Supplementary information for:

Landscape changes affect habitat quality during the non-breeding season in three species of long-distance migratory songbirds

Table S1. Home range size, overlap and bird densities of three different Palaearctic migrants wintering in two different sites in northern Ghana. Different measures for home range size and overlap are shown. KD is fixed kernel density and MCP is minimum convex polygon. $PHR_{i,j}$ is the average probability of individual i to be in the home range of individual j. UDOI is the utilisation distribution overlap index (see methods). $HR_{i,j}$ is the percent of the home range of individual i that is within the home range of individual j.

Parameter	Method	Willow warbler		Melodious warbler		Pied flycatcher	
		Undisturbed	*Disturbed*	*Undisturbed*	*Disturbed*	*Undisturbed*	*Disturbed*
Home-range size (ha)	MCP100% (s.d.)	8.9 (6.4)	13.6 (11.2)	1.6 (1.5)	4.1 (4.7)	1.2 (1)	2.3 (2.6)
	MCP 50% (s.d.)	0.8 (0.8)	3.3 (1.6)	0.2 (0.2)	0.5 (0.8)	0.1 (0.1)	1.1 (1.7)
	95% KD (s.d.)	49.9 (41.9)	77.5 (86.4)	3.7 (3.7)	15.1 (25.8)	2.6 (1.9)	7.2 (7.3)
	50% KD (s.d.)	12.4 (11.3)	20.6 (22.8)	0.8 (0.8)	3.7 (7.1)	0.5 (0.3)	1.8 (2)
Home-range overlap (%)	$PHR_{i,j}$ (s.d.)	58 (38)	61 (27)	20 (25)	26 (19)	21 (30)	39 (37)
	UDOI (s.d.)	0.26 (0.08)	0.36 (0.2)	0.08 (0.07)	0.07 (0.06)	0.06 (0.08)	0.21 (0.23)
	$HR_{i,j}$ 95% KD (s.d.)	54 (35)	58 (28)	19 (27)	25 (17)	22 (18)	40 (36)
	$HR_{i,j}$ 50% KD (s.d.)	40 (37)	35 (17)	17 (24)	3 (5)	2 (4)	27 (39)
Average bird counts (hectare^{-1})	-	0.34 (1.42)	0.91 (2.47)	0.12 (0.53)	0.15 (0.58)	0.82 (1.25)	0.62 (1.19)

Table S2. The adjusted R^2 values of the different model structures predicting different measures of home range size as well as overlap. Including p-values for each of the different factors in the model structure tested. For each measure of home range size, we run models both with site and with tree cover as predictors. All models include first day of tracking and number of points as parameters to take any effect into account, but we are not interested in estimating their effect. All p-values < 0.05 are highlighted in grey.

Model*	Adjusted R2	df	P-WW	P-MW	P Site/Tree cover	P WW-interaction	P MW-interaction
KD95 ~ Species + Site + Species*Site	0.54	8, 22	0.004	0.541	0.101	0.616	0.888
KD95 ~ Species + Site	0.57	6, 24	0.000	0.421	0.031	-	-
KD95 ~ Species	0.50	5, 25	0.000	0.295	-	-	-
KD95 ~ Site	0.33	4, 26	-	-	0.004	-	-
KD95 ~ Species + Treecover + Species*Treecover	0.54	8, 22	0.134	0.792	0.153	0.638	0.997
KD95 ~ Species + Treecover	0.57	6, 24	0.001	0.337	0.032	-	-
KD95 ~ Species	0.50	5, 25	0.000	0.295	-	-	-
KD95 ~ Treecover	0.36	4, 26	-	-	0.002	-	-
MCP100 ~ Species + Site + Species*Site	0.46	8, 22	0.006	0.430	0.162	0.781	0.882
MCP100 ~ Species + Site	0.50	6, 24	0.000	0.303	0.053	-	-
MCP100 ~ Species	0.44	5, 25	0.000	0.213	-	-	-
MCP100 ~ Site	0.22	4, 26	-	-	0.007	-	-
MCP100 ~ Species + Treecover + Species*Treecover	0.49	8, 22	0.281	0.868	0.089	0.821	0.872
MCP100 ~ Species + Treecover	0.53	6, 24	0.000	0.257	0.020	-	-
MCP100 ~ Species	0.44	5, 25	0.000	0.213	-	-	-
MCP100 ~ Treecover	0.28	4, 26	-	-	0.002	-	-
KD50 ~ Species + Site + Species*Site	0.58	8, 22	0.004	0.438	0.053	0.545	0.649
KD50 ~ Species + Site	0.61	6, 24	0.000	0.469	0.019	-	-
KD50 ~ Species	0.52	5, 25	0.000	0.325	-	-	-
KD50 ~ Site	0.38	4, 26	-	-	0.003	-	-
KD50 ~ Species + Treecover + Species*Treecover	0.62	8, 22	0.249	0.717	0.025	0.786	0.479
KD50 ~ Species + Treecover	0.64	6, 24	0.000	0.340	0.006	-	-
KD50 ~ Species	0.52	5, 25	0.000	0.325	-	-	-
KD50 ~ Treecover	0.44	4, 26	-	-	0.001	-	-
MCP50 ~ Species + Site + Species*Site	0.56	8, 22	0.024	0.139	0.007	0.860	0.098
MCP50 ~ Species + Site	0.53	6, 24	0.005	0.711	0.004	-	-
MCP50 ~ Species	0.35	5, 25	0.001	0.479	-	-	-
MCP50 ~ Site	0.38	4, 26	-	-	0.000	-	-
MCP50 ~ Species + Treecover + Species*Treecover	0.56	8, 22	0.432	0.114	0.007	0.623	0.056

Model							
MCP50 ~ Species + Treecover	0.52	6, 24	0.005	0.463	0.005	-	-
MCP50 ~ Species	0.35	5, 25	0.001	0.479	-	-	-
MCP50 ~ Treecover	0.37	4, 26	-	-	0.001	-	-
PHR ~ Species + Site + Species*Site	0.25	8, 22	0.011	0.544	0.516	0.514	0.147
PHR ~ Species + Site	0.24	6, 24	0.009	0.466	0.918	-	-
PHR ~ Species	0.27	5, 25	0.004	0.445	-	-	-
PHR ~ Site	-0.04	4, 26	-	-	0.263	-	-

* All models include first day of tracking and number of relocations as parameters to take any effect into account

Table S3. Number of trees and tall trees per home range. 100% MCP is used as home range, and multiplied by average tree and tall tree density per site.

	Willow warbler		Melodious warbler		Pied flycatcher	
	Undisturbed	*Disturbed*	*Undisturbed*	*Disturbed*	*Undisturbed*	*Disturbed*
Trees per home range (s.d.)	8542 (6085)	8109 (6669)	1499 (1465)	2450 (2781)	1134 (971)	1391 (1565)
Tall trees per home range (s.d.)	884 (629)	583 (480)	155 (152)	176 (200)	117 (100)	100 (113)

Table S4. Measures of available and used tree heights as well as densities of tress (>2 m) and of tall trees (>10 m) in a disturbed and an undisturbed site in northern Ghana. The used tree heights are shown for three different species of Palearctic migrants, and the available tree height is average height of trees in transect plots.

Metric	*Disturbed*		*Undisturbed*	
	n	**Estimate**	**n**	**Estimate**
PF tree height (m)	49	14	101	18
WW tree height (m)	40	15	29	20
MW tree height (m)	15	17	74	18
Available tree height (m)	611	5	510	5
Tree density (trees/ha)	129	607	68	957
Tall tree density (trees/ha)	129	43	68	99

Table S5. Selection rank of the 5 most available tree genera for the three species. For each species the genera have been ranked both from a model including only genus and from a model including both genus and tree height. When height is taken into account, there is less selection for tall genera like *Daniellia*.

Rank	WW		MW		PF	
	Genus	Genus+height	Genus	Genus+height	Genus	Genus+height
1	*Acacia*	*Other*	*Acacia*	*Acacia*	*Other*	*Other*
2	*Daniellia*	*Acacia*	*Daniellia*	*Other*	*Acacia*	*Acacia*
3	*Other*	*Lophira*	*Other*	*Daniellia*	*Daniellia*	*Vitellaria*
4	*Lophira*	*Daniellia*	*Pterocarpus*	*Pterocarpus*	*Vitellaria*	*Daniellia*
5	*Vitellaria*	*Vitellaria*	*Vitellaria*	*Vitellaria*	*Pterocarpus*	*Pterocarpus*
6	*Pterocarpus*	*Pterocarpus*	*Lophira*	*Lophira*	*Lophira*	*Lophira*

TableS6. Home range metrics of all birds. Home ranges are measured in hectares and overlaps are measured in percentage.

| Name	Species	site	Start date	days	Num points	MCP100	MCP50	KD95	KD50	Overlap KD95	Overlap KD50	Overlap MCP100	Overlap MCP50	PHR KD	UDOI KD
A17_2011	MW	A	13-03-2011	13	28	1.27	0.11	2.44	0.44	NA	NA	NA	NA	NA	NA
A02_2012	MW	A	04-02-2012	12	25	0.71	0.13	1.43	0.34	50.00	43.92	38.53	0.00	0.12	0.13
A04_2012	MW	A	06-02-2012	11	22	3.81	0.47	9.20	2.09	7.78	7.21	7.14	0.00	0.47	0.13
A17_2012	MW	A	11-02-2012	5	12	0.48	0.10	1.79	0.42	0.00	0.00	0.00	0.00	0.00	0.00
C03_2011	MW	C	23-02-2011	18	46	2.71	0.05	3.89	0.54	22.48	8.41	15.71	0.00	0.01	0.00
C10_2011	MW	C	24-02-2011	19	38	2.21	0.17	4.26	0.70	42.80	17.82	27.34	0.00	0.34	0.07
C11_2011	MW	C	26-02-2011	18	38	0.77	0.08	1.39	0.27	55.40	27.72	16.24	0.00	0.20	0.12
C12_2011	MW	C	26-02-2011	22	36	5.34	0.57	11.48	2.26	29.57	8.38	24.64	0.00	0.52	0.02
C96_2011	MW	C	28-03-2011	2	12	0.62	0.07	2.53	0.53	50.66	12.91	16.50	0.00	0.24	0.13
C14_2012	MW	C	10-02-2012	4	11	12.93	2.06	67.21	18.11	NA	NA	NA	NA	NA	NA
A01_2011	PF	A	20-02-2011	17	13	0.09	0.01	0.28	0.07	36.33	0.00	50.00	0.00	0.01	0.01
A14_2011	PF	A	01-03-2011	19	35	0.24	0.03	0.51	0.10	50.00	0.00	22.87	0.00	0.04	0.04
A15_2011	PF	A	01-03-2011	16	32	2.64	0.10	4.88	0.89	7.29	0.00	3.71	0.00	0.82	0.04
A01_2012	PF	A	04-02-2012	13	27	1.46	0.11	3.30	0.59	10.98	0.00	0.00	0.00	0.07	0.01
A05_2012	PF	A	06-02-2012	11	25	2.38	0.18	4.81	0.88	20.27	4.58	9.84	0.00	0.34	0.17
A06_2012	PF	A	06-02-2012	11	24	0.91	0.07	2.36	0.39	31.86	10.28	25.87	0.00	0.17	0.17
A15_2012	PF	A	11-02-2012	5	14	0.58	0.02	2.02	0.35	0.00	0.00	0.00	0.00	0.00	0.00
C04_2011	PF	C	24-02-2011	18	40	6.22	3.70	17.90	4.73	29.75	24.83	9.46	1.11	0.93	0.42
C97_2011	PF	C	28-03-2011	4	12	1.14	0.24	5.70	1.44	93.31	82.24	51.63	17.10	0.35	0.42
C08_2012	PF	C	08-02-2012	8	22	0.58	0.15	1.87	0.49	24.05	0.00	0.00	0.00	0.09	0.01
C09_2012	PF	C	08-02-2012	6	21	1.36	0.21	3.37	0.71	13.33	0.00	0.00	0.00	0.20	0.01
A03_2012	WW	A	06-02-2012	3	12	12.82	0.81	52.40	11.75	43.54	24.71	26.51	0.00	0.72	0.30
A19_2012	WW	A	11-02-2012	5	11	12.37	1.59	90.43	24.03	25.74	13.14	28.94	0.89	0.88	0.32
A21_2012	WW	A	11-02-2012	5	11	1.59	0.07	6.78	1.48	93.16	82.40	54.48	20.22	0.16	0.17
C06_2011	WW	C	24-02-2011	7	13	6.46	3.61	29.09	8.42	57.83	29.23	29.98	3.06	0.60	0.57
C07_2011	WW	C	24-02-2011	9	14	9.11	3.32	32.95	9.22	53.66	30.43	22.32	0.09	0.65	0.53
C08_2011	WW	C	24-02-2011	9	12	14.16	3.32	75.38	19.64	31.09	15.64	16.63	3.25	0.90	0.52
C10_2012	WW	C	09-02-2012	7	11	35.67	5.85	249.95	66.16	13.70	9.01	5.30	0.00	0.90	0.18
C12_2012	WW	C	09-02-2012	4	12	8.16	2.38	50.42	13.36	56.57	29.53	12.25	0.00	0.34	0.17
C13_2012	WW	C	10-02-2012	3	15	7.81	1.10	27.26	6.82	78.94	33.91	21.28	0.00	0.28	0.16
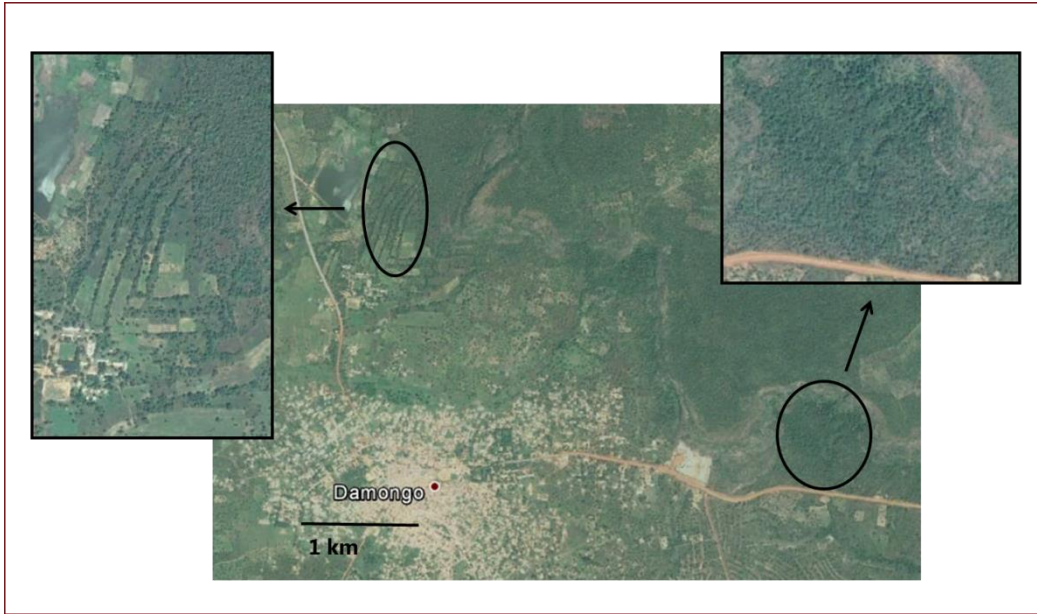
Figure S1. Study area near Damongo, northern Ghana. Circles and insert images show the two study sites. Left circle and insert image are the disturbed site and right circle and insert image are the undisturbed site.
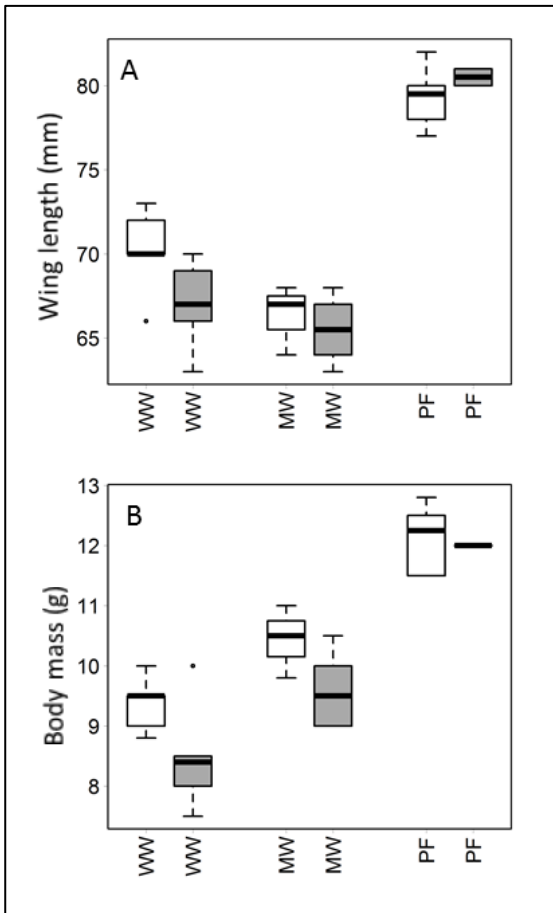
Figure S2. Biometrics. Flattened wing length (A), measured to the nearest 0.5 mm using a wing ruler and body mass (B), measured to the nearest 0.5 g using a Pesola spring scale, of each species in each site (undisturbed: open boxes, disturbed: filled boxes). The box plots show: minimum, 1st quartile, median, 3rd quartile and maximum. The tracked Willow Warblers at the undisturbed site had significantly longer wings than those at the disturbed site (undisturbed: 70.2 ± 2.7mm [mean ± SD], n=5; disturbed: 67.1 ± 2.3mm, n=10; U=41, P=0.047; Fig.S2), and a higher body mass (undisturbed: 9.4 ± 0.47g; disturbed: 8.5 ± 0.84g; U=41, P=0.047), indicating that the individuals tracked at the undisturbed site were bigger than those tracked at the disturbed site. Neither Pied Flycatcher nor Melodious Warbler differed significantly in biometrics between the two sites.