



## Golden Gate National Recreation Area

### Background

Birds are useful indicators of ecological change because they are highly mobile and generally conspicuous. As climate in a particular place changes, suitability may worsen for some species and improve for others. These changes in climate may create the potential for local extirpation or new colonization. **This brief summarizes projected changes in climate suitability by mid-century for birds at Golden Gate National Recreation Area (hereafter, the Recreation Area) under two climate change scenarios (see Wu et al. 2018 for full results, and Langham et al. 2015 for more information regarding how climate suitability is characterized).** The high-emissions pathway (RCP8.5) represents a future in which little action is taken to reduce global emissions of greenhouse gases. The low-emissions pathway (RCP2.6) is a best-case scenario of aggressive efforts to reduce emissions. These emissions pathways are globally standardized and established by the Intergovernmental Panel on Climate Change for projecting future climate change. The findings below are model-based projections of how species distributions may change in response to climate change. A 10-km buffer was applied to each park to match the spatial resolution of the species distribution models (10 x 10 km), and climate suitability was taken as the average of all cells encompassed by the park and buffer.

### Results

**Climate change is expected to alter the bird community at the Recreation Area, with greater impacts under the high-emissions pathway than under the low-emissions pathway (Figure 1).**

Among the species likely to be found at the Recreation Area today, climate suitability in summer under the high-emissions pathway is projected to improve for 38, remain stable for 50, and worsen for 39 species. Suitable climate ceases to occur for 28 species in summer, potentially resulting in extirpation of those species from the Recreation Area (e.g., Figure 2). Climate is projected to become suitable in summer for 14 species not found at the Recreation Area today, potentially resulting in local colonization. Climate suitability in winter under the high-emissions pathway is projected to improve for 73, remain stable for 74, and worsen for 48 species. Suitable climate ceases to occur for 25 species in winter, potentially resulting in extirpation from the Recreation Area. Climate is projected to become suitable in winter for 20 species not

### IMPORTANT

This study focuses exclusively on changing climatic conditions for birds over time. But projected changes in climate suitability are not definitive predictions of future species ranges or abundances. Numerous other factors affect where species occur, including habitat quality, food abundance, species adaptability, and the availability of microclimates (see Caveats). Therefore, managers should consider changes in climate suitability alongside these other important influences.

We report trends in climate suitability for all species identified as currently present at the Recreation Area based on both NPS Inventory & Monitoring Program data and eBird observation data (2016), plus those species for which climate at the Recreation Area is projected to become suitable in the future (Figure 1 & Table 1). This brief provides park-specific projections whereas Wu et al. (2018), which did not incorporate park-specific species data and thus may differ from this brief, provides system-wide comparison and conclusions.

found at the Recreation Area today, potentially resulting in local colonization.

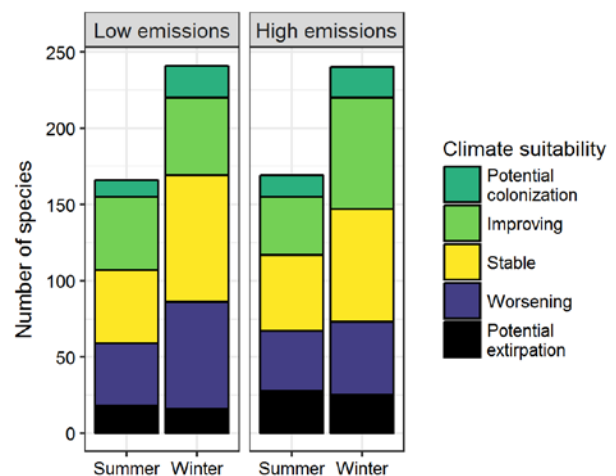


Figure 1. Projected changes in climate suitability for birds at the Recreation Area, by emissions pathway and season.

## Results (continued)

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### Potential Turnover Index

**Potential bird species turnover for the Recreation Area between the present and 2050 is 0.18 in summer (26<sup>th</sup> percentile across all national parks) and 0.10 in winter (8<sup>th</sup> percentile) under the high-emissions pathway. Potential species turnover declines to 0.13 in summer and 0.08 in winter under the low-emissions pathway.** Turnover index was calculated based on the theoretical proportions of potential extirpations and potential colonizations by 2050 relative to today (as reported in Wu et al. 2018), and therefore assumes that all potential extirpations and colonizations are realized. According to this index, no change would be represented as 0, whereas a complete change in the bird community would be represented as 1.

### Climate Sensitive Species

The Recreation Area is or may become home to 49 species that are highly sensitive to climate change across their range (i.e., they are projected to lose climate suitability in over 50% of their current range in North America in summer and/or winter by 2050; Table 1; Langham et al. 2015). While the Recreation Area may serve as an

### Management Implications

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Parks differ in potential colonization and extirpation rates, and therefore different climate change adaptation strategies may apply. **Under the high-emissions pathway, Golden Gate National Recreation Area falls within the low change group.** Parks anticipating low change can best support landscape-scale bird conservation by emphasizing habitat restoration, maintaining natural disturbance regimes, and reducing

### Caveats

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The species distribution models included in this study are based solely on climate variables (i.e., a combination of annual and seasonal measures of temperature and precipitation), which means there are limits on their interpretation. Significant changes in climate suitability, as measured here, will not always result in a species response, and all projections should be interpreted as potential trends. Multiple other factors mediate responses to climate change, including habitat availability, ecological processes

important refuge for 44 of these climate-sensitive species, 5 might be extirpated from the Recreation Area in at least one season by 2050.



**Figure 2. Although currently found at the Recreation Area, suitable climate for the American Robin (*Turdus migratorius*) may cease to occur here in summer by 2050, potentially resulting in local seasonal extirpation.** Photo by Andy Reago & Chrissy McClarren/Flickr (CC BY 2.0).

other stressors. Furthermore, park managers have an opportunity to focus on supporting the 44 species that are highly sensitive to climate change across their range (Table 1; Langham et al. 2015) but for which the park is a potential refuge. Monitoring to identify changes in bird communities will inform the selection of appropriate management responses.

that affect demography, biotic interactions that inhibit and facilitate species' colonization or extirpation, dispersal capacity, species' evolutionary adaptive capacity, and phenotypic plasticity (e.g., behavioral adjustments). Ultimately, models can tell us where to focus our concern and which species are most likely to be affected, but monitoring is the only way to validate these projections and should inform any on-the-ground conservation action.

## More Information

For more information, including details on the methods, please see the scientific publication ([Wu et al. 2018](#)) and the [project overview brief](#), and visit the [NPS Climate Change Response Program website](#).

### References

eBird Basic Dataset (2016) Version: ebd\_relAug-2016. Cornell Lab of Ornithology, Ithaca, New York.

Langham et al. (2015) Conservation Status of North American Birds in the Face of Future Climate Change. PLOS ONE.

Wu et al. (2018) Projected avifaunal responses to climate change across the U.S. National Park System. PLOS ONE.

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## Species Projections

**Table 1. Climate suitability projections by 2050 under the high-emissions pathway for all birds currently present at the Recreation Area based on both NPS Inventory & Monitoring Program data and eBird observation data, plus those species for which climate at the Recreation Area is projected to become suitable in the future. "Potential colonization" indicates that climate is projected to become suitable for the species, whereas "potential extirpation" indicates that climate is suitable today but projected to become unsuitable. Omitted species were either not modeled due to data deficiency or were absent from the I&M and eBird datasets. Observations of late-season migrants may result in these species appearing as present in the park when they may only migrate through. Species are ordered according to taxonomic groups, denoted by alternating background shading.**

\* Species in top and bottom 10th percentile of absolute change

^ Species that are highly climate sensitive

- Species not found or found only occasionally, and not projected to colonize by 2050

x Species not modeled in this season

Common Name	Summer Trend	Winter Trend
Brant	x	Stable
Cackling/Canada Goose	x	Stable
Mute Swan	x	Improving
Wood Duck	x	Improving*
Gadwall	Potential extirpation <sup>^</sup>	Stable
Eurasian Wigeon	-	Improving
American Wigeon	Potential extirpation <sup>^</sup>	Improving
Mallard	Improving <sup>^</sup>	Worsening
Mottled Duck	Potential colonization	-
Blue-winged Teal	Stable	Improving
Cinnamon Teal	x	Improving*
Northern Shoveler	Stable <sup>^</sup>	Stable
Northern Pintail	Potential extirpation	x
Green-winged Teal	-	Worsening
Canvasback	-	Stable

Common Name	Summer Trend	Winter Trend
Ring-necked Duck	-	Stable
Greater Scaup	Stable	Worsening* <sup>^</sup>
Lesser Scaup	-	Improving
Harlequin Duck	x	Potential extirpation
Surf Scoter	x	Stable
White-winged Scoter	x	Potential extirpation
Black Scoter	x	Stable
Long-tailed Duck	Stable	Stable
Bufflehead	x	Stable
Common Goldeneye	-	Potential extirpation
Barrow's Goldeneye	-	Potential extirpation <sup>^</sup>
Hooded Merganser	-	Stable <sup>^</sup>
Common Merganser	x	Potential extirpation
Red-breasted Merganser	Stable	Stable <sup>^</sup>

<b>Common Name</b>	<b>Summer Trend</b>	<b>Winter Trend</b>
Ruddy Duck	Stable	Stable
Plain Chachalaca	-	Potential colonization
California Quail	Worsening	Worsening
Ring-necked Pheasant	Improving*	Potential extirpation
Wild Turkey	x	Stable
Red-throated Loon	Stable	Stable
Pacific Loon	Stable	Worsening
Common Loon	Potential extirpation	Stable^
Pied-billed Grebe	x	Improving
Horned Grebe	x	Worsening
Red-necked Grebe	Potential extirpation	Potential extirpation^
Eared Grebe	x	Stable
Western Grebe	x	Improving
Clark's Grebe	x	Stable
Northern Fulmar	x	Stable
Black-vented Shearwater	-	Stable
Northern Gannet	Stable^	-
Brandt's Cormorant	x	Worsening
Double-crested Cormorant	x	Stable
Pelagic Cormorant	x	Worsening
Anhinga	Potential colonization^	-
American White Pelican	x	Improving*
Brown Pelican	Improving	Worsening^
American Bittern	-	Improving^
Least Bittern	-	Potential colonization
Great Blue Heron	Improving	Improving
Great Egret	Improving*	Stable
Snowy Egret	x	Improving*
Tricolored Heron	Potential colonization^	-

<b>Common Name</b>	<b>Summer Trend</b>	<b>Winter Trend</b>
Reddish Egret	-	Potential colonization
Cattle Egret	-	Improving
Green Heron	Improving*	Improving*
Black-crowned Night-Heron	x	Improving*
Yellow-crowned Night-Heron	Potential colonization	-
White Ibis	Potential colonization	-
Turkey Vulture	x	Stable
Osprey	x	Stable
White-tailed Kite	Stable	Stable
Golden Eagle	x	Potential extirpation
Northern Harrier	Stable^	Worsening
Sharp-shinned Hawk	x	Improving
Cooper's Hawk	x	Improving
Bald Eagle	x	Potential extirpation
Harris's Hawk	Potential colonization	-
Red-shouldered Hawk	Stable	Stable
Red-tailed Hawk	Worsening	Improving
Ferruginous Hawk	-	Stable
Rough-legged Hawk	-	Potential extirpation
Virginia Rail	x	Worsening
Sora	-	Stable
Common Gallinule	x	Improving*
American Coot	x	Improving
Black-necked Stilt	x	Stable
American Avocet	x	Stable^
American Oystercatcher	-	Potential colonization^
Black Oystercatcher	x	Worsening*
Black-bellied Plover	x	Stable
Snowy Plover	x	Stable

Common Name	Summer Trend	Winter Trend
Semipalmated Plover	-	Stable^
Killdeer	Improving	Improving
Spotted Sandpiper	x	Improving
Wandering Tattler	x	Stable
Greater Yellowlegs	Potential extirpation	Stable
Willet	Stable^	Improving*^
Lesser Yellowlegs	Potential extirpation^	Improving
Whimbrel	x	Improving*
Long-billed Curlew	Stable^	Worsening*
Marbled Godwit	Stable^	Improving
Ruddy Turnstone	x	Improving^
Black Turnstone	x	Worsening
Red Knot	x	Stable^
Surfbird	x	Worsening*^
Sanderling	x	Stable
Dunlin	-	Worsening^
Rock Sandpiper	-	Potential extirpation
Least Sandpiper	x	Improving
Western Sandpiper	Stable	Stable
Short-billed Dowitcher	x	Improving^
Long-billed Dowitcher	x	Stable
Wilson's Snipe	-	Stable
Wilson's Phalarope	Stable^	-
Red-necked Phalarope	Stable	-
Pomarine Jaeger	x	Stable^
Parasitic Jaeger	Stable	-
Common Murre	x	Worsening*
Pigeon Guillemot	Stable	Worsening
Marbled Murrelet	Stable	Worsening*
Ancient Murrelet	x	Worsening
Rhinoceros Auklet	x	Worsening
Bonaparte's Gull	Potential extirpation	Improving

Common Name	Summer Trend	Winter Trend
Laughing Gull	-	Improving
Heermann's Gull	x	Stable
Mew Gull	Stable	Stable
Ring-billed Gull	Stable^	Improving*
Western Gull	Improving*	Stable^
California Gull	x	Stable^
Herring Gull	Potential extirpation	Worsening^
Iceland Gull (Thayer's)	-	Worsening*
Glaucous-winged Gull	Stable	Worsening
Gull-billed Tern	-	Potential colonization
Caspian Tern	x	Improving*
Forster's Tern	x	Improving
Rock Pigeon	Improving	Stable
Band-tailed Pigeon	Worsening*	Worsening
Eurasian Collared-Dove	x	Improving*
White-winged Dove	-	Improving
Mourning Dove	Improving	Improving
Common Ground-Dove	-	Potential colonization
Greater Roadrunner	-	Potential colonization
Groove-billed Ani	-	Potential colonization
Barn Owl	x	Worsening
Western Screech-Owl	x	Stable
Great Horned Owl	x	Worsening
Northern Pygmy-Owl	-	Worsening
Burrowing Owl	-	Worsening*
Lesser Nighthawk	Potential colonization	Potential colonization
White-throated Swift	x	Stable
Anna's Hummingbird	Stable	Stable
Rufous Hummingbird	Potential extirpation	-
Allen's Hummingbird	Worsening^	-

<b>Common Name</b>	<b>Summer Trend</b>	<b>Winter Trend</b>
Belted Kingfisher	Stable	Improving
Lewis's Woodpecker	-	Stable
Acorn Woodpecker	Worsening	Stable
Yellow-bellied Sapsucker	-	Improving
Red-naped Sapsucker	-	Improving
Red-breasted Sapsucker	-	Worsening
Nuttall's Woodpecker	Stable	Stable
Downy Woodpecker	Stable	Potential extirpation
Hairy Woodpecker	Worsening	Potential extirpation
Northern Flicker	Worsening	Worsening
Pileated Woodpecker	Worsening	Potential extirpation
American Kestrel	x	Improving
Merlin	-	Stable^
Peregrine Falcon	x	Stable
Prairie Falcon	-	Stable
Olive-sided Flycatcher	Worsening*	-
Western Wood-Pewee	Worsening^	-
Willow Flycatcher	Potential extirpation	-
Hammond's Flycatcher	-	Improving
Gray Flycatcher	-	Potential colonization
Dusky Flycatcher	Stable	-
Pacific-slope Flycatcher	Worsening*	-
Black Phoebe	Stable	Stable
Eastern Phoebe	Improving	-
Say's Phoebe	-	Stable
Vermilion Flycatcher	-	Potential colonization
Ash-throated Flycatcher	Worsening*	-
Western Kingbird	Stable	-
Scissor-tailed Flycatcher	Improving	-
Loggerhead Shrike	Improving	Improving
White-eyed Vireo	Improving	-

<b>Common Name</b>	<b>Summer Trend</b>	<b>Winter Trend</b>
Hutton's Vireo	Worsening*^	Worsening
Warbling Vireo	Potential extirpation	-
Red-eyed Vireo	Improving	-
Steller's Jay	Worsening*	Worsening*
California/Woodhouse's Scrub-Jay (Western Scrub-Jay)	Stable	Stable
Clark's Nutcracker	Stable^	-
American Crow	Improving	Improving
Fish Crow	Potential colonization	-
Common Raven	Worsening	Stable
Horned Lark	Potential extirpation	Stable
Northern Rough-winged Swallow	Improving*	Potential colonization
Purple Martin	Worsening	-
Tree Swallow	Improving*	Stable
Violet-green Swallow	Worsening*	Stable
Barn Swallow	Potential extirpation	x
Cliff Swallow	Stable	-
Mountain Chickadee	-	Potential colonization
Chestnut-backed Chickadee	Worsening*	Worsening*
Oak Titmouse	Worsening	Worsening
Bushtit	Worsening	Worsening
Red-breasted Nuthatch	Potential extirpation	Potential extirpation
White-breasted Nuthatch	Stable	Improving*
Pygmy Nuthatch	Worsening	Worsening*^
Brown-headed Nuthatch	Potential colonization^	-
Brown Creeper	Worsening*^	Potential extirpation
Rock Wren	Improving	Improving
Canyon Wren	-	Potential colonization

<b>Common Name</b>	<b>Summer Trend</b>	<b>Winter Trend</b>
House Wren	Stable	Improving*
Pacific/Winter Wren	Potential extirpation	Potential extirpation
Marsh Wren	x	Stable
Bewick's Wren	Worsening	Worsening
Cactus Wren	-	Potential colonization
Blue-gray Gnatcatcher	Improving*	Improving*
Black-tailed Gnatcatcher	Potential colonization	-
American Dipper	x	Potential extirpation
Golden-crowned Kinglet	Potential extirpation	Potential extirpation
Ruby-crowned Kinglet	-	Improving
Wrentit	Worsening	Worsening
Western Bluebird	Worsening	Improving
Townsend's Solitaire	-^	Potential extirpation
Swainson's Thrush	Worsening*	-
Hermit Thrush	Potential extirpation	Improving
American Robin	Potential extirpation	Worsening
Varied Thrush	-	Worsening*
Gray Catbird	-	Improving
California Thrasher	Improving*	Worsening
Northern Mockingbird	Improving*	Improving
European Starling	Stable	Improving
American Pipit	-	Stable
Cedar Waxwing	Potential extirpation	Improving*
Ovenbird	Stable	-
Black-and-white Warbler	Improving	Improving
Swainson's Warbler	Potential colonization	-
Tennessee Warbler	Potential extirpation	x
Orange-crowned Warbler	Worsening	Improving*

<b>Common Name</b>	<b>Summer Trend</b>	<b>Winter Trend</b>
MacGillivray's Warbler	Potential extirpation	-
Common Yellowthroat	Improving*	Improving
Hooded Warbler	Improving	-
American Redstart	Improving	-
Northern Parula	Improving	-
Magnolia Warbler	Potential extirpation	-
Yellow Warbler	Improving	x
Chestnut-sided Warbler	Stable	-
Palm Warbler	-	Improving^
Pine Warbler	Potential colonization^	-
Yellow-rumped Warbler	Potential extirpation	Improving
Prairie Warbler	-	Improving
Black-throated Gray Warbler	Potential extirpation	Improving
Townsend's Warbler	-	Stable
Hermit Warbler	Worsening	Stable^
Wilson's Warbler	Worsening*	Improving*
Yellow-breasted Chat	Improving*	-
Green-tailed Towhee	-	Potential colonization
Spotted Towhee	Worsening	x
Rufous-crowned Sparrow	x	Stable
California Towhee	Worsening	Stable
Bachman's Sparrow	Potential colonization	-
Chipping Sparrow	Stable	Potential colonization
Vesper Sparrow	-	Potential colonization
Lark Sparrow	Worsening	Improving*
Sagebrush/Bell's Sparrow (Sage Sparrow)	Improving^	-
Savannah Sparrow	Potential extirpation	Improving

<b>Common Name</b>	<b>Summer Trend</b>	<b>Winter Trend</b>
Grasshopper Sparrow	Improving*	Potential colonization
Nelson's/Saltmarsh Sparrow (Sharp-tailed Sparrow)	-	Improving^
Fox Sparrow	Stable	Worsening
Song Sparrow	Worsening	Stable
Lincoln's Sparrow	-	Stable
Swamp Sparrow	-	Potential extirpation
White-throated Sparrow	-	Potential extirpation
Harris's Sparrow	-	Stable
White-crowned Sparrow	Stable	Worsening
Golden-crowned Sparrow	-	Worsening
Dark-eyed Junco	x	Worsening
Summer Tanager	Improving	x
Western Tanager	Worsening	Stable
Rose-breasted Grosbeak	Improving	x
Black-headed Grosbeak	Worsening	x
Blue Grosbeak	Improving*	-
Lazuli Bunting	Worsening	-
Indigo Bunting	Improving	Potential colonization

<b>Common Name</b>	<b>Summer Trend</b>	<b>Winter Trend</b>
Red-winged Blackbird	Improving*	Stable
Tricolored Blackbird	Improving	Worsening*
Western Meadowlark	Stable	Worsening
Brewer's Blackbird	Worsening	Stable
Boat-tailed Grackle	Potential colonization^	-
Great-tailed Grackle	Stable	Improving*
Brown-headed Cowbird	Stable	Improving
Hooded Oriole	Improving*	x
Bullock's Oriole	Worsening	x
House Finch	Stable	Improving
Purple Finch	Worsening*	Potential extirpation
Red Crossbill	Stable^	x
Pine Siskin	Potential extirpation	Potential extirpation
Lesser Goldfinch	Stable	Improving
Lawrence's Goldfinch	Stable	x
American Goldfinch	Stable	Improving
Evening Grosbeak	Potential extirpation	Potential extirpation
House Sparrow	x	Improving