Fire, humans and climate: Modeling distribution dynamics of boreal forest waterbirds.

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Appendix A.

Supplemental tables and figures with landcover composition of the study area, a description of the environmental covariates used, information on the modeled waterbird species, tables with parameter estimates and model performance measures, and supplemental figures of estimated model predictions and bird distribution maps.

Supplemental Tables

Table A1	Landcover composition
Table A2	Environmental covariates
Table A3	Waterfowl species detected
Table A4 – A17	HSI estimates and predictive ability
Table A18	Summary of model accuracy measures
Table A19	Niche similarity estimates
Table A20 – A33	Parameter estimates and model fit for each species and model

Supplemental Figures

Figure A1 Effects of sampling intensity (N point counts)

Figure A2 South section difference for OBBA2pc

Figure A3 Trends in probability of occupancy

Figure A4 – A17 Bird distribution maps

TABLE A1A. Landcover composition of the Ontario shield ecozone and of the areas sampled by the four bird surveys within the ecozone.

Ecozone or Survey	Open Water	Wetland		Crop and Grass	Forest		Recent Cut and Burn		Old Cut and Burn	Urban and Mining
		Bogs and Fens	Marsh and Swamps		Deciduous	Coniferous	Recent Cut	Recent Burn		
ON shield	13	10	<1	1	20	44	4	2	4	1
FWS	13 (0 – 97)	9 (0 – 52)	<1 (0 – 6)	1 (0 – 17)	19 (0 – 81)	49 (0 – 90)	4 (0 – 50)	2 (0 – 56)	3 (0 – 65)	1 (0 – 20)
OBBA2	12 (0 – 76)	4 (0 – 87)	<1 (0 – 9)	1 (0 – 79)	34 (0 – 92)	37 (0 – 86)	5 (0 – 65)	1 (0 – 54)	4 (0 – 68)	1 (0 – 79)
CWS	9 (0 – 46)	4 (0 – 40)	<1 (0 – 1)	2 (0 – 66)	33 (0 – 76)	45 (0 – 82)	5 (0 – 38)	<1 (0 - 1)	2 (0 – 31)	<1 (0 – 5)
BBS	5 (0 – 27)	2 (0 – 14)	1 (0 – 13)	18 (0 – 100)	31 (0 – 77)	29 (0 – 72)	7 (0 – 44)	<1 (0 – 7)	3 (0 – 59)	4 (0 – 39)

Note: Values refer to the percentage of the total area covered by each landcover category, based on the Provincial Landcover Map of Ontario (25m grid resolution), reclassified to 11 landcover types from the original 28 categories (bare and non classified areas were excluded for the analyses; in all cases this accounted for <1% of the areas). For the Ontario shield area values refer to the total land area, Great Lakes and coastal islands excluded; for the bird surveys values refer to the total area sampled during the surveys (for the latter also the range (min/max) of landcover percentages within single survey units is tabulated). The resolution of the survey sampling units was 11.52 km^2 for the fixed wing waterfowl surveys (FWS; 28.8 x 0.4 km; 252 segments in total), 100 km^2 for the Ontario

Breeding Bird Atlas squares (OBBA2; 10 x 10 km; 1361 squares), 25 km^2 for the Breeding Bird Roadside Surveys (BBS; 39.4 x 0.8 km; 79 routes), and 25 km^2 for the Black Duck Joint Venture helicopter plots (CWS; 5 x 5 km; 39 plots). See Fig. 1 for a map.

TABLE A1B. Landcover composition of the Hudson Bay Lowlands ecozone and of the areas sampled by the bird surveys.

Ecozone or Survey	Open Water	Wetland		Crop and Grass	Forest		Recent Cut and Burn		Old Cut and Burn	Urban and Mining
		Bogs and Fens	Marsh and Swamps		Deciduous	Coniferous	Recent Cut	Recent Burn		
Hudson Bay	6	73	1	<1	2	17	1	1	<1	<1
FWS	6 (0 – 37)	74 (12 – 99)	1 (0 – 42)	<1 (0 – 17)	2 (0 – 34)	14 (0 – 76)	0 (0)	1 (0 – 18)	<1 (0 – 11)	<1 (0 – 5)
OBBA2	1 (0 – 72)	62 (0 – 97)	5 (0 – 57)	1 (0 – 18)	5 (0 – 37)	14 (0 – 72)	<1 (0 – 18)	<1 (0 – 12)	1 (0 – 37)	<1 (0 – 8)
CWS	ecozone not sampled by the survey									
BBS	ecozone not sampled by the survey									

Note: Values refer to the percentage of the total area covered by each landcover category, based on the Provincial Landcover Map of Ontario (25m grid resolution), reclassified to 11 landcover types from the original 28 categories (bare and non classified areas were excluded for the analyses; in all cases this accounted for <1% of the areas). For the Ontario shield area values refer to the total land area, Great Lakes and coastal islands excluded; for the bird surveys values refer to the total area sampled during the surveys (for the latter also the range (min/max) of landcover percentages within single survey units is tabulated). The resolution of the survey sampling units was 11.52 km^2 for the fixed wing waterfowl surveys (FWS; 28.8 x 0.4 km; 252 segments in total), 100 km^2 for the Ontario Breeding Bird Atlas squares (OBBA2; 10 x 10 km; 1361 squares). Note that coastal islands are excluded. See Fig. 1 for a map. BBS routes and CWS plots did not sample this ecozone.

TABLE A2. Fixed-effect covariates used to model boreal forest waterbird occupancy dynamics in the Ontario Shield ecozone (Canada) and the mean and SD values used for standardization.

Covariate group	Covariate acronym	Definition	Mean (2 x SD)	
			FWS	OBBA2
Observation bias	Npcs	number of point counts per square/year; fitted as linear or polynomial term	NA	25 (21.13106)
	Section	south or north sector	NA	NA
Population dynamics	YEAR	year fitted as linear or polynomial term	2003 (3.994191)	2003 (2.571643)
Climate variability (large-scale)	ENSO	based on the Oceanic Niño Index	0 (1.572675)	0 (1.156316)
	NAO	winter (Dec-Mar) station based NAO index	0 (2.730337)	0 (1.576532)
	NAOmay	monthly NAO index for May	0 (1.738081)	0 (1.000877)
Climate variability (local-scale)	Tdev or	deviation from average May temperature (ºC)	0 (4.515107)	0 (3.460302)
	TdevMonth	deviation from the average temperature of the survey month (ºC)		0 (2.682117)
	Sdev	deviation from average May snowfall (cm)	0 (14.34182)	0 (12.07764)
	Pdev or	deviation from average May precipitation (mm)	0 (58.82542)	0 (61.56889)
	PdevMonth	deviation from the average precipitation of the survey month (mm)		0 (62.05871)
	BSdev or	deviation from average May hours of bright sunshine	0 (70.60844)	0 (71.05883)
	BSdevMonth	deviation from the average hours of bright sunshine of the survey month		0 (57.0797)

Geographic gradient	X	longitude (in meters; Lambert Conformal Conic)	862109.2 (726499.3)	1038009 (796127.2)
	Y	latitude (in meters; Lambert Conformal Conic)	12584372 (546051.9)	12350701 (469948.3)
Bioclimate	BioClim01	annual mean temperature in 0.1 degrees (ºC)	4.960046 (41.78456)	24.89080 (40.52103)
	BioClim04	temperature seasonality (standard deviation *100)	12356.83 (2162.201)	11357.41 (2044.650)
	BioClim05	max temperature of warmest month in 0.1 degrees (ºC)	233.629 (20.16182)	240.8321 (21.36677)
	BioClim15	precipitation seasonality (coefficient of variation)	32.14269 (23.05994)	24.67290 (22.30405)
Habitat heterogeneity	HHind	quantitative index of habitat heterogeneity[1]	0.5752169 (0.2383635)	0.6029875 (0.2122555)
Landcover availability	Open Water	proportion of the survey unit covered by open water	0.13 (0.2523657)	0.13 (0.2742217)
	Wetland	proportion of the survey unit covered by wetlands	0.10 (0.2080142)	0.10 (0.1151464)
	Bogs and Fens	proportion of the survey unit covered by bogs or fens	0.10 (0.2083355)	0.10 (0.1150031)
	Marshes and Swamps	proportion of the survey unit covered by marshes or swamps	0.01 (0.008095282)	0.01 (0.0130066)
	Forest	proportion of the survey unit covered by dense to sparse forest (100 – 30% canopy closure)	0.64 (0.3345948)	0.64 (0.3677150)
	Deciduous	proportion of the survey unit covered by deciduous dominated forest cover (>50%)	0.20 (0.3930193)	0.20 (0.4261304)
	Coniferous	proportion of the survey unit covered by conifer dominated forest cover (>50%)	0.44 (0.3542956)	0.44 (0.3595976)
	Crop and Grassland	proportion of the survey unit covered by open grassland and agricultural fields	0.01 (0.02934337)	0.01 (0.1091052)
Fire and Logging	Recent Cut	proportion of the survey unit covered by forest clear-	0.04	0.04

		cuts (< 10 years of age)	(0.1547444)	(0.1715898)
	Recent Burn	proportion of the survey unit covered by forest burns (< 10 years of age)	0.02 (0.1374155)	0.02 (0.06226773)
	Recent Cut and Burn	proportion of the survey unit covered by forest clear-cuts or burns (< 10 years of age)	0.06 (0.1939755)	0.06 (0.1820456)
	Old Cut and Burn	proportion of the survey unit covered by forest clear-cuts or burns (10 – 20 years of age)	0.04 (0.1505244)	0.04 (0.1610546)
	Regen	proportion of the survey unit covered by forest clear-cuts or burns (< 10 years of age)	0.10 (0.2521408)	0.10 (0.2618642)
Settlements and Mining	Urban and Mining	proportion of the survey unit covered by urban areas or mines	0.01 (0.04978931)	0.01 (0.1113101)
Roads	Road density	road density (km/km^2) within the survey unit	0.05064626 (0.2057268)	6.918395 (22.03410)

[1]Calculated following the equation on page 5033 in Gotelli et al. (2010). Specifically:

$$HHind = 1.0 - \sum_{i=1}^{11}\left(p_i^2\right)$$

where pi is the proportion of the total area within each survey unit covered by habitat *i*.

TABLE A3 A. Waterfowl species detected in the Ontario shields ecozone by the bird surveys.

Species name	Survey type and species prevalence (%)				
	OBBA2	OBBA2pc	BBS	CWS	FWS
American Black Duck	23	1	5	90	20
American Wigeon	3		1	7	2
Scoters[1]					2
Surf Scoter				1	
White-winged Scoter	<1			1	
Bufflehead	5	<1		25	20
Blue-winged Teal	9	1	4	10	<1
Canada goose	29	10	28	31	13
Canvasback	<1				<1
Common Goldeneye	29	3	8	69	36
Mergansers[1]					55
Common Merganser	40	8	15	72	
Red-breasted Merganser	6	1	1	2	
Hooded Merganser	28	3	10	90	
Gadwall	1	<1	<1	<1	<1
Green-winged Teal	8	3	4	45	13
Scaups[1]					2
Greater Scaup	<1				
Lesser Scaup	2	<1		3	
Long-tailed Duck				2	<1
Mallard	41	7	35	87	40
Northern Pintail	1		<1		<1
Northern Shoveler	1		0	1	<1
Redhead	<1				<1
Ring-necked Duck	25	1	8	87	58
Rudy Duck	1				<1
Swans[1]					<1
Trumpeter Swan	1			1	
Mute Swan	<1		<1		
Wood Duck		3	22	53	

Note: An empty cell denotes the species was never detected by the survey.

[1] Mergansers, scaups, scoters and swans are not distinguished to the species level by the FWS survey and the Wood Duck is not among the species recorded. Surveys were repeated once per year, except for the Breeding Bird Atlas at the cell-level (OBBA2 - maximum breeding status from 2001-2005); here, data from 1997 – 2006 (2001 – 2005 for the OBBA2) are considered.

TABLE A3 B. Shorebird species detected in the Ontario shields ecozone by the four bird surveys.

Species name	Survey type and species prevalence (%)			
	OBBA2	OBBA2pc	BBS	CWS
Arctic Tern	<1			
Black Tern	2	<1	2	
Bonaparte's Gull	7	1	<1	14
Caspian Tern	2	<1		
Common Tern	7	1	1	
Forster's Tern	<1			
Dunlin	<1			
Greater Yellowlegs	5	2	<1	2
Great Black-backed Gull	<1			
Herring Gull	38	14	41	38
Least Sandpiper	<1			
Lesser Yellowlegs	1	<1		3
Marbled Godwit	<1	<1		
Piping Plover	<1			
Red-necked Phalarope	<1			
Ring-billed Gull	8	3	35	2
Semipalmated Plover	<1			
Semipalmated Sandpiper	<1			
Solitary Sandpiper	7	1	1	56
Spotted Sandpiper	36	3	4	84
Upland Sandpiper	2	1	3	
Wilson's (Common) Snipe	30	13	46	

Note: An empty cell denotes the species was never detected by the survey. Shorebirds were not recorded by the FWS waterfowl survey. Surveys were repeated once per year, except for the Breeding Bird Atlas at the cell-level (OBBA2 - maximum breeding status from 2001–2005); here, data from 1997 – 2006 (2001 – 2005 for the OBBA2) are considered.

TABLE A3 C. Other waterbird species detected in the Ontario shields ecozone by the four bird surveys.

Species name	Survey type and species prevalence (%)				
	OBBA2	OBBA2pc	BBS	CWS	FWS
Alder Flycatcher	54	51	88		
American Bittern	23	8	35	11	
American White Pelican	1		3		
American Coot	1	<1	1	1	<1
Bald Eagle	24	2	4	4	
Belted Kingfisher	44	14	52	27	
Black-crowned Night-Heron	<1	<1			
Common Loon	61	41	68	87	
Common Moorhen	1	<1	<1		
Common Yellowthroat	55	59	97		
Double-crested Cormorant	9	1	8	9	
Eared Grebe	<1				
Great Blue Heron	31	9	52	56	
Great Egret	<1				
Green Heron	4	<1	4		
Horned Grebe	<1				
King Rail	<1				
Least Bittern	1		2		
Lincoln's Sparrow	24	19	25		
Louisiana Waterthrush	<1				
Marsh Wren	5	1	3		
Northern Waterthrush	41	30	57		
Olive-sided Flycatcher	25	16	16		
Osprey	24	2	6	8	
Palm Warbler	11	11	8		
Pied-billed Grebe	11	2	6		
Red-necked Grebe	2	<1	2		
Rusty Blackbird	7	2	2		
Red-winged Blackbird	40	28	82		
Sandhill Crane	15	6	15	17	
Sedge Wren	6	1	9		
Sora	8	1	4		
Swamp Sparrow	54	43	87		
Virginia Rail	10	1	4		
Wilson's Warbler	12	9	12		
Yellow Rail	1	<1			
Yellow-headed Blackbird	1	<1	<1		

Note: An empty cell denotes the species was never detected by the survey. The FWS survey only sampled the American Coot among non-waterfowl waterbirds. Surveys were repeated once per year, except for the Breeding Bird Atlas at the cell-level (OBBA2 - maximum breeding status from 2001–2005); here, data from 1997 – 2006 (2001 – 2005 for the OBBA2) are considered.

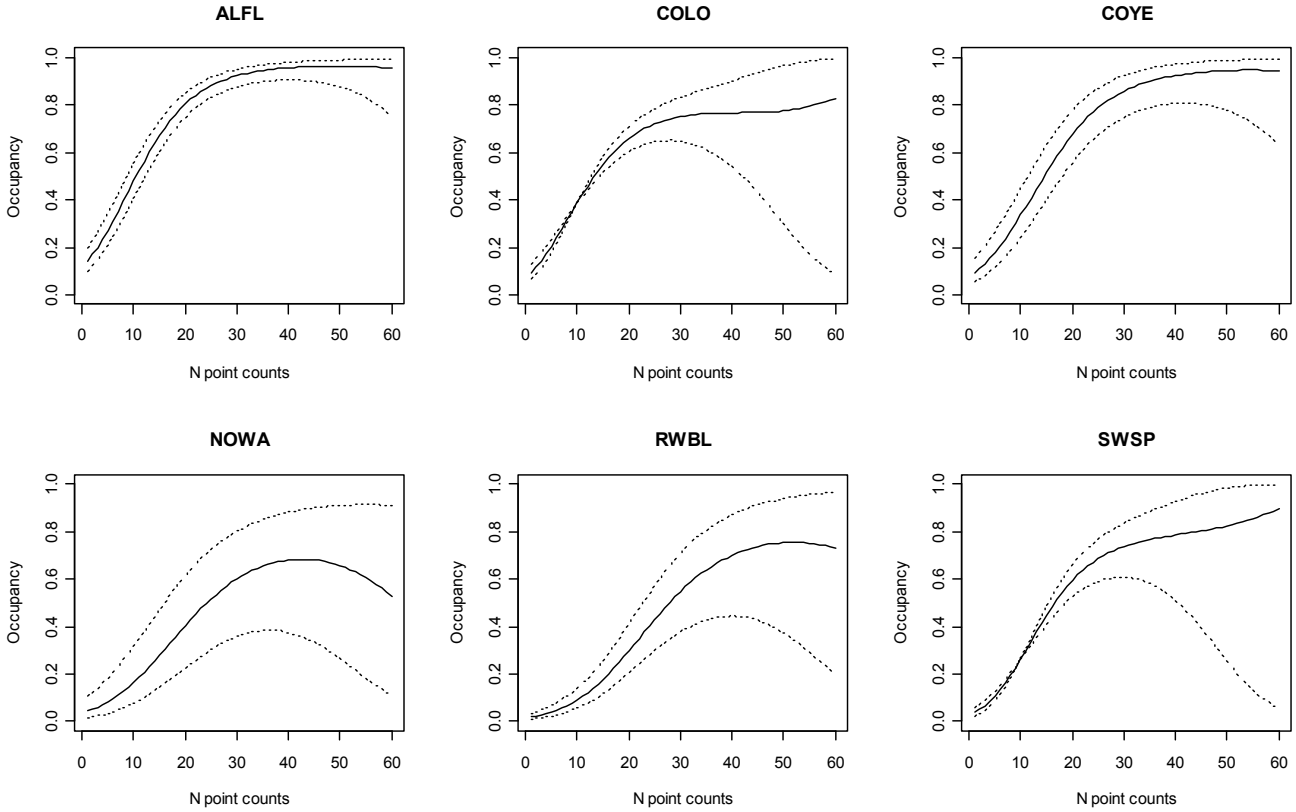

FIG. A1. Effects of sampling intensity (N point counts) on the probability of occupancy for six Boreal forest waterbird species living in the Ontario Shield ecozone. Point count data were obtained from the Ontario Breeding Bird Atlas. Model-averaged estimates and 95% confidence intervals were obtained using logistic regression mixed effects models and Bayesian multi-model selection procedures (BIC statistics).

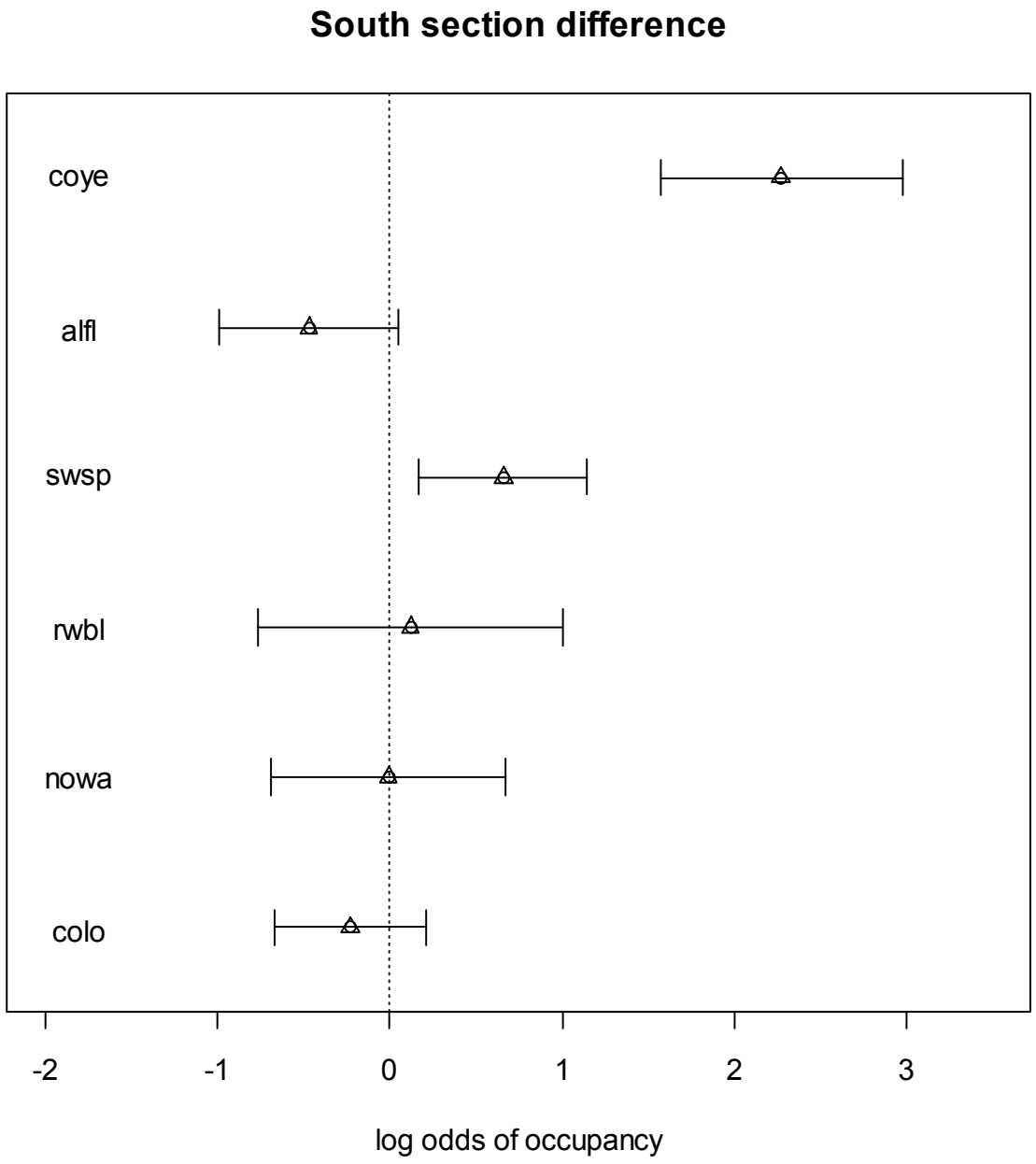

FIG. A2. Difference in the probability of occupancy for points counts of the south section of the Ontario Breeding Bird Atlas, compared to the north section. Sampling intensity was considerably higher in the south section, as was the proportion of voluntary birders, yet no consistent effect on occupancy is found among the species. Point count data were obtained from the Ontario Breeding Bird Atlas (years 2001 – 2005). Model-averaged estimates and 95% confidence intervals were obtained using logistic regression mixed effects models and Bayesian multi-model selection procedures (BIC statistics).

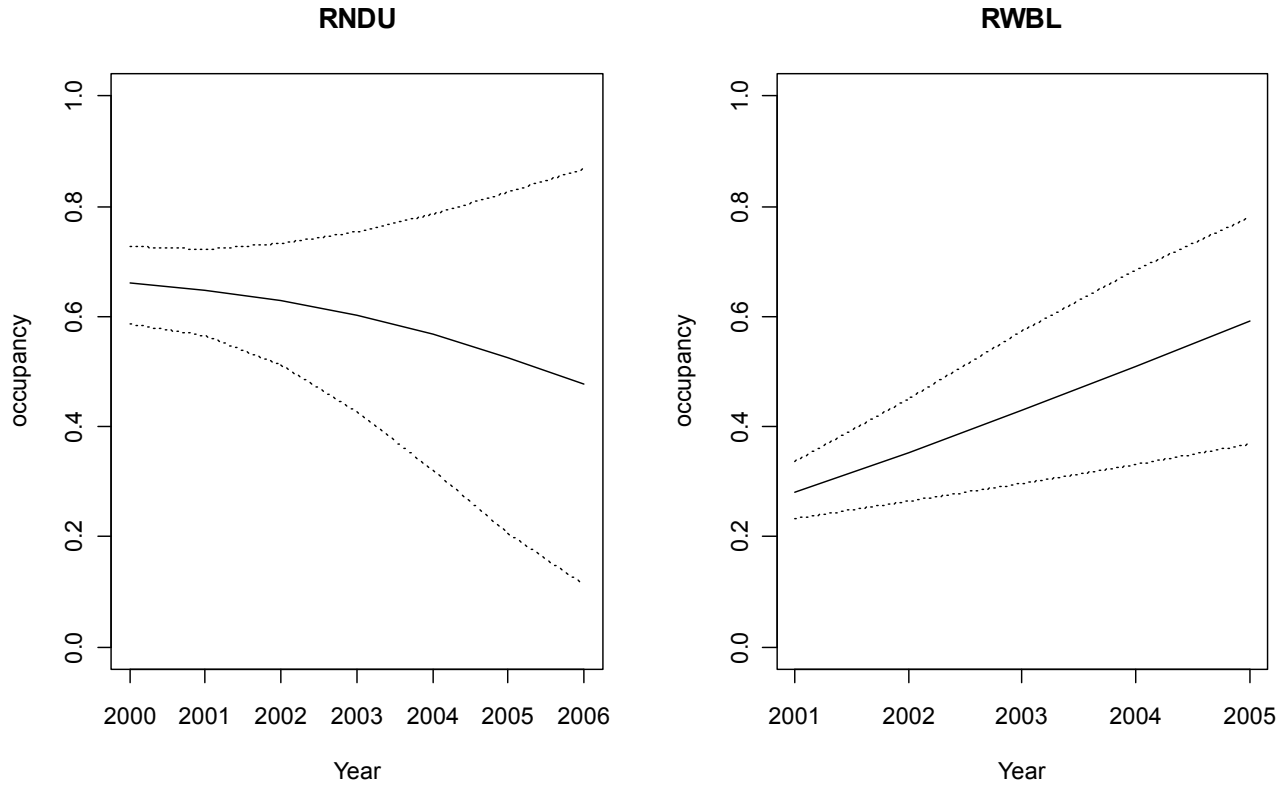

FIG. A3. Yearly trends in the probability of occupancy in the Ontario Shield ecozone. Consistent trends in the probability of occupancy were detected for two waterbird species, the ring-necked duck (RNDU) and the red-winged blackbird (RWBL), whereas the available data did not support a consistent trend for the other 12 modeled waterbird species. Model-averaged estimates and 95% confidence intervals were obtained using logistic regression mixed effects models and information-theoretic model selection procedures (using the BIC statistics).

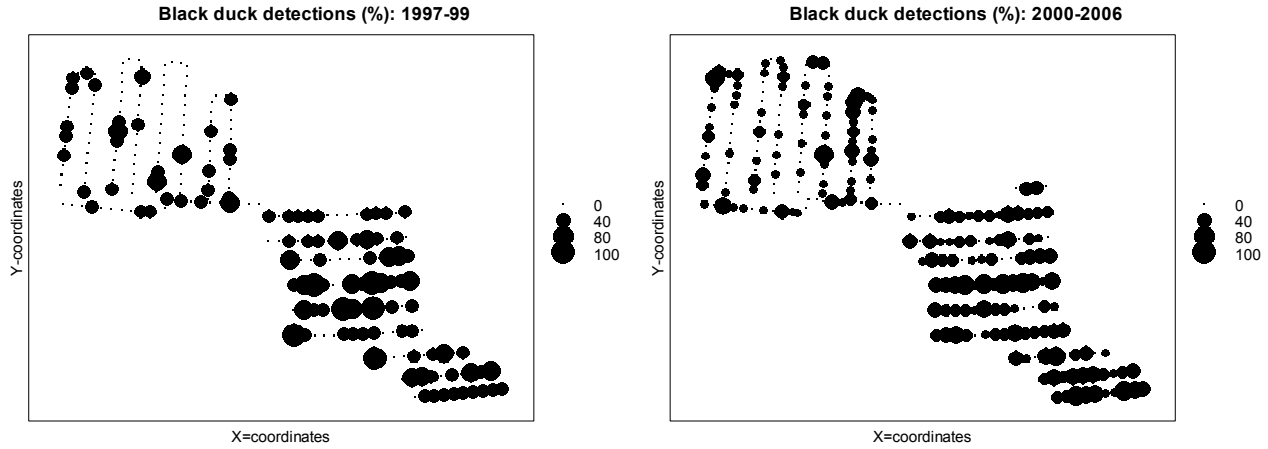

FIG. A4. Distribution of American black duck sightings in the Ontario Shield ecozone for each USFWS fixed winged survey segment (28.8 km long and 400 m wide); data from 2000-2006 were used for model selection (right map) and the model averaged fixed effects predictions (Table A1) were validated using data from 1997-1999 (left map). The dimension of the dots is proportional to the percentage of years with detection for each segment, as shown in the legend on the right for each map. Easting and northing are in Lambert Conformal Conic coordinates.

TABLE A4. Model averaged parameter estimates of covariates (HSI) of American black duck occupancy in the Ontario Shield ecozone.

Covariate	Parameter estimate	SE	Covariate Importance
Intercept	-1.2861	0.180069912	1
Coniferous cover	-0.9054	0.160510264	1
Recent CutandBurn	-0.4114	0.157769012	1

Validation of Model Predictions

Predictive Ability over Time: 1997 – 1999

Prevalence train data	Prevalence test data	TSS	sens	spec	OA	AUC	PPV	NPV
0.21	0.18	**0.08**	0.53	0.55	0.54	0.53	0.21	0.84

Predictive Ability over Space: Hudson Bay Lowlands

Prevalence train data	Prevalence test data	TSS	sens	spec	OA	AUC	PPV	NPV
0.21	0.16	**0.31**	**0.62**	0.69	0.68	**0.63**	0.27	0.90

All numeric covariates were centered and standardized by dividing by 2 standard deviations. Model averaged estimates and SEs were obtained following Burnham and Andersson (2002) and Link and Barker (2006), as for the estimate of covariate importance (= sum of the weights of the model(s) were a covariate is included). TSS = true skill statistics; sens = sensitivity; spec = specificity; OA = overall accuracy; AUC = area under the ROC plot; PPV = positive predictive value; NPV = negative predictive value. All accuracy measures, except PPV and NPV are in bold if the value is better than random prediction ($p < 0.05$). See Table 2 for covariate acronyms and Methods for further details.

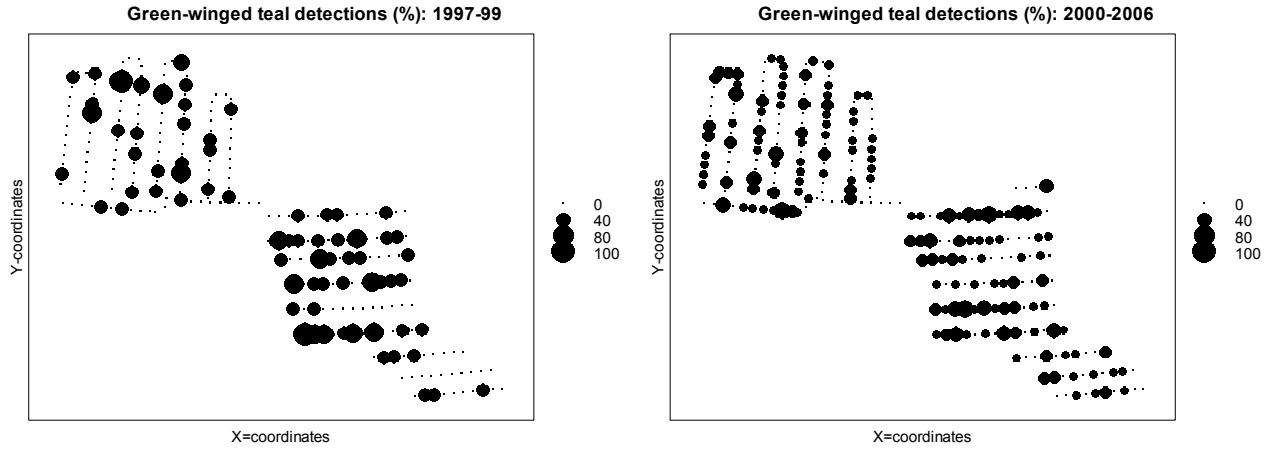

FIG. A5. Distribution of Green Winged Teal sightings in the Ontario Shield ecozone for each USFWS fixed winged survey segment (28.8 km long and 400 m wide); data from 2000–2006 were used for model selection (right map) and the model averaged fixed effects predictions (Table A1) were validated using data from 1997–1999 (left map). The dimension of the dots is proportional to the percentage of years with detection for each segment, as shown in the legend on the right for each map. Easting and northing are in Lambert Conformal Conic coordinates.

TABLE A5. Model averaged parameter estimates of covariates (HSI) of Green-winged Teal occupancy in the Ontario Shield ecozone.

Covariate	Parameter estimate	SE	Covariate Importance
Intercept	-2.043633323	0.171831066	0.99
BSdev	-0.025933493	0.028663237	0.09
Latitude	-0.004842598	0.005221815	0.01
Temperature seasonality	-0.010747132	0.011268749	0.02
Habitat heterogeneity	0.013278536	0.014106892	0.03
Deciduous cover	0.008100088	0.008732786	0.02
Road density	-0.10522293	0.103970472	0.22
NAOmay	0.022215697	0.028581531	0.05

Validation of Model Predictions

Predictive Ability over Time: 1997 – 1999

Prevalence train data	Prevalence test data	TSS	sens	spec	OA	AUC	PPV	NPV
0.13	0.12	**0.09**	**0.95**	0.14	0.23	**0.58**	0.13	0.96

Predictive Ability over Space: Hudson Bay Lowlands

Prevalence train data	Prevalence test data	TSS	sens	spec	OA	AUC	PPV	NPV
0.13	0.17	0.01	0.06	**0.95**	**0.80**	0.30	0.19	0.83

All numeric covariates were centered and standardized by dividing by 2 standard deviations. Model averaged estimates and SEs were obtained following Burnham and Andersson (2002) and Link and Barker (2006), as for the estimate of covariate importance (= sum of the weights of the model(s) were a covariate is included). TSS = true skill statistics; sens = sensitivity; spec = specificity; OA = overall accuracy; AUC = area under the ROC plot; PPV = positive predictive value; NPV = negative predictive value. All accuracy measures, except PPV and NPV are in bold if the value is better than random prediction ($p < 0.05$). See Table 2 for covariate acronyms and Methods for further details.

FIG. A6. Distribution of Bufflehead sightings in the Ontario Shield ecozone for each USFWS fixed winged survey segment (28.8 km long and 400 m wide); data from 2000–2006 were used for model selection (right map) and the model averaged fixed effects predictions (Table A3) were validated using data from 1997–1999 (left map). The dimension of the dots is proportional to the percentage of years with detection for each segment, as shown in the legend on the right for each map. Easting and northing are in Lambert Conformal Conic coordinates.

TABLE A6. Model averaged parameter estimates of covariates (HSI) of Bufflehead occupancy in the Ontario Shield ecozone.

Covariate	Parameter estimate	SE	Covariate Importance
Intercept	-1.849709572	0.23109985	1
Tdev	-0.250931418	0.149802265	0.6
Y	-0.003463766	0.00402179	0.01
Temperature seasonality	-0.022897324	0.023516958	0.04
BogFen	-0.265598575	0.167681819	0.45
RecCut	0.00347588	0.006798554	0.02
RecBurn	0.00347588	0.006798554	0.02
OldCutBurn	0.00347588	0.006798554	0.02

Validation of Model Predictions

Predictive Ability over Time: 1997 – 1999

Prevalence train data	Prevalence test data	TSS	sens	spec	OA	AUC	PPV	NPV
0.21	0.15	0.07	**0.98**	0.09	0.23	0.45	0.16	0.97

Predictive Ability over Space: Hudson Bay Lowlands

Prevalence train data	Prevalence test data	TSS	sens	spec	OA	AUC	PPV	NPV
0.21	0.10	0.02	**1**	0.02	0.12	0.43	0.10	1

All numeric covariates were centered and standardized by dividing by 2 standard deviations. Model averaged estimates and SEs were obtained following Burnham and Andersson (2002) and Link and Barker (2006), as for the estimate of covariate importance (= sum of the weights of the model(s) were a covariate is included). TSS = true skill statistics; sens = sensitivity; spec = specificity; OA = overall accuracy; AUC = area under the ROC plot; PPV = positive predictive value; NPV = negative predictive value. All accuracy measures, except PPV and NPV are in bold if the value is better than random prediction ($p < 0.05$). See Table 2 for covariate acronyms and Methods for further details.

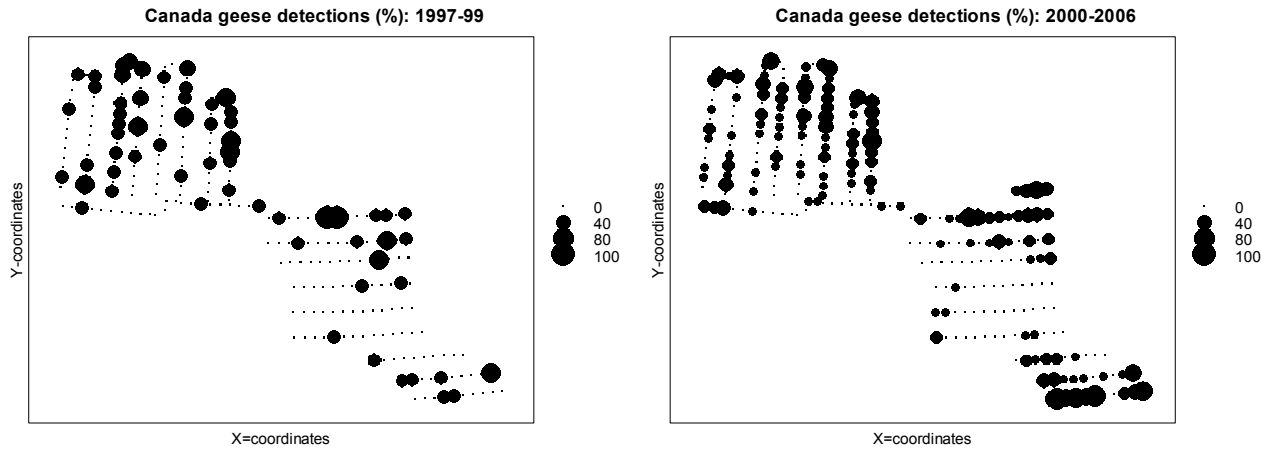

FIG. A7. Distribution of Canada goose sightings in the Ontario Shield ecozone for each USFWS fixed winged survey segment (28.8 km long and 400 m wide); data from 2000–2006 were used for model selection (right map) and the model averaged fixed effects predictions (Table A4) were validated using data from 1997–1999 (left map). The dimension of the dots is proportional to the percentage of years with detection for each segment, as shown in the legend on the right for each map. Easting and northing are in Lambert Conformal Conic coordinates.

TABLE A7. Model averaged parameter estimates of covariates (HSI) of Canada geese occupancy in the Ontario Shield ecozone.

Covariate	Parameter estimate	SE	Covariate Importance
Intercept	-2.142623298	0.279067596	1
BSdev	0.003053641	0.006035538	0.01
Y	0.088257144	0.08650714	0.05
Precipitation seasonality	0.352821728	0.301779969	0.18
BogFen	0.43982407	0.186767253	0.66
MarshSwamp	0.43982407	0.186767253	0.66
CropGrass	0.582999238	0.313784602	0.66
RecCut	-0.819873658	0.326431992	1
RecBurn	-0.151317256	0.243977713	0.23
OldCutBurn	-0.032221895	0.062978041	0.05
Road density	0.118953001	0.194060902	0.24

Validation of Model Predictions

Predictive Ability over Time: 1997 – 1999

Prevalence train data	Prevalence test data	TSS	sens	spec	OA	AUC	PPV	NPV
0.15	0.10	**0.27**	**0.84**	0.43	0.48	**0.68**	0.15	0.96

Predictive Ability over Space: Hudson Bay Lowlands

Prevalence train data	Prevalence test data	TSS	sens	spec	OA	AUC	PPV	NPV
0.15	0.61	**0.55**	**0.80**	0.75	**0.78**	**0.83**	0.84	0.71

All numeric covariates were centered and standardized by dividing by 2 standard deviations. Model averaged estimates and SEs were obtained following Burnham and Andersson (2002) and Link and Barker (2006), as for the estimate of covariate importance (= sum of the weights of the model(s) were a covariate is included). TSS = true skill statistics; sens = sensitivity; spec = specificity; OA = overall accuracy; AUC = area under the ROC plot; PPV = positive predictive value; NPV = negative predictive value. All accuracy measures, except PPV and NPV, are in bold if the value is better than random prediction ($p < 0.05$). See Table 2 for covariate acronyms and Methods for further details.

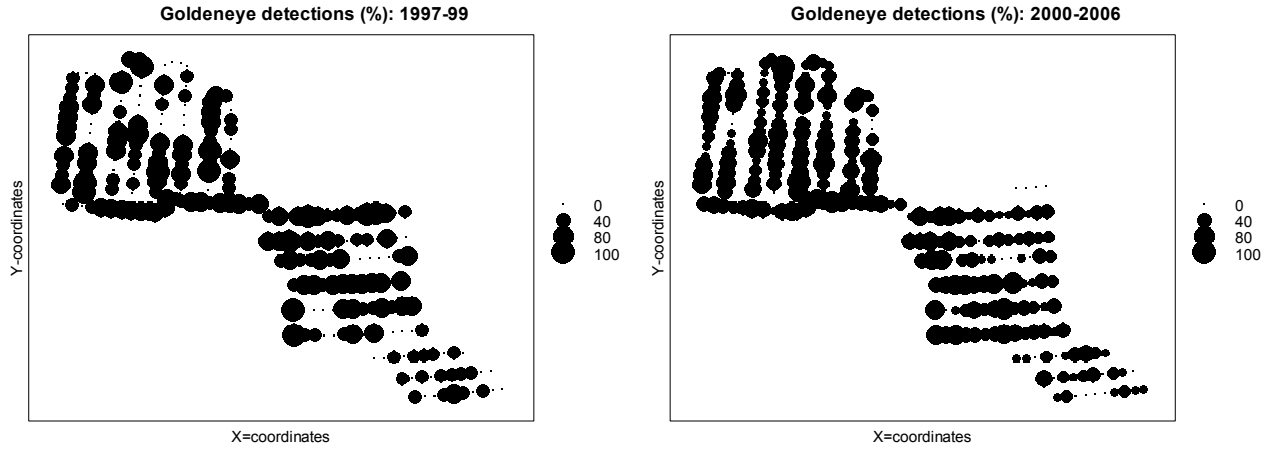

FIG. A8. Distribution of Goldeneye sightings in the Ontario Shield ecozone for each USFWS fixed winged survey segment (28.8 km long and 400 m wide); data from 2000–2006 were used for model selection (right map) and the model averaged fixed effects predictions (Table A5) were validated using data from 1997–1999 (left map). The dimension of the dots is proportional to the percentage of years with detection for each segment, as shown in the legend on the right for each map. Easting and northing are in Lambert Conformal Conic coordinates.

TABLE A8. Model averaged parameter estimates of covariates (HSI) of Goldeneye occupancy in the Ontario Shield ecozone.

Covariate	Parameter estimate	SE	Covariate Importance
Intercept	-1.227541124	0.393025485	1
ENSO	0.94460988	0.36219775	1
Pdev	-0.393129893	0.152421088	1
OpenWater	1.735665451	0.232145484	1
Forest	0.772031587	0.210556572	1
OldCutBurn	0.580925634	0.166496004	1
WaterC x Forest	0.792231693	0.186627466	1

Validation of Model Predictions								
Predictive Ability over Time: 1997 – 1999								
Prevalence train data	Prevalence test data	TSS	sens	spec	OA	AUC	PPV	NPV
0.37	0.36	0.02	0.04	**0.98**	**0.65**	0.43	0.56	0.65
Predictive Ability over Space: Hudson Bay Lowlands								
Prevalence train data	Prevalence test data	TSS	sens	spec	OA	AUC	PPV	NPV
0.37	0.17	**0.18**	**0.90**	0.28	0.38	**0.62**	0.20	0.94

All numeric covariates were centered and standardized by dividing by 2 standard deviations. Model averaged estimates and SEs were obtained following Burnham and Andersson (2002) and Link and Barker (2006), as for the estimate of covariate importance (= sum of the weights of the model(s) were a covariate is included). TSS = true skill statistics; sens = sensitivity; spec = specificity; OA = overall accuracy; AUC = area under the ROC plot; PPV = positive predictive value; NPV = negative predictive value. All accuracy measures, except PPV and NPV, are in bold if the value is better than random prediction ($p < 0.05$). See Table 2 for covariate acronyms and Methods for further details.

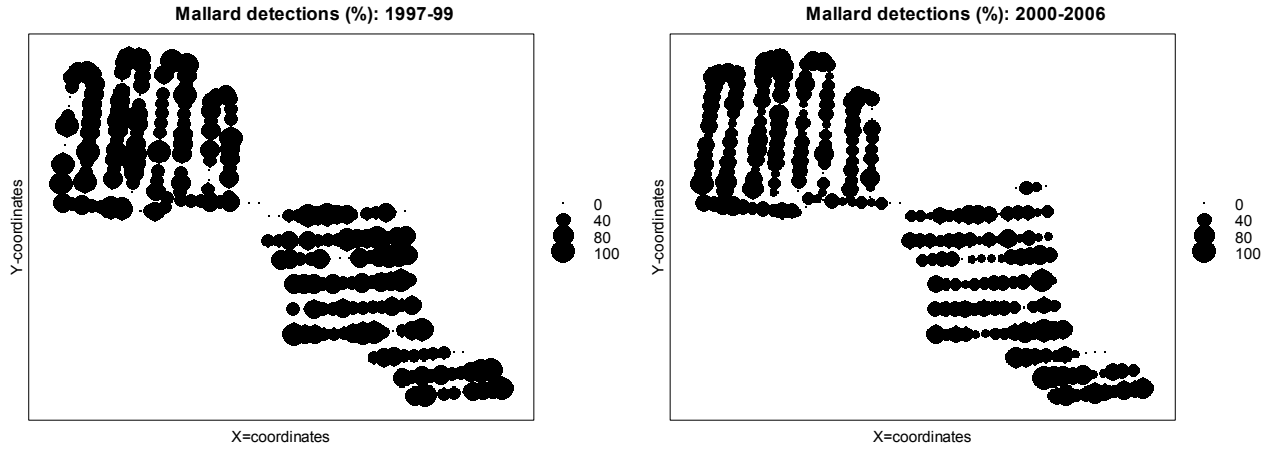

FIG. A9. Distribution of Mallard sightings in the Ontario Shield ecozone for each USFWS fixed winged survey segment (28.8 km long and 400 m wide); data from 2000–2006 were used for model selection (right map) and the model averaged fixed effects predictions (Table A6) were validated using data from 1997–1999 (left map). The dimension of the dots is proportional to the percentage of years with detection for each segment, as shown in the legend on the right for each map. Easting and northing are in Lambert Conformal Conic coordinates.

TABLE A9. Model averaged parameter estimates of covariates (HSI) of Mallard occupancy in the Ontario Shield ecozone.

Covariate	Parameter estimate	SE	Covariate Importance
Intercept	-0.350400755	0.177342766	1
YEAR	0.002379908	0.008153819	0.02
$YEAR^2$	0.01529516	0.038826818	0.02
ENSO	0.566438454	0.190962054	0.99
Sdev	0.313756978	0.152909962	0.97
Pdev	-0.292882107	0.126951819	0.97
Longitude	-0.011616661	0.012942607	0.02
Latitude	0.0024598	0.006320127	0.02
Precipitation seasonality	0.1395297	0.120713472	0.29
Habitat heterogeneity	0.338450438	0.141942865	0.82
BogFen	-0.184277175	0.118131014	0.51
MarshSwamp	-0.184277175	0.118131014	0.51
Deciduous	-0.271621943	0.156380811	0.51
Conif	-0.271621943	0.156380811	0.51
RecCutBurn	-0.432952952	0.214147674	0.99
OldCutBurn	0.055988111	0.097364656	0.17
roadDens	0.453885935	0.171924402	0.99
MiningSettl	0.203679308	0.158702105	0.99
X x Y	-0.027166305	0.028012723	0.02
MiningSettl x RecCutBurn	-1.318758772	0.415161468	0.99

Validation of Model Predictions

Predictive Ability over Time: 1997 – 1999

Prevalence train data	Prevalence test data	TSS	sens	spec	OA	AUC	PPV	NPV
0.41	0.47	**0.10**	0.50	**0.60**	**0.55**	**0.56**	0.53	0.57

Predictive Ability over Space: Hudson Bay Lowlands

Prevalence train data	Prevalence test data	TSS	sens	spec	OA	AUC	PPV	NPV
0.41	0.37	**0.14**	**0.66**	0.48	0.55	**0.58**	0.43	0.70

All numeric covariates were centered and standardized by dividing by 2 standard deviations. Model averaged estimates and SEs were obtained following Burnham and Andersson (2002) and Link and Barker (2006), as for the estimate of covariate importance (= sum of the weights of the model(s) were a covariate is included). TSS = true skill statistics; sens = sensitivity; spec = specificity; OA = overall accuracy; AUC = area under the ROC plot; PPV = positive predictive value; NPV = negative predictive value. All accuracy measures, except PPV and NPV are in bold if the value is better than random prediction ($p < 0.05$). See Table 2 for covariate acronyms and Methods for further details.

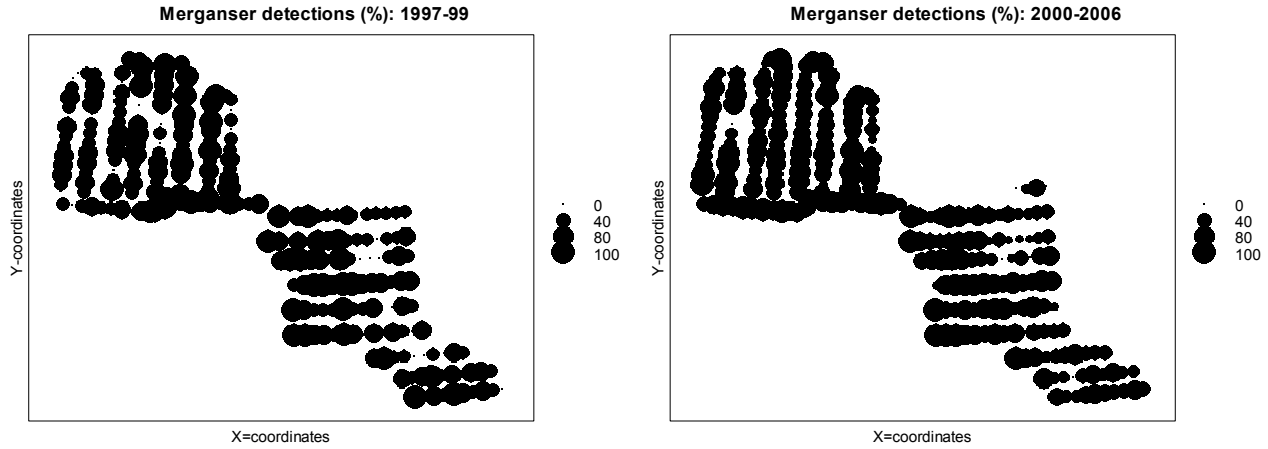

FIG. A10. Distribution of Merganser sightings in the Ontario Shield ecozone for each USFWS fixed winged survey segment (28.8 km long and 400 m wide); data from 2000–2006 were used for model selection (right map) and the model averaged fixed effects predictions (Table A7) were validated using data from 1997–1999 (left map). The dimension of the dots is proportional to the percentage of years with detection for each segment, as shown in the legend on the right for each map. Easting and northing are in Lambert Conformal Conic coordinates.

TABLE A10. Model averaged parameter estimates of covariates (HSI) of Merganser occupancy in the Ontario Shield ecozone.

Covariate	Parameter estimate	SE	Covariate Importance
Intercept	0.202167749	0.146910584	1
ENSO	0.638868921	0.162641824	1
Tdev	-0.469382426	0.118310754	1
WaterCover	0.737035654	0.164241927	1
BogFen	-0.76556954	0.154748734	1
roadDens	-0.415257901	0.152890677	1

Validation of Model Predictions

Predictive Ability over Time: 1997 – 1999

Prevalence train data	Prevalence test data	TSS	sens	spec	OA	AUC	PPV	NPV
0.57	0.50	**0.10**	0.21	**0.89**	**0.55**	**0.55**	0.66	0.53

Predictive Ability over Space: Hudson Bay Lowlands

Prevalence train data	Prevalence test data	TSS	sens	spec	OA	AUC	PPV	NPV
0.57	0.32	0.05	0.25	**0.79**	**0.62**	0.47	0.36	0.70

All numeric covariates were centered and standardized by dividing by 2 standard deviations. Model averaged estimates and SEs were obtained following Burnham and Andersson (2002) and Link and Barker (2006), as for the estimate of covariate importance (= sum of the weights of the model(s) were a covariate is included). TSS = true skill statistics; sens = sensitivity; spec = specificity; OA = overall accuracy; AUC = area under the ROC plot; PPV = positive predictive value; NPV = negative predictive value. All accuracy measures, except PPV and NPV are in bold if the value is better than random prediction ($p < 0.05$). See Table 2 for covariate acronyms and Methods for further details.

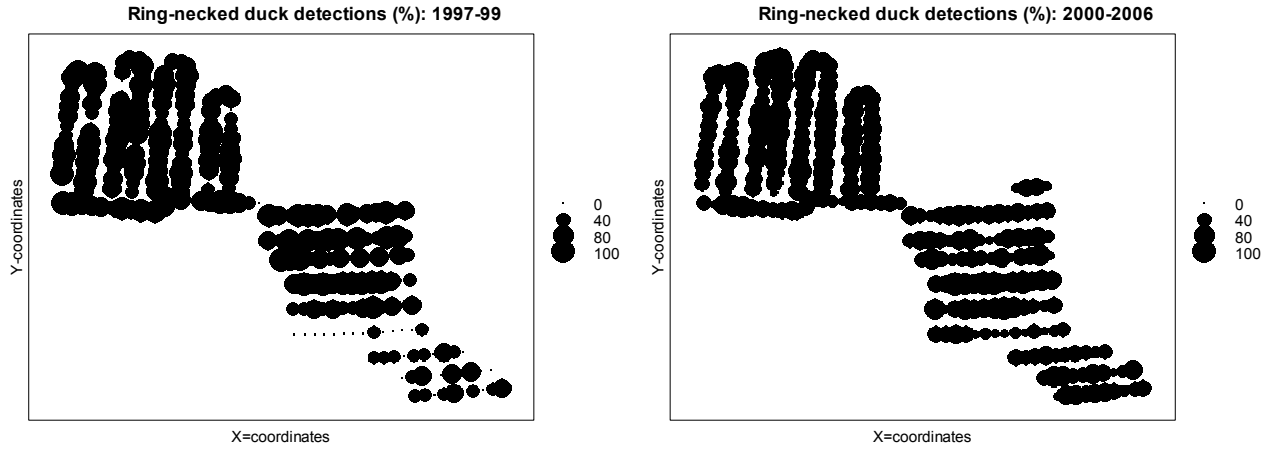

FIG. A11. Distribution of Ring-necked duck sightings in the Ontario Shield ecozone for each USFWS fixed winged survey segment (28.8 km long and 400 m wide); data from 2000–2006 were used for model selection (right map) and the model averaged fixed effects predictions (table A8) were validated using data from 1997–1999 (left map). The dimension of the dots is proportional to the percentage of years with detection for each segment, as shown in the legend on the right for each map. Easting and northing are in Lambert Conformal Conic coordinates.

TABLE A11. Model averaged parameter estimates of covariates (HSI) of Ring-necked Duck occupancy in the Ontario Shield ecozone.

Covariate	Parameter estimate	SE	Covariate Importance
Intercept	0.41324285	0.359223148	1
YEAR	-0.501379894	0.559944939	0.73
$YEAR^2$	-0.227563227	0.395913287	0.15
ENSO	0.064071756	0.111197216	0.08
Tdev	-0.415573546	0.479007678	0.58
Pdev	-0.301879023	0.26738712	0.77
Y	0.003629425	0.004261296	0.01
Annual Mean Temperature	-0.173168383	0.133514823	0.33
Habitat heterogeneity	0.196178246	0.171176072	0.52
Deciduous	0.084626717	0.076310998	0.19
OldCutBurn	0.121543095	0.155297685	0.34
NAO	0.03935402	0.068321724	0.09

Validation of Model Predictions

Predictive Ability over Time: 1997 – 1999

Prevalence train data	Prevalence test data	TSS	sens	spec	OA	AUC	PPV	NPV
0.59	0.56	**0.07**	0.53	**0.54**	**0.54**	0.52	0.59	0.48

Predictive Ability over Space: Hudson Bay Lowlands

Prevalence train data	Prevalence test data	TSS	sens	spec	OA	AUC	PPV	NPV
0.59	0.37	**0.22**	**0.60**	0.63	**0.62**	**0.60**	0.48	0.73

All numeric covariates were centered and standardized by dividing by 2 standard deviations. Model averaged estimates and SEs were obtained following Burnham and Andersson (2002) and Link and Barker (2006), as for the estimate of covariate importance (= sum of the weights of the model(s) were a covariate is included). TSS = true skill statistics; sens = sensitivity; spec = specificity; OA = overall accuracy; AUC = area under the ROC plot; PPV = positive predictive value; NPV = negative predictive value. All accuracy measures, except PPV and NPV are in bold if the value is better than random prediction ($p < 0.05$). See Table 2 for covariate acronyms and Methods for further details.

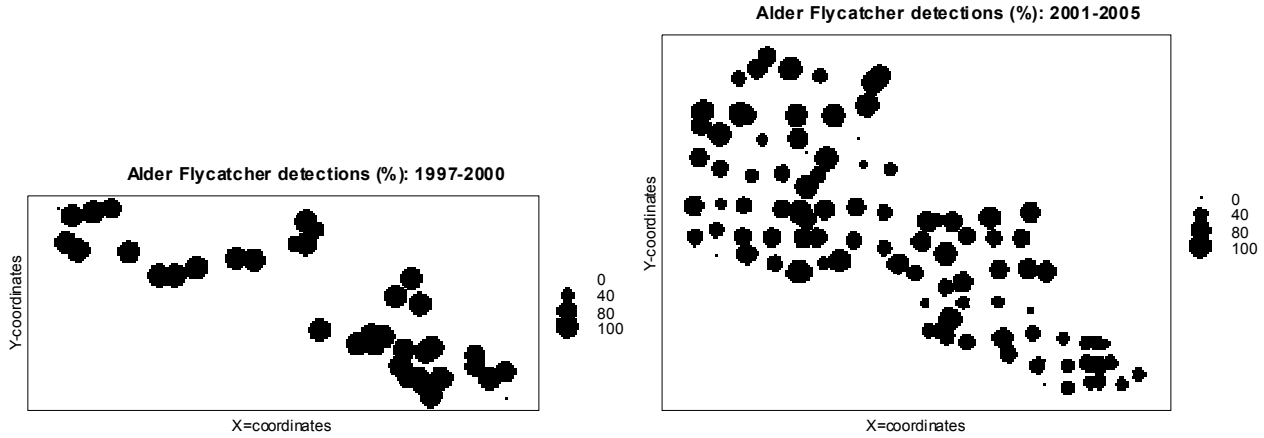

FIG. A12. Distribution of Alder Flycatcher sightings in the Ontario Shield ecozone for each OBBA2pc atlas square (10 km^2); data from 2001–2005 were used for model selection (right map) and the model averaged fixed effects predictions (Table A9) were validated using BBS data from 1997–2000 (left map). The dimension of the dots is proportional to the percentage of years with detection for each segment, as shown in the legend on the right for each map. Easting and northing are in Lambert Conformal Conic coordinates.

TABLE A12. Model averaged parameter estimates of covariates (HSI) of Alder Flycatcher occupancy in the Ontario Shield ecozone.

Covariate	Parameter estimate	SE	Covariate Importance
Intercept	2.007358546	0.204807595	1
Npcs	2.24364747	0.196240495	1
$Npcs^2$	-0.976459506	0.171706465	1
South Section	-0.467759057	0.267195016	1
Latitude	0.009548635	0.010043482	0.01
Annual Mean Temperature	-0.0427605	0.043224225	0.04
Water Cover	-1.003015775	0.204099688	0.98
Forest	-0.546738445	0.214271141	0.98
Recent CutBurn	0.553912312	0.204036445	1

Validation of Model Predictions

Predictive Ability over Time: 1997 – 1999

Prevalence train data	Prevalence test data	TSS	sens	spec	OA	AUC	PPV	NPV
0.51	0.86	**0.31**	0.64	**0.67**	0.65	0.56	0.92	0.23

Predictive Ability over Space: Hudson Bay Lowlands

Prevalence train data	Prevalence test data	TSS	sens	spec	OA	AUC	PPV	NPV
0.51	0.44	**0.39**	**0.79**	0.60	**0.68**	**0.70**	0.60	0.78

All numeric covariates were centered and standardized by dividing by 2 standard deviations. Model averaged estimates and SEs were obtained following Burnham and Andersson (2002) and Link and Barker (2006), as for the estimate of covariate importance (= sum of the weights of the model(s) were a covariate is included). TSS = true skill statistics; sens = sensitivity; spec = specificity; OA = overall accuracy; AUC = area under the ROC plot; PPV = positive predictive value; NPV = negative predictive value. All accuracy measures, except PPV and NPV are in bold if the value is better than random prediction ($p < 0.05$). See Table 2 for covariate acronyms and Methods for further details.

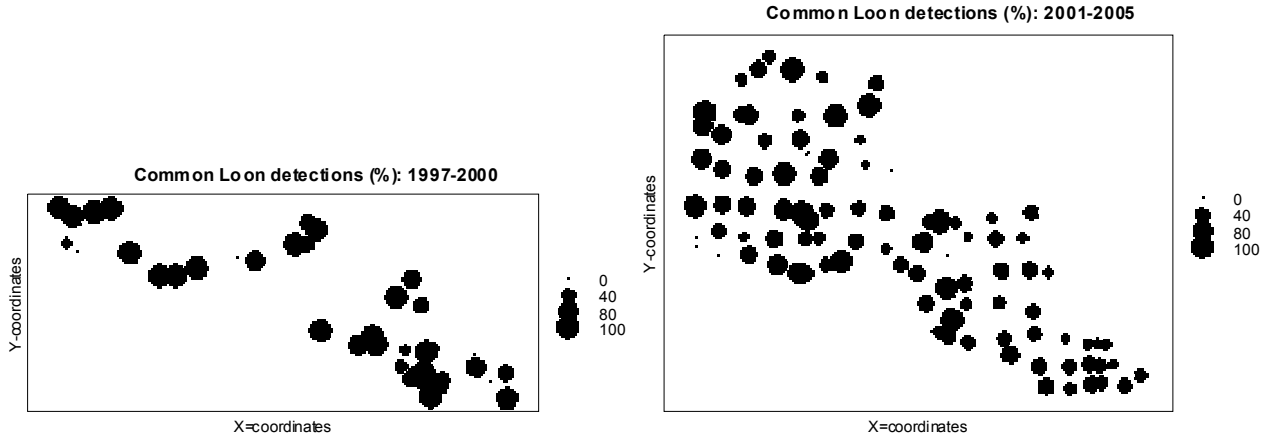

FIG. A13. Distribution of Common Loon sightings in the Ontario Shield ecozone for each OBBA2pc atlas square (10 km^2); data from 2001–2005 were used for model selection (right map) and the model averaged fixed effects predictions (Table A10) were validated using BBS data from 1997–2000 (left map). The dimension of the dots is proportional to the percentage of years with detection for each segment, as shown in the legend on the right for each map. Easting and northing are in Lambert Conformal Conic coordinates.

TABLE A13. Model averaged parameter estimates of covariates (HSI) of Common Loon occupancy in the Ontario Shield ecozone.

Covariate	Parameter estimate	SE	Covariate Importance
Intercept	0.945925574	0.177361223	1
Npcs	0.913793855	0.269543652	1
$Npcs^2$	-1.144118863	0.175542771	1
$Npcs^3$	0.493467608	0.197359195	1
South Section	-0.231264789	0.223659669	1
Water Cover	2.221936478	0.282097238	1
Forest	0.91852007	0.26821636	1
Forest regrowth	1.056985081	0.240899642	1
roadDens	-0.356609227	0.151246268	1
NAOmay	0.295885635	0.124112642	1
Water C. x Forest	0.744338747	0.195425514	1
Water C. x Regen	1.571471168	0.466214043	1

Validation of Model Predictions

Predictive Ability over Time: 1997 – 1999

Prevalence train data	Prevalence test data	TSS	sens	spec	OA	AUC	PPV	NPV
0.42	0.63	0.14	**0.94**	0.20	0.67	0.53	0.67	0.67

Predictive Ability over Space: Hudson Bay Lowlands

Prevalence train data	Prevalence test data	TSS	sens	spec	OA	AUC	PPV	NPV
0.42	0.29	**0.44**	**0.71**	0.73	**0.72**	**0.71**	0.52	0.86

All numeric covariates were centered and standardized by dividing by 2 standard deviations. Model averaged estimates and SEs were obtained following Burnham and Andersson (2002) and Link and Barker (2006), as for the estimate of covariate importance (= sum of the weights of the model(s) were a covariate is included). TSS = true skill statistics; sens = sensitivity; spec = specificity; OA = overall accuracy; AUC = area under the ROC plot; PPV = positive predictive value; NPV = negative predictive value. All accuracy measures, except PPV and NPV are in bold if the value is better than random prediction ($p < 0.05$). See Table 2 for covariate acronyms and Methods for further details.

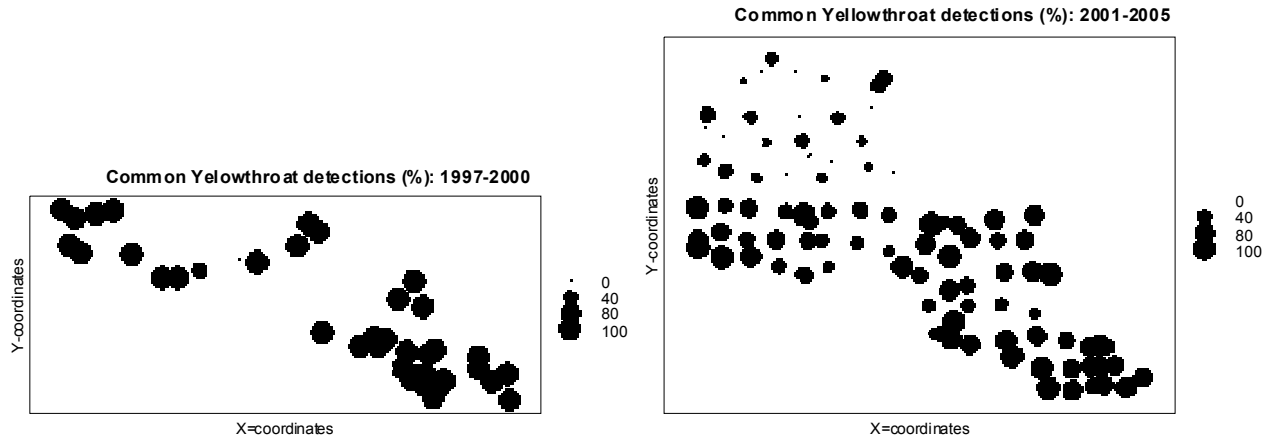

FIG. A14. Distribution of Common Yellowthroat sightings in the Ontario Shield ecozone for each OBBA2pc atlas square (10 km^2); data from 2001–2005 were used for model selection (right map) and the model averaged fixed effects predictions (Table A11) were validated using BBS data from 1997–2000 (left map). The dimension of the dots is proportional to the percentage of years with detection for each segment, as shown in the legend on the right for each map. Easting and northing are in Lambert Conformal Conic coordinates.

TABLE A14. Model averaged parameter estimates of covariates (HSI) of Common Yellowthroat occupancy in the Ontario Shield ecozone.

Covariate	Parameter estimate	SE	Covariate Importance
Intercept	1.320688594	0.303140439	1
Npcs	2.247944031	0.218692119	1
Npcs^2	-0.802554754	0.184138647	1
South Section	2.271484766	0.358450909	1
Annual Mean Temperature	0.013173711	0.013597349	0.01
Water cover	-1.989691026	0.264801609	0.99
Forest cover	-1.708255207	0.255979852	0.99
Recent CutBurn	0.009434883	0.018829904	0.01
Old CutBurn	-0.6535978	0.186188606	0.99
MiningSettl	0.005386839	0.010957374	0.01
Water C. x Forest	-0.696926689	0.227996033	0.99

Validation of Model Predictions

Predictive Ability over Time: 1997 – 1999

Prevalence train data	Prevalence test data	TSS	sens	spec	OA	AUC	PPV	NPV
0.59	0.96	**0.47**	0.72	**0.75**	0.72	**0.69**	0.99	0.09

Predictive Ability over Space: Hudson Bay Lowlands

Prevalence train data	Prevalence test data	TSS	sens	spec	OA	AUC	PPV	NPV
0.59	0.25	0.13	**0.70**	0.43	0.50	0.51	0.29	0.81

All numeric covariates were centered and standardized by dividing by 2 standard deviations. Model averaged estimates and SEs were obtained following Burnham and Andersson (2002) and Link and Barker (2006), as for the estimate of covariate importance (= sum of the weights of the model(s) were a covariate is included). TSS = true skill statistics; sens = sensitivity; spec = specificity; OA = overall accuracy; AUC = area under the ROC plot; PPV = positive predictive value; NPV = negative predictive value. All accuracy measures, except PPV and NPV are in bold if the value is better than random prediction ($p < 0.05$). See Table 2 for covariate acronyms and Methods for further details.

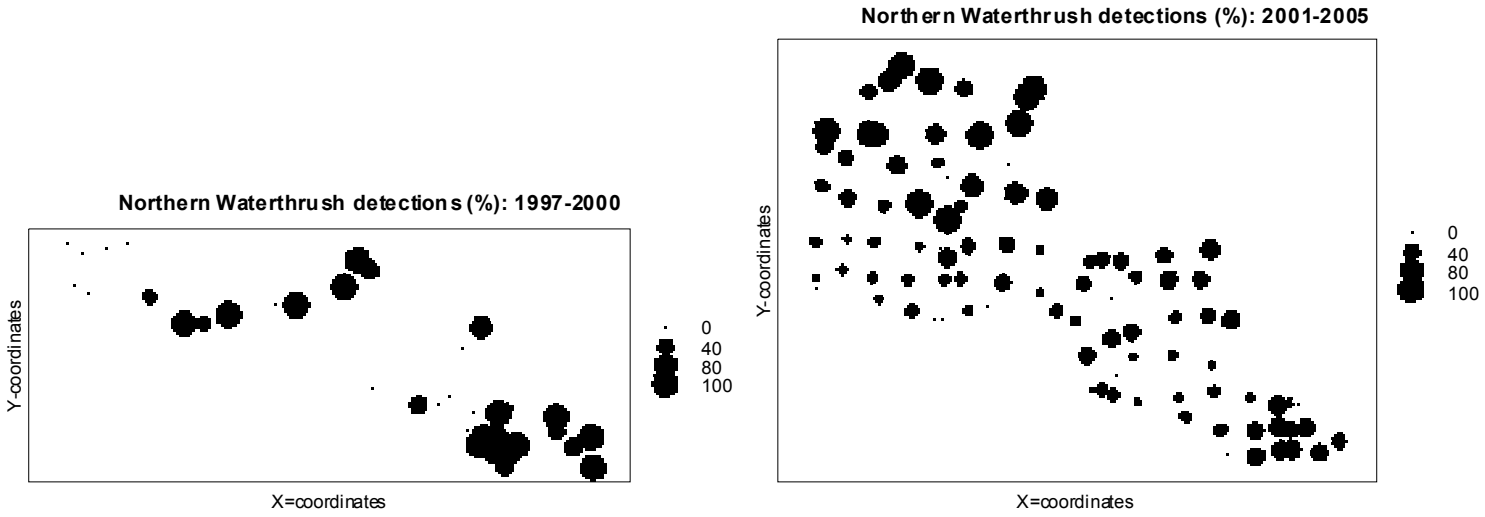

FIG. A15. Distribution of Northern Waterthrush sightings in the Ontario Shield ecozone for each OBBA2pc atlas square (10 km^2); data from 2001–2005 were used for model selection (right map) and the model averaged fixed effects predictions (Table A12) were validated using BBS data from 1997–2000 (left map). The dimension of the dots is proportional to the percentage of years with detection for each segment, as shown in the legend on the right for each map. Easting and northing are in Lambert Conformal Conic coordinates.

TABLE A15. Model averaged parameter estimates of covariates (HSI) of Northern Waterthrush occupancy in the Ontario Shield ecozone.

Covariate	Parameter estimate	SE	Covariate Importance
Intercept	0.069488582	0.461482333	1
Npcs	1.669723563	0.147681667	1
Npcs^2	-0.993464145	0.154824499	1
South Section	-0.007830863	0.348346765	1
Longitude	1.156323502	0.579152034	0.54
Latitude	0.687084881	0.401312405	0.54
Water Cover	0.466345228	0.306966724	0.45
Bog and Fen Cover	0.351852148	0.214275764	0.45
Presence of Marsh and Swamps	0.594237238	0.361262608	0.45
WaterC x BogFen	0.611639376	0.399531938	0.45
WaterC x MarshSwampPres	-1.374352464	0.906392556	0.45
Longitude x Latitude	-1.051021338	0.571887982	0.54

Validation of Model Predictions

Predictive Ability over Time: 1997 – 1999

Prevalence train data	Prevalence test data	TSS	sens	spec	OA	AUC	PPV	NPV
0.31	0.47	**0.37**	0.56	**0.81**	0.69	**0.67**	0.73	0.67

Predictive Ability over Space: Hudson Bay Lowlands

Prevalence train data	Prevalence test data	TSS	sens	spec	OA	AUC	PPV	NPV
0.31	0.56	**0.49**	**0.78**	**0.71**	**0.75**	**0.72**	0.78	0.71

All numeric covariates were centered and standardized by dividing by 2 standard deviations. Model averaged estimates and SEs were obtained following Burnham and Andersson (2002) and Link and Barker (2006), as for the estimate of covariate importance (= sum of the weights of the model(s) were a covariate is included). TSS = true skill statistics; sens = sensitivity; spec = specificity; OA = overall accuracy; AUC = area under the ROC plot; PPV = positive predictive value; NPV = negative predictive value. All accuracy measures, except PPV and NPV are in bold if the value is better than random prediction ($p < 0.05$). See Table 2 for covariate acronyms and Methods for further details.

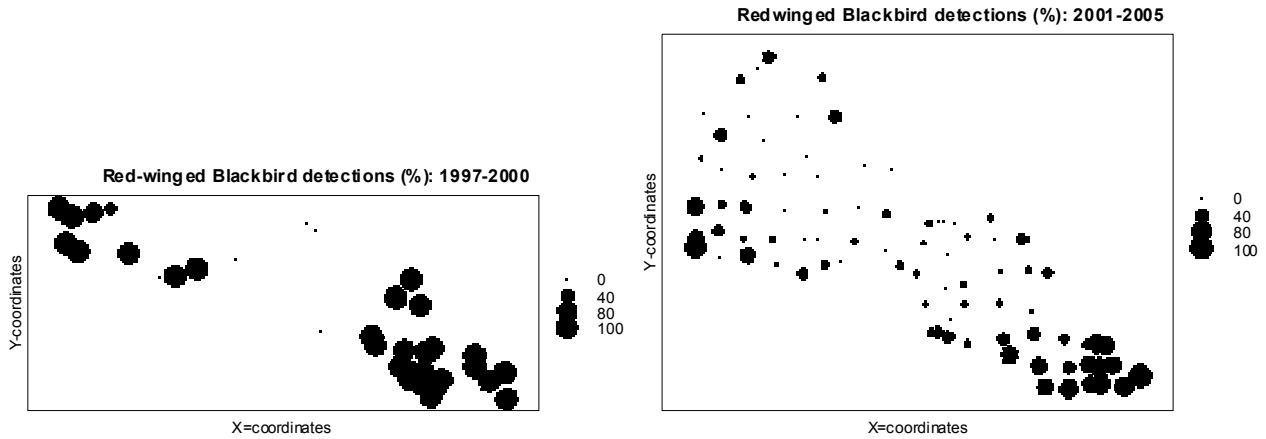

FIG. A16. Distribution of Redwinged Blackbird sightings in the Ontario Shield ecozone for each OBBA2pc atlas square (10 km^2); data from 2001–2005 were used for model selection (right map) and the model averaged fixed effects predictions (Table A12) were validated using BBS data from 1997–2000 (left map). The dimension of the dots is proportional to the percentage of years with detection for each segment, as shown in the legend on the right for each map. Easting and northing are in Lambert Conformal Conic coordinates.

TABLE A16. Model averaged parameter estimates of covariates (HSI) of Red-winged Blackbirds occupancy in the Ontario Shield ecozone.

Covariate	Parameter estimate	SE	Covariate Importance
Intercept	-0.285865168	0.294541092	1
Npcs	2.222674714	0.209647782	1
Npcs^2	-0.873508888	0.208502945	1
South Section	0.121420768	0.453324692	1
YEAR	0.837295869	0.213468977	1
Annual Mean Temperature	3.622412343	0.487683046	1
Habitat Heterogeneity	0.638607552	0.204440431	1
OldCutBurn	-0.694558061	0.31677187	1
ENSO	-0.525497534	0.226765678	1

Validation of Model Predictions

Predictive Ability over Time: 1997 - 1999

Prevalence train data	Prevalence test data	TSS	sens	spec	OA	AUC	PPV	NPV
0.28	0.76	0.11	0.42	**0.69**	0.48	0.53	0.81	0.27

Predictive Ability over Space: Hudson Bay Lowlands

Prevalence train data	Prevalence test data	TSS	sens	spec	OA	AUC	PPV	NPV
0.28	0.03	**0.75**	**1**	0.75	0.76	**0.83**	0.12	1

All numeric covariates were centered and standardized by dividing by 2 standard deviations. Model averaged estimates and SEs were obtained following Burnham and Andersson (2002) and Link and Barker (2006), as for the estimate of covariate importance (= sum of the weights of the model(s) were a covariate is included). TSS = true skill statistics; sens = sensitivity; spec = specificity; OA = overall accuracy; AUC = area under the ROC plot; PPV = positive predictive value; NPV = negative predictive value. All accuracy measures, except PPV and NPV are in bold if the value is better than random prediction ($p < 0.05$). See Table 2 for covariate acronyms and Methods for further details.

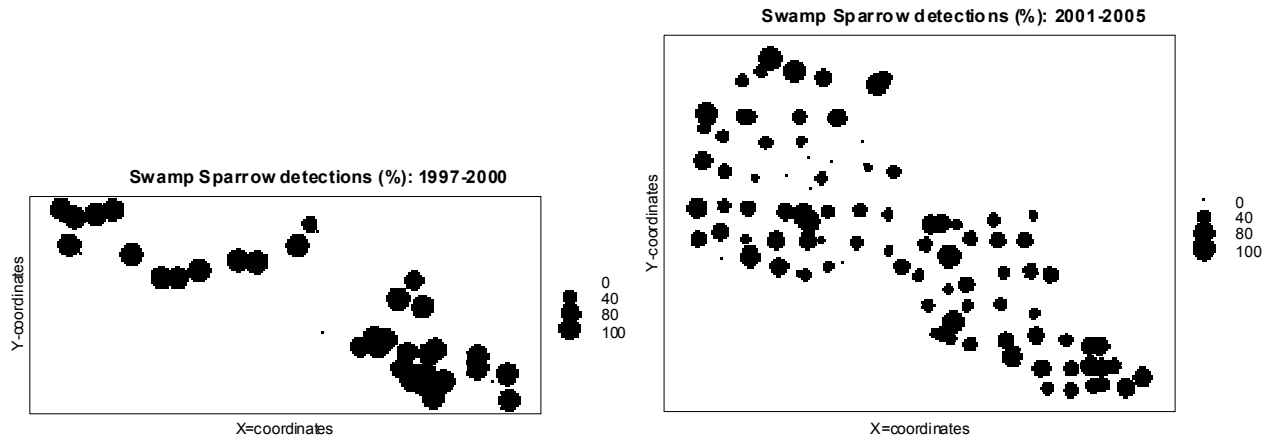

FIG. A17. Distribution of Swamp Sparrow sightings in the Ontario Shield ecozone for each OBBA2pc atlas square (10 km^2); data from 2001–2005 were used for model selection (right map) and the model averaged fixed effects predictions (Table A12) were validated using BBS data from 1997–2000 (left map). The dimension of the dots is proportional to the percentage of years with detection for each segment, as shown in the legend on the right for each map. Easting and northing are in Lambert Conformal Conic coordinates.

TABLE A17. Model averaged parameter estimates of covariates (HSI) of Swamp Sparrow occupancy in the Ontario Shield ecozone.

Covariate	Parameter estimate	SE	Covariate Importance
Intercept	0.783598955	0.210621142	1
Npcs	1.349830142	0.319526819	1
Npcs^2	-1.278941654	0.228458155	1
Npcs^3	0.580897597	0.25949672	1
South Section	0.659501954	0.247673899	1
Pdev	-0.001248301	0.002201907	0.01
Latitude	-0.001401377	0.003792989	0.01
Annual Mean Temp	0.002387505	0.004166704	0.01
Wetland cover	0.106602026	0.090567919	0.24
Recent Regrowth	-0.176071249	0.113344945	0.53
roadDens	-0.252508477	0.147093946	0.53
MiningSettl	0.237096105	0.136938608	0.53

Validation of Model Predictions

Predictive Ability over Time: 1997 – 1999

Prevalence train data	Prevalence test data	TSS	sens	spec	OA	AUC	PPV	NPV
0.42	0.86	**0.27**	0.46	**0.81**	0.51	0.59	0.93	0.20

Predictive Ability over Space: Hudson Bay Lowlands

Prevalence train data	Prevalence test data	TSS	sens	spec	OA	AUC	PPV	NPV
0.42	0.49	**0.48**	**0.78**	**0.70**	**0.74**	**0.78**	0.71	0.77

All numeric covariates were centered and standardized by dividing by 2 standard deviations. Model averaged estimates and SEs were obtained following Burnham and Andersson (2002) and Link and Barker (2006), as for the estimate of covariate importance (= sum of the weights of the model(s) were a covariate is included). TSS = true skill statistics; sens = sensitivity; spec = specificity; OA = overall accuracy; AUC = area under the ROC plot; PPV = positive predictive value; NPV = negative predictive value. All accuracy measures, except PPV and NPV are in bold if the value is better than random prediction ($p < 0.05$). See Table 2 for covariate acronyms and Methods for further details.

TABLE A18A. Summary of accuracy measures and predictive ability of habitat suitability estimates (see Tables S4 – A17) for boreal forest Waterbirds in Ontario (Canada). – Prediction over time (1997 – 2000 for OBBA2; 1997 - 1999 for FWS data) but same area (Ontario shield).

Data set	Species Code	Prevalence train data	Prevalence test data[1]	TSS	sens	spec	OA	AUC	PPV	NPV
FWS	Abdu	0.21	0.18	**0.08**	0.53	**0.55**	**0.54**	0.53	0.21	0.84
	Agwt	0.13	0.12	**0.09**	**0.95**	0.14	**0.23**	**0.58**	0.13	0.96
	Buff	0.21	0.15	0.07	**0.98**	0.09	0.23	0.45	0.16	0.97
	Cago	0.15	0.10	**0.27**	**0.84**	0.43	0.48	**0.68**	0.15	0.96
	Gold	0.37	0.36	0.02	0.04	**0.98**	**0.65**	0.43	0.56	0.65
	Mall	0.41	0.47	**0.10**	0.50	**0.60**	**0.55**	**0.56**	0.53	0.57
	Merg	0.57	0.50	**0.10**	0.21	**0.89**	**0.55**	**0.55**	0.66	0.53
	Rndu	0.59	0.56	**0.07**	0.53	**0.54**	**0.54**	0.52	0.59	0.48
OBBA2pc	Alfl	0.51	0.86	**0.31**	0.64	**0.67**	0.65	0.56	0.92	0.23
	Colo	0.42	0.64	0.14	**0.94**	0.20	0.67	0.53	0.67	0.67
	Coye	0.59	0.96	**0.47**	0.72	**0.75**	0.72	**0.69**	0.99	0.09
	Nowa	0.31	0.47	**0.37**	0.56	**0.81**	0.69	**0.67**	0.73	0.67
	Rwbl	0.28	0.76	0.11	0.42	**0.69**	0.48	0.53	0.81	0.27
	Swsp	0.42	0.86	**0.27**	0.46	**0.81**	0.51	0.59	0.93	0.20

TABLE A18B. Summary of accuracy measures and predictive ability of habitat suitability estimates (see Tables S4 – A17) for boreal forest Waterbirds in Ontario (Canada). – Prediction over space (Hudson Bay Lowlands) but same time (2000 – 2006 for FWS; 2001–2005 for OBBA2pc).

Data set	Species Code	Prevalence train data	Prevalence test data[2]	TSS	sens	spec	OA	AUC	PPV	NPV
FWS	Abdu	0.21	0.16	**0.31**	**0.62**	0.69	0.68	**0.63**	0.27	0.90
	Agwt	0.13	0.17	0.01	0.06	**0.95**	**0.80**	0.30	0.19	0.83
	Buff	0.21	0.10	0.02	**1.00**	0.02	0.12	0.43	0.10	1.00
	Cago	0.15	0.61	**0.55**	**0.80**	0.75	**0.78**	**0.83**	0.84	0.71
	Gold	0.37	0.17	**0.18**	**0.90**	0.28	0.38	**0.62**	0.20	0.94
	Mall	0.41	0.37	**0.14**	**0.66**	0.48	0.55	**0.58**	0.43	0.70
	Merg	0.57	0.32	0.05	0.25	**0.79**	**0.62**	0.47	0.36	0.70
	Rndu	0.59	0.37	**0.22**	**0.60**	0.63	**0.62**	**0.60**	0.48	0.73
OBBA2pc	Alfl	0.51	0.44	**0.39**	**0.79**	0.60	**0.68**	**0.70**	0.60	0.78
	Colo	0.42	0.29	**0.44**	**0.71**	0.73	**0.72**	**0.71**	0.52	0.86
	Coye	0.59	0.25	0.13	**0.70**	0.43	0.50	0.51	0.29	0.81
	Nowa	0.31	0.56	**0.49**	**0.78**	**0.71**	**0.75**	**0.72**	0.78	0.71
	Rwbl	0.28	0.03	**0.75**	**1.00**	0.75	0.76	**0.83**	0.12	1.00
	Swsp	0.42	0.49	**0.48**	**0.78**	**0.70**	**0.74**	**0.78**	0.71	0.77

FWS = Waterfowl fixed-wing Survey; OBBA2pc = Ontario Breeding Bird Atlas point counts; TSS = true skill statistics; sens = sensitivity; spec = specificity; OA = overall accuracy; AUC = area under the ROC plot; PPV = positive predictive value; NPV = negative predictive value. Accuracy measures, except PPV and NPV, are in bold if better than random prediction ($p < 0.05$). [1] Sample sizes of validation data are $N = 729$ for FWS and $N = 110$ for OBBA2. [2] Sample sizes of validation data are $N = 312$ for FWS and $N = 119$ for OBBA2.

TABLE A19A. Niche similarity (Spearman Rank correlations between Habitat Suitability Indices) - Waterfowl

	Abdu	Agwt	Buff	Cago	Gold	Mall	Merg	Rndu
Abdu	1							
Agwt	-0.1	1						
Buff	0.43	0.01	1					
Cago	-0.08	-0.1	-0.43	1				
Gold	0.36	-0.24	0.32	-0.08	1			
Mall	0.54	-0.49	0.35	-0.04	0.66	1		
Merg	0.27	0.03	0.66	-0.26	0.75	0.46	1	
Rndu	0.42	0.17	0.35	-0.02	0.1	0.29	0.17	1

TABLE A19B. Niche similarity (Spearman Rank correlations between Habitat Suitability Indices) – other waterbirds

	ALFL	COLO	COYE	NOWA	RWBL	SWSP
ALFL	1					
COLO	0.65	1				
COYE	0.5	0.31	1			
NOWA	0.57	0.51	0.58	1		
RWBL	0.12	0.16	0.66	0.46	1	
SWSP	0.51	0.46	0.66	0.7	0.59	1

TABLE A20A Parameter estimates and model weights of waterbird occupancy models.
AMERICAN BLACK DUCK – BASELINE MODEL

Covariate	Parameter estimate	SE	*z*	*p*	ΔBIC	BIC weight
(Intercept)	-1.296731604	0.212303581	-6.107912056	1.01E-09	16	0

Table A20B. AMERICAN BLACK DUCK – DISTURBANCE MODEL

Covariate	Parameter estimate	SE	*z*	*p*	ΔBIC	BIC weight
(Intercept)	-1.308850775	0.211317979	-6.193750187	5.87E-10	22	0
snRecCut	-0.21701936	0.164960019	-1.315587626	0.188312489		
snRecBurn	-0.21701936	0.164960019	-1.315587626	0.188312489		

Table A20C. AMERICAN BLACK DUCK – CLIMATE VARIABILITY

Covariate	Parameter estimate	SE	*z*	*p*	ΔBIC	BIC weight
(Intercept)	-1.24049797	0.208404398	-5.952359842	2.64E-09	20	0
snPdev	-0.316141445	0.164102972	-1.926482137	0.0540442		

Table A20D. AMERICAN BLACK DUCK – GEOGRAPHIC MODEL

Covariate	Parameter estimate	SE	*z*	*p*	ΔBIC	BIC weight
(Intercept)	-1.523299431	0.15639022	-9.740375288	2.03E-22	16	0
snX	1.06092874	0.242913028	4.367525063	1.26E-05		
snHHind	0.462763217	0.160959133	2.875035462	0.004039821		

Table A20E. AMERICAN BLACK DUCK – BIOCLIMATE MODEL

Covariate	Parameter estimate	SE	*z*	*p*	ΔBIC	BIC weight
(Intercept)	-1.420676592	0.159584262	-8.902360274	5.47E-19	21	0
snPdev	-0.374556266	0.159231505	-2.352274856	0.018658982		
snbioclim04Gridcode	-0.919916392	0.235387493	-3.908093762	9.30E-05		
snHHind	0.404726015	0.159528146	2.537019494	0.011180073		

Table A20F. AMERICAN BLACK DUCK – LANDCOVER MODEL

Covariate	Parameter estimate	SE	*z*	*p*	ΔBIC	BIC weight
(Intercept)	-1.286115434	0.180069912	-7.142311664	9.18E-13	0	1
snConif	-0.905422527	0.160510264	-5.640901101	1.69E-08		
snRecCut	-0.411384822	0.157769012	-2.607513467	0.009120248		
snRecBurn	-0.411384822	0.157769012	-2.607513467	0.009120248		

All numeric covariates were centered and standardized by dividing by 2 standard deviations (see Table A2). See Table A2 for covariate acronyms and Methods for further details.

TABLE A21A. Parameter estimates and model weights of waterbird occupancy models.
GREEN-WINGED TEAL – BASELINE MODEL

Covariate	Parameter estimate	SE	*z*	*p*	ΔBIC	BIC weight
(Intercept)	-2.067378704	0.170629746	-12.11616821	8.67E-34	0	0.68

Table A21B. GREEN-WINGED TEAL – DISTURBANCE MODEL

Covariate	Parameter estimate	SE	*z*	*p*	ΔBIC	BIC weight
(Intercept)	-2.024211726	0.166006802	-12.19354688	3.36E-34	3	0.17
roadDensSn	-0.420119635	0.204236424	-2.05702601	0.039683724		

Table A21C. GREEN-WINGED TEAL – CLIMATE VARIABILITY MODEL

Covariate	Parameter estimate	SE	*z*	*p*	ΔBIC	BIC weight
(Intercept)	-2.150065429	0.185945069	-11.56290643	6.35E-31	4	0.09
snBSdev	-0.288149926	0.153957392	-1.871621243	0.061259022		

Table A21D. GREEN-WINGED TEAL – GEOGRAPHIC MODEL

Covariate	Parameter estimate	SE	*z*	*p*	ΔBIC	BIC weight
(Intercept)	-2.01250557	0.13109003	-15.35208719	3.43E-53	8	0.01
snY	-0.484259756	0.206960666	-2.339863731	0.019290777		
snHHind	0.442610163	0.169222019	2.615558939	0.008908155		
roadDensSn	-0.723939315	0.229132324	-3.159481396	0.001580502		

Table A21E. GREEN-WINGED TEAL – BIOCLIMATE MODEL

Covariate	Parameter estimate	SE	*z*	*p*	ΔBIC	BIC weight
(Intercept)	-2.023262598	0.132150313	-15.3103126	6.52E-53	7	0.02
snbioclim04Gridcode	-0.537356622	0.200360131	-2.68195384	0.007319356		
snHHind	0.442621718	0.168781469	2.622454475	0.008729893		
roadDensSn	-0.741145227	0.227973224	-3.251018758	0.001149923		

Table A21F. GREEN-WINGED TEAL – LANDCOVER MODEL

Covariate	Parameter estimate	SE	*z*	*p*	ΔBIC	BIC weight
(Intercept)	-1.980180724	0.134091192	-14.7674183	2.38E-49	7	0.02
snDecid	0.405004424	0.181991312	2.225405269	0.026054044		
roadDensSn	-0.587014724	0.219110324	-2.679082912	0.007382411		
snNAOmay	0.448817744	0.171430726	2.618070601	0.008842851		

All numeric covariates were centered and standardized by dividing by 2 standard deviations (se Table A2). See Table A2 for covariate acronyms and Methods for further details.

TABLE A22A. Parameter estimates and model weights of waterbird occupancy models.
BUFFLEHEAD – BASELINE MODEL

Covariate	Parameter estimate	SE	*z*	*p*	ΔBIC	BIC weight
(Intercept)	-1.756991394	0.206323192	-8.515724178	1.66E-17	0.2	0.4

Table A22B. BUFFLEHEAD – DISTURBANCE MODEL

Covariate	Parameter estimate	SE	*z*	*p*	ΔBIC	BIC weight
(Intercept)	-1.73124561	0.204567958	-8.462936352	2.61E-17	7	0.02
snRecCut	0.17379399	0.162859657	1.067139603	0.285908801		
snRecBurn	0.17379399	0.162859657	1.067139603	0.285908801		
snOldCutBurn	0.17379399	0.162859657	1.067139603	0.285908801		

Table A22C. BUFFLEHEAD – CLIMATE VARIABILITY MODEL

Covariate	Parameter estimate	SE	*z*	*p*	ΔBIC	BIC weight
(Intercept)	-1.757561244	0.205827136	-8.53901616	1.35E-17	3	0.1
snTdev	-0.441348179	0.195015084	-2.263148937	0.02362651		

Table A22D. BUFFLEHEAD – GEOGRAPHIC MODEL

Covariate	Parameter estimate	SE	*z*	*p*	ΔBIC	BIC weight
(Intercept)	-1.905837003	0.248164088	-7.679745373	1.59E-14	9	0.01
snTdev	-0.435154586	0.176776696	-2.461606067	0.013831649		
snY	-0.346376632	0.210139803	-1.6483152	0.099288007		

Table A22E. BUFFLEHEAD – BIOCLIMATE MODEL

Covariate	Parameter estimate	SE	*z*	*p*	ΔBIC	BIC weight
(Intercept)	-2.018706338	0.289244944	-6.979227739	2.97E-12	5	0.04
snTdev	-0.445088676	0.171705877	-2.592157489	0.00953761		
snbioclim04Gridcode	-0.572433111	0.208961685	-2.739416607	0.006154833		

Table A22F. BUFFLEHEAD – LANDCOVER MODEL

Covariate	Parameter estimate	SE	*z*	*p*	ΔBIC	BIC weight
(Intercept)	-1.859389676	0.216221129	-8.599481878	8.01E-18	0	0.45
snTdev	-0.41031446	0.184238405	-2.227084297	0.025941641		
snBogFen	-0.590219055	0.182953207	-3.226065632	0.001255046		

All numeric covariates were centered and standardized by dividing by 2 standard deviations (se Table A2). See Table A2 for covariate acronyms and Methods for further details.

TABLE A23A. Parameter estimates and model weights of waterbird occupancy models.
CANADA GEESE – BASELINE MODEL

Covariate	Parameter estimate	SE	*z*	*p*	ΔBIC	BIC weight
(Intercept)	-2.136639481	0.293770827	-7.273150659	3.51E-13	10	0.01

Table A23B. CANADA GEESE – DISTURBANCE MODEL

Covariate	Parameter estimate	SE	*z*	*p*	ΔBIC	BIC weight
(Intercept)	-2.16928028	0.263461397	-8.233768997	1.81E-16	4	0.1
snRecCut	-1.064019266	0.337645827	-3.151288069	0.001625521		

Table A23C. CANADA GEESE – CLIMATE VARIABILITY MODEL

Covariate	Parameter estimate	SE	*z*	*p*	ΔBIC	BIC weight
(Intercept)	-2.151090048	0.260849437	-8.246481462	1.63E-16	9	0.01
snBSdev	0.305364085	0.136697431	2.233868504	0.025491726		
snRecCut	-1.067092542	0.336525669	-3.170909802	0.001519623		
roadDensSn	0.496819711	0.210534577	2.359801034	0.018284739		

Table A23D. CANADA GEESE – GEOGRAPHIC MODEL

Covariate	Parameter estimate	SE	*z*	*p*	ΔBIC	BIC weight
(Intercept)	-1.972705506	0.320053127	-6.163681398	7.11E-10	5	0.05
snY	1.765142889	0.425967479	4.14384425	3.42E-05		
snRecCut	-0.644437892	0.210349456	-3.063653721	0.002186518		

snRecBurn	-0.644437892	0.210349456	-3.063653721	0.002186518
snOldCutBurn	-0.644437892	0.210349456	-3.063653721	0.002186518
roadDensSn	0.586761526	0.211320104	2.776647912	0.005492264

Table A23E. CANADA GEESE – BIOCLIMATE MODEL

Covariate	Parameter estimate	SE	*z*	*p*	ΔBIC	BIC weight
(Intercept)	-1.899277536	0.344268756	-5.516845504	3.45E-08	2	0.18
snbioclim15Gridcode	1.960120711	0.47689404	4.110180765	3.95E-05		
snRecCut	-0.661640895	0.228661591	-2.893537529	0.003809288		
snRecBurn	-0.661640895	0.228661591	-2.893537529	0.003809288		
roadDensSn	0.470259597	0.209925104	2.240130347	0.025082462		

Table A23F. CANADA GEESE – LANDCOVER MODEL

Covariate	Parameter estimate	SE	*z*	*p*	ΔBIC	BIC weight
(Intercept)	-2.185322338	0.227904971	-9.588743609	8.92E-22	0	0.66
snBogFen	0.666400105	0.169532795	3.930803505	8.47E-05		
snMarshSwamp	0.666400105	0.169532795	3.930803505	8.47E-05		
GrassCropPress	0.883332179	0.368557954	2.396725318	0.016542319		
snRecCut	-0.835581136	0.328171808	-2.546169772	0.01089122		

All numeric covariates were centered and standardized by dividing by 2 standard deviations (se Table A2). See Table A2 for covariate acronyms and Methods for further details.

TABLE A24A. Parameter estimates and model weights of waterbird occupancy models.
GOLDENEYE – BASELINE MODEL

Covariate	Parameter estimate	SE	*z*	*p*	ΔBIC	BIC weight
(Intercept)	-1.309197866	0.31545756	-4.1501553	3.32E-05	21	0

Table A24B. GOLDENEYE – DISTURBANCE MODEL

Covariate	Parameter estimate	SE	*z*	*p*	ΔBIC	BIC weight
(Intercept)	-1.267281784	0.349089084	-3.630253259	0.000283143	25	0
snENSO	0.972814095	0.31480396	3.090221913	0.00200007		
snOldCutBurn	0.277370437	0.151269992	1.833611762	0.066711645		

Table A24C. GOLDENEYE – CLIMATE VARIABILITY MODEL

Covariate	Parameter estimate	SE	*z*	*p*	ΔBIC	BIC weight
(Intercept)	-1.258385275	0.373002367	-3.373665654	0.000741744	26	0
snENSO	0.949952797	0.351177891	2.705047274	0.006829467		
snPdev	-0.293300302	0.150187628	-1.952892565	0.050832327		

Table A24D. GOLDENEYE – GEOGRAPHIC MODEL

Covariate	Parameter estimate	SE	*z*	*p*	ΔBIC	BIC weight
(Intercept)	-1.082011859	0.336216524	-3.218199531	0.00128998	15	0
snPdev	-0.569752292	0.161141051	-3.535736483	0.00040664		
snX	-1.752236439	0.348393185	-5.029479661	4.92E-07		
snY	-1.509835641	0.319435022	-4.726581422	2.28E-06		
snOldCutBurn	0.375553737	0.150526383	2.494936303	0.012597974		

All numeric covariates were centered and standardized by dividing by 2 standard deviations (se Table A2). See Table A2 for covariate acronyms and Methods for further details.

Table A24E. GOLDENEYE – BIOCLIMATE MODEL

Covariate	Parameter estimate	SE	*z*	*p*	ΔBIC	BIC weight
(Intercept)	-1.522214318	0.456224912	-3.336543618	0.000848271	32	0

snENSO	1.013309146	0.396502622	2.555617768	0.010599949
snPdev	-0.329343051	0.15233542	-2.161959774	0.030621277
snbioclim04Gridcode	-0.621817083	0.286373587	-2.171349284	0.02990478
snHHind	0.519900005	0.163111101	3.187398052	0.001435591
snRecCut	-0.455691017	0.171457142	-2.657754653	0.007866314
snRecBurn	-0.455691017	0.171457142	-2.657754653	0.007866314

Table A24F. GOLDENEYE – LANDCOVER MODEL

Covariate	Parameter estimate	SE	*z*	*p*	ΔBIC	BIC weight
(Intercept)	-1.227541124	0.393025485	-3.123311777	0.001788282	0	1
snENSO	0.94460988	0.36219775	2.607994889	0.009107431		
snPdev	-0.393129893	0.152421088	-2.579235573	0.009901924		
snWaterCover	1.735665451	0.232145484	7.476628114	7.63E-14		
snDeciduous	0.772031587	0.210556572	3.666623089	0.000245775		
snConif	0.772031587	0.210556572	3.666623089	0.000245775		
snOldCutBurn	0.580925634	0.166496004	3.489126593	0.000484602		
snWaterC:snForst	0.792231693	0.186627466	4.244989815	2.19E-05		

All numeric covariates were centered and standardized by dividing by 2 standard deviations (se Table A2). See Table A2 for covariate acronyms and Methods for further details.

TABLE A25A. Parameter estimates and model weights of waterbird occupancy models.
MALLARD – BASELINE MODEL

Covariate	Parameter estimate	SE	*z*	*p*	ΔBIC	BIC weight
(Intercept)	-0.37552802	0.221021085	-1.699059705	0.089307935	7	0.01

Table A25B. MALLARD – DISTURBANCE MODEL

Covariate	Parameter estimate	SE	*z*	*p*	ΔBIC	BIC weight
(Intercept)	-0.637364816	0.254345685	-2.505899861	0.012214021	6	0.03
snYEAR	0.120251475	0.266696266	0.450892982	0.652066682		
I(snYEAR^2)	0.762402107	0.92674715	0.822664636	0.410698731		
snENSO	1.251293241	0.450896164	2.775125051	0.005518049		
snRecCut	0.02183492	0.138169024	0.158030498	0.874432767		
snRecBurn	0.02183492	0.138169024	0.158030498	0.874432767		
snOldCutBurn	0.02183492	0.138169024	0.158030498	0.874432767		
roadDensSn	0.467763006	0.171294053	2.730760342	0.00631884		
snMiningSettl	0.14913586	0.166836121	0.8939063	0.371372027		
snMiningSettl:snRegen	-1.520729945	0.418883613	-3.630435517	0.000282943		

Table A25C. MALLARD – CLIMATE VARIABILITY MODEL

Covariate	Parameter estimate	SE	*z*	*p*	ΔBIC	BIC weight
(Intercept)	-0.406173286	0.177448611	-2.288962891	0.022081509	2	0.17
snENSO	0.568828012	0.179842137	3.16292957	0.001561901		
snSdev	0.313231478	0.127091771	2.464608649	0.013716297		
snPdev	-0.289547448	0.130305084	-2.222073294	0.026278353		
snRecCut	0.031514095	0.139589772	0.225762208	0.821386372		
snRecBurn	0.031514095	0.139589772	0.225762208	0.821386372		
snOldCutBurn	0.031514095	0.139589772	0.225762208	0.821386372		
roadDensSn	0.447766854	0.173594298	2.579386872	0.009897587		
snMiningSettl	0.151462334	0.168329512	0.899796671	0.368228466		
snMiningSettl:snRegen	-1.54455837	0.422228411	-3.658110941	0.000254081		

Table A25D. MALLARD – GEOGRAPHIC MODEL

Covariate	Parameter estimate	SE	*z*	*p*	ΔBIC	BIC weight
(Intercept)	-0.622211805	0.183269885	-3.395057536	0.000686142	7	0.01
snENSO	0.603419161	0.185037926	3.261056656	0.001109979		
snSdev	0.326710735	0.139444729	2.342940731	0.019132422		
snPdev	-0.342642124	0.136444818	-2.511213902	0.012031677		
snX	-0.579177435	0.307789084	-1.881734815	0.05987203		
snY	0.121628556	0.291989992	0.416550428	0.677007275		
snHHind	0.427140977	0.146476963	2.91609662	0.003544407		
snRecCut	-0.369326637	0.15025327	-2.458027288	0.013970256		
snRecBurn	-0.369326637	0.15025327	-2.458027288	0.013970256		
roadDensSn	0.449455139	0.172074555	2.611979091	0.009001976		
snMiningSettl	0.141552772	0.153789385	0.920432655	0.357346711		
snMiningSettl:snRecCutBurn	-1.346318614	0.435201181	-3.093554593	0.001977742		
snX:snY	-1.358197799	0.435675451	-3.117453133	0.001824209		

Table A25E. MALLARD – BIOCLIMATE MODEL

Covariate	Parameter estimate	SE	*z*	*p*	ΔBIC	BIC weight
(Intercept)	-0.323913447	0.169023911	-1.916376475	0.055317193	1	0.29
snENSO	0.540846154	0.177923615	3.039765989	0.00236762		
snSdev	0.33197228	0.124998514	2.655809811	0.007911822		
snPdev	-0.310914122	0.129490966	-2.401048745	0.016348159		
snbioclim15Gridcode	0.481031105	0.237739063	2.023357453	0.043036307		
snHHind	0.493797719	0.146495639	3.370733233	0.000749684		
snRecCut	-0.393884485	0.151916663	-2.592766829	0.00952073		
snRecBurn	-0.393884485	0.151916663	-2.592766829	0.00952073		
roadDensSn	0.504448839	0.172054092	2.931920026	0.003368735		
snMiningSettl	0.138680851	0.156282936	0.887370398	0.374879516		
snMiningSettl:snRecCutBurn	-1.402439076	0.441307368	-3.177919013	0.001483362		

Table A25F. MALLARD – LANDCOVER MODEL

Covariate	Parameter estimate	SE	*z*	*p*	ΔBIC	BIC weight
(Intercept)	-0.360615072	0.166100586	-2.171064414	0.029926304	0	0.48
snENSO	0.564591759	0.179748788	3.141004532	0.001683694		
snSdev	0.317679827	0.128025767	2.481374128	0.013087692		
snPdev	-0.299931544	0.130398654	-2.300112266	0.021441861		
snHHind	0.375227122	0.149747064	2.505739418	0.012219564		
snBogFen	-0.361017252	0.149089704	-2.421476758	0.015457589		
snMarshSwamp	-0.361017252	0.149089704	-2.421476758	0.015457589		
snDeciduous	-0.532578004	0.161438734	-3.298948095	0.000970479		
snConif	-0.532578004	0.161438734	-3.298948095	0.000970479		
snRecCut	-0.618797463	0.162122337	-3.816855058	0.000135164		
snRecBurn	-0.618797463	0.162122337	-3.816855058	0.000135164		
roadDensSn	0.420915513	0.16550199	2.543265561	0.010982173		
snMiningSettl	0.148851296	0.154739372	0.96194843	0.33607551		
snMiningSettl:snRecCutBurn	-1.426858231	0.43796553	-3.257923587	0.001122306		

All numeric covariates were centered and standardized by dividing by 2 standard deviations (se Table A2). See Table A2 for covariate acronyms and Methods for further details.

TABLE A26A. Parameter estimates and model weights of waterbird occupancy models.
MERGANSER – BASELINE MODEL

Covariate	Parameter estimate	SE	*z*	*p*	ΔBIC	BIC weight
(Intercept)	0.225123566	0.169893817	1.325083926	0.185143317	45	0

Table A26B. MERGANSER – DISTURBANCE MODEL

Covariate	Parameter estimate	SE	*z*	*p*	ΔBIC	BIC weight
(Intercept)	0.236212971	0.170049697	1.389081993	0.164807819	48	0
snENSO	0.745699658	0.208635162	3.574180158	0.000351327		
snRecCut	0.260093723	0.16081769	1.61732035	0.105809149		
snRecBurn	0.260093723	0.16081769	1.61732035	0.105809149		
snOldCutBurn	0.260093723	0.16081769	1.61732035	0.105809149		

Table A26C. MERGANSER – CLIMATE VARIABILITY MODEL

Covariate	Parameter estimate	SE	*z*	*p*	ΔBIC	BIC weight
(Intercept)	0.181348702	0.142940672	1.268699097	0.204548405	40	0
snENSO	0.602272533	0.170229554	3.538002178	0.000403167		
snSdev	0.514866359	0.1381784	3.726098723	0.000194466		

Table A26D. MERGANSER – GEOGRAPHIC MODEL

Covariate	Parameter estimate	SE	*z*	*p*	ΔBIC	BIC weight
(Intercept)	0.267199661	0.14931589	1.789492474	0.073535538	32	0
snENSO	0.653371506	0.160195261	4.078594465	4.53E-05		
snTdev	-0.445721259	0.115782142	-3.849654616	0.000118284		
snX	-1.543059937	0.312133596	-4.943588124	7.67E-07		
snY	-1.562190212	0.316055432	-4.942772868	7.70E-07		
roadDensSn	-0.422763674	0.174178474	-2.427186696	0.015216423		

Table A26E. MERGANSER – BIOCLIMATE MODEL

Covariate	Parameter estimate	SE	*z*	*p*	ΔBIC	BIC weight
(Intercept)	0.127955714	0.155896951	0.820771116	0.411776654	46	0
snENSO	0.623564442	0.179214105	3.479438409	0.000502466		
snSdev	0.5014735	0.1414223	3.545929467	0.000391231		
snbioclim04Gridcode	-0.536790989	0.233074446	-2.303088123	0.021273885		
snHHind	0.47349064	0.152129219	3.112424057	0.001855577		
roadDensSn	-0.534603574	0.179456338	-2.979017512	0.002891743		

Table A26F. MERGANSER – LANDCOVER MODEL

Covariate	Parameter estimate	SE	*z*	*p*	ΔBIC	BIC weight
(Intercept)	0.202167749	0.146910584	1.376127866	0.16878205	0	1
snENSO	0.638868921	0.162641824	3.928072771	8.56E-05		
snTdev	-0.469382426	0.118310754	-3.967369063	7.27E-05		
snWaterC	0.737035654	0.164241927	4.487500036	7.21E-06		
snBogFen	-0.76556954	0.154748734	-4.947178056	7.53E-07		
roadDensSn	-0.415257901	0.152890677	-2.716044621	0.006606701		

All numeric covariates were centered and standardized by dividing by 2 standard deviations (se Table A2). See Table A2 for covariate acronyms and Methods for further details.

TABLE A27A. Parameter estimates and model weights of waterbird occupancy models.
RING-NECKED DUCK – BASELINE MODEL

Covariate	Parameter estimate	SE	*z*	*p*	ΔBIC	BIC weight
(Intercept)	0.676922068	0.180907733	3.741808354	0.000182701	2	0.14

Table A27B. RING-NECKED DUCK – DISTURBANCE MODEL

Covariate	Parameter estimate	SE	*z*	*p*	ΔBIC	BIC weight
(Intercept)	0.178589776	0.220839437	0.808686069	0.418695744	3	0.08
snENSO	0.80089695	0.206688277	3.874902639	0.000106667		
snOldCutBurn	0.356779739	0.132619996	2.690240918	0.007140045		
snNAO	0.431469766	0.141737856	3.044139222	0.002333471		

Table A27C. RING-NECKED DUCK – CLIMATE VARIABILITY MODEL

Covariate	Parameter estimate	SE	*z*	*p*	ΔBIC	BIC weight
(Intercept)	0.427655693	0.14583537	2.932455225	0.003362934	1	0.25
snYEAR	-0.708738453	0.17457436	-4.0598084	4.91E-05		
snTdev	-0.716662644	0.184036981	-3.894123023	9.86E-05		
snPdev	-0.402242347	0.132364568	-3.038897443	0.002374457		
snOldCutBurn	0.358799312	0.133145402	2.694793104	0.007043235		

Table A27D. RING-NECKED DUCK – GEOGRAPHIC MODEL

Covariate	Parameter estimate	SE	*z*	*p*	ΔBIC	BIC weight
(Intercept)	0.842233924	0.203469187	4.139368404	3.48E-05	7	0.01
snYEAR	-0.236628042	0.223140407	-1.060444611	0.288942376		
I(snYEAR^2)	-2.03517743	0.397582709	-5.118878124	3.07E-07		
snY	0.362942501	0.229086302	1.584304681	0.113124401		
snOldCutBurn	0.330088787	0.133461514	2.473288198	0.013387613		
snNAO	0.483643873	0.141705203	3.41302833	0.000642453		

Table A27E. RING-NECKED DUCK – BIOCLIMATE MODEL

Covariate	Parameter estimate	SE	*z*	*p*	ΔBIC	BIC weight
(Intercept)	0.475128804	0.131768792	3.605776413	0.000311221	0	0.33
snYEAR	-0.712794507	0.171124581	-4.165354299	3.11E-05	0	0.33
snTdev	-0.716387529	0.181126718	-3.955173143	7.65E-05	0	0.33
snPdev	-0.389526145	0.131616175	-2.959561355	0.003080773	0	0.33
snbioclim01Gridcode	-0.524752676	0.200204532	-2.621082902	0.008765094	0	0.33
snHHind	0.393102195	0.122734003	3.202879271	0.00136061	0	0.33

Table A27F. RING-NECKED DUCK – LANDCOVER MODEL

Covariate	Parameter estimate	SE	*z*	*p*	ΔBIC	BIC weight
(Intercept)	0.168725319	0.239648937	0.704052022	0.481400377	1	0.19
snPdev	-0.383025307	0.138618258	-2.763166367	0.005724358		
snHHind	0.34976064	0.121822038	2.87107855	0.004090739		
snDecid	0.445403773	0.176499457	2.523541884	0.011617922		

All numeric covariates were centered and standardized by dividing by 2 standard deviations (se Table A2). See Table A2 for covariate acronyms and Methods for further details.

TABLE A28A. Parameter estimates and model weights of waterbird occupancy models.
ALDER FLYCATCHER – BASELINE MODEL

Covariate	Parameter estimate	SE	*z*	*p*	ΔBIC	BIC weight
(Intercept)	1.939270462	0.18270219	10.61437992	2.55E-26	32	0
snNpcs	2.211682162	0.175814281	12.57965023	2.73E-36		
I(snNpcs^2)	-0.920310928	0.160121458	-5.747580229	9.05E-09		
SECTIONS	-0.753874023	0.239213191	-3.151473467	0.001624489		

Table A28B. ALDER FLYCATCHER – DISTURBANCE MODEL

Covariate	Parameter estimate	SE	*z*	*p*	ΔBIC	BIC weight
(Intercept)	1.872775757	0.180156779	10.39525555	2.61E-25	11	0
snNpcs	2.190153869	0.177942552	12.30820759	8.18E-35		
I(snNpcs^2)	-0.932410742	0.163530878	-5.701741193	1.19E-08		
SECTIONS	-0.501627302	0.235745588	-2.12783326	0.033350911		
snRecCut	0.86407853	0.165293105	5.22755337	1.72E-07		
snRecBurn	0.86407853	0.165293105	5.22755337	1.72E-07		

Table A28C ALDER FLYCATCHER – CLIMATE VARIABILITY MODEL

Covariate	Parameter estimate	SE	*z*	*p*	ΔBIC	BIC weight
(Intercept)	1.864007338	0.181935126	10.24545053	1.24E-24	16.87454424	0
snNpcs	2.196865021	0.178134126	12.33264546	6.04E-35	16.87454424	0
I(snNpcs^2)	-0.938419687	0.163164502	-5.751371631	8.85E-09	16.87454424	0
SECTIONS	-0.51979209	0.238320786	-2.181060657	0.02917893	16.87454424	0
snTdev	-0.160872243	0.135241105	-1.189521799	0.234234398	16.87454424	0
snRecCut	0.873886462	0.165992425	5.264616506	1.40E-07	16.87454424	0
snRecBurn	0.873886462	0.165992425	5.264616506	1.40E-07	16.87454424	0

Table A28D. ALDER FLYCATCHER – GEOGRAPHIC MODEL

Covariate	Parameter estimate	SE	*z*	*p*	ΔBIC	BIC weight

(Intercept)	1.466994898	0.222135058	6.60406743	4.00E-11	11	0.01
snNpcs	2.186081683	0.176293052	12.40027135	2.60E-35		
I(snNpcs^2)	-0.930531812	0.161772858	-5.752088605	8.81E-09		
SECTIONS	0.275159333	0.355260904	0.77452748	0.438618924		
snY	0.954863481	0.33925674	2.814574829	0.004884181		
snRecCut	0.867374218	0.165141068	5.252322918	1.50E-07		
snRecBurn	0.867374218	0.165141068	5.252322918	1.50E-07		

Table A28E. ALDER FLYCATCHER – CLIMATE ENVELOPE MODEL

Covariate	Parameter estimate	SE	*z*	*p*	ΔBIC	BIC weight
(Intercept)	1.415545038	0.22114832	6.400885342	1.54E-10	9	0.04
snNpcs	2.187314983	0.177406264	12.32941233	6.29E-35		
I(snNpcs^2)	-0.920716852	0.163883839	-5.618106444	1.93E-08		
SECTIONS	0.386243256	0.355579178	1.08623699	0.277374156		
snbioclim01Gridcode	-1.069012495	0.338401185	-3.159009315	0.001583064		
snRecCut	0.815461749	0.164390816	4.960506712	7.03E-07		
snRecBurn	0.815461749	0.164390816	4.960506712	7.03E-07		

Table A28F. ALDER FLYCATCHER – LANDCOVER MODEL

Covariate	Parameter estimate	SE	*z*	*p*	ΔBIC	BIC weight
(Intercept)	1.975578	0.174366	11.33006	9.31E-30	0	0.98
snNpcs	2.177851	0.179049	12.16343	4.87E-34		
I(snNpcs^2)	-0.94931	0.1642	-5.78143	7.41E-09		
SECTIONS	-0.49588	0.224735	-2.2065	0.027349		
snWaterCover	-1.02349	0.207257	-4.93825	7.88E-07		
snDeciduous	-0.5579	0.218359	-2.55495	0.01062		
snConif	-0.5579	0.218359	-2.55495	0.01062		
snRecCut	0.523082	0.189484	2.760555	0.00577		
snRecBurn	0.523082	0.189484	2.760555	0.00577		

All numeric covariates were centered and standardized by dividing by 2 standard deviations (se Table A2). See Table A2 for covariate acronyms and Methods for further details.

TABLE A29A. Parameter estimates and model weights of waterbird occupancy models.
COMMON LOON – BASELINE MODEL

Covariate	Parameter estimate	SE	*z*	*p*	ΔBIC	BIC weight
(Intercept)	0.857407063	0.197461297	4.342152485	1.41E-05	27	0
snNpcs	0.938005982	0.247430355	3.790989919	0.000150048		
I(snNpcs^2)	-1.160669194	0.168899991	-6.871931663	6.33E-12		
I(snNpcs^3)	0.397162116	0.15613731	2.543672073	0.010969401		
SECTIONS	-0.366521858	0.249345113	-1.469938007	0.141578545		

Table A29B. COMMON LOON – DISTURBANCE MODEL

Covariate	Parameter estimate	SE	*z*	*p*	ΔBIC	BIC weight
(Intercept)	0.825491194	0.196040175	4.210826658	2.54E-05	29	0
snNpcs	0.932665006	0.248920789	3.746834523	0.00017908		
I(snNpcs^2)	-1.156036531	0.168803147	-6.848429972	7.47E-12		
I(snNpcs^3)	0.401174186	0.159543987	2.514505215	0.011919954		
SECTIONS	-0.306267871	0.246979896	-1.240051828	0.214956225		
roadDensSn	-0.342864414	0.148770512	-2.304653053	0.021186012		

Table A29C. COMMON LOON – CLIMATE VARIABILITY MODEL

Covariate	Parameter estimate	SE	*z*	*p*	ΔBIC	BIC weight
(Intercept)	0.908122568	0.19451949	4.668542826	3.03E-06	32	0
snNpcs	0.927107398	0.252626037	3.669880629	0.000242664		
I(snNpcs^2)	-1.146171876	0.16892772	-6.784983999	1.16E-11		
I(snNpcs^3)	0.409307636	0.166678052	2.455678065	0.014061907		
SECTIONS	-0.323638986	0.242689698	-1.333550573	0.182351191		
snTdevMonth	-0.265151037	0.120306342	-2.203965577	0.027526765		
roadDensSn	-0.350873525	0.14876844	-2.358521236	0.01834791		

Table A29D. COMMON LOON – GEOGRAPHIC MODEL

Covariate	Parameter	SE	*z*	*p*	ΔBIC	BIC

	estimate					weight
(Intercept)	0.685046633	0.203391736	3.3681144	0.000756842	31	0
snNpcs	0.926893124	0.245562904	3.774564926	0.000160287		
I(snNpcs^2)	-1.17159136	0.168769901	-6.941944937	3.87E-12		
I(snNpcs^3)	0.397086447	0.153075434	2.594057298	0.009485068		
SECTIONS	0.022913204	0.304442762	0.075262764	0.940005648		
snX	-0.695173224	0.322085045	-2.158353001	0.030900397		

Table A29E. COMMON LOON – BIOCLIMATE MODEL

Covariate	Parameter estimate	SE	*z*	*p*	ΔBIC	BIC weight
(Intercept)	0.718608433	0.206250738	3.484149635	0.000493703	36	0
snNpcs	0.909382913	0.251714521	3.612755075	0.000302961		
I(snNpcs^2)	-1.168735397	0.169108567	-6.911154301	4.81E-12		
I(snNpcs^3)	0.413072482	0.164576083	2.509918061	0.012075918		
SECTIONS	-0.10247058	0.274114168	-0.373824456	0.708534923		
snbioclim05Gridcode	-0.393704237	0.204814418	-1.92224864	0.054574479		
snHHind	0.290555535	0.130042492	2.234312273	0.025462533		

Table A29F. COMMON LOON – LANDCOVER MODEL

Covariate	Parameter estimate	SE	*z*	*p*	ΔBIC	BIC weight
(Intercept)	0.945925574	0.177361223	5.333327979	9.64E-08	0	1
snNpcs	0.913793855	0.269543652	3.390151644	0.00069854		
I(snNpcs^2)	-1.144118863	0.175542771	-6.517607382	7.14E-11		
I(snNpcs^3)	0.493467608	0.197359195	2.500352767	0.012406969		
SECTIONS	-0.231264789	0.223659669	-1.034003089	0.301134719		
snWaterC	2.221936478	0.282097238	7.876491437	3.37E-15		

snDeciduous	0.91852007	0.26821636	3.424549011	0.000615821
snConif	0.91852007	0.26821636	3.424549011	0.000615821
snRecCut	1.056985081	0.240899642	4.387657334	1.15E-05
snRecBurn	1.056985081	0.240899642	4.387657334	1.15E-05
snOldCutBurn	1.056985081	0.240899642	4.387657334	1.15E-05
roadDensSn	-0.356609227	0.151246268	-2.357805137	0.01838334
snNAOmay	0.295885635	0.124112642	2.384008845	0.017125191
snWaterC:snForst	0.744338747	0.195425514	3.808810496	0.000139637
snWaterC:snRegen	1.571471168	0.466214043	3.370707495	0.000749754

All numeric covariates were centered and standardized by dividing by 2 standard deviations (se Table A2). See Table A2 for covariate acronyms and Methods for further details.

TABLE A30A. Parameter estimates and model weights of waterbird occupancy models.
COMMON YELLOWTHROAT – BASELINE MODEL

Covariate	Parameter estimate	SE	*z*	*p*	ΔBIC	BIC weight
(Intercept)	1.205379102	0.284736351	4.233316526	2.30E-05	34	0
snNpcs	2.279115743	0.217407308	10.48316066	1.03E-25		
I(snNpcs^2)	-0.758638195	0.182852808	-4.148900987	3.34E-05		
SECTIONS	2.081414241	0.338369421	6.151307162	7.68E-10		

Table A30B. COMMON YELLOWTHROAT – DISTURBANCE MODEL

Covariate	Parameter estimate	SE	*z*	*p*	ΔBIC	BIC weight
(Intercept)	1.134383201	0.270927589	4.187034645	2.83E-05	13	0
snNpcs	2.236505434	0.215264595	10.38956467	2.77E-25		
I(snNpcs^2)	-0.784388586	0.182066467	-4.308254003	1.65E-05		
SECTIONS	2.164382386	0.326397574	6.631122775	3.33E-11		
snRecCut	0.861211324	0.164414095	5.238062608	1.62E-07		
snRecBurn	0.861211324	0.164414095	5.238062608	1.62E-07		
snMiningSettl	0.591663816	0.18008794	3.28541609	0.001018319		

Table A30C. COMMON YELLOWTHROAT – CLIMATE VARIABILITY MODEL

Covariate	Parameter estimate	SE	*z*	*p*	ΔBIC	BIC weight
(Intercept)	1.02979644	0.250150729	4.116703737	3.84E-05	25	0
snNpcs	2.248122755	0.214928819	10.45984791	1.32E-25		
I(snNpcs^2)	-0.791497446	0.181910233	-4.351033111	1.35E-05		
SECTIONS	1.937953454	0.310096661	6.249514102	4.12E-10		
snPdev	-0.049844514	0.192807508	-0.258519571	0.796005947		
snBSdev	0.223352596	0.202155206	1.104857007	0.269221554		
snRecCut	0.932406381	0.169835041	5.490070702	4.02E-08		
snMiningSettl	0.61689939	0.179455835	3.437611218	0.00058687		

snPdev:snBSdev	-1.027939511	0.37292437	-2.756428898	0.005843632		

Table A30D. COMMON YELLOWTHROAT – GEOGRAPHIC MODEL

Covariate	Parameter estimate	SE	*z*	*p*	ΔBIC	BIC weight
(Intercept)	1.586303483	0.276046889	5.746500119	9.11E-09	15	0
snNpcs	2.245290087	0.220385954	10.18799086	2.24E-24		
I(snNpcs^2)	-0.787841707	0.186358797	-4.227553086	2.36E-05		
SECTIONS	1.2957842	0.39760041	3.259011223	0.001118012		
snY	-1.097832214	0.401591675	-2.733702619	0.006262658		
snRecCut	0.890992859	0.166006402	5.367219877	8.00E-08		
snRecBurn	0.890992859	0.166006402	5.367219877	8.00E-08		
snMiningSettl	0.612429874	0.182574561	3.354409674	0.000795345		

Table A30E. COMMON YELLOWTHROAT – BIOCLIMATE MODEL

Covariate	Parameter estimate	SE	*z*	*p*	ΔBIC	BIC weight
(Intercept)	1.697951219	0.275812357	6.156182559	7.45E-10	11	0.01
snNpcs	2.246957136	0.217603847	10.32590722	5.38E-25		
I(snNpcs^2)	-0.799062206	0.182770375	-4.371945977	1.23E-05		
SECTIONS	1.074876422	0.396840356	2.708586478	0.00675705		
snbioclim01Gridcode	1.317371055	0.384640358	3.424942357	0.00061493		
snRecCut	0.943488292	0.167408596	5.635841374	1.74E-08		
snRecBurn	0.943488292	0.167408596	5.635841374	1.74E-08		
snMiningSettl	0.538683866	0.178699285	3.014471305	0.002574276		

Table A30F. COMMON YELLOWTHROAT – LANDCOVER MODEL

Covariate	Parameter estimate	SE	*z*	*p*	ΔBIC	BIC weight
(Intercept)	1.316877861	0.301457849	4.368364809	1.25E-05	0	0.99
snNpcs	2.247954	0.218703088	10.27856541	8.80E-25		
I(snNpcs^2)	-0.802590032	0.184152128	-4.358298988	1.31E-05		

SECTIONS	2.283571719	0.34912816	6.54078354	6.12E-11
snWaterC	-2.009788915	0.266720237	-7.535194686	4.88E-14
snDeciduous	-1.72551031	0.257989114	-6.688306672	2.26E-11
snConif	-1.72551031	0.257989114	-6.688306672	2.26E-11
snOldCutBurn	-0.660199798	0.181347167	-3.640529973	0.000272077
snWaterC:snForst	-0.703966352	0.230191405	-3.058178265	0.002226871

All numeric covariates were centered and standardized by dividing by 2 standard deviations (se Table A2). See Table A2 for covariate acronyms and Methods for further details.

TABLE A31A. Parameter estimates and model weights of waterbird occupancy models.
NORTHERN WATERTHRUSH – BASELINE MODEL

Covariate	Parameter estimate	SE	*z*	*p*	ΔBIC	BIC weight
(Intercept)	0.12413197	0.255881237	0.485115562	0.627594374	8	0.01
snNpcs	1.669879622	0.145186787	11.50159496	1.30E-30		
I(snNpcs^2)	-1.002631581	0.150929776	-6.643033636	3.07E-11		
SECTIONS	0.038343849	0.299415968	0.128062137	0.8980998		

Table A31B. NORTHERN WATERTHRUSH – DISTURBANCE MODEL

Covariate	Parameter estimate	SE	*z*	*p*	ΔBIC	BIC weight
(Intercept)	0.098833838	0.257645967	0.383603281	0.701272508	11	0
snNpcs	1.665768667	0.14477647	11.50579697	1.23E-30		
I(snNpcs^2)	-0.995187514	0.150182974	-6.626500226	3.44E-11		
SECTIONS	0.079612173	0.301551474	0.264008568	0.791773316		
roadDensSn	-0.290721156	0.150172651	-1.93591279	0.052878383		

Table A31C. NORTHERN WATERTHRUSH – CLIMATE VARIABILITY MODEL

Covariate	Parameter estimate	SE	*z*	*p*	ΔBIC	BIC weight
(Intercept)	0.121804548	0.255808598	0.47615502	0.633963941	15	0
snNpcs	1.669581181	0.145233656	11.49582834	1.38E-30		
I(snNpcs^2)	-1.005519925	0.151650977	-6.630487628	3.35E-11		
SECTIONS	0.036322606	0.299289398	0.121362821	0.903403664		
snTdev	-0.028103841	0.131021821	-0.214497407	0.830159189		

Table A31D. NORTHERN WATERTHRUSH – GEOGRAPHIC MODEL

Covariate	Parameter estimate	SE	*z*	*p*	ΔBIC	BIC weight
(Intercept)	-0.295374817	0.233076268	-1.267288254	0.205052239	0	0.54
snNpcs	1.682424086	0.147879156	11.3770198	5.44E-30		
I(snNpcs^2)	-0.973186231	0.153525165	-6.338936227	2.31E-10		
SECTIONS	-0.101480284	0.38648399	-0.262573059	0.792879667		
snX	2.141339818	0.424272538	5.047085603	4.49E-07		
snY	1.272379409	0.457966844	2.778322114	0.005464042		
snX:snY	-1.94633581	0.565687856	-3.440653338	0.000580312		

Table A31E. NORTHERN WATERTHRUSH – BIOCLIMATE MODEL

Covariate	Parameter estimate	SE	*z*	*p*	ΔBIC	BIC weight
(Intercept)	0.01665017	0.265174436	0.062789498	0.949934129	11	0
snNpcs	1.680297684	0.145665501	11.53531667	8.76E-31		
I(snNpcs^2)	-1.010734975	0.151348899	-6.678178557	2.42E-11		
SECTIONS	0.248729725	0.3172692	0.7839706	0.433057362		
snbioclim05Gridcode	-0.450328844	0.20239859	-2.224960383	0.026083898		

Table A31F. NORTHERN WATERTHRUSH – LANDCOVER MODEL

Covariate	Parameter estimate	SE	*z*	*p*	ΔBIC	BIC weight
(Intercept)	0.506110364	0.243962161	2.074544518	0.038028769	0.4	0.45
snNpcs	1.654479467	0.146053471	11.32790243	9.55E-30		
I(snNpcs^2)	-1.017593922	0.152972594	-6.652132205	2.89E-11		
SECTIONS	0.103522337	0.267953096	0.386344993	0.699241183		
snWaterC	1.036322729	0.374769154	2.765229525	0.005688276		
snBogFen	0.781893662	0.204451969	3.824339106	0.000131123		

MarshSwampPres	1.320527196	0.342052691	3.860595844	0.000113111
snWaterC:snBogFen	1.359198614	0.478989136	2.837639753	0.004544845
snWaterC:MarshSwampPres	-3.054116587	1.111493146	-2.747760161	0.006000388

All numeric covariates were centered and standardized by dividing by 2 standard deviations (se Table A2). See Table A2 for covariate acronyms and Methods for further details.

TABLE A32A. Parameter estimates and model weights of waterbird occupancy models.
RED-WINGED BLACKBIRD – BASELINE MODEL

Covariate	Parameter estimate	SE	*z*	*p*	ΔBIC	BIC weight
(Intercept)	-1.976139001	0.274529879	-7.198265658	6.10E-13	42	0
snNpcs	2.076722922	0.195507372	10.62222307	2.35E-26		
I(snNpcs^2)	-0.741745047	0.194112095	-3.821220142	0.000132793		
SECTIONS	3.235266213	0.381108772	8.489088814	2.08E-17		
snYEAR	0.439306416	0.175052463	2.509570039	0.012087824		

Table A32B. RED-WINGED BLACKBIRD – DISTURBANCE MODEL

Covariate	Parameter estimate	SE	*z*	*p*	ΔBIC	BIC weight
(Intercept)	-1.971601914	0.26978356	-7.308087682	2.71E-13	42.43654436	0
snNpcs	2.12038465	0.199680986	10.61886109	2.44E-26	42.43654436	0
I(snNpcs^2)	-0.749912337	0.197968894	-3.788031157	0.000151846	42.43654436	0
SECTIONS	2.973326559	0.389076259	7.64201488	2.14E-14	42.43654436	0
snYEAR	0.481585249	0.176695842	2.725504142	0.006420337	42.43654436	0
snRecCut	-0.547828894	0.273154622	-2.005563328	0.044902858	42.43654436	0
snRecBurn	-0.547828894	0.273154622	-2.005563328	0.044902858	42.43654436	0
snOldCutBurn	-0.547828894	0.273154622	-2.005563328	0.044902858	42.43654436	0
snMiningSettl	0.501076993	0.157271774	3.186058001	0.001442257	42.43654436	0

Table A32C. RED-WINGED BLACKBIRD – CLIMATE VARIABILITY MODEL

Covariate	Parameter estimate	SE	*z*	*p*	ΔBIC	BIC weight
(Intercept)	-1.83221995	0.335524764	-5.460759231	4.74E-08	57	0
snNpcs	2.183313878	0.203761345	10.7150543	8.65E-27		

I(snNpcs^2)	-0.795861282	0.201511697	-3.949454509	7.83E-05
SECTIONS	2.94150145	0.381908474	7.702110981	1.34E-14
snYEAR	0.139902534	0.292170184	0.478839187	0.632053036
snSdev	-4.239425583	1.271357927	-3.334564951	0.000854329
snRecBurn	-0.433461709	0.307951999	-1.407562576	0.159260636
snOldCutBurn	-0.668460223	0.293740995	-2.275679032	0.022865227
presMiningSettl	0.244954808	0.21492397	1.139727728	0.254399752
snENSO	-0.573550049	0.226658737	-2.530456391	0.011391424
snSdev:presMiningSettl	4.190956372	1.275536427	3.285642248	0.001017502
snYEAR:snRecBurn	-2.113678262	0.728444568	-2.901632266	0.00371224

Table A32D. RED-WINGED BLACKBIRD – GEOGRAPHIC MODEL

Covariate	Parameter estimate	SE	*z*	*p*	ΔBIC	BIC weight
(Intercept)	-1.287471946	0.291154909	-4.421948268	9.78E-06	33	0
snNpcs	2.140614928	0.203059919	10.54178953	5.54E-26		
I(snNpcs^2)	-0.797760773	0.200221738	-3.984386423	6.77E-05		
SECTIONS	0.460094147	0.544134331	0.845552506	0.39780243		
snYEAR	0.520331898	0.183238081	2.839649346	0.004516315		
snX	-0.411233222	0.475290944	-0.86522419	0.386915751		
snY	-3.692265809	0.661509164	-5.58157923	2.38E-08		
snHHind	0.704936808	0.210073971	3.355659936	0.000791759		
snRecCut	-0.730212389	0.302115724	-2.416995647	0.015649204		
snRecBurn	-0.730212389	0.302115724	-2.416995647	0.015649204		
snOldCutBurn	-0.730212389	0.302115724	-2.416995647	0.015649204		
snX:snY	-2.923891432	0.737735186	-3.963334662	7.39E-05		

Table A32E. RED-WINGED BLACKBIRD – BIOCLIMATE MODEL

Covariate	Parameter estimate	SE	*z*	*p*	ΔBIC	BIC weight
(Intercept)	-0.285865168	0.294541092	-0.970544266	0.331775272	0	1

snNpcs	2.222674714	0.209647782	10.6019472	2.92E-26
I(snNpcs^2)	-0.873508888	0.208502945	-4.189431892	2.80E-05
SECTIONS	0.121420768	0.453324692	0.267845035	0.788818604
snYEAR	0.837295869	0.213468977	3.92233045	8.77E-05
snbioclim01Gridcode	3.622412343	0.487683046	7.427800435	1.10E-13
snHHind	0.638607552	0.204440431	3.123685224	0.001786014
snOldCutBurn	-0.694558061	0.31677187	-2.192612812	0.028335287
snENSO	-0.525497534	0.226765678	-2.317359213	0.020484172

Table A32F. RED-WINGED BLACKBIRD – LANDCOVER MODEL

Covariate	Parameter estimate	SE	*z*	*p*	ΔBIC	BIC weight
(Intercept)	-2.089076259	0.267786098	-7.80128719	6.13E-15	31	0
snNpcs	2.128256366	0.203448253	10.46092229	1.31E-25		
I(snNpcs^2)	-0.779759059	0.203662351	-3.828685357	0.00012883		
SECTIONS	2.842477153	0.38857553	7.315121341	2.57E-13		
snYEAR	0.421999257	0.177579506	2.376396159	0.017482681		
snHHind	0.778115515	0.206002339	3.777216883	0.000158591		
snConif	-0.820419247	0.205479416	-3.992707711	6.53E-05		
snRecCut	-1.062633443	0.29591404	-3.591020697	0.000329385		
snRecBurn	-1.062633443	0.29591404	-3.591020697	0.000329385		
snOldCutBurn	-1.062633443	0.29591404	-3.591020697	0.000329385		

All numeric covariates were centered and standardized by dividing by 2 standard deviations (se Table A2). See Table A2 for covariate acronyms and Methods for further details.

TABLE A33A. Parameter estimates and model weights of waterbird occupancy models.
SWAMP SPARROW – BASELINE MODEL

Covariate	Parameter estimate	SE	*z*	*p*	ΔBIC	BIC weight
(Intercept)	0.745153359	0.195197191	3.817438942	1.35E-04	0	0.47
snNpcs	1.390174303	0.316629324	4.390541861	1.13E-05		
I(snNpcs^2)	-1.266897617	0.225868098	-5.609015298	2.03E-08		
I(snNpcs^3)	0.547664798	0.249860241	2.191884536	0.028387845		
SECTIONS	0.703491123	0.233026966	3.018925821	0.002536726		

Table A33B. SWAMP SPARROW – DISTURBANCE MODEL

Covariate	Parameter estimate	SE	*z*	*p*	ΔBIC	BIC weight
(Intercept)	0.738374017	0.194962573	3.787260323	0.000152317	1	0.26
snNpcs	1.325976724	0.317428809	4.177241284	2.95E-05		
I(snNpcs^2)	-1.295517577	0.229306421	-5.649722188	1.61E-08		
I(snNpcs^3)	0.606218263	0.26252769	2.309159325	0.020934742		
SECTIONS	0.572737583	0.23798527	2.406609383	0.016101381		
snRecCut	-0.349948831	0.145449623	-2.405979636	0.016129164		
snRecBurn	-0.349948831	0.145449623	-2.405979636	0.016129164		
roadDensSn	-0.483219709	0.164256467	-2.941861085	0.003262462		
snMiningSettl	0.43684491	0.150045303	2.911420099	0.003597899		

Table A33C. SWAMP SPARROW – CLIMATE VARIABILITY MODEL

Covariate	Parameter estimate	SE	*z*	*p*	ΔBIC	BIC weight
(Intercept)	0.752545537	0.196152737	3.836528345	0.000124786	8	0.01
snNpcs	1.323270269	0.317331801	4.169989473	3.05E-05		

I(snNpcs^2)	-1.296618135	0.228993517	-5.662248224	1.49E-08
I(snNpcs^3)	0.60898473	0.2622855	2.3218391	0.020241601
SECTIONS	0.574282579	0.238357311	2.409334863	0.015981627
snPdev	-0.12483008	0.14132202	-0.883302408	0.377072903
snRecCut	-0.356585701	0.145620714	-2.448729247	0.014336117
snRecBurn	-0.356585701	0.145620714	-2.448729247	0.014336117
roadDensSn	-0.473041814	0.164544652	-2.874853774	0.004042147
snMiningSettl	0.440973178	0.150052202	2.938798449	0.003294873

Table A33D. SWAMP SPARROW – GEOGRAPHIC MODEL

Covariate	Parameter estimate	SE	*z*	*p*	ΔBIC	BIC weight
(Intercept)	0.792884093	0.235626494	3.365003989	0.000765426	9	0.01
snNpcs	1.331123217	0.317729335	4.189487937	2.80E-05		
I(snNpcs^2)	-1.296772668	0.229183768	-5.658222133	1.53E-08		
I(snNpcs^3)	0.603512759	0.262142469	2.302231916	0.021322097		
SECTIONS	0.464692389	0.358098162	1.297667615	0.194401577		
snY	-0.140137718	0.353015433	-0.396973348	0.691387115		
snRecCut	-0.349439294	0.14549377	-2.401747472	0.016316968		
snRecBurn	-0.349439294	0.14549377	-2.401747472	0.016316968		
roadDensSn	-0.490207138	0.165465189	-2.962599821	0.003050529		
snMiningSettl	0.438779931	0.150232704	2.920668525	0.003492812		

Table A33E. SWAMP SPARROW – BIOCLIMATE MODEL

Covariate	Parameter estimate	SE	*z*	*p*	ΔBIC	BIC weight
(Intercept)	0.832319	0.232677	3.577142	0.000347	8	0.01
snNpcs	1.330617	0.317362	4.192737	2.76E-05		
I(snNpcs^2)	-1.30111	0.229107	-5.67905	1.35E-08		

I(snNpcs^3)	0.603755	0.261138	2.312011	0.020777
SECTIONS	0.384404	0.355047	1.082684	0.278949
snbioclim01Gridcode	0.23875	0.343142	0.695777	0.486569
snRecCut	-0.33838	0.146159	-2.31512	0.020606
snRecBurn	-0.33838	0.146159	-2.31512	0.020606
roadDensSn	-0.49819	0.16647	-2.99265	0.002766
snMiningSettl	0.430085	0.150622	2.855395	0.004298

Table A33F. SWAMP SPARROW – LANDCOVER MODEL

Covariate	Parameter estimate	SE	*z*	*p*	ΔBIC	BIC weight
(Intercept)	0.90675895	0.209662897	4.324842236	1.53E-05	1	0.24
snNpcs	1.299350678	0.317668591	4.090271165	4.31E-05		
I(snNpcs^2)	-1.282167424	0.231130876	-5.547365407	2.90E-08		
I(snNpcs^3)	0.6154828	0.266783823	2.307046928	0.021052204		
SECTIONS	0.690481525	0.244954221	2.818818648	0.004820074		
snBogFen	0.44417511	0.168670569	2.633388338	0.008453763		
snMarshSwamp	0.44417511	0.168670569	2.633388338	0.008453763		
snRecCut	-0.311002259	0.145579146	-2.136310511	0.032654113		
snRecBurn	-0.311002259	0.145579146	-2.136310511	0.032654113		
roadDensSn	-0.467737519	0.163326188	-2.863824375	0.0041856		
snMiningSettl	0.460075213	0.149943553	3.068322726	0.00215264		

All numeric covariates were centered and standardized by dividing by 2 standard deviations (se Table A2). See Table A2 for covariate acronyms and Methods for further details.

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