SUPPLEMENTARY MATERIAL

Avian Species and Presence

Avian species inventory records collected by TRCA in natural areas from 2010 to 2017 were used in this study [1]. Inventory data collection is completed during the breeding season, which spans from early June to mid-July annually. The methodology to identify confirmed or possible breeding birds followed a standardized protocol [2]. Briefly, this included visiting all parts of a site at least twice during a breeding season from half an hour before sunrise until about midday. Repeat visits began on the fourth week of June or until all initial visits were completed. Once a breeding bird is observed, a breeding bird point was created and considered to be a species presence within the study area.

Pseudo-absence

As the inventory data provides only the presence of species, pseudo-absences are necessary to enable Functional Trait Analysis (FTA) by providing a contrast in landscape characteristics from the sampling locations that are mainly from natural cover areas [3]. We identified pseudo-absences in natural areas that were in close proximity to where all sampling occurred for all species, but there was no species presence data. The pseudo-absence points contrast unsampled areas by using a 500-m buffer around species presence data points and generated a set of random pseudo-absence points spaced that had a minimum distance of at least 1 km between each other. This process was completed using ArcMap 10.4.1 [4]. The FTA accounts for all species presences and therefore the pseudo-absences are unsampled areas for all species.

Collinearity of Functional Trait Analysis Predictors

Collinearity among predictors was assessed using Pearson correlation and low/medium-density residential areas were highly correlated with roads, maximum patch size of meadows was correlated with total meadow, and maximum patch size of beach/bluff with total area of beach/bluff ($r > 0.7$). Low-density residential areas, total area of meadows, total area of beach/bluff was retained in the analysis. The final list of predictors contained a total of 31 variables for patch quality, land use, and habitat pinch point connectivity (Table S.5).

Connectivity

We created a resistance layer using the landcover data (see section 2.3) summarized in 100-m raster resolution to assess the connectivity of avian species that require forest or wetland habitat (Table S.1). Then, the resistance to the movement of species is based on the movement tendency of avian species, which is related to the suitability of landcover to provide foraging and breeding habitat [5]. Resistance values were assigned from 1 to 100, with 1 being the lowest resistance (e.g., natural cover) and 100 being the highest resistance (e.g., high-intensity development).

The analysis conducted at the watershed scale also considered habitat patches in a 2-km buffer extending beyond each watershed boundary to produce corridors into adjacent watersheds for a mosaic map of the entire TRCA jurisdiction and to limit the boundary effect. The resulting connectivity provides a potential corridor assessment, using Linkage Pathways and the cost-weighted distance between patches for each watershed within the entire study area.

To identify the influence of regional connectivity on the presence of species on the landscape, we used Pinchpoint Mapper tool in the ArcGIS Linkage Mapper Toolkit [6] to

produce pinch point maps indicating areas based on the least-cost corridors and where the loss of such corridors would be detrimental for regional connectivity of corridors [6]. For each connectivity analysis (forest-forest, wetland-wetland connectivity), we used habitat patches as raster layers to identify nodes based on the habitat type of interest. The habitat nodes extended beyond a 2-km buffer around study area to limit a boundary effect of corridors. We performed the analysis using an all-to-one mode that calculates one focal node that is grounded, and all remaining focal nodes are sources of current. The process is then repeated for each focal node and then the pinch point map is the cumulative current density of all the iterations. The cumulative current density was used as predictor variables for the functional trait analysis and the habitat suitability analysis.

Boosted Regression Tree

The parameters for the BRT models require the learning rate, tree complexity, and bagging fraction. The learning rate is the contribution of each tree to the growing model, the tree complexity is the number of nodes on the tree and subsequently controls the ability to fit interactions in the model, and the bag fraction is the proportion of data to be selected at each step. In all BRT models with sufficient sample sizes that produced a minimum of 1000 trees, a learning rate of 0.005, a tree complexity of 3 for three-way interactions, and a bag fraction 0.5 were selected.

To assess model performance, we used 10-fold cross-validation to evaluate the model performance compared to held portions of data. The AUC value determined if the predictive discrimination model was no better than random with a value of 0.5, and greater than 0.8 was

deemed to be a good model. A value of 1 would indicate that the model has a perfect discrimination between presences and absences [7].

Collinearity among predictors was assessed using Pearson correlation ($r > 0.7$) and there was collinearity between low-density residential and roads, where the former was retained in the analysis.

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Table S1. Predictors used for the RLQ-fourth corner (functional trait analysis) and boosted regression tree (habitat suitability analysis) within 100-m grids across the jurisdiction of the TRCA. Landcover and patch quality predictors are calculated as moving windows with a 500-m radius.

Classification	Description	Name	Code	RLQ	BRT
Landcover type	Total amount	Airport	LC_airport	•	•
		Cemetery	LC_cemetery	•	•
		Commercial	LC_commercial	•	•
		Conservation area	LC_conserve	•	•
		Residential – Estate	LC_res_estate	•	•
		Farm	LC_farm	•	•
		Golf course	LC_golf	•	•
		Hydro corridor	LC_hydro	•	•
		Industrial area	LC_industry	•	•
		Institutional	LC_institution	•	•
		Natural space	LC_natural	•	•
		Open green space	LC_open_space	•	•
		Park	LC_park	•	•
		Recreational	LC_recreation	•	•
		Residential – High density	LC_res_high	•	•
		Residential – Low-medium density	LC_res_lowmed	•	•
		Road	LC_road	•	•
		Residential - Rural	LC_res_rural	•	•
		Transportation	LC_transport	•	•
		Water	LC_water	•	•
Patch quality	Maximum patch size for each habitat type	Largest beach patch	P_beach	•	•
		Largest forest patch	P_forest	•	•
		Largest meadow patch	P_meadow	•	•
		Largest wetland patch	P_wetland	•	•
	Mean amount of edge (perimeter-area ratio)	Mean edge (perimeter-area ratio) of beach patches	E_beach	•	•
		Mean edge (perimeter-area ratio) of forest patches	E_forest	•	•
		Mean edge (perimeter-area ratio) of meadow patches	E_meadow	•	•
		Mean edge (perimeter-area ratio) of wetland patches	E_wetland	•	•
Connectivity	Regional (Pinchpoint between habitat types)	Forest	C_reg_forest	•	•
		Wetland	C_reg_wetland	•	•
	Local	Forest	C_loc_forest		•
		Wetland	C_loc_wetland		•

	(Cost-weighted distance between habitat types)				
Ecological Land Classification (ELC)	Total amount	Barren	LC_barren		•
		Beach	LC_beach		•
		Bluff	LC_bluff		•
		Bog	LC_bog		•
		Cliff	LC_cliff		•
		Coniferous forest	LC_coniferous		•
		Deciduous forest	LC_deciduous		•
		Fen	LC_fen		•
		Marsh	LC_marsh		•
		Meadow	LC_meadow		•
		Mixed forest	LC_mixedforest		•
		Savannah	LC_savannah		•
		Swamp	LC_swamp		•
		Tallgrass	LC_tallgrass		•
		Thicket	LC_thicket		•
		Woodland	LC_woodland		•
Urban forest canopy	Total amount	Urban forest	LC_urbanforest		•

Table S2. List of avian functional traits (n = 24) to determine the trait-environment relationship of sensitive functional trait groups.

Function	**Foraging location**	**Diet**	**Nesting location**	**Territoriality**
Trait	aerial	carnivore	ground	restricted
	arboreal	granivore	canopy	non-restricted
	arboreal-ground	herbivore	shrub	
	arboreal-shrub	insectivore	floating	
	bark	omnivore	mid-canopy	
	ground	piscivore	cavity	
	shoreline		burrow	
	water			
	wetland			

Table S3. Resistance values for avian species based on habitat dependency (forest-forest, wetland-wetland) in 100-m grids. Resistance will vary according to their individual tendency to move between habitat, which will affect the overall metapopulation persistence.

Cover type	Resistance values for habitat connectivity type	
	Forest-Forest	Wetland-Wetland
LC_airport	30	30
LC_cemetery	25	25
LC_commercial	100	100
LC_conserve	10	10
LC_farm	25	25
LC_golf	25	25
LC_hydro	25	25
LC_industry	100	100
LC_institution	100	100
LC_natural	10	10
LC_openspace	25	25
LC_park	25	25
LC_recreation	25	25
LC_res_estate	25	25
LC_res_high	100	100
LC_res_lowmed	25	25
LC_res_rural	25	25
LC_road	25	25
LC_transport	25	25
LC_water	45	5
beach_bluff	25	25
forest	1	20

meadow	25	25
wetland	20	1

Table S4. Species list of avian species (n = 116) within the Toronto region, Canada between 2010 and 2017 using species inventory. The resulting RLQ-fourth corner analysis using the species and their response based on functional traits to landscape characteristics (patch quality, habitat connectivity, and land cover type) derived 21 functional trait groups (Groups A-U).

Common name	Scientific name	Code	Functional trait group
Acadian Flycatcher	*Empidonax virescens*	ACFL	S
Alder Flycatcher	*Empidonax alnorum*	ALFL	K
American Black Duck	*Anas rubripes*	ABDU	A
American Coot	*Fulica americana*	AMCO	C
American Kestrel	*Falco sparverius*	AMKE	K
American Redstart	*Setophaga ruticilla*	AMRE	O
American Woodcock	*Scolopax minor*	AMWO	I
Bank Swallow	*Riparia riparia*	BANS	J
Barn Swallow	*Hirundo rustica*	BARS	M
Barred Owl	*Strix varia*	BADO	U
Belted Kingfisher	*Megaceryle alcyon*	BEKI	B
Black-and-white Warbler	*Mniotilta varia*	BAWW	U
Black-billed cuckoo	*Coccyzus erythropthalmus*	BBCU	O
Blackburnian Warbler	*Setophaga fusca*	BLBW	O
Black-crowned Night-heron	*Nycticorax nycticorax*	BCNH	B
Black-throated Green Warbler	*Setophaga virens*	BTNW	O
Blue-grey Gnatcatcher	*Polioptila caerulea*	BGGN	O
Blue-headed Vireo	*Vireo solitarius*	BHVI	O
Blue-winged Teal	*Spatula discors*	BWTE	A
Blue-winged Warbler	*Vermivora cyanoptera*	BWWA	G
Bobolink	*Dolichonyx oryzivorus*	BOBO	E

Broad-winged Hawk	*Buteo platypterus*	BWHA	K
Brown Creeper	*Certhia americana*	BRCR	R
Brown Thrasher	*Toxostoma rufum*	BRTH	K
Canvasback	*Aythya valisineria*	CANV	A
Carolina Wren	*Thryothorus ludovicianus*	CARW	P
Caspian Tern	*Hydroprogne caspia*	CATE	C
Chestnut-sided Warbler	*Setophaga pensylvanica*	CSWA	Q
Chimney Swift	*Chaetura pelagica*	CHSW	M
Clay-coloured Sparrow	*Spizella pallida*	CCSP	K
Common Gallinule	*Gallinula chloropus*	COMO	C
Common Merganser	*Mergus merganser*	COME	B
Common Nighthawk	*Chordeiles minor*	CONI	H
Common Raven	*Corvus corax*	CORA	H
Common Tern	*Sterna hirundo*	COTE	C
Common Yellowthroat	*Geothlypis trichas*	COYE	Q
Cooper’s Hawk	*Accipiter cooperii*	COHA	N
Double-crested Cormorant	*Phalacrocorax auritus*	DCCO	C
Eastern Bluebird	*Sialia sialis*	EABL	T
Eastern Kingbird	*Tyrannus tyrannus*	EAKI	K
Eastern Meadowlark	*Sturnella magna*	EAME	E
Eastern Screech-Owl	*Megascops asio*	EASO	R
Eastern Towhee	*Pipilo erythrophthalmus*	EATO	E
Eastern Wood-Pewee	*Contopus virens*	EAWP	S
Field Sparrow	*Spizella pusilla*	FISP	E
Gadwall	*Mareca strepera*	GADW	D
Golden-crowned Kinglet	*Regulus satrapa*	GCKI	O
Grasshopper Sparrow	*Ammodramus savannarum*	GRSP	E
Great Blue Heron	*Ardea herodias*	GBHE	L
Great Crested Flycatcher	*Myiarchus crinitus*	GCFL	K
Great Egret	*Ardea alba*	GREG	L

Great Horned Owl	*Bubo virginianus*	GHOW	U
Green Heron	*Butorides virescens*	GRHE	B
Grey Catbird	*Dumetella carolinensis*	GRCA	K
Hairy Woodpecker	*Leuconotopicus villosus*	HAWO	P
Hermit Thrush	*Catharus guttatus*	HETH	E
Herring Gull	*Larus argentatus*	HERG	I
Hooded Merganser	*Lophodytes cucullatus*	HOME	B
Hooded Warbler	*Setophaga citrina*	HOWA	Q
Horned Lark	*Eremophila alpestris*	HOLA	I
Indigo Bunting	*Passerina cyanea*	INBU	Q
Killdeer	*Charadrius vociferus*	KILL	I
Least Bittern	*Ixobrychus exilis*	LEBI	A
Least Flycatcher	*Empidonax minimus*	LEFL	S
Long-eared Owl	*Asio otus*	LEOW	U
Magnolia Warbler	*Setophaga magnolia*	MAWA	O
Marsh Wren	*Cistothorus palustris*	MAWR	H
Merlin	*Falco columbarius*	MERL	N
Mourning Warbler	*Geothlypis philadelphia*	MOWA	F
Nashville Warbler	*Oreothlypis ruficapilla*	NAWA	G
Northern Flicker	*Colaptes auratus*	NOFL	T
Northern Harrier	*Circus cyaneus*	NOHA	H
Northern Mockingbird	*Mimus polyglottos*	NOMO	G
Northern Rough-winged Swallow	*Stelgidopteryx serripennis*	NRWS	J
Northern Shoveler	*Anas clypeata*	NSHO	A
Northern Waterthrush	*Parkesia noveboracensis*	NOWA	H
Osprey	*Pandion haliaetus*	OSPR	B
Ovenbird	*Seiurus aurocapilla*	OVEN	F
Peregrine Falcon	*Falco peregrinus*	PEFA	J
Pied-billed Grebe	*Podilymbus podiceps*	PBGR	C
Pileated Woodpecker	*Dryocopus pileatus*	PIWO	P

Pine Siskin	*Spinus pinus*	PISI	P
Pine Warbler	*Setophaga pinus*	PIWA	P
Purple Finch	*Haemorhous purpureus*	PUFI	G
Purple Martin	*Progne subis*	PUMA	M
Red-breasted Nuthatch	*Sitta canadensis*	RBNU	P
Red-eyed Vireo	*Vireo olivaceus*	REVI	O
Red-necked Grebe	*Podiceps grisegena*	RNGR	D
Ring-billed Gull	*Larus delawarensis*	RBGU	I
Ring-necked Duck	*Aythya collaris*	RNDU	A
Rose-breasted Grosbeak	*Pheucticus ludovicianus*	RBGR	O
Ruffed Grouse	*Bonasa umbellus*	RUGR	I
Savannah Sparrow	*Passerculus sandwichensis*	SAVS	E
Scarlet Tanager	*Piranga olivacea*	SCTA	O
Sedge Wren	*Cistothorus stellaris*	SEWR	G
Sharp-shinned Hawk	*Accipiter striatus*	SSHA	N
Sora	*Porzana carolina*	SORA	C
Spotted Sandpiper	*Actitis macularius*	SPSA	H
Swamp Sparrow	*Melospiza georgiana*	SWSP	G
Tree Swallow	*Tachycineta bicolor*	TRES	M
Upland Sandpiper	*Bartramia longicauda*	UPSA	I
Veery	*Catharus fuscescens*	VEER	G
Vesper Sparrow	*Pooecetes gramineus*	VESP	E
Virginia Rail	*Rallus limicola*	VIRA	I
White-breasted Nuthatch	*Sitta carolinensis*	WBNU	P
White-throated Sparrow	*Zonotrichia albicollis*	WTSP	E
Wild Turkey	*Meleagris gallopavo*	WITU	I
Willow Flycatcher	*Empidonax traillii*	WIFL	K
Wilson’s Snipe	*Gallinago delicata*	WISN	I
Winter Wren	*Troglodytes hiemalis*	WIWR	T
Wood Duck	*Aix sponsa*	WODU	B

Wood Thrush	*Hylocichla mustelina*	WOTH	G
Yellow-bellied Sapsucker	*Sphyrapicus varius*	YBSA	P
Yellow-billed Cuckoo	*Coccyzus americanus*	YBCU	O
Yellow-rumped Warbler	*Setophaga coronata*	YRWA	O
Yellow-throated Vireo	*Vireo flavifrons*	YTVI	O

Table S5. Correlation matrix (Pearson's *r*) of 31 variables with code numbers: total habitat of (1) beach/bluff, (2) forest, (3) meadow, (4) wetland; maximum patch size of (5) beach/bluff, (6) forest, (7) meadow, (8) wetland; mean edge of (9) beach/bluff, (10) forest, (11) meadow, (12) wetland; land cover type (13) airport, (14) cemetery, (15) commercial, (16) conservation area, (17) residential – estate, (18) farm, (19) golf course, (20) hydro corridor, (21) industrial area, (22) institutional, (23) natural, (24) open space, (25) park, (26) recreation, (27) residential – high density, (28) residential – low/medium density, (29) road, (30) regional pinchpoint connectivity – forest, (31) regional pinchpoint connectivity – wetland. Correlations of $r > 0.7$ are indicated in bold and shaded red.

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31
1	1.00	-0.06	-0.01	-0.01	0.77	-0.14	0.23	-0.02	0.20	0.00	-0.08	-0.10	-0.01	-0.02	-0.06	-0.02	-0.04	-0.08	-0.03	-0.04	-0.02	-0.05	-0.12	-0.07	-0.03	-0.02	-0.04	-0.04	-0.11	-0.05	-0.02
2	-0.06	1.00	0.02	0.00	-0.07	0.57	0.00	-0.03	-0.07	-0.04	-0.02	-0.07	-0.02	-0.03	-0.09	0.11	0.03	0.04	-0.06	-0.06	-0.11	-0.09	-0.09	-0.06	-0.10	-0.06	-0.08	-0.23	-0.27	-0.04	-0.06
3	-0.01	0.02	1.00	-0.01	-0.04	-0.02	0.96	-0.02	-0.02	-0.03	-0.12	0.00	-0.02	-0.02	-0.07	0.03	-0.03	-0.08	0.04	-0.04	-0.05	-0.09	0.02	-0.08	-0.08	-0.04	-0.07	-0.15	-0.21	-0.05	-0.01
4	-0.01	0.00	-0.01	1.00	0.00	-0.03	0.00	-0.01	-0.02	0.02	-0.01	-0.01	0.00	-0.01	0.04	-0.01	0.00	0.05	-0.01	0.06	0.04	-0.01	0.02	0.07	-0.01	-0.02	-0.01	-0.03	-0.02	0.04	0.00
5	0.77	-0.07	-0.04	0.00	1.00	-0.16	0.11	0.14	0.30	0.04	-0.05	-0.13	0.03	-0.02	-0.04	0.05	-0.04	-0.09	-0.02	-0.02	0.02	-0.01	-0.13	-0.06	-0.03	0.08	-0.02	-0.04	-0.09	-0.05	-0.02
6	-0.14	0.57	-0.02	-0.03	-0.16	1.00	0.06	-0.09	-0.15	-0.14	-0.06	-0.05	-0.07	-0.02	-0.16	0.09	0.10	0.05	-0.08	-0.10	-0.25	-0.08	0.13	-0.08	-0.11	-0.15	-0.12	-0.30	-0.36	0.09	-0.14
7	0.23	0.00	0.96	0.00	0.11	0.06	1.00	-0.05	0.06	-0.06	-0.11	-0.05	-0.03	-0.04	-0.08	0.01	-0.03	-0.05	-0.08	-0.05	-0.09	-0.14	0.04	-0.03	-0.12	-0.09	-0.09	-0.32	-0.34	-0.01	-0.03
8	-0.02	-0.03	-0.02	-0.01	0.14	-0.09	-0.05	1.00	0.20	0.06	0.04	-0.08	0.40	0.00	-0.01	0.18	0.03	-0.03	0.07	0.13	0.06	-0.02	-0.06	0.03	0.03	0.37	0.00	-0.08	-0.11	0.01	0.02
9	0.20	-0.07	-0.02	-0.02	0.30	-0.15	0.06	0.20	1.00	0.09	0.00	-0.02	0.12	-0.03	-0.02	0.12	-0.05	-0.13	-0.03	0.02	0.03	-0.07	-0.07	-0.06	-0.04	0.14	-0.01	-0.12	-0.16	-0.07	0.00
10	0.00	-0.04	-0.03	0.02	0.04	-0.14	-0.06	0.06	0.09	1.00	0.04	-0.01	0.06	0.03	0.04	0.02	-0.04	-0.01	0.00	0.03	0.10	0.06	-0.07	0.02	0.02	0.08	0.07	0.04	0.08	-0.03	0.03
11	-0.08	-0.02	-0.12	-0.01	-0.05	-0.06	-0.11	0.04	0.00	0.04	1.00	0.02	0.01	-0.03	0.01	0.02	0.00	0.01	0.00	-0.02	-0.03	0.19	-0.14	0.06	0.12	-0.01	0.14	0.13	0.15	0.01	-0.01
12	-0.10	-0.07	0.00	-0.01	-0.13	-0.05	-0.05	-0.08	-0.02	-0.01	0.02	1.00	-0.05	0.01	0.01	-0.02	-0.04	0.02	0.07	0.00	-0.01	-0.02	0.14	-0.01	0.01	-0.03	0.02	0.05	0.04	0.05	0.11
13	-0.01	-0.02	-0.02	0.00	0.03	-0.07	-0.03	0.40	0.12	0.06	0.01	-0.05	1.00	0.00	-0.01	-0.02	0.01	-0.03	0.08	0.07	0.09	-0.02	-0.03	0.02	0.02	0.22	-0.02	-0.05	-0.05	-0.02	0.02
14	-0.02	-0.03	-0.02	-0.01	-0.02	-0.02	-0.04	0.00	-0.03	0.03	-0.03	0.01	0.00	1.00	0.02	0.04	-0.01	0.01	-0.02	0.03	0.00	-0.01	-0.03	-0.02	0.00	-0.01	0.09	-0.01	0.03	0.00	0.00
15	-0.06	-0.09	-0.07	0.04	-0.04	-0.16	-0.08	-0.01	-0.02	0.04	0.01	0.01	-0.01	0.02	1.00	-0.02	-0.05	-0.07	-0.06	0.02	0.11	0.00	0.08	-0.02	0.05	0.07	0.11	0.00	0.19	-0.05	0.04
16	-0.02	0.11	0.03	-0.01	0.05	0.09	0.01	0.18	0.12	0.02	0.02	-0.02	-0.02	0.04	-0.02	1.00	-0.03	-0.10	-0.07	-0.05	-0.05	-0.04	-0.10	-0.11	-0.07	-0.03	0.03	-0.17	-0.17	-0.05	-0.05
17	-0.04	0.03	-0.03	0.00	-0.04	0.10	-0.03	0.03	-0.05	-0.04	0.00	-0.04	0.01	-0.01	-0.05	-0.03	1.00	0.06	0.07	0.06	-0.05	-0.08	0.12	-0.04	-0.08	-0.02	-0.06	-0.14	-0.10	0.11	-0.01
18	-0.08	0.04	-0.08	0.05	-0.09	0.05	-0.05	-0.03	-0.13	-0.01	0.01	0.02	-0.03	0.01	-0.07	-0.10	0.06	1.00	-0.03	0.11	-0.08	-0.13	0.12	0.00	-0.14	-0.01	-0.12	-0.23	-0.20	0.27	-0.03
19	-0.03	-0.06	0.04	-0.01	-0.02	-0.08	-0.08	0.07	-0.03	0.00	0.00	0.07	0.08	-0.02	-0.06	-0.07	0.07	-0.03	1.00	0.21	-0.06	-0.09	0.01	-0.04	-0.04	0.06	-0.05	-0.07	-0.12	-0.02	-0.04
20	-0.04	-0.06	-0.04	0.06	-0.02	-0.10	-0.05	0.13	0.02	0.03	-0.02	0.00	0.07	0.03	0.02	-0.05	0.06	0.11	0.21	1.00	0.00	-0.03	-0.04	-0.05	-0.03	0.22	0.00	-0.12	-0.09	0.01	-0.01
21	-0.02	-0.11	-0.05	0.04	0.02	-0.25	-0.09	0.06	0.03	0.10	-0.03	-0.01	0.09	0.00	0.11	-0.05	-0.05	-0.08	-0.06	0.00	1.00	-0.03	-0.07	0.00	-0.08	0.04	0.03	-0.19	0.04	-0.05	0.25
22	-0.05	-0.09	-0.09	-0.01	-0.01	-0.08	-0.14	-0.02	-0.07	0.06	0.19	-0.02	-0.02	-0.01	0.00	-0.04	-0.08	-0.13	-0.09	-0.03	-0.03	1.00	-0.10	-0.01	0.13	-0.02	0.18	0.23	0.23	-0.05	-0.04
23	-0.12	-0.09	0.02	0.02	-0.13	0.13	0.04	-0.06	-0.07	-0.07	-0.14	0.14	-0.03	-0.03	0.08	-0.10	0.12	0.12	0.01	-0.04	-0.07	-0.10	1.00	0.03	-0.05	-0.06	-0.09	-0.15	-0.08	0.19	0.01

24	-0.07	-0.06	-0.08	0.07	-0.06	-0.08	-0.03	0.03	-0.06	0.02	0.06	-0.01	0.02	-0.02	-0.02	-0.11	-0.04	0.00	-0.04	-0.05	0.00	-0.01	0.03	1.00	0.00	0.02	-0.03	0.09	0.14	-0.02	-0.02
25	-0.03	-0.10	-0.08	-0.01	-0.03	-0.11	-0.12	0.03	-0.04	0.02	0.12	0.01	0.02	0.00	0.05	-0.07	-0.08	-0.14	-0.04	-0.03	-0.08	0.13	-0.05	0.00	1.00	0.00	0.11	0.31	0.29	-0.08	-0.04
26	-0.02	-0.06	-0.04	-0.02	0.08	-0.15	-0.09	0.37	0.14	0.08	-0.01	-0.03	0.22	-0.01	0.07	-0.03	-0.02	-0.01	0.06	0.22	0.04	-0.02	-0.06	0.02	0.00	1.00	0.00	-0.09	-0.05	-0.05	-0.02
27	-0.04	-0.08	-0.07	-0.01	-0.02	-0.12	-0.09	0.00	-0.01	0.07	0.14	0.02	-0.02	0.09	0.11	0.03	-0.06	-0.12	-0.05	0.00	0.03	0.18	-0.09	-0.03	0.11	0.00	1.00	0.09	0.21	-0.05	0.02
28	-0.04	-0.23	-0.15	-0.03	-0.04	-0.30	-0.32	-0.08	-0.12	0.04	0.13	0.05	-0.05	-0.01	0.00	-0.17	-0.14	-0.23	-0.07	-0.12	-0.19	0.23	-0.15	0.09	0.31	-0.09	0.09	1.00	0.79	-0.15	-0.07
29	-0.11	-0.27	-0.21	-0.02	-0.09	-0.36	-0.34	-0.11	-0.16	0.08	0.15	0.04	-0.05	0.03	0.19	-0.17	-0.10	-0.20	-0.12	-0.09	0.04	0.23	-0.08	0.14	0.29	-0.05	0.21	0.79	1.00	-0.13	-0.03
30	-0.05	-0.04	-0.05	0.04	-0.05	0.09	-0.01	0.01	-0.07	-0.03	0.01	0.05	-0.02	0.00	-0.05	-0.05	0.11	0.27	-0.02	0.01	-0.05	-0.05	0.19	-0.02	-0.08	-0.05	-0.05	-0.15	-0.13	1.00	-0.01
31	-0.02	-0.06	-0.01	0.00	-0.02	-0.14	-0.03	0.02	0.00	0.03	-0.01	0.11	0.02	0.00	0.04	-0.05	-0.01	-0.03	-0.04	-0.01	0.25	-0.04	0.01	-0.02	-0.04	-0.02	0.02	-0.07	-0.03	-0.01	1.00

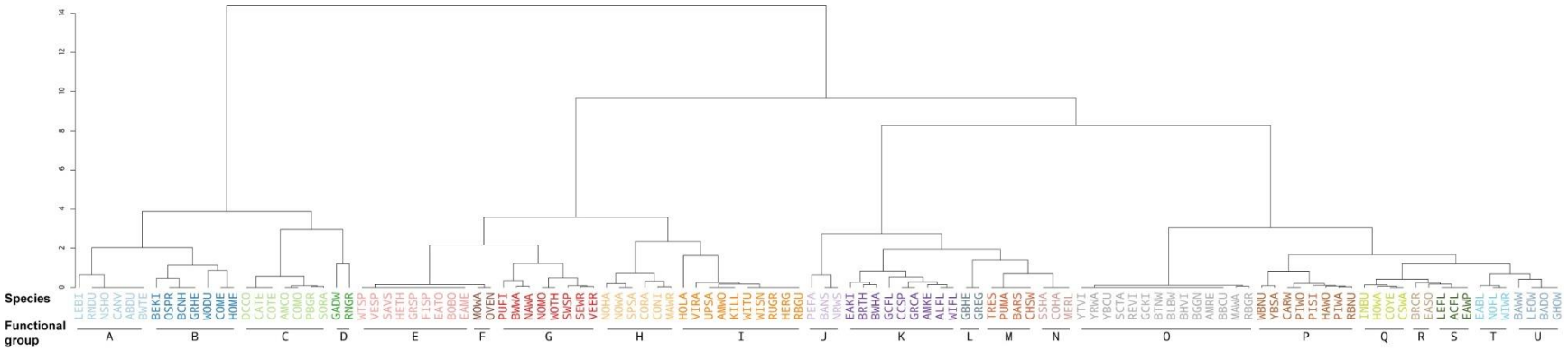

Figure S1. A dendrogram of the species (*n* = 116) associated in functional trait groups (*n* = 21) from the RLQ-fourth corner analysis. Each colored group is a functional trait group derived from clustering. The four key functional trait groups from this analysis are groups F (ground-nesting), M (aerial insectivore), O (forest canopy), and K (forest insectivore). Two functional trait groups P (bark forager) and U (forest carnivore) are forest-related but were not included to complete a habitat suitability analysis due to sample size.

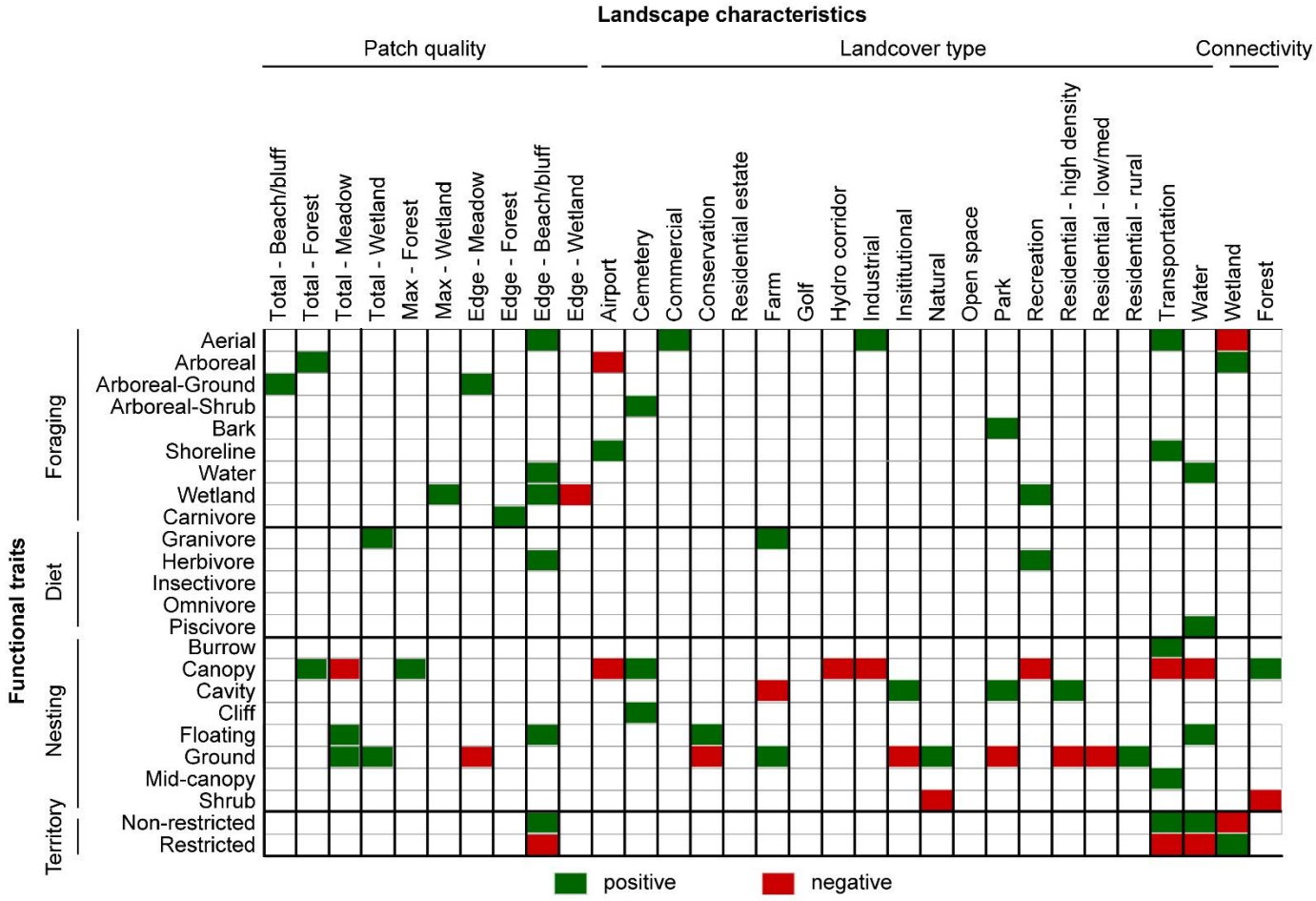

Figure S2. Associations from the RLQ-fourth corner analysis based on individual birds (*n* = 11,089) and pseudoabsences (*n* = 149) and avian functional traits (foraging location, diet, nesting location, and territoriality; *n* = 24 traits) in relation to landscape characteristics. Green indicates a positive association and red indicates a negative association.