Urbanization does not affect green space bird species richness in a mid-sized city

Urban Ecosystems

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Supplementary material

Fig. S1 Typical German allotments with bushes, fruit trees, vegetable plants, small lawn patches and bungalows (photos by P. Batáry).

Appendix S1 UrbanEcosyst_Koranyi.kmz

Location of the 52 bird survey points in the 34 green spaces in the city of Göttingen. Allotment names are coded with ‘KGV’, parks with ‘Park’.

Table S1 List of the selected artificial landscape elements around each GSs**,** their degree of soul sealing (based on the mapping guide of European Urban atlas and Google aerial photographs) and their total proportions in the examined 500 m radius buffers. For more details on these landscape elements see the mapping guide (https://land.copernicus.eu/user-corner/technical-library/urban-atlas-mapping-guide).

Landscape element	Degree of soil sealing	Total percentage
Urban fabrics		
Continuous urban fabric	90	17.25
Discontinuous dense urban fabric	65	15.80
Discontinuous medium density urban fabric	40	0.14
Discontinuous low density urban fabric	20	0.07
Discontinuous very low density urban fabric	5	0.07
Industrial, commercial, public, military, private and transport units		
Industrial, commercial, public, military and private units	5	13.67
Railways and associated land	100	1.15
Other roads and associated land	100	5.97
Mine, dump and construction sites		
Mineral extraction and dump sites	50	0.56
Construction sites	90	0.23
Land without current use	40	0.42

Table S2 Kendall rank correlation coefficients between functional traits of birds. Significant relationships between traits are indicated by a star ($P < 0.05$).

	Foraging technique	Diet	Nest location	Migration status
Diet	0.323			
Nest location	0.045	0.019		
Migration status	0.163	0.204	-0.351	
Body mass (g)	-0.527*	-0.418*	0.114	-0.189

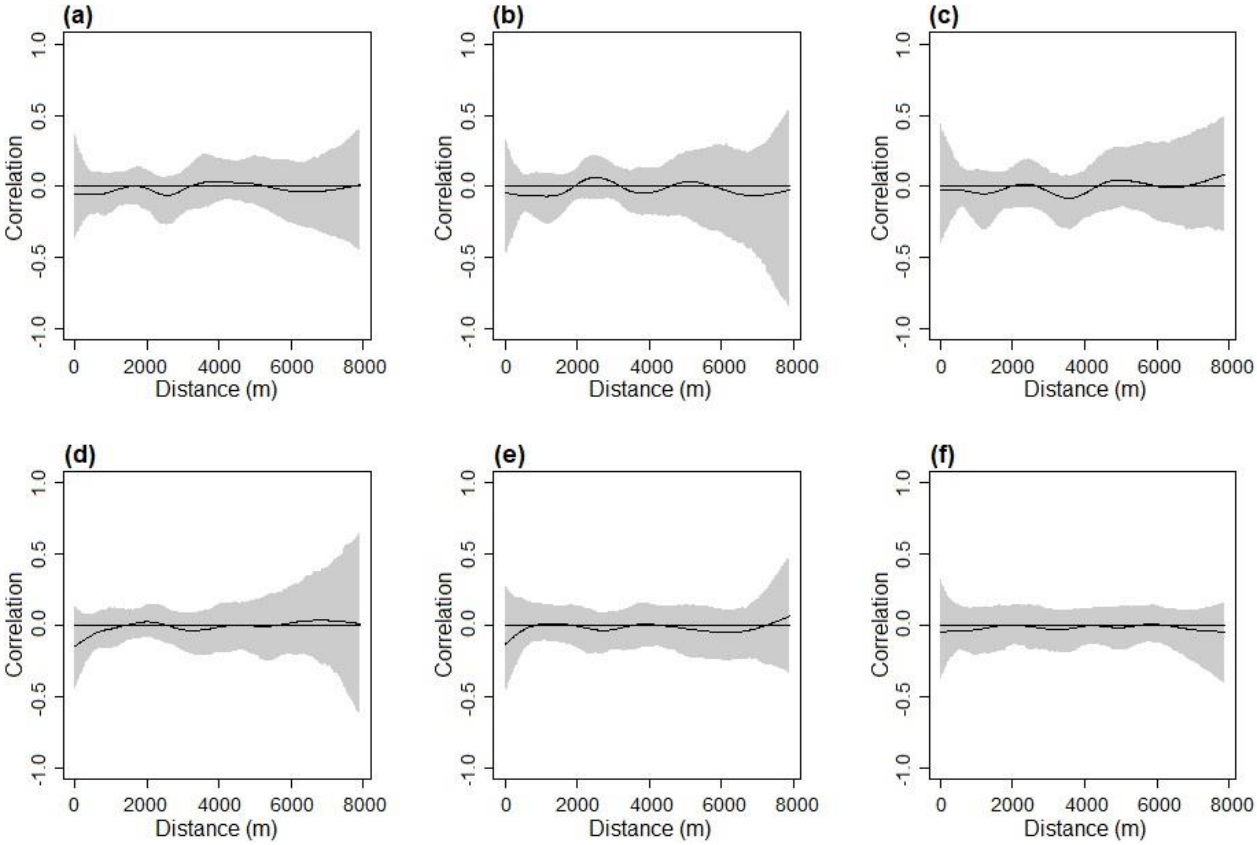

Fig. S2 Spline correlograms for testing spatial autocorrelation in model residuals for the studied responses: a) species richness; (b) CWM body mass; (c) CWM foraging technique; (d) CWM diet; (e) CWM nest location; (f) CWM migration status. Grey shaded areas correspond to 95% confidence bands obtained by bootstrap (1000 iterations).

Table S3 Summary table for GLMM results after multimodel averaging of the best candidate models, showing the relative importance of tree and shrub percentage variables on species richness and community weighted mean (CWM) indices of birds. The following traits were considered: body size (continuous variable in grams), foraging technique (ground prober, ground gleaner, understory gleaner, bark forager, canopy foliage gleaner/hawker), diet (granivore, mixed diet, insectivore), nest location (open on ground, open in shrub, open in tree, cavity), migration status (resident, temperate/partial migrant, tropical migrant).

Model[a]	Variable[b]	Relative importance (%)[c]	Multimodel estimate	± 95 % CI[d]
Species richness	Tree	84	0.042	± 0.034*
(0.14/0.43;4)	Shrub	39	0.045	± 0.072
CWM Body mass	Tree	71	0.001	± 0.001*
(0.19/0.30;4)	Shrub	68	-0.002	± 0.002
CWM Foraging	Tree	37	0.001	± 0.001
(0.10/0.71;4)	Shrub	85	0.003	± 0.002*
CWM Diet	Tree	34	0.001	± 0.001
(0.12/0.45;3)	Shrub	86	0.003	± 0.002*
CWM Nesting	Tree	23	0.000	± 0.001
(0.10/0.64;3)	Shrub	92	-0.003	± 0.003*
CWM Migration	Tree	45	0.000	± 0.001
(0.13/0.45;4)	Shrub	61	0.002	± 0.002

[a] Models were fitted with normal distribution (marginal/conditional R^2 of full model; number of candidate models, ΔAIC <6).
[b] Tree effect: percentage; shrub effect: percentage.
[c] Each variable's importance within the best candidate models (ΔAIC <6).
[d] Significance levels: *: <0.05.

Table S4 Trait values, abundances (N) and indicator values (IndVal) of observed bird species. Foraging technique: ground prober (1), ground gleaner (2), understory gleaner (3), bark forager (4), canopy foliage gleaner/hawker (5); diet: granivore (1), mixed diet (2), insectivore (3); nest location: open on ground (1), open in shrub (2), open in tree (3), cavity (4); migration status: resident (1), temperate/partial migrant (2), tropical migrant (3) and body size values (in grams). The asterisks after IndVal (Indicator Value) indicate the significance level: *$P < 0.05$, **$P < 0.01$, ***$P < 0.001$.

Species	Foraging technique	Diet	Nest location	Migration status	Body mass	N	IndVal
Aegithalos caudatus	3	3	2	1	8.2	4	0.07
Carduelis cannabina	2	1	2	2	20.5	19	0.27*
Carduelis carduelis	3	1	3	2	16.8	33	0.33*
Carduelis flammea	5	2	2	2	13.5	4	0.04
Carduelis spinus	5	2	3	2	14.3	4	0.04
Certhia brachydactyla	4	3	4	1	9.3	4	0.13
Chloris chloris	3	1	2	1	25.5	62	0.40
Columba palumbus	2	1	3	2	487.0	55	0.56**
Corvus corone	1	2	3	2	499.0	42	0.41
Corvus monedula	2	2	4	1	200.5	2	0.08
Cyanistes caeruleus	5	3	4	1	11.1	80	0.52
Dendrocopos major	4	3	4	1	84.0	14	0.25
Erithacus rubecula	2	3	1	2	19.5	24	0.41**
Fringilla coelebs	2	2	3	1	23.0	55	0.65***
Garrulus glandarius	2	2	3	1	170.0	5	0.08
Hippolais icterina	5	3	3	3	13.5	1	0.04
Luscinia megarhynchos	2	3	1	3	27.5	6	0.04
Motacilla alba	2	3	4	2	21.0	15	0.20
Motacilla flava	2	3	1	2	17.9	14	0.08
Muscicapa striata	5	3	4	3	16.6	2	0.02
Parus major	5	3	4	1	17.0	137	0.59*
Passer domesticus	2	2	4	1	29.5	132	0.38
Passer montanus	2	2	4	1	23.5	45	0.47**
Periparus ater	5	3	4	1	9.6	1	0.04
Phoenicurus ochruros	2	3	4	2	16.0	24	0.48***
Phoenicurus phoenicurus	5	3	4	3	17.0	17	0.50***
Phylloscopus collybita	5	3	1	2	8.5	46	0.66***
Phylloscopus trochilus	5	3	1	3	10.5	18	0.32
Pica pica	1	2	3	1	235.0	8	0.18
Picus viridis	1	3	4	1	194.0	3	0.06
Poecile palustris	3	3	4	1	12.0	1	0.04
Prunella modularis	2	3	2	2	19.5	13	0.19
Pyrrhula pyrrhula	3	1	3	1	29.5	8	0.15
Regulus ignicapillus	5	3	3	2	6.0	3	0.08
Regulus regulus	5	3	3	2	6.0	4	0.08
Serinus serinus	2	1	3	2	11.3	29	0.49**
Sitta europaea	4	3	4	1	22.5	9	0.17
Streptopelia decaocto	2	1	3	1	166.8	4	0.02

Table S4 continued.

Species	Foraging technique	Diet	Nest location	Migration status	Body mass	N	IndVal
Sturnus vulgaris	1	2	4	2	77.5	39	0.30
Sylvia atricapilla	3	3	2	2	19.7	79	0.59*
Sylvia borin	3	3	2	3	19.0	14	0.20
Sylvia communis	3	3	2	3	15.5	7	0.15
Sylvia curruca	3	3	2	3	13.8	13	0.14
Troglodytes troglodytes	2	3	2	1	9.0	39	0.22
Turdus merula	1	2	2	1	104.5	275	0.50
Turdus philomelos	1	2	3	2	78.5	8	0.09
Turdus pilaris	1	2	3	2	111.0	28	0.42***