	58	604.94	1419.18	23.77	142.84
3	21z03962	M	2010	33	599.46	2458.83	35.43	157.45
4	21z03963	F	2010	55	582.89	1791.24	24.84	179.86
5	21z03965	M	2010	37	453.75	1447.09	11.67	54.97
6	21z03977	F	2010	23	1175.48	2318.69	42.27	242.76
7	22z05133	M	2010	45	702.81	2391.79	28.51	93.51
3	21z03962	M	2011	38	451.69	1122.00	23.93	120.41
8	21z03985	M	2011	79	466.09	2309.88	12.55	64.49
9	21z03988	M	2011	74	474.44	1282.42	11.69	97.01
10	21z03990	M	2011	27	686.08	1635.28	17.36	92.38
11	21z03991	F	2011	66	669.89	2084.92	32.69	133.69
12	22z70312	M	2011	35	625.39	1740.52	22.86	121.31
13	22z70316	F	2011	51	691.45	2379.93	28.47	192.95
1	20Z70973	M	2012	44	669.75	3554.06	28.23	128.90
14	20Z70970	F	2012	40	835.41	3477.06	28.18	128.90
15	21Z03992	M	2012	76	672.06	3860.70	31.18	116.34
16	22z70322	M	2012	57	788.38	5109.92	28.87	108.50
17	22z70325	M	2012	45	677.73	1484.67	21.80	114.86
18	22z70326	F	2012	63	696.00	2522.66	20.85	91.03
19	22z70327	F	2012	34	760.28	2432.34	25.00	185.49
20	22z70328	M	2012	52	1042.98	5623.59	45.03	227.94
21	22z70329	M	2012	56	1366.59	5430.36	146.58	691.66
22	22z70331	M	2012	62	538.96	1790.23	13.41	60.30
23	22z70338	F	2012	46	1114.18	3039.82	54.88	255.09
24	22z70339	F	2012	30	1062.63	3059.80	39.56	264.57
25	22z70349	M	2012	21	959.77	2580.48	37.56	156.43
26	22Z05139	M	2013	38	826.39	2184.44	23.70	103.40
27	22z70382	M	2013	35	780.74	1981.13	39.74	233.09
28	22z70384	F	2013	38	427.53	1868.63	14.44	42.13
29	22Z70385	F	2013	48	937.77	1927.52	23.40	123.03
30	22Z70386	M	2013	41	761.89	1389.88	55.35	163.26
31	22Z70388	F	2013	36	734.63	1446.89	61.62	250.01
32	22Z70392	M	2013	24	953.06	2149.69	48.50	117.50
1	20Z70973	M	2014	78	785.61	2253.59	25.01	171.87
12	22Z70312	M	2014	68	1028.50	3474.40	111.72	291.29
33	21Z03987	M	2014	56	848.98	2194.08	99.17	264.30
34	21Z03996	F	2014	39	1195.47	4017.29	39.01	234.66
35	21Z39159	M	2014	70	1084.43	2237.37	101.73	332.98
36	21Z39181	M	2014	60	771.97	4181.13	73.37	201.32
37	21Z39197	M	2014	80	690.26	2043.31	39.36	151.05
38	22Z70301	F	2014	44	1292.11	4334.26	89.17	582.37
39	22Z70358	M	2014	61	1163.95	3723.25	59.40	324.85
40	22Z70394	M	2014	75	665.49	1706.39	53.93	226.14
41	22Z70395	M	2014	45	615.10	2190.29	35.30	111.61
42	23z32601	M	2014	100	489.64	1712.97	15.61	95.63
43	23z32605	F	2014	66	649.75	3262.00	46.15	133.72
44	23z32607	F	2014	87	1049.31	2728.06	115.30	379.26
45	23z32624	M	2014	61	1105.57	1311.60	17.68	56.38
46	23z32629	M	2014	49	1728.34	4453.25	116.23	428.60
47	23z32637	M	2014	50	1709.55	2295.09	34.06	183.69
48	23z32638	M	2014	52	710.16	2949.31	60.32	275.80