Projected Effects of Climate Change on Birds in Parks Canada Protected Areas

Background

Climate change is leading to changes in habitats, communities and plant and animal species' ranges. As environmental conditions in a particular place change, they become more suitable for some species and less suitable for others and even create the potential for local extirpation or new colonization (Figure 1). Birds are useful indicators of ecological change because they are highly mobile, generally conspicuous and respond to local conditions through movement into or out of areas based on resource conditions (Root et al. 2003, Mettke-Hofmann 2016). Birds also help form healthy ecosystems by playing critical roles in pollination, insect control, forest regeneration, seed dispersal, carrion scavenging and many other ecosystem services.

In 2019, Audubon used species distribution models to predict future ranges of 604 species based on climate and vegetation projections. In 2022, scientists from Parks Canada, Audubon, the Canadian Wildlife Service and Birds Canada published an analysis of projected changes in bird assemblages due to climate change within the Canadian National Park System (Gahbauer et al 2022). **This brief summarizes projected changes in climate and vegetation biome suitability by mid-century for 434 native bird species across 49 national parks, national marine conversation areas, and a national urban park in Canada (hereafter 'parks') under IPCC's high emissions trajectory (RCP8.5) to mid-century (2050s), representing a 2°C mean rise in temperatures worldwide.**

The Canada Jay is highly vulnerable to climate change. It is projected to lose 71% of its current breeding range in Canada, with only a 22% projected gain. Canada Jay. Photo: Mick Thompson (CC BY-NC 2.0)

Important Note to Readers

This brief focuses exclusively on bird responses to future climate and vegetation projections, but projected changes in suitability are not definitive predictions of future species ranges or abundances. Numerous other factors affect where species occur, including habitat quality, adaptability, interspecific interactions, and food abundance (see Caveats). Therefore, managers should consider out projections as "potential changes" resulting from combinations of important environmental and social influences

Methods

This analysis was based on the system (c. 2018) of 49 parks spanning all provinces and territories in Canada that fell within the northern limits of the developed species models. The parks spanned 42 and 76°N latitude and 140 and 54°W longitude and represent 9 ecological regions defined under the National Ecological Framework for Canada: Arctic (7 parks); Atlantic Maritime (7 parks); Boreal (11 parks); Hudson Plain (1 park); Mixedwood Plains (5 parks); Mountain (7 parks); Pacific Maritime (3 parks); Prairie (2 parks); Taiga (6 parks).

These results draw on a large-scale assessment of climate change vulnerability of 604 North American birds at a continental scale across both summer and winter (Bateman et al. 2020) and the subsequent Parks Canada-focused assessment (Gahbauer et al. 2022) based on a similar assessment made for the U.S. National Wildlife Refuge System (Wu et al. 2022). The researchers removed 14 exotic species from this analysis for a final set of 590 native bird species. The modelling effort involved building species distribution models based on more than 140 million records from 70+ avian datasets across Canada, the United States, and Mexico (Bateman et al. 2020). The researchers used the climate data that corresponds to the IPCC AR5 report (AdaptWest Project 2015). In addition to nine climate variables that are pertinent to species distributions, the researchers included vegetation projections (Rehfeldt 2012), terrain ruggedness (Riley et al. 1999), and anthropogenic land cover projections (CCRS et al. 2013). The researchers also grouped all species into habitat groups and applied ecologically relevant land-use covariates, such as surface water for waterbirds and marshbirds (Pekel et al. 2016), and distance to coast for coastal birds (Wessel and Smith 1996). The researchers used advanced modeling techniques that are well-regarded in the literature for accuracy and their ability to model non-linear species-habitat relationships (Elith 2009).

The researchers modelled the associated environmental conditions for each species and assessed change in suitability of those conditions in the coming decades (Bateman et al. 2020). In this brief, results were summarized under IPCC's high emissions trajectory (RCP8.5) for mid-century (2050s), representing a 2°C mean rise in temperatures worldwide. All the results reported are to mid-century except for one comparison of the amount of anticipated change from the 2020s through the 2080s.

The researchers determined how vulnerable a species is to climate change based on projected change across its overall North American range (Wilsey et al. 2019; Bateman et al. 2020). Vulnerability is a combination of how much of a species' range is lost (extirpation) under future climate and the ability of a species to cope with climate change through shifting or gaining range (colonization). Species of neutral or low vulnerability are considered not vulnerable, while species of moderate or high vulnerability are considered vulnerable to climate change.

For each species, each 1-km cell across North America was classified as having a climate trend that's either improving, stable, or worsening in suitability, or favoring potential extirpation or potential colonization when a species' modeled suitability crosses a species-specific minimum suitability threshold (Figure 1). The suitability trend of each species was determined as its most dominant trend, by area, within each park. For the national marine conservation areas, the researchers limited analyses to the islands and coastal components.

To improve accuracy of results, the researchers systematically had experts review species outputs by comparing species modeled as being present in each park compared to contemporary lists based on NatureCounts database and other avian survey records to generate species lists for birds currently at each park, then removed species that were transient, migrant, or accidental from the baseline projection to avoid overprediction (17% of modeled records).

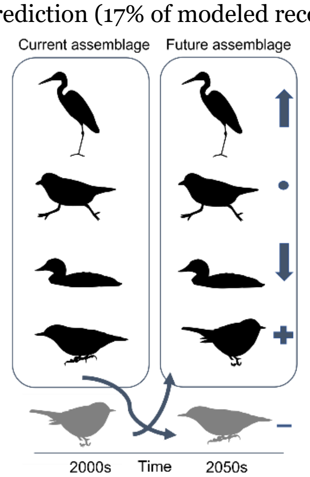

Figure 1. Example of potential changes in the bird assemblage at Prince Edward Island National Park by mid-century under 2°C of warming.

Potential colonizations were filtered to remove improbable colonization scenarios (3.2% of records) and retained all other colonization scenarios that comprised >1% of a park's area.

Using this approach, the researchers generated a species list for the present and future time periods at each park, assuming that climate conditions becoming suitable or unsuitable would translate into potential colonization or extirpation. The researchers treated parks as the unit of analysis, in some cases grouping parks into regions or analyzing trends by latitude. To quantify potential species turnover, the researchers calculated the Sørensen similarity index within each park, along with the number of species within each park.

Arctic species like the Willow Ptarmigan will have to cope with drastically different climate and environmental conditions in the coming decades, or face losses to their current ranges. Willow Ptarmigan. Photo: [George C. Wood] ([CC BY-SA 2.0])

Results

Parks, in general, are projected to see a net loss of species in summer and net gain of species in winter. Across the 49 parks in summer, an average of 36.4 species per park may be gained, whereas 50.2 species may be lost (gain to loss ratio = 0.7:1). In winter, parks are projected to gain an average of 34.6 species per park and lose an average of 7.1 species (gain to loss ratio = 4.9:1). Vulnerability of birds to climate change is generally lower in winter as conditions become milder across much of North America (Figure 2).

Birds are not equally affected; waterbird, boreal forest, western forest, and eastern forest habitat groups have the most species vulnerable to climate change (Figure 2). Notably, all arctic and boreal forest species analyzed (except for Black-capped chickadee, Alder Flycatcher, American Redstart, Northern Waterthrush, Purple Finch, Ruffed Grouse, and Northern Hawk Owl) are vulnerable to climate change in summer as many of them (89%) may be pushed out of potential habitat if they are unable to adapt. Despite lower vulnerability in winter, at least 20% of species in six (boreal and western forests, coastal, arctic, grasslands, and aridlands) ofnthe 11 habitat groups are vulnerable to climate change.

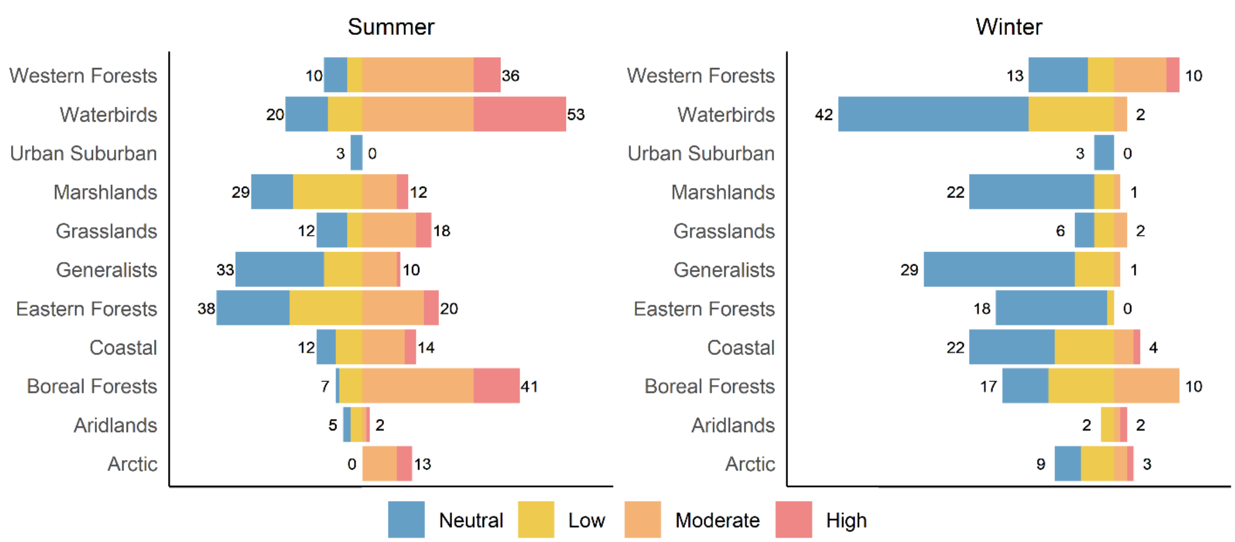

Figure 2. Number of species by their vulnerability to climate change in each habitat group across the 49 parks. The species in each group are ones currently present at parks, though vulnerability is assessed across the species' full North American range to better account for range-wide changes. Red

and orange indicate number of species vulnerable (high and moderate), and yellow and blue indicate number of non-vulnerable (low and neutral) species.

Across the 49 parks, the cumulative impact of potential colonizations and extirpations, if realized, would be a 25% change, on average, in summer bird assemblage between today and mid-century. The average species turnover rate in winter is 30%. These findings are based on an index of potential species turnover (i.e., the proportions of potential extirpations and potential colonizations by 2050, relative to today under a 2°C warming scenario) calculated for each park (Figure 3)

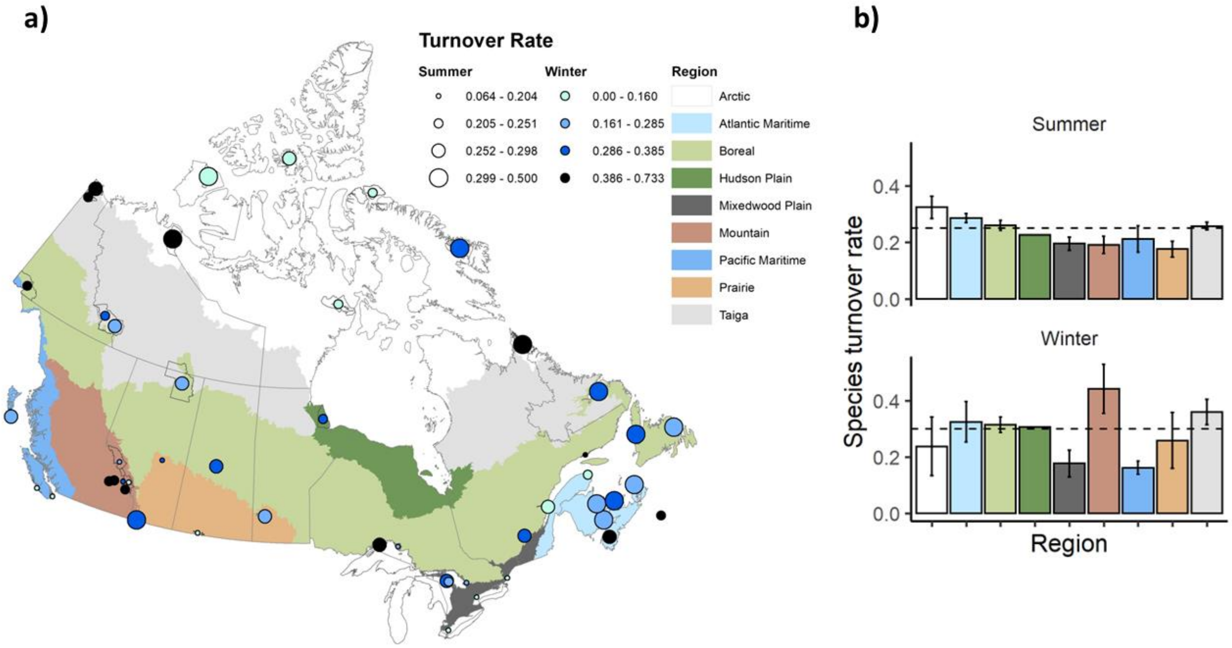

Figure 3. a) Projected Sørensen species turnover rates from the 2000s to 2050s for each of the 49 parks across the nine Canadian ecoregions. These are potential turnover rates if all projected extirpations and colonizations are realized, with 0 being no change and 1 being complete turnover in bird assemblage. Circle sizes represent turnover ranges in summer, and colours represent ranges in winter. b) Mean and standard error of the mean of turnover index by ecoregion. The dotted lines show the mean turnover index across ecoregions in both summer (0.25 ± SE 0.005) and winter (0.30 ± 0.006).

Over half of the bird species across parks are expected to experience changes in environmental suitability under a 2°C warming scenario (RCP8.5). Across seasons, 70% of species analyzed showed a change in climate suitability (i.e., potential extirpation, worsening, improving, or potential colonization trend). More species have positive trends (improving suitability or potential colonization) in winter (60% of species across parks) than summer (39%). Conversely, more species have negative trends (worsening suitability or potential extirpation) in summer (29%) than in winter (12%).

Under the RCP8.5 emissions scenario, the park system may no longer support some species it currently hosts by mid-century. In summer, Cassin's Finch, Harris' s Sparrow, Henslow's Sparrow, McCown's Longspur, Mountain Chickadee, Prairie Falcon, Ross's Goose, Smith's Longspur, Stilt Sandpiper, and Whooping Crane are some species that are projected to be completely absent from the park system by mid-century. In winter, some of those species that are predicted to be lost in the park system include Gray-crowned Rosy-Finch and Mountain Chickadee (impacted in both seasons). **Some species currently at parks only in summer may overwinter at those sites as winter conditions become suitable.** An average of 4 bird species per park (8% of the average number of current summer species) may stay to overwinter across the parks, ranging from no overwintering additions at 6 parks to 12 potential overwintering additions at Kejimkujik National Park. The birds that may become year-round residents at the largest number of parks include Brown-headed Cowbird, Canada Goose, Cooper's Hawk, Great Blue Heron, Killdeer, Mallard, and Wild Turkey.

Arctic, mountainous, and coastal regions are expected to see more colonizing species than other ecoregions, while parks in the Boreal region are expected to see greater species extirpations under climate change (scenario RCP8.5) (Figure 4). As a result, parks in the Arctic and Atlantic Maritime regions have the highest species turnover in summer, while parks in the Taiga and Mountain regions have higher turnover rates in winter (Fig 3 b). For Arctic parks, this may be due to warmer and milder winters, allowing species to reside year-round. Additionally, climatic consequences such as decreased ice cover and thawing are resulting in changes in vegetation and resulting new habitat for bird species. Higher elevations and micro-refugia from the complex terrain in mountainous parks and mild temperatures in coastal parks may provide refugia for climate refugees. Protected areas particularly in these regions will be more important for birds and other organisms in the coming decades as they may see more species colonizing.

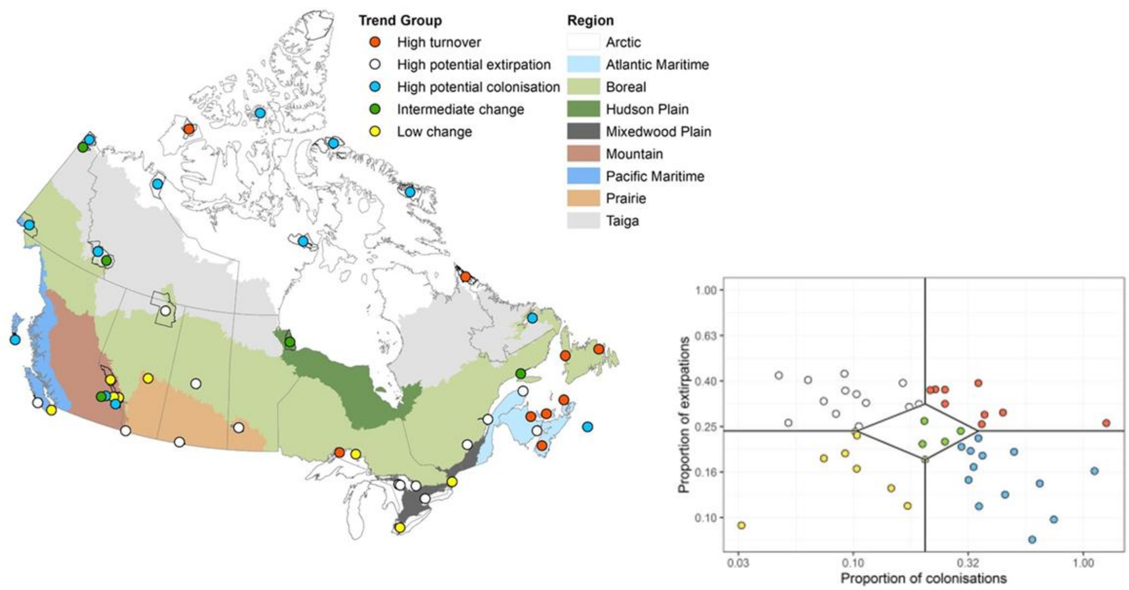

Figure 4. Classification of parks into trend groups based on the proportion of potential colonizations and extirpations. Each circle represents a park. Solid vertical and horizontal lines in the plot mark the median proportion of colonizations and extirpations across parks under the high-emissions trajectory in summer, used to classify parks into all trend groups except intermediate change. The boundaries of the intermediate change group, represented by the diamond in the center of the plot, are delimited by the upper and lower quartiles of each axis.

For several ecoregions, the most dominant species group in a region changes between the 2010s and 2050s. Turnover in bird species is expected to change the largest habitat group by area in most ecoregions. In summer, the largest group across Atlantic Maritime parks currently is boreal forest species, but by mid-century, eastern forest species are projected to be the most dominant group. The largest group across Hudson Plain parks is currently waterbird species, projected to be outnumbered by boreal forest species. The largest groups across Mixedwood Plains and Pacific Maritime parks currently are eastern forest species and western forest species (accordingly), but by mid-century, generalist species are projected to be a competitive dominant group in both regions. Similarly, the largest groups across Prairie parks are currently shared between generalist, grassland, and marshland species. By mid-century, only generalist species are projected to be the most dominant group. This change in species guilds can be indicative of large-scale ecological changes, with generalist species having the greatest ability to adapt to these changes.

Over much of Canada, Great Blue Herons migrate south after breeding. In a changing climate, winter conditions will become increasingly suitable for this bird, and they are projected to overwinter in many Canadian National Parks. Great Blue Heron. Photo: Mick Thompson (CC BY-NC 2.0)

Regional Results

Species Projections in the Arctic Ecoregion

Parks in this region include Aulavik National Park, Auyuittuq National Park, Sirmilik National Park, Torngat Mountains National Park, Tuktut Nogait National Park, Ukkusiksalik National Park, and Quasuittuq National Park.

In summer, 73% of 147 species that currently inhabit or may colonize the parks across the region are climate-vulnerable. In winter, 28% of 46 species that inhabit or may colonize the region are climate-vulnerable. Species with high climate vulnerability and substantial potential loss in their summer ranges across parks in the region are King Eider, Snowy Owl, and Pectoral Sandpiper.

King Eider. Photo: Mick Thompson (CC BY-NC 2.0)

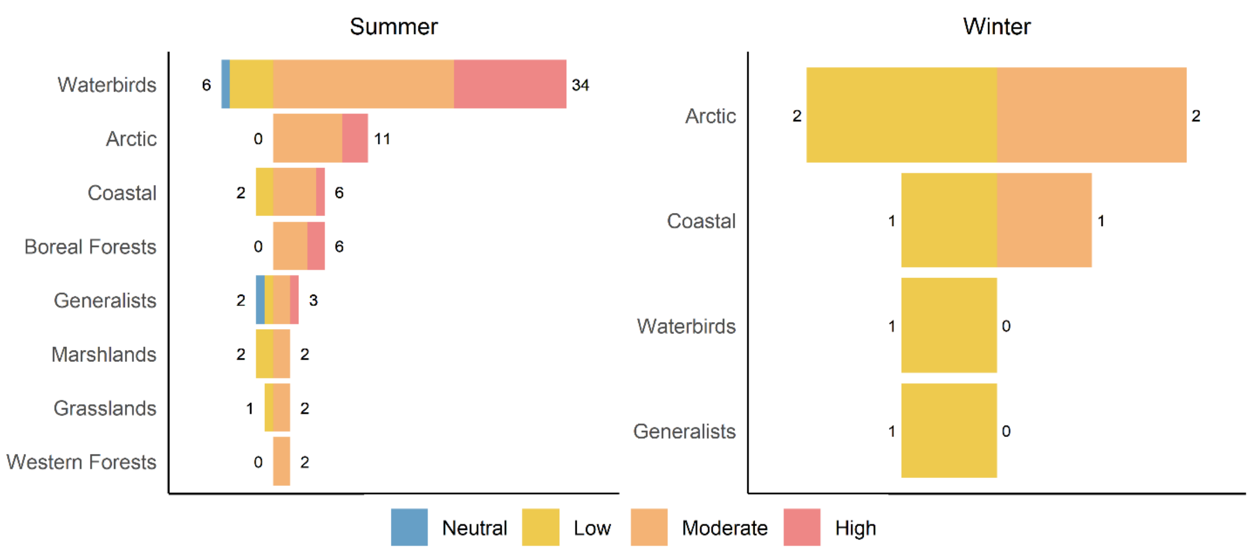

Figure 5. Number of species by their vulnerability to climate change in each habitat group across parks in the region. The species in each group are ones currently present at parks, though vulnerability is assessed across the species' full North American range to better account for range-wide changes. Red and orange indicate number of species vulnerable (high and moderate), and yellow and blue indicate number of non-vulnerable (low and neutral) species.

Species Projections in the Atlantic Maritime Ecoregion

Parks in this region include Cape Breton Highlands National Park, Forillon National Park, Fundy National Park, Kejimkujik National Park, Kouchibouguac National Park, Prince Edward Island National Park, and Sable Island National Park Reserve.

In summer, 44% of 205 species that currently inhabit or may colonize the parks across the region are climate-vulnerable. In winter, 9% of 167 species that inhabit or may colonize the region are climate-vulnerable. In their summer ranges, vulnerable species with high projected loss across parks in the region include Hermit Thrush (expected to be lost across 92% of the total park area in this region), Least Flycatcher, and Ruby-crowned Kinglet. Climate-vulnerable species with substantial potential loss in their winter ranges across parks in the region are Boreal Chickadee and Spruce Grouse.

Spruce Grouse. Photo: [Peter Pearsall/U.S. Fish & Wildlife Service] ([Public Domain Mark 1.0])

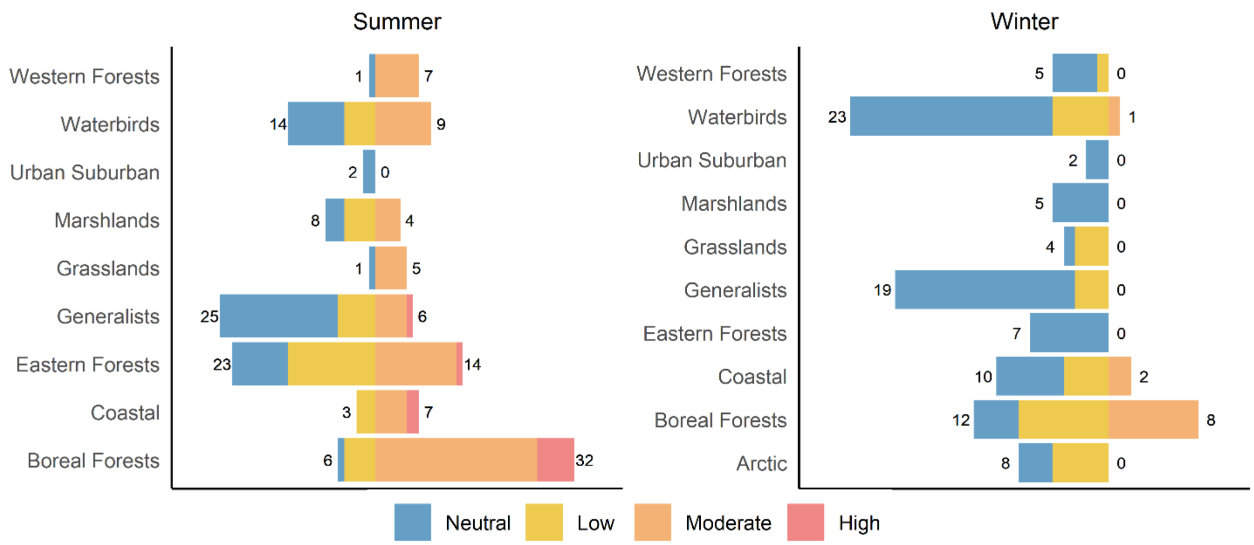

Figure 6. Number of species by their vulnerability to climate change in each habitat group across parks in the region. The species in each group are ones currently present at parks, though vulnerability is assessed across the species' full North American range to better account for range-wide changes. Red and orange indicate number of species vulnerable (high and moderate), and yellow and blue indicate number of non-vulnerable (low and neutral) species.

Species Projections in the Boreal Ecoregion

Parks in this region include Georgian Bay Islands National Park, Gros Morne National Park, Kluane National Park and Reserve, La Mauricie National Park, Mingan Archipelago National Park Reserve, Prince Albert National Park, Pukaskwa National Park, Riding Mountain National Park, Saguenay-St. Lawrence Marine Park, Terra Nova National Park, and Lake Superior National Marine Conservation Area.

In summer, 54% of 307 species that currently inhabit or may colonize the parks across the region are climate-vulnerable. In winter, 13% of 156 species that inhabit or may colonize the region are climate-vulnerable. In summer, vulnerable species projected to lose nearly half their range across parks in the region include Boreal Chickadee, Lincoln's Sparrow, Canada Jay, and Philadelphia Vireo. Canada Jay and Boreal Chickadee area also expected to lose half their winter range in this region, in addition to Boreal Owl, Spruce Grouse and Black-backed Woodpecker.

Boreal Owl. Photo: [Tim Rains/U.S. National Park Service](#) ([CC BY 2.0](#))

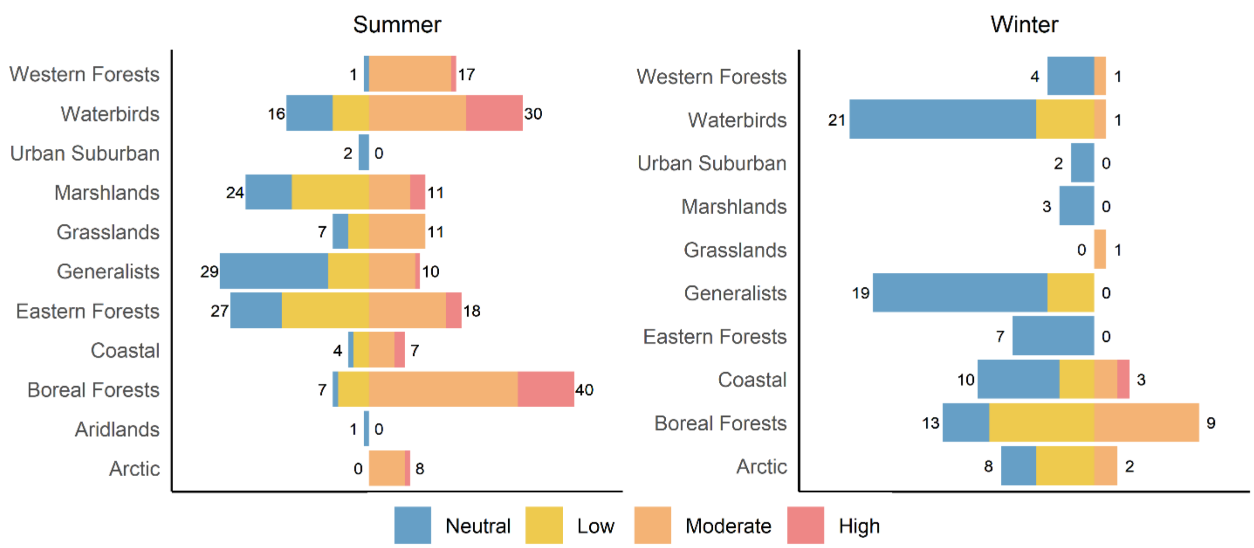

Figure 7. Number of species by their vulnerability to climate change in each habitat group across parks in the region. The species in each group are ones currently present at parks, though vulnerability is assessed across the species' full North American range to better account for range-wide changes. Red and orange indicate number of species vulnerable (high and moderate), and yellow and blue indicate number of non-vulnerable (low and neutral) species.

Species Projections in the Hudson Plain Ecoregion

Parks in this region include Wapusk National Park.

In summer, 68% of 145 species that currently inhabit or may colonize the parks across the region are climate-vulnerable. In winter, 32% of 31 species that inhabit or may colonize the region are climate-vulnerable. In their summer ranges, American Tree Sparrow, Dunlin, Arctic Tern, and Common Redpoll are climate-vulnerable species that are all expected to be lost across greater than 90% of park area in this region.

Common Redpoll. Photo: Mick Thompson (CC BY-NC 2.0)

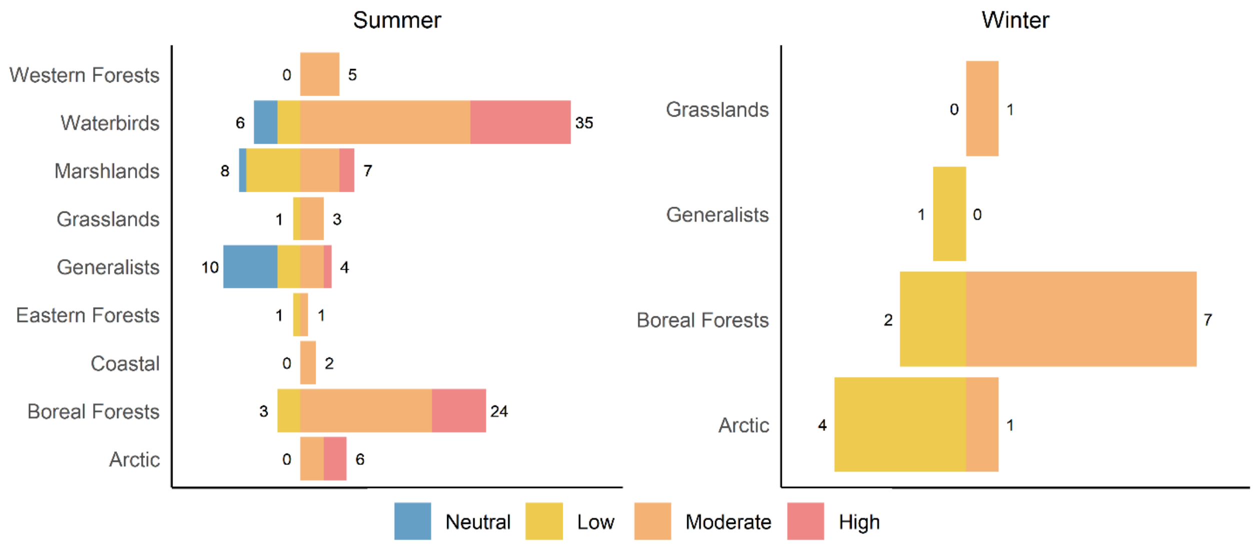

Figure 8. Number of species by their vulnerability to climate change in each habitat group across parks in the region. The species in each group are ones currently present at parks, though vulnerability is assessed across the species' full North American range to better account for range-wide changes. Red and orange indicate number of species vulnerable (high and moderate), and yellow and blue indicate number of non-vulnerable (low and neutral) species.

Species Projections in the Mixedwood Plains Ecoregion

Parks in this region include Bruce Peninsula National Park, Fathom Five National Marine Park, Point Pelee National Park, Thousand Islands National Park, and Rouge National Urban Park.

In summer, 34% of 190 species that currently inhabit or may colonize the parks across the region are climate-vulnerable. In winter, 3% of 144 species that inhabit or may colonize the region are climate-vulnerable. In their summer ranges, vulnerable species with high projected loss across parks in the region include Eastern Whip-poor-will and Pine Warbler (expected to be lost across greater than 90% of park area in this region). In winter, vulnerable species with high projected loss across the region include Bohemian Waxwing and Red Crossbill.

Pine Warbler. Photo: [N. Lewis/U.S National Park Service](#) [(Public Domain Mark 1.0)](#)

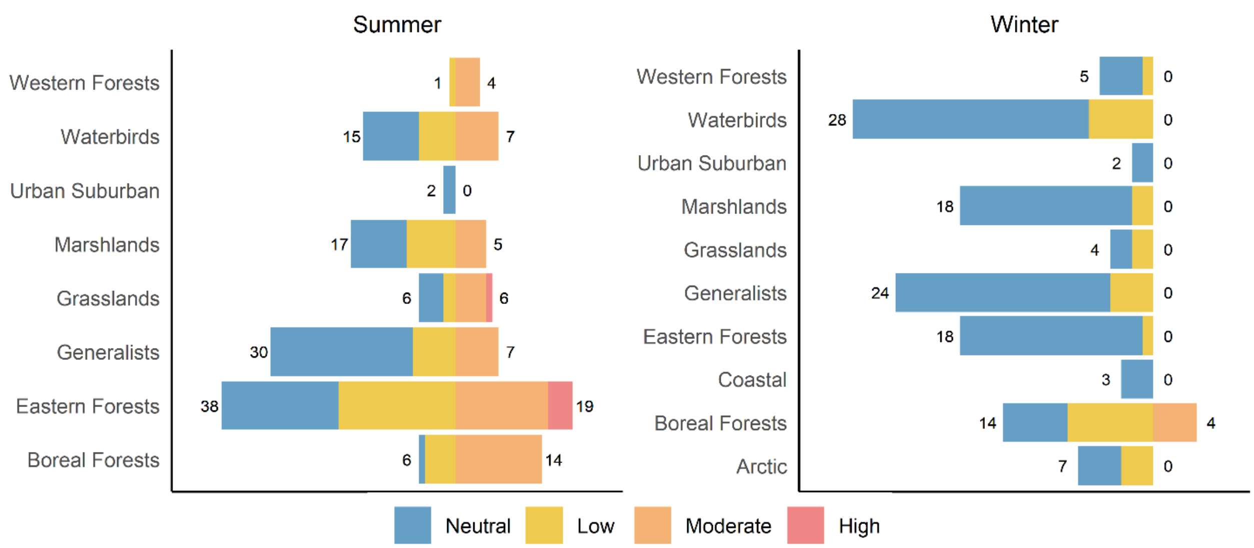

Figure 9. Number of species by their vulnerability to climate change in each habitat group across parks in the region. The species in each group are ones currently present at parks, though vulnerability is assessed across the species' full North American range to better account for range-wide changes. Red and orange indicate number of species vulnerable (high and moderate), and yellow and blue indicate number of non-vulnerable (low and neutral) species.

Species Projections in the Mountain Ecoregion

Parks in this region include Banff National Park, Glacier National Park, Jasper National Park, Kootenay National Park, Mount Revelstoke National Park, Waterton Lakes National Park, and Yoho National Park.

In summer, 52% of 239 species that currently inhabit or may colonize the parks across the region are climate-vulnerable. In winter, 19% of 117 species that inhabit or may colonize the region are climate-vulnerable. In their summer ranges, vulnerable species with projected losses across half the park area in the region include Lesser Scaup, Solitary Sandpiper, and Red-naped Sapsucker. In winter, vulnerable species with high projected loss across the region include Mountain Chickadee and Gray-crowned Rosy-Finch (greater than 50% of park area in this region).

Lesser Scaup.

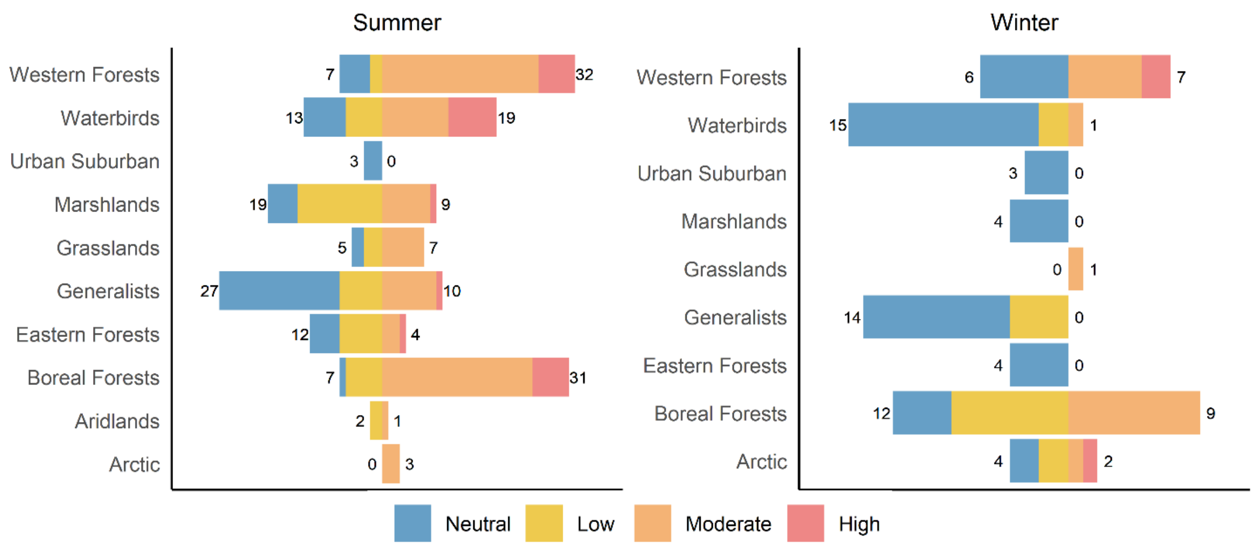

Figure 10. Number of species by their vulnerability to climate change in each habitat group across parks in the region. The species in each group are ones currently present at parks, though vulnerability is assessed across the species' full North American range to better account for range-wide changes. Red and orange indicate number of species vulnerable (high and moderate), and yellow and blue indicate number of non-vulnerable (low and neutral) species.

Species Projections in the Pacific Maritime Ecoregion

Parks in this region include Gulf Islands National Park Reserve, Gwaii Haanas National Park Reserve, National Marine Conservation Area Reserve, and Haida Heritage Site, and Pacific Rim National Park Reserve.

In summer, 44% of 163 species that currently inhabit or may colonize the parks across the region are climate-vulnerable. In winter, 11% of 189 species that inhabit or may colonize the region are climate-vulnerable. Species with high climate vulnerability and greatest potential loss in summer include Red-breasted Sapsucker (across nearly 70% of park area in this region), while in winter, Barrow's Goldeneye is expected to be lost across nearly 20% of park area in this region.

Red-breasted Sapsucker. Photo: [Mick Thompson] ([CC BY-NC 2.0])

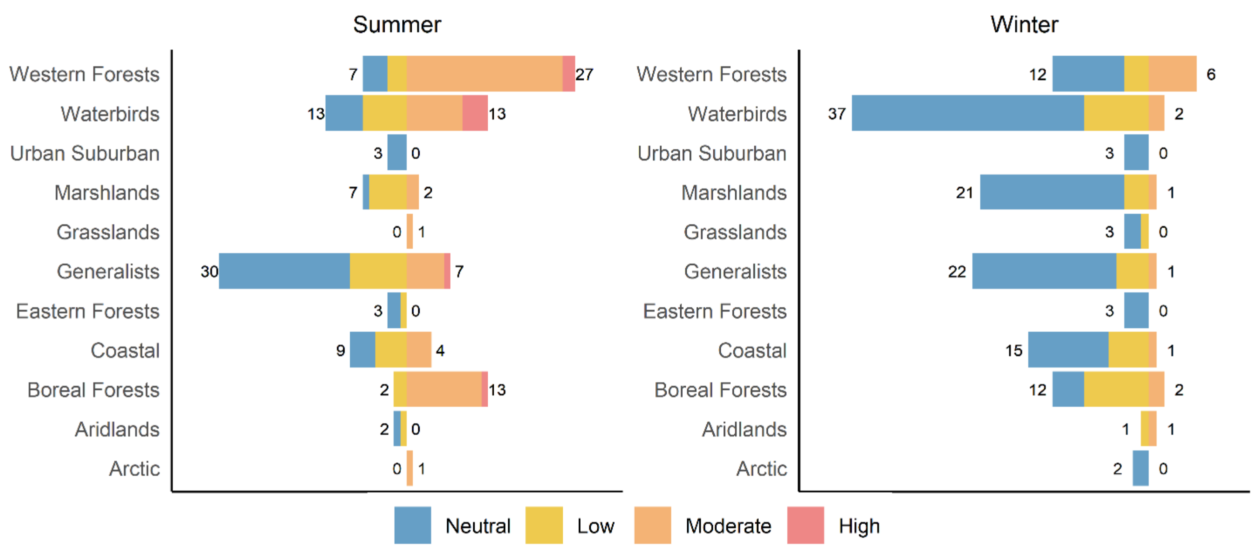

Figure 11. Number of species by their vulnerability to climate change in each habitat group across parks in the region. The species in each group are ones currently present at parks, though vulnerability is assessed across the species' full North American range to better account for range-wide changes. Red and orange indicate number of species vulnerable (high and moderate), and yellow and blue indicate number of non-vulnerable (low and neutral) species.

Species Projections in the Prairie Ecoregion

Parks in this region include Elk Island National Park and Grasslands National Park.

In summer, 43% of 183 species that currently inhabit or may colonize the parks across the region are climate-vulnerable. In winter, 9% of 74 species that inhabit or may colonize the region are climate-vulnerable. In their summer ranges, 15 vulnerable species have high projected loss, greater than 50% of total park area in the region, with those at most risk including Least Flycatcher, Clay-colored Sparrow, Baird's Sparrow, Savannah Sparrow, and Wilson's Snipe. Boreal Chickadee and Boreal Owl are vulnerable species with the highest projected loss in their winter ranges within Prairie parks (~20% of park area in this region).

Savannah Sparrow. Photo: [Mick Thompson](#) ([CC BY-NC 2.0](#))

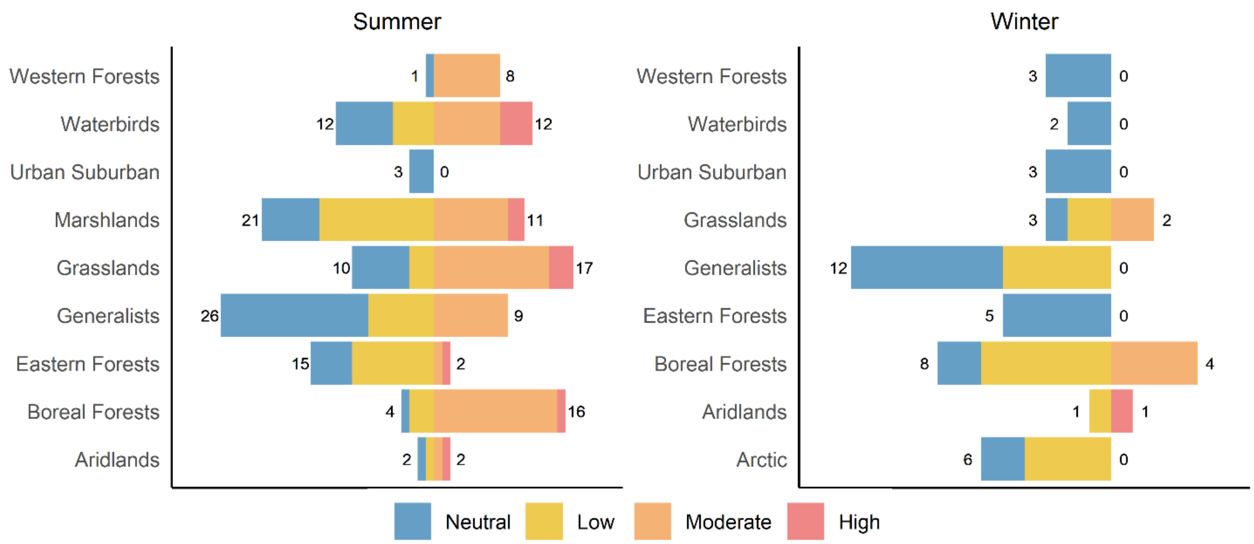

Figure 12. Number of species by their vulnerability to climate change in each habitat group across parks in the region. The species in each group are ones currently present at parks, though vulnerability is assessed across the species' full North American range to better account for range-wide changes. Red and orange indicate number of species vulnerable (high and moderate), and yellow and blue indicate number of non-vulnerable (low and neutral) species.

Species Projections in the Taiga Ecoregion

Parks in this region include Ivvavik National Park, Nahanni National Park Reserve, Vuntut National Park, Wood Buffalo National Park, Akami–Uapishku-KakKasuak-Mealy Mountains National Park Reserve, and Nááts'ihch'oh National Park Reserve.

In summer, 63% of 261 species that currently inhabit or may colonize the parks across the region are climate-vulnerable. In winter, 21% of 84 species that inhabit or may colonize the region are climate-vulnerable. In their summer ranges, vulnerable species with high projected loss across parks in the region include Lesser Yellowlegs and White-winged Scoter. In winter, vulnerable species with the highest projected loss across the region include Willow Ptarmigan and American Three-toed Woodpecker (~20% of park area in this region).

Lesser Yellowlegs. Photo: U.S. Fish & Wildlife Service (Public Domain Mark 1.0)

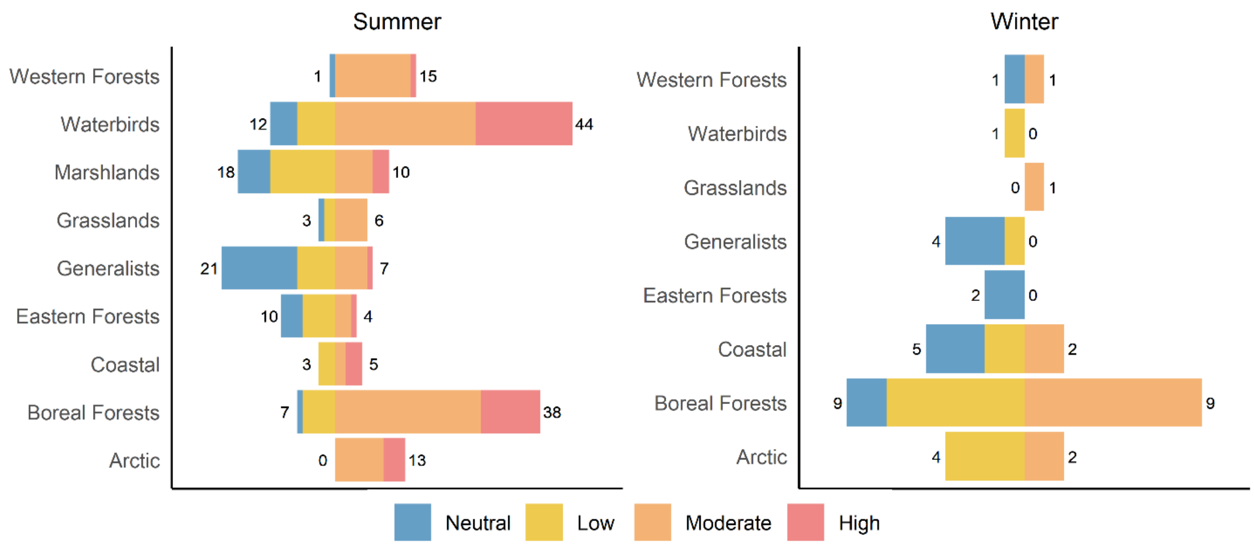

Figure 13. Number of species by their vulnerability to climate change in each habitat group across parks in the region. The species in each group are ones currently present at parks, though vulnerability is assessed across the species' full North American range to better account for range-wide changes. Red and orange indicate number of species vulnerable (high and moderate), and yellow and blue indicate number of non-vulnerable (low and neutral) species.

Considerations for Park Managers and Management Partners

Parks differ in rates of birds colonizing or becoming extirpated in a changing climate, and therefore different climate change adaptation strategies may apply. **Understanding projected trends across parks can inform decision-making for active management at individual sites, with outcomes that can extend to the larger Canadian park system.** Parks were classified into trend groups based on their proportions of potential colonizations and extirpations under the high-emissions trajectory in summer (Figure 4).

Parks that fall in the low and intermediate change groups can best support landscape-scale bird conservation by emphasizing habitat restoration, maintaining natural disturbance regimes, and reducing other stressors. Parks within one of the three high change groups (high turnover, high potential colonization, or high potential extirpation) can focus on actions that increase species' ability to respond to environmental change, such as increasing the amount of potential habitat, working with Indigenous partners, collaborators, cooperating agencies and adjacent land managers to improve habitat connectivity for birds across boundaries, managing the disturbance regime (e.g., fire), and possibly more intensive management actions (e.g., intensive nest site management). Monitoring to identify changes in bird communities in relation to their habitats will inform selection of appropriate management responses.

Safeguarding the existing investment in conservation represented by the park system will require a forward-looking approach to natural resource management that explicitly recognizes the prospect of climate-driven ecological change beyond historical ranges of variability. Effective conservation in the face of climate change will require landscape-level thinking, including working with other protected and conservation areas, Indigenous partners, and land managers to encourage connectivity in the matrix and allow for species movement to more suitable environmental conditions. Such thinking would apply various conservation and restoration approaches and allow species to persist at current locations, or move to more suitable environs within the park system and adjacent areas.

Caveats

The species distribution models included in this study are based on climate variables and vegetation projections, which means there are limits on their interpretation. Significant changes in environmental suitability, as measured here, will not always result in a species response, and all projections should be interpreted as potential trends. Multiple other factors mediate responses to climate change, including resource availability, ecological processes that affect demography, biotic interactions that inhibit and facilitate species' colonization or extirpation, dispersal capacity, species' evolutionary adaptive capacity, and phenotypic plasticity (e.g., behavioral adjustments). Ultimately, models can tell us where to focus our concern and which species are most likely to be affected, but monitoring is needed to validate these projections and should inform any on-the-ground conservation action. Indeed, recent validation of climate change models by community scientists (see Audubon's Climate Watch Program) suggest birds track climate conditions (Saunders et al. 2020).

More Information

Survival by Degrees: 389 Species on the Brink was conducted by the National Audubon Society. All species model outputs for two future climate change scenarios (RCP 4.5 and RCP 8.5) for the 2020s (not presented here), 2050s (i.e. 1.5°C and 2.0°C scenarios), and 2080s (3.0°C scenario) are available for download here. For more information, the supporting studies, and details on the methods, please see the project website.

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