SURVIVAL BY DEGREES:

389 Bird Species on the Brink

Audubon

NATIONAL AUDUBON SOCIETY, 2019

Great Gray Owl

Audubon

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American Oystercatcher

Foreword

David O’Neill
Chief Conservation Officer
& Senior Advisor to the CEO

People and birds have shared a strong connection for millennia.

Birds are treasured guests in our backyards, heralding the changing of the seasons with their arrivals. They have inspired artists from cave painters at the dawn of civilization to award-winning poets like Maya Angelou. They are our national symbols, our mascots, our emblems of pride. Birds live easily among us as one of the most visible ambassadors of the natural world.

Our connection with birds is even deeper than that. When landscapes change, they are among the first to bear the consequences, and that has implications for the rest of us. We may not notice day to day if our average global temperature is rising, but we will notice that there are not as many American Goldfinches as there used to be, or that the American Robin, traditionally the harbinger of spring, is suddenly showing up in February. Birds actually are the “canaries in the coal mine,” giving us an indication that fundamental environmental changes are happening.

Five years ago, we looked into what birds were telling us about climate change, and what we found out was that more than half of the birds in North America would be at risk by century’s end. This year, our scientists once again surveyed the effects of climate change on America’s birds, this time with more sophisticated research tools and an expanded regional analysis that included Mexico as well as the United States and Canada.

Our findings in this report are the fifth alarm in a five-alarm fire. Still, there is reason for hope if we act now.

American Goldfinches

First, the news that should snap all of us to attention: More than two-thirds of America’s birds are at risk if the current pace of global warming continues. Birds we love are in peril, including the Saltmarsh Sparrow, which could lose 62% of its current winter range. Some species may be able to adapt, but others will be left with nowhere to go, and we risk losing them forever.

Audubon scientists have run models that show that an increase of even one degree Celsius could alter life on Earth as we know it. Not just for the birds, but for all living things that live in places that will see increased coastal flooding, like communities ringing the Gulf of Mexico. Stronger storms, like recent hurricanes, will occur more regularly along the Eastern Seaboard. Wildfires, like those that have ravaged California, will be even more prevalent in the West. Some areas will see extreme drought, others extreme rainfall.

While this all sounds dire, we have the power to take action right now to slow these trends. If we limit the rise of global temperatures to 1.5 degrees Celsius, we can lessen the threats to birds and the places we all need to thrive.

Audubon’s climate program is committed to doing everything in our power to achieve this goal by engaging and activating our network of 22 state offices, 465 chapters, and 1.7 million members, and by growing to be a voice for change. Our activist network and our climate experts are taking action in states to advance clean energy policies that reduce our reliance on fossil fuels. Our work in Washington, D.C., is expanding funds for innovation and new technologies that reduce carbon emissions and strengthen the economy. We are working with landowners and public agencies to support nature-based solutions like protecting and enhancing grasslands, wetlands, and forest ecosystems that are essential to birds and critical to meeting our climate goals. And we are working with our partners to define and advance comprehensive climate solutions at all levels of government. We have a window to act, but it is narrowing.

By investing in the habitats of birds, we are investing in our own futures. Our birds are telling us that **it’s time to act now**.

Audubon's Climate Science

In 2014, Audubon released the Birds and Climate Change Report. The report, which was based on original, peer-reviewed science, found that nearly half of all North American bird species are sensitive to climate change. Audubon set to work leveraging these findings to tap into people's passion for birds and create a greater demand for climate solutions at the local, state, national, and hemispheric levels through mitigation and adaptation. Climate change mitigation includes efforts to reduce or prevent the causes of climate change, such as greenhouse gas emissions. Climate change adaptation includes efforts to alter and adapt both our natural surroundings and our buildings, roads, and other structures to better withstand the threats posed by climate change.

Since 2014, Audubon has remained committed to science-based advocacy and conservation around the changing climate. Audubon partnered with BirdLife International to develop The Messengers, a summary of 68 case studies of what birds tell us about the threats of climate change and potential solutions for both nature and people. Audubon and BirdLife then joined forces with 12 BirdLife partner organizations to develop the Climate Action Plan for the Americas, whose original science projects how the ranges of more than 2,000 bird species will shift in response to a changing climate across Latin America and the Caribbean. Most recently, Audubon partnered with the U.S. National Park Service to produce a report called Birds and Climate Change in Our National Parks, which summarizes the potential impacts of climate change on the composition of bird communities in 274 national park system units. Meanwhile, Audubon has been working steadily to document how birds have already responded to climate change with Climate Watch, Audubon's community science program, which quantifies bird range shifts as they happen. Finally, Audubon has continued to update its own scientific understanding of the vulnerability of birds to climate change.

Survival by Degrees: 389 Bird Species on the Brink offers a fresh look at the vulnerability of birds across North America to climate change based on a new, updated scientific analysis that leverages big data and incorporates the unique biology of each bird to determine its vulnerability. Part 1 outlines the key findings of this new climate change vulnerability assessment for North American birds.

In Part 2 of the report, Audubon takes a closer look at how the threats associated with climate change will affect birds. This section summarizes the results of an in-depth threats assessment for the conterminous United States, where high-resolution threats data were available. We explored which species and places are most at risk to climate-driven changes in their environment, including sea level rise, urban and cropland conversion, and extreme weather.

Finally, Part 3 outlines Audubon's strategy for addressing the causes and consequences of climate change by translating scientific knowledge into action to protect birds and people from the threat of climate change.

PART 1:
Climate Change Vulnerability of North American Birds

Royal Terns

Background

Climate change is making the global species extinction crisis worse.[1] In North America, 37% of birds are already at a high risk of extinction,[2] and while historically birds are known to respond to climate change by shifting their ranges,[3] climate change is occurring 20 times faster today than it has during any historical period over the past 2 million years.[4] The unprecedented pace and magnitude of climate change make it an existential threat to birds, people, and the natural systems we depend on.

Birds are an ideal taxa for assessing vulnerability to climate change. Not only are they ubiquitous but there are millions of geolocated observations covering much of North America available to help us identify and understand the particular climates and habitats occupied by each bird species. These avian observations come from the growth of community science platforms, such as eBird; large online databases, such as the Global Biodiversity Information Facility (GBIF), the Avian Knowledge Network (AKN), and Biodiversity Information Serving Our Nation (BISON); long-term surveys, such as the North American Breeding Bird Survey (BBS); and scientific studies by a multitude of researchers. Moreover, birds, because of their relatively greater capacity to disperse and migrate, serve as a conservative baseline for other taxa facing the threats posed by climate change. It is likely that birds will fare better in a warming world than less mobile species.[5,6]

In this research,[7] we related bird observations for 604 species with climate and habitat conditions at the same locations to capture the unique composition of each species' suitable range. We did this by using machine learning algorithms common to big data analytics and data science. The collection of observations used in this study features more than 140 million bird records from more than 70 data sources. Machine learning models for each species related observations to current environmental conditions, including climate, vegetation type, land use, and topography. These present-day models captured the current range of environmental conditions inhabited by the species. We then mapped the expected future range of each species by substituting projected future climate and vegetation conditions as inputs to the models. We compared the projected current and future ranges to estimate the percent of projected range loss and gain under multiple future climate change scenarios. These projections were then used to assess the three components of climate change vulnerability identified by the International Union for the Conservation of Nature (IUCN): climate change exposure, sensitivity, and adaptive capacity (Fig. 1).

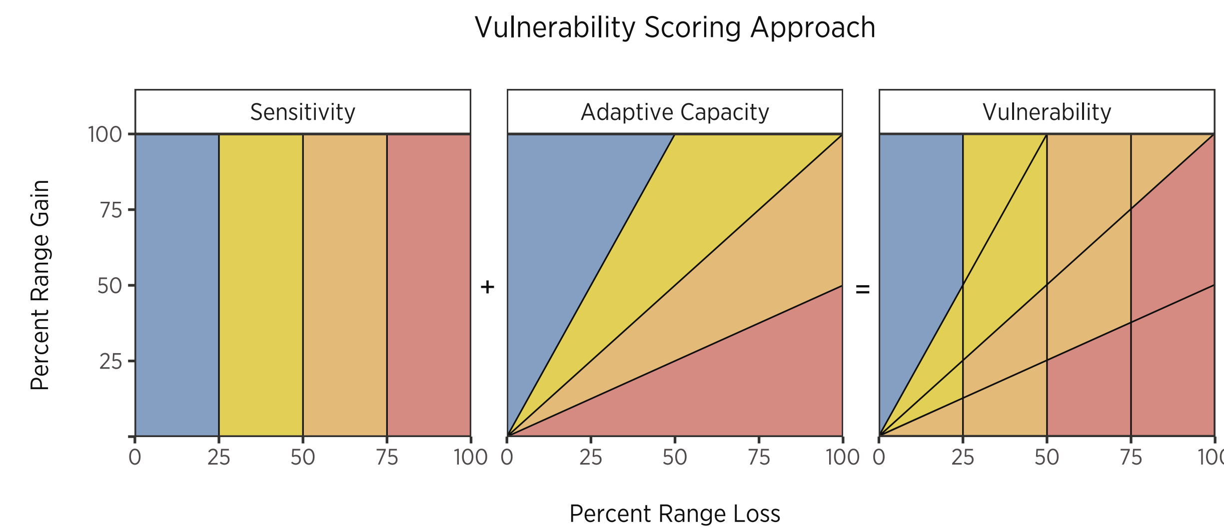


FIGURE 1 | Conceptual diagram for assessing climate change vulnerability as a function of climate change exposure, sensitivity, and adaptive capacity. Climate change exposure reflects the amount of warming (1.5°C, 2.0°C, and 3.0°C increases in global mean temperature, not shown in diagram). Climate sensitivity is the percent of projected current range loss. Adaptive capacity is the ratio of projected range gain to loss. Darker colors indicate higher vulnerability. Projected summer range gains are limited by a species' estimated dispersal capacity.

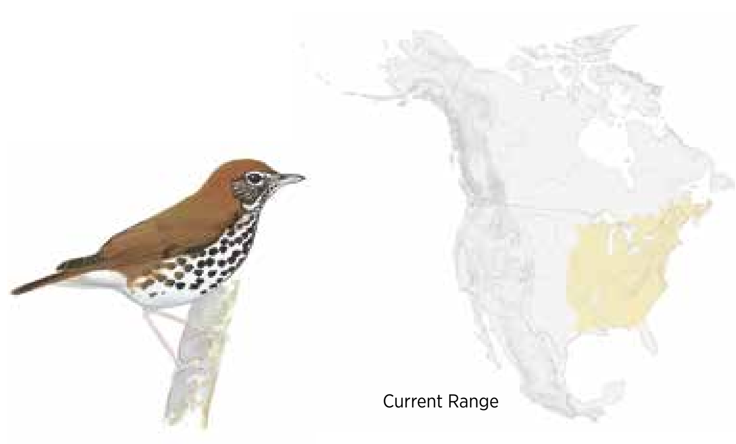
We built species models for the breeding and non-breeding seasons and assessed the species' vulnerability in each season separately. Breeding season range projections also incorporated the potential dispersal distance of each species as a way to realistically limit potential range expansion and thus more accurately assess a species' adaptive capacity. Each species was given a vulnerability score: neutral, low, moderate, or high. *Highly vulnerable species were those projected to experience the highest percent of current range loss with limited opportunity for future range gains.*

To understand how climate change mitigation could potentially reduce the vulnerability of birds to climate change, we assessed that vulnerability in the context of accepted future climate trajectories. The Intergovernmental Panel on Climate Change (IPCC) recommends limiting global mean temperature to less than 2.0°C (3.6°F) above pre-industrial levels, and, if possible, to 1.5°C (2.7°F).[8,9] Currently, we are on track to surpass this limit, with approximately 1.0°C (0.8-1.2°C, or 1.8°F) of warming having already occurred[9] and an expected temperature rise of at least 3.0°C (5.4°F) by 2100 under a conservative, business-as-usual trajectory.[35] Indeed, there is high confidence that we will reach 1.5°C of warming between 2030 and 2052,[9] regardless of mitigation strategy. The currently pledged reductions in greenhouse gas emissions outlined in the Paris Agreement framework (comprised of each country's Nationally Determined Contributions, or emissions-reductions commitments for the accord) would lead to at least a 3.2°C increase in global mean temperature.[10] In this report, we assess climate change vulnerability of birds in North America under three policy-relevant scenarios: increases in global mean temperature of 1.5°C, 2.0°C, and 3.0°C (2.7°F, 3.6°F, 5.4°F). These scenarios reflect current and potential climate change emissions-reduction targets and provide relevant context for national policies on climate change mitigation.

To address optimal adaptation strategies and determine where we should focus conservation actions to help species adapt to rapid change, we identified the places and species most vulnerable to climate change. We mapped regions projected to have increased potential colonization by new species, increased likelihood of local extirpation from range loss, and high net change in the number of species present in the future. All of these areas merit attention for climate change adaptation. Finally, we identified species most vulnerable to climate change regardless of the future scenario, then compared our lists of climate-vulnerable species to the Partners in Flight (PIF) Watch List for North American birds vulnerable to extinction. Species identified on both lists require immediate attention for climate change adaptation.

In summary, we assessed the vulnerability of 604 bird species to climate change under three scenarios, representing a 1.5°C, 2.0°C, and 3.0°C (2.7°F, 3.6°F, 5.4°F) increase in global mean temperature. This work is the most comprehensive model-based assessment of climate change vulnerability of birds in North America to date.

Climate change will affect the area of suitable climate and habitat for two birds found in unique habitats

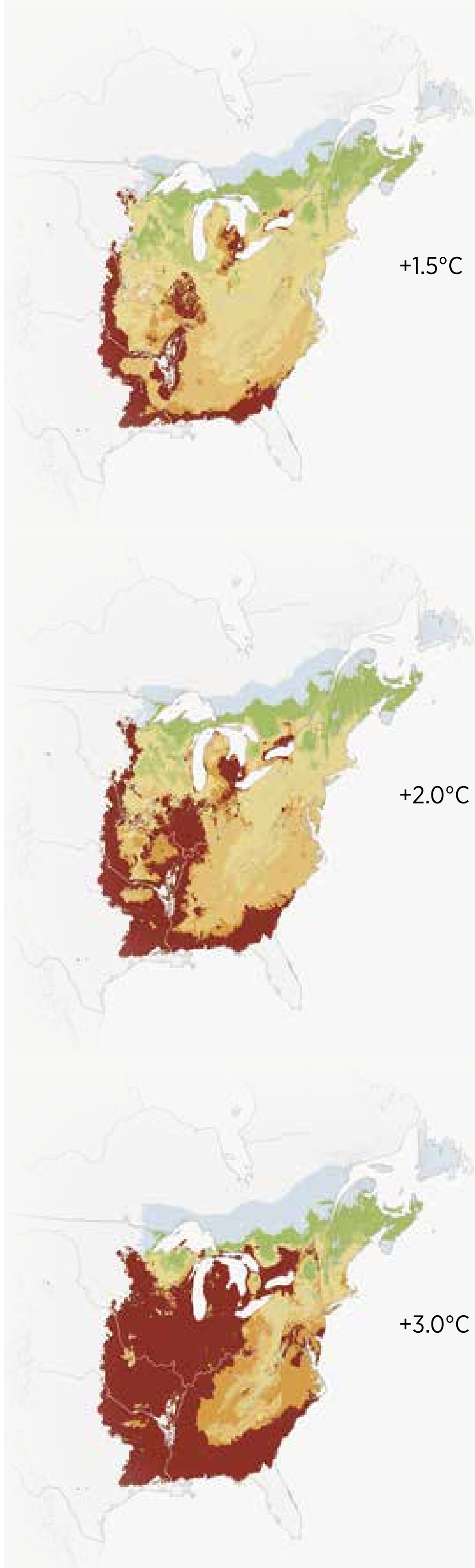


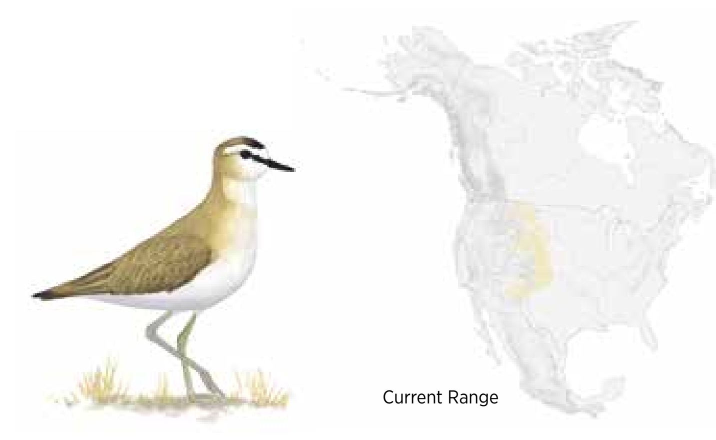
Wood Thrush

The Wood Thrush is a migrant that breeds primarily in the deciduous forests of the eastern United States and southeastern Canada. Under a 3.0°C (5.4°F) warming scenario, the Wood Thrush would be highly vulnerable to climate change in the breeding season, potentially losing 57% of its current range while potentially colonizing an area equal to only 20% of that range. Furthermore, the Wood Thrush may no longer breed in Florida, Louisiana, Nebraska, South Dakota, or Texas, where projected climate and habitat are no longer similar to where the Wood Thrush is found today. However, the Wood Thrush is a species we can help: Climate change vulnerability would be moderate under the 2.0°C (3.6°F) warming scenario and low under the 1.5°C (2.7°F) scenario.

- Range Gain
- Improving
- Slightly Improving
- Stable
- Slightly Worsening
- Worsening
- Range Loss

Conditions Within Stable Range (Improving through Worsening)



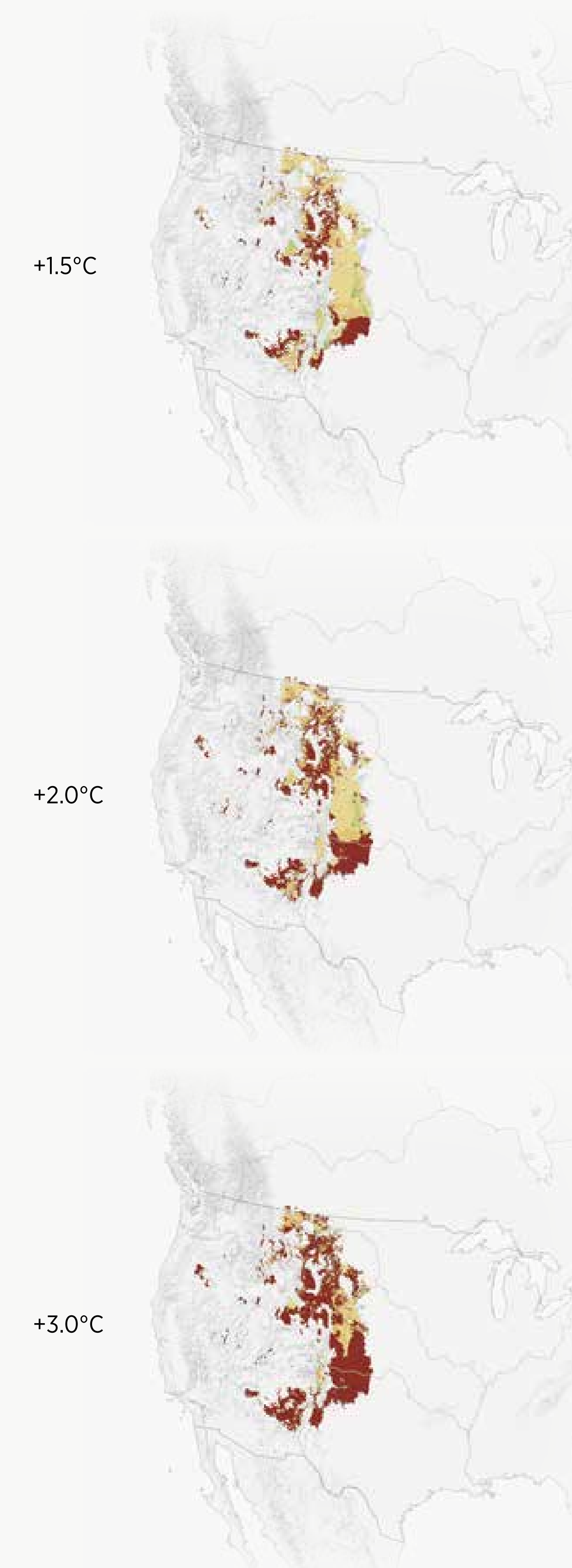


Mountain Plover

The Mountain Plover is a migrant that breeds in the short-grass prairie and arid plains in the western United States. Under a 3.0°C (5.4°F) warming scenario, the Mountain Plover would be highly vulnerable to climate change in the breeding season, potentially losing 76% of its current range while potentially colonizing an area equal to only 1% of that range. Furthermore, the Mountain Plover may no longer breed in Oklahoma or New Mexico, where projected climate and habitat are no longer similar to where the Mountain Plover is found today. Climate change vulnerability was moderate under the 2.0°C (3.6°F) and 1.5°C (2.7°F) warming scenarios.

- Range Gain
- Improving
- Slightly Improving
- Stable
- Slightly Worsening
- Worsening
- Range Loss

Conditions Within Stable Range (Improving through Worsening)

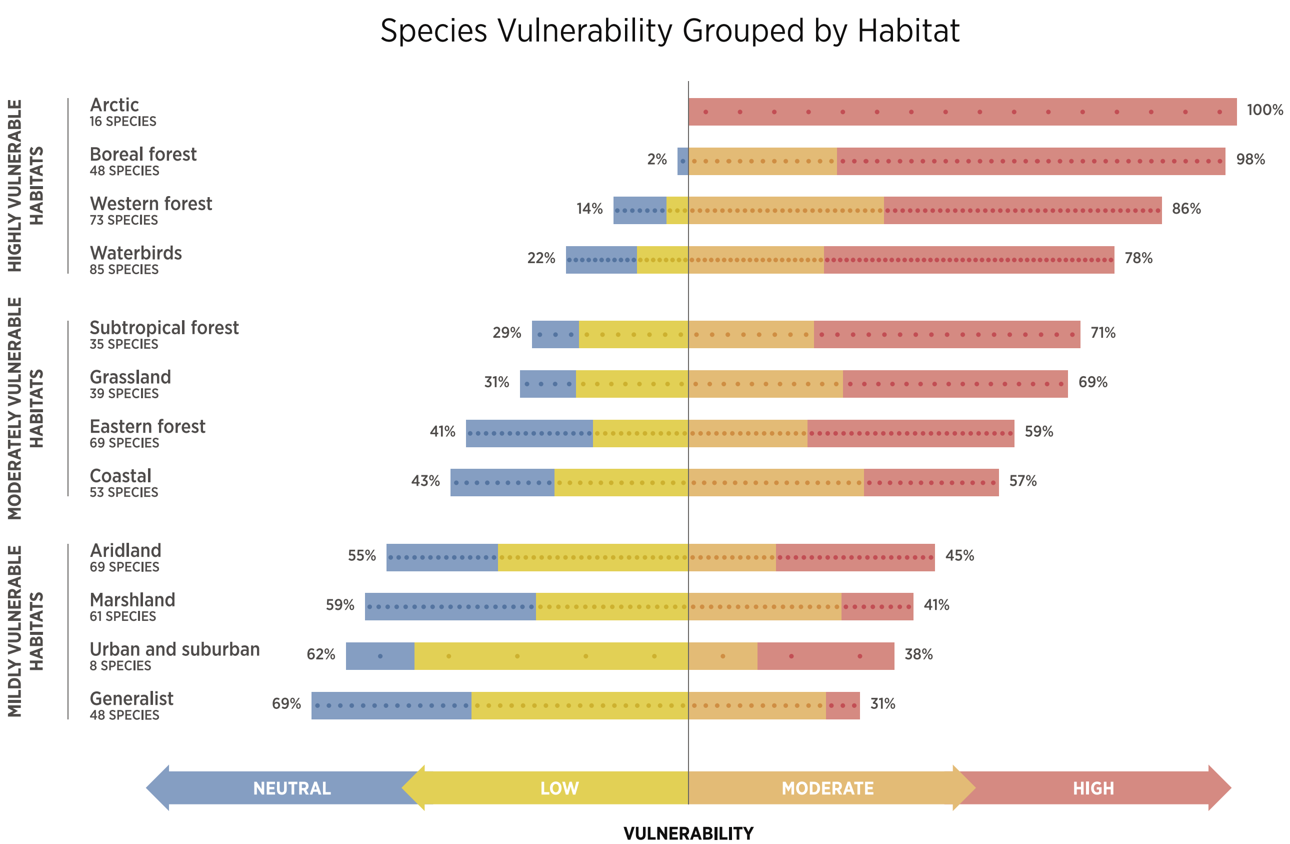


Key Findings

Nearly two-thirds of birds are vulnerable to climate change

Our report found that 64% of species (389 of 604) across breeding and non-breeding seasons were moderately or highly vulnerable to climate change. However, climate change vulnerability was not evenly distributed across habitats. Across seasons and scenarios (Fig. 2), 100% of Arctic bird species (16/16), followed by 98% of boreal forest birds (47/48), 86% of western forest birds (63/73), and 78% of waterbirds (66/85) were vulnerable to climate change. Habitat groups with intermediate vulnerability included subtropical forests (71%, 25/35), grasslands (69%, 27/39), eastern forests (59%, 41/69), and coastal areas (57%, 30/53). Habitat groups with lower vulnerability included aridlands (45%, 31/69), marshlands (41%, 25/61), urban/suburban areas (38%, 3/8), and generalists (31%, 15/48). However, even in the low-vulnerability groups, more than a quarter of the species were considered climate-vulnerable.

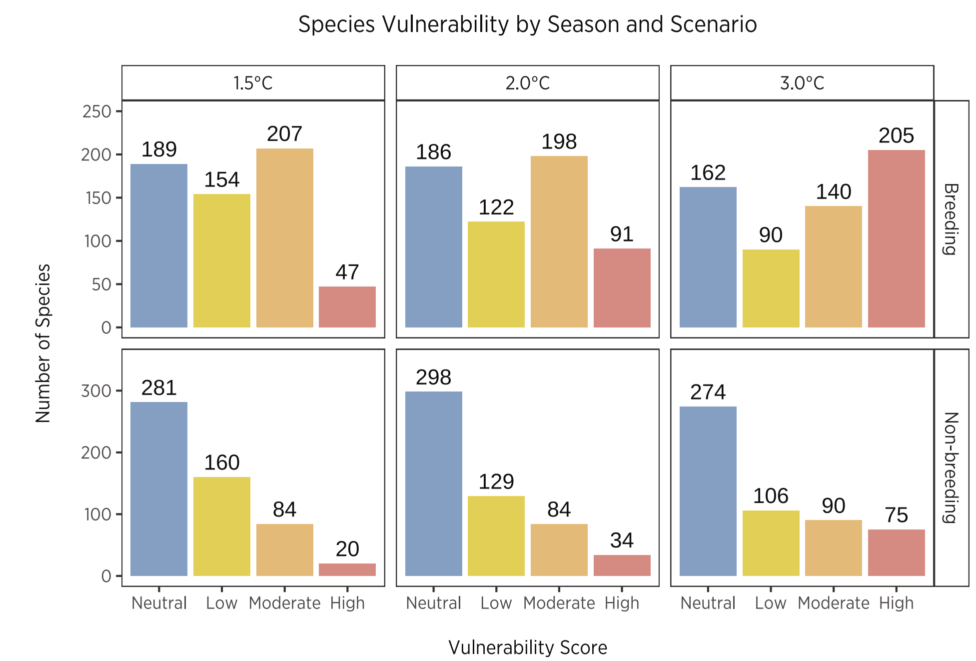
FIGURE 2 | Percentage of species vulnerable by bird habitat groupings across all scenarios and seasons. Purple and green indicate the percentage of highly and moderately vulnerable species, and blue and yellow indicate species of low and neutral vulnerability, with the vertical line dividing the vulnerable from non-vulnerable species. Projected summer range gains are limited by a species' estimated dispersal capacity.



Climate change mitigation will reduce vulnerability for 76% of birds

Nearly two-thirds (63%, 383/604) of all species across both seasons were classified as vulnerable under a 3.0°C global mean temperature rise, compared to 54% at 2.0°C (327/604) and 47% at 1.5°C (286/604) (Fig. 3). Across seasons for species considered vulnerable at 3.0°C (this includes both high and moderate vulnerability classes), 76% (290) drop at least one climate vulnerability category lower in at least one season if we are able to keep warming under a 1.5°C rise. Furthermore, 38% of vulnerable species (146) were no longer considered vulnerable under a 1.5°C warming scenario.

FIGURE 3 | Vulnerability classification in the breeding and non-breeding seasons under 1.5°C, 2.0°C, and 3.0°C (2.7°F, 3.6°F, 5.4°F) global warming scenarios. Vulnerable species are within the moderate or high vulnerability classes, and non-vulnerable species are within the neutral or low vulnerability classes.



Climate change mitigation efforts that stabilize mean global temperature rise at 1.5°C as compared to 3.0°C would lead to the greatest reduction in the number of species vulnerable in the breeding season. Furthermore, mitigation would most benefit birds in urban/suburban habitats (38% reduction in vulnerability), followed by the boreal forests (23% reduction), grasslands (23% reduction), eastern forests (20% reduction), and generalists (17% reduction). Mitigation would also lead to moderate reductions in the vulnerability of species living in western forests, subtropical forests, marshlands, aridlands, waterbirds, and coastal areas. Additional climate change adaptation actions would be required for Arctic species, which were 100% vulnerable, regardless of climate change scenario.

Vulnerability was considerably lower in the non-breeding season than in the breeding season, with 30% (165/546) of species in the non-breeding season vulnerable under the 3.0°C scenario. This would be reduced to just 19% of species classified as vulnerable under a 1.5°C scenario in the non-breeding season.

The places and species in greatest need for climate change adaptation

Climate change adaptation includes efforts to increase the ability of places and species to cope with a changing climate. However, geographies differed greatly in their anticipated changes. We mapped changes in the composition of bird communities across North America based on our species range projections to inform where adaptation actions can have the greatest impact.

In the breeding season, some locations may lose up to 106 bird species under a 3.0°C scenario, with a pronounced loss of species in the northern and eastern temperate forests, the Boreal Shield of Canada, and the northern parts of the U.S. Midwest and Northeast (U.S., Fig. 4). Projected losses were also high in the Pacific Northwest, the Rocky Mountains, and Alaska. Losses were less dramatic under a 1.5°C scenario, with up to 79 species lost locally, and concentrated mostly within the Boreal Plain region of Canada. In the non-breeding season, anticipated species losses varied under different warming scenarios, with up to 70 species lost from communities locally under the 1.5°C scenario but 90 species lost at the 3.0°C scenario.

Locations gained up to 115 potential colonizers in the breeding season and 105 in the non-breeding season under the 3.0°C scenario. In the breeding season, peak gains were in the taiga and tundra ecoregions of Canada, and to a lesser extent in the northern forests of the United States and Canada and along mountain ranges, including the Rockies and the Sierra Madre of Mexico (Fig 4). In the non-breeding season, peak gains were in western Alaska, Newfoundland and Nova Scotia, the Great Lakes, the southern United States, and the Sierra Madre. In both the breeding and non-breeding seasons, under the 1.5°C scenario, species range gains were uniformly distributed, with up to 93 and 66 species gained.

Audubon has worked with the U.S. National Park Service to identify national park units where bird communities are expected to change because of climate change. The National Parks study translated projected changes in the composition of bird communities under a changing climate into park-specific recommendations for climate change adaptation (Hole et al., 2010; Wu et al., 2018). Places with low net change in the bird community can best support landscape-scale bird conservation by emphasizing habitat restoration, maintaining natural disturbance regimes (e.g., fire), and reducing other stressors. Places with high net change in the bird community can focus on actions that increase species' ability to respond to environmental change, such as increasing the amount of potential habitat, working with cooperating agencies and landowners to improve habitat connectivity for birds across boundaries, managing the disturbance regime, and possibly more robust management actions (e.g., intensive nest site management, translocations) (Wu et al., 2018). Monitoring efforts that identify changes in bird communities, such as Audubon's Climate Watch community science program, will also inform the selection of appropriate adaptation responses.

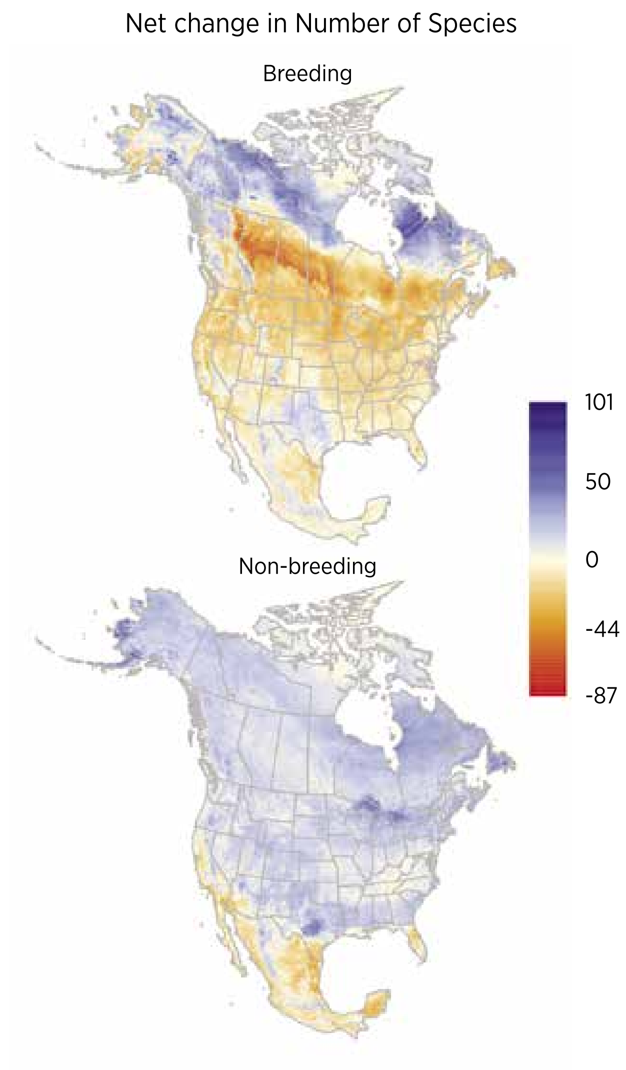


FIGURE 4 | Net gain or loss in number of species per square kilometer across North America for the breeding and non-breeding seasons. The scale ranges from a net loss (red) to a net gain (blue) of species with 3.0°C (5.4°F) warming (1.5°C [2.7°F] not shown). Net species change ranged from a negative 87 to 101 in the breeding season and from a negative 62 to 97 in the non-breeding season.

We can also advance climate change adaptation by focusing on the species that are both most vulnerable to climate change and already at a high level of conservation need. The conservation status of climate-vulnerable species varied widely. Fifty climate-vulnerable species across seasons were also listed on the PIF Watch List (Fig. 5). Thus, the adaptive capacity of these species is further diminished by their current state of conservation need. These include species from grasslands (7); aridlands (7); coastal areas (8); subtropical (3), western (7), eastern (5), and boreal forests; marshlands (5); waterbirds (5); and the Arctic (2). Sixteen of the species were Audubon priority birds (Table 1). Furthermore, 323 of our climate-vulnerable species across seasons are not currently on the Watch List (Fig. 5), suggesting an emerging future conservation need as climate change advances.

TABLE 1 | Audubon priority species that are both climate-vulnerable and on the Partners in Flight Watch List.

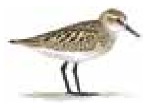
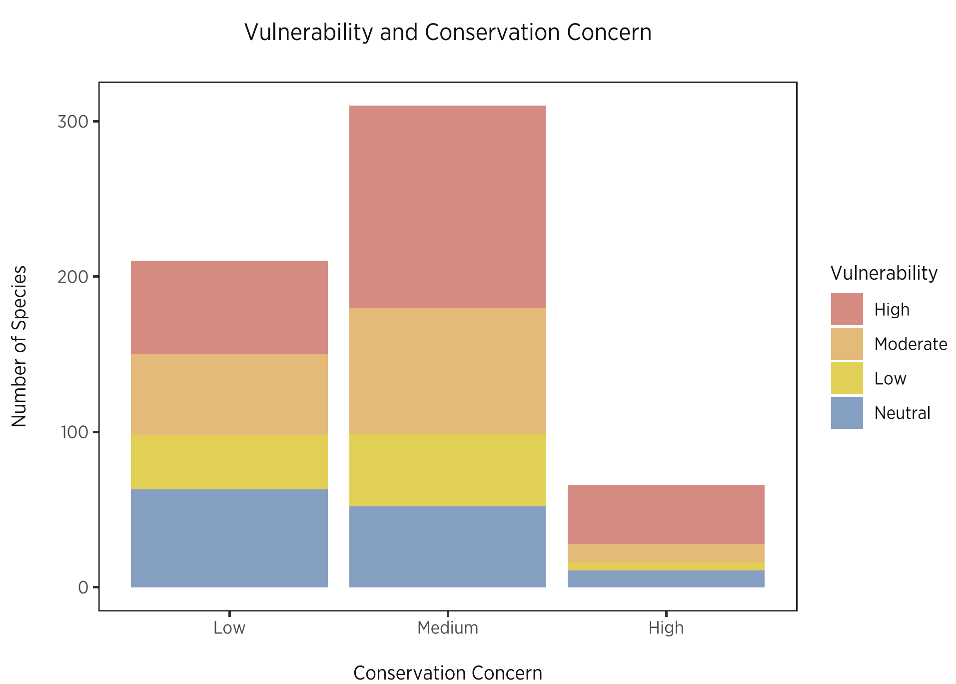
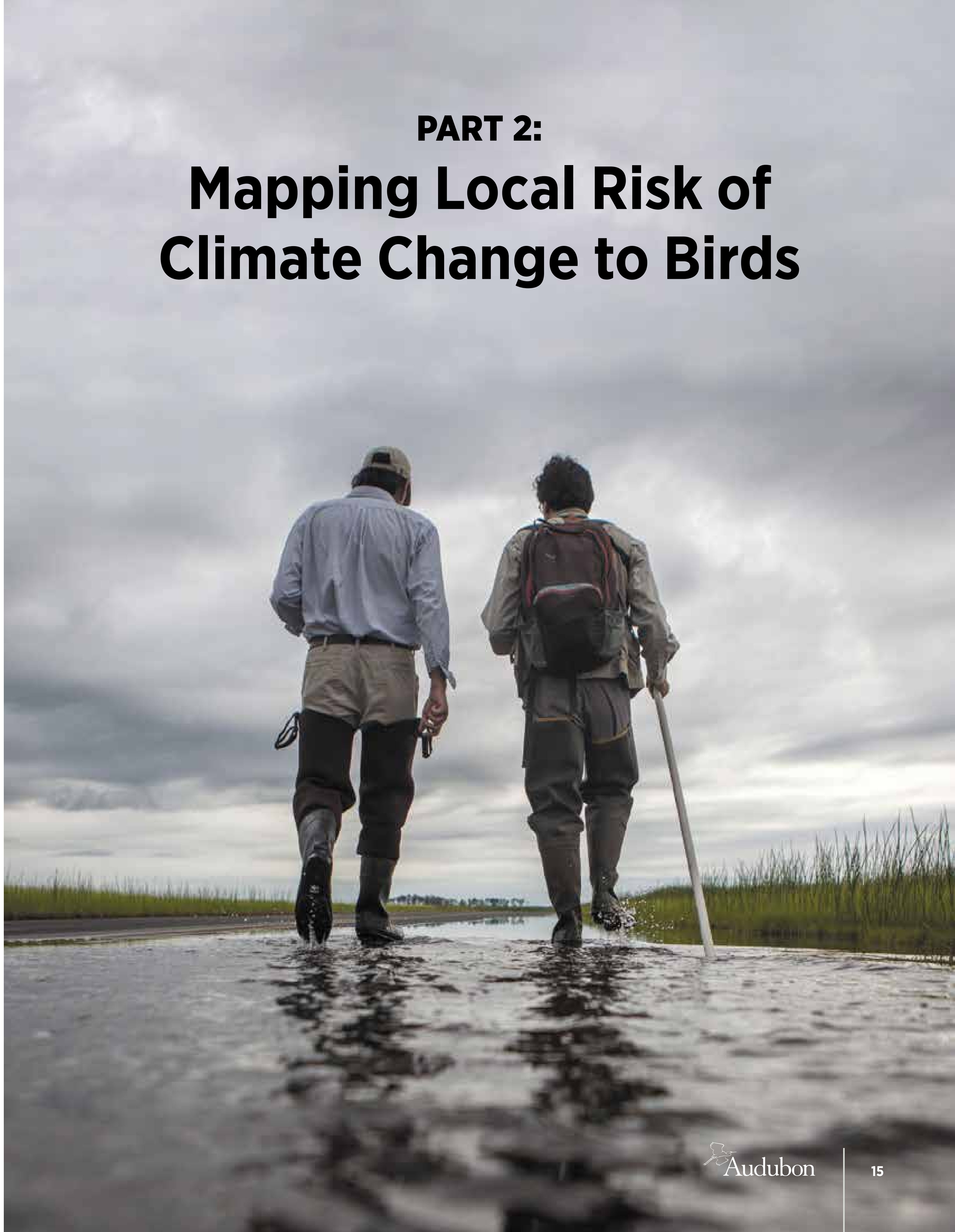
 **Baird's Sparrow**	 **Chestnut-collared Longspur**	 **Marbled Godwit**	 **Semipalmated Sandpiper**
 **Bobolink**	 **Florida Scrub-Jay**	 **Mountain Plover**	 **Sprague's Pipit**
 **Canada Warbler**	 **Golden-winged Warbler**	 **Piping Plover**	 **Tricolored Blackbird**
 **Cerulean Warbler**	 **Greater Sage-Grouse**	 **Saltmarsh Sparrow**	 **Wood Thrush**

FIGURE 5 | Species vulnerability across seasons for the 3.0°C (5.4°F) warming scenario according to conservation status from the State of the Birds. Species were grouped into low, moderate, and high conservation concern based on their overall score, with species on the Partners in Flight (PIF) Watch List considered of high conservation concern. Many species currently considered of low conservation concern are vulnerable to climate change and could be at risk in the future.



PART 2:

Mapping Local Risk of Climate Change to Birds



Background

In the preceding section, we assessed species' range-wide vulnerability to climate change in North America. At the continental scale, this study included the best possible information to project future conditions and assess impacts. However, climate change encompasses more than just long-term changes in average temperature, precipitation, and vegetation, and considering additional and more acute threats where available will result in information that's useful for conservation planning.[81] In this research,[11] we mapped multiple climate change-associated threats for the conterminous United States and quantified their impact on birds in order to identify places and species at risk.

The climate change-related threats we considered in this analysis included sea level rise and lake level change; urbanization; cropland expansion; and extreme weather events, including extreme spring heat, fire weather, spring droughts, heavy rains, and false springs. Sea level rise, changes in lake levels, cropland expansion, and urbanization will cause long-term changes in habitat, while extreme weather events can have significant effects on populations through direct impacts on reproduction and survival and indirect impacts on habitat and resource availability. We incorporated these threats, along with results from the preceding section on future bird ranges and vulnerability, to assess the local risk of climate change to birds for two policy-relevant scenarios also included in the vulnerability assessment in Part 1: 1.5°C and 3.0°C (2.7°F and 5.4°F) increases in global mean temperature. These scenarios reflect current and potential climate change emissions-reduction targets. For sea level rise, we selected median scenarios to match IPCC estimates for 1.5°C and 3.0°C warming scenarios by the end of the century. We also considered an additional "extreme" high-end sea level rise estimate for 3.0°C warming that has been identified in a number of other analyses.[12–15] We mapped extreme weather primarily from the spring season, when most birds are starting to breed. It is well documented that in isolation, extreme weather events have negative consequences; however, species will likely face multiple, more general threats locally from these events.[16–19] The combined influence of these threats can dramatically alter populations and bird communities,[16,20] and cause added physiological stress to birds.[16]

To determine which species will be affected by each climate change-related threat, we calculated the percent of a species' projected future range in the conterminous United States that could be affected. For threats that would result in long-term persistent change to bird habitat (e.g., sea level rise, lake level change, human land-use change), we considered a species to be affected if at least 10% of its range overlapped with the area under threat. For threats that would result in short-term or intermittent changes to habitat (e.g., extreme weather), we considered a species to be affected if at least 50% of its range overlapped with the area under threat. For each season and climate change scenario, we identified the total number of species affected by each threat. Although some of the threats were calculated for the breeding season, we still estimated impacts in the non-breeding season because extreme weather in one season can also have cascading effects on other parts of the year, and can have a delayed effect on habitat quality and bird populations.[21,22]

To map local places at risk from climate change, we implemented an IPCC framework in which the highest risk occurs in areas projected to experience high levels of hazard, exposure, and vulnerability (Fig. 6, also[23]). For any one location, we defined hazard as the number of overlapping climate change-related threats (Fig. 6); exposure as the total number of bird species' that occur under future climate conditions; and vulnerability as the number of species under future conditions with range-wide vulnerability to climate change. Range-wide vulnerability was based on the findings in Part 1 of this report. In summary, we tallied the number of species affected by each climate change-related threat from the 544 total species considered and mapped risk under scenarios representing both a 1.5°C and a 3.0°C increase in global mean temperature. *This work is a one-of-a-kind assessment of risk to birds that combines range-wide vulnerability with mapped cumulative hazard from climate change-related threats such as sea level rise and extreme weather.*

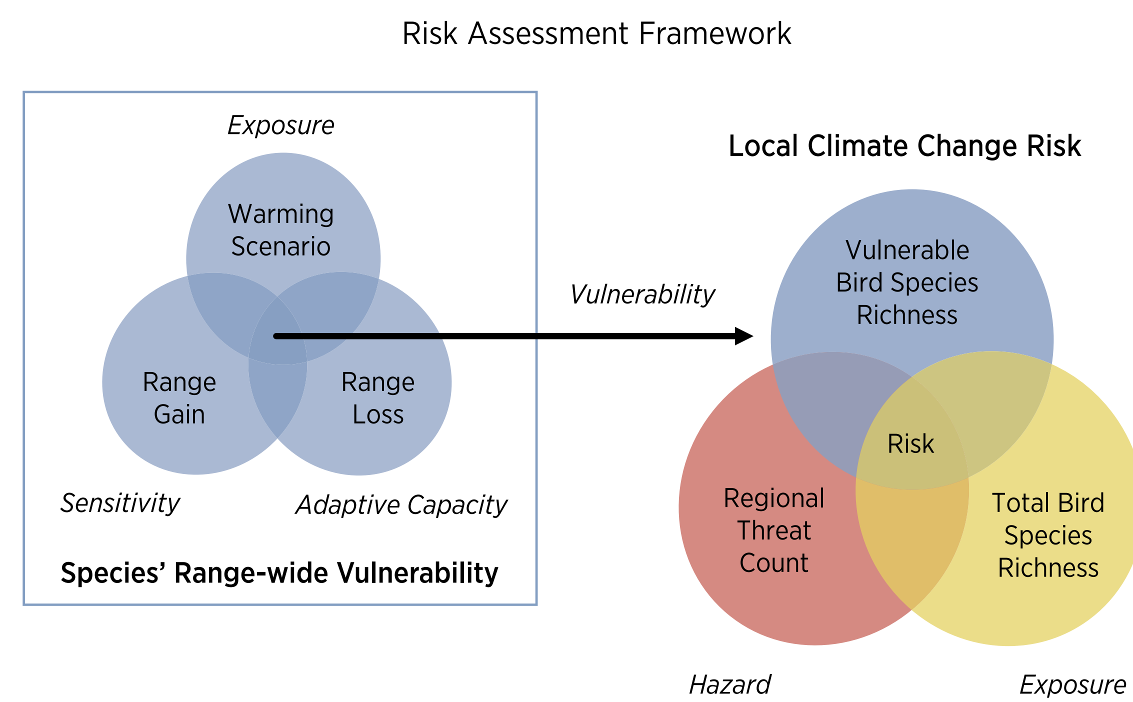


FIGURE 6 | Framework used for mapping risk from climate change in the conterminous United States. A species' range-wide vulnerability was a function of its exposure to change (measured here by global warming scenario), sensitivity to change (range loss), and adaptive capacity in the face of change (range gain relative to range loss). Local climate change risk was a function of hazard (cumulative threats), exposure (number of species), and vulnerability (number of vulnerable species). Adapted from Foden & Young, 2016[23]

Key Findings

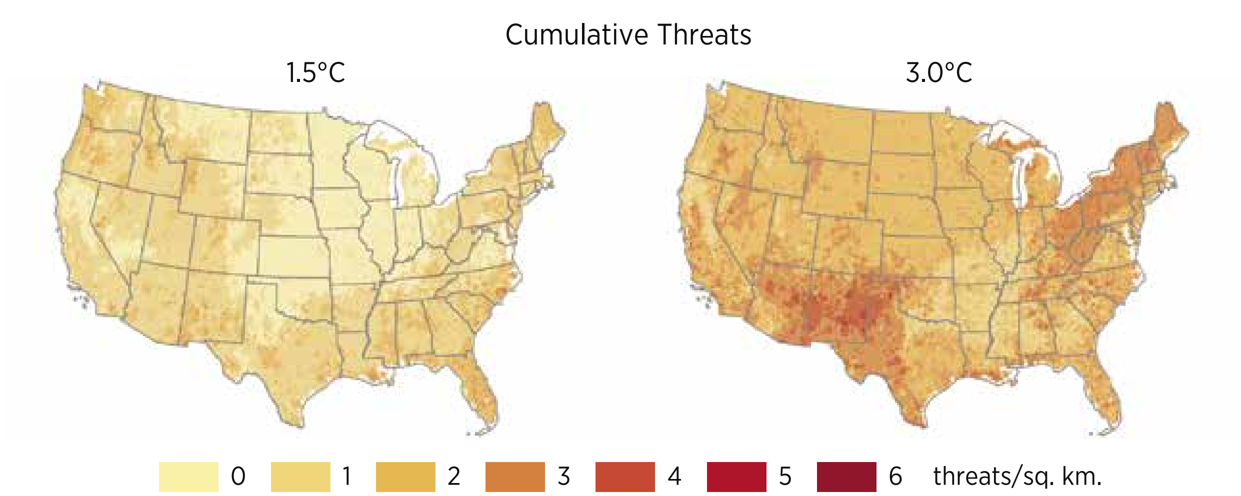
Ninety-eight percent of the conterminous 48 states could be affected by one or more climate-related threats

Overall, short-term intermittent threats (e.g., extreme weather) cover a much greater area than persistent threats (e.g., sea level rise, lake level change, and human land-use change). Extreme spring heat is the most ubiquitous threat, covering more than 98% of the conterminous United States under 3.0°C of warming and more than half of this area under 1.5°C of warming. By contrast, sea level rise and lake level change are the most geographically restricted threats, covering only about 1% of the conterminous United States under both warming scenarios. Increased fire weather affects about two-thirds of the conterminous United States under 3.0°C warming.

Under the 3.0°C scenario, the degree of potential hazard from cumulative threats ranged from zero to six threats per square kilometer at any given location. More than 98% of the United States was affected by at least one threat and more than 88% was affected by two or more threats. Threats would be most concentrated in the Northeast (from Maine to West Virginia), the Southwest (from Arizona to Texas), and the Gulf Coast (Louisiana). They would be least concentrated in the South's interior lowlands and coastal plains.

Climate change mitigation that reduces warming from a 3.0°C rise to a 1.5°C rise would reduce the maximum cumulative threats to five per square kilometer as well as the extent of areas projected to experience a climate change-related threat (Fig. 7). Under a 1.5°C scenario, 66% of the conterminous United States was projected to experience at least one threat, and 19% would be affected by two or more threats. Hazard was greatest in the coastal Southeast (the Carolinas, Florida, and Louisiana), the Pacific Northwest (western Oregon and Washington), and the Intermountain West (Idaho, Wyoming, and New Mexico), and least in the Midwest and northern Great Plains (Fig. 7). Nearly all threats covered more area under 3.0°C of warming than under 1.5°C; the one exception was cropland expansion, which affected a small area under both scenarios but actually covered more area under a 1.5°C scenario than a 3.0°C scenario (2.3% versus 0.8% of the conterminous United States).

FIGURE 7 | Hazard from cumulative (i.e., overlapping) threats due to climate change in the conterminous United States under two climate change scenarios.



Ninety-seven percent of species could be affected by two or more climate change-related threats

The number of species affected by each threat generally scaled proportionately to the amount of area covered, with a few exceptions (Fig. 8). Intermittent threats from extreme weather events were projected to affect the greatest area and number of birds. Most of these threats were greatly reduced under 1.5°C of warming, with only extreme spring heat and heavy rains still affecting species to a significant degree. Persistent threats generally covered a smaller area and had a smaller impact on birds, but urbanization and sea level rise both had a disproportionate effect on species relative to the area they occupy. Although urbanization was projected to affect 10% of the conterminous United States under a 3.0°C warming scenario, it was among the greatest threats to birds, affecting 44% and 61% of species in the breeding and non-breeding seasons. Sea level rise had a smaller, but even more disproportionate, impact. Although it covers less than 1% in area based on median sea level rise estimates for a 3.0°C warming scenario, sea level rise was projected to affect 5% and 9% of breeding and non-breeding species. Furthermore, when considering the "extreme" high-end sea level rise estimate under a 3.0°C scenario, the number of species affected increased to 6% and 14% of breeding and non-breeding species. Other persistent threats, including cropland expansion and lake level change, were projected to have minimal effects. The impacts of all persistent threats would be reduced under a 1.5°C warming scenario, particularly the impact of urbanization, which would decrease to less than 3% of both area and species affected.

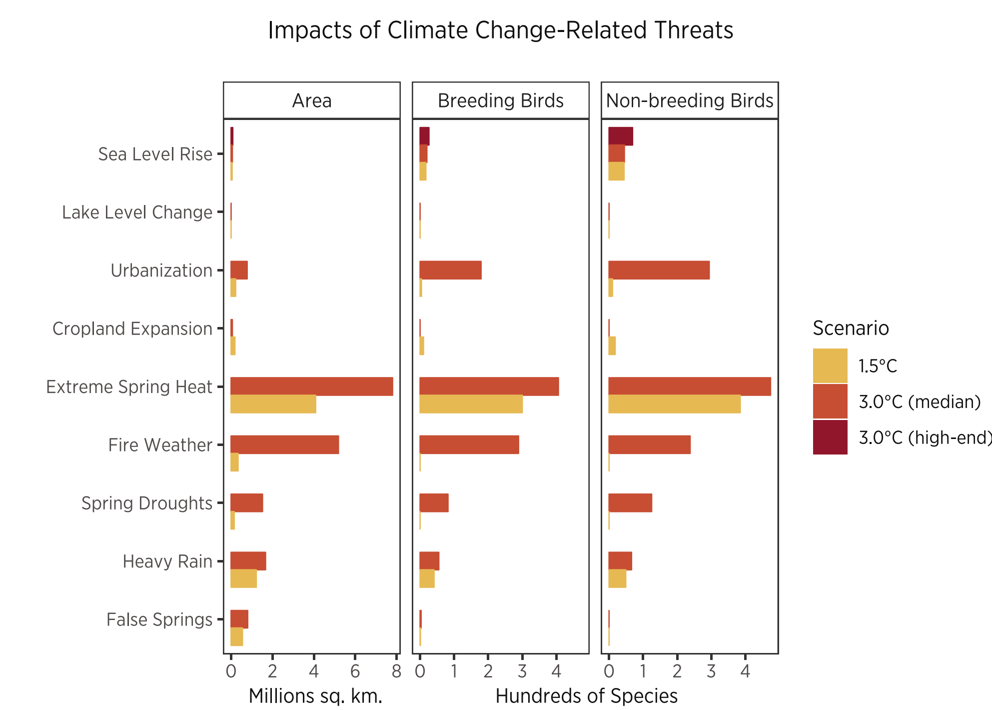


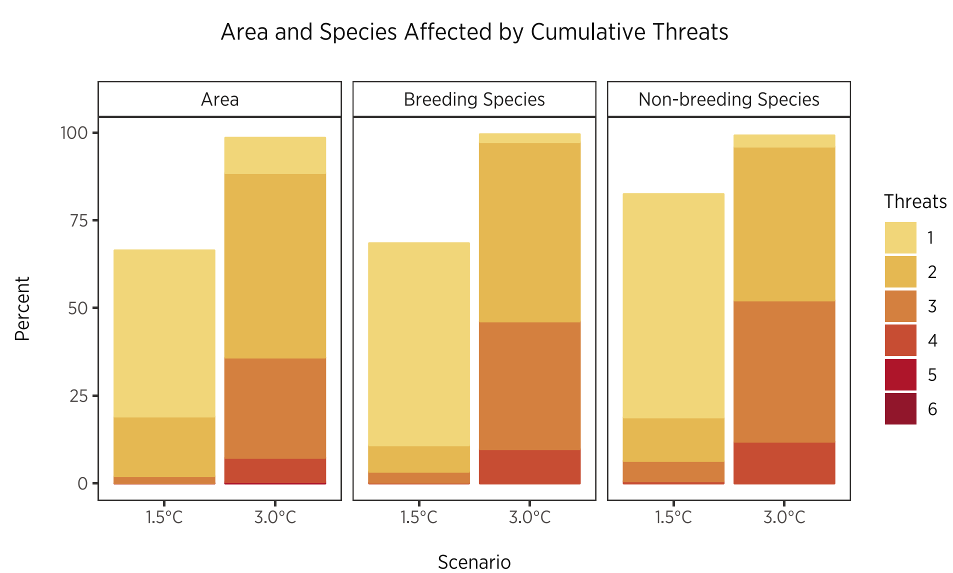
FIGURE 8 | Area and number of species affected by threats under future global change scenarios of 1.5 and 3.0°C (2.7°F and 5.4°F, including a median and "extreme" high-end projection for sea level rise). Affected species overlap with threats in at least 10% (for persistent threats) or 50% (for intermittent threats) of their range in the conterminous United States.

The majority of species analyzed were projected to be affected by at least one threat in each season and scenario analyzed, with up to four threats affecting a single species across seasons and scenarios (Fig. 9). Under 3.0°C of warming, the vast majority of species were affected by two or more threats (97% of breeding species, 96% of non-breeding species), and 40 (10%) and 57 (12%) were affected by four threats. These included 14 Audubon priority birds (Table 2). Limiting the rise in warming to 1.5°C would result in most species projected to experience only a single threat (58% of breeding species, 64% of non-breeding species).

TABLE 2 | Audubon priority species projected to be affected by four climate change-related threats.

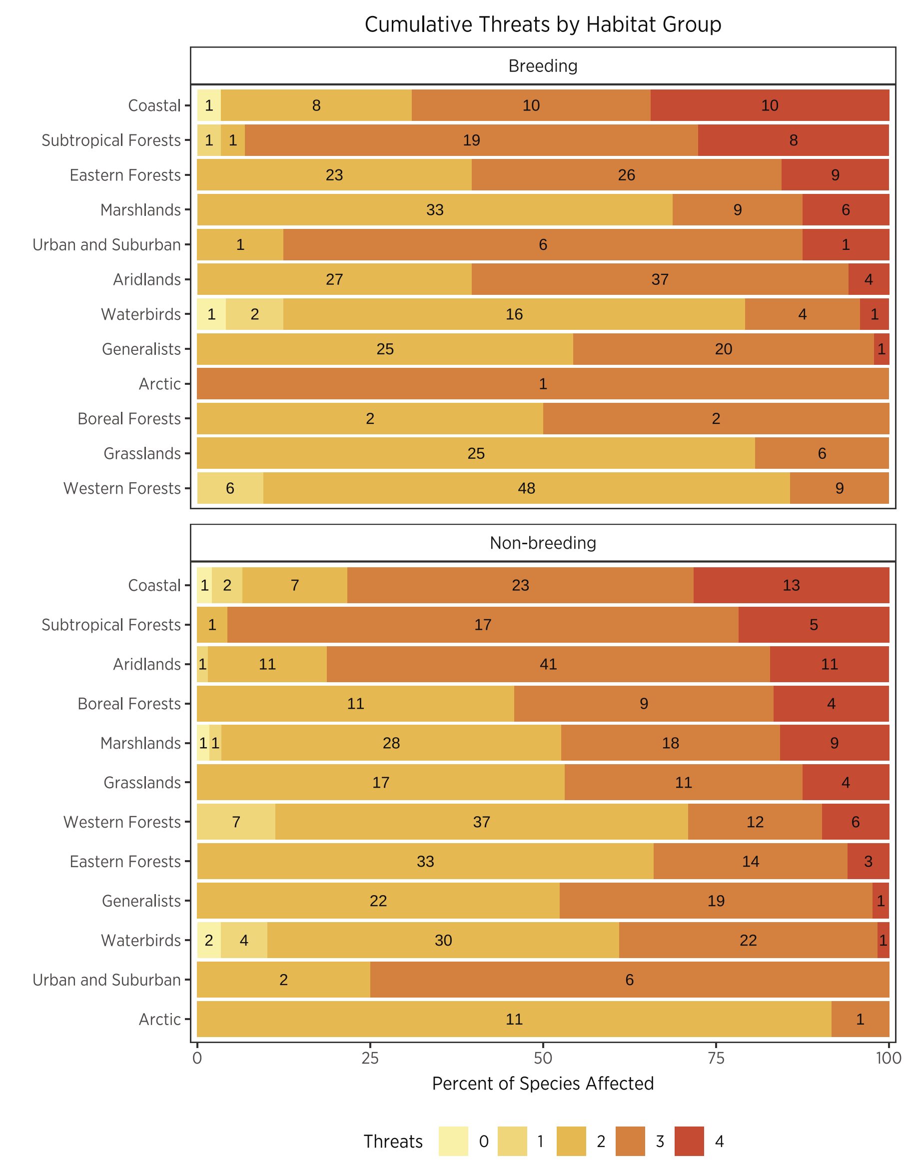
Brown Pelican	Mountain Plover	Saltmarsh Sparrow	Wilson's Plover
Burrowing Owl	Piping Plover	Sandwich Tern	Wood Stork
Cerulean Warbler	Ridgway's Rail	Scarlet Tanager	Wood Thrush
Clapper Rail	Royal Tern		

FIGURE 9 | Area and percent of species affected by cumulative number of threats in breeding and non-breeding seasons under future global climate change scenarios of 1.5°C and 3.0°C (2.7°F and 5.4°F).



Some species habitat groups were more likely to face multiple climate change-related threats than others (Fig. 10). In both breeding and non-breeding seasons under a 3.0°C scenario, the coastal, subtropical forest, and marshland groups had the most species facing at least four potential threats. Habitats where more than 50% of species were affected by three or more threats included coastal (69%), eastern forests (60%), subtropical forests (93%), aridlands (60%), and urban/suburban areas (88%) during the breeding season, and coastal (78%), aridlands (81%), subtropical forests (96%), boreal forests (54%), and urban/suburban areas (75%) in the non-breeding season. In contrast, under a 1.5°C warming scenario, the majority of groups had 50% or more of species facing zero to one coincident threats (figure not shown).

FIGURE 10 | Percent and number of (a) breeding and (b) non-breeding species per bird habitat group affected by multiple threats under a 3.0°C (5.4°F) warming scenario. Groups are listed in descending order by the total number of species that face four threats.



Climate change mitigation would reduce risk to birds across more than 91% of the conterminous United States

Risk, highlighting areas of high hazard (cumulative threats), exposure (bird richness), and vulnerability (vulnerable bird richness) (Fig. 11), was greater with 3.0°C warming than with 1.5°C warming, and greater during the breeding season than the non-breeding season. Areas of high risk are priorities for climate change adaptation action.

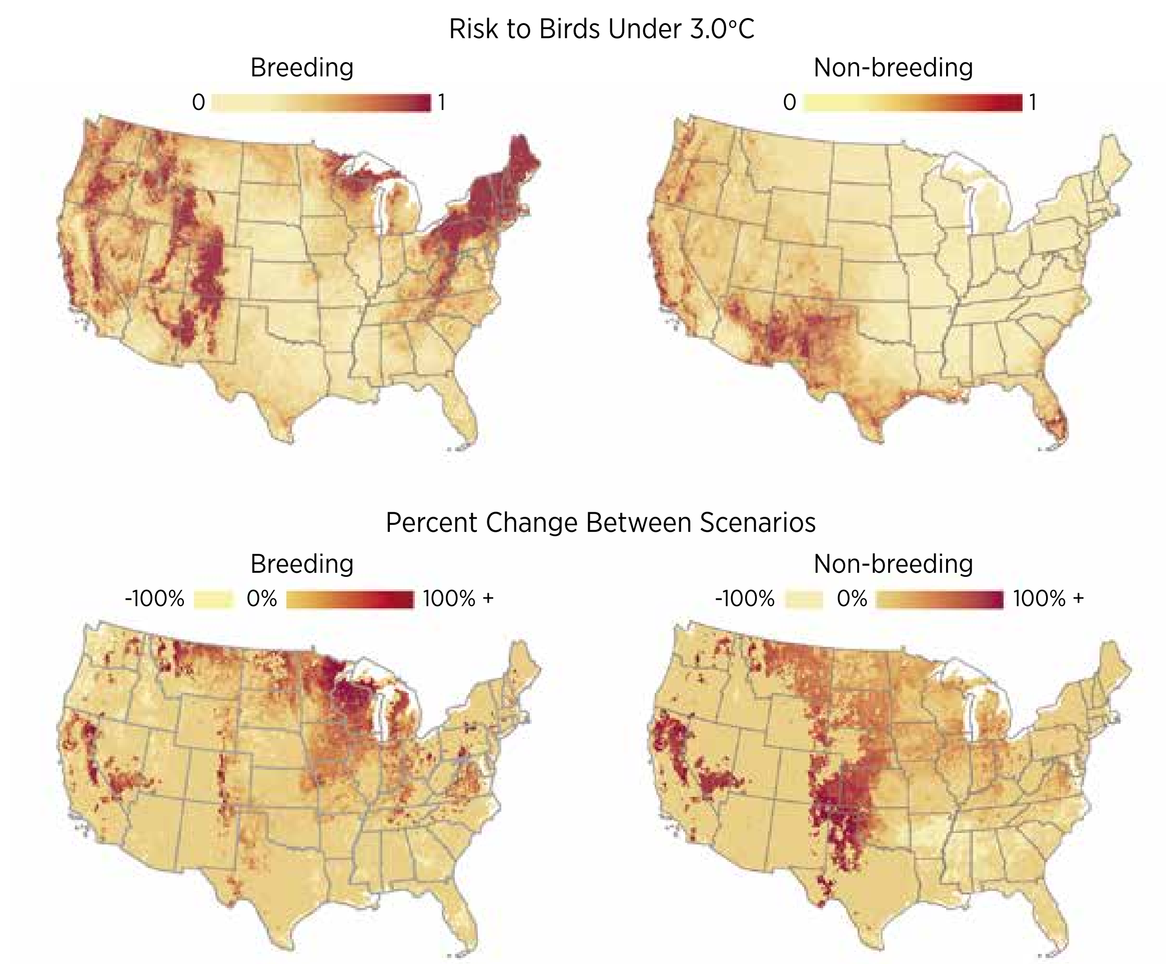


FIGURE 11 | Risk to birds in the breeding and non-breeding seasons under a 3.0°C (5.4°F) warming scenario and the percent difference under a 1.5°C (2.7°F) scenario. Risk was calculated as the product of projected hazard (cumulative threats), exposure (bird richness), and vulnerability (vulnerable bird richness) and then rescaled between zero and one. For each season, the percent change between scenarios was calculated as the difference between risk under the 3.0°C and 1.5°C scenarios divided by risk under a 1.5°C scenario.

Brown Pelican

In the breeding season, risk was greater across more than 91% of the conterminous United States with 3.0°C warming than with 1.5°C warming. Furthermore, across 70% of the United States, risk was twice as high under the 3.0°C scenario than the 1.5°C scenario. Risk was highest in mountainous regions of the West and in the Northeast under both scenarios (Fig. 11) and higher under the 3.0°C scenario in the Midwest, the Mid-Atlantic, Northern California, southern Nevada, and east of the Rockies in Montana, Colorado, and Texas. Risk declined under the 3.0°C scenario in less than 9% of the conterminous United States and in only a few areas: western Washington and Oregon, small patches across the Intermountain West, the South's coastal plains, and Nebraska due to both lower hazard and fewer species present in those areas. These patterns closely follow distributions of species richness and vulnerability (not shown), which were also highest in western mountain ranges under both scenarios, and greater in the Northeast and Upper Midwest under a 3.0°C scenario. Despite high hazard in the Southeast, risk was low in this region during the breeding season due to relatively low exposure and vulnerability.

In the non-breeding season, risk was greater across more than 93% of the conterminous United States under a 3.0°C scenario than a 1.5°C scenario. Furthermore, across 82% of the United States, risk was twice as high with 3.0°C of warming than 1.5°C of warming. Risk was highest in New Mexico, Texas, the Gulf Coast, and the Southeast (Fig. 11) and higher under the 3.0°C scenario, particularly east of the Rockies in Texas as well as in Northern California and southern Nevada. These patterns were the result of high hazard in the mountainous West, Gulf Coast, and Southeast; elevated exposure along the Pacific, Gulf, and southern Atlantic coasts in the non-breeding season; and high vulnerability in the mountainous West and Florida. Despite high hazard in the Northeast, risk was low in this region during the non-breeding season due to relatively low exposure and vulnerability. Compared with warming of 1.5°C, risk was reduced under 3.0°C of warming in only 7% of the conterminous United States: a few areas along the northern extent of the coastal plains and in the southern Interior Lowlands due to both lower hazard and fewer vulnerable species present in these areas.

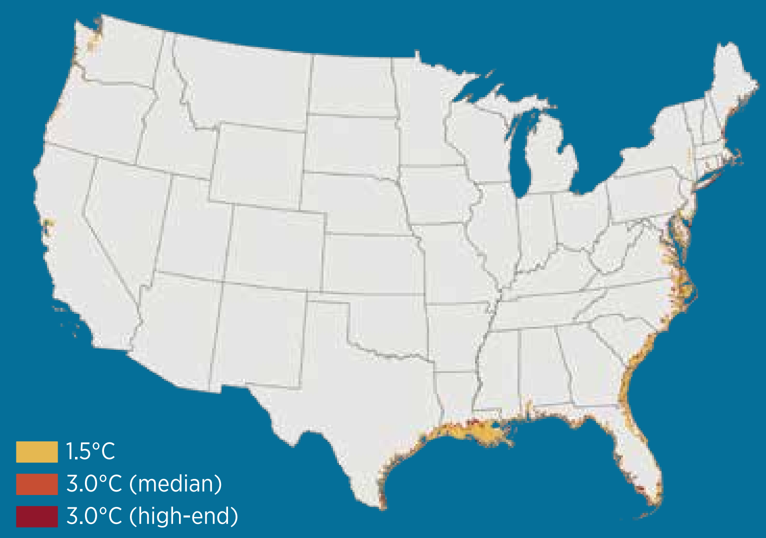
Persistent Threats

Persistent threats such as sea level rise, changes in lake levels, cropland expansion, and urbanization will cause long-term changes in habitat. Land-use change has already created a fragmented and degraded landscape, with estimates that more than 50% of the Earth's land surface has been modified for human use[24] and projections that human land-use change will likely intensify in the future.[25,26] In the conterminous United States, we have already seen rapid rates of land-use conversion in both agricultural and urban expansion with human population growth. Habitat loss and degradation due to human activity and land-use change are a major threat to biodiversity, including birds.[27–29] Both the richness and abundance of bird species are negatively associated with anthropogenic land use,[30–32] especially for habitat specialists and species of conservation concern.[33] Areas facing increased pressure from both land-use change and climate change have also seen accelerated losses in bird populations and communities.[34] As species shift their ranges in response to climate change, finding appropriate habitat not already altered by humans will become increasingly difficult.[35] The combined and additive effects of land use and climate change will likely lead to high rates of biodiversity loss, a homogenization of communities, and reduced ecosystem functioning.[36,37]

Sea Level Rise and Lake Level Change

Loss of beach and wetland habitats from rising or fluctuating water levels

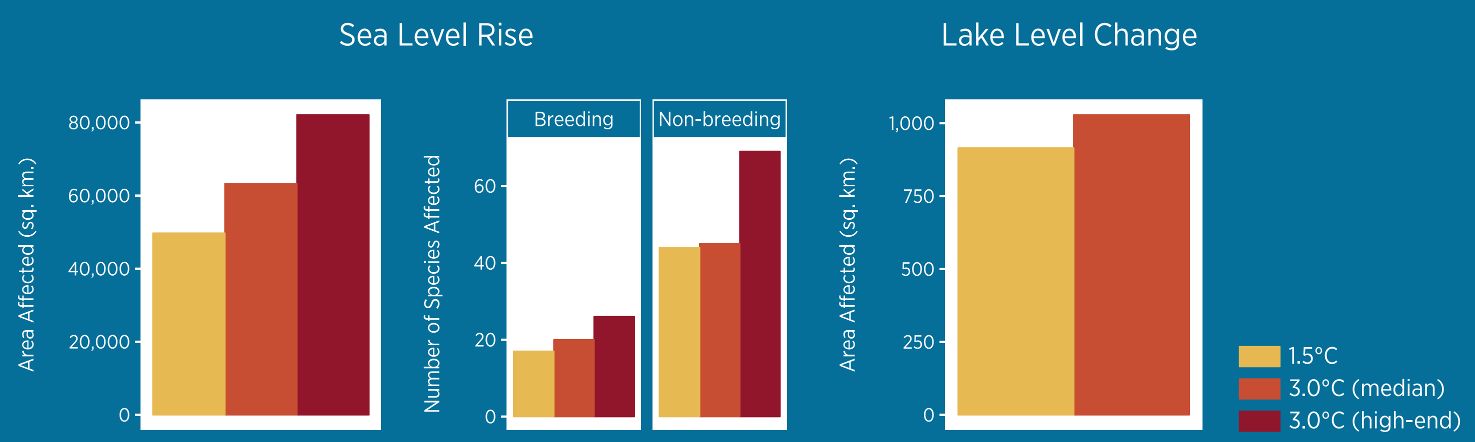
Sea level rise is likely to cause catastrophic habitat loss over the long term, as nesting sites become inundated or transition to different habitat types.[38] Coastal species will also suffer in the short term, as flooding becomes more frequent and catastrophic from storm tides,[17,39] leading to direct mortality of chicks as nests and burrows are destroyed.[39] The unpredictable pattern of these changes may also create ecological traps, leaving birds unable to adapt or move to new areas.[39] Similarly, changes in lake level variability, especially associated with reductions in lake levels, can alter shoreline and wetland habitats and their ecological function.[40–42] Waterbird and shorebird species are often tied to specific wetland vegetation communities, and changes in seasonal hydrology can increase reproductive failure through reduced breeding pairs and higher numbers of nest failures.[43]



We mapped areas of sea level rise-induced flooding and ensuing habitat transitions as marshlands migrate into uplands. We selected scenarios of 0.5-meter and 1.0-meter rise to match estimates from the IPCC for 1.5°C and 3.0°C warming scenarios by the end of century,[44] respectively, as well as an additional "extreme" scenario (2.0 meters) to capture current high-end estimates of sea level rise with 3.0°C warming.[12,13,15] We then downscaled these global scenarios to individual states using a dataset from the National Climate Assessment that localizes global sea level rise projections.[45]

We mapped areas expected to see changes in lake levels, which are generally expected to decline under climate change as (1) surface water temperatures warm, increasing rates of evaporation, and (2) lake ice forms later, extending the season for evaporation.[46] However, lake levels also vary considerably,[47] and variability in the future is expected to increase.[48] Therefore, we combined historical variability and projections of future water levels for each lake to identify areas affected by high and low lake levels under our two climate change scenarios.[49]

Median projected sea level rise under a 3.0°C warming scenario affected more than 10% of the conterminous U.S. range for 20 (5%) and 45 (9%) species in the breeding and non-breeding seasons, and this included 3% and 12% of species classified as vulnerable to climate change range-wide. These numbers increased to 26 (6%) and 69 (14%) species in the breeding and non-breeding seasons, representing 3% and 18% of climate-vulnerable species, under the high-end 3.0°C warming sea level rise scenario. Under a 1.5°C warming scenario, increased sea level rise would affect more than 10% of the range of 17 (4%) and 44 (9%) species in the breeding and non-breeding seasons, including 2% and 12%, respectively, of species classified as vulnerable range-wide. Thus, action to reduce global warming from a rise of 3.0°C to 1.5°C would reduce species affected by sea level rise. No species had more than 10% of its U.S. range affected by lake level changes.



SPECIES projected to be most affected by sea level rise in their conterminous U.S. range include:

- American Oystercatcher
- Black Skimmer
- Brown Pelican
- Boat-tailed Grackle
- Clapper Rail
- Marbled Godwit
- Nelson's Sparrow
- Piping Plover
- Purple Sandpiper
- Reddish Egret
- Red Knot
- Royal Tern
- Saltmarsh Sparrow
- Semipalmated Plover
- Seaside Sparrow
- Snowy Plover
- Wilson's Plover

STATES with the greatest area projected to be affected by sea level rise include:

- Louisiana
- Florida
- North Carolina
- Texas
- South Carolina
- Georgia
- Maryland
- Virginia


Reddish Egret

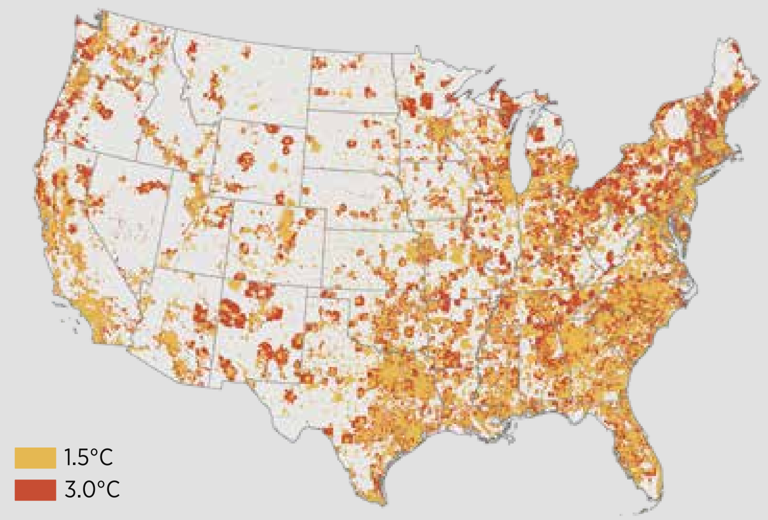

American Oystercatcher

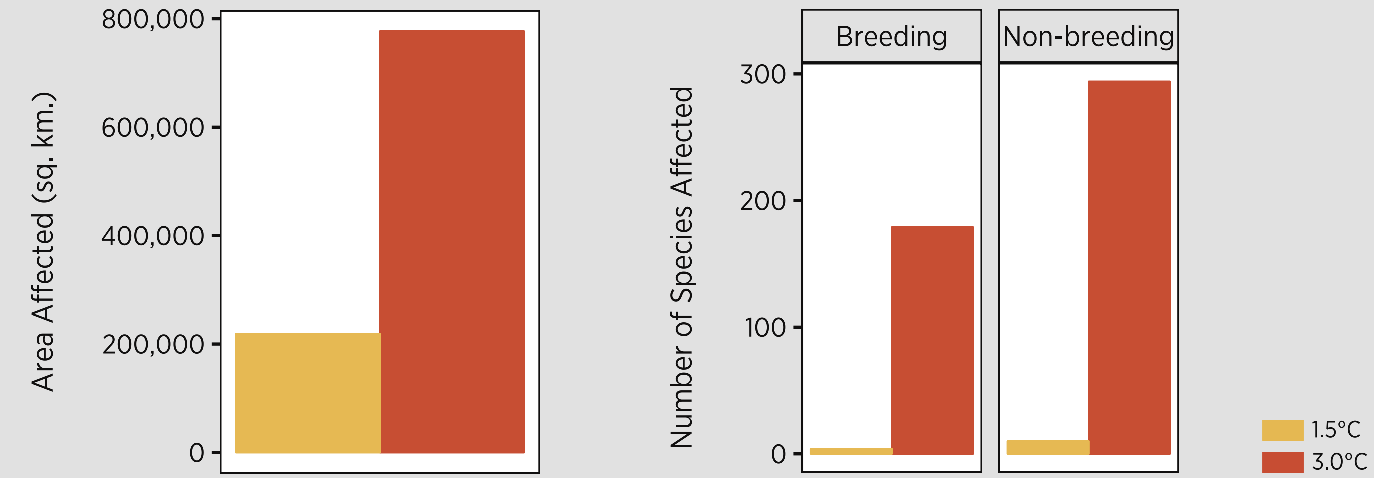
Urban Land-Use Change

The conversion of natural landscapes to urban and suburban land uses

Urbanization, defined as the conversion of natural landscapes to urban and suburban land uses, often includes an increase in impervious surfaces and a change in tree cover. Urbanization often alters bird communities, favoring some species over others, so that while overall bird abundance remains high, species diversity declines.[50] Although urbanization is projected to cover only 10% of the conterminous United States under a 3.0°C scenario, it is among the greatest threats to birds because of the high percent of species affected.

Projected urbanization under a 3.0°C warming scenario is expected to affect 179 (44%) and 294 (61%) species in the breeding and non-breeding seasons, and this includes 33% and 49% of species classified as vulnerable to climate change range-wide. Action to limit the increase in global warming from 3.0°C to 1.5°C would reduce species affected by increased urbanization. Under a 1.5°C warming scenario, increased urbanization would affect more than 10% of the range of 4 (1%) and 10 (2%) species in the breeding and non-breeding seasons, including 2% and 8%, respectively, of species classified as vulnerable range-wide.






Allen's Hummingbird

SPECIES projected to be most affected by urbanization in their conterminous U.S. range include:

- Allen's Hummingbird
- Fish Crow
- Swallow-tailed Kite
- White-crowned Pigeon
- Black Oystercatcher
- California Thrasher
- Red-cockaded Woodpecker
- Roseate Spoonbill

STATES with the greatest area projected to be affected by urbanization include:

- Texas
- California
- Georgia
- North Carolina
- New Mexico
- Florida
- Alabama

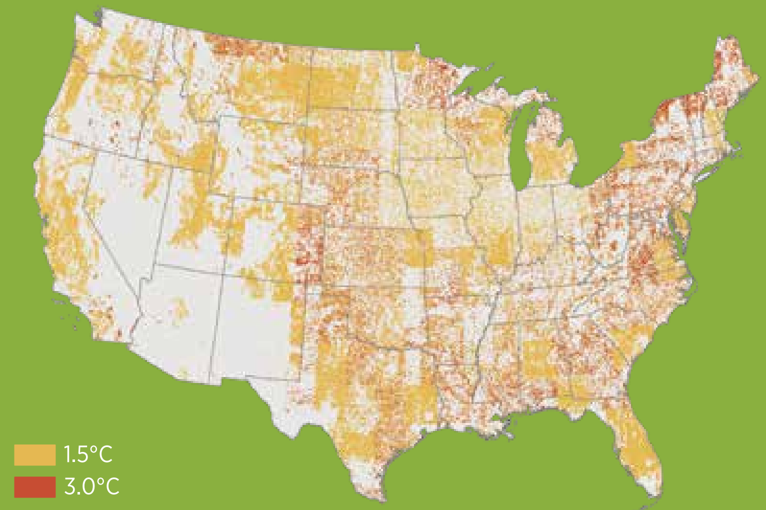

Black Oystercatchers

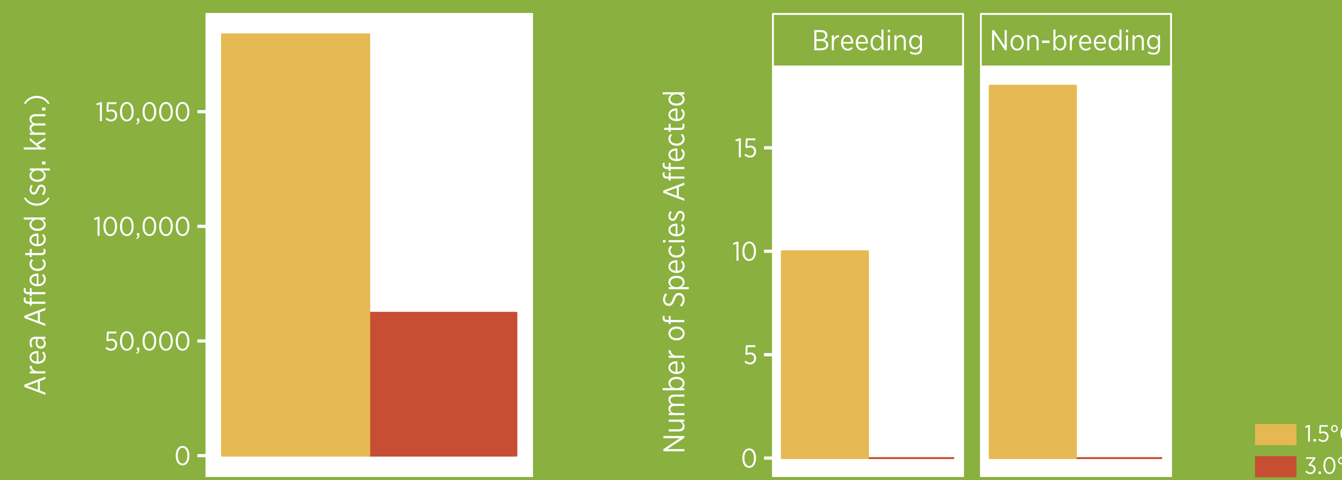
Cropland Expansion

The conversion of natural landscapes to agricultural land

Cropland expansion, the conversion of natural landscapes to agricultural land, continued at an alarming pace in recent decades. In the conterminous United States, rates of net conversion to cropland exceeded 10% per year in some regions.[51] Continued habitat loss and fragmentation mean declining populations, most notably for grassland birds, which have declined by more than 40% since 1966.[52]

Projected cropland expansion under a 1.5°C warming scenario affected 10 (2%) and 18 (4%) species in the breeding and non-breeding seasons, and this included 2% and 9% of species classified as vulnerable to climate change range-wide. No species is projected to be affected across more than 10% of its conterminous U.S. range under a 3.0°C warming scenario. Thus, based on these projections, action to reduce the rise of global warming from 3.0°C to 1.5°C would not decrease the projected impacts of cropland expansion on birds. However, range-wide vulnerability of 38 grassland bird species, whose habitats are at particularly high risk to cropland conversion, could be reduced from 61% to 39% in the breeding season.[53]





SPECIES projected to be most affected by cropland expansion in their conterminous U.S. range include:

- Florida Scrub-Jay
- Limpkin
- Mangrove Cuckoo
- Snail Kite
- Short-tailed Hawk
- Wood Stork
- White-crowned Sparrow

STATES with the greatest area projected to be affected by cropland expansion include:

- Texas
- Florida
- Montana
- California
- Utah
- Colorado

Mangrove Cuckoo

White-crowned Sparrow

Intermittent Threats

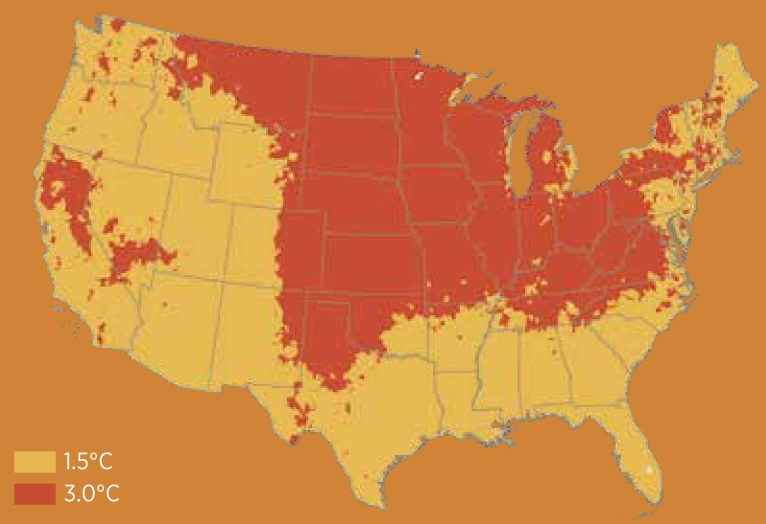
We considered five extreme weather variables: extreme spring heat, spring droughts, fire weather, heavy rain, and false springs. There is evidence that these types of intermittent events will become stronger and more frequent with climate change.[8,17] Birds may be more vulnerable to extreme events because of their haphazard and abrupt nature, which can drastically reduce population numbers.[39] Extreme weather can have significant effects on populations through direct impacts on reproduction and survival and indirect impacts on habitat and resource availability.[16,54]

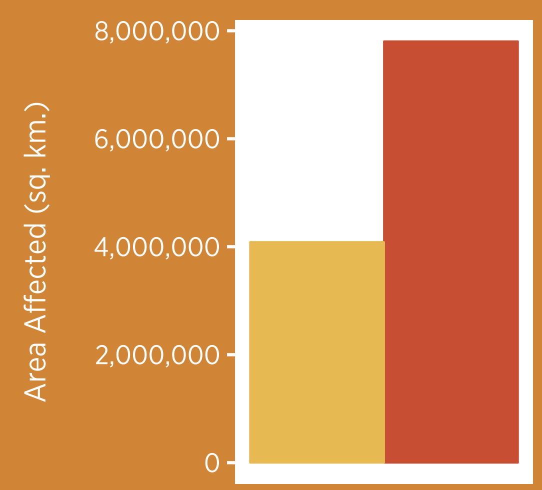
Extreme Spring Heat

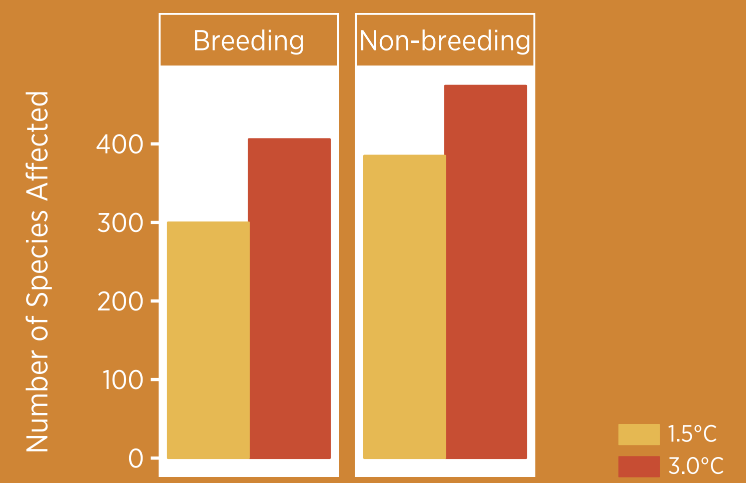
Warming temperatures and accompanying extreme heat

Warming temperatures and accompanying extreme heat are the most probable threat of future climate change.[8,9] Extreme spring heat can directly affect birds through heat stress,[55] which can lead to mass mortality events,[56] and subsequently reduce populations and species richness locally.[57] Here, we estimated the frequency of extreme spring heat based on a standardized temperature index (STI) that defines extreme events in terms of a standard normal distribution, with the index representing the frequency of a 20-year extreme event, and reciprocal values (i.e., 1/STI) representing the return interval for that event. We mapped locations where we expect extreme spring heat to occur at least every two years in the future.

In both the breeding and non-breeding seasons, extreme spring heat affected 99% of species under a 3.0°C warming scenario, including 99% and 100% of vulnerable breeding and non-breeding species. These impacts on species were commensurate with the area affected, as extreme spring heat was projected to occur more broadly across the conterminous United States under 3.0°C warming. Action to reduce global warming from a 3.0°C scenario to a 1.5°C scenario would reduce the number of species affected by increased extreme spring heat events. Under a 1.5°C warming scenario, increased extreme spring heat would affect more than 50% of the range of 300 (67%) and 385 (82%) species in the breeding and non-breeding seasons, including 73% and 97%, respectively, of species classified as vulnerable range-wide.








American Robin

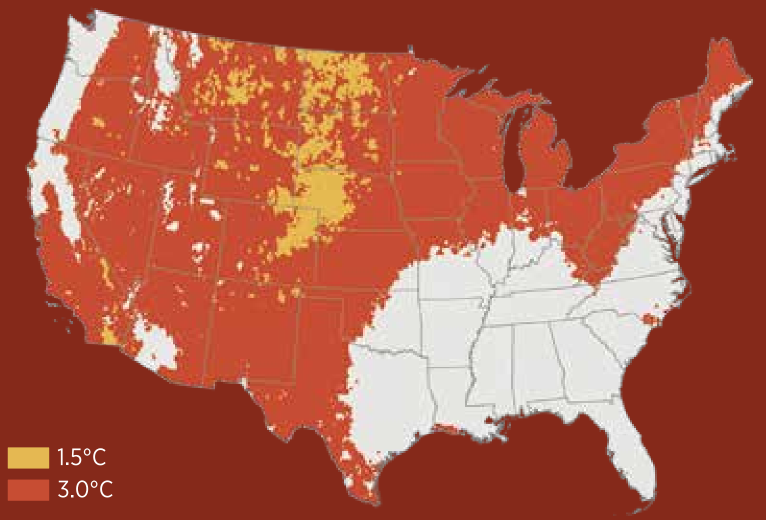

Northern Pintail

Nearly all species and states would be affected by higher frequencies of extreme spring heat under a 3.0°C warming scenario. The projected occurrence of extreme spring heat coincided with high species richness in the West and Southeast under a 3.0°C warming scenario.

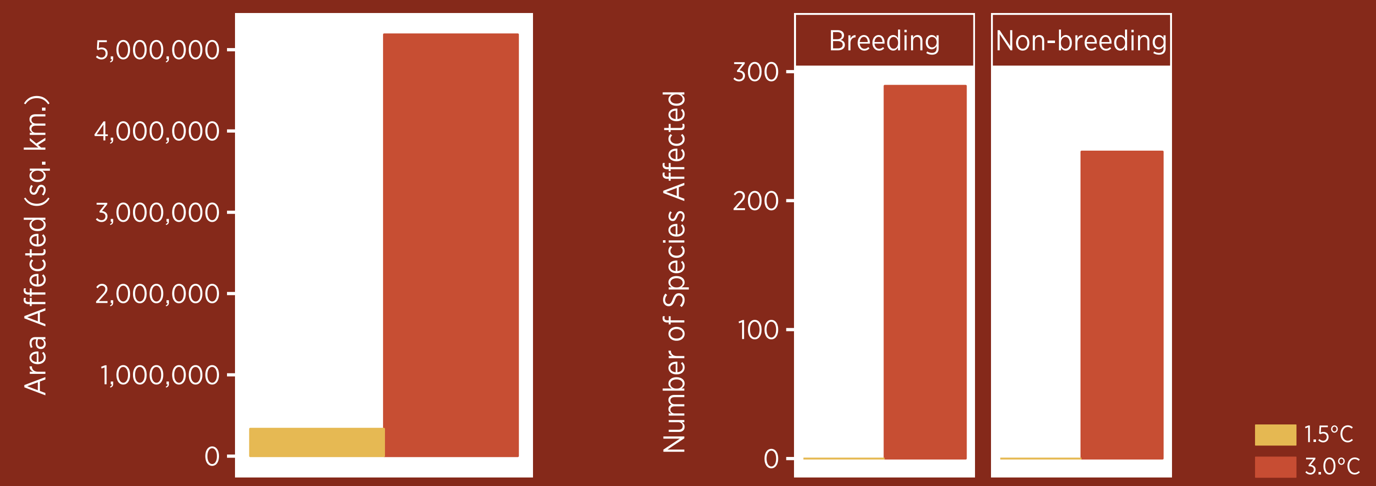
Fire Weather

Weather conditions suitable for fire in a given season

Fire is a complex process that, while destructive in its immediate effects, can also play an important role in maintaining habitat and avian diversity over time.[58] The impacts of fire vary depending on multiple factors, including species, habitat type, and severity, but are generally damaging in the short term, leading to mortality, displacement, and population declines for some species.[59] Over time, birds may return to burned areas as vegetation regenerates, providing diverse foraging and nesting opportunities for many species.[60] Here, fire weather (based on the Keetch-Byram Drought Index), a measure of soil moisture deficit and drought indicative of wildfire potential, was mapped as locations where 90 days a year or more exceed the current 95th percentile of the fire weather index. This suggests an increase in weather conditions suitable to fire in a given season, but does not necessarily translate into more fires because fire events also require appropriate weather in addition to available fuels and suitable topography, plus an ignition source.[61]



Under a 3.0°C warming scenario, increase in fire weather affected 289 (71%) and 238 (50%) species in the breeding and non-breeding seasons, and this included 78% and 56% of species classified as vulnerable to climate change range-wide. Action to reduce global warming rise from 3.0°C to 1.5°C would reduce the number of species affected by increased fire weather. Under a 1.5°C warming scenario, increased fire weather would not affect more than 50% of the range of any species.




Greater Sage-Grouse

SPECIES projected to be most affected by higher frequencies of fire weather in their conterminous U.S. range include:

ARIDLANDS

Greater Sage-Grouse
Brewer's Sparrow
Sage Thrasher
Scaled Quail

WESTERN FORESTS

Pinyon Jay
Hepatic Tanager
Virginia's Warbler
Juniper Titmouse

GRASSLANDS

Baird's Sparrow
Lesser Prairie-Chicken
Lark Bunting

STATES with the greatest area projected to be affected by increased fire weather include:

Large portions of all western states, the Upper Midwest and Great Lakes region, and the Northeast

Texas, Montana, New Mexico, California, and Colorado, though this is only because they are the largest western states

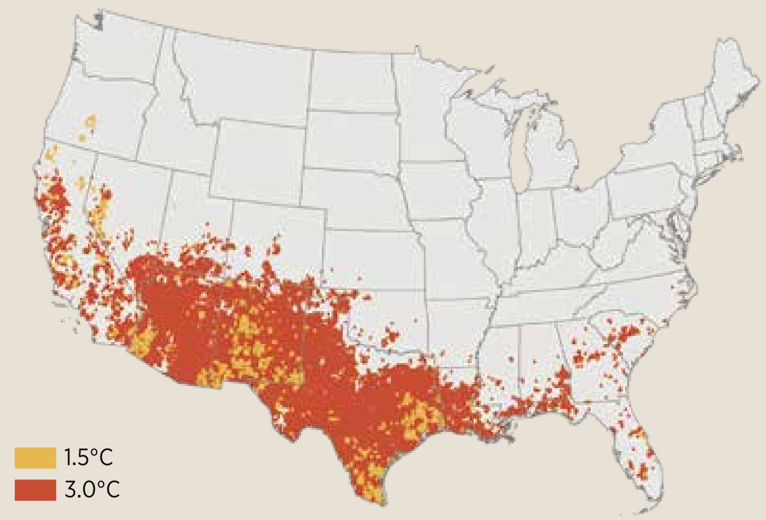

Scaled Quail

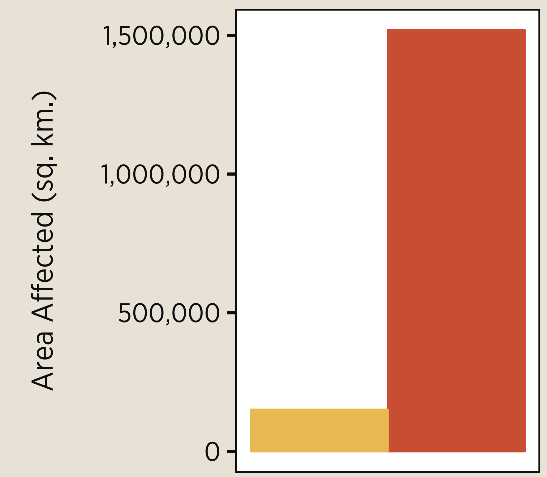
Spring Droughts

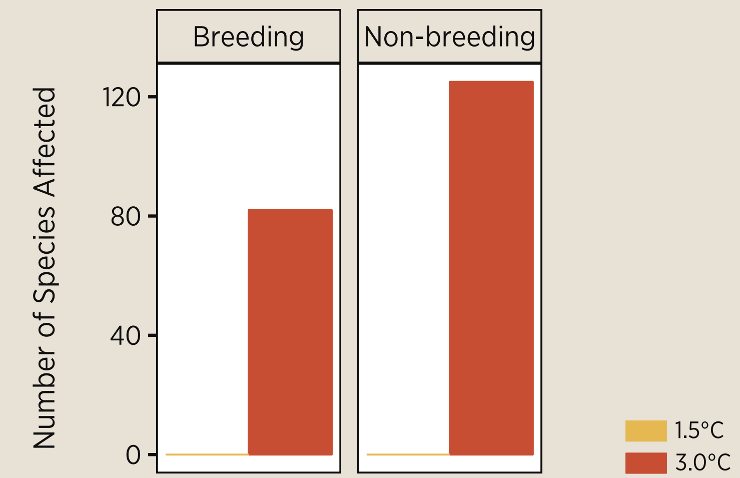
Drier than normal conditions due to less rainfall and higher temperatures

Both the frequency and magnitude of spring droughts are projected to increase with climate change.[61] Similarly, droughts can also cause mortality,[54,62] diminish reproductive success,[63] lead to declines in abundance and richness,[64] and trigger species movement.[65] Here, we estimated spring drought frequency based on a standardized precipitation index (SPI) that defined extreme events in terms of a standard normal distribution, with the index representing the frequency of 20-year extreme events, and reciprocal values (i.e., 1/SPI) representing the return interval for that event. We mapped locations where spring droughts are expected to occur every 10 years or more often in the future.

Under a 3.0°C warming scenario, spring droughts affected 82 (20%) and 125 (26%) breeding and non-breeding species, amounting to 14% and 24% of species classified as vulnerable in the breeding and non-breeding seasons, respectively. Action to reduce the increase in global warming from 3.0°C to 1.5°C would reduce the impact of spring droughts. Under a 1.5°C warming scenario, spring droughts would not affect more than 50% of the range of any species.







SPECIES projected to be most affected by drought in their conterminous U.S. range include:

Those whose range extends into northern Mexico:

- Montezuma Quail
- White-tipped Dove
- Altamira Oriole
- Verdin

Southwestern species with ranges concentrated in the United States:

- Abert's Towhee
- Gambel's Quail
- Black-capped Vireo

STATES with the greatest area projected to be affected by spring droughts include:

- Texas
- New Mexico
- Arizona
- California
- Louisiana


Altamira Oriole

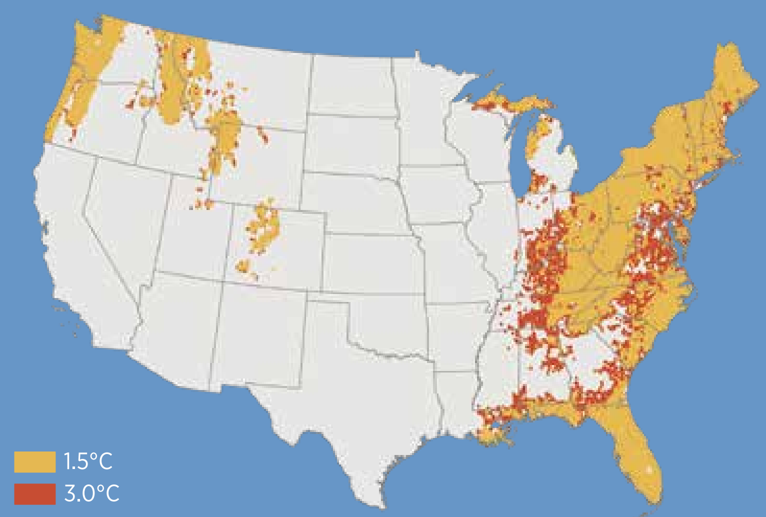

Gambel's Quail

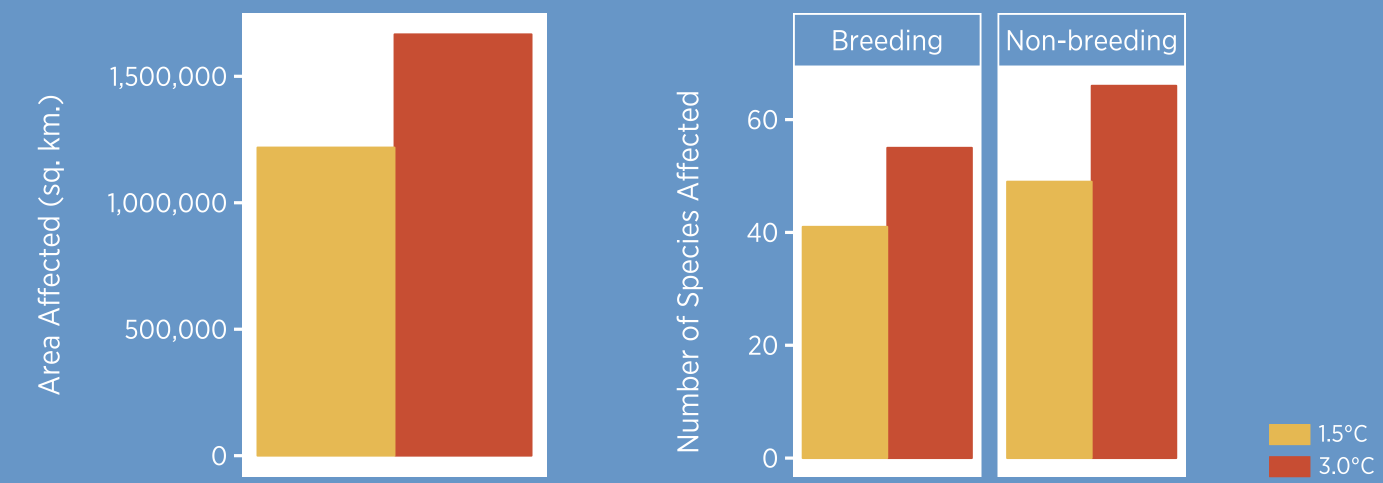
Heavy Rainfall

More frequent, single-day high rainfall events

What are today considered infrequent heavy rain events will become stronger and more frequent with climate change.[9,17] Heavy rainfall can reduce foraging time as well as flooding nests and burrows, killing chicks.[54,66–70] Here, we estimated the frequency of heavy rain events based on the number of days above the 95th percentile of historical precipitation totals and mapped any location projected to have more than 10 days a year of heavy rain events.

Under a 3.0°C warming scenario, heavy rains affected 55 (13%) and 66 (14%) breeding and non-breeding species, amounting to 19% and 22% of species classified as vulnerable in the breeding and non-breeding seasons, respectively. Action to limit global warming to 1.5°C instead of 3.0°C would reduce the impact of heavy spring rain events. Under a 1.5°C warming scenario, heavy spring rains would affect 9% of breeding and 10% of non-breeding species, including 15% and 20% of species classified as vulnerable in the breeding and non-breeding seasons, respectively.






Fish Crow

SPECIES projected to be most affected by heavy spring rains in more than 90% of their range include:

- Snail Kite
- Spot-breasted Oriole
- Brown-headed Nuthatch
- Fish Crow
- Worm-eating Warbler

STATES with the greatest area projected to be affected by heavy rains include:

- Florida
- New York
- North Carolina
- Pennsylvania
- Virginia
- Maine
- Washington
- Kentucky

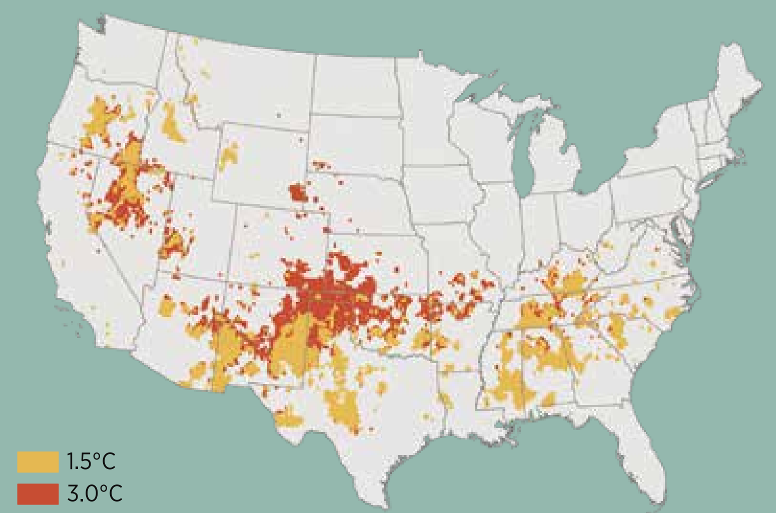

Brown-headed Nuthatch

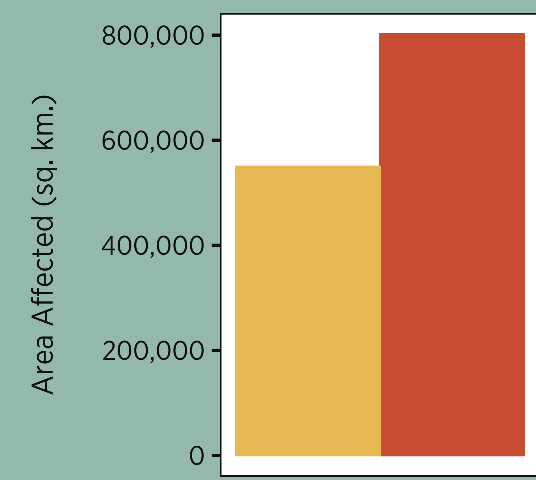
False Springs

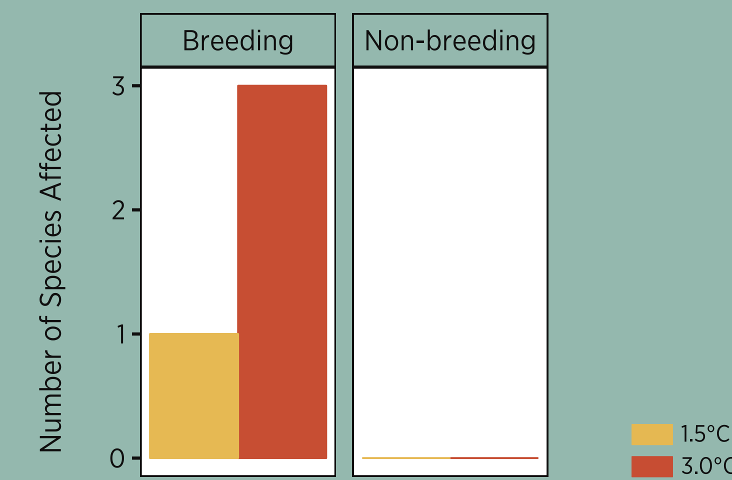
When a hard freeze occurs after vegetation has begun to grow leaves because of unseasonably warm temperatures

False springs happen when a hard freeze occurs after trees and other vegetation have already begun to grow leaves because of unseasonably warm temperatures in late winter or early spring. The freeze can damage leaves and new growth, affecting plant vigor and seed production, and causing subsequent cascading effects throughout the ecosystem.[71,72] These include fewer food sources for primary consumers,[73] which then limits the resources needed for survival of young.[74] Here, false springs were calculated as the probability of a hard freeze after leaf and flower emergence, and we mapped places projected to have a 50% or greater chance of a false spring in the future.

False springs threatened the fewest number of species of all the extreme weather events considered. In total, three species (less than 1%) across seasons had false springs likely to occur in more than 50% of their conterminous U.S. range. However, all three of these species were classified as vulnerable range-wide. Actions to limit global warming to 1.5°C instead of 3.0°C would reduce from three to one the number of species affected by false springs across more than 50% of their U.S. range.







SPECIES projected to be most affected by false springs include:

More than 50% of the conterminous U.S. range of three southwestern species:

Golden-fronted Woodpecker
Bridled Titmouse
Montezuma Quail

Each of these species has a large percent of its range in northern Mexico, which was not part of this analysis. Thus, the area affected in the species' entire range was likely less than 50%.

Other species expected to face false springs in less than 50% of their conterminous U.S. range were concentrated in the southwestern states.

STATES with the greatest area projected to be affected by false springs include:

New Mexico
Texas
Oklahoma
Nevada
Oregon
Arizona


Golden-fronted Woodpecker


Montezuma Quail

PART 3:

Policy Agenda

Translating Science Into Action

This report outlines a number of ways in which climate change harms birds. Warming will influence temperature and precipitation, alter plant and insect communities, and affect the availability of food, forage, water, and shelter for birds. Predator and prey relationships will change, as will migration patterns. In addition, climate change will cause sea level rise and increasingly extreme weather volatility, amplifying the intensity and unpredictability of storms, rainfall, drought, wildfires, flooding, heat waves, and false springs. Over time, how people use land—for urban living or agriculture—will also change, with inevitable impacts on bird populations. The number and complexity of these threats and their cumulative impacts on birds is sobering.

Audubon is translating these scientific findings into an action plan for bird conservation and public policy change. We work in critical places that birds need—in coastal areas, watersheds, grasslands, forests, working lands, and other ecosystems—to address all of the threats they face from climate change. We do this because we love birds, but also because we know that birds are sentinel species, the proverbial canary in the coal mine. They are nature's early indicators of harm to the environment that is also our life-support system, and of growing danger to people and the places we need, too.

The findings of this report make it clear that we must not only protect birds and the places they need, but we must also advance solutions that address the underlying causes of climate change.

We can do this

We know what we need to do.

We have the ability to reverse the direction of this massive threat. We can adapt, improve, and innovate; we can protect birds, the planet, and ourselves. We can power our cars, homes, cities, factories, farms, communities, and economy with clean energy—without contributing to climate change. We can plan for and adapt to the changing climate. We can build a productive, resilient, and climate-safe future. We can do all of this in ways that spur innovation, create good jobs, promote homegrown industries, and build our economy for a smarter future.

We still have time.

We can avert and limit dangerous warming and its worst impacts if we act quickly. Science tells us that in order to limit warming to a rise of 1.5°C (2.7°F), we must reduce greenhouse gas emissions 45% below 2010 levels by 2030, and reach net-zero carbon emissions by 2050.*

Audubon's science tells us what this means for birds: 64% of bird species will be vulnerable to extinction due to the various pressures caused by the changing climate if we continue on our current trajectory. The good news is that for 70% of those species, we can reduce their vulnerability by limiting warming to 1.5°C.

Some **64% of bird species will be vulnerable** to extinction due to the various pressures caused by the changing climate, but **we can reduce the vulnerability of 70%** of those species by limiting warming.

We must act now.

We are on a dangerous path, but we have the power to chart a better one. Still, change will come only if we demand action from the public officials who represent us and the businesses we support. We must mitigate the underlying causes of the changing climate and build resiliency into our natural and human systems to give us time to act and adapt. At Audubon, we are asking our public officials to change course, to address climate change now, and to set an example for the rest of the world to follow.

We ask you to join us. Be part of the solution. We can do this, together.

** In October 2018, the Intergovernmental Panel on Climate Change (IPCC) released the Special Report on Global Warming of 1.5°C. The report was prepared by 91 authors from 40 countries, and included more than 6,000 scientific references. One of the key findings is that warming of 2°C (3.6°F) will result in challenging impacts to ecosystems and human health, but that limiting warming to 1.5°C (2.7°F) would greatly reduce these outcomes. The report also found that while a 1.5°C (2.7°F) target is possible, it will require deep emissions reductions across all aspects of society, culminating in a goal of net-zero emissions by 2050.*

Causes of the changes to our climate

Climate change is the result of the rapid increase in greenhouse gas emissions following the Industrial Revolution. Earth's atmosphere naturally contains greenhouse gases like carbon dioxide (CO2), methane (CH4), and water vapor (H2O), which trap heat from the sun and make Earth a habitable place for people, plants, and birds. However, CO2 concentrations in the atmosphere have risen from 280 ppm around 1750 to more than 400 ppm today. This increase in greenhouse gas concentration disrupts natural cycles and causes temperatures to rise across the globe.

The scientific consensus is clear. The only way to achieve a more favorable future for birds and people is to address the underlying causes of the changing climate. We must reduce greenhouse gas emissions at an urgent speed and on a wide scale from every sector of the economy—electricity generation, agriculture, transportation, commercial and residential buildings, and industrial processes. There is no single perfect solution, but we can make a series of changes that lead to large-scale, systemic adjustments to achieve the required reductions.

There are two goals we must meet:

By 2030 | Greenhouse gas emissions must drop 45% below 2010 levels.

By 2050 | The world must achieve net-zero greenhouse gas emissions.

Net-zero means that some emissions may be offset by carbon sequestration like reforestation or by technology that removes greenhouse gases from the air.

Decarbonization: The reduction of carbon emissions

Greenhouse gases (GHG) are heat-trapping gases in our atmosphere. They include carbon dioxide (CO2), methane (CH4), nitrous oxide (N2O), and hydrofluorocarbons. GHG are emitted through the burning of fossil fuels and other industrial processes. They are reported as atmospheric concentrations in parts per million (ppm).

The U.S. Environmental Protection Agency divides up and tracks greenhouse gas emissions across six sectors: electricity, transportation, industry, agriculture, commercial, and residential. These six sectors break up the U.S. economy into smaller pieces that make it easier to understand trends. Each year, the EPA publishes an estimate of greenhouse gases produced by each sector.

Audubon's strategy for addressing the changing climate focuses on climate adaptation and climate change mitigation

Audubon has a two-pronged approach: Protecting birds and the places they need, and addressing the underlying causes of climate change.

Climate change is a worldwide problem that will affect birds and people. There is no single silver bullet or simple solution to this complex, systemic threat. We need to act on a range of policy solutions that work at a speed and scale that matches the gravity and urgency of the problem.

Fortunately, there is good news. We understand a lot about how the climate is changing and why, and we understand what we need to do about it. Many of the tools we need already exist, and many people and institutions are working to implement them. We are also confident that we can continue to build innovative new technologies to help avert climate change in the future, and in the process lead the world in developing the products that will drive that change.

Climate adaptation refers to efforts to alter and adapt both our natural surroundings and our buildings, roads, and other structures to better withstand the threats posed by climate change.

Climate mitigation refers to efforts to reduce or prevent the causes of climate change, like greenhouse gas emissions.

Climate adaptation: Protecting birds and the places they need—and people and the places we need

Our report highlights the places and species in greatest need of climate adaptation planning. Audubon has comprehensive conservation strategies in place to protect these places and the species that depend on them. We are working to adapt to the new extremes that make it harder for birds and people to thrive, and at the same time working to avert those impacts. Across all of our conservation and advocacy, we aim to stabilize and increase the populations of flagship species in our high-priority conservation areas.

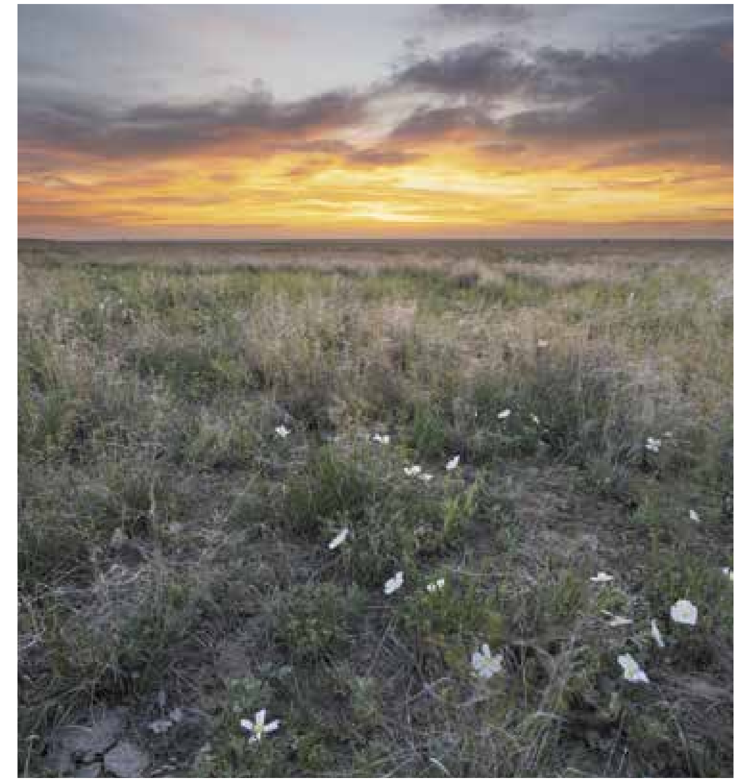
Climate change is causing rising temperatures and sea levels as well as more frequent extreme weather events. Drought is more common in the West, while heavy rain events and flooding are more regular in the East. These disruptions necessitate the protection and adaptation of our communities and natural spaces to the changing world, even as we work to mitigate the causes.

Some of the worst impacts of climate change can be avoided by building more resilient infrastructure, meaning our cities, roads, and other structures. This approach includes raising roads, erecting seawalls, and siting construction farther from the coast. Some of these same outcomes can be accomplished through a focus on natural—or green—infrastructure. This means using and enhancing natural areas and processes to help manage extreme weather and seasonal variations. Natural infrastructure has the dual benefit of protecting investments and providing habitat for birds and other wildlife. Enhancing and protecting "natural infrastructure" along our coasts, rivers, and in other strategic places will help delay and mitigate the anticipated impacts of climate change, allowing birds, wildlife, and people to adapt.

Climate adaptation: Protect and expand the places birds need by persuading localities, states, and the federal government to plan and prepare for the impacts of climate change on our coasts, watersheds, grasslands, forests, working lands—public and private—and communities.

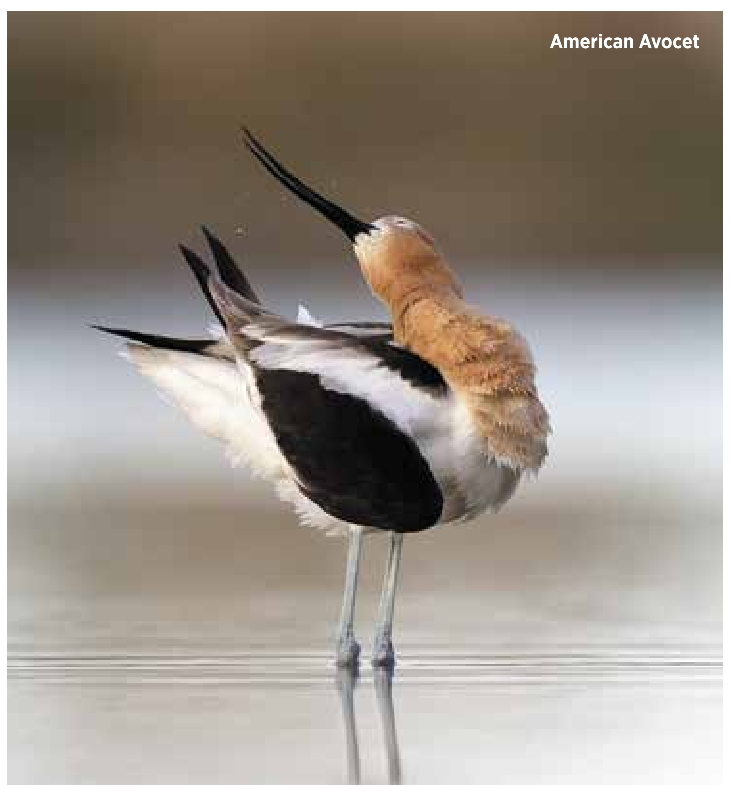
Coasts

Audubon has identified the best opportunities to increase the resilience of coastal wetlands in key places, and has implemented innovative restoration and adaptation solutions capable of being replicated. We are driving public investment to projects offering the greatest benefits for birds and people, and advancing federal and state policies that preserve coastal habitats. Investing in natural infrastructure—such as restoring wetlands, living shorelines, and barrier islands—can serve as our first line of defense against the threat of sea level rise and lake level change. Audubon's Coastal Resilience Initiative works to protect and restore coastal habitats for birds and people.



Grasslands, Forests, and Other Working Lands

Audubon works to increase bird-friendly and sustainable land management practices by partnering with private land managers, using conservation incentives and easements, pioneering market-based incentives, and striving to influence state and federal policies. We have been successful in increasing the public/private funding available to conservation-minded landowners, and in engaging large numbers of partners in this work. Conservation management of working lands can help birds adapt to threats like cropland expansion and wildfires. Minimizing additional conversion of natural habitats to croplands through market-based programs like Audubon's Conservation Ranching Initiative is an important climate change adaptation strategy.


American Avocet

Water

Audubon works to ensure that key landscapes critical to birds have clean and reliable sources of water, now and in the future. We aim to ensure adequate funding to protect and restore priority watersheds and rivers, at the state and federal level. We lead on-the-ground habitat restoration projects, and work to protect water quality and water supply for people and birds. We advocate for international, federal, and state policy actions to ensure adequate flows and clean water to critical ecosystems. Smart water management, including the adoption of natural infrastructure, can help birds adapt to threats like drought and extreme rain events. Audubon's Western Water Initiative and our work in the Everglades have helped protect the freshwater and associated ecosystems that birds and people need.

Bird-Friendly Communities

Audubon is committed to transforming our communities into places where birds flourish. We work to restore the ecological functioning of our cities, towns, and rural areas by ensuring urban conservation that is mindful of native plants and natural ecosystems. We also mobilize municipalities to advocate for climate-friendly policies. The creation of bird-friendly communities is essential to helping birds adapt to such threats as urbanization and false springs. Audubon's Plants for Birds program helps homeowners identify native plants that provide forage and shelter to birds and other wildlife.

Black Skimmer

Adaptation is an important part of responding to climate change, but it cannot be the only part.

Adaptation must be combined with efforts to meaningfully reduce greenhouse gas emissions.

Gray infrastructure:

Engineered and constructed systems such as roads, pipes, ditches, and pumps. The term "gray" is used because these structures are often made of concrete.

Green or natural infrastructure:

Landscape management practices that mimic natural cycles such as wetland restoration and green roofs. Many of these practices can provide the same benefits as gray infrastructure at a lower cost and with less frequent maintenance.

Climate change mitigation: Addressing the underlying causes of climate change

We are working against the clock to get solutions in place that counteract the underlying causes of climate change. In order to keep the world on track for a 1.5°C (2.7°F) warming scenario, we must reduce greenhouse gas emissions by 45% below 2010 levels by 2030 and reach net-zero carbon emissions by 2050. This means working to dramatically reduce carbon emissions from the U.S. and world economies, and finding ways to offset what we cannot eliminate, for instance by planting trees or by testing new technologies to capture (i.e., sequester) carbon through industrial processes and store it underground permanently.

In order to achieve this vision, we are advocating for a suite of solutions and policies that will work together to drive down emissions at the scale and speed we need.

Economy-Wide Solutions

We support comprehensive federal legislation or large building block policies that set binding emissions reduction targets, drive large-scale emission reductions, and protect or expand the places birds need.

Using the power of the economy to drive solutions to the climate crisis is essential and has broad appeal in principle, though many of the details are still up for debate. Attaching a price to carbon emissions can help drive innovation and raise revenue to make widespread changes, and help level the playing field for clean energy. Those sources that continue to emit carbon emissions would either pay for their impact or find a new way to do business that is less harmful to the climate. Some examples of economy-wide solutions include placing a fee on carbon emissions, which would require businesses to pay for each metric ton of carbon emitted, or a cap-and-trade program, which sets a limit—or a cap—on total emissions throughout the economy. With a cap-and-trade program, businesses that want to continue to emit carbon must purchase credits they can then trade with other businesses.

100% Clean Electricity

We support a transition to 100% clean electricity by increasing renewable energy, preserving carbon-free energy sources, and phasing out coal power while protecting birds in their interactions with transmission lines and new energy systems.

Electricity generation contributes more than a quarter of greenhouse gas emissions in the United States. The reason we can turn on a light is that we are connected to an electrical grid that links generators—like power plants—to users—like us. Emissions from this sector are significant because the majority of our electrical grid is connected to power plants that burn fossil fuels like coal, oil, and natural gas.

While we currently rely on these fuels to generate the majority of our electricity, there are a number of technology options that do not emit greenhouse gases as they operate, like wind turbines, photovoltaic solar panels, geothermal, and hydropower. Replacing fossil fuel-burning power plants with these cleaner alternatives is essential to reducing emissions.

State and federal standards that require electricity suppliers to provide 100% clean electricity can drive this change. Audubon supports the expansion of renewable energy—like wind, solar, geothermal, and hydropower—that avoids, minimizes, and mitigates impacts to birds and their habitat. It is important to rapidly deploy this technology, and to deploy it in a way that minimizes negative impacts to birds, land, and communities. Scientifically sound and innovative approaches for siting and operating renewable projects exist, and are getting better all the time. Audubon also supports maintaining all carbon-free energy technologies—at least during the transitional period as renewable power is scaled up and built out—with some conditions.

American Robin

Natural Climate Solutions

We support the expansion, preservation, restoration, and protection of landscapes that can naturally store carbon and provide places that birds need. These landscapes include forests, wetlands, coasts, and grasslands. This includes the improvement of agriculture greenhouse gas reduction programs such as soil sequestration and livestock/land-use management.

Natural solutions rely on living things that remove carbon dioxide from the atmosphere, like forests, prairies, sea grass, and soil. We call these features carbon sinks because they remove more emissions from the atmosphere than they emit. With natural solutions helping to remove carbon, it may be possible to achieve net-zero carbon emissions even if all manmade emissions cannot be eliminated. As Audubon's science shows, North American birds will become increasingly vulnerable as climate alters and shrinks their suitable ranges. The restoration of forests, grasslands, marshes, and marine ecosystems as well as diversified agricultural practices can draw down emissions while simultaneously improving critical bird habitat. As an example, Audubon's Conservation Ranching Program was developed to combat the negative effects of grassland degradation resulting from invasive species encroachment, urbanization, energy development, and unsustainable livestock management practices. Careful management of these landscapes provides an opportunity for natural carbon sequestration while also preserving important bird habitat.

Energy Efficiency for Buildings, Homes, and Industry

We support a reduction of the amount of energy needed to power our homes, cities, and factories through the advancement and adoption of energy-efficient appliances, machines, and practices.

While it is important to make sure that our supply of energy is emissions-free, we can make that goal more attainable by reducing our demand for electricity, meaning the total amount of electricity that must be generated. The challenge of the electrical grid is that there must be enough electricity flowing through it to match the needs of consumers at all times. However, if we reduce the amount of energy needed by consumers—particularly at times of peak need—we can significantly reduce the amount we need to generate, meaning that we do not need to run power plants as much or install as many renewables. This demand-side reduction eases the pathway to 100% clean energy. Taking actions like installing more efficient appliances and weatherizing buildings can add up to make a big difference.

Clean Transportation

We support actions that reduce tailpipe emissions from vehicles including cars, freight trucks, and airplanes. These reductions may be reached through fleet-wide improvements in fuel economy, increased use of electric vehicles, and strengthening and expanding public transit systems.

Transportation is currently the largest source of greenhouse gas emissions in the United States. These emissions come from the combustion of gasoline that powers the engines of personal vehicles, as well as the trucking and shipping of goods and materials across the country and around the world. These emissions can be eliminated by shifting to electric vehicles, which do not require gasoline, or to more fuel-efficient vehicles, which require less gasoline for every mile traveled. Policies that can incentivize this transition include setting fuel-efficiency standards that require manufacturers to build fleets that are more fuel-efficient, and building charging infrastructure for electric vehicles so that there are more places where drivers can fuel up. Improvements can also be made in public transit—by expanding and improving routes and transitioning to electric buses—to get more cars off the road.

Innovation

We support investment in the invention, improvement, and deployment of technology that will reduce greenhouse gas emissions in every sector of the economy through research, public-private partnerships, and market-driven solutions.

Many of the solutions we will need to achieve a zero-carbon future have already been developed, but there are still gaps where technology needs to be improved or has not yet been invented. Improving energy storage technology—to even out surges in renewable energy generation and to provide continuous, resilient power—is an area of great promise. We still have questions about how to make the electrical grid more secure and reliable, whether it is possible to design more efficient electrical generation units, and whether it is possible to capture greenhouse gases from the air and securely store them. We must dedicate resources to institutions and researchers who are working to fill these gaps.

Audubon is working on climate solutions in backyards and at all levels of government across the country. Visit **climate.audubon.org** to learn more about our work and what you can do to help.

Appendix

American Goldfinch

Datasets

Sea Level Rise

We mapped areas of sea level rise-induced flooding and ensuing habitat transitions based on spatial projections of sea level rise and associated marsh migration from NOAA's Office for Coastal Management (available from *https://coast.noaa.gov/slr/*). Projections are based on a modified bathtub approach that incorporates LIDAR-derived elevation data and attempts to account for local and regional tidal variability.[75] Outputs are available for the conterminous United States at a 10-meter spatial resolution, with scenarios of up to 10 feet (about 3 meters) provided in half-foot increments. We selected scenarios of 0.5 meter and 1.0 meter, which crosswalk with estimates from the IPCC for 1.5°C and 3.0°C warming scenarios by the end of the century,[43] as well as an additional "extreme" scenario (2 meters) to capture current high-end estimates of sea level rise under a 3.0°C scenario.[12,13,15] We then downscaled these global scenarios to states using a dataset from the National Climate Assessment that localizes global sea level rise projections.[44] Downscaled estimates are available for six sea level rise scenarios (0.3, 0.5, 1.0, 1.5, 2.0, and 2.5 meters) at 263 locations within the 22 coastal states in the conterminous United States (mean = 12 locations per state, range = 2-44). Because downscaling by state resulted in variations of more than 1.0 meter (i.e., the 2.5-meter scenario could result in state-level sea level rise of more than 3.5 meters), the 2.0-meter scenario was the highest scenario we could include to maintain our ability to match downscaled estimates to spacial projections, which were only available for scenarios up to 10 feet (about 3 meters).

Lake Level Change

We obtained spatial projections of lake level change for the Laurentian Great Lakes from NOAA's Office for Coastal Management (available from *https://coast.noaa.gov/llv/*). Estimates of lake extent within the United States are available for scenarios of - minus-6 to +plus-6 feet of change based on LIDAR-derived topographic and bathymetric elevation data. Lake levels are generally expected to decline under climate change as (1) surface water temperatures warm, increasing rates of evaporation, and (2) lake ice forms later, extending the season for evaporation.[46] However, lake levels also vary considerably.[46] Therefore, we combined historical low and high water levels with projections of future mean water levels for each lake to identify areas that could be affected by both drying (with low lake levels) and flooding (with high lake levels) in the future. Because minimums and maximums can be subject to outliers, we calculated the 1st and 99th percentile of water levels between 1860 and 2015 to estimate historical low and high water levels for each lake based on shoreline gauging data from NOAA's Great Lakes Environmental Research Laboratory (available from *www.glerl.noaa.gov*). Lake St. Clair was also included, and lakes Michigan and Huron were grouped because they are connected at the same water level. We combined historical variability with estimated mean water levels for Michigan-Huron for our two global warming scenarios from a previous assessment.[48] Estimates of long-term change for the other lakes are negligible under the assumption that water regulation practices will continue.[48] We used our combined estimates to select a low and high water level projection for each lake, and then combined these spatial projections (removing the current lake extent) to identify the total area prone to drying or flooding under our two climate change scenarios.

Urbanization

We obtained projections of urban growth from the EPA's Integrated Climate and Land Use Scenarios (ICLUS) dataset (available from *https://iclus.epa.gov*). ICLUS projections are derived from a pair of models: a demographic model generates county-level population estimates, and a spatial allocation model distributes new urban development in response to population growth. Outputs are available for the conterminous United States at a 90-meter spatial resolution for every decade between 2000 and 2100 under two general circulation models (GISS-E2-R, HadGEM2-ES) and two climate change scenarios combining shared socioeconomic pathways (SSPs) and RCPs (SSP2+RCP4.5 and SSP5+RCP8.5). We equated these scenarios at 2050 and 2100, respectively, to our two global warming scenarios, 1.5°C and 3.0°C.

Cropland Expansion

Projections of cropland expansion were obtained from a downscaled version of the Land-Use Harmonization (LUH) dataset,[76] a coarse-resolution gridded dataset spanning the years 1500 to 2100 that estimates urban and agricultural land-use patterns and transitions.[77] A previous assessment downscaled this dataset to a 1-kilometer resolution using a Cellular Automata approach, and outputs were generated for every decade between 2010 and 2100 under four representative concentration pathways (RCP2.6, RCP4.5, RCP6.0, and RCP8.5).[76] We utilized projections from RCPs 4.5 and 8.5 at 2050 and 2100, respectively, for our 1.5°C and 3.0°C scenarios.

Extreme Weather

We considered five extreme weather variables: extreme spring heat, spring droughts, fire weather, heavy rain, and false springs. Spatial projections were obtained from previous assessments[18,19] (available from *http://silvis.forest.wisc.edu/climate-averages-and-extremes/*)[71] that derived these variables from daily projections of the 19 GCMs participating in the Coupled Model Intercomparison Project 5 (CMIP5), statistically downscaled to a 12-kilometer resolution using the Bias-Corrected Constructed Analog technique.[78] Again we used projections from two RCPs (4.5 and 8.5), aligned with mid- and late-century, respectively, for our climate change scenarios. Extreme spring heat and spring droughts were calculated based on standardized indices, the standard temperature index [STI],[18] and the precipitation index [SPI],[79] respectively, that define extreme events based on a standard normal distribution, with outputs representing the frequency of 20-year extreme events, and reciprocal values (i.e., 1/x) representing the return interval.[18] Fire weather (based on the Keetch-Byram Drought Index, KBDI)[80] and heavy rain were calculated as the number of days above the 95th percentile of historical values.[19] Fire weather, a measure of soil moisture deficit and drought indicative of wildfire potential, provides a reference for weather conditions suitable for fire in a given season, but does not directly translate into more fires because fire events require not only appropriate weather, but also fuels, ignition sources, and topography.[60] False springs were calculated as the probability of a hard freeze after leaf and flower emergence.[71] We mapped areas affected by these extreme weather events by applying thresholds to convert continuous values into categorical outputs. We explored multiple thresholds of more frequent return intervals than 20 years for extreme spring heat and spring droughts, increased number of days above the historical values for fire weather and heavy rain, and increase in the probability of false springs. From this, we mapped the following areas: extreme spring heat happening every two years or more often in the future, spring droughts happening every 10 years or more often in the future, 90 days of the year or more exceeding the current 95th percentile of fire weather, 10 days of the year or more exceeding the 95th percentile of precipitation, and a 50% or greater chance of a false spring in the future.

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Captions and Credits

Cover Great Gray Owl. Photo: Connor Stefanison; **Inside Front** American Oystercatcher. Photo: Eric Mitch/Audubon Photography Awards; **Pg. 2** David O'Neill. Photo: Mike Fernandez/Audubon; **Pg. 2-3** American Goldfinches. Photo: Kathryn Sullivan/Shutterstock; **Pg. 4** Audubon has been working steadily to document how birds are already responding to climate change with Climate Watch, Audubon's community science program. Photo: Camilla Cerea/Audubon; **Pg. 5** Royal Terns. Photo: Peter Brannon/Audubon Photography Awards; **Pg. 8** Wood Thrush. Illustration: David Allen Sibley; Figures: Stamen Design; **Pg. 9** Mountain Plover. Illustration: David Allen Sibley; Figures: Stamen Design; **Pg. 10** Figures: Stamen Design; **Pg. 13** Black Rail. Photo: William Widmer; **Pg. 14** Illustrations: David Allen Sibley; **Pg. 15** National Audubon Society staff walk through Blackwater National Wildlife Refuge in Cambridge, Maryland. Photo: Camilla Cerea/Audubon; **Pg. 16** Sage Thrasher. Photo: Sharon Lindsay/Audubon Photography Awards; **Pg. 20** Illustrations: David Allen Sibley; **Pg. 23** Brown Pelican. Photo: Jean Hall/Audubon Photography Awards; **Pg. 24-25** Hurricane Florence made landfall on the North Carolina coast in September, 2018 causing extensive overwash and damage to the developed beaches of southern North Carolina. A few weeks later, this image was taken on Topsail Beach, North Carolina as Hurricane Michael moved through the area. Photo: Walker Golder; **Pg. 26** Banner: Tomasz Baranowski/Flickr (CC BY 2.0); **Pg. 27** Reddish Egret. Photo: Peter Brannon/Audubon Photography Awards; American Oystercatcher. Photo: Brian Kushner; **Pg. 28** Banner: Arizona Department of Transportation/Flickr (CC BY NC ND 2.0); Allen's Hummingbird. Photo: Barry Schirm/Audubon Photography Awards; **Pg. 29** Black Oystercatchers. Photo: Steve Lefkovits/Audubon Photography Awards; **Pg. 30** Banner: Gerrit van Harreveld/Flickr (CC BY NC ND 2.0); Mangrove Cuckoo. Photo: Jesse Gordon/Audubon Photography Awards; **Pg. 31** White-crowned Sparrow. Photo: Lou Orr; **Pg. 32-33** Alaska Army National Guard and Department of Forestry crews fight a wildfire near Talkeetna, Alaska in June 2019. Photo: Spc. Michael Risinger/U.S. Army National Guard; **Pg. 34** Banner: Jack Pease Photography/Flickr (CC BY 2.0); American Robin. Photo: Brian Kushner; **Pg. 35** Northern Pintail. Photo: Ann Pacheco/Audubon Photography Awards; **Pg. 36** Banner: Pacific Southwest Region 5/Flickr (CC BY 2.0); Greater Sage-Grouse. Photo: Evan Barrientos/Audubon; **Pg. 37** Scaled Quail. Photo: Jill Smith/Audubon Photography Awards; **Pg. 38** Banner: Jose Antonio Alba/Water Alternatives/Flickr (CC BY NC 2.0). Altamira Oriole. Photo: Darrell Crisp/Audubon Photography Awards; **Pg. 39** Gambel's Quail. Photo: Mick Thompson/Audubon Photography Awards; **Pg. 40** Banner: Elke Mader/Flickr (CC BY NC 2.0); Fish Crow. 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Photo: Luke Franke/Audubon; **Pg. 50** Rich Inlet, located in Pender County between Figure 8 Island and Lea-Hutaff Island, is one of the few natural inlets left in North Carolina. It is designated as critical habitat for Piping Plovers. Photo: Walker Golder; **Pg. 51** Because 85% of the forested land in the eastern United States is privately owned, Audubon North Carolina is helping private owners to preserve the shrub-land habitat fundamental for the survival of the Golden-winged Warbler. Photo: Camilla Cerea/Audubon; **Pg. 52** From top: Audubon's Coastal Resilience Initiative works to protect and restore coastal habitats for birds and people. Photo: Mike Fernandez/Audubon; American Avocet. Photo: Melissa Groo/Audubon Photography Awards; **Pg. 53** From top: Audubon's Conservation Ranching Initiative is an important climate change adaptation strategy. Photo: Evan Barrientos/Audubon; the creation of bird-friendly communities is essential to helping birds adapt to such threats as urbanization and false springs. Photo: Justin Merriman; **Pg. 54** Black Skimmer. Photo: Melyssa St. Michael/Audubon Photography Awards; **Pg. 55** Audubon advocates in Washington, D.C. Photo: Luke Franke/Audubon; **Pg. 57** American Robin. Photo: Luke Franke/ Audubon; **Pg. 58** Careful management of ranches provides an opportunity for natural carbon sequestration while also preserving important bird habitat. Photo: Evan Barrientos/Audubon; **Pg. 60** Audubon strongly supports properly sited wind power as a renewable energy source that helps reduce the threats posed to birds and people by climate change. Photo: Dennis Schroeder/NREL; **Pg. 61** American Goldfinch. Photo: Brian Kushner; **Inside Back** Piping Plovers. Photo: Melissa Groo/Audubon Photography Awards; **Figures and maps not credited above:** National Audubon Society, Science Division

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