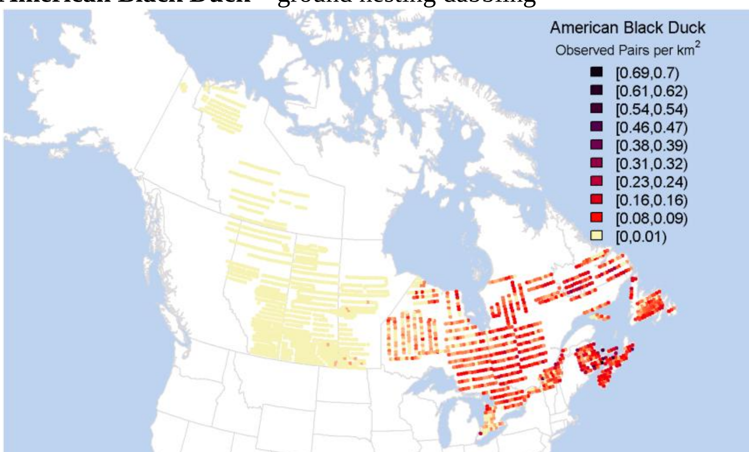
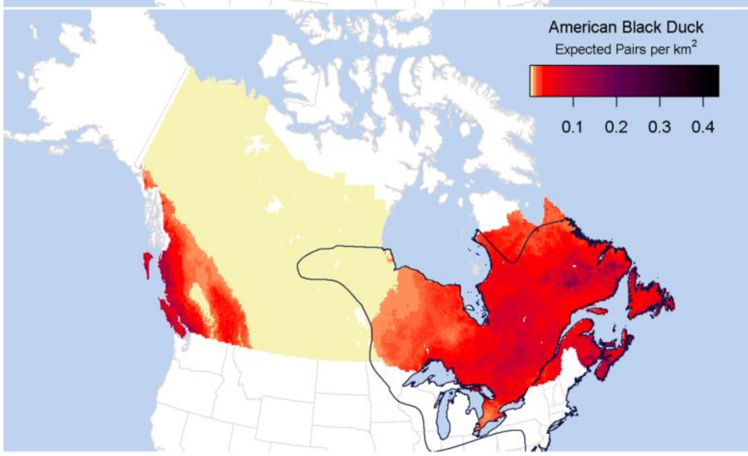
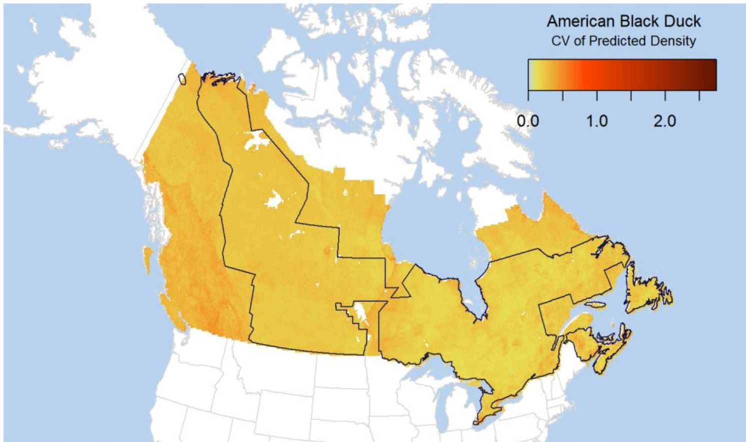
Appendix 4. Individual species results.

For each species, we present three maps: 1) observed segment-level density from the WBPHS dataset; 2) mean predicted relative density per km² with NatureServe range map (BirdLife International and NatureServe 2012; blue outline); and 3) coefficient of variation (CV) of predicted abundance with an outline of the survey area as reference. We also present a table of the relative importance of environmental predictors. This relative importance table includes the mean and SD across 20 replicates for each variable, in descending order of importance (a percentage of 100), up to a cumulative sum of 80%. For each species, we discuss our predicted distribution and influential predictor variables in relation to published range maps and habitat associations.

American Black Duck – ground nesting dabbling







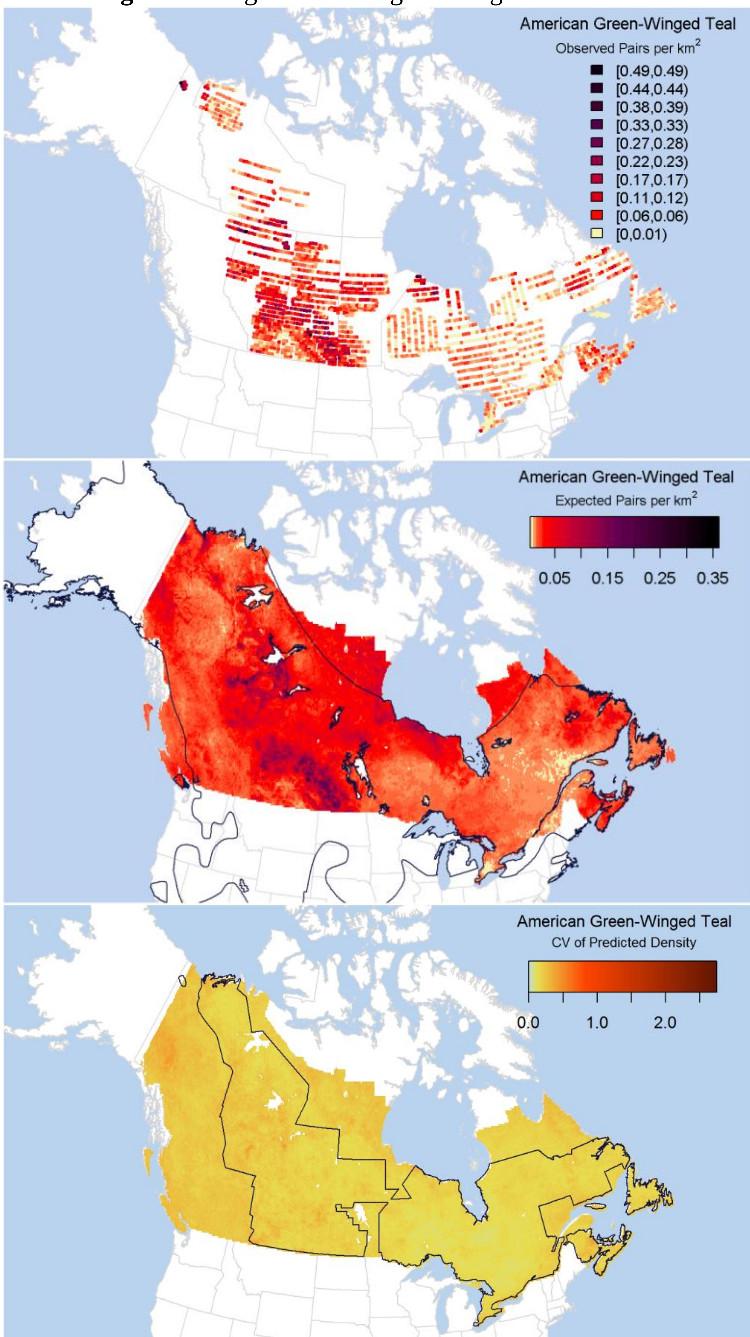
Our models predicted a relatively homogenous distribution of Black Ducks across eastern Canada, including the Boreal, Laurentians, and Great Lakes Lowlands, which is consistent with Longcore et al. (2000) and Johnsgard (2010). Our models also predicted relatively high densities on the west coast of Canada. We interpret these predictions as artefacts of extrapolation error from a model that does not incorporate biogeohistory of the Black Duck. This region of predicted high abundances outside of the Black Duck's range represents theoretically suitable habitat in an uninhabited area. The existence of a small, introduced population of American Black Ducks in southwest British Columbia on the mainland and Vancouver Island (Campbell et al. 1990, Longcore et al. 2000) suggests that this area represents suitable Black Duck habitat. See Model Limitations, in the Discussion for a thorough discussion of model limitations related to extrapolation.

Variable	Mean %	SD	Cumulative %
Topographic Ruggedness	13.77	3.88	13.77
Mean Climate Moisture Index	7.24	2.37	21.01
Standard Deviation of Maximum Temperature in November	5.85	1.67	26.86
Mean Autumn Precipitation	5.67	1.93	32.53
% Wetland (HWL)	3.14	0.95	35.68
Standard Deviation of Minimum Temperature in April	3.06	1.48	38.74
Standard Deviation of Maximum Temperature in February	2.77	1.16	41.51
Standard Deviation of Maximum Temperature in December	2.75	0.99	44.25
Standard Deviation of Minimum Temperature in February	2.38	0.99	46.63
Mean Waterbody Area (neighbourhood metric)	2.29	1.20	48.93
Standard Deviation of Precipitation in October	2.09	0.63	51.02
Mean Summer Precipitation	1.94	0.28	52.97
Standard Deviation of Maximum Temperature in August	1.93	1.14	54.90
Standard Deviation of Maximum Temperature in September	1.89	0.56	56.80
Standard Deviation of Maximum Temperature in March	1.70	0.44	58.49
Standard Deviation of Maximum Temperature in October	1.59	0.63	60.09
Mean Summer Maximum Temperature	1.58	0.71	61.67
Amount of Shoreline (km/km^2)	1.56	0.49	63.22
Standard Deviation of Maximum Temperature in January	1.25	0.39	64.47
Standard Deviation of Precipitation in May	1.22	0.64	65.69
Standard Deviation of Maximum Temperature in June	1.10	0.70	66.79
Standard Deviation of Precipitation in December	1.09	0.28	67.88

Mean Summer Minimum Temperature	1.06	0.66	68.94
Mean Gross Primary Productivity	1.03	0.35	69.97
Standard Deviation of Maximum Temperature in April	1.02	0.47	70.99
Standard Deviation of Precipitation in April	0.96	0.23	71.95
Precipitation Seasonality	0.91	0.41	72.86
Standard Deviation of Minimum Temperature in October	0.90	0.38	73.76
Shannon's Diversity Index of Land Cover Types	0.84	0.37	74.60
Amount of Streams (km/km^2)	0.78	0.27	75.38
Standard Deviation of Precipitation in August	0.78	0.53	76.16
Standard Deviation of Minimum Temperature in November	0.75	0.53	76.91
% Cropland-woodland	0.75	0.60	77.66
% Shrubland	0.74	0.24	78.40
Standard Deviation of Minimum Temperature in March	0.74	0.24	79.13
Mean Shoreline Complexity (neighbourhood metric)	0.73	0.19	79.86
Standard Deviation of Precipitation in March	0.72	0.24	80.58

Black Duck abundance was associated with topographic ruggedness, CMI, variability in maximum November temperature, mean autumn precipitation, and amount of wetland. The top four of these variables may capture the species' eastern-restricted distribution, while the amount of wetland represents the species' association with water. Black Ducks are reported to nest in most wetland types, including coastal marshes, beaver ponds, and boreal bogs (Longcore et al. 2000, Johnsgard 2010). Given this wide range in habitat suitability, along with the eastern-restricted range, most of the most important variables likely capture the spatial correlation rather than a mechanistic association with any given habitat type or limiting factor.

Green-winged Teal – ground nesting dabbling



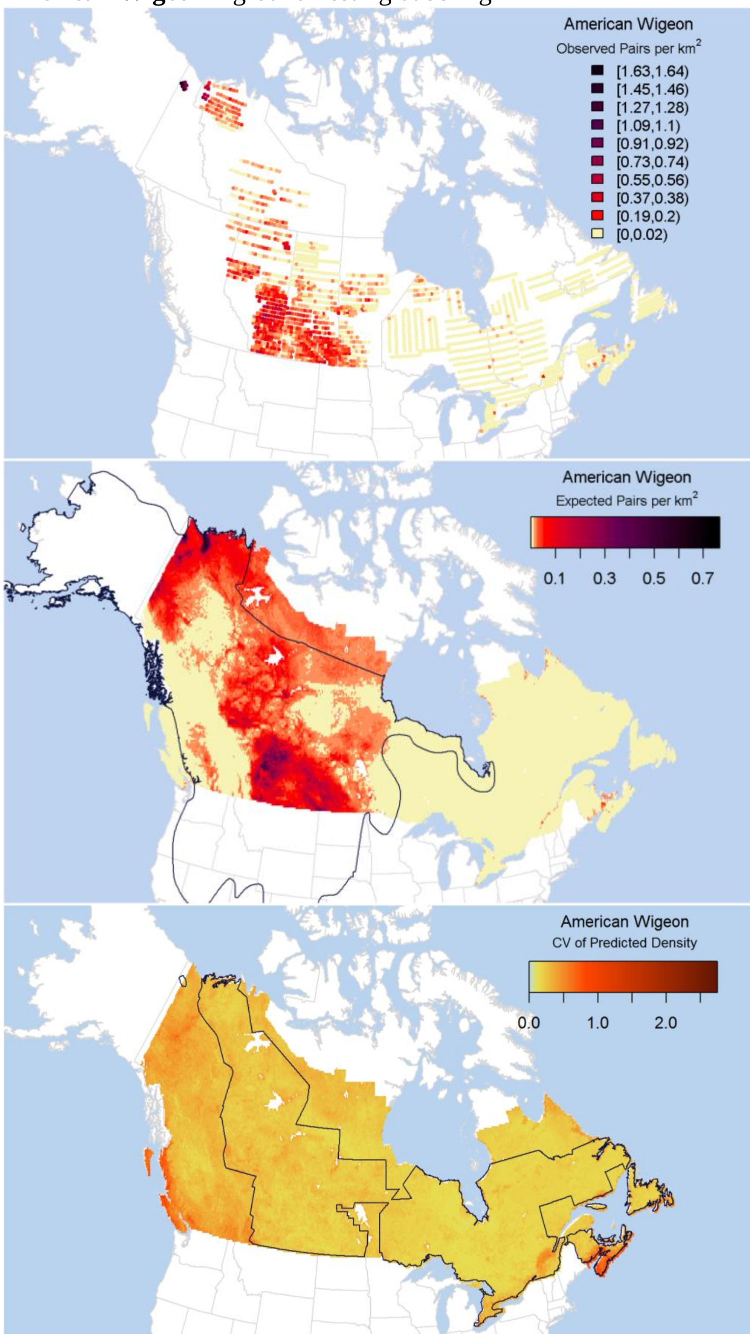
Our models predicted the highest densities of Green-winged Teal in the aspen parkland, the Peace-Athabasca Delta, and the Slave River Lowlands, consistent with Johnsgard (2010). Lower densities were observed in the prairies, which is consistent with a reported avoidance of eutrophic, agricultural lakes in favour of wooded ponds of the aspen parkland (Moisan et al. 1967). Our observed distribution extended well north of published ranges

(Johnsgard 2010, BirdLife International and NatureServe 2012), but these areas were partly extrapolations beyond the survey area (see Model Limitations, in Discussion).

Variable	Mean %	SD	Cumulative %
Mean Climate Moisture Index	7.82	1.26	7.82
Density of Waterbodies (neighbourhood metric)	6.67	1.16	14.49
Precipitation Seasonality	3.31	0.63	17.79
Mean Gross Primary Productivity	3.17	0.65	20.96
Standard Deviation of Maximum Temperature in March	2.75	0.87	23.71
Amount of Streams (km/km^2)	2.68	0.77	26.39
Standard Deviation of Maximum Temperature in October	2.66	0.61	29.05
Amount of Shoreline (km/km^2)	2.57	0.78	31.61
% Cropland-woodland	2.53	0.67	34.14
Topographic Ruggedness	2.50	0.57	36.64
% Deciduous Forest	2.44	0.70	39.09
Standard Deviation of Minimum Temperature in November	2.41	0.61	41.49
Standard Deviation of Maximum Temperature in December	2.36	0.72	43.86
Standard Deviation of Maximum Temperature in September	2.13	0.64	45.99
Standard Deviation of Precipitation in August	1.78	0.53	47.77
Mean Spring Maximum Temperature	1.78	0.59	49.55
Standard Deviation of Growing Season Length	1.78	0.38	51.32
Standard Deviation of Minimum Temperature in June	1.73	0.48	53.05
% Wetland (HWL)	1.69	0.33	54.74
Standard Deviation of Precipitation in October	1.55	0.53	56.29
Mean Shoreline Complexity (neighbourhood metric)	1.36	0.24	57.65
Standard Deviation of Minimum Temperature in January	1.34	0.48	58.99
Mean Autumn Maximum Temperature	1.33	0.49	60.32
Standard Deviation of Precipitation in December	1.33	0.46	61.65
Mean Spring Precipitation	1.31	0.47	62.97
% Open Water (HWL)	1.29	0.30	64.26
Mean Summer Precipitation	1.25	0.40	65.51
Mean Autumn Minimum Temperature	1.25	0.41	66.76
Standard Deviation of Maximum Temperature in February	1.23	0.54	67.99
Standard Deviation of Minimum Temperature in March	1.17	0.40	69.16
Mean Summer Maximum Temperature	1.13	0.35	70.29
Standard Deviation of Maximum Temperature in January	1.12	0.30	71.41
Standard Deviation of Maximum Temperature in August	1.08	0.38	72.49
Standard Deviation of Minimum Temperature in December	1.07	0.30	73.56
% Shrubland	1.05	0.37	74.61
Annual Range in Temperature	0.99	0.25	75.60
Standard Deviation of Precipitation in September	0.98	0.23	76.58
% Cropland	0.90	0.28	77.48
Mean Waterbody Area (neighbourhood metric)	0.89	0.30	78.38
Standard Deviation of Maximum Temperature in April	0.87	0.28	79.25
% Mixed Forest - Deciduous-dominated	0.87	0.26	80.11

Green-winged Teal abundance was most closely associated with climate moisture index (CMI) and segment-level water body density. The next two most important covariates were precipitation seasonality and gross primary productivity (GPP). CMI may play a role in isolating the aspen parkland, where highest densities occurred, from the drier prairies to the south and the more western boreal to the North. The relationship with water body density is consistent with (Johnson and Grier 1988), and may also represent selection for smaller water bodies, as reported by Toft et al. (1982), Décarie et al. (1995), Rempel et al. (1997), and Kindopp (2002). This association with water body density may also represent a spatial rather than biological relationship, since this variable appeared higher in the aspen parkland than the surrounding areas, when assessed visually. The sixth most important variable was stream length, which is consistent with Lemelin et al. (2010)'s finding that the species prefers moving water to lakes or ponds. Even the top variables showed low relative importance, which agrees with previous findings that this species shows few and weak habitat associations (Kindopp 2002). At the individual wetland scale used by Kindopp (2002), this result may indicate flexibility in habitat selection (Johnson 1995, Nummi and Pöysä 1997). At large scales such as in our study, it also likely represents the extremely broad distribution with homogenous abundance across much of the species' range (Johnsgard 2010). Most of the broadly-distributed species we studied exhibited the same pattern, where top predictor variables had lower relative importance, or explanatory power, than the top variables for narrowly-distributed species.

American Wigeon – ground nesting dabbling



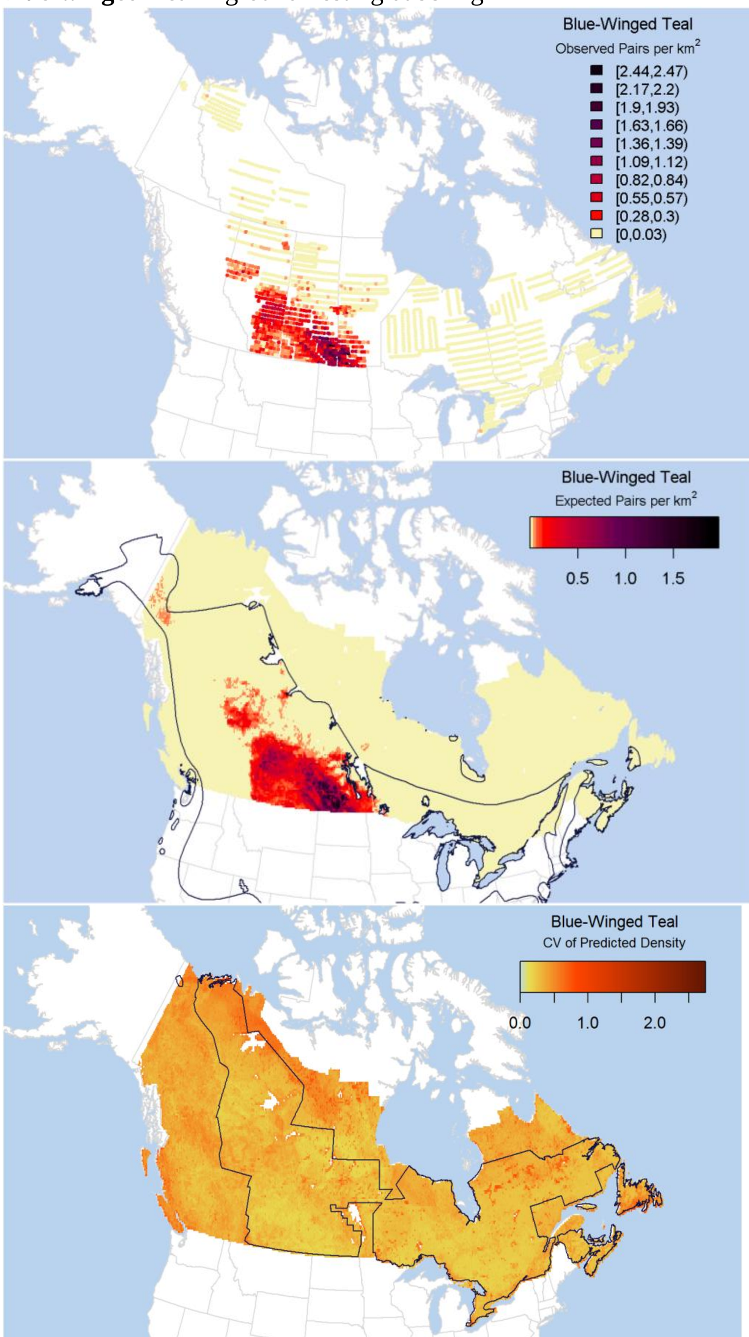
Our models predicted high abundances of American Wigeon in the prairie-parkland and throughout the western boreal forest, with the highest densities in the prairie-parkland region and the MacKenzie Delta. While this is generally consistent with published range maps (Johnsgard 2010, BirdLife International and NatureServe 2012), our predictions extended beyond the recognized northern limits, though these areas were partly extrapolations.

Our maps also predict limited abundances in Eastern Canada, while the NatureServe range excludes most of this region. These eastern predictions are consistent with observations from the WBPHS and from the Breeding Bird Atlases of Ontario and Québec (Bird Studies Canada et al. 2009, Regroupement QuébecOiseaux et al. 2014).

Variable	Mean %	SD	Cumulative %
Standard Deviation of Minimum Temperature in October	12.36	4.02	12.36
Standard Deviation of Maximum Temperature in September	10.76	1.99	23.12
Amount of Shoreline (km/km^2)	6.92	1.52	30.04
Mean Climate Moisture Index	4.40	0.73	34.44
Mean Autumn Precipitation	4.22	1.82	38.66
Standard Deviation of Growing Season Length	3.77	0.93	42.42
% Open Water (HWL)	3.44	1.07	45.86
Density of Waterbodies (neighbourhood metric)	3.10	0.80	48.96
Precipitation Seasonality	3.04	0.96	52.00
% Cropland	2.92	0.76	54.91
Topographic Ruggedness	2.38	0.67	57.30
Standard Deviation of Maximum Temperature in January	2.10	0.63	59.40
Standard Deviation of Precipitation in April	1.96	1.00	61.36
Standard Deviation of Minimum Temperature in April	1.93	1.06	63.29
Standard Deviation of Maximum Temperature in October	1.40	0.93	64.68
Standard Deviation of Maximum Temperature in February	1.37	1.01	66.05
Mean Winter Precipitation	1.28	0.47	67.33
Standard Deviation of Minimum Temperature in February	1.19	0.69	68.52
% Shrubland	1.19	0.64	69.71
Standard Deviation of Minimum Temperature in September	1.11	0.58	70.82
Standard Deviation of Maximum Temperature in November	1.09	0.42	71.91
Standard Deviation of Maximum Temperature in May	1.09	0.62	73.00
Mean Gross Primary Productivity	1.05	0.29	74.05
Standard Deviation of Precipitation in October	0.99	0.41	75.05
Mean Summer Maximum Temperature	0.95	0.35	75.99
Standard Deviation of Maximum Temperature in December	0.91	0.31	76.91
Shannon's Diversity Index of Land Cover Types	0.88	0.22	77.79
% Cropland-woodland	0.86	0.21	78.64
Standard Deviation of Maximum Temperature in August	0.84	0.16	79.49
Standard Deviation of Maximum Temperature in March	0.76	0.39	80.25

American Wigeon abundance was most closely associated with variability in minimum October temperature and maximum September temperature, as well as amount of shoreline and CMI. The bioclimatic variables likely capture the large-scale spatial pattern of abundance. The seventh and eighth most important variables were amount of open water and water body density. In association with the amount of shoreline, these variables capture the relationship of American Wigeon to water. In particular, the amount of open water may relate to the American Wigeon's use of more open water for feeding, compared to other *Anas* species (Johnsgard 2010).

Blue-winged Teal – ground nesting dabbling

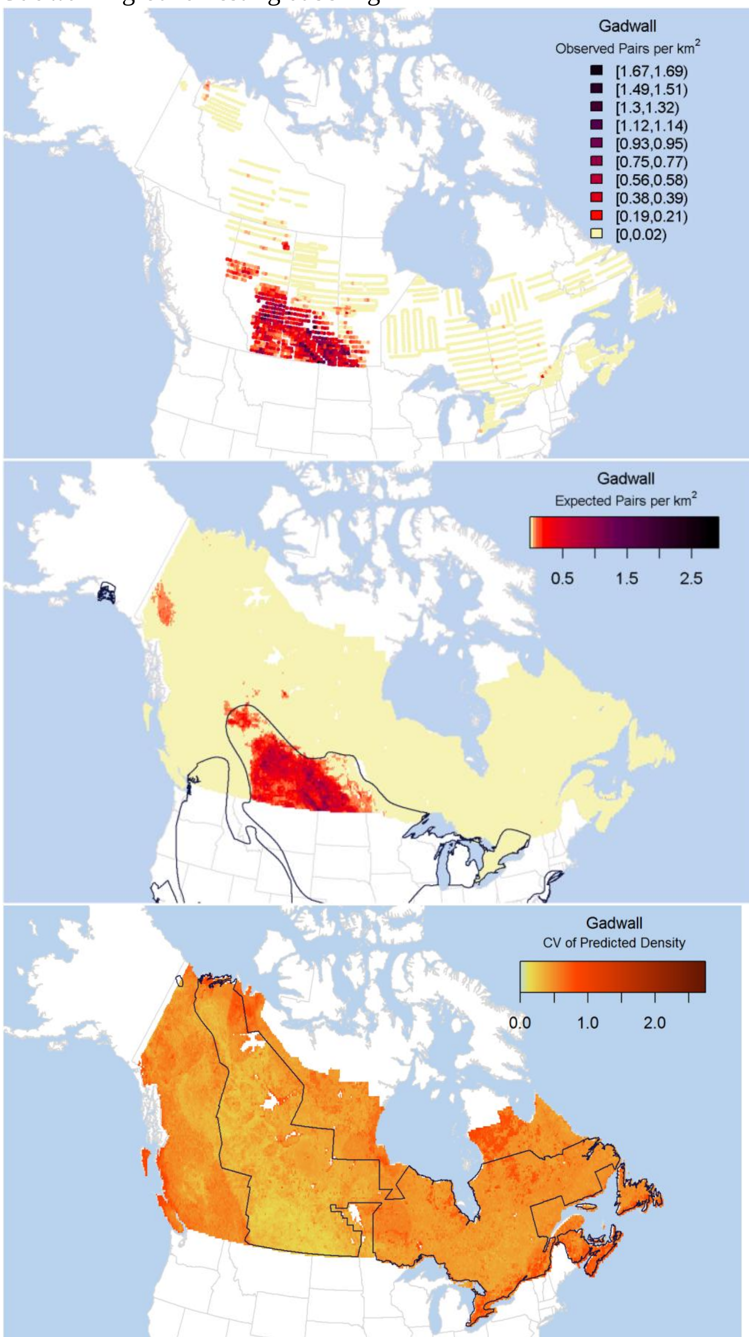


Our models predicted high densities of Blue-winged Teal concentrated in the prairie-parkland region and lower densities elsewhere. This pattern is generally consistent with Johnson and Grier (1988). NatureServe (BirdLife International and NatureServe 2012) and Johnsgard (2010) suggest a larger range than depicted in our map, but Johnsgard highlights that the species is not a common breeder outside of the prairies. Our map therefore highlights the difference in abundances within and outside of the core breeding area. The map of raw observations suggest that Blue-winged Teals inhabit southern Ontario, which is consistent with the Breeding Bird Atlas of Ontario (Bird Studies Canada et al. 2009) and the NatureServe range map. Our model, however, predicted very low abundances (effectively absence) of Blue-winged Teals within southern Ontario. There may be insufficient data within the survey to allow the model to accurately predict Blue-Winged Teals in this location.

Variable	Mean %	SD	Cumulative %
% Cropland	24.92	2.53	24.92
Density of Waterbodies (neighbourhood metric)	10.34	2.94	35.26
Amount of Shoreline (km/km^2)	8.08	2.21	43.34
Standard Deviation of Minimum Temperature in June	6.22	1.92	49.57
Mean Climate Moisture Index	6.06	1.75	55.63
Standard Deviation of Precipitation in August	3.12	1.29	58.75
Standard Deviation of Maximum Temperature in August	3.12	1.48	61.87
Precipitation Seasonality	2.94	0.56	64.81
Standard Deviation of Maximum Temperature in April	2.12	1.29	66.93
% Open Water (HWL)	1.97	0.60	68.90
Topographic Ruggedness	1.82	0.38	70.72
Amount of Streams (km/km^2)	1.39	0.36	72.11
Standard Deviation of Precipitation in December	1.36	0.74	73.47
Standard Deviation of Maximum Temperature in June	1.25	0.88	74.72
% Deciduous Forest	1.23	0.27	75.95
Standard Deviation of Precipitation in November	1.22	1.13	77.18
% Cropland-woodland	1.18	0.31	78.36
Standard Deviation of Minimum Temperature in May	1.14	0.74	79.49
Standard Deviation of Precipitation in October	1.13	0.72	80.63

Abundance of Blue-winged Teal was most closely associated with amount of cropland, followed by water body density, amount of shoreline, and the standard deviation of minimum June temperature. The most important variable contrasts with Rohwer et al. (2002)'s suggestion that Blue-winged Teals prefer grassland over cropland. However, we suspect that at the scale of our study, cropland was associated with grassland habitat and pothole type wetlands. Therefore, the amount of cropland likely acted as a proxy, capturing the high abundance of Blue-winged Teal within the prairie-parkland and low abundance elsewhere. The association with water body density and amount of shoreline may relate to the species' dependence on small, shallow, and productive wetlands Rohwer et al. (2002), though it could also represent a spatial association of the species with the aspen parklands of Saskatchewan and Manitoba where the species was most abundant.

Gadwall – ground nesting dabbling

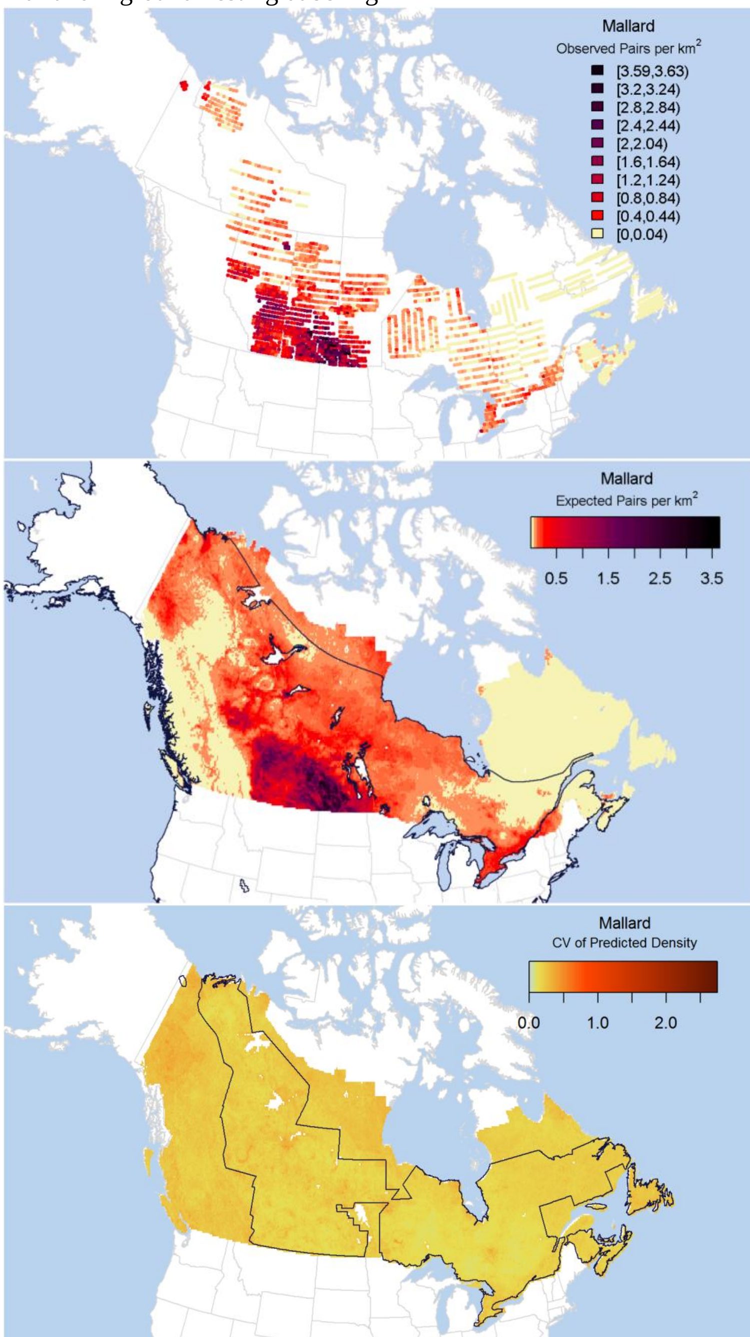


Our models predicted apparently high densities of Gadwall concentrated in the prairie-parkland region, and lower densities elsewhere, which is consistent with published range maps (Johnson and Grier 1988, Johnsgard 2010, BirdLife International and NatureServe 2012).

Variable	Mean %	SD	Cumulative %
% Cropland	29.77	2.64	29.77
% Open Water (HWL)	11.22	1.42	40.99
Mean Climate Moisture Index	9.04	2.90	50.03
Amount of Shoreline (km/km^2)	6.09	1.83	56.12
Precipitation Seasonality	5.06	1.42	61.18
Density of Waterbodies (neighbourhood metric)	3.21	1.20	64.39
Standard Deviation of Maximum Temperature in August	2.86	1.25	67.25
Amount of Streams (km/km^2)	2.46	0.91	69.71
Standard Deviation of Maximum Temperature in September	2.10	0.64	71.81
% Cropland-woodland	1.58	0.25	73.38
% Wetland (HWL)	1.13	0.17	74.52
Topographic Ruggedness	1.06	0.17	75.58
Mean Gross Primary Productivity	1.04	0.34	76.61
Standard Deviation of Precipitation in October	0.93	0.53	77.55
Mean Shoreline Complexity (neighbourhood metric)	0.93	0.25	78.48
Standard Deviation of Precipitation in July	0.90	0.41	79.37
Shannon's Diversity Index of Land Cover Types	0.85	0.22	80.22

Gadwall abundance was most closely associated with amount of cropland, followed by amount of open water and CMI. As with Blue-winged Teals, Gadwalls avoid cropland in favour of untilled upland (Higgins 1977), but at our study's scale and resolution, this positive association with cropland likely represents a continental spatial association with the prairie-parklands rather than actual selection for cropland habitat. CMI may separate the prairies from the parkland via a negative water balance. A positive association with open water may reflect the preference of Gadwall for wetlands comprised of 50:50 water to emergent vegetation compared to those with more vegetation (Kaminski and Prince 1981).

Mallard – ground nesting dabbling

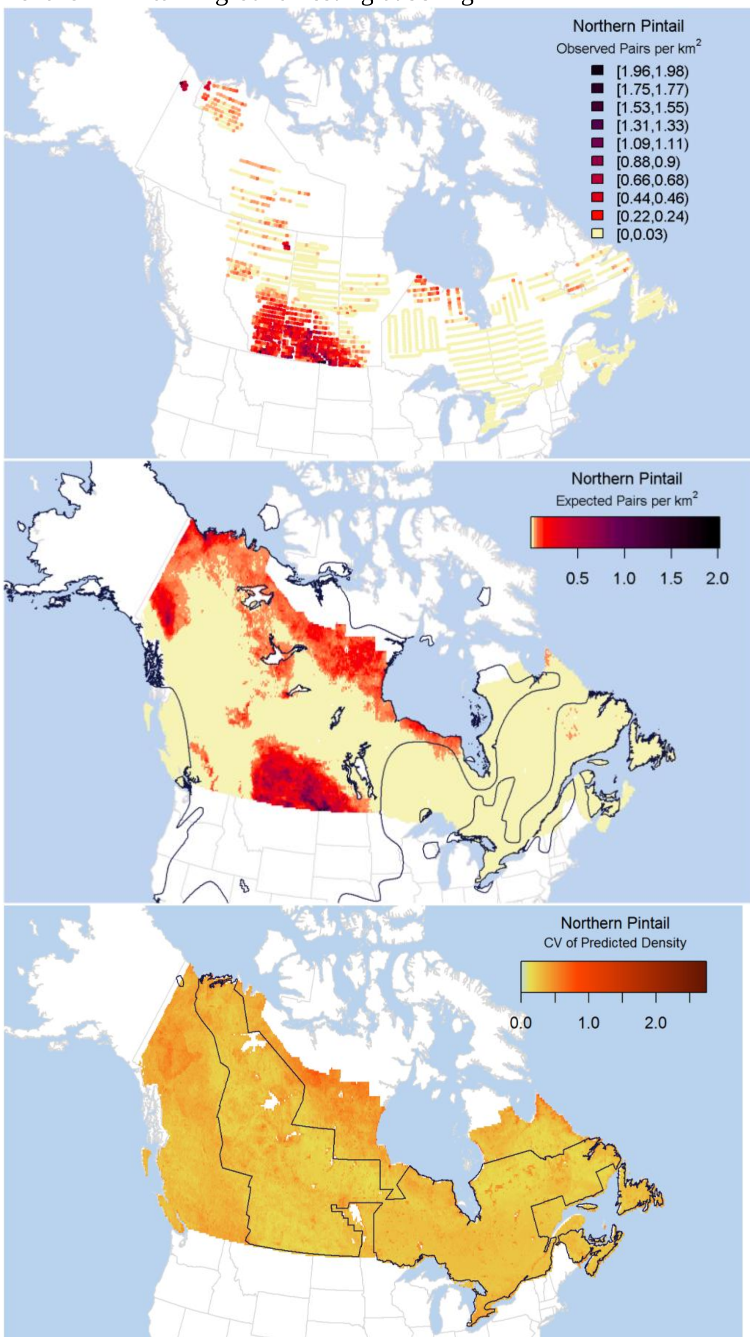


Our models predicted high densities of Mallards in the prairie-parkland region, and throughout the Peace-Athabasca Delta, the Slave River Lowlands, and the Great Lakes Lowlands. Pockets of relatively high density were also predicted in the MacKenzie Delta and in southern Yukon. The overall range appears similar to published accounts (Johnsgard 2010, BirdLife International and NatureServe 2012), including the fact that highest densities are reported in the prairie-parkland region (Drilling et al. 2002).

Variable	Mean %	SD	Cumulative %
% Cropland	41.50	1.88	41.50
Amount of Shoreline (km/km^2)	6.29	1.50	47.79
Density of Waterbodies (neighbourhood metric)	5.38	1.37	53.17
Mean Climate Moisture Index	3.65	1.46	56.82
Precipitation Seasonality	3.56	1.16	60.38
% Open Water (HWL)	3.17	0.73	63.55
Standard Deviation of Minimum Temperature in June	2.73	1.23	66.28
Standard Deviation of Maximum Temperature in August	1.89	1.01	68.17
% Cropland-woodland	1.76	0.29	69.93
Topographic Ruggedness	1.74	0.55	71.67
Standard Deviation of Maximum Temperature in April	1.27	0.49	72.93
Amount of Streams (km/km^2)	1.22	0.46	74.15
Standard Deviation of Maximum Temperature in June	1.13	0.54	75.29
Standard Deviation of Precipitation in August	1.00	0.62	76.28
% Wetland (HWL)	0.96	0.15	77.24
% Deciduous Forest	0.96	0.20	78.20
Mean Spring Maximum Temperature	0.75	0.29	78.95
Mean Summer Minimum Temperature	0.72	0.15	79.67
Shannon's Diversity Index of Land Cover Types	0.70	0.18	80.37

As with other dabbling species, Mallard abundance was associated with amount of cropland, amount of shoreline, water body density, and CMI. These variables seem to best explain high abundances in the prairie-parkland region and lower abundances in the surrounding area. The amount of shoreline and water body density may also relate to Mallards' preference for shallow wetlands (Stewart and Kantrud 1973). The association with cropland may or may not represent a biological correspondence in this case since Mallards prefer to nest in tall vegetation, including hayfields (Johnsgard 2010), but also reportedly avoid nesting in cropland (Greenwood et al. 1995). The sixth most important variable was the amount of open water, which may reflect the preference of Mallards for more open water areas in the boreal forest (Drilling et al. 2002).

Northern Pintail – ground nesting dabbling

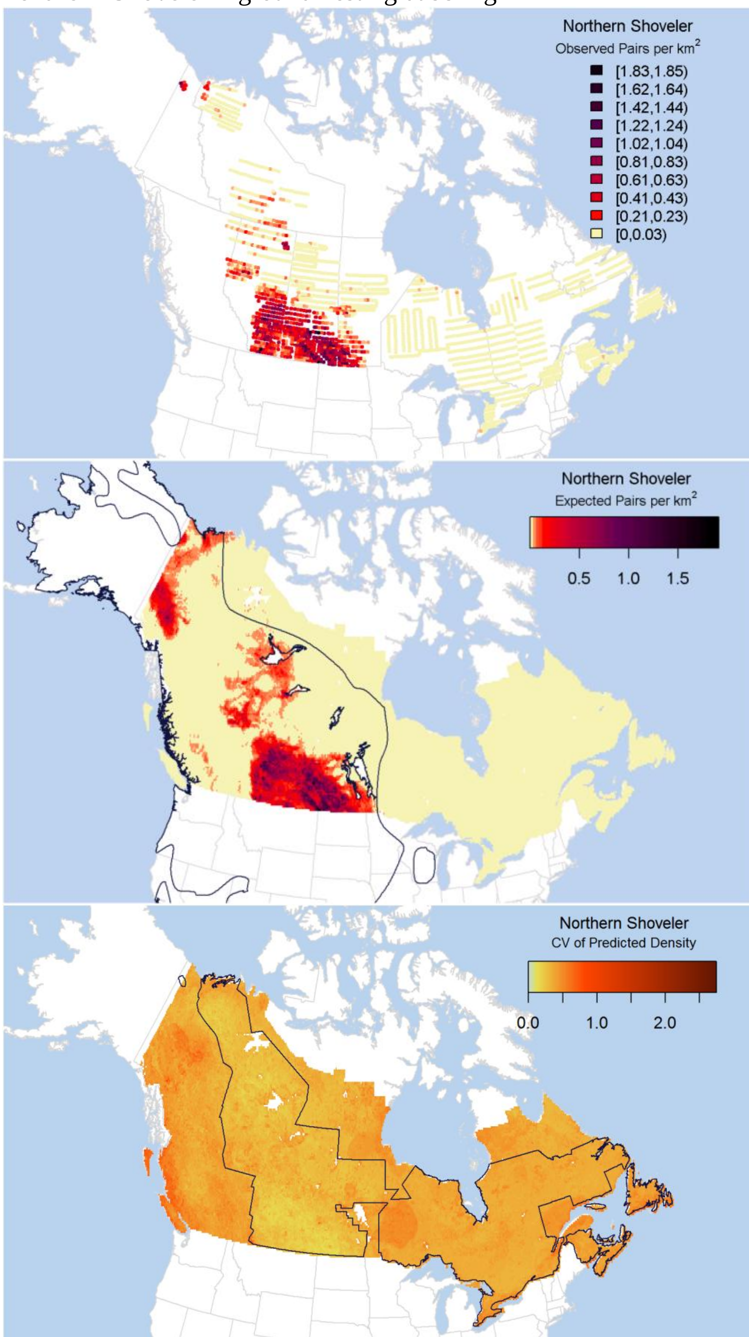


Our models predicted high densities of Pintails in the prairies but also in the Yukon, along the northern limits of our study area, and among some of the parkland areas. Johnsgard (2010) classified Pintails as a low Arctic species, likely reflecting its high abundance in Alaska, which is consistent with our predictions of the species living in the North. That the species is abundant in the prairies is also consistent with Johnson and Grier (1988) and Johnsgard (2010).

Variable	Mean %	SD	Cumulative %
Mean Climate Moisture Index	36.31	2.52	36.31
Amount of Shoreline (km/km^2)	7.72	1.86	44.03
% Cropland	5.43	1.48	49.46
Standard Deviation of Minimum Temperature in November	4.99	1.60	54.45
Topographic Ruggedness	3.97	0.62	58.41
Standard Deviation of Maximum Temperature in September	3.40	1.28	61.81
% Open Water (HWL)	2.94	0.83	64.75
Standard Deviation of Maximum Temperature in August	2.06	0.57	66.82
Density of Waterbodies (neighbourhood metric)	1.95	0.72	68.76
Standard Deviation of Maximum Temperature in February	1.87	0.52	70.64
Mean Winter Precipitation	1.64	0.46	72.28
Standard Deviation of Precipitation in October	1.58	0.70	73.85
Amount of Streams (km/km^2)	1.27	0.34	75.12
Standard Deviation of Minimum Temperature in February	1.24	0.66	76.36
Standard Deviation of Maximum Temperature in October	1.08	0.33	77.44
Standard Deviation of Maximum Temperature in July	1.03	0.33	78.46
% Cropland-woodland	0.95	0.15	79.41
Standard Deviation of Maximum Temperature in November	0.92	0.42	80.33

Pintail abundance was most closely associated with CMI, followed by amount of shoreline, amount of cropland, two temperature variability measures (November and September), and topographic ruggedness. As with other dabblers, the high abundance of the species in the western prairies likely explains the association with the former three variables. The Pintail reportedly has a stronger dependence on open habitats than other dabblers (Johnsgard 2010), which is reflected in higher abundances in the prairies. This pattern is reflected in the relationships with CMI and topographic ruggedness. When examining maps of predictor variables, variability in maximum temperature in September identifies the prairie region, while variability in minimum November temperature likely identifies portions of the boreal region where Pintails occurred in higher abundances. While the importance of amount of shoreline may reflect a biological relationship describing Pintails dependence on water, it appears that most of the variables simply reflect a spatial rather than mechanistic relationship. This finding is not surprising because observed Pintails likely represent at least two populations: those inhabiting the prairies and those that fly directly to the arctic (Miller et al. 2005, Mattsson et al. 2012). Modelling the two groups together may yield predictive environmental variables that are not mechanistically meaningful.

Northern Shoveler – ground nesting dabbling

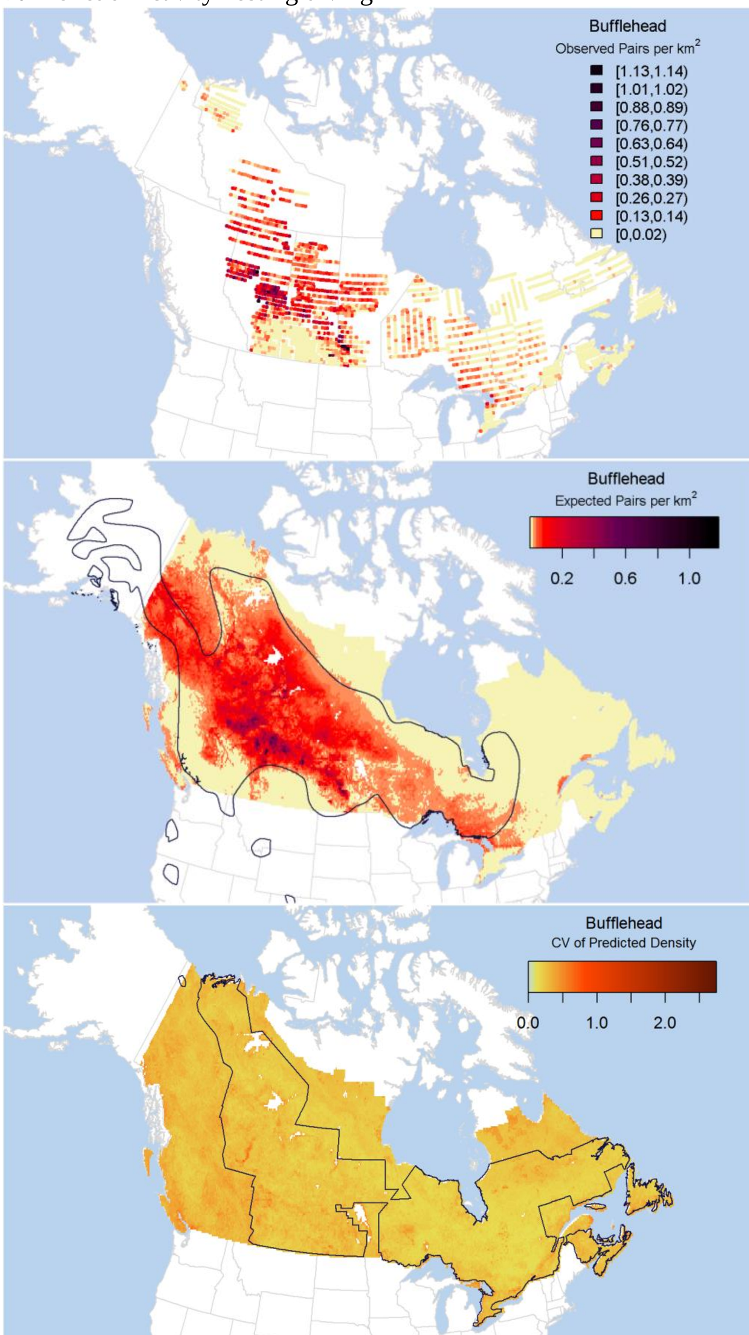


Our models predicted high densities of Shovelers in the prairies, along with the Yukon and among some of the parkland areas around the Slave Lakes, which is generally consistent with published ranges (Dubowy 1996, BirdLife International and NatureServe 2012). Johnsgard (2010), however, states that it is an uncommon breeder in Alaska, suggesting that our predicted northern abundances are higher than traditionally recognized. Our model predicted only very low abundances of Shovelers within Ontario and Québec, despite observations within Ontario in the raw data, and records of breeding Shoveler in the Breeding Bird Atlases of Ontario and Québec (Bird Studies Canada et al. 2009, Regroupement QuébecOiseaux et al. 2014).

Variable	Mean %	SD	Cumulative %
Mean Climate Moisture Index	22.91	3.46	22.91
% Cropland	19.06	3.43	41.97
Amount of Shoreline (km/km^2)	8.14	1.91	50.11
% Open Water (HWL)	5.65	1.10	55.76
Density of Waterbodies (neighbourhood metric)	3.83	1.86	59.60
Topographic Ruggedness	3.74	0.48	63.33
Standard Deviation of Maximum Temperature in August	3.09	1.10	66.42
Precipitation Seasonality	2.15	1.00	68.57
Standard Deviation of Maximum Temperature in September	2.00	0.69	70.58
Amount of Streams (km/km^2)	1.85	0.49	72.43
% Wetland (HWL)	1.32	0.26	73.75
% Cropland-woodland	1.24	0.26	74.99
Mean Shoreline Complexity (neighbourhood metric)	0.88	0.30	75.88
Standard Deviation of Maximum Temperature in January	0.85	0.29	76.72
Standard Deviation of Precipitation in October	0.79	0.32	77.51
Standard Deviation of Minimum Temperature in November	0.78	0.26	78.29
Standard Deviation of Precipitation in August	0.77	0.30	79.06
% Deciduous Forest	0.74	0.22	79.80
Mean Gross Primary Productivity	0.70	0.29	80.51

Shoveler abundance was most closely associated with CMI and amount of cropland, followed by three hydrological variables: amount of shoreline; amount of open water; and water body density. As with other western dabblers, the former two variables may capture the high densities of the species in the prairie-parkland region. Shovelers prefer hayland and avoid nesting in cropland (Greenwood et al. 1995), a subtle distinction our coarse-scale models likely did not identify. Since they especially favour shallow, eutrophic wetlands with abundant floating animal and plant life (Johnsgard 2010), we might have expected a strong relationship with GPP. Instead, we found a strong relationship with hydrological variables, suggesting that GPP may not indicate wetland productivity as intended, and/or that this coarse-scale analysis identifies variables associated with large-scale patterns in abundance but not reflecting fine-scale habitat selection.

Bufflehead – cavity nesting diving

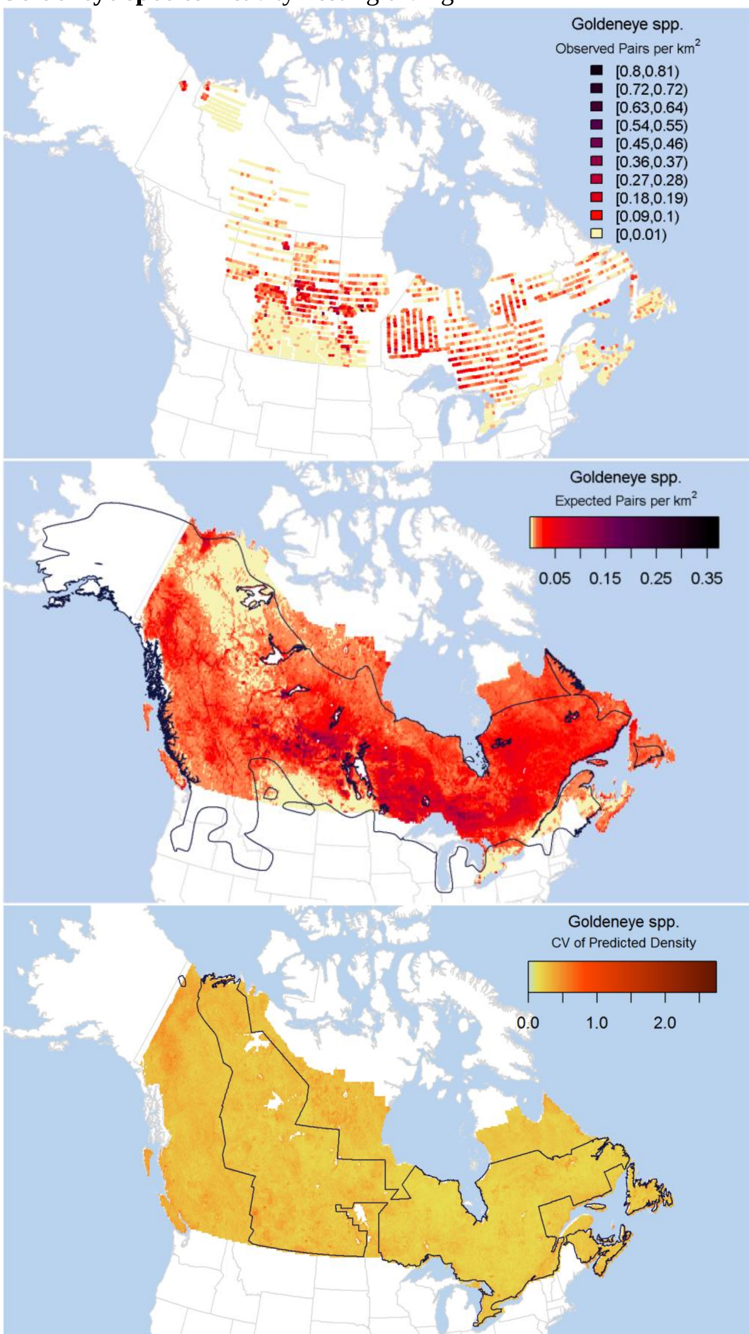


Compared to dabblers, the predicted distribution of Buffleheads was more homogenous across the study area, with a less well-defined core area. The highest densities were located in the Peace-Athabasca Parklands, with a few areas of high abundance in the southern aspen parkland. The species was nearly absent from the prairies, which is consistent with published ranges (Johnsgard 2010, BirdLife International and NatureServe 2012) and their dependence on trees for nesting.

Variable	Mean %	SD	Cumulative %
Standard Deviation of Minimum Temperature in July	18.81	3.02	18.81
% Deciduous Forest	9.04	1.28	27.85
Standard Deviation of Growing Season Length	5.40	0.91	33.26
Density of Waterbodies (neighbourhood metric)	4.62	1.14	37.88
Standard Deviation of Minimum Temperature in November	4.21	0.71	42.08
% Open Water (HWL)	4.10	1.11	46.19
Amount of Shoreline (km/km^2)	2.80	0.71	48.99
Standard Deviation of Minimum Temperature in December	2.36	0.53	51.34
% Cropland-woodland	2.15	0.80	53.50
Standard Deviation of Maximum Temperature in November	1.77	0.80	55.27
Standard Deviation of Maximum Temperature in December	1.72	0.41	56.99
Standard Deviation of Minimum Temperature in June	1.56	0.74	58.55
Standard Deviation of Minimum Temperature in January	1.30	0.38	59.85
Standard Deviation of Minimum Temperature in October	1.26	0.57	61.11
Mean Climate Moisture Index	1.24	0.41	62.35
Mean Summer Maximum Temperature	1.19	0.32	63.54
Mean Shoreline Complexity (neighbourhood metric)	1.15	0.36	64.69
Standard Deviation of Maximum Temperature in October	1.14	0.63	65.83
Mean Gross Primary Productivity	1.13	0.23	66.96
Precipitation Seasonality	1.12	0.52	68.08
Standard Deviation of Maximum Temperature in September	1.11	0.46	69.19
Standard Deviation of Maximum Temperature in March	1.06	0.37	70.24
Mean Summer Precipitation	1.06	0.58	71.30
Mean Autumn Minimum Temperature	1.00	0.41	72.30
Standard Deviation of Maximum Temperature in January	1.00	0.32	73.30
Topographic Ruggedness	0.94	0.30	74.24
Standard Deviation of Maximum Temperature in February	0.93	0.30	75.17
Mean Growing Season Length	0.91	0.47	76.08
Annual Range in Temperature	0.83	0.26	76.91
Standard Deviation of Maximum Temperature in April	0.83	0.40	77.74
Standard Deviation of Minimum Temperature in March	0.80	0.24	78.54
Standard Deviation of Precipitation in June	0.79	0.48	79.33
% Mixed Forest - Deciduous-dominated	0.78	0.28	80.11

Bufflehead abundance was closely associated with variability in minimum July temperature, followed by amount of deciduous forest and variability in growing season length. Three of the seven most important variables were hydrological: water body density; amount of open water; and shore length. We suspect that the bioclimatic variables are associated with the large-scale spatial pattern of abundance, though the variability in growing season may reflect the species' more boreal distribution. The relationship with amount of deciduous forest is as expected for a cavity-nesting species "associated with temperate forests" (Johnsgard 2010). The top three hydrological variables identified were wetland density, stream length, and the amount of open water as measured by the high resolution HWL product. These relationships are consistent with the species' association with small ponds (Gauthier 1993) on riparian networks such as produced by beavers (Naiman et al. 1988).

Goldeneye species – cavity nesting diving



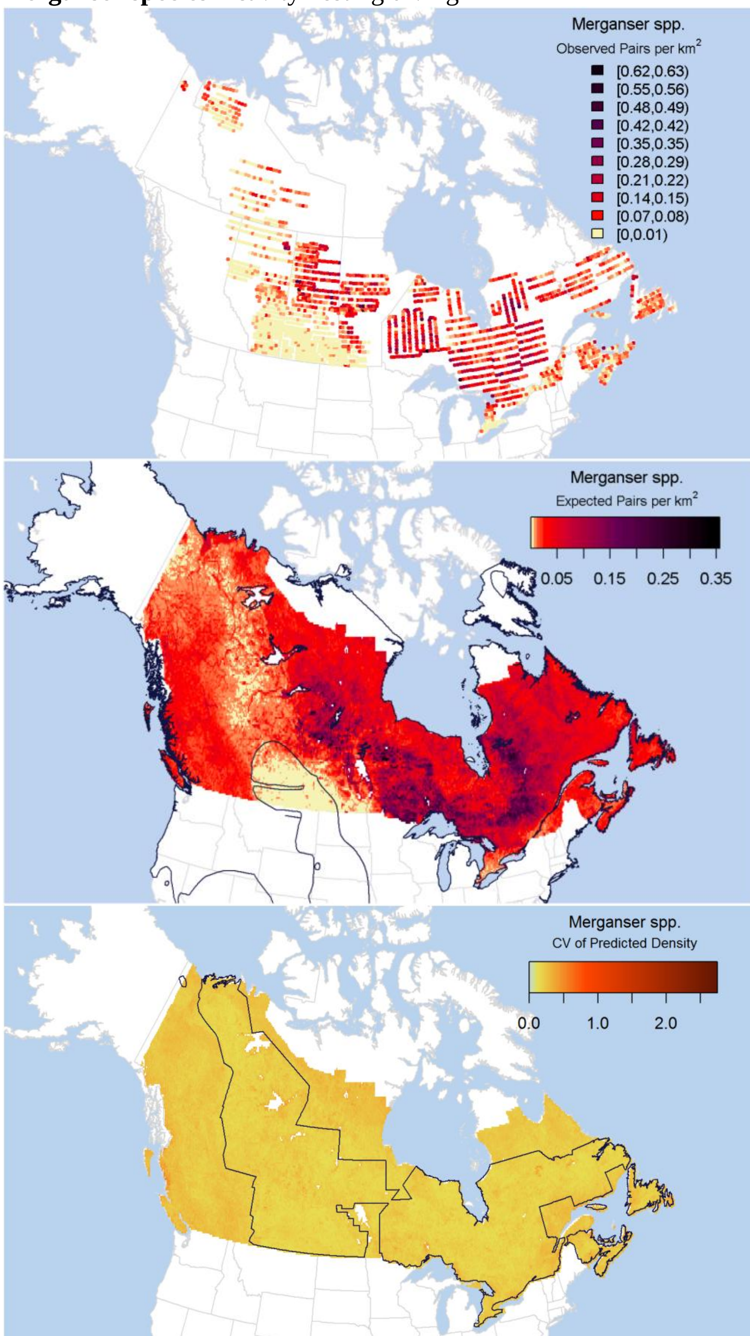
Our models predicted that goldeneyes live across much of our study area, with higher densities in the East and around the aspen parkland. Although our models grouped the Barrow’s and Common Goldeneye species together, we might conclude that the majority of the observations were for Common Goldeneye, given the larger distribution of this species. Our predictions largely match range maps (BirdLife International and NatureServe

2012), including absence from the southern lowlands, and are consistent with higher abundances in eastern provinces (Johnsgard 2010). As with the Bufflehead, goldeneye species are much less abundant in the prairies (Eadie et al. 1995), which is reflected in our predictions.

Variable	Mean %	SD	Cumulative %
% Open Water (HWL)	20.76	3.40	20.76
Precipitation Seasonality	7.75	2.26	28.51
Mean Summer Maximum Temperature	6.29	1.58	34.80
Standard Deviation of Minimum Temperature in July	3.09	0.74	37.89
Standard Deviation of Minimum Temperature in December	2.30	0.89	40.19
% High Density Evergreen Forest	2.21	0.52	42.40
Topographic Ruggedness	2.01	1.02	44.41
Mean Waterbody Area (neighbourhood metric)	1.99	0.57	46.40
Standard Deviation of Minimum Temperature in June	1.99	0.39	48.39
Shannon's Diversity Index of Land Cover Types	1.95	0.57	50.33
Mean Gross Primary Productivity	1.91	0.68	52.24
% Deciduous Forest	1.79	0.43	54.03
% Mixed Forest - Evergreen-dominated	1.73	0.45	55.76
Amount of Shoreline (km/km^2)	1.66	0.39	57.43
Standard Deviation of Minimum Temperature in August	1.66	0.55	59.08
Mean Winter Precipitation	1.65	0.68	60.73
Mean Autumn Minimum Temperature	1.58	0.82	62.31
Standard Deviation of Maximum Temperature in August	1.53	0.46	63.84
Mean Spring Minimum Temperature	1.50	0.47	65.35
% Low Density Evergreen	1.34	0.53	66.69
Mean Growing Season Length	1.29	0.44	67.98
Mean Summer Minimum Temperature	1.21	0.38	69.20
Standard Deviation of Minimum Temperature in January	1.10	0.86	70.30
Standard Deviation of Growing Season Length	1.08	0.43	71.38
Density of Waterbodies (neighbourhood metric)	1.05	0.60	72.43
Mean Spring Maximum Temperature	1.03	0.49	73.46
Standard Deviation of Minimum Temperature in March	1.02	0.53	74.49
% Mixed Forest - Deciduous-dominated	0.97	0.28	75.46
Standard Deviation of Minimum Temperature in November	0.94	0.44	76.40
Mean Shoreline Complexity (neighbourhood metric)	0.90	0.30	77.30
Standard Deviation of Precipitation in January	0.84	0.39	78.14
Mean Summer Precipitation	0.84	0.22	78.99
Standard Deviation of Precipitation in November	0.84	0.43	79.83
Standard Deviation of Minimum Temperature in October	0.83	0.36	80.66

Goldeneye abundance was most closely associated with amount of open water, followed by precipitation seasonality and the mean maximum July temperature. The amount of high density evergreen forest was ranked sixth most important, and the amount of coniferous forest was ranked twelfth. The very strong association with amount of open water may represent both a biological and spatial association. It is the only hydrological variable in the top seven, and likely captures the dependence of the species on water bodies for feeding. Goldeneyes also prefer water bodies with less shoreline vegetation (Eadie et al. 1995), which may be reflected in this open water variable. Area of water bodies was the eighth most important variable, and the goldeneye group represents one of the only species with this variable ranked within the top 10 variables. Goldeneyes tend to prefer smaller lakes over larger ones, but they also prefer lakes with a depth of at least 1 m (Eadie et al. 1995, 2000). Our water body area variable may be providing information about water depth, as we had intended. The roughly quadratic association with mean July temperature appears to be a spatial correspondence explaining the species' trans-continental distribution. The association with coniferous and deciduous forest further captures this trans-continental distribution, as well as the dependence of the species on trees for cavities, which is stronger for Common Goldeneyes than for Barrow's (Johnsgard 2010).

Merganser species – cavity nesting diving

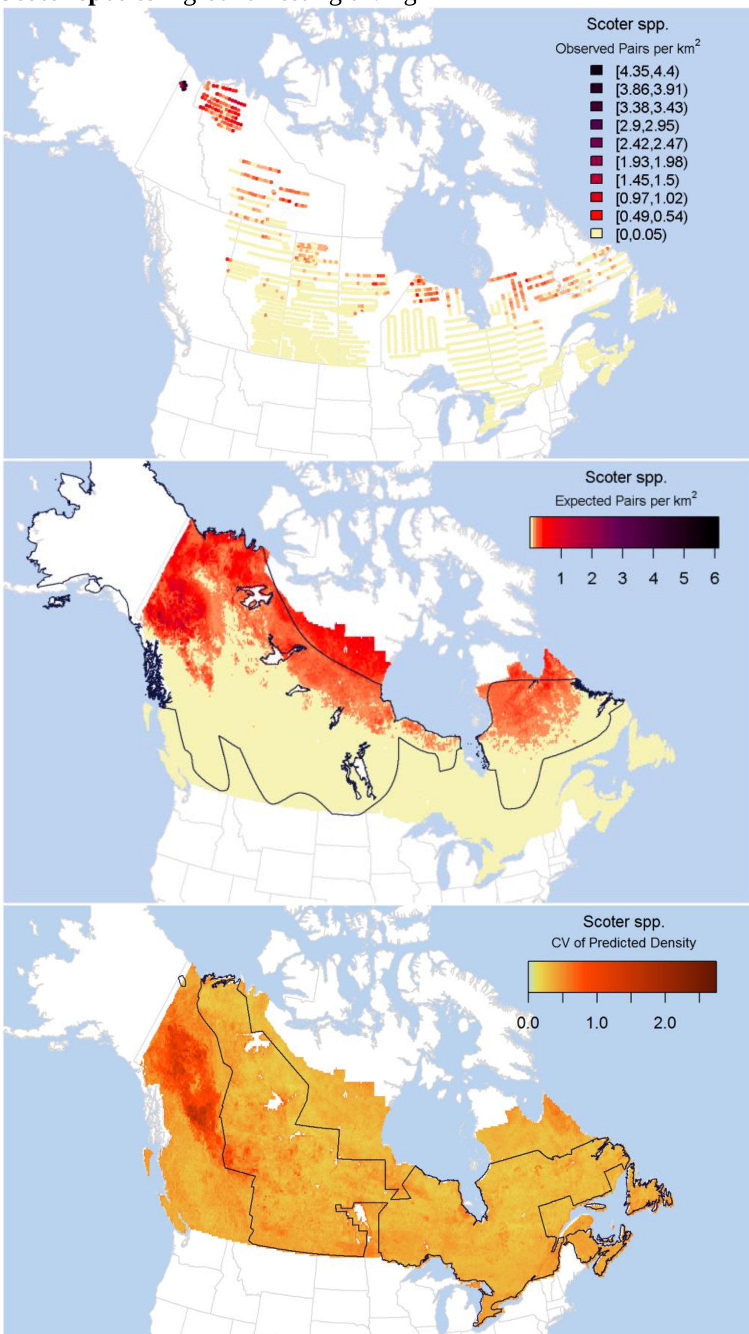


Our models predicted a very similar distribution for merganser species as it did for goldeneye species. Like the goldeneyes, this model grouped more than one species, but our predictions are largely consistent with the combined distribution of the three species included in the group (BirdLife International and NatureServe 2012).

Variable	Mean %	SD	Cumulative %
% Open Water (HWL)	21.44	2.24	21.44
% High Density Evergreen Forest	10.60	1.22	32.04
Standard Deviation of Minimum Temperature in June	5.60	0.98	37.65
Mean Waterbody Area (neighbourhood metric)	4.48	1.46	42.13
Amount of Shoreline (km/km^2)	3.10	0.50	45.23
Density of Waterbodies (neighbourhood metric)	3.01	0.85	48.24
Standard Deviation of Maximum Temperature in November	2.85	0.46	51.09
Mean Gross Primary Productivity	2.12	0.66	53.21
Mean Shoreline Complexity (neighbourhood metric)	2.08	0.46	55.29
% Wetland (HWL)	1.98	0.72	57.27
Mean Summer Maximum Temperature	1.90	0.54	59.16
% Low Density Evergreen	1.80	0.53	60.96
% Mixed Forest - Evergreen-dominated	1.65	0.27	62.61
Standard Deviation of Maximum Temperature in July	1.48	0.22	64.09
Standard Deviation of Minimum Temperature in August	1.42	0.44	65.51
Shannon's Diversity Index of Land Cover Types	1.36	0.29	66.87
Topographic Ruggedness	1.25	0.21	68.13
Standard Deviation of Maximum Temperature in February	1.15	0.26	69.28
Mean Summer Minimum Temperature	1.09	0.46	70.37
Standard Deviation of Precipitation in June	1.05	0.23	71.43
Amount of Streams (km/km^2)	1.04	0.38	72.47
% Mixed Forest - Deciduous-dominated	1.01	0.22	73.47
Standard Deviation of Precipitation in July	0.98	0.37	74.46
Standard Deviation of Maximum Temperature in June	0.94	0.32	75.40
% Medium-density Evergreen Forest	0.93	0.31	76.33
Standard Deviation of Minimum Temperature in January	0.93	0.41	77.26
Mean Growing Season Length	0.90	0.54	78.16
Standard Deviation of Precipitation in April	0.90	0.33	79.06
Standard Deviation of Minimum Temperature in July	0.86	0.31	79.92
Standard Deviation of Maximum Temperature in April	0.80	0.22	80.72

Merganser abundance was strongly associated with amount of open water, followed by amount of high density evergreen forest, variability in minimum June temperature, area of water bodies in the surrounding area, amount of shoreline, and water body density. Relationships with forest and the climatic variable likely originate from the transcontinental distribution of this species group. The relationship with evergreen forest may capture the association of the Common Merganser with forested landscapes, but the more flexible, facultative ground-nesting Red-breasted Merganser is somewhat less associated with forests (Johnsgard 2010). This species group was closely associated with more water variables than most other species. In addition to the above four hydrological variables, shoreline complexity and amount of wetland were the ninth and tenth most important variables. This pattern may reflect the species' strong dependence on relatively deeper, more oligotrophic, open and clear water for foraging for fish (Mallory and Metz 1999, Johnsgard 2010).

Scoter species – ground nesting diving



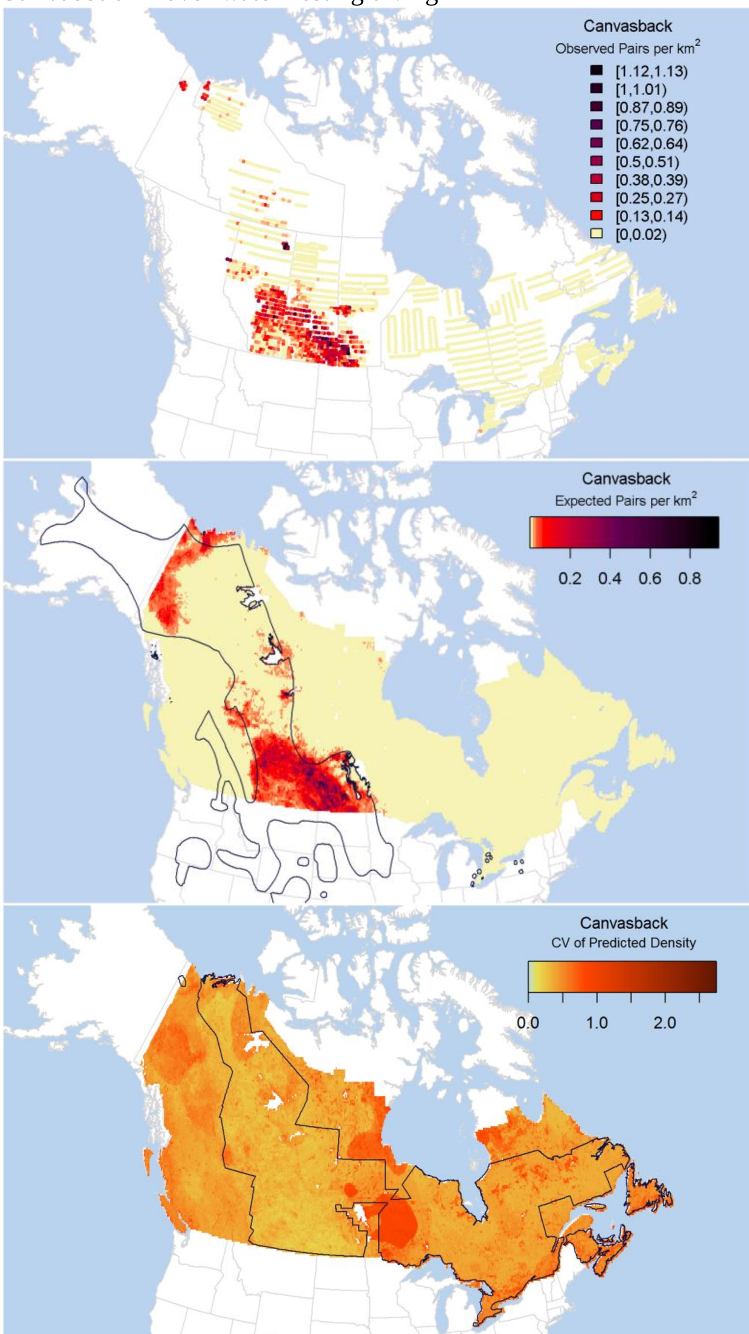
Our models predicted the highest abundances of scoters along the northern limits of our study area and in much of the Yukon. Although the survey, and therefore our model, does not distinguish among the scoter species, published range maps suggest that our predictions likely represent Surf and White-winged Scoter, since these species live primarily in the surveyed western boreal forest (Johnsgard 2010, BirdLife International and

NatureServe 2012), with highest population densities in the northwestern boreal (Bellrose 1980). This is somewhat consistent with our prediction maps, but our models predictions extended well north of published ranges, likely due to extrapolation error (see Discussion).

Variable	Mean %	SD	Cumulative %
Mean Autumn Maximum Temperature	36.89	7.82	36.89
Mean Winter Minimum Temperature	16.02	5.22	52.91
Standard Deviation of Minimum Temperature in October	7.17	3.67	60.08
Mean Growing Season Length	6.56	4.77	66.64
Standard Deviation of Minimum Temperature in April	4.54	2.57	71.19
Mean Spring Precipitation	3.34	1.84	74.53
Standard Deviation of Minimum Temperature in September	2.69	1.20	77.22
Mean Gross Primary Productivity	2.52	2.74	79.74
Temperature Seasonality	2.37	1.00	82.11

Scoter abundance was strongly related to mean maximum autumn temperature, followed by mean minimum winter temperature, variability in minimum October temperature, and the mean growing season length. Moreso than any other species, the top variables for scoters were climatic in nature, many of which have a strong North-South gradient. This gradient explains the overprediction north of the treeline. Scoters are generally associated with freshwater lakes and ponds in boreal forests (Savard et al. 1998) and avoid tundra (Haszard and Clark 2007, Johnsgard 2010). However, since the raw survey data did not include areas of tundra to calibrate the models, scoter density appears to be increasing with latitude, which is captured by environmental variables with North-South gradients, leading to overprediction in northern areas beyond the survey limits and treeline.

Canvasback – over-water nesting diving



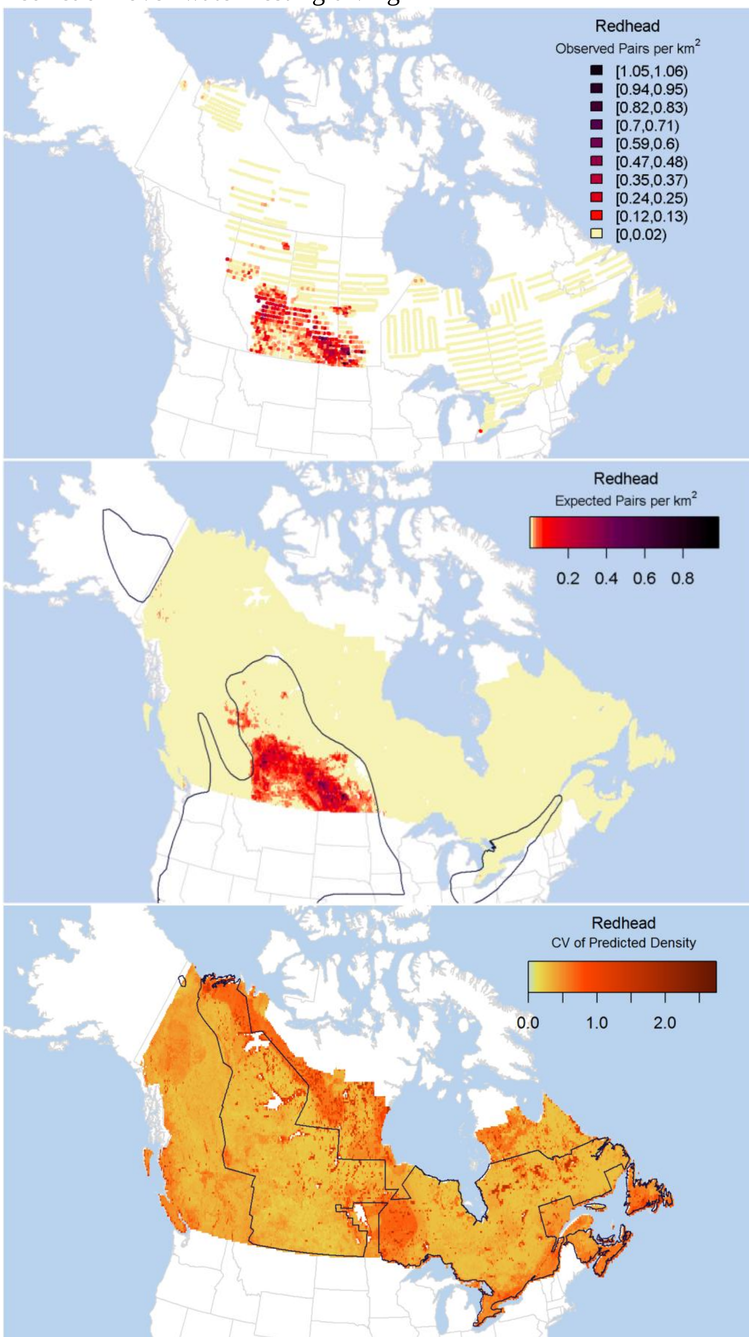
Our models predicted high densities of Canvasback in the aspen parkland, as well as some areas of higher abundance in the Yukon, which is largely consistent with published accounts of their distribution (Mowbray 2002) and range limits (Johnsgard 2010, BirdLife International and NatureServe 2012), however the

NatureServe range excludes the MacKenzie Delta, in contrast with relatively high observed and predicted abundances in the region.

Variable	Mean %	SD	Cumulative %
% Open Water (HWL)	10.87	1.50	10.87
Amount of Shoreline (km/km^2)	10.12	1.87	20.99
% Cropland	9.76	2.18	30.75
% Deciduous Forest	5.20	1.17	35.95
Precipitation Seasonality	4.11	0.89	40.06
% Cropland-woodland	3.97	0.78	44.03
Standard Deviation of Maximum Temperature in August	3.23	1.21	47.26
Topographic Ruggedness	3.17	0.66	50.43
Amount of Streams (km/km^2)	3.15	0.89	53.57
Density of Waterbodies (neighbourhood metric)	2.83	0.90	56.41
Mean Climate Moisture Index	2.75	1.52	59.16
Mean Spring Maximum Temperature	1.54	0.94	60.70
Mean Summer Precipitation	1.51	0.90	62.21
Mean Winter Maximum Temperature	1.46	0.64	63.68
Standard Deviation of Precipitation in August	1.46	0.60	65.13
Standard Deviation of Maximum Temperature in September	1.42	0.49	66.55
Standard Deviation of Minimum Temperature in November	1.35	0.78	67.90
Standard Deviation of Precipitation in November	1.31	0.52	69.21
Mean Winter Precipitation	1.09	0.18	70.31
Standard Deviation of Minimum Temperature in October	1.07	0.53	71.38
% Wetland (HWL)	1.01	0.38	72.39
Standard Deviation of Minimum Temperature in June	0.94	0.48	73.33
% Mixed Forest - Deciduous-dominated	0.93	0.59	74.26
Standard Deviation of Maximum Temperature in March	0.90	0.35	75.16
Standard Deviation of Precipitation in July	0.85	0.41	76.01
Standard Deviation of Precipitation in October	0.85	0.58	76.86
Standard Deviation of Maximum Temperature in February	0.81	0.32	77.67
Mean Autumn Precipitation	0.80	0.37	78.47
Shannon's Diversity Index of Land Cover Types	0.79	0.30	79.26
Mean Winter Minimum Temperature	0.75	0.52	80.01

The most important variables in predicting Canvasback abundance were the amount of open water, the amount of shoreline, and the amount of cropland, followed by the amount of deciduous forest. The first two variables capture the dependence of the species on water, and may reflect the Canvasback's need for relatively large, open bodies of water for nesting, landing, and takeoff (Johnsgard 2010). While Johnsgard (2010) states that Canvasbacks prefer shallow prairie marshes, Mowbray (2002) and our work suggest a closer dependence on lakes and deeper ponds and marshes. The association with cropland and deciduous forest likely reflects the high abundance in the aspen parkland (Mowbray 2002).

Redhead – over-water nesting diving

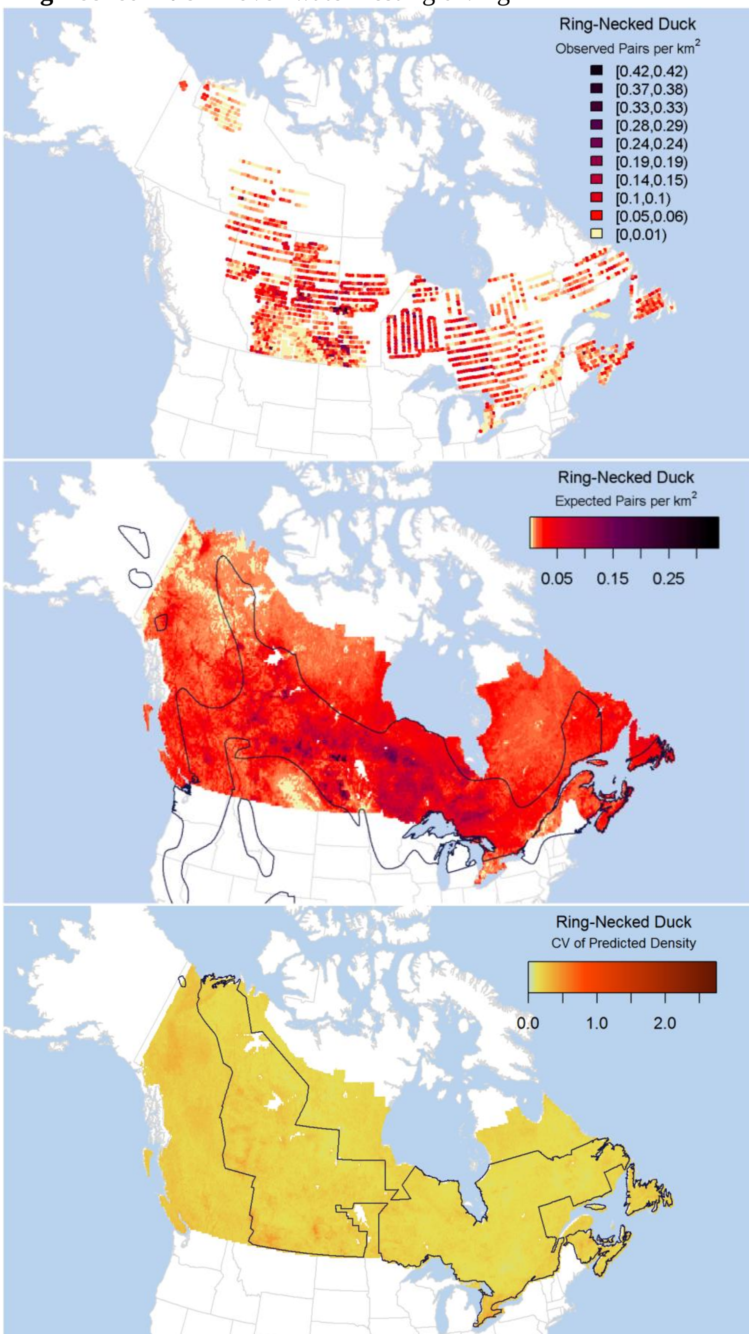


Our models predicted high densities of Redheads in the aspen parkland forest, which is largely consistent with published range maps (Johnsgard 2010, BirdLife International and NatureServe 2012).

Variable	Mean %	SD	Cumulative %
% Cropland	12.23	1.61	12.23
Amount of Shoreline (km/km^2)	11.47	2.42	23.70
% Open Water (HWL)	8.67	1.40	32.37
Density of Waterbodies (neighbourhood metric)	6.41	2.05	38.78
% Cropland-woodland	5.13	0.92	43.91
Precipitation Seasonality	3.52	0.80	47.43
Topographic Ruggedness	3.10	0.95	50.53
% Deciduous Forest	2.89	1.06	53.42
Amount of Streams (km/km^2)	2.53	0.66	55.95
Mean Summer Precipitation	2.44	1.02	58.39
Standard Deviation of Precipitation in August	1.86	0.68	60.25
Standard Deviation of Maximum Temperature in May	1.69	0.62	61.94
Standard Deviation of Precipitation in September	1.61	1.43	63.55
% Low Density Evergreen	1.49	1.30	65.05
Mean Gross Primary Productivity	1.41	0.77	66.46
Mean Precipitation in the Wettest Month	1.41	0.67	67.86
Shannon's Diversity Index of Land Cover Types	1.34	0.73	69.20
Standard Deviation of Maximum Temperature in August	1.31	0.49	70.51
Standard Deviation of Precipitation in December	1.20	0.85	71.71
% Wetland (HWL)	1.14	0.50	72.85
Standard Deviation of Precipitation in November	1.12	0.46	73.97
Mean Climate Moisture Index	1.10	0.56	75.07
Mean Spring Maximum Temperature	1.04	0.49	76.10
Standard Deviation of Maximum Temperature in November	1.00	0.59	77.10
Standard Deviation of Minimum Temperature in June	0.87	0.46	77.97
Standard Deviation of Maximum Temperature in September	0.81	0.25	78.79
Standard Deviation of Maximum Temperature in January	0.75	0.46	79.53
Standard Deviation of Precipitation in June	0.73	0.28	80.26

The variables most closely associated with Redhead abundance were similar to those for the Canvasback. Amount of cropland was most important, followed by amount of shore line, amount of open water, water body density, and amount of cropland-woodland. The first four describe the large-scale pattern of association with the prairie-parkland region as well as the association of the species with water. The association with cropland-woodland likely captures the high abundances in the aspen parkland. Like Canvasback, Redheads prefer deeper, more open water bodies (Woodin and Michot 2002), and they are more abundant in the parklands, despite a reported association with nonforested wetlands (Johnsgard 2010).

Ring-necked Duck – over-water nesting diving

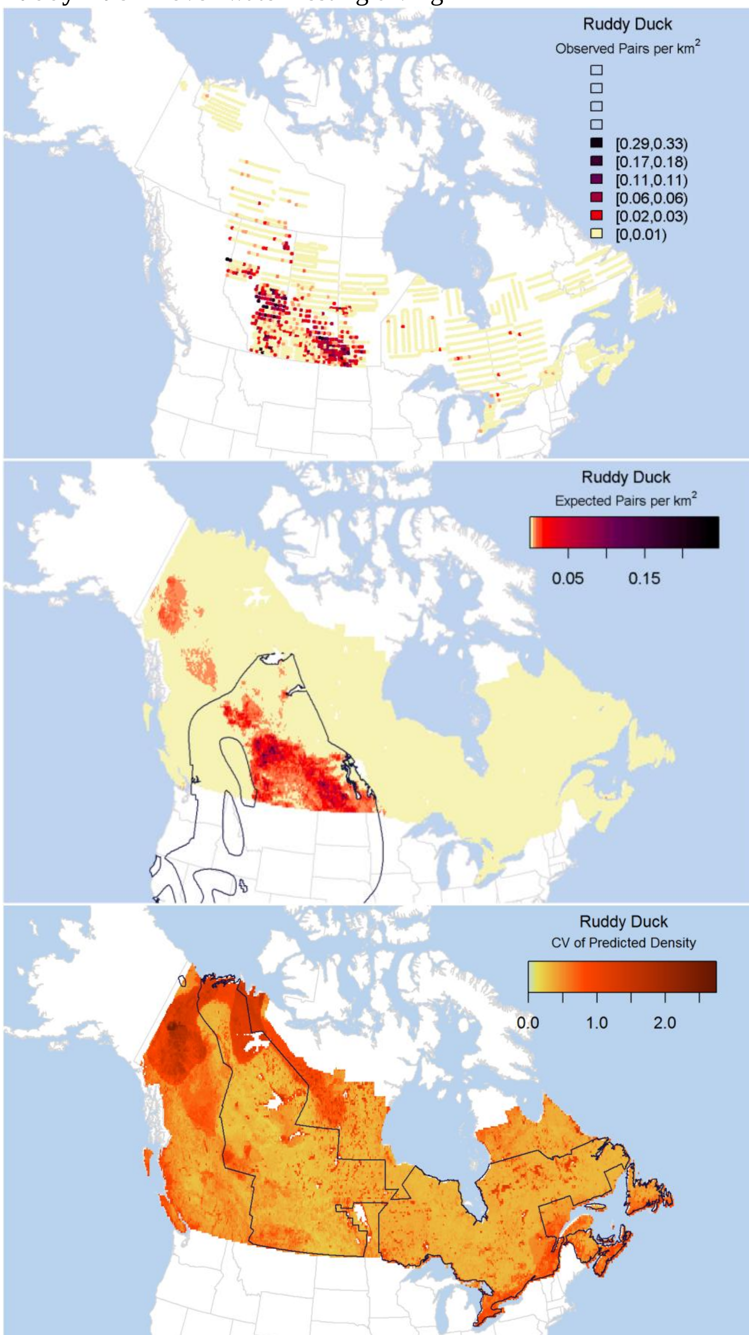


Our models predicted an extensive range of relatively homogenous abundance for Ring-necked Ducks. Slightly higher abundances were predicted within the published breeding range (BirdLife International and NatureServe 2012), but our models also predicted relatively high abundances well outside the documented range limits. Since raw observations of the species also indicate relatively high abundances outside the documented range, our modeled predictions may be more correct than current range maps in this case.

Variable	**Mean %**	**SD**	**Cumulative %**
% Deciduous Forest	7.37	1.33	7.37
% Open Water (HWL)	6.39	0.59	13.76
Amount of Shoreline (km/km^2)	4.51	0.94	18.28
Mean Gross Primary Productivity	4.22	0.54	22.50
Standard Deviation of Minimum Temperature in June	3.71	0.71	26.21
Density of Waterbodies (neighbourhood metric)	3.18	0.45	29.39
Mean Summer Maximum Temperature	2.88	0.78	32.27
Standard Deviation of Maximum Temperature in April	2.76	0.66	35.03
Standard Deviation of Growing Season Length	2.72	0.68	37.75
Standard Deviation of Precipitation in June	2.28	0.47	40.03
Mean Winter Precipitation	2.23	0.95	42.26
% Mixed Forest - Evergreen-dominated	2.00	0.43	44.26
Standard Deviation of Precipitation in November	1.83	0.27	46.09
Topographic Ruggedness	1.78	0.39	47.87
Standard Deviation of Minimum Temperature in December	1.76	0.52	49.63
% Mixed Forest - Deciduous-dominated	1.73	0.28	51.35
Amount of Streams (km/km^2)	1.62	0.23	52.98
% Wetland (HWL)	1.62	0.38	54.59
Standard Deviation of Precipitation in August	1.56	0.35	56.15
Mean Summer Minimum Temperature	1.55	0.36	57.70
Standard Deviation of Precipitation in January	1.54	0.39	59.23
Standard Deviation of Minimum Temperature in September	1.48	0.34	60.72
Standard Deviation of Precipitation in December	1.46	0.41	62.18
Standard Deviation of Precipitation in July	1.33	0.29	63.51
Standard Deviation of Maximum Temperature in November	1.26	0.31	64.77
% Medium-density Evergreen Forest	1.25	0.29	66.01
Standard Deviation of Maximum Temperature in June	1.22	0.22	67.23
Standard Deviation of Maximum Temperature in August	1.18	0.44	68.41
Standard Deviation of Minimum Temperature in July	1.17	0.26	69.58
% Low Density Evergreen	1.09	0.41	70.66
Standard Deviation of Maximum Temperature in September	1.01	0.38	71.67
Shannon’s Diversity Index of Land Cover Types	1.00	0.23	72.67
Precipitation Seasonality	0.98	0.30	73.65
Standard Deviation of Minimum Temperature in October	0.96	0.19	74.61
% High Density Evergreen Forest	0.92	0.25	75.53
Standard Deviation of Maximum Temperature in July	0.91	0.25	76.43
Mean Climate Moisture Index	0.90	0.27	77.33
Standard Deviation of Minimum Temperature in August	0.90	0.12	78.23
Standard Deviation of Precipitation in September	0.84	0.21	79.07
Standard Deviation of Minimum Temperature in May	0.81	0.18	79.89
Mean Summer Precipitation	0.81	0.23	80.70

Ring-necked Duck abundance was associated with the amounts of deciduous forest, open water, and shoreline, as well as GPP, variability in minimum June temperature, and water body density. Given the relatively homogenous distribution, it is difficult to identify clear spatial associations with environmental variables by examining predictor variable maps, except perhaps the variability in minimum June temperature, which may be associated with relatively higher abundances in the middle of the species' range. Ring-necked Ducks nest in shallow marshes, swamps, and bogs, but especially favour bogs (Hohman and Eberhardt 1998, Johnsgard 2010). Our wetland classification did not differentiate between bogs and other wetlands, so it is possible that variables such as deciduous forest, a hydrological variable, GPP, or interactions among these variables acted as surrogates for bog wetlands.

Ruddy Duck – over-water nesting diving



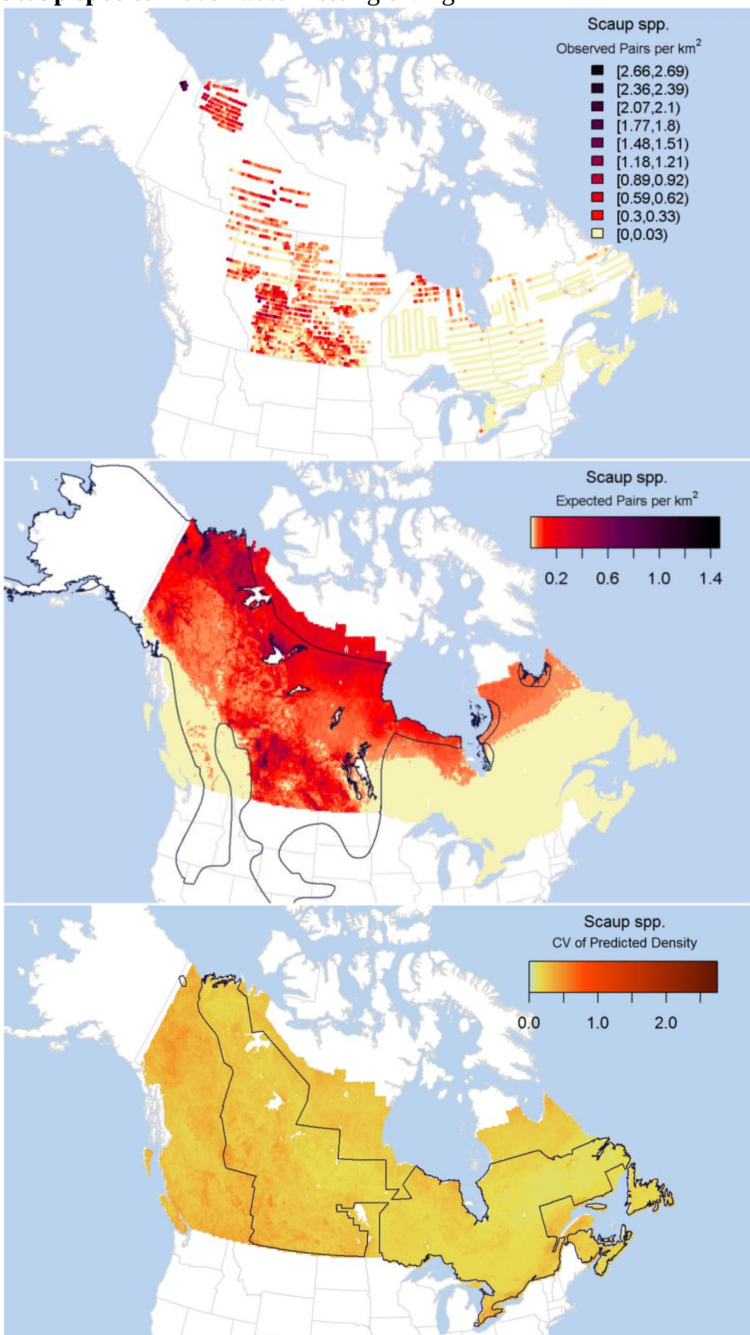
The Ruddy Duck had the lowest predicted abundance of all species we studied. Its highest predicted densities occurred in the prairie-parkland region, which is mostly consistent with Johnsgard (2010) and Brua (2002). However, published ranges extend to unsurveyed areas of British Columbia where our models predict the species to be effectively absent. Our model predicted only very low abundances of Ruddy Ducks within Ontario and

Québec, despite observations from the WBPHS, and the Breeding Bird Atlases of Ontario and Québec (Bird Studies Canada et al. 2009, Regroupement QuébecOiseaux et al. 2014).

Variable	Mean %	SD	Cumulative %
% Open Water (HWL)	10.19	2.96	10.19
% Cropland-woodland	7.12	1.51	17.32
Density of Waterbodies (neighbourhood metric)	4.69	1.82	22.00
% Cropland	4.67	1.17	26.67
Standard Deviation of Maximum Temperature in December	4.65	3.12	31.32
Amount of Shoreline (km/km^2)	3.93	1.72	35.25
Precipitation Seasonality	3.45	1.15	38.70
Standard Deviation of Precipitation in May	3.31	2.59	42.01
Standard Deviation of Maximum Temperature in November	3.26	2.01	45.27
Standard Deviation of Growing Season Length	3.23	1.53	48.50
% Deciduous Forest	2.27	0.85	50.77
% Wetland (HWL)	2.11	0.97	52.88
Standard Deviation of Maximum Temperature in January	1.92	1.19	54.80
Standard Deviation of Maximum Temperature in February	1.90	1.29	56.70
Mean Climate Moisture Index	1.88	0.74	58.58
Amount of Streams (km/km^2)	1.85	0.79	60.43
Shannon’s Diversity Index of Land Cover Types	1.62	1.19	62.06
Topographic Ruggedness	1.48	0.61	63.54
Standard Deviation of Maximum Temperature in May	1.48	0.57	65.02
Standard Deviation of Precipitation in June	1.41	0.90	66.43
% High Density Evergreen Forest	1.34	1.40	67.77
Standard Deviation of Maximum Temperature in September	1.30	0.59	69.07
Standard Deviation of Minimum Temperature in July	1.28	0.57	70.35
Standard Deviation of Minimum Temperature in June	1.28	0.41	71.63
Mean Precipitation in the Wettest Month	1.23	0.79	72.86
Standard Deviation of Minimum Temperature in October	1.23	0.99	74.09
Standard Deviation of Precipitation in April	1.13	0.46	75.22
Standard Deviation of Precipitation in September	1.11	0.66	76.34
Mean Gross Primary Productivity	1.03	0.50	77.37
Mean Summer Precipitation	1.00	0.52	78.37
% Mixed Forest - Deciduous-dominated	0.99	0.70	79.36
Standard Deviation of Minimum Temperature in December	0.94	0.58	80.30

Ruddy Duck abundance was related to amounts of open water, cropland-woodland, cropland, and to water body density. The landcover covariates appear to identify the prairie-parkland region where the species occurs in greatest abundance. A relationship with water body density may reflect an association of this species with potholes, while a relationship with amount of open water may relate to the species’ preferences for permanent and semi-permanent wetlands rather than shallow, seasonal ones (Brua 2002, Johnsgard 2010).

Scaup species – over-water nesting diving



Our models predicted high scaup abundances in the northwestern prairie-parkland region, and in northwestern Canada. Since Lesser and Greater Scaup are not differentiated within the survey, these predicted densities represent a combination of both species. The relative contribution of each species at a given location is not known with any precision, but the Greater Scaup's range is reportedly more northerly than that of the Lesser

Scaup (Johnsgard 2010). Both species reportedly use the western boreal forest, but the Lesser Scaup's range extends further south into the prairie-parkland while the Greater Scaup extends north to the treeline and also into eastern Canada (Johnsgard 2010). Our predicted densities are consistent with these published maps, with slight overpredictions in the northeastern boreal.

Variable	Mean %	SD	Cumulative %
% Open Water (HWL)	10.59	1.42	10.59
Standard Deviation of Growing Season Length	5.43	1.35	16.02
Standard Deviation of Minimum Temperature in October	5.24	2.30	21.26
Density of Waterbodies (neighbourhood metric)	3.72	1.00	24.98
Mean Winter Precipitation	3.17	0.96	28.15
Mean Autumn Precipitation	3.07	0.78	31.22
Mean Climate Moisture Index	2.80	0.64	34.02
Topographic Ruggedness	2.78	0.72	36.80
Precipitation Seasonality	2.78	0.85	39.57
Mean Autumn Maximum Temperature	2.50	1.47	42.07
Amount of Shoreline (km/km^2)	2.30	0.78	44.37
Standard Deviation of Minimum Temperature in September	2.30	0.91	46.67
Standard Deviation of Maximum Temperature in April	2.09	0.65	48.76
Standard Deviation of Maximum Temperature in January	2.06	0.69	50.82
% Deciduous Forest	1.85	0.56	52.68
Mean Winter Minimum Temperature	1.73	1.03	54.40
% Cropland-woodland	1.56	0.47	55.96
Mean Gross Primary Productivity	1.45	0.53	57.41
Standard Deviation of Maximum Temperature in November	1.36	0.66	58.78
Standard Deviation of Minimum Temperature in April	1.36	0.67	60.14
Amount of Streams (km/km^2)	1.35	0.48	61.48
Standard Deviation of Precipitation in January	1.34	0.32	62.82
Standard Deviation of Precipitation in April	1.34	0.82	64.16
Mean Summer Precipitation	1.28	0.53	65.44
Standard Deviation of Maximum Temperature in March	1.20	0.27	66.65
Mean Spring Precipitation	1.17	0.84	67.82
Standard Deviation of Precipitation in October	1.15	0.60	68.98
Standard Deviation of Precipitation in September	1.13	0.40	70.11
Standard Deviation of Minimum Temperature in May	1.11	0.51	71.22
Standard Deviation of Minimum Temperature in August	1.11	0.50	72.33
Standard Deviation of Maximum Temperature in September	1.09	0.42	73.42
Mean Shoreline Complexity (neighbourhood metric)	1.06	0.27	74.48
Standard Deviation of Maximum Temperature in December	1.03	0.25	75.51
Annual Range in Temperature	1.01	0.53	76.52
Mean Precipitation in the Wettest Month	0.96	0.58	77.47
Standard Deviation of Precipitation in March	0.92	0.41	78.40
Standard Deviation of Maximum Temperature in October	0.92	0.31	79.32
Standard Deviation of Precipitation in June	0.89	0.44	80.20

Scaup abundance was most closely associated with the amount of open water, followed by inter-annual variation in growing season length and minimum October temperature, and water body density. The relatively high importance of climate variables may be related to the high abundances in the far North; many of the species living in boreal regions tended to be more strongly associated with climatic than land cover variables. A relationship with both open water and water body density relates to the species' associations with water, and may capture the regional variation in the nature of open water habitats as between the southern and northern limits of the combined species ranges. Greater Scaup tend to prefer open, shallow wetlands in the tundra (Johnsgard 2010) while Lesser Scaup prefer prairie marshes, semipermanent wetlands, and partially wooded wetlands (Austin et al. 1998, Johnsgard 2010).

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