Alaska

Landbird Conservation Plan

Version 2.0

BOREAL Partners in Flight


Red-breasted Nuthatch

Photo © John Schoen

Alaska Landbird Conservation Plan

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Editors

Colleen M. Handel

US Geological Survey, Alaska Science Center

Iain J. Stenhouse

Biodiversity Research Institute

Steven M. Matsuoka

US Geological Survey, Alaska Science Center

BOREAL
Partners in Flight

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Authors (*alphabetical*)· Original Affiliation (Current)

Travis L. Booms · Alaska Department of Fish and Game

Melissa N. Cady · USDA Forest Service (US Fish and Wildlife Service)

Cheryl A. Carrothers · USDA Forest Service (Retired)

Lucas H. DeCicco · US Fish and Wildlife Service (University of Kansas)

Maureen L. de Zeeuw · US Fish and Wildlife Service (Bureau of Ocean Energy Management)

Melanie J. Flamme · US Fish and Wildlife Service (National Park Service)

Julie C. Hagelin · Alaska Department of Fish and Game

Colleen M. Handel · US Geological Survey, Alaska Science Center

James A. Johnson · US Fish and Wildlife Service

Matthew D. Kirchhoff · Audubon Alaska (Retired)

Michelle L. Kissling · US Fish and Wildlife Service (University of Montana)

Stephen B. Lewis · US Fish and Wildlife Service

Steven M. Matsuoka · US Geological Survey, Alaska Science Center

Debora A. Nigro · Bureau of Land Management

Deborah E. Perkins · First Light Consulting and Contract Services

Heather M. Renner · US Fish and Wildlife Service

Susan E. Savage · US Fish and Wildlife Service (Retired)

Kristine M. Sowl · US Fish and Wildlife Service

Susan M. Sharbaugh · Alaska Bird Observatory (Retired)

Iain J. Stenhouse · Biodiversity Research Institute

Caroline Van Hemert · US Geological Survey, Alaska Science Center

Reviewers

Courtney L. Amundson · US Geological Survey, Alaska Science Center (National Park Service)

Lynn Fuller · Pacific Birds Habitat Joint Venture

Daniel D. Gibson · University of Alaska Museum (Retired)

Robb S. A. Kaler · US Fish and Wildlife Service

Lance B. McNew · US Geological Survey, Alaska Science Center (Montana State University)

John M. Pearce · US Geological Survey, Alaska Science Center

Mary Rabe · Alaska Department of Fish and Game (Retired)

David Tessler · Alaska Department of Fish and Game (Deceased)

David Fair Tessler
1967–2017

Rusty Blackbird

Photo © Ted Swem

Dedication

We dedicate the second edition of the Alaska Landbird Conservation Plan to the memory of our dear friend and colleague David Fair Tessler. Dave grew up in Denver, Colorado, where he learned to love the outdoors during his family's camping and backpacking trips. He became fascinated with ecology as a teenager and subsequently earned a B.S. in Wildlife Biology from Colorado State University in 1989. After working in New Mexico and Wyoming, Dave ventured north to Alaska in 1998 for graduate work at the University of Alaska Anchorage, where he earned his M.S. in Ecology in 2001. This marked the beginning of his influential professional career in wildlife ecology.

Between 2003 and 2015, Dave worked for the Alaska Department of Fish and Game (ADFG) as a Regional Wildlife Biologist and as Coordinator of the Wildlife Diversity Program. Dave was one of the most impassioned and active members of Boreal Partners in Flight and served as Chair from 2006 to 2008. Within Alaska ornithological circles he was best known for his well published research on Rusty Blackbirds and Black Oystercatchers. Dave also led citizen-science projects on bats, loons and grebes, and wood frogs.

In 2015, Dave's final career step took him from Alaska to Honolulu, Hawaii, where he served as the Deputy Field Supervisor for Geographic Operations in the Pacific Islands Fish and Wildlife Office of the US Fish and Wildlife Service. Dave was an incredibly well-rounded ornithologist and ecologist who studied just about everything under the sun during the course of his career: songbirds, shorebirds, waterbirds, seabirds, amphibians, bats, bears, deer, walrus, salmon, marine fishes, alpine flora, invasive plants, and endangered flora and fauna.

Dave was an accomplished outdoorsman who enjoyed skiing, mountaineering, surfing, and hunting and fishing—he found freedom in just about anything having to do with being outside. He was devoted to his family and shared his passions with every member of it, including his wife, Tracey Gotthardt, their son, River, daughter, Sierra, and faithful dog, Strider.

Dave will always be respected by the Alaska ornithological community for his scientific acumen and his considerable contributions to our understanding and the conservation of Alaska's birds. However, he will be most fondly remembered and dearly missed for his endless enthusiasm, his generosity, his unequaled ability to laugh and smile, and the genuine, bright, open-hearted way he lived his life and shared himself with all.

Photo © Rachel Richardson

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Photo © Daniel Poleschook

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Boreal Partners in Flight (BPIF) extends sincere thanks to all members who have contributed their ideas, time, and expertise to produce the second edition of the Alaska Landbird Conservation Plan. This revision builds upon the original plan produced by BPIF in 1999, which was compiled largely through the energy and efforts of Brad Andres, Chair of the Alaska Working Group at that time. Our knowledge of landbirds in Alaska and associated conservation issues has increased dramatically since then. This plan reflects the synergy that has developed among members of myriad government agencies, non-governmental organizations, Native corporations, industry, and the general public, who have joined forces in the name of landbird conservation in Alaska. BPIF sincerely thanks all who have contributed to this effort, recognizing that we could not possibly list all of their names here.

The development and completion of the Alaska Landbird Conservation Plan would not have been possible without the financial support of the US Geological Survey, US Fish and Wildlife Service, Alaska Department of Fish and Game, and Pacific Birds Habitat Joint Venture. BPIF is extremely grateful for their commitment to this project and to conservation of landbirds in Alaska. Any use of trade, firm, or product names is for descriptive purposes only and does not imply endorsement by the US Government.

The Alaska Landbird Conservation Plan is the result of an extensive team effort. The overall structure of the plan was developed by Colleen Handel and Iain Stenhouse after several working sessions with all members of BPIF and then with authors of each section. Iain and Colleen wrote the statewide perspective and Steve Matsuoka helped compile information for the tables and appendices and assisted with final editing. Other authors contributed to sections on the Bird Conservation Regions and Appendix I. Draft versions of the plan and sections were reviewed by BPIF committee members and others, including Courtney Amundson, Lynn Fuller, Lance McNew, John Pearce, Mary Rabe, and David Tessler. Daniel Gibson and Robb Kaler provided specific comments on subspecies or avian groups present in Alaska. Colleen Handel served as final editor.

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The editors are extremely grateful for everyone's invaluable contributions.

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Executive Summary

Alaska is a land of extremes. The diversity of its avifauna reflects the heterogeneity of its landscape, with more than 500 species of birds recorded in the state. Species inhabiting primarily terrestrial habitats, known collectively as landbirds, constitute the largest and most ecologically diverse component of the Alaska avifauna. Habitats used by landbirds range from temperate rainforests in southeastern Alaska to Arctic tundra across much of northern Alaska. Most of these landbird species are migratory, and four major global migration flyways converge on rich breeding areas in Alaska.

Alaska has one endemic landbird species, the McKay's Bunting, and is home to an impressive number of landbird populations for which it hosts a large proportion of the regional, continental, or global population. Thus, Alaska has a significant stewardship responsibility for these particular landbird species and subspecies.

Habitats in Alaska remain largely pristine due to the region's remote nature, vast size, and small human population. Alaska's growing population and attendant economic development, however, present many challenges that could affect all wildlife, including landbirds. Threats in Alaska are often considered to be less significant than those occurring elsewhere, where habitats are being altered by more rapidly increasing anthropogenic pressures, but they carry far-reaching consequences nonetheless. Habitats and ecosystem dynamics are changing rapidly due to the magnitude of climate warming at high latitudes. As such, effective landbird conservation in Alaska requires a broad, landscape-scale approach.

Conservation of landbirds over such an extensive and diverse landscape highlights the need for integrated efforts in habitat management, population monitoring, research, education, and outreach at local, regional, continental, and international scales. Incorporating information on the distribution and habitat requirements of landbirds strengthens land-use planning decisions. Synthesizing information on distribution and population trends of landbirds is a critical, time-sensitive task. Such information should be provided in a form that is readily available to land managers and policy decision-makers.

The primary objectives of this plan are to (1) describe the region and Alaska's landbird avifauna; (2) identify species of concern, important habitats, and key information needs; (3) highlight major conservation issues and threats to landbirds; and (4) identify potential conservation actions. We first examine landbird conservation at the statewide level within broad perspectives (regional, continental, and global), then take a detailed look at the specific issues, information needs, and potential conservation actions within each Bird Conservation Region in Alaska.

Photo © Bill Thompson

Roaring Cove in Kenai Fjords National Park

Northern Pygmy-Owl

Photo © Milo Burcham

Alaska: A Statewide Perspective on the Landbird Avifauna, Habitats, and Conservation Issues

Iain J. Stenhouse, Colleen M. Handel, and Steven M. Matsuoka

Introduction

Birds are perhaps the most obvious, widely recognized, and actively enjoyed component of biological diversity in North America and elsewhere around the world. About 1,200 species, nearly 15% of the world's known bird species, inhabit the United States, Canada, and Mexico (NABCI 2016). Approximately three-quarters of these species occupy terrestrial habitats and are known collectively as landbirds (Rich et al. 2004).

Global and continental declines in bird populations have raised concerns for the future of many migratory and resident bird species in North America (BirdLife International 2018, Rosenberg et al. 2019). Some species are in sufficiently dire circumstances to merit immediate conservation action, while others remain widespread but vulnerable and deserve focused attention to prevent continued declines. The causes of avian population declines are numerous, but habitat loss, modification, degradation, and fragmentation almost always play a major role. Threats to habitats arise primarily from intensified land-use practices and other impacts associated with development and human population growth. In recent decades, climate change has compounded these issues and raised new threats to birds and their habitats (Crick 2004). Climate-related impacts are projected to be accelerated in Arctic, alpine, and boreal regions (IPCC 2014), which encompass much of Alaska.

In late 1990, the National Fish and Wildlife Foundation brought together federal and state agencies, local governments, foundations, conservation groups, industry, and the academic community to form a program to address these problems in North America. Thus, Partners in Flight (PIF; https://partnersinflight.org) was launched as a voluntary, international coalition of public and private groups dedicated to keeping common birds common and reversing the downward trends of declining landbird species. Initially the program focused on Neotropical migrants (species that breed in North America and winter in Central and South America), but it now addresses all North American landbirds and other species that use terrestrial habitats. PIF's primary goal is to focus international, national, and regional attention on the conservation of landbirds and their habitats

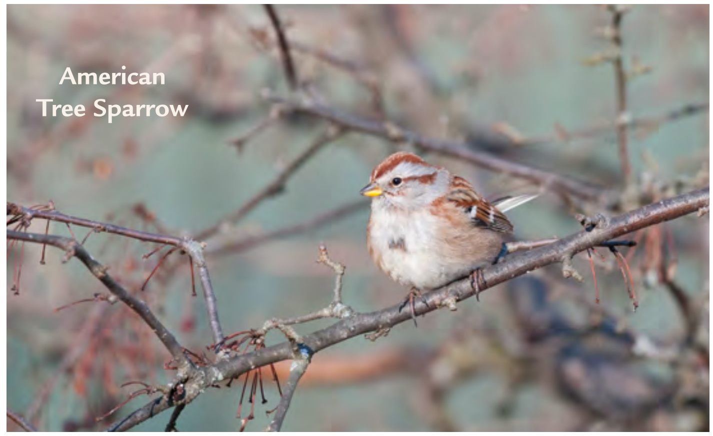

Photo © Bill Thompson

through cooperative efforts in the areas of monitoring, research, management, education, and international cooperation.

PIF conservation planning emphasizes effective and efficient management through a four-step process designed to identify and achieve necessary actions for bird conservation: (1) identify species and habitats most in need of conservation; (2) describe desired conditions for these habitats based on knowledge of species' life history and habitat requirements; (3) develop biological objectives that can be used as management targets or goals to achieve desired conditions; and (4) identify potential conservation actions that can be implemented by various entities at multiple scales to achieve biological objectives. The details of this approach are outlined in the original PIF North American Landbird Conservation Plan (Rich et al. 2004) and its recent revision (Rosenberg et al. 2016). These are intended to provide blueprint for continental habitat conservation under the North American Bird Conservation Initiative (NABCI; https://www.nabci-us.org), a tri-national effort involving the United States, Canada, and Mexico.

Boreal Partners in Flight (BPIF; https://www.usgs.gov/centers/asc/science/boreal-partners-flight), established in 1991, is a coalition of biologists, land managers, academics, and birders working together to help conserve bird populations throughout Arctic and boreal regions of North America. BPIF is the official Alaska state working group of the international PIF program, and includes members from adjacent Canadian provinces, which share many of the same species, habitats, and conservation issues.

BPIF has more than 100 members, including representatives from federal and state land and resource management agencies in Alaska and western Canada, universities, Alaska Native corporations, local environmental consulting firms, and nongovernmental organizations such as the Alaska Natural Heritage Program, Audubon Alaska, Alaska Songbird Institute, and Pacific Birds Habitat Joint Venture.

Common Redpoll

Photo © Milo Burcham

Purpose and Scope of the Plan

BPIF produced the first Alaska Landbird Conservation Plan in 1999 as a framework to guide conservation planning for landbirds in Alaska (Boreal Partners in Flight Working Group 1999). Like the original plan, this second edition aims to ensure the long-term maintenance of healthy populations of native landbirds through a proactive approach to landbird conservation in Alaska.

This current version of the plan is also designed to complement the North American Landbird Conservation Plan (Rich et al. 2004, Rosenberg et al. 2016) as well as other recent statewide conservation plans that address specific avian taxa, such as the Alaska Shorebird Plan (Alaska Shorebird Group 2019), and regional conservation assessments, such as the All-Bird Conservation Plan for Bird Conservation Region 4 (Sharbaugh 2007) and the Alaska Wildlife Action Plan (ADFG 2015).

Specifically, the Alaska Landbird Conservation Plan is designed to provide research biologists, land managers, and natural resource decision-makers with a synthesis of issues and potential actions for the management and conservation of landbirds in Alaska. It is also intended to help identify critical information gaps and coordinate the collection of data on landbirds among state, federal, and international agencies, nongovernmental organizations, and academic institutions.

Wilson's Warbler

Photo © Milo Burcham

The plan addresses all of this at two scales, first providing a statewide perspective on the Alaska landbird avifauna, habitats, and conservation concerns, and then presenting a regional perspective for each of the five Bird Conservation Regions in Alaska.

The goals of this plan are to:

1. Describe each region and the landbird avifauna;
2. Identify species of concern, important habitats, and key information needs;
3. Highlight the major conservation issues and threats to landbirds; and
4. Identify potential research, management, and conservation actions within each Bird Conservation Region.

BPIF will evaluate and update the objectives of the Alaska Landbird Conservation Plan periodically and assumes the primary responsibility for the coordination and implementation of the goals and objectives identified in the plan.

The Alaska Landbird Conservation Plan addresses all landbird species regularly occurring in Alaska (Gibson et al. 2021), including species in the following taxonomic orders: Galliformes (grouse), Columbiformes (pigeons and doves), Caprimulgiformes (goatsuckers), Apodiformes (swifts and hummingbirds), Accipitriformes (ospreys, hawks, eagles, and allies), Strigiformes (typical owls), Coraciiformes (kingfishers), Piciformes (woodpeckers), Falconiformes (falcons), and Passeriformes (songbirds).

The Alaska Landscape

Alaska, a land of geographic and climatic extremes, encompasses more than 1.4 million km^2 and is one-fifth the area of the contiguous United States. The state spans more than 20 degrees of latitude and 57 degrees of longitude. Its coastline stretches for almost 55,000 km. Broad, shallow rivers and their associated valleys dominate Alaska's interior landscape. The Yukon River, the third longest river in the US, flows over more than 2,800 km in Alaska and drains a watershed of 855,000 km^2. Mountains are also a dominant feature of the Alaska landscape. Seventeen of the 20 highest peaks in the US are found in Alaska. Denali, located in the Alaska Range of interior Alaska, is North America's tallest mountain at 6,190 m. More than 100,000 glaciers and extensive ice fields occur here, covering around 5% of Alaska's land area.

Habitats range from temperate rainforest in southeastern Alaska to Arctic tundra across much of northern Alaska. Discontinuous permafrost is found between the Alaska and Brooks mountain ranges; north of the Brooks Range there is continuous permafrost. Alaska encompasses the only Arctic and subarctic tundra and almost all the boreal forest in the United States. The maritime climate of southeastern Alaska is characterized by warm winters, cool summers, heavy precipitation, and intermittent strong winds, while interior Alaska has warm summers, very cold winters, little wind, and light precipitation. Cool summers, cold winters, moderate winds, and light precipitation are typical of western and northwestern Alaska. The town of Utqiaġvik, at the northernmost point in Alaska, sees 67 days of continuous darkness in winter and 84 days of continuous sunlight in summer.

About 88% of Alaska (>1.2 million km^2) is publicly owned (ADFG 2019a). These lands and waters are managed by multiple federal and state agencies. National parks and preserves, national wildlife refuges, and national forests constitute the largest portion, at around 40% (~565,000 km^2; Alaska Shorebird Group 2019). Federal holdings in Alaska include the two largest forest units in the country, the Tongass National Forest and Chugach National Forest; nine of the ten largest national parks in the country; and more than 80% of all national wildlife refuge lands in the country, including the 77,000 km^2 Arctic National Wildlife Refuge. In addition, the Bureau of Land Management administers about 280,000 km^2 of public lands, including more than 10,000 km^2 of national conservation lands and recreation areas, 2,200 km of wild and scenic rivers, and a 96,000 km^2 parcel on Alaska's North Slope, known as the National Petroleum

Photo © Bill Thompson

Mount Foraker in the foothills of Denali National Park

Reserve–Alaska (USDOI 2020). The Department of Defense is responsible for more than 7,900 km^2 across numerous military installations (Alaska Shorebird Group 2019).

The State of Alaska manages over 400,000 km^2, with legislative authority for the management of about 46,000 km^2 of state wildlife sanctuaries, game management units, and critical habitat areas falling to the Alaska Department of Fish and Game (ADFG 2019b). Other state lands, including 46,000 km^2 of state parks, are managed by the Alaska Department of Natural Resources (State of Alaska 2006). Private lands constitute about 12% of Alaska, with the largest component, some 170,000 km^2, belonging to the 12 Alaska Native regional corporations and 174 Alaska Native village corporations currently operating (Alaska Shorebird Group 2019, ANCSA Regional Association 2020).

Alaska's human population has more than doubled during the last five decades, from about 300,000 in 1970 to about 731,000 in 2019, although the population has remained relatively stable during the past decade (State of Alaska 2020). About 80% of the population resides in communities of 2,500 or more. The majority of residents live in south-central Alaska, with more than 290,000 people in the Municipality of Anchorage. Other major cities include Fairbanks, in interior Alaska, and Juneau, in southeastern Alaska, each with about 31,000 residents.

About 16% of the state's population self-identify as belonging to Native Alaskan peoples, including Aleut, Athabascan, Haida, Inupiaq, Tlingit, Tsimshian, and Yup'ik (State of Alaska 2020). Alaska's land area constitutes 16% of the entire United States but the state's population density is only 0.5/km^2, in contrast with 36/km^2 nationally. The harvest or extraction of natural resources, such as

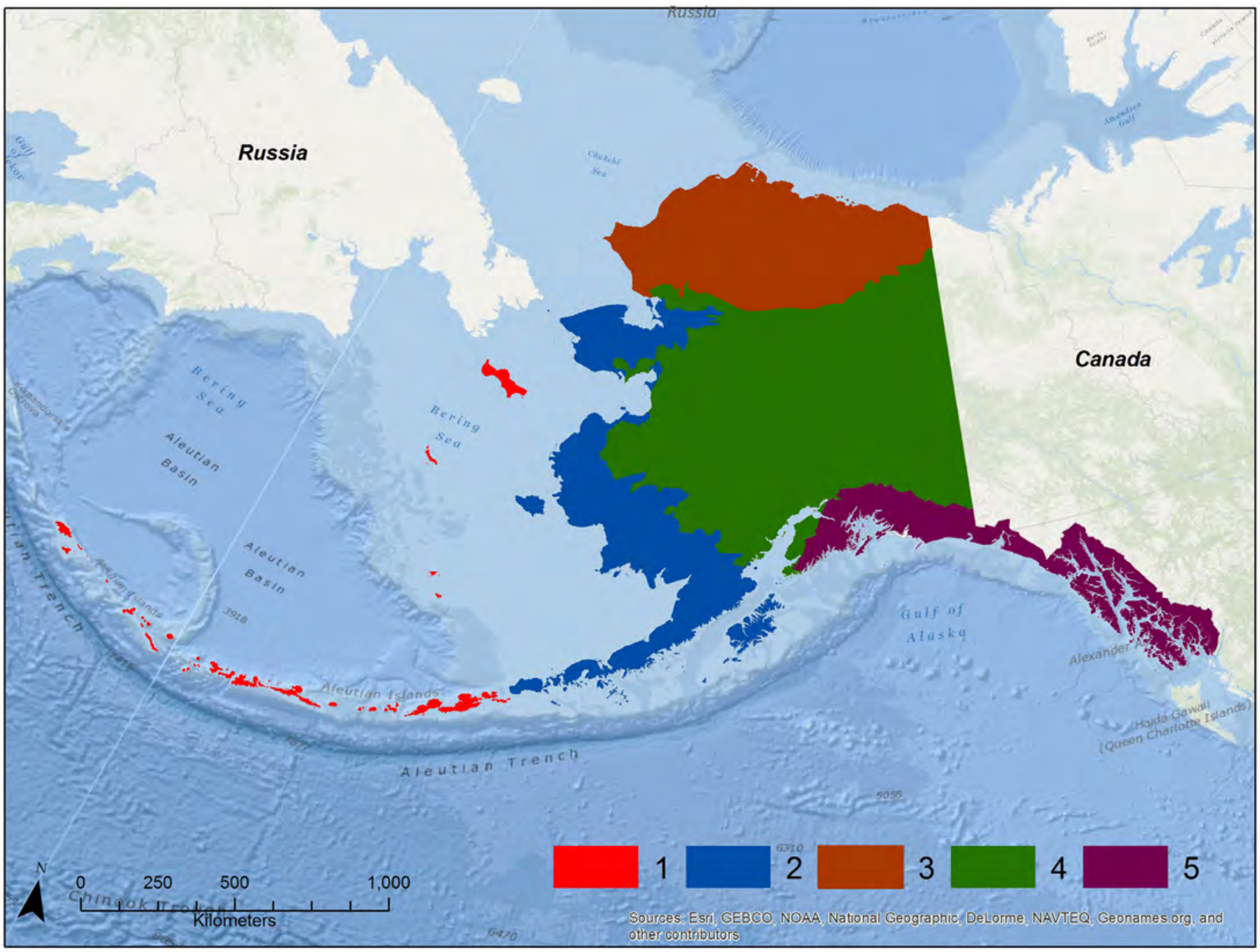

Figure 1. Bird Conservation Regions (BCRs) in Alaska: 1 = Aleutian and Bering Sea Islands, 2 = Western Alaska, 3 = Arctic Plains and Mountains, 4 = Northwestern Interior Forest, 5 = Northern Pacific Rainforest.

seafood, timber, oil, gas, and minerals, and their export are the major revenue-producing industries in Alaska, although tourism is an increasingly important element in the state's economy (Knapp 2012).

Bird Conservation Regions in Alaska

Bird Conservation Regions (BCRs) are ecologically distinct regions across North America with characteristic bird communities, habitats, and resource management issues (US NABCI Committee 2000). They are designed to function as the primary units within which ecological issues are resolved. Here we introduce the five BCRs in Alaska (Figure 1) and later discuss the habitats, species of concern, management issues, and potential research and conservation actions for each BCR in detail. The following brief descriptions are adapted from US NABCI Committee (2000).

BCR 1—The Aleutian and Bering Sea Islands BCR includes the long Aleutian Island chain, largely permafrost-free, that delineates the southern Bering Sea, plus seven isolated islands in the Bering Sea itself that have historically been strongly affected by winter pack ice. Volcanic, glacial, and tectonic processes shaped the region, and the Aleutian arc is still very active seismically and volcanically. All islands are treeless, and vegetation at higher elevations is dominated by dwarf shrubs. Meadows and marshes of herbs, sedges, and grasses are plentiful, and some islands have ericaceous bogs. Maritime influences are strong throughout the region.

BCR 2—The Western Alaska BCR encompasses the subarctic coastal plain of western Alaska and the mountains of the Alaska Peninsula. Wet and mesic graminoid herbaceous communities dominate the lowlands, and ponds, lakes, and rivers dot the landscape. Tall shrub communities are found along rivers and streams, and low shrub communities occupy uplands. Forests of spruce (*Picea* spp.) and hardwoods penetrate the region on the eastern edge. Permafrost is continuous in the north but discontinuous elsewhere in the region.

BCR 3—The Arctic Plains and Mountains BCR includes low-lying coastal tundra and drier uplands of the Brooks Range across the entire northern edge of Alaska. The region has thick and continuous permafrost, and surface water dominates the landscape (20–50% of the Arctic Coastal Plain). Freezing and thawing form patterned mosaics of polygonal ridges and ponds; rivers flowing north to the Arctic Ocean dissect the Plain. The ocean surface is generally frozen 9–10 months of the year and, historically, pack ice has rarely been far from shore.

BCR 4—The Northwestern Interior Forest BCR encompasses the western end of the boreal forest region of North America. The interplay of elevation, permafrost, surface water, fire, and aspect creates an extensive patchwork of ecological types. Forest habitat in the region is dominated by spruce, poplar (*Populus* spp.), and paper birch (*Betula papyrifera*). Tall shrub communities occur along rivers, in drainages, and near treeline. Bogs, dominated by low shrubs and shrub–graminoid communities, are common in the lowlands. Alpine dwarf-shrub communities are common in mountainous regions, and the highest elevations are generally devoid of vegetation and often covered by snow and ice.

BCR 5—The Northern Pacific Rainforest BCR, delineated by coastal mountain ranges, includes the coastal temperate rainforest along the Gulf of Alaska. This region's maritime climate is characterized by heavy precipitation and mild temperatures. The northern part of the BCR in Alaska is dominated by forests of hemlock (*Tsuga* spp.) and Sitka spruce (*Picea sitchensis*) interspersed with boggy wetlands. Large mainland river drainages support deciduous forests and major wetlands.

Landbirds in Alaska

The Alaska avifauna is an extremely diverse assemblage of 530 naturally occurring species representing 21 avian orders and 67 families (Gibson et al. 2021). Among these species, 301 occur regularly, 153 are casual visitors, and 76 are considered accidental, with only one or two records in the state. Alaska has such an outstanding avifauna for several reasons, mainly biogeographic in nature (Kessel and Gibson 1978, Winker et al. 2002, Winker and Gibson 2018): (1) Alaska has numerous relict populations as a result of its geologic and glacial paleohistory; (2) Alaska, being at the juncture of the Palearctic and Nearctic regions, supports Asian, Beringian, and North American breeding components and is visited by many vagrants during migration; (3) Alaska spans an enormous area and includes a vast array of habitat types, from temperate rainforest to oceanic islands to Arctic tundra; and (4) Alaska supports many unique subspecies of birds because of its numerous remote regions and isolated islands.

Populations of landbirds that exist in isolated areas often show local adaptations to specific conditions, and such isolation may result in the evolution of subspecies.

Downy Woodpecker

Photo © Milo Burcham

Table 1. The orders, families, and number of species considered in the Alaska Landbird Conservation Plan (after Gibson et al. 2021).

Order	Family		Number of species
Galliformes	Phasianidae	Grouse	7
Columbiformes	Columbidae	Pigeons and doves	3
Caprimulgiformes	Caprimulgidae	Goatsuckers	1
Apodiformes	Apodidae	Swifts	2
	Trochilidae	Hummingbirds	2
Accipitriformes	Pandionidae	Ospreys	1
	Accipitridae	Hawks, eagles, and allies	8
Strigiformes	Strigidae	Typical owls	10
Coraciiformes	Alcedinidae	Kingfishers	1
Piciformes	Picidae	Woodpeckers	7
Falconiformes	Falconidae	Falcons	4
Passeriformes	Tyrannidae	Tyrant flycatchers	8
	Laniidae	Shrikes	1
	Vireonidae	Vireos	2
	Corvidae	Crows and jays	5
	Alaudidae	Larks	2
	Hirundinidae	Swallows	6
	Paridae	Chickadees	4
	Sittidae	Nuthatches	1
	Certhiidae	Creepers	1
	Troglodytidae	Wrens	1
	Cinclidae	Dippers	1
	Regulidae	Kinglets	2
	Phylloscopidae	Leaf warblers	1
	Muscicapidae	Old World flycatchers and chats	3
	Turdidae	Thrushes	8
	Sturnidae	Starlings	1
	Bombycillidae	Waxwings	2
	Motacillidae	Wagtails and pipits	4
	Fringillidae	Fringilline and cardueline finches	9
	Calcariidae	Longspurs and snow buntings	4
	Emberizidae	Old World buntings	1
	Passerellidae	New World sparrows and allies	12
	Icteridae	Blackbirds	3
	Parulidae	Wood-warblers	12
	Cardinalidae	Cardinals and allies	2

Furthermore, landbird species with extremely broad ranges may show graded (or clinal) variation across their ranges, particularly latitudinal or longitudinal differences. Landbird species with isolated and with broad distributions clearly both occur in Alaska; thus, it is not surprising that the region is home to many recognized subspecies. The list of landbird populations restricted wholly or in large part to Alaska is impressive, although Alaska has only one endemic species of landbird, the McKay's Bunting (see Appendix II for all scientific names). For example, there are seven subspecies of Pacific Wren, seven subspecies of Fox Sparrow, and five subspecies of Rock Ptarmigan in Alaska (Gibson and Withrow 2015). Most of these are confined to Aleutian or Bering Sea islands or stretches of rocky Pacific coast.

Landbirds make up the largest and most ecologically diverse component of Alaska's avifauna, including 288 species in 13 orders and 45 families (Gibson et al. 2021). This plan addresses the 142 landbird species that occur regularly (usually annually) in the state, though sometimes in small numbers (Table 1). Among these, 54 (38%) regularly remain in the state during the boreal winter, occurring mostly in south-central and southeastern Alaska (Gabrielson and Lincoln 1959, Kessel and Gibson 1978; Appendix II). Most of the landbirds are migratory and travel to Alaska from other regions of the Americas, Asia, and Africa. About half (72) of the landbird species regularly occurring in Alaska have a significant portion of their winter range south of the US border with Mexico, and 12 species are Palearctic or Paleotropical migrants (Appendix II). Clearly, effective conservation for these migratory species relies on a collaborative approach across their entire ranges.

The Alaska landbird avifauna includes a few major avian groups, distinguished by ecological requirements, life-history characteristics, foraging ecology, and migration strategies. The major groups include grouse and ptarmigan, raptors, woodpeckers, and passerines. Minor groups include pigeons and doves, nightjars, swifts and hummingbirds, and kingfishers. The following sections briefly describe the major groups of landbirds in Alaska.

Spruce Grouse

Photo © Milo Burcham

Grouse and Ptarmigan

Seven species have been documented in Alaska (Gibson et al. 2021), including three forest dwellers (Ruffed, Spruce, and Sooty grouse), one that favors lower elevation grasslands and shrubby wooded areas (Sharp-tailed Grouse), and three upland or tundra species (Willow, Rock, and White-tailed ptarmigan). All of these species are year-round residents and breed in Alaska, although some may make short-distance migrations. Many northern populations of grouse and ptarmigan exhibit cyclic fluctuations at nearly predictable intervals of 8–10 years (e.g., Hannon et al. 2020), aiding biologists in setting harvest limits for hunting. Given strong cyclic patterns, however, it is important to understand the demographic consequences of age-related variation in population structure in order to assess potential effects of natural disturbances, human activities, and environmental changes (Sandercock et al. 2005). Management concerns for grouse and ptarmigan in Alaska include timber harvest (Russell 1999), habitat changes due to spruce beetle (*Dendroctonus rufipennis*) infestations and wildfire, accumulation of toxins and other contaminants in northern areas (Letcher et al. 2010), climate change (Christie et al. 2014), and disturbance due to mining, oil and gas development, recreational activities, and development of transportation routes.

Raptors

Thirty-three species, including 20 species of diurnal raptors (Cathartiformes, Accipitriformes, Falconiformes) and 13 species of owls (Strigiformes), have been documented in Alaska (Gibson et al. 2021). Among these, 23 breed and occur regularly in the state. Many of these species are migratory or nomadic, spending nearly half of their lives outside of Alaska, and thus face diverse conservation challenges across broad areas. Resident species, such as Bald Eagles and most owls, face unique challenges, including the cascading effects of a rapidly warming and changing climate. While raptors share many traits with other landbirds, the life-history characteristics and the different methods used to study raptors set this group somewhat apart. Raptors are apex predators in many of the ecosystems in which they occur, often at the top of complex food chains, and as such,

Photo © Milo Burcham

they serve as sentinels to the health of those systems (e.g., McIntyre and Schmidt 2012). The status and trends of their populations are poorly monitored by existing multi-species surveys, however, and require specific methodologies because of their rarity and often nocturnal behavior (e.g., Kissling et al. 2010, Millsap et al. 2013, Swem and Matz 2018).

Woodpeckers

Ten species of woodpeckers (Picidae) have been documented in Alaska (Gibson et al. 2021), seven of which breed in the state. Among the breeding species, four are year-round residents (Downy, Hairy, Three-toed, and Black-backed woodpeckers), one remains year-round only in southeastern Alaska (Northern Flicker), and two winter well south of the state (Yellow-bellied and Red-breasted sapsuckers). Woodpeckers generally prefer specific forest habitats and are thus highly susceptible to habitat changes (Virkkala 2006). Their populations can thus be affected directly by loss and fragmentation of forests due to urbanization, timber harvest, insect outbreaks, and wildfire. They can also be affected indirectly through alteration of forest age and structure through specific forest management practices and through habitat degradation, mediated by climate change (Albert and Schoen 2013).

Passerines

Songbirds constitute the largest component of the landbird avifauna, with 213 species from 31 families being documented in Alaska (Gibson et al. 2021). Among these, 96 species from 25 families are known to occur regularly in the state. Due to the diversity of life histories, foraging strategies, geographic ranges, and habitat use across this broad group, the list of threats to these species is long and equally diverse. The greatest impacts to landbird populations will likely result from the loss, fragmentation, and degradation of important habitats.

Many species reliant on boreal forest habitats exhibit clear population declines or lack sufficient data to establish a population trend (Handel and Sauer 2017). As a group, aerial insectivores are also showing striking and substantial declines, which are likely linked to climate change (Nebel et al. 2010, Handel and Sauer 2017, Sauer et al. 2017). The majority (up to 60%) of Alaska landbird species are Neotropical migrants, most of which will be exposed to a series of additional threats and pressures along their migration routes and in their wintering areas outside of Alaska. The songbird group also includes Alaska's only endemic species, the McKay's Bunting, which is characterized by a small population, a restricted breeding area, and a restricted wintering range (Matsuoka and Johnson 2008).

Continental Priorities

The PIF conservation planning process has several goals, including assessing the vulnerability of landbird species and populations to various threats and identifying priority species most in need of conservation attention at the continental level (Rich et al. 2004, Rosenberg et al. 2016). The PIF Species Assessment Process, based entirely on biological criteria that evaluate distinct components of vulnerability, has evolved over time; the procedures have been thoroughly tested, externally reviewed, and regularly updated (Beissinger et al. 2000, Panjabi et al. 2020).

The six biological vulnerability factors considered by PIF are global population size, the spatial extents of global breeding and nonbreeding distributions, threats to the

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North American population during the breeding and nonbreeding seasons, and the North American population trend (see Appendices III and IV; Panjabi et al. 2020). Scores for each of the factors range from 1 to 5, with 1 indicating least concern and 5 indicating highest concern, based on the best available science and expert review. Population size and distributions are scored at the global scale whereas population trends and threats are scored at both continental and regional (BCR) scales.

These six scores are combined in various ways to produce an overall measure of vulnerability and to identify Species of Continental and Regional Importance (Panjabi et al. 2020). At the continental level, Watch List species are considered of greatest conservation concern because of a combination of small and declining populations, limited distributions, and high threats throughout their ranges. Common Birds in Steep Decline (CBSD) include species whose populations have declined continentally by about 50% or more since 1970 but do not exhibit the broad vulnerability of Watch List species (Berlanga et al. 2010, Panjabi et al. 2020).

Alaska supports regularly breeding populations of 5 Watch List and 14 CBSD species (Table 2, Appendix I). Three other CBSD species occur rarely in Alaska (Gibson et al. 2021) and thus are not considered priorities for the state: Band-tailed Pigeon, Common Nighthawk, and Least Flycatcher (Appendix II). Among the Watch List species, the McKay's Bunting, an endemic breeder to Alaska, is considered highly vulnerable due to its small population size and greatly restricted breeding

Table 2. Partners in Flight Watch List species and Common Birds in Steep Decline (CBSD) that occur regularly in Alaska, primary habitat type, percentage of the North American population breeding in Alaska, percent change in the continental breeding population since 1970 (Panjabi et al. 2020), and projected percent change in the continental breeding range extent from 2010–2100 (Bateman et al. 2020b).

Species	Primary Habitat	Status	% Breeding in Alaska	% Change in Breeding Population 1970–2017	Projected % Change in Breeding Range Extent 2010–2100
Black Swift	Western forest	Watch List	<1%	−90%	−11%
Rufous Hummingbird	Western forest	Watch List	21%	−62%	−47%
Snowy Owl	Arctic tundra	Watch List	?	−55%	−93%
Short-eared Owl	Arctic tundra	CBSD	22%	−68%	−23%
Olive-sided Flycatcher	Boreal forest	Watch List	22%	−76%	−37%
Western Wood-Pewee	Western forest	CBSD	2%	−54%	−42%
Horned Lark	Grassland	CBSD	<1%	−69%	5%
Bank Swallow	Habitat generalist	CBSD	15%	−89%	48%
Arctic Warbler	Arctic tundra, boreal forest	CBSD	100%	−65%	−60%
Varied Thrush	Western forest	CBSD	66%	−64%	−49%
Bohemian Waxwing	Boreal forest	CBSD	22%	−55%	−34%
Common Redpoll	Arctic tundra, boreal forest	CBSD	74%	−43%	−47%
Pine Siskin	Boreal forest	CBSD	9%	−80%	−31%
Snow Bunting	Arctic tundra	CBSD	6%	−58%	−66%
McKay's Bunting	Arctic tundra	Watch List	100%	?	?
American Tree Sparrow	Arctic tundra	CBSD	36%	−58%	−65%
Rusty Blackbird	Boreal forest	CBSD	14%	−70%	−53%
Blackpoll Warbler	Boreal forest	CBSD	24%	−84%	−27%
Wilson's Warbler	Boreal forest	CBSD	43%	−52%	−42%

Table 3. Continental Stewardship species, primary habitat type, estimated size of the North American breeding population, percentage of the North American population breeding in Alaska, percent change in the continental breeding population since 1970 (Stanton et al. 2019, Panjabi et al. 2020, Will et al. 2020), and projected percent change in the continental breeding range extent from 2010–2100 (Bateman et al. 2020b). A Continental Stewardship species is defined as one with ≥10% of its global population occurring in North America and ≥25% of its North American population occurring in Alaska.

Species	Primary Habitat	North American Breeding Population	% Breeding in Alaska	% Change in Breeding Population 1970–2017	Projected % Change in Breeding Range Extent 2010–2100
Willow Ptarmigan	Arctic tundra	13,000,000	50%	2%	−44%
Sooty Grouse	Western forest	2,000,000	34%	−39%	?
Northern Goshawk	Forest generalist	210,000	34%	31%	−43%
Bald Eagle	Wetland generalist	200,000	35%	1092%	7%
Northern Hawk Owl	Boreal forest	130,000	53%	?	−18%
Red-breasted Sapsucker	Western forest	2,800,000	31%	79%	−83%
Chestnut-backed Chickadee	Western forest	12,000,000	27%	−47%	54%
Pacific Wren	Western forest	7,500,000	39%	−23%	38%
Arctic Warbler	Arctic tundra	8,200,000	100%	−65%	−60%
Northern Wheatear	Arctic tundra	260,000	30%	?	?
Gray-cheeked Thrush	Boreal forest	42,000,000	44%	−12%	−60%
Varied Thrush	Western forest	35,000,000	66%	−64%	−49%
Gray-crowned Rosy-Finch	Alpine tundra	200,000	45%	−63%	−71%
Common Redpoll	Arctic tundra	76,000,000	74%	−43%	−47%
McKay's Bunting	Arctic tundra	31,000	100%	?	?
Fox Sparrow	Boreal forest	35,000,000	45%	−43%	−56%
American Tree Sparrow	Arctic tundra	26,000,000	36%	−58%	−65%
Dark-eyed Junco	Forest generalist	220,000,000	26%	−46%	−38%
White-crowned Sparrow	Arctic tundra	79,000,000	44%	−13%	−65%
Golden-crowned Sparrow	Arctic tundra	7,500,000	89%	−27%	−84%
Orange-crowned Warbler	Western forest	82,000,000	38%	−34%	−45%
Townsend's Warbler	Western forest	21,000,000	28%	−30%	−38%
Wilson's Warbler	Boreal forest	81,000,000	43%	−52%	−42%

distribution. The remaining Watch List species are ranked as highly vulnerable due to severe population declines, restricted distributions, and conservation threats.

Distributions of many North American birds are projected to shift during this century in response to climate change, and species breeding in Arctic habitats, boreal forests, and western forests are those most vulnerable to a net loss in breeding range extent (Bateman et al. 2020b). Such projected changes should be considered in addition to other risk factors when assessing priorities for protection of habitat, identification of potential refugia, and other actions that may aid in the conservation of continental priority species (Table 2).

The conservation of Watch List and CBSD species alone is not sufficient to ensure that healthy populations are maintained for all native bird species across their ranges. Thus, PIF has traditionally emphasized the importance of stewardship for those species with a high proportion of their global population or range within a particular region (Rich et al. 2004). In addition to measures of vulnerability, PIF also provides measures of relative importance of areas at various geographic scales for the breeding population of each species, including the estimated proportions of the global and North American (US and Canada) breeding populations encompassed within each state, province, and BCR (Stanton et al. 2019, Panjabi et al. 2020, Will et al. 2020).

Spatially restricted species and subspecies are considered to be more susceptible to threats and vulnerable to extinction than broadly distributed species. Due to its sheer scale and diversity of habitats, Alaska is home to many landbird populations (species and subspecies) for which it hosts a large proportion of the regional, continental, or global population (Boreal Partners in Flight Working Group 1999). We designated a species as one for which Alaska has Continental Stewardship responsibility if ≥10% of its global population occurs in North America and ≥25% of its North American population occurs in Alaska (Table 3). We designated Regional Stewardship responsibility at the BCR level for subspecies that are endemic or largely restricted to particular BCRs within Alaska and for species that have been the focus of research, monitoring, or conservation efforts because of regional concerns.

Alaska has a considerable responsibility for the conservation of these stewardship species and subspecies. Although they may not qualify as high priorities for immediate conservation action, sufficient monitoring efforts should be made to maintain at least baseline data on population sizes, population trends, resource requirements, and limiting factors. The continental and regional population estimates in the PIF database are based primarily on extrapolations from the North American Breeding Bird Survey, with many assumptions, and thus are admittedly imprecise, with well recognized analytical limitations (Rosenberg and Blancher 2005, Thogmartin et al. 2006, Thogmartin 2010, Stanton et al. 2019, Sólymos et al. 2020). Estimates are particularly poor or completely missing for species in northern and western Alaska and on the Aleutian and Bering Sea islands due to the paucity of roads and BBS routes in these areas. Expert opinion is highly valued and heavily relied upon in species-status assessments in Alaska.

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Recent efforts by Boreal Partners in Flight to maximize coverage of existing BBS routes and to augment these with riverine BBS routes and Alaska Landbird Monitoring Surveys in off-road areas have improved our ability to estimate densities and assess population trends for many northern species (Handel and Sauer 2017, Sauer et al. 2017). Expansion of these monitoring programs into poorly sampled areas will increase our understanding of the status and resource requirements of this group of birds. Targeted studies of species of continental concern, such as the McKay's Bunting (Matsuoka and Johnson 2008), will also be necessary for species or populations with highly restricted distributions, for which little is currently known about population status or trend.

Conservation Issues in Alaska

Avian habitats in Alaska are largely pristine due to the state's remote nature, large expanses of protected areas, and small human population. The state's growing population and economy, however, present many challenges that could affect landbird populations. Anthropogenic changes in Alaska, though not unique to the region, could have significant impacts on landbird populations at the global or continental level because the state provides important habitat for so many species, particularly those restricted to northern biomes (Matsuoka et al. 2019).

The following list of threats to landbirds in Alaska is based on the Conservation Measures Partnership's (2020) taxonomy of direct threats. This lexicon provides a consistent language for describing conservation issues and provides an effective framework for discussing relevant conservation actions or mitigation (Salafsky et al. 2008). Issues are grouped into 11 categories, some of which are currently pervasive across Alaska (such as pollution and climate change), while others are limited in scope or restricted in scale across the state (such as residential and industrial development, and invasive species). Many of the issues are interrelated or interactive.

Residential and Commercial Development
This category incorporates threats resulting in loss of or damage to habitats associated with human settlements, including housing, related non-housing development, factories, commercial centers, and tourism and recreational sites (e.g., golf courses, ski areas, sports fields). The state's relatively pristine landscapes will likely only grow in importance to landbirds on the continental and global scale, as habitats outside Alaska are subject to increasingly rapid development and degradation. Despite the relatively small footprint of human activity in Alaska thus far, the impacts of habitat degradation will undoubtedly increase along with Alaska's growing human population. Direct mortality associated with such development can be high, particularly for passerines. Loss et al. (2014a) estimated that 365–988 million birds are killed annually in the US due to collisions with buildings, particularly their glass windows. Free-ranging domestic cats, primarily un-owned cats, kill another 1.3–4.0 billion birds annually in the US (Loss et al. 2013b). There are no estimates available for the level of such mortality in Alaska, but there are anecdotal accounts of mass mortality of large flocks of Bohemian Waxwings after colliding with large glass office buildings in Anchorage during winter.

Agriculture and Aquaculture
Farming and ranching can also pose threats to landbird populations through expansion and intensification of agriculture, silviculture, mariculture, and aquaculture, but all of these are currently very limited in geographic scope within Alaska. Some bird populations breeding in the state are strongly affected by agricultural practices elsewhere on migration corridors and wintering areas. Within Alaska, the primary effect of agricultural development on landbirds is the loss of natural breeding habitat, although there are ancillary effects such as trampling of nests (Wright 1979), introduction of invasive

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The Matanuska Valley is at the heart of a limited agricultural economy in Alaska.

plants and insect pests, and potential range expansion of the Brown-headed Cowbird, an agriculture-reliant brood parasite (Lowther 2020). The cowbird has recently been recorded breeding in both southeastern and south-central Alaska (Gibson and Withrow 2015), and its breeding range is projected to expand further into interior Alaska in response to climate change during this century (Stralberg et al. 2017).

In Alaska, there are approximately 990 farms that encompass about 3,500 km^2 (USDA NASS 2019). Farming operations are concentrated in valleys of south-central and interior Alaska, and primary crops include grains, vegetables, and nursery plants. There are large, free-roaming ranching operations for bison, cattle, and reindeer in interior and south-central Alaska, and on the Seward Peninsula, Nunivak Island, and Kodiak Island (State of Alaska 2010). Smaller ranches occur on several islands in the Bering Sea, northern Gulf of Alaska, and Aleutian Island archipelago. There are a few small dairy, poultry, and small-animal farms, primarily in south-central Alaska. Aquaculture and mariculture are very limited in the state and are expected to have few effects on landbird populations.

Energy Production and Mining

Wildlife and their habitats are directly affected by activities associated with the exploration, development, and production of non-biological resources, such as oil and gas, minerals, and renewable energy. Oil and gas production continues to be the driving force behind Alaska's economy (Institute of Social and Economic Research 2006, Knapp 2012), although these activities are currently concentrated in relatively small areas of the North Slope, Kenai Peninsula, and Cook Inlet. Historically, mining has been a cornerstone of development in Alaska, and many roads, docks, and other types of infrastructure have been built to support the industry. According to Alaska's Resource Development Council (https://www.akrdc.org/mining), the mining industry in Alaska currently produces zinc, lead, copper, gold, silver, and coal, as well as construction minerals such as sand, gravel, and rock. There are six major mines operating in Alaska, in interior, western, and southeastern Alaska, and active mining claims encompass about 15,000 km^2 of land. Two large proposed mines are currently under environmental review and several others are undergoing feasibility studies. Impacts on landbirds from mining industries pertain primarily to direct loss,

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Wind farm on Fire Island near Anchorage in the Upper Cook Inlet degradation, and disturbance of habitat, but also include the introduction of toxic chemicals and indirect effects associated with infrastructure development (e.g., Peluso 2016).

An emerging industry in the state involves development of alternative sources of energy, including hydroelectric power and wind farms (AEA 2019). There are several hydroelectric projects in south-central and southeastern Alaska and another proposed but recently vetoed for the Susitna River in interior Alaska. Impacts to landbirds from such projects are fairly localized and involve loss or alteration of habitat. Wind farms are being built throughout the state, but avian mortality due to collision with wind turbines is estimated to comprise only 140,000 to 328,000 birds annually in the US (Loss et al. 2013a). Some species such as raptors are more susceptible than others to mortality from collisions with rotors, but mortality can be reduced by siting turbines away from topographic features attractive to the birds (Smallwood et al. 2009, Ferrer et al. 2012).

Transportation and Service Corridors

The development of transportation and service corridors can affect birds not only through alteration and fragmentation of habitats but also through associated mortality and disturbance. Alaska's network of roads, railroads, shipping lanes, flight paths, and utility lines is currently limited, but impacts on birds will increase as the transportation network expands to support resource development and associated human infrastructure. The state's Roads to Resources initiative (Longan and Glenn 2015) proposes a multitude of extensions to Alaska's existing transportation corridors across the state to support development of natural resources in the oil and gas, alternative energy, mining, timber, fisheries, and agricultural industries. A joint record of decision was issued in March 2020 approving a proposal by the Alaska Industrial Development and Export Authority to construct a new 200-mile-long gravel access road in the southern Brooks Range foothills, which would provide industrial access to the Ambler Mining District in northwestern Alaska (https://eplanning.blm.gov/eplanning-ui/project/57323/510). The proposed Arctic Strategic Transportation and Resources (ASTAR) project, a large network of roads connecting Native communities and oil and gas production facilities, would dissect vast expanses of tundra on Alaska's North Slope (https://dggs.alaska.gov/pubs/project/1557). The USDA Forest Service recently adopted (on 29 October 2020) the Alaska Roadless Rule (85 Federal Register 68688), which

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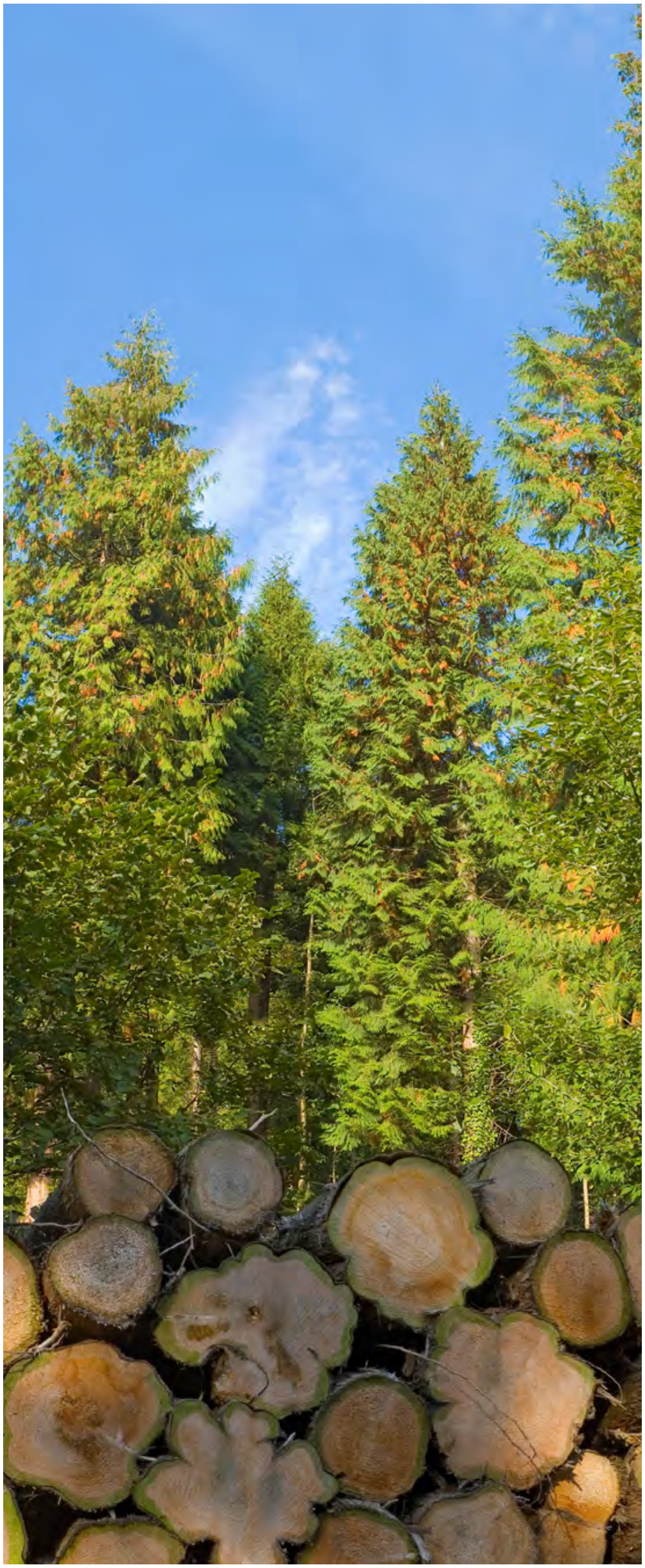
exempts the nation's largest national forest, the Tongass National Forest in southeastern Alaska, from the 2001 Roadless Rule, a provision that had prohibited road construction, road reconstruction, and timber harvest within inventoried roadless areas (https://www.fs.usda.gov/project/?project=54511).

Roads can affect wildlife in many direct and indirect ways, including mortality from road construction, mortality from collisions with vehicles, modification of behavior (e.g., movement patterns), alteration of the physical environment (e.g., dust, hydrology), alteration of the chemical environment (e.g., gasoline additives and deicing salts), spread of exotic organisms, and increased disturbance from humans (Trombulak and Frissell 2000). Across the US, an estimated 89–340 million birds are killed annually through collision with vehicles (Loss et al. 2014b) and another 8–57 million are lost through collisions with electric utility lines (Loss et al. 2014c). Another 6.6 million birds are lost each year through direct collision with communications towers across the US and Canada (Longcore et al. 2012). Indirect effects are much more difficult to measure.

Biological Resource Use

The consumptive use (commercial or subsistence) of "wild" biological resources, including hunting, trapping, fishing, and logging, can also pose threats to landbirds. Commercial logging probably has the greatest impact



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Timber is a valuable resource in Alaska.

on Alaska's landbirds by virtue of its landscape-level alterations of habitat in terms of age, composition, and structure. Although much of Alaska's vast interior boreal forest region is largely intact (Matsuoka et al. 2019), there is a significant timber harvest and forest products industry in the temperate rainforest region of southeastern Alaska, which supplies about 75% of the state's total harvest (Halbrook et al. 2009). As of 2014, harvest of productive forest in southeastern Alaska was split about evenly between the Tongass National Forest and state and private lands (USDA Forest Service 2016c). Stands with a higher volume of larger trees have been targeted disproportionately, with extremely large trees being almost completely removed from the landscape (Albert and Schoen 2013, Albert et al. 2016).

The leading species harvested are Sitka spruce, western hemlock (*Tsuga heterophylla*), Alaska cedar (*Callitropsis nootkatensis*), and western redcedar (*Thuja plicata*) in southeastern Alaska, and white spruce (*Picea glauca*) and paper birch in the interior. Various timber management practices have been developed that can minimize impacts to wildlife populations in Alaska, including protection of beach and stream buffers, preservation of residual trees, snags, and clumps of trees, and assurance of connectivity between forest patches (e.g., USDA 2008a, 2008b). In some areas of Alaska, trees are also harvested for household firewood, with little or no oversight or regulation. Although this harvest usually does not involve particularly large trees, this activity can have a significant impact on slow-growing species in old-growth forest and riparian areas.

There is traditional subsistence and sport harvest of some species of landbirds in Alaska, including grouse, ptarmigan, and Snowy Owls (subsistence only). Since 2004, the Subsistence Division of the Alaska Department of Fish and Game has compiled data on the annual subsistence harvest of birds and their eggs through the successful collaborative Harvest Assessment Program of the Alaska Migratory Bird Co-Management Council; however, data on harvest levels are summarized for groups of landbirds (grouse, ptarmigan, other species) and impacts at the specific level have not yet been assessed (Naves and Keating 2019). The Small Game Division collects information on sport harvest of grouse and ptarmigan through voluntary hunter surveys and wing surveys and reports biennially on the general status of regional populations for each species (Merizon and Carroll 2019). Estimates of total harvest and direct impacts on the populations, however, are generally lacking. There may also be ancillary effects on target and non-target species from harvest-related activities, such as the transplantation of Ruffed Grouse by the Alaska Department of Fish and Game from interior Alaska to the Matanuska–Susitna Valley in the 1980s and to the Kenai Peninsula in the 1990s to increase sport hunting opportunities. Direct mortality of adults, eggs, and nestlings resulting from research activities or take for falconry is minimal.

Human Intrusions and Disturbance

Habitats required by many landbirds overlap with preferred human-use areas, with subsequent disturbance and degradation of these habitats. Tourism is one of Alaska's biggest industries, generating an estimated $1.97 billion in revenue from almost 1.9 million visitors per year (McDowell Group 2016). As an increasing number of visitors and residents alike focus their recreation in wilderness settings, pressures will mount on landbirds using sensitive natural habitats. Most recreational activities are concentrated, however, within relatively narrow corridors defined by accessibility through motorized transport (automobiles, all-terrain vehicles, boats, airplanes, snow machines). Increased human activity is often accompanied by increases in predators or scavengers, which can lead to increases in nest predation (Liebezeit et al. 2009). Military activities, particularly training exercises and use of shooting ranges, have some impacts through disturbance, alteration of habitats, and contamination. Such impacts are generally limited to areas around active and abandoned military bases and training sites in south-central Alaska, interior Alaska, and the Aleutian Islands. Disturbance from research and other work activities occurs at a small scale throughout the state.

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Habitats required by many landbirds overlap with preferred human-use areas.

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Fire is an important ecological process in northern biomes, particularly in the boreal forest.

Natural System Modifications

Actions that convert or degrade habitat in order to manage natural systems, often to improve human welfare, can also pose threats to bird populations. Suppression and control of natural and human-caused fires are perhaps the greatest current threats to natural systems in this category in Alaska. Fire is an important ecological process in northern biomes, particularly in the boreal forest, where it shapes the structure and composition of vegetation across the landscape (Van Cleve et al. 1991, Payette 1992, Kasischke et al. 2010, Beck et al. 2011a). Resource agencies in Alaska recognize the importance of fire as a natural process in boreal and Arctic ecosystems and have developed the Alaska Interagency Wildland Fire Management Plan (AWFCG 2020) to guide decisions on management and suppression of natural and human-caused fires across the state. As the human population grows and economic development is fostered across Alaska, however, human habitations are becoming increasingly embedded in the landscape matrix of wild lands. Suppression to protect human life and property may alter the scale, intensity, and frequency of naturally occurring fires. Resultant changes in habitat structure and composition are expected to have

Barn Swallows

Photo © Milo Burcham

the greatest impact on birds that are reliant on specific seral stages (or intermediate communities) of the boreal forest ecosystem (Schieck and Song 2006).

Invasive & Problematic Species, Pathogens, & Genes
Threats can arise from species that have a negative effect on natural systems following their introduction, spread, or increase in abundance. These may be non-native species that negatively affect natural ecosystems, such as Norway rats (*Rattus norvegicus*), which prey on nesting birds in the Aleutian Islands (Fritts 2007), or European Starlings, which could usurp cavity nest sites in Alaska forests. Native species that sustain unnatural increases in abundance because of anthropogenic disturbance can also be problematic, such as Common Ravens that nest on artificial structures and prey on eggs and nestlings of tundra-nesting birds on the North Slope (Backensto 2010). Evidence suggests that the recent intrusion of Barred Owls into southeastern Alaska and British Columbia is having a negative impact on the much smaller Western Screech-Owl (Elliott 2006, Kissling and Lewis 2009), although there is debate about whether the larger owl's rapid range expansion into western North America is due to anthropogenic or natural causes (Monahan and Hijmans 2007, Livezey et al. 2008).

The effects of some invasive or problematic species may be restricted in geographic area but may still have serious impacts on landbird populations. Others may have much more widespread and far-reaching impacts. Outbreaks of spruce beetles, for example, can have serious effects on forest habitat structure and composition at a landscape scale (Allen et al. 2006, Matsuoka et al. 2006), with concomitant effects on avian populations that inhabit the affected forests (Lance and Howell 2000, Matsuoka et al. 2001, Matsuoka and Handel 2007).

This category also includes direct or indirect effects of parasites, disease organisms, and genetically modified organisms. Currently there is little known about threats to landbirds in Alaska from genetically modified organisms such as crops, insects, trees, or salmon (*Onchorhynchus* spp.). Recent strains of avian influenza circulating in Asia and Eastern Europe, however, have proven highly virulent to some landbird species and pose a direct mortality threat (Boon et al. 2007, but see Ip et al. 2008). Landbirds that spend part of their annual cycle in Eurasia and migrate to Alaska could transmit virulent diseases to Nearctic or Neotropical species in areas where their ranges overlap (Peterson et al. 2007).

A recent epizootic of a disease termed avian keratin disorder (Handel et al. 2010, Van Hemert and Handel 2010) is currently affecting a broad array of species in Alaska and a significant segment of the populations of both Black-capped Chickadees and American Crows. Recent evidence suggests that it may be caused by a novel picornavirus, which has now been found in multiple species not only in Alaska but elsewhere in North America (Zylberberg et al. 2016, 2018, 2021). Such an epizootic can have far-reaching impacts not only on the affected species but also on community dynamics. Emerging infectious diseases in wildlife have increasingly been linked to climate-related environmental changes (Van Hemert et al. 2014), so we should continue surveillance efforts for the occurrence of pathogens and their impacts on landbird populations.

Pollution

Avian populations can be harmed by many types of pollution, including water- and air-borne toxicants (e.g., sewage, oil, fertilizers, heavy metals, PCBs), solid wastes (e.g., garbage), and excess energy (e.g., heat, light, and noise). Some landbirds gather in large flocks during spring and fall migration and as such are susceptible to the effects of point-source pollutants, while others may be heavily affected by widespread, pervasive, and chronic pollutants (Scheuhammer 1987).

Alaska is known to be a sink for atmospheric pollutants, such as methylmercury, due to the state's geographic location and the long-range transport of contaminants from industrial regions in Asia (AMAP 2005). A recent study in the Yukon River Basin has projected significant increases of methylmercury in aquatic ecosystems as permafrost thaws in response to climate change (Schaefer et al. 2020). Bald Eagles nesting in the Aleutian Islands have shown elevated levels of elemental mercury and several organochlorines, which have been attributed to exposure to both point sources from past military activities and long-distance transport from Asia (Anthony et al. 1999, 2007). Raptors are particularly susceptible to bioaccumulation of contaminants because they are apex predators and scavengers (Espín et al. 2016, Herring et al. 2017, Bourbour et al. 2019).

Recent studies of the Rusty Blackbird, whose continental population has been declining rapidly (Greenberg and Droege 1999, Greenberg et al. 2011), found levels of mercury among blackbirds breeding in Alaska to be below adverse levels and only a third as high as those among blackbirds breeding in eastern North America (Edmonds et al. 2010). Information on contaminant levels among other passerines in Alaska is lacking (but see Handel and Van Hemert 2015).

Geological Events

Located at the northern junction between the North American plate and the Pacific plate, at the center of a lengthy subduction zone known as the Ring of Fire, Alaska is one of the most geologically active regions of the world. Sudden geological events can have profound regional or local effects, both rapid and long-lasting, on natural habitats and, therefore, on the distribution of associated landbird species. In terms of seismic activity, Alaska accounts for more earthquakes than the other 49 states combined (https://www.usgs.gov/natural-hazards/earthquake-hazards/lists-maps-and-statistics). In fact,

Photo © Kristine Sowl

Alaska is extremely active volcanically, particularly along the Aleutian Arc, with over 130 volcanoes and volcanic fields in the state.

earthquakes are a regular, almost daily, occurrence in Alaska, with as many as 54,000 being detected in a single year (https://earthquake.alaska.edu/earthquakes/about). The world's second largest earthquake, with a magnitude of 9.2 on the Richter Scale, was recorded in Prince William Sound in 1964. This event led to the uplift of a large area of south-central Alaska, by up to 15 m in some places (https://earthquake.usgs.gov/earthquakes/events/alaska1964/largest_in_alaska.php), and subsequent and far-reaching habitat changes. For example, the earthquake resulted in an uplift of 2–3.5 m above sea level on the Copper River Delta, which then caused a large expanse of coastal wetlands to shift rapidly to drier woody vegetation types (Crow 1971, Thilenius 1990).

Alaska is also extremely active volcanically, particularly along the Aleutian Arc, with over 130 volcanoes and volcanic fields in the state. Over 50 volcanoes are known to have been historically active (over the last 250 years or so), with 14 of these showing at least one major eruptive episode since 1990 (DeGange 2010). Major volcanic events, such as the eruption of Kasatochi Island in the Aleutian Island chain in 2008, can have immediate and dramatic effects on both terrestrial and marine habitats (DeGange 2010). The impact of volcanic eruptions on the surrounding landscape may be highly localized and acute, or far-reaching and chronic, depending on the duration of the event and the meteorological conditions at the time. Landbird habitats may be completely lost by being buried under pyroclastic flows or heavy ash deposits, or seriously affected by lighter layers of ash or poisonous gas clouds. The energy release and physical movement involved in earthquakes and volcanic eruptions can also produce tsunamis that can cause sudden and severe erosion of sensitive coastal habitats or the slower degradation of drier interior habitats from salinization of soils (Kume et al. 2009).

Alaska is also recognized for its many glaciers. In Alaska and adjacent Canada, glaciers cover 90,000 km^2, or about 13% of the montane glaciers on earth (Arendt et al. 2002). Many of Alaska's glaciers have receded rapidly (Koppes and Hallet 2002) or thinned (Arendt et al. 2002) over at least the last century, but some glaciers have shown advancement over the same period (Trabant et al. 2003). Dynamics of surface melt are complex and highly variable, but rates of land-terminating mass loss are generally higher in interior Alaska than in coastal

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The Northern Pacific Rainforest BCR is characterized by rich coastal forests, braided rivers, and rugged, glaciated mountainous terrain and supports a diverse avifauna.

regions (Larsen et al. 2015). Glacial advance generally results in a loss of terrestrial habitats, while glacial retreat exposes scoured bedrock and opens up new areas to plant colonization and the process of habitat succession. Rapid changes in glacial activity can also have significant influence on habitats downstream due to changes in hydrology (Moore et al. 2009). With thinning ice sheets, some regions of Alaska have undergone habitat changes due to relatively rapid isostatic rebound, or post-glacial uplift (Larsen et al. 2004, Mann and Streeveler 2008).

Climate Change

This category includes threats linked to global climate change, such as alterations of habitat, increased variability of climate, and disruption of seasonal phenology. Biomes at high latitudes are projected to experience greater climate change than most other regions during this century (IPCC 2014). Significant changes in vegetation at northern latitudes have already been found, including increases in shrub growth, conversion of tundra to forest, alteration of wetland hydrology, changes in vegetative species composition, and changes in the frequency and scale of fires, disease, and insect outbreaks (Jorgenson et al. 2001, Chapin et al. 2004, Edwards et al. 2005, Juday et al. 2005, Berg et al. 2006, Kasischke et al. 2010, Beck et al. 2011a, Mann et al. 2012, Lara et al. 2016, Pastick et al. 2019).

Small changes in temperature or precipitation in the Arctic, alpine, and boreal forest biomes are projected to result in large changes in species composition and biodiversity during the next century (Sala et al. 2000, Stralberg et al. 2015, 2017, Bateman et al. 2020a, 2020b). Climate change is already affecting the distribution and abundance of many plant and animal species at both latitudinal and elevational margins of their ranges (Lenoir et al. 2008). Breeding distributions of several species of landbirds in Alaska have recently been shifting northwards (Gibson and Kessel 1992, Benson et al. 2000, Erwin et al. 2004, Martin et al. 2006, Handel et al. 2009, Gibson and Withrow 2015), but little is understood about the demographic processes involved. Climate-suitability models project that up to 40 species of songbirds may expand their ranges into boreal Alaska by the 2080s (Stralberg et al. 2017). Range shifts among North American birds in response to global warming are projected to result in significant net range loss for many species, among which those breeding in the Arctic, boreal forests, and western forests are predicted to be the most vulnerable (Bateman et al. 2020b).

Changes in temperature and precipitation are causing shrubs and boreal forests to expand farther north and higher in elevation (Tape et al. 2006, Dial et al. 2007, Myers-Smith et al. 2011, Jorgenson et al. 2015, Brodie et al. 2019), which in turn are projected to provide opportunities for expansion of shrub-nesting species and possibly displace tundra- and alpine-breeding species of wildlife (Marcot et al. 2015, Mizel et al. 2016, Thompson et al. 2016). A massive decline of the Alaska cedar in temperate rainforests of southeastern Alaska has been linked to warming winter trends associated with global climate change (Beier et al. 2008). Warmer, drier growing seasons increase the risk and severity of forest fires (Flannigan et al. 2005), increase the frequency and extent of insect outbreaks in forested landscapes (Berg et al. 2006), and result in changes in wetlands due permafrost thawing (Yoshikawa and Hinzman 2003, Smith et al. 2005, Lara et al. 2016) and wetland drying (Klein et al. 2005, Riordan et al. 2006, Roach et al. 2011, 2013). Changes in the presence and types of wetlands will likely affect prey distributions for boreal and tundra-nesting landbirds.

For many species, the timing of their annual cycle events is coupled to the life cycles of their prey, predators, parasites, and pathogens. With warming temperatures, the timing of insect emergence has advanced, but it is not clear if birds can adjust their breeding cycles rapidly enough to match (Visser et al. 2006). Long-term

Photo © Norman Turing, NASA

Climate change models predict increasing stochasticity in weather patterns.

increases in precipitation have been linked to lower nestling growth rates and reduced adult body mass in a declining population of aerial insectivores, likely due to reduced availability of flying insects (Cox et al. 2019). The rapid advancement of breeding phenology among Tree Swallows in Alaska has been linked more strongly to declines in windiness and precipitation than to increasing spring temperatures (Irons et al. 2017).

Changes in broad-scale climatological patterns could also affect landbirds that rely on predictable wind patterns during migration. A high frequency of severe fall storms has been associated with landbird population declines (Butler 2000), and the highest rates of mortality in some migratory landbird populations occur during migration (Sillett and Holmes 2002, Rushing et al. 2017). The distribution and abundance of predators (LaManna et al. 2015), parasites (Loiseau et al. 2012, Wilkinson et al. 2015), and pathogens (Van Hemert et al. 2014) may also change in response to habitat and climatic conditions. Given the extent of potential impacts, threats to Alaska's birds posed by climate change will likely be complex and profound.

Photo © Lucas DiCicco

The Alaska Landbird Monitoring Survey (ALMS) is designed to meet the challenges of monitoring in remote regions.

Conservation Strategies for Alaska

The conservation of landbirds in Alaska requires integrated efforts in habitat management and protection, population monitoring, research, education, and public outreach at local, regional, continental, and international scales. Our conservation strategy is based on the biological requirements of landbird species and the processes that govern the ecosystems upon which they rely. This conservation strategy is shaped from a landscape perspective within each of Alaska's BCRs and relies heavily on partnerships for success. The overall goal of BPIF is to maintain or enhance current breeding populations, species diversity, and distribution of landbirds throughout Alaska.

Habitat Management and Protection

There are many strong voices and influential lobbying groups, representing both recreational and industrial interests, involved in land-use planning and decision-making processes in Alaska. Balancing these intensifying anthropogenic pressures with landbird conservation needs in Alaska is increasingly challenging.

The most effective conservation actions for landbirds will be the identification and protection of their habitats. Alaska has rather unique circumstances and challenges when it comes to landbird conservation—we have vast areas of relatively pristine habitat, but suffer from a lack of even basic information to inform conservation or management-related decisions. The identification of important habitats will be critical as infrastructure and other population stressors increase within the state. Efforts to identify important habitats for birds across the state, such as the National Audubon Society's Important Bird Areas (IBA) Program in partnership with BirdLife International, are a useful first step, but, once recognized, sites often require further conservation action. In many cases, action may be needed to improve the protection, conservation status, and management of key sites for landbirds in Alaska. For example, management strategies for all state and federal public lands are outlined in conservation, resource, and land management plans that are revised periodically. These plans provide an opportunity to nominate important fish and wildlife habitats for protection from other incompatible uses on public lands (Matsuoka et al. 2019).

Given the challenges of monitoring landbirds across the state, the development of bird-habitat models that predict abundance and distribution in remote and difficult-to-reach areas will be incredibly valuable.

Such predictive information will assist land managers in assessing the impacts of proposed developments and in protecting important areas throughout Alaska. Recent bioclimatic niche models across the boreal–Arctic transition zone of North America provide important first steps in projecting potential range shifts, identifying potential climate-change refugia, and understanding the potential restructuring of avian communities that may occur in response to long-term changes in climatic factors (Stralberg et al. 2015, 2017, 2018, Bateman et al. 2020a).

The collection of additional data on species' habitat requirements, interspecific interactions, and other biotic factors within the region and their relationship to demographic processes can help develop and refine more realistic models for predicting changes in distribution and biodiversity dynamics under different climate and habitat scenarios (Fordham et al. 2017, Zurell 2017, Layton-Matthews et al. 2018). Integrated demographic-habitat models can also help assess the relative importance of different habitats to different cohorts of a population, which can then aid in prioritizing conservation efforts to maximize population viability for a given species (Wiederholt et al. 2018).

The development and evaluation of best management practices in forest management (Gende et al. 1997, 1998, Kissling and Garton 2008, Sperry et al. 2008, Matsuoka et al. 2012), wind energy development (USFWS 2012), and other industries, such as hydrocarbon and mineral exploration and extraction, would be extremely valuable. For example, salvage logging in areas affected by insect outbreaks may have more detrimental effects than the initial disturbance (Lance and Howell 2000, Werner et al. 2006a, 2006b). Opportunities for habitat restoration may be limited across the state. In southeastern Alaska, however, there is potential to hasten the recovery of highly productive old-growth rainforest that has been heavily logged (Dellasala et al. 1996). Integrated economic–ecological spatial models can be developed to assess the trade-offs of alternative resource-management decisions (Hauer et al. 2010).

Habitat Management and Protection Objectives

1. Identify important landbird resource needs and habitats in Alaska during breeding, winter, and migration, and, where appropriate, nominate significant sites for formal protection or inclusion in conservation networks.

Photo © Lucas DiCicco

Banding and other marking programs can provide important information on habitat use, movements, and survival.

2. Coordinate, promote, initiate, and participate in flyway-wide initiatives to conserve important landbird habitats.
3. Model the potential impact of changing environmental conditions on landbird habitats in Alaska.
4. Identify landbird habitats prone to human disturbance and develop and evaluate best-management practices to reduce negative impacts.

Population Monitoring

Using data from multiple monitoring programs, Rosenberg et al. (2019) recently documented a staggering net loss of nearly 3 billion birds from the North American avifauna during the past 48 years, 29% of their abundance in 1970. Losses were particularly pronounced among songbirds and within the boreal forest, western forest, and Arctic tundra biomes, which dominate the Alaska landscape. Greater than 90% of the total loss could be attributed to 12 bird families, including sparrows, warblers, blackbirds, and finches.

Estimating and monitoring population sizes is critical to evaluating long-term population trends and identifying species and habitats most in need of conservation. The traditional method of assessing population trends of most non-harvested species of birds in the US and Canada is an analysis of data from the two longest-running bird survey programs in North America: the

Photo © Milo Burcham

North American Breeding Bird Survey (BBS; https://www.pwrc.usgs.gov/BBS/index.html), jointly administered by the US Geological Survey and Canadian Wildlife Service, and the National Audubon Society's Christmas Bird Count (CBC; https://www.audubon.org/conservation/science/christmas-bird-count).

Neither of these survey schemes is optimally suited to Alaska, however, as they rely on volunteers visiting roadside transect routes or easily accessible count areas. Coverage in Alaska is extremely limited and these methods often do not provide enough information to assess population trends across such a vast landscape with few roads (Sauer et al. 2013, Handel and Sauer 2017). Furthermore, roadside surveys in regions with sparse roads can result in biased estimates of population size and trend due to habitat-representation bias (Sólymos et al. 2020). Thus, implementation of effective monitoring programs in northern areas complementary to these existing programs is a high priority (Dunn et al. 2005, USGS and CWS 2020).

Standardized point counts provide a well recognized, reliable method for monitoring landbirds (Ralph and Scott 1981, Matsuoka et al. 2014). There are many different methods for adjusting raw counts for detectability (Nichols et al. 2009), but nearly all have assumptions that can be difficult to meet in the field (Simons et al. 2009). Furthermore, most of the available methods are not robust to heterogeneity in detectability relative to distance from observers—distance-sampling is an exception (Efford and Dawson 2009).

The Alaska Landbird Monitoring Survey (ALMS) is a broad-scale monitoring program specifically designed to meet the logistical and fiscal challenges of monitoring breeding birds across a largely roadless landscape (Handel and Cady 2004, Handel et al. in press). This point-count survey protocol uses a systematic sampling design with a random start point, and includes a combination of time-removal and distance-sampling methodology to account for variation in detection probability (Amundson et al. 2014, Handel and Sauer 2017). An alternative protocol uses repeated point counts (Schmidt et al. 2013). Techniques for collecting and analyzing point count data are continually being assessed and improved. Promising avenues of research focus on jointly analyzing disparate data sets to increase power for detecting population trends (Sólymos et al. 2013, 2018) and using autonomous acoustic recorders to collect survey data in remote areas where it may be difficult or expensive to deploy human observers (Thompson et al. 2017, Van Wilgenberg et al. 2017, Vold et al. 2017). Citizen-science observations opportunistically collected through eBird (https://ebird.org/home) are also now being analyzed to model population change across broad spatial scales (Walker and Taylor 2017, Horns et al. 2018).

Diurnal point counts and observations are not suitable for all landbirds, however, or even all passerines (Matsuoka et al. 2010a). Nocturnal species, such as owls, require an adapted point-count monitoring technique, including call playbacks (Kissling et al. 2010). Monitoring for diurnal raptors is usually focused on activity at nest sites, often allowing estimates of both abundance and productivity (Jacobson and Hodges 1999, Zwiefelhofer 2007, Swem and Matz 2018). Where possible, these surveys should also be adjusted for incomplete detectability (Bowman and Schempf 1999, Martin et al. 2009a, 2009b, Booms et al. 2010b). Migration counts can also be an effective tool for monitoring species that use known migration corridors, including passerines (Andres et al. 2005, Benson et al. 2006) and raptors (Hoffman and Smith 2003, but see McCaffery and McIntyre 2005). Broad citizen-science efforts to count fecal pellets have been proposed for monitoring ptarmigan populations, whose complex cyclical patterns and high spatial variability render traditional landbird monitoring protocols inefficient (Fuglei et al. 2020).

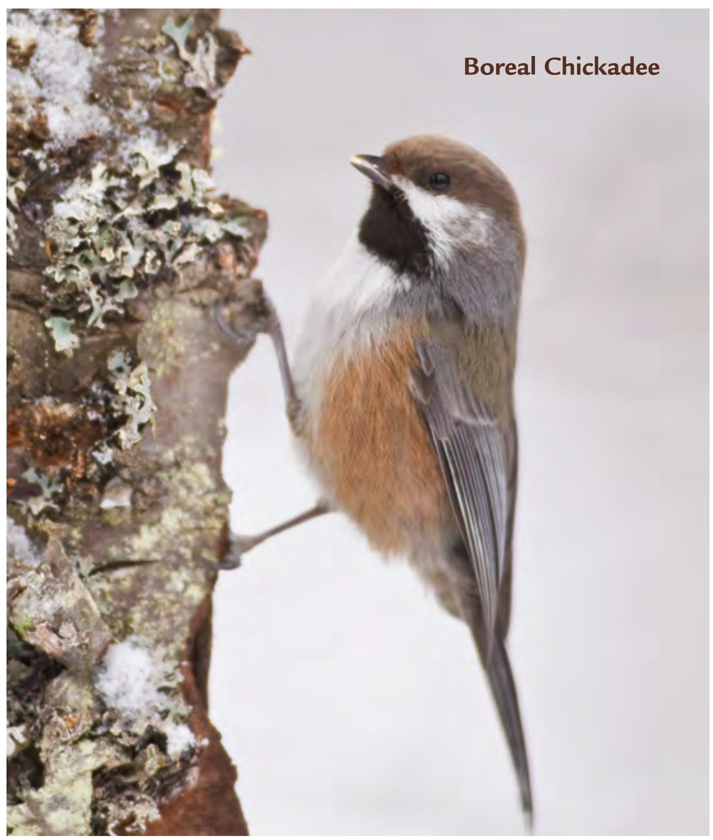

Boreal Chickadee

Photo © Milo Burcham

The value of monitoring results can be further enhanced when surveys are focused on evaluating the effectiveness of specific management practices (Gende et al. 1997, 1998, Kissling and Garton 2008) or conservation actions (US NABCI Monitoring Subcommittee 2007). Such focused monitoring is critical in adaptive management (Coordinated Bird Monitoring Working Group 2004), and may be accomplished simply through the replication of previous studies (cf. DellaSala et al. 1996, Matsuoka et al. 2012). Active conservation can best be served through an integrated conservation framework that is driven by hypothesis testing and adaptive management, rather than as a two-step sequential process of identifying population declines through broad surveillance monitoring and then seeking to discover the underlying causes (Nichols and Williams 2006).

Demographic data on parameters such as productivity, survival, immigration, and emigration are essential for understanding the drivers underlying population declines and for identifying the most effective management actions to reverse them. Thus, conservation and management would best be served through analysis of these parameters in concert with trend data within a hypothesis-driven framework. Coordinated continental efforts such as the Monitoring Avian Productivity and Survivorship (MAPS) program can provide useful insights into broadscale patterns and drivers of population dynamics across multiple species within a given region (e.g., Saracco et al. 2008, 2010, George et al. 2015). Such capture-recapture programs, however, require relatively large sample sizes and concerted, multi-year commitments across many stations and may not always target the species of greatest concern.


Fox Sparrow

Photo © Lucas DeCicco

Given the expense and logistical difficulties of monitoring demographic parameters in Alaska, such efforts should be carefully targeted to address specific questions pertinent to conservation and management actions. In general, monitoring efforts on the breeding grounds should focus on priority species with small or declining populations, or in habitats where accurate and precise trend information may be more readily derived and applicable to management questions. For species with widely dispersed breeding populations that are impractical or financially infeasible to survey, support should be given to monitoring programs outside of Alaska since they may provide the only comparable or useful information available for these species.

Recent analytical advances in development of integrated population models (Ahrestani et al. 2017) and network metapopulation models (Sample et al. 2018, Wiederholt et al. 2018) provide useful frameworks for integrating disparate data sets across the landscape and different portions of the annual cycle to obtain inferences about demographic processes beyond individual sampling areas.

Population Monitoring Objectives

1. Broaden the scope of current monitoring for landbird populations across Alaska to effectively inform conservation and management decisions.
2. Improve the accuracy of landbird population estimates and distributions in Alaska.
3. Coordinate monitoring programs among agencies and organizations across Alaska.
4. Develop regional, national, and international partnerships to promote range-wide monitoring of landbird populations.
5. Increase the value of monitoring information by improving statistical design, combining analysis of disparate data sets to increase statistical power, and applying results to evaluate management practices and land-use decisions.

6. Monitor demographic parameters of landbirds in Alaska and use demographic and integrated population models to better understand limiting factors at the population level.

7. Develop better estimates of subsistence harvest of nongame landbird species in Alaska.

8. Archive and maintain population monitoring data in central, modern data management systems and accessible databases.

Scientific Research

We often rely on research both to understand the ecological requirements of avian populations and to make informed management decisions for populations relative to conservation issues. This section outlines priority areas where research is most needed to help support the conservation of landbirds in Alaska. We provide a brief explanation of the general information needs and then list several specific research objectives related to these needs.

Identify general habitat requirements across large spatial extents.—We still lack a basic understanding of the distribution, abundance, and habitat requirements of most species of landbirds in Alaska. This information is needed for a variety of applications, such as assessing the potential effects of natural resource development on birds, identifying important habitats to conserve for priority bird species, and modeling avian responses to planned developments, future land use, and climate change scenarios.

Developing models of landbird distribution and abundance relative to habitat at the regional and statewide scales (Cotter and Andres 2000) is critical for a range of applications. One approach for tackling this issue is the compilation and analysis of data from existing surveys conducted throughout a region of interest to develop robust models in a timely fashion (Booms et al. 2010b). The Boreal Avian Modelling project is currently compiling and analyzing avian point count data from across the boreal forest of North America in this manner (Cumming et al. 2010). These data have recently been analyzed to project likely changes in the distribution and abundance of boreal breeding species in response to climate change and to identify areas that could serve as macrorefugia for songbirds through the end of the century (Stralberg et al. 2015, 2017, 2018). Such efforts could be refined further to identify potential microrefugia within the existing network of protected lands in Alaska for the conservation of boreal and Arctic species and to


Tree Swallow

Photo © Lucas DeCicco

identify other key unprotected areas that could be added to the network.

Although the abundance of a species can often be linked to specific habitat characteristics, demographic processes of the population can be strongly driven by the temporal and spatial availability of predators and prey, which may in turn influence the true importance of the habitat. One major consequence of climate warming for many organisms is a change in the seasonal timing of events, and differential responses among species and their prey can result in trophic mismatches and negative consequences for reproductive success (Visser et al. 2006, 2012). The degree of trophic asynchrony can be highly variable among avian species, and the complex dynamics and cross-seasonal interactions make it difficult to determine what mechanistic relationships are in play and how strong they may be (Dunn and Møller 2014, Townsend et al. 2016, Franks et al. 2017).

Predator-specific rates of nest predation can also be governed by climatic factors such as temperature (Cox et al. 2013), with patterns driven through physiological as well as community-level mechanisms. Similarly, the dynamics of parasites and pathogens and their impacts on avian populations are generally poorly understood although they can have significant effects on survival (George et al. 2015). Detailed studies of the relationships among vegetation structure and phenology, seasonal availability and abundance of predators and prey, pathways and effects of parasites and pathogens, climatic factors, and reproductive success will help elucidate important relationships

Photo © Chris Harwood

Riparian habitats support some of the highest densities and diversity of landbirds in Alaska.

(e.g., Booms et al. 2011b, Boelman et al. 2015, Lany et al. 2016, Schmidt et al. 2020). Understanding such complex relationships will be key to predicting how landbird populations will respond to climate-mediated changes in the availability and quality of habitat and other resources needed for reproduction and survival.

Rangewide approach for the conservation and management of priority species.— For priority species, we need targeted research to identify critical habitats and resource requirements for conservation, identify appropriate population units for management, and determine where and when during the annual cycle a population is being limited. Such knowledge will help us develop the most effective conservation and management strategies. Measures of population sizes and trends will help us gauge progress towards meeting recovery goals. A collaborative approach for research and conservation is particularly appropriate because many of our priority species have breeding or nonbreeding ranges that extend far outside of Alaska (Faaborg et al. 2010a, 2010b).

Knowledge of the full annual cycle is critically important for the conservation and management of birds because events occurring in one period often profoundly influence individuals and populations in subsequent periods through seasonal interactions and carryover effects (Marra et al. 2015). Broad collaborative efforts help weigh the relative importance of events occurring in different locations or periods of the annual cycle for a species. Such an approach has been particularly useful in making rapid progress in understanding the conservation needs of Rusty Blackbirds across their range (Niven et al. 2004, Greenberg and Matsuoka 2010, Matsuoka et al. 2010a, 2010b, Powell et al. 2010).

Integrated population models can help identify the relative contributions of different vital rates to population growth (Rushing et al. 2017). Spatially structured demographic network models can be used to gauge the sensitivity of a population to perturbations relative to population size, distribution, and movement patterns (Sample et al. 2018) as well as to determine the relative importance of different habitat types for population growth (Wiederholt et al. 2018). Such information can be further assessed in economic models to determine the most effective and efficient management actions to promote recovery or conservation of a given population, by considering the net flow of ecosystem services, in terms of benefits and subsidies, across the range of a migratory species (Semmens et al. 2018).

Population structuring and links to nonbreeding grounds.— Understanding how populations are spatially structured and the strength of connectivity among breeding, migration, and wintering areas is also critical for determining how populations will respond to selective pressures throughout their annual cycle (Webster et al. 2002, Cohen et al. 2018). Breeding populations with strong connectivity to specific wintering areas, for example, could be severely constrained in their ability to adapt to a regional stressor, compared with populations with weak connectivity that could adapt by moving elsewhere within their range. Knowledge of the degree to which migrant bird populations spread out and mix during the nonbreeding season is critical for assessing and predicting the responses of populations to global climate change and changes in habitat (Finch et al. 2017).

Landbird research in Alaska, as elsewhere in North America (Faaborg et al. 2010a, 2010b), has focused primarily on the breeding season, but this only addresses a few months of the annual cycle; in general, the nonbreeding season of most species of Alaska landbirds remains poorly studied. Understanding key migration corridors and wintering areas for migratory species of Alaska-breeding landbirds may be particularly important because the loss and degradation of habitats are often much greater in temperate and tropical regions than in Alaska.

Recent advances in stable isotopes, tracking technology, and genomics make these tools particularly useful for assessing migratory pathways and the strength of connectivity (McIntyre et al. 2008, 2009, Hobson et al. 2010, Ruegg et al. 2020), and analysis using combinations of these tools can be particularly powerful (Paxton et al. 2013, Ruegg et al. 2017). Integrating population genomics with environmental data can also help us assess how well northern breeding populations may be able to adapt to the rapid climatic shifts that are now occurring (Bay et al. 2018).

Satellite telemetry and collaborative networks of Motus tracking stations have the added benefit of allowing for the estimation of survival rates, the speed of migration, and the importance of stopover and wintering sites through tracking of individual birds (McIntyre et al.

Photo © Dirk Derksen

2006b, 2012, Gómez et al. 2017, Taylor et al. 2017). Combining tracking data with integrated population models can provide a powerful framework for understanding the demographic processes that drive population dynamics and where conservation actions will be most effective (Rushing et al. 2017).

Scientific Research Objectives

1. Quantify habitat requirements of landbird species at various spatial scales to allow land managers to evaluate impacts of proposed resource development and to identify potential refugia from climate-mediated changes.
2. Use established and developing techniques and technologies (such as genomics, banding, tracking, stable isotope analysis) to understand the population structuring of landbirds in Alaska, determine phenology of seasonal events, and link areas and habitats used throughout their annual cycles.
3. Encourage targeted, long-term studies that measure landbird breeding phenology, productivity, and survival relative to environmental conditions, the abundance of prey, and susceptibility to predators, parasites, and pathogens.
4. Develop quantitative models to evaluate the effects of key factors that may affect the viability of landbird populations and assess the efficacy of alternative conservation and management actions.
5. Identify population limiting factors and causes of population declines in priority landbird species in Alaska through collaborative efforts across the species' ranges.

Public Outreach and Information Dissemination
BPIF seeks to inform government agencies, industries, nongovernmental organizations, private landowners, and citizens about Alaska's landbirds, the importance and sensitivity of their habitats, their role in ecosystem function, and the importance of biodiversity in general. Clearly, the strategic implementation of education and outreach programs is critical in order to facilitate the acceptance of conservation recommendations by key stakeholders. Increasing awareness of Alaska's diverse landbird avifauna, and the remarkable behavior and ecology of landbird species, may be the greatest contribution BPIF can make towards bird conservation.

BPIF's primary goals in this area are to (1) increase opportunities to view, enjoy, and learn about landbirds in Alaska, and (2) increase regional, national, and international coordination and collaboration among landbird researchers and their outreach efforts.

Public Outreach Objectives

1. Raise the profile of Alaska's landbirds by supporting annual bird festivals held throughout Alaska, such as the Tanana Valley Sandhill Crane Festival, Alaska Bald Eagle Festival, Alaska Hummingbird Festival, and Gunsight Mountain Hawk Watch Weekend.
2. Share results of research, management, and conservation efforts with the public through presentations at local Audubon meetings and other similar venues.
3. Encourage the synthesis and reporting of results of Alaska landbird studies to scientific audiences via oral or poster presentations at regional meetings such as the Alaska Bird Conference and at national and international scientific conferences.
4. Host presentations and workshops in remote villages to improve communication with rural Alaskans about landbird resources and their conservation.
5. Involve students at various levels, from elementary through undergraduate, in local research and monitoring projects whenever practicable.
6. Encourage the participation of the general public in citizen-science projects such as eBird, the Breeding Bird Survey, International Migratory Bird Day, Great Backyard Bird Count, and Christmas Bird Count.

International Collaborations

Landbird populations are exposed to different threats across their ranges. Alaska, at the terminus of four major global flyways, provides crucial breeding habitat for many migratory landbirds. As such, Alaska is well situated to lead rangewide conservation efforts. Clearly, effective migratory bird conservation can best be achieved through integrated management, research, and conservation efforts across entire flyways (see Berlanga et al. 2010). BPIF must collaborate with colleagues across the US, and at an international level within each of the major flyways, to work towards joint protection and conservation of landbirds. Although it may be challenging to promote landbird conservation actions outside of Alaska, BPIF should work to identify opportunities and play a role in their implementation.

International Collaboration Objectives

1. Foster cooperative research efforts throughout North America and elsewhere along landbird migratory flyways in the Americas, Asia, and Africa.
2. Coordinate and participate in international, national, and other regional landbird conservation planning efforts.
3. Participate in species-specific conservation planning efforts (such as the International Rusty Blackbird Working Group; https://rustyblackbird.org).
4. Cooperate with neighboring countries to standardize population monitoring protocols, enhance the investigation of ecological factors affecting landbird populations, and identify conservation issues that occur at larger spatial scales.

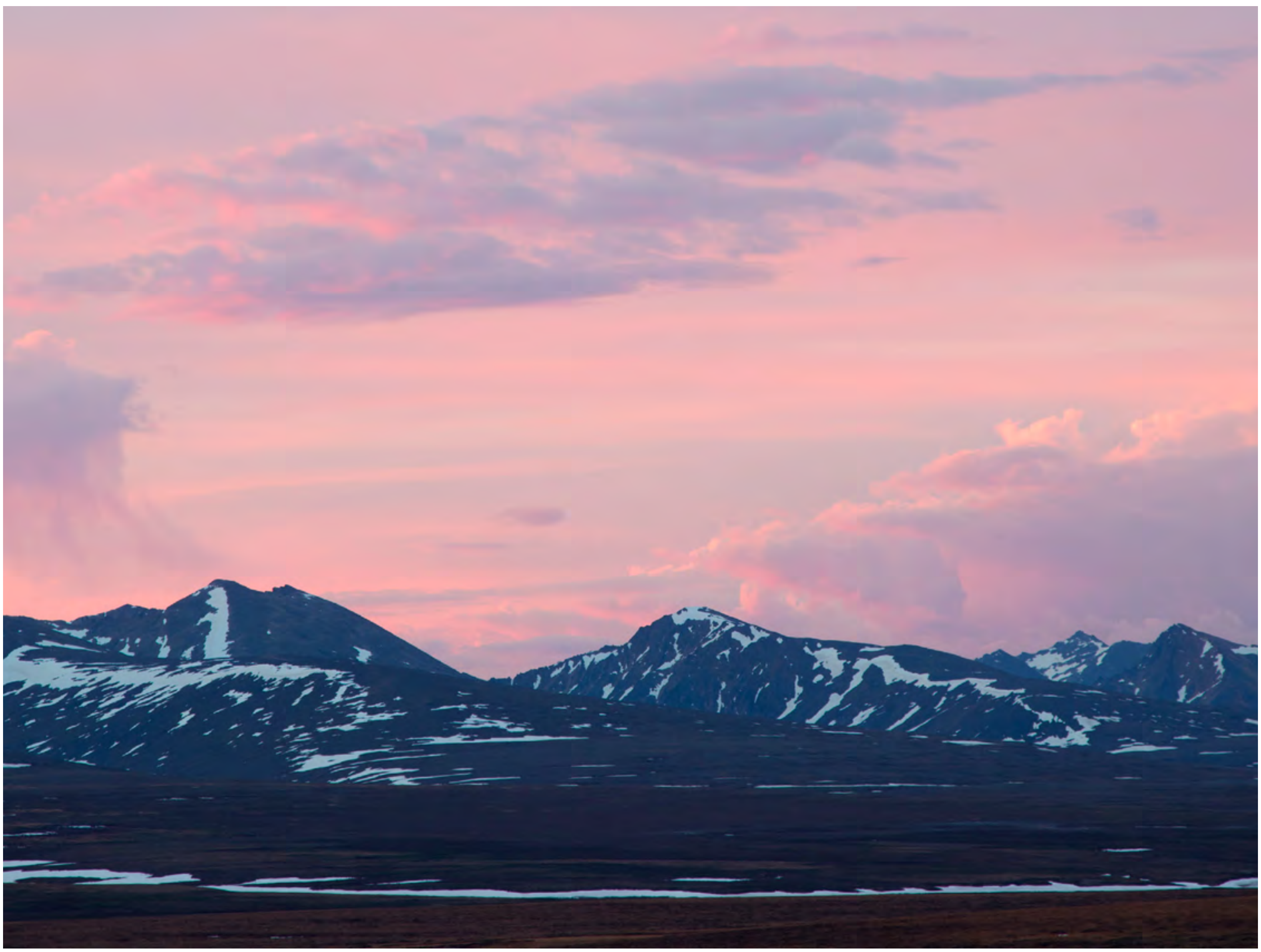


Photo © Ken Archer

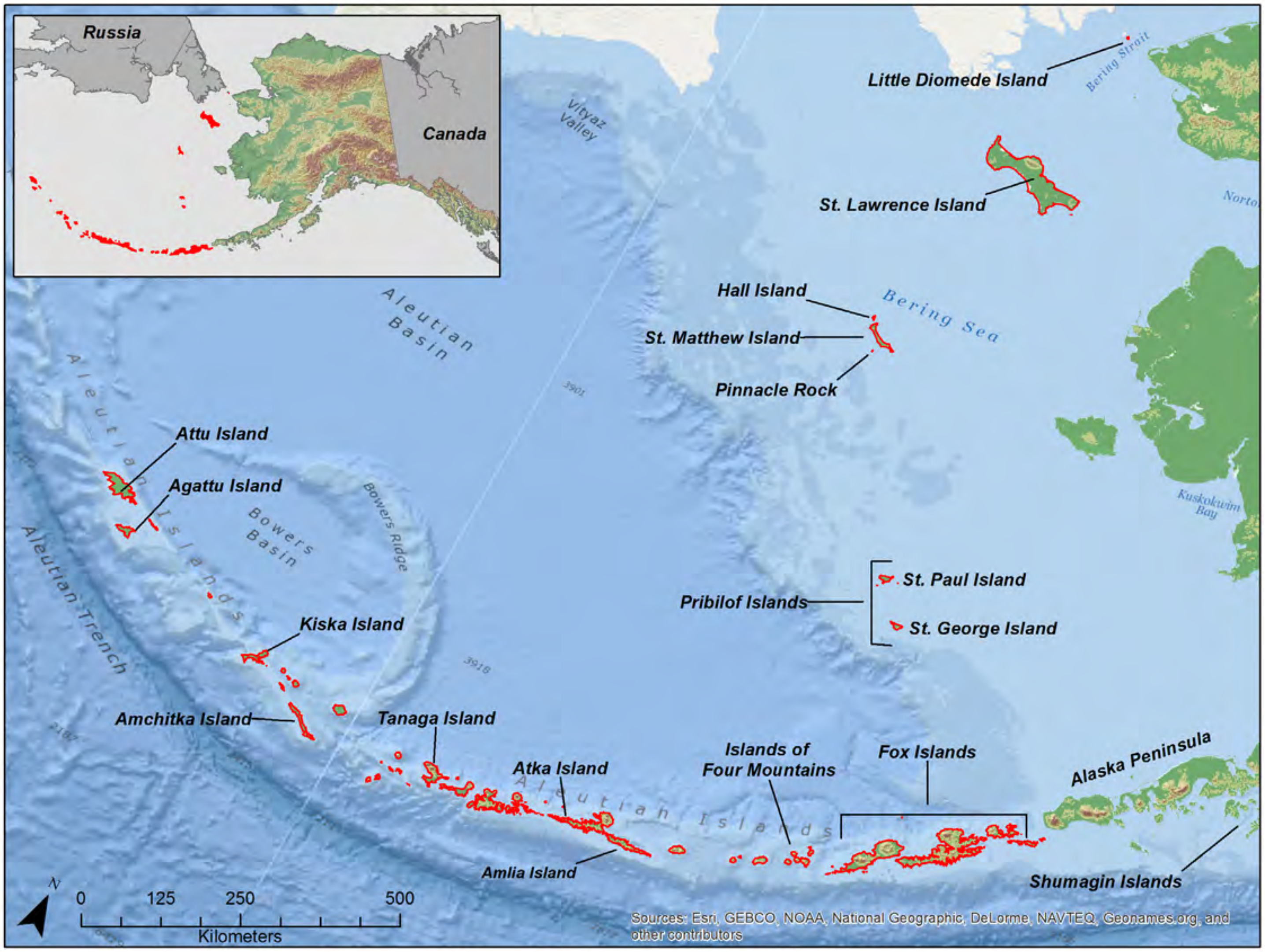
Northern biomes are changing rapidly in response to climate change.

Photo © Robert Gill, Jr.

Virtually the entire population of the McKay's Bunting breeds on the remote St. Matthew and Hall islands, which are protected as part of the Alaska Maritime Refuge and can only be reached through a major expedition.

Bird Conservation Region 1 – Aleutian and Bering Sea Islands

James A. Johnson, Lucas H. DeCicco, Steven M. Matsuoka, Heather M. Renner, and Colleen M. Handel



The Aleutian and Bering Sea Islands Bird Conservation Region (BCR) includes a relatively small area, only 18,000 km^2, but encompasses the breeding ranges and migratory movements of diverse Palearctic and Nearctic avifaunas. These islands constitute part of a separate faunal region known as Beringia, which exhibits the highest level of endemism in Alaska due to its physical isolation from major faunal regions in Asia and North America (Hopkins et al. 1982, Winker et al. 2002, Gibson and Byrd 2007).

Tectonic, volcanic, and glacial processes are the dominant forces to have shaped this region. Situated at the transition between the North American and Pacific plates, the Aleutian Island arc is one of the most volcanically and seismically active regions in the world. The Aleutian Islands were heavily glaciated during the Late Wisconsin period c. 21,000 years before present (BP) and ice fields are still present on the highest peaks (Kaufman and Manley 2004). In contrast, the Bering Sea islands were formed by basaltic lava flowing from widely distributed volcanic fields (Winer et al. 2004). These islands were mostly ice-free during the last glacial period (10,000–117,000 years BP; Hamilton et al. 1986), when they rose as ridgelines above the vast grassland steppe that bridged Asia and North America (Guthrie 2004, Maley and Winker 2010).

The Aleutian Island archipelago includes 150 named islands that arc across 1,800 km from east to west between North America and Asia and span 475 km from

Photo © Peter Morris

north to south. The Bering Sea islands are mostly isolated islands, including the Pribilof Islands (St. George and St. Paul islands), St. Matthew Island and adjacent Hall Island and Pinnacle Rock, St. Lawrence Island, and Little Diomede Island. With the exception of privatedly owned St. Lawrence Island, nearly all of this BCR (97%) falls within the 14,000 km^2 Alaska Maritime National Wildlife Refuge (AMNWR). Elevations range from sea level to mountain peaks rising to nearly 2,000 m. The region is treeless, and dominant vegetated habitats include freshwater wetlands, grass and forb meadows, dwarf shrub tundra, and low to tall shrub thickets. Unvegetated habitats include coastal and inland cliffs, blockfields, scree slopes, and driftwood-covered beaches (Fay and Cade 1959, Gibson and Byrd 2007, Matsuoka and Johnson 2008, Ruthrauff et al. 2012).

Moderated by oceanic waters, temperatures in the Aleutian Islands are characterized by relatively low seasonal variation. Mean daily temperatures range from about 0 °C in winter to 8–9 °C in summer (NOAA NCEI 2020). Snow does not generally accumulate at low elevations and sea ice does not form. Rain and dense fog are common during summer, and windy conditions persist throughout the year (Gibson and Byrd 2007). In comparison, the climate on the Bering Sea islands is colder and drier. Mean daily temperatures on St. Lawrence Island range from about −14 °C in winter to 7 °C in summer (Lehman 2019). Historically, sea ice has formed in the Bering Sea each winter, occasionally as far south as the Pribilof Islands (Stabeno et al. 2007), but its winter extent appears to be diminishing rapidly in response to climate change (Jones et al. 2020).

Landbird Avifauna

The region's landbird avifauna is characterized by a small number of species and a high level of endemism. Overall, 31species of landbirds, representing 6 avian orders and 17 families, occur regularly as residents or during the summer breeding season (Preble and McAtee 1923, Fay and Cade 1959, Kessel and Gibson 1978, Gibson and Kessel 1997, Winker et al. 2002, Johnson et al. 2004, Lehman 2005, 2019, Gibson and Byrd 2007, Robinson et al. 2020; Appendix II).

Additionally, two Paleotropical migrant species occur only as trans-Beringian migrants (Arctic Warbler and Bluethroat) and three species that breed sparingly in the region occur commonly as trans-Beringian migrants (the Paleotropical Northern Wheatear and Eastern Yellow Wagtail, and the Neotropical Gray-cheeked Thrush). The region supports 15 resident species (14 in the Aleutian Islands and 8 on the Bering Sea islands). The region supports one endemic species (McKay's Bunting) and 12 endemic or nearly endemic subspecies.

Priority Species and Subspecies

The Aleutian and Bering Sea islands support significant populations of several Partners in Flight species of continental importance (Table 4). The endemic McKay's Bunting, a Watch List species, is known to breed regularly only on St. Matthew and Hall islands, although small numbers have been reported during summer on St. Lawrence (with evidence of breeding) and the Pribilof islands (Matsuoka and Johnson 2008, Johnson et al. 2013, Lehman 2019). It is rare to casual during winter throughout the region (Kessel and Gibson 1998, Gibson and Byrd 2007, Lehman 2019).

The Snowy Owl, another Watch List species, is a rare to uncommon resident breeder throughout the region, and significant numbers of several Continental Stewardship species occur as either resident or migrant breeders, including the Bald Eagle, Pacific Wren, Gray-crowned Rosy-Finch, and Common Redpoll (Preble and McAtee 1923, Fay and Cade 1959, Kessel and Gibson 1978, Winker et al. 2002, Gibson and Byrd 2007, Lehman 2019, Robinson et al. 2020). The Short-eared Owl, Bank Swallow, Common Redpoll, and Snow Bunting are all Common Birds in Steep Decline (Panjabi et al. 2020). Among these, the Snow Bunting is a common to uncommon resident and breeder throughout the region except being rare during summer on St. Matthew Island, and the others occur uncommonly primarily during summer (Winker et al. 2002, Gibson and Byrd 2007, Lehman 2019, Robinson et al. 2020).

Twelve subspecies are designated for Regional Stewardship because they are endemic or nearly so within this BCR (Table 4). In general, the endemic birds of the region have extremely restricted ranges and are highly susceptible to extirpations and reductions in population size, particularly from introduced mammalian predators. Aleutian Island endemics include three subspecies of the Rock Ptarmigan (*atkhensis*, *evermanni*, and *townsendi*), one subspecies of the Pacific Wren (*meligerus*), and one subspecies of the Song Sparrow (*maxima*; Gibson and Byrd 2007). Endemic subspecies of the Gray-crowned Rosy-Finch (*umbrina*) and Pacific Wren (*alascensis*) occur on the Bering Sea islands (Winker et al. 2002).

Other subspecies are endemic to Beringia, but not solely restricted to BCR 1 (Gibson and Withrow 2015). The *sanaka* Song Sparrow is resident throughout the Islands of the Four Mountains and Fox Islands, east to the Alaska Peninsula and adjacent islands, and the *kiskensis* Pacific Wren occurs from Kiska Island east to islands off the western Alaska Peninsula. The *griseonucha* Gray-crowned Rosy-Finch breeds throughout the Aleutian Islands, east to islands off the central Alaska Peninsula, and west to the Commander Islands in Russia. The *townsendi* Snow Bunting breeds on the Pribilof and Aleutian islands as well as on the Shumagin and Commander islands. The

Table 4. Seasonal occurrence of species and subspecies within the Aleutian and Bering Sea Islands BCR of Alaska recognized as of continental importance (Watch List or Common Birds in Steep Decline [CBSD]; Panjabi et al. 2020) or as a Continental or Regional Stewardship species. Some species that occur primarily during the breeding season may also occur in small numbers during winter in southern parts of the region.

Species	Continental Status	Continental Stewardship	Regional Stewardship	Seasonal Occurrence
Rock Ptarmigan (*atkhensis, evermanni, townsendi*)			●	Year-round
Bald Eagle		●		Year-round
Snowy Owl	Watch List			Year-round
Short-eared Owl	CBSD			Breeding
Common Raven (*kamtschaticus*)			●	Year-round
Bank Swallow	CBSD			Breeding
Pacific Wren (*alascensis, meligerus, kiskensis*)		●	●	Year-round
Gray-crowned Rosy-Finch (*umbrina, griseonucha*)		●	●	Year-round
Common Redpoll	CBSD	●		Year-round
Snow Bunting (*townsendi*)	CBSD			Year-round
McKay's Bunting	Watch List	●		Breeding
Song Sparrow (*maxima, sanaka*)			●	Year-round

Photo © Lucas DiCicco

kamtschaticus Common Raven is resident throughout the Aleutian Islands, west to northeastern Russia, and east to the central Alaska Peninsula and Cape Newenham in BCR 2. An assessment of avifaunal systematics in the region is incomplete, however, particularly on St. Lawrence Island (but see Lehman 2019). Thus, the degree of endemism described here may be underestimated (Gibson and Byrd 2007).

Important Landbird Areas

The restriction of several endemic landbird populations to single islands or island groups in this region renders natural designation of these islands as important landbird areas. St. Matthew and Hall islands have been recognized by BirdLife International in partnership with the National Audubon Society as a Global Important Bird Area (IBA) because the islands support virtually the entire known breeding population of the McKay's Bunting in addition to significant concentrations of other shorebird and seabird species of conservation concern (Matsuoka and Johnson 2008; http://datazone.birdlife.org/site/factsheet/st-matthew-and-hall-islands-iba-usa).

Several endemic subspecies of landbirds have limited ranges in the Aleutian or Pribilof islands (Preble and McAtee 1923, Winker 2002, Gibson and Byrd 2007, Gibson and Withrow 2015, Robinson et al. 2020). The *evermanni* subspecies of Rock Ptarmigan was restricted to Attu Island until it was reintroduced to Agattu during 2003–2006; the *townsendi* subspecies is restricted to the Rat Islands (Kiska to Amchitka) and *atkhensis* is restricted to the Andreanof Islands (Tanaga to Amlia). The *meligerus* subspecies of Pacific Wren is restricted to the Near Islands (Attu and Agattu) and *alascensis* is restricted to the Pribilof Islands (primarily St. George). The *maxima* subspecies of Song Sparrow is resident from the Andreanof Islands to and including the Near Islands (Attu to Amlia). The *umbrina* subspecies of Gray-crowned Rosy-Finch is resident on the Pribilof Islands and breeds on St. Matthew and Hall islands.

Important habitats for the priority landbird species and endemic populations are varied and largely intact (Preble and McAtee 1923, Fay and Cade 1959, Gibson and Byrd 2007, Matsuoka and Johnson 2008, Johnson et al. 2013, Holt et al. 2020, Macdougall-Shackleton et al. 2020). Coastal cliffs and sea stacks provide important nesting substrates for Bald Eagles, Common Ravens, Gray-crowned Rosy-Finches, and McKay's Buntings, and Snowy Owls generally nest in more interior upland habitats. Gray-crowned Rosy-Finches and both McKay's and Snow buntings also nest on scree slopes and blockfields. Grass and forb meadows are used for nesting by many species, including Rock Ptarmigan, Short-eared Owls, and Song Sparrows. Artificial habitats, particularly abandoned equipment and structures in the Aleutians, are used for nesting by Bald Eagles, Gray-crowned Rosy-Finches, and Snow Buntings. Bank Swallows forage primarily over fluviatile and lacustrine waters and nest along their banks. Beaches and tidal flats provide foraging and nesting habitats for many landbirds of the region, especially Song Sparrows and Pacific Wrens.

Primary Conservation Objectives

By virtue of their small population sizes and restricted distributions, endemic landbirds in this BCR are particularly susceptible to extirpation from introduced predators, disease, and other types of disturbance. Introduced mammalian predators, particularly Norway rats (*Rattus norvegicus*) and foxes (*Vulpes* spp.), pose the greatest conservation threat in the region due to their predation on birds and nests. Populations of Rock Ptarmigan, Pacific Wren, and Song Sparrow have already been extirpated or greatly reduced on some Aleutian Islands because of such introductions (Gibson and Byrd 2007). Unintended introductions of rats from shipping and fishing vessels pose a continual threat, even in areas with aggressive rat prevention programs, such as St. Paul Island (ADFG 2015, Gilman 2019).

Increases in trans-Pacific shipping traffic, including the opening of new shipping routes through the Northeast and Northwest passages, heighten concerns for catastrophic fuel spills and rat invasions. The region has also experienced relatively rapid increases in temperature that have significantly altered hydrology and the extent of winter Bering Sea ice; rapid ecological changes are expected in the future (Stabeno et al. 2007, Post et al. 2009, Jones et al. 2020).

A small human population (State of Alaska 2020), combined with the protected status of most lands in the region, minimizes levels of urbanization and development here compared to other regions of Alaska. Economic incentives, however, are expected to increase infrastructure-building, mineral mining, and energy development in the region, particularly on St. Lawrence Island (Kawerak, Inc. 2019). St. Lawrence's large size, diverse habitats, and position within a narrow migratory corridor between Asia and North America are compelling reasons for a thorough avifaunal inventory and assessment of endemic taxa on this poorly studied island (but see Lehman 2019). Throughout BCR 1, the AMNWR is currently involved in ongoing survey and monitoring projects, programs to remove introduced mammals, and efforts to reintroduce native species, and thus will be a key partner in managing and conserving landbirds across the region.

The following objectives may facilitate conservation of landbirds in BCR 1:

- Restore endemic and other natural populations of landbirds on the islands to historic distributions (prior to introduction of mammalian predators) and minimize future impacts from introduced mammals, fuel spills, and other types of disturbance.
- Estimate current genetic diversity and abundance of endemic landbirds on poorly studied islands in the region, particularly St. Lawrence Island.
- Conduct long-term, periodic monitoring to track the population status of Watch List species, Common Birds in Steep Decline, Continental Stewardship species, and Regional Stewardship endemic taxa.


Bald Eagle

Photo © Daniel Poleschook

Priority Conservation Issues and Actions

Invasive & Problematic Species, Pathogens, & Genes

Soon after Vitus Bering's exploration of the region in 1741, arctic fox (*Vulpes lagopus*) and red fox (*V. vulpes*) were intentionally released by Russian fox farmers on several of the Aleutian Islands (Ebbert and Byrd 2002). Fox farming peaked during 1910–1940, when foxes were introduced on nearly every habitable island.

Other intentionally introduced mammals on the Aleutian Islands include arctic ground squirrels (*Spermophilus parryii*), European hare (*Lepus europaeus*), sheep (*Ovis aries*), goats (*Capra aegagrus*), cattle (*Bos taurus*), horses (*Equus ferus*), caribou (*Rangifer tarandus groenlandicus*), reindeer (*R. t. tarandus*), and bison (*Bison bison*). By the 1940s, most of the Aleutian Islands had some species of introduced mammal (Bailey 1993). The first accidental introduction to the Aleutians was in 1780 when Norway rats became established following a Japanese shipwreck. Norway rat

Photo © Lucas DeCicco

The Aleutian and Bering Sea Islands BCR supports several endemic or near-endemic populations of birds, including two subspecies of the Song Sparrow.

populations have since become established on at least 16 other islands in the Aleutians (Ebbert and Byrd 2002).

Introduced foxes and rats have severely reduced numbers of endemic landbirds in the Aleutian Islands. Foxes are believed to have extirpated Evermann's Rock Ptarmigan from as many as 10 Aleutian Islands (Bailey 1993). Following removal of foxes, ptarmigan numbers increased substantially on Amchitka and Attu, where small extant populations of ptarmigan had persisted, and on Agattu Island, where ptarmigan were reintroduced (Emison and White 1988, Kaler et al. 2010).

Removal of rats is also known to have a positive effect. Abundances of Pacific Wren and Rock Ptarmigan were significantly higher on Rat Island following rat eradication (Buckelew et al. 2011). Although intentional release of invasive species is prohibited within the AMNWR, new (Northwest and Northeast passages) and existing (trans-Pacific) international shipping routes increase the risk of accidental release of invasive species resulting from shipwrecks or escape when ships are ashore at harbors.

Reindeer were also introduced on other Bering Sea islands, including St. Lawrence (1900), the Pribilofs (1911), and St. Matthew (1944). They continue to occur in free-ranging herds on all these islands except on uninhabited St. Matthew, where they increased exponentially in population size before undergoing a crash die-off in the 1960s (Preble and McAtee 1923, Fay and Cade 1959, Klein 1968, 1987). The introduction of these and other free-ranging ungulates on islands within this BCR has led to overgrazing and trampling of vegetation and changes in composition of plant communities (Klein 1987, Swanson and Barker 1992). The effects of ungulates on ground- and shrub-nesting landbirds in Beringia are unknown (Ebbert and Byrd 2002). However, McKay's Buntings breed at higher densities on Hall Island, where there have been no reindeer introductions, compared to adjacent St. Matthew Island, where lichen-dominated tundra had still not recovered 20 years after the major die-off of introduced reindeer (Klein 1987, Matsuoka and Johnson 2008).

Actions

- Support ongoing efforts by AMNWR and regional communities to establish rat-control programs at docks and on vessels throughout the region.
- Support ongoing efforts to remove or reduce numbers of rats, foxes, and other introduced mammals from selected islands and to reintroduce endemic subspecies of Rock Ptarmigan to islands from which they were extirpated.
- Implement pre- and post-eradication monitoring programs that target priority landbirds. The temporal scale of this effort should be of a duration long enough to discern interannual variability.
- Evaluate the utility of rat-proof nest boxes for McKay's Buntings in the event that rats become established on St. Matthew and Hall islands.
- Assess the effects on ground- and shrub-nesting landbirds of habitat alteration resulting from introduced ungulates.
- Identify factors that influence differential breeding densities of McKay's Buntings on St. Matthew and Hall islands, monitor the status of the breeding population, and identify important nonbreeding areas.
- Estimate population sizes and current levels of genetic diversity of endemic landbird taxa on St. Lawrence Island and other poorly studied islands affected by introduced mammals.


Gray-crowned Rosy-Finch

Photo © Brian Guzetti

Pollution

Currently, more than 3,500 ships pass through the Aleutians every year in transit between North America and Asia (Brewer 2006). Furthermore, ship traffic through the Bering Sea is projected to increase with the continued warming of the Arctic Ocean. New routes through the Northwest and Northeast passages offer substantial savings in time and fuel and as a result these routes are projected to account for 5% of global trade volume by 2050 (Arctic Council 2009). This expansion of Arctic ship traffic will increase air pollution (Corbett et al. 2010) and increase the risk of fuel spills. Since 2005, 190 ships,

Photo courtesy of Alaska Department of Fish and Game

The M/V *Selendang Ayu* ran aground and broke up off of Unalaska Island in 2004.

including freighters, barges, cargo vessels, and passenger ships have wrecked on the Aleutian Islands (https://www.boem.gov/sites/default/files/uploadedFiles/BOEM/About_BOEM/BOEM_Regions/Alaska_Region/Ships/2011_Shipwreck.pdf). One recent incident was the grounding of M/V *Selendang Ayu*, which released over 300,000 gallons of fuel oil and diesel into the nearshore waters of Unalaska Island (Brewer 2006, Byrd and Daniel 2008, Byrd et al. 2009).

Fuel spills are less likely to have severe, direct effects on landbirds than on more aquatic species; however, the many passerines that forage along wrack lines and intertidal areas, especially during winter, may be vulnerable. Bald Eagles and other raptors that opportunistically feed on animals killed or injured by fuel spills are particularly at risk of feather oiling and secondary exposure to bio-accumulated toxins.

Both point-source and atmospheric-deposited contaminants have been documented to occur in the region (Anthony et al. 1999, Rocque and Winker 2004). Contamination from military sites is a chronic issue, but its effect on landbirds is unknown. There is evidence of increased mercury contamination in some Arctic bird species since the 1980s, following increased coal-burning in China (AMAP 1998). Aquatic birds that feed at the top of marine food webs are most susceptible, but landbirds associated with marine environments and freshwater wetlands are also at risk (Stout and Trust 2002).

Actions

- Ensure landbirds are addressed in oil spill response plans.
- Assess levels and effects of mercury and other contaminants for high-risk species (e.g., Bald Eagle, McKay's Bunting).

Climate Change

This region is experiencing increased summer and winter air temperatures and decreased cover of sea ice (Overland and Stabeno 2004, Stabeno et al. 2007, Stabeno and Bell 2019, Jones et al. 2020). Increases in temperature are also causing shifts in the distributions of subarctic fauna and flora, which have the potential to influence the distribution and dynamics of endemic landbird populations. Red foxes that colonized St. Matthew Island prior to 1995 appear to have replaced the less dominant arctic foxes on the island (Post et al. 2009, Klein and Sowls 2015), as has happened elsewhere in their range with climate warming (Stickney et al. 2014, Elmhagen et al. 2017).Consequences for predation on landbirds and their nests are unknown. Subarctic shrubs are increasing in extent and height in response to climate warming (Sturm et al. 2001, Tape et al. 2006).

The establishment of forbs and grasses on talus slopes has drastically reduced the availability of nest crevices for Least Auklets (*Aethia pusilla*) on St. George Island (Roby and Brink 1986). Changes in abundance of alternative prey may alter predation pressures on landbirds, and changes in vegetation may affect the amount of suitable foraging and nesting habitats available to landbirds.

Earlier arrival of spring may also create phenological mismatches in the timing and availability of insect prey relative to timing of landbird reproduction (MacLean 1980). Changes in the location, frequency, timing, and severity of storms in the North Pacific may influence weather patterns that shape migration timing and routes (McCabe et al. 2001). Maley and Winker (2010) proposed that the earlier arrival of McKay's Buntings at St. Matthew Island provides them with a competitive advantage that excludes breeding by Snow Buntings. Changes in the timing of spring migration and arrival dates due to weather may interrupt this balance.

Actions

- Conduct long-term, periodic monitoring to track the status and demography of continentally important and regionally endemic landbird populations to assess how climate-mediated changes ultimately affect population dynamics. Studies should include breeding chronology (e.g., arrival, nest initiation, and fledging dates), measures of habitat phenology, composition, and structure, predator-prey relationships, and population trends.
- Evaluate effects of the recent climate-related colonization of St. Matthew Island by red foxes on breeding McKay's Buntings.
- Analyze high-resolution imagery to assess climate-related changes in landcover for priority landbird taxa on major island groups in the region.
- Monitor establishment of vegetation on talus slopes that could reduce suitable habitat for crevice-nesting species.

Photo © Heather Renner

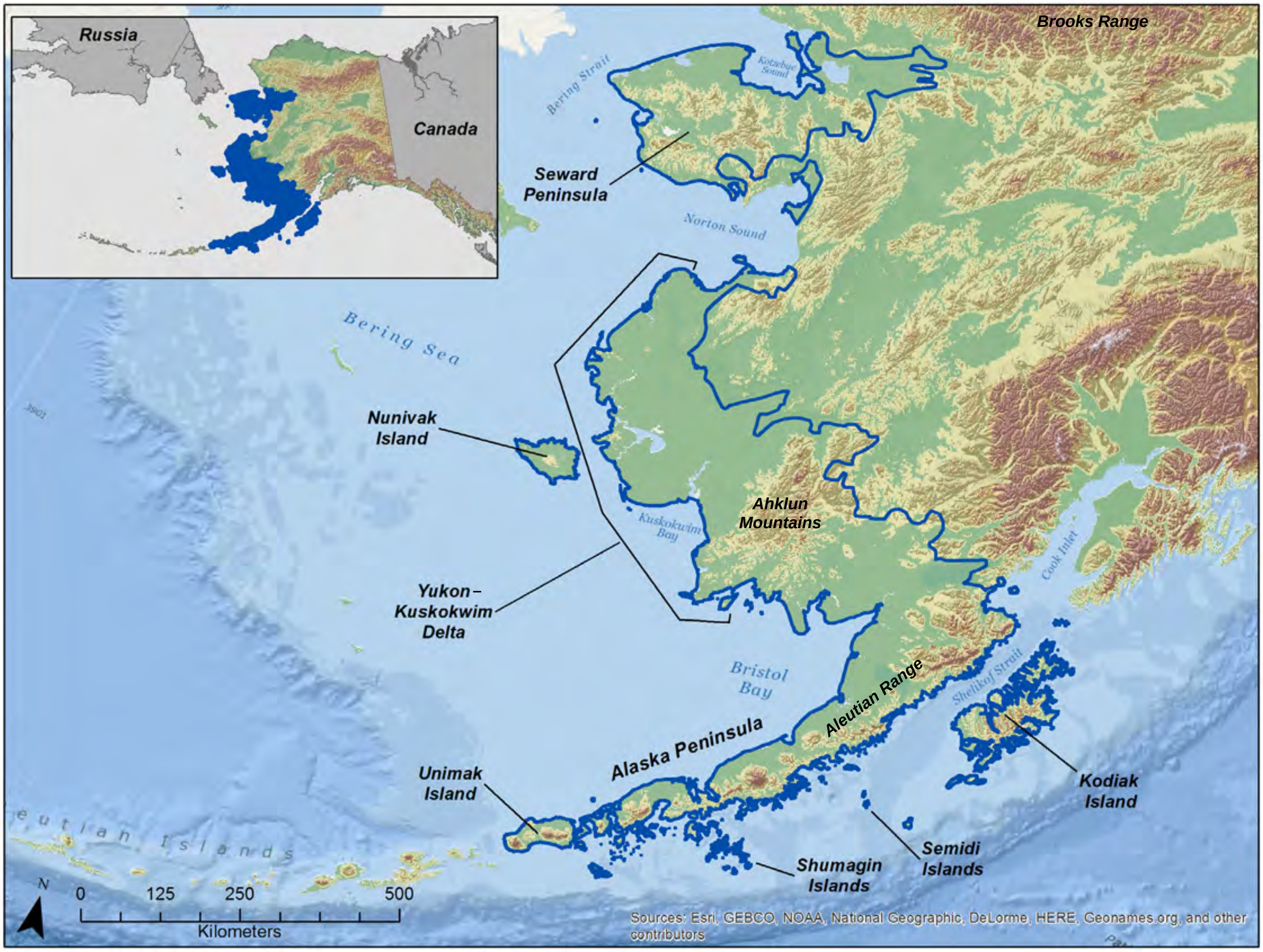
The grassy slopes of Hall Island in the central Bering Sea.

Photo © Ken Archer

Western Alaska includes vast expanses of lowland tundra and rugged mountains.

Bird Conservation Region 2 – Western Alaska

Susan E. Savage, Kristine M. Sowl, Colleen M. Handel, Steven M. Matsuoka, James A. Johnson, and Lucas H. DeCicco



The Western Alaska Bird Conservation Region (BCR) encompasses 293,000 km^2 and extends from southern Unimak Island to just north of the Arctic Circle. From east to west, the region spans from the Kodiak Archipelago to the Bering Strait. Elevations range from sea level to volcanic summits on the Alaska Peninsula that exceed 2,000 m. This region is bounded to the west by the Chukchi and Bering seas and to the south by the North Pacific Ocean. The northern border is delineated by the foothills of the Brooks Range and the region's eastern extent intergrades with interior Alaska's boreal forest biome.

The region's geologic history, physiographic complexity, and geographic proximity to Asia are all important determinants of its unique avifauna. Although southern portions of the region were heavily glaciated during the Late Wisconsin period c. 21,000 years before present (BP), and some remain so today, much of the region was encompassed by the vast refugium known as Beringia (Hopkins 1982, Kaufman and Manley 2004). Dominant continental physiographic units include the Seward Peninsula, Yukon–Kuskokwim Delta, Ahklun Mountains, and Aleutian Range. Lowlands along the Kobuk and Selawik rivers bordering Kotzebue Sound to the north and lowlands in the Nushagak Bay–Bristol Bay watersheds to the south are also important physiographic features. This region also encompasses several small island groups (e.g., Semidi and Shumagin islands) as well as three of Alaska's largest islands: Kodiak, Nunivak, and Unimak.

Complex geophysical characteristics and processes help shape the region's diverse habitats. Subarctic coastal plain, dominated by mesic graminoid and dwarf shrub communities, covers the northern portions of the Seward and Alaska peninsulas and much of the Kotzebue Sound lowlands, Yukon–Kuskokwim Delta, and Bristol Bay lowlands. Numerous lakes and ponds occur throughout low-lying areas, as do large riverine systems and their accompanying cliffs and tall shrub communities. Rugged upland areas are characterized by alpine tundra and barren, rocky ridgelines. Fell-fields and discrete rock formations are interspersed across the region. Coniferous and deciduous forests typical of interior Alaska penetrate into the region via major river systems. Permafrost conditions range from continuous on the northern Seward Peninsula to isolated or absent on the Alaska Peninsula and Kodiak Island (Jorgenson et al. 2008).

Climatological conditions vary considerably. In general, the climate is continental in the northern and eastern portions, transitional in the central portion, and maritime at capes, islands, and portions of the southern Alaska Peninsula. Mean annual temperatures range from −3 °C in Nome to about 5 °C in the town of Kodiak, and annual precipitation varies from about 40 cm in Nome to about 200 cm in Kodiak (WRCC 2016). Rain and dense fog are common during summer months and windy conditions persist throughout the year (Williamson and Peyton 1962, Kessel 1989, Petersen et al. 1991, Savage et al. 2018).

Over half of this region is included within federal land conservation units, including national parks, preserves, monuments, and wildlife refuges. This region also includes several Alaska state conservation units. Notable among these protected areas are the Yukon Delta National Wildlife Refuge, the second largest refuge in the national system, and the Wood–Tikchik State Park, the largest state park in the US.

Landbird Avifauna

There are 84 species representing 8 orders and 28 families that regularly occur in this region (Appendix II). For 10 species, BCR 2 supports populations of two or more subspecies. All 84 species, except McKay's Bunting, are known or suspected to breed in the region (Gabrielson and Lincoln 1959, Kessel and Gibson 1978, Gill et al. 1981, Kessel 1989, Petersen et al. 1991, Gibson and Kessel 1997, Ruthrauff et al. 2007, Ruthrauff and Tibbitts 2009, Corcoran et al. 2014, Savage et al. 2018). Thirty species are considered permanent residents but individuals of at least 17 other species remain regularly

Photo © Stacy Studebaker

Habitats change rapidly across a steep latitudinal gradient in northwestern Alaska.

Table 5. Seasonal occurrence of species and subspecies within the Western Alaska BCR recognized as of continental importance (Watch List or Common Birds in Steep Decline [CBSD]; Panjabi et al. 2020) or as a Continental or Regional Stewardship species. Some species that occur primarily during the breeding season may also occur in small numbers during winter in southern parts of the region.

Species	Continental Status	Continental Stewardship	Regional Stewardship	Seasonal Occurrence
Willow Ptarmigan		●		Year-round
Golden Eagle			●	Breeding
Northern Goshawk		●		Year-round
Bald Eagle		●		Year-round
Snowy Owl	Watch List			Year-round
Northern Hawk Owl		●		Year-round
Short-eared Owl	CBSD			Breeding
Gyrfalcon			●	Year-round
Olive-sided Flycatcher	Watch List			Breeding
Horned Lark	CBSD			Breeding
Bank Swallow	CBSD			Breeding
Pacific Wren (*semidiensis, helleri*)		●	●	Year-round
Arctic Warbler	CBSD	●		Breeding
Northern Wheatear		●		Breeding
Gray-cheeked Thrush		●		Breeding
Varied Thrush	CBSD	●		Breeding
Bohemian Waxwing	CBSD			Breeding
Gray-crowned Rosy-Finch		●		Year-round
Common Redpoll	CBSD	●		Year-round
Snow Bunting	CBSD			Year-round
McKay's Bunting	Watch List	●		Wintering
Fox Sparrow (*unalaschcensis, insularis*)		●	●	Breeding
American Tree Sparrow	CBSD	●		Breeding
Dark-eyed Junco		●		Breeding
White-crowned Sparrow		●		Breeding
Golden-crowned Sparrow		●		Breeding
Song Sparrow (*insignis*)			●	Year-round
Rusty Blackbird	CBSD			Breeding
Orange-crowned Warbler		●		Breeding
Blackpoll Warbler	CBSD		●	Breeding
Wilson's Warbler	CBSD	●		Breeding


Peregrine Falcon

Photo © Ken Archer

during winter in southern parts of the region. The remaining species migrate out of the region along one of several continental or intercontinental flyways. Notable among these migratory species are several Paleotropical migrants (e.g., Arctic Warbler, Bluethroat, Northern Wheatear, Eastern Yellow Wagtail) that regularly breed in the region and winter in southeast Asia or Africa.

Priority Species and Subspecies

BCR 2 regularly supports several Partners in Flight (PIF) species of continental importance, including three Watch List species and 12 Common Birds in Steep Decline (Table 5, Appendix II). Among the Watch List species, the Snowy Owl is a nomadic Holarctic predator whose seasonal occurrence and breeding status in the region depend largely on the availability of rodents (Kessel 1989, Holt et al. 2020). The Olive-sided Flycatcher is a Neotropical migrant rarely observed in the region and whose breeding range extends into the region with fringes of the boreal forest (Kessel and Gibson 1978, Kessel 1989, Petersen et al. 1991, Ruthrauff et al. 2007). Virtually the entire population of McKay's Bunting breeds on St. Matthew and Hall islands (BCR 1), and it is almost entirely restricted to western Alaska during winter (Kessel and Gibson 1978, Winker et al. 2002, Matsuoka and Johnson 2008, Johnson et al. 2013, Lehman 2019).

The 12 Common Birds in Steep Decline include 2 species that can be found year-round in the region and 10 that occur primarily during the breeding season (Table 5, Appendix II). Common Redpolls are common across the region year-round but irruptive movements can also cause them to occur irregularly across the northern Nearctic and the eastern Palearctic during winter (Kessel 1989, Petersen et al. 1991, Ruthrauff et al. 2007, Ruthrauff and Tibbitts 2009, Savage et al. 2018, Knox and Lowther 2020). The Snow Bunting exhibits a mixed migration pattern, with part of the breeding population migrating to Nearctic wintering areas and others remaining to winter in southern areas of BCR 2 and elsewhere in Alaska (Kessel and Gibson 1978, Kessel 1989). Among the other 10 species, the Arctic Warbler is a Palearctic migrant, 4 species are Nearctic migrants wintering primarily in North America (Bohemian Waxwing, Varied Thrush, American Tree Sparrow, Rusty Blackbird), 2 winter in both North America and the Neotropics (Short-eared Owl, Horned Lark), and 3 winter primarily in the Neotropics (Bank Swallow, Blackpoll Warbler, Wilson's Warbler).

This region also supports populations of 19 species that have Continental Stewardship status based on the proportion of the North American population that occurs in Alaska (Table 5, Appendix II). These include one Watch List species (McKay's Bunting) and five Common Birds in Steep Decline (Arctic Warbler, Varied Thrush, Common Redpoll, American Tree Sparrow, and Wilson's Warbler). Among the remaining species, six of these species are largely resident in the region throughout the year (Willow Ptarmigan, Northern Goshawk, Bald Eagle, Northern Hawk Owl, Pacific Wren, Gray-crowned Rosy-Finch), the Northern Wheatear is a Paleotropical migrant, the Golden-crowned Sparrow is a Nearctic migrant, and the remaining species winter in both North America and the Neotropics (Fox Sparrow, White-crowned Sparrow, Dark-eyed Junco) or primarily in the Neotropics (Gray-cheeked Thrush, Orange-crowned Warbler).

Regional Stewardship status is warranted for three species of conservation concern and five endemic subspecies (Table 5). The Golden Eagle occurs in low numbers where fell-fields, rock outcrops, and riverine cliffs provide important nesting habitat. Conservation concern for this species is focused on potential cumulative threats along its migration pathways and on its wintering grounds (Smith et al. 2008). The Gyrfalcon, a circumpolar species with a low global population size and high breeding site fidelity, faces serious conservation threats from resource development and global warming, and western Alaska supports some of its highest nesting densities in the state (Booms et al. 2010a, 2011b). Some of the highest known breeding densities of the Blackpoll Warbler within Alaska have been recorded in riparian tall shrub communities on the Yukon–Kuskokwim Delta (McCaffery 1996, Harwood 1999, 2000, 2001, 2002a,b). Although there is uncertainty about population trends for this species because of poor survey coverage and low abundance, recent estimates from the North American Breeding Bird Survey suggest severe, long-term declines across the species' range, including Alaska (Sauer et al. 2013, Handel and Sauer 2017). Five subspecies, representing the Pacific Wren, Fox Sparrow, and Song Sparrow, are endemic to the region for all or a portion of the annual cycle and thus merit regional attention for management and conservation.

Important Landbird Areas

Although no sites in the region have yet been designated by the National Audubon Society as Important Bird Areas for landbirds, many areas are deemed critical because they support endemic taxa and concentrations of raptors and other landbirds of conservation concern. Coastal tundra habitats from the northern Seward Peninsula to the northern Alaska Peninsula, particularly the Yukon–Kuskokwim Delta, encompass the core nonbreeding range of the McKay's Bunting (Kessel and Gibson 1978), but knowledge is lacking about specific areas of importance. The majority of birds (72%) caught during annual winter banding at Bethel, about 80 km inland along the Kuskokwim River, were males; from this finding and other records, Rogers (2005) suggested that females may winter farther south than males and that winter distribution in general may be influenced by the severity of the weather. During winter banding on the Alaska Peninsula at Cold Bay, however, Bailey (1974) also found a preponderance of males (62%). Thus, information is still needed on where within BCR 2 this endemic species winters, how distribution varies interannually, and whether there is sex-segregated distribution.

Within this BCR, the Pacific Wren subspecies *semidiensis* and *helleri* are resident to the Semidis and Chirikof Island and to the Kodiak archipelago, respectively, and the partially migratory *insignis* subspecies of Song Sparrow occurs on the Kodiak archipelago and adjacent Alaska Peninsula (Gibson and Withrow 2015). Two migratory subspecies of the Fox Sparrow also occur—*unalaschensis* on

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Coastal areas along the south side of the Alaska Peninsula and nearby islands are particularly important for several endemic landbird populations.

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the western Alaska Peninsula and nearby island groups, and *insularis* on the Kodiak archipelago (Gibson and Withrow 2015). Thus, coastal areas along the south side of the Alaska Peninsula and nearby islands are particularly important for several endemic landbird populations.

Areas particularly important to raptors include the Kisaralik and Tuluksak rivers, which support relatively high densities of nesting Rough-legged Hawks, Golden Eagles, and Gyrfalcons (Petersen et al. 1991). These three raptors also rely on cliffs, bluffs, outcrops, and riparian banks on the Seward Peninsula, Yukon–Kuskokwim Delta, and Alaska Peninsula for nest sites; these areas also support wintering Gyrfalcon populations (Gill et al. 1981, Kessel 1989, Savage 2007, Booms et al. 2010a, 2011a). Coastal tundra habitats on the Seward Peninsula, Yukon–Kuskokwim Delta, and Alaska Peninsula are known to support periodically high densities of breeding Short-eared Owls, which in western Alaska are typically irruptive in response to fluctuating microtine populations (Petersen et al. 1991, Johnson et al. 2017, Savage et al. 2018; B. McCaffery, pers. comm.). The Yukon–Kuskokwim Delta is also important for migrating raptors that rely on concentrations of waterbirds during autumn. Coastal areas along the Alaska Peninsula and the Kodiak Archipelago support high densities of nesting Bald Eagles (Gabrielson and Lincoln 1959, Murie 1959, Gill et al. 1981, Zwiefelhofer 2007, Savage et al. 2018).

Tall shrub communities along the tributaries of the lower Yukon and Kuskokwim rivers (Harwood 1999, 2000, 2001, 2002a,b) and along rivers and open valley floors in the Kilbuck and Ahklun mountains (Petersen et al. 1991) support a diverse breeding bird community, including high densities of Rusty Blackbirds, Blackpoll Warblers, and other boreal-affiliated species. These areas are projected to become continentally important refugia for many boreal landbirds as climatic conditions continue to change through the 21st century (Stralberg et al. 2018). Very little is understood about population dynamics of landbirds in the ecotone between boreal forest and coastal tundra, but the stature and density of shrubs appear to be extremely important determinants of the structure and diversity of the breeding passerine community across both the Seward Peninsula and Alaska Peninsula (Kessel 1989, Thompson et al. 2016, Savage et al. 2018).

Primary Conservation Objectives

The development footprint from human land use is currently small across the Western Alaska BCR owing to the region's low human population density, extremely limited road network, and widely dispersed and generally small settlements along coastlines and rivers (State of Alaska 2020). This is therefore a region where natural ecosystem processes prevail, important avian habitats remain largely unfragmented from human development, and landbirds are expected to maintain healthy and well distributed populations. Sustaining these natural conditions is therefore an overarching conservation objective.

Although landscapes across BCR 2 remain relatively intact, ecological changes relevant to landbird populations are occurring or are projected to occur both within the region and along the flyways used by the region's landbirds. Regional changes include impacts to landbird habitats and communities in response to climate change, large-scale mineral mining and associated infrastructure development, and numerous small wind energy developments.

Key migration stopover sites and wintering areas in temperate and tropical regions are often undergoing high rates of development that are leading to direct losses or degradation of habitats used by migratory species. Thus, the conservation objectives in BCR 2 are to understand, minimize, mitigate, and enable adaptation to these and other ecological changes, particularly as they relate to priority species or important landbird habitats and areas.

To meet these objectives, we must keep in mind that our overall understanding of landbird ecology, basic resource requirements, population sizes and trends, and migration pathways is cursory for nearly all species that use this BCR. Thus, new data collections and analyses will be needed to fill key information gaps if we are to be able to understand and respond to the important drivers of ecological change.

In 2010, the US Fish and Wildlife Service initiated the Western Alaska Partnership, a multi-agency partnership to enhance conservation of the region's ecosystems and biota (http://www.westernalaskalcc.org/). The Western Alaska Partnership may be an important cooperator for achieving landbird objectives in the region.

The following objectives may facilitate conservation of landbirds in BCR 2:

- Fill knowledge gaps of landbird distribution, abundance, resource requirements, demography, and migration. This information is particularly needed for priority species and for geographic areas where we anticipate large future landscape changes from land use or climate change.
- Identify key habitats and specific areas of particular importance to priority landbird species.
- Support population monitoring programs, such as the Alaska Landbird Monitoring Survey and the North American Breeding Bird Survey, to assure sufficient power to monitor regional population trends of landbirds, particularly priority species and regularly breeding species.
- Ensure that environmental assessments of proposed developments in the region include sufficient surveys of landbird distribution, abundance, movement, and toxicology in all potentially affected habitats to guide development. When possible, include information from nearby control sites so that impacts can be measured using a before-after control-impact design (Smith 2002).
- Work with resource managers, industrial developers, and local communities to develop and implement best management practices for protecting landbird populations and important habitats.
- Advocate that all studies use standardized protocols and contribute their data to national data centers like eBird, the Boreal Avian Modelling Project, and Avian Knowledge Network so that the data are archived and easily made available for broad-scale analyses.
- Work with the Western Alaska Partnership to address information needs and conservation measures for priority landbirds, particularly those vulnerable to effects of climate change. Identify areas likely to serve as continental refugia for landbirds in boreal and tundra biomes.

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- Work with biologists and conservation groups in temperate and tropical regions to identify key migration stopover sites and wintering areas for priority landbird species.
- Develop education and outreach programs about landbird populations, their habitats in the region, and their international connections for the general public, land managers, resource developers, and policy-makers.

Priority Conservation Issues and Actions

Energy Production and Mining

Mineral mining and wind energy developments are currently the largest development issues in the region. Mineral mining in BCR 2 dates back to the Nome Gold Rush when, beginning in 1899, there was a northward surge to mine for gold in stream and beach placer deposits and underground quartz lode deposits on the Seward Peninsula (Koschmann and Bergendahl 1968). Since the early 20th century, mining in the region has been dispersed and small in scale. However, rising demand for copper and other metals has fueled multinational interests in extracting the rich mineral resources along the eastern border of BCR 2. These include some of world's largest remaining untapped deposits of copper, gold, molybdenum, silver, and zinc in the Ambler Mineral Belt (Goldfarb et al. 2016), Donlin Creek Deposit (USACE 2018), and Pebble Deposit (Pebble Partnership 2012, USACE 2020). Although these deposits technically reside in BCR 4 immediately adjacent to BCR 2, extracting and transporting these minerals and their wastes would require the development of ports, roads, gas pipelines, and electrical transmission lines between the remote deposits and transportation access points in BCR 2. Development would also likely result in increased shipping and associated risks of pollution in BCR 2 (see below). The added infrastructure, traffic, and human population increase associated with large mining operations could potentially open up remote and largely pristine areas to more expansive mining development and a myriad of other anthropogenic disturbances, such as increased hunting, increased recreation, and additional pathways for the spread of invasive species and pathogens.

Western Alaska also has abundant sources of potential energy from renewable resources such as geothermal, hydroelectric, ocean and river hydrokinetics, wind, and biomass from fish processing plants (AEA 2019). Coastal communities throughout the region have recently begun using wind turbines to offset the high costs of barging diesel from outside suppliers. For example, Kodiak recently installed six 1.5 megawatt (MW) turbines, which now supply more than18% of the city's electricity (AEA 2019). As of February 2017, there were more than 20 wind projects in BCR 2 completed or in the design or construction phase (AEA 2019). The region's largest project in Nome (19 turbines, 3 MW) is considerably smaller than the average wind farm in the contiguous US (45 turbines; Loss et al. 2013a).

The movement towards using wind-generated energy is clearly beneficial in terms of reducing costs and eliminating carbon emissions associated with petroleum-based electricity generation. Turbines can be constructed away from bird concentration areas and migration pathways to minimize the risk that birds collide with the turbines (URS Corporation 2009, US Fish and Wildlife Service 2012). Such collisions have been estimated to kill 140,000–573,000 birds per year in the contiguous US (Loss et al. 2013a, Smallwood 2013) and 23,300 birds per year in Canada, with a predicted 10-fold increase during the next 10–15 years (Zimmerling et al. 2013). Raptors comprised 3–14% of the mortalities (Smallwood 2013, Zimmerling et al. 2013). Although avian mortality from wind farms is generally much less than that from other human-related sources (Calvert et al. 2013, Loss et al. 2013a), mortality can be high overall or high for species of concern at poorly sited facilities (Smallwood and Karas 2009, Smallwood 2013).

A particular concern in western Alaska is that wind facilities are primarily constructed along coasts and rivers where migrating birds concentrate. Such areas also provide key habitats for overwintering McKay's Buntings, whose global population is restricted to the Bering Sea coast during winter (Gibson and Kessel 1997, Montgomerie and Lyon 2020), and for declining species, such as the Rusty Blackbird and Blackpoll Warbler, which reach some of the highest known continental breeding densities in riparian habitats in this region (Harwood 1999, 2000, 2001, 2002a, 2002b). Recent evaluations of bird mortality at wind farms in the US and Canada have primarily been at inland sites (Loss et al. 2013a, Smallwood 2013, Zimmerling et al. 2013), so findings from these studies likely have limited application to western Alaska. After construction, wind facilities in coastal Alaska can be monitored to understand their impacts on landbirds.

Actions

- Identify critical habitats and specific critical areas for priority species in areas proposed for mining, energy production, and associated infrastructure and transportation corridors. Work with stakeholders to minimize impacts.
- Provide guidance on how best to incorporate natural habitat recovery into post-mining reclamation plans.

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- Identify migration corridors and concentration areas for migratory birds to inform land managers of potential conflict with wind turbines and transmission lines. Support efforts to monitor impacts of infrastructure on landbirds.

Transportation and Service Corridors
Large industrial mining operations have been proposed for three locations along the eastern border of BCR 2: Ambler Mineral District, Donlin Creek Deposit, and the Pebble Deposit. Extracting and transporting minerals from these sites would likely require construction of ports, roads, transmission lines, and gas pipelines in BCR 2 or BCR 4 for transportation and service (USACE 2018, 2020). A joint record of decision was issued in March 2020 approving a proposal by the Alaska Industrial Development and Export Authority to construct a new 200-mile-long gravel access road in the southern Brooks Range foothills, which would provide industrial access to the Ambler Mining District in northwestern Alaska (https://eplanning.blm.gov/eplanning-ui/project/57323/510). This road would then possibly continue to Kotzebue or the Seward Peninsula (Longan and Glenn 2015).

Shipping and barge traffic would also likely increase along the region's coasts, rivers, or lakes to service large industrial operations. Riparian habitats could suffer degradation from increased disturbance and erosion due to shipping traffic. Barge traffic on the Kuskokwim River alone is projected to increase significantly with the construction and operation of the Donlin Mine (USACE 2018). Such changes could lead to direct losses to bird habitat from development and to direct mortality of birds through collisions with vehicles, power poles, and transmission lines (Calvert et al. 2013). Development could also lead to degradation of habitats adjacent to roads from increases in habitat edges, hunting pressure, noise, and dust (McClure et al. 2013). Many species of invasive non-native plants, which are easily introduced into transportation corridors by "hitch-hiking" on equipment, are becoming naturalized across Alaska and spreading rapidly across the landscape, posing a serious threat to ecosystem dynamics (Carlson and Shephard 2007).

Actions

- Identify critical habitats for landbirds, especially priority species, within proposed transportation and service corridors as potential construction plans are developed. Work with land owners, developers, and land managers during planning, construction, and operation phases to minimize impacts on landbird populations.
- Work with land managers to identify ways to reduce impacts of off-road activities along new transportation corridors.
- Support monitoring along transportation corridors for potential establishment of invasive plant species and encourage rapid response to eradicate them.

Pollution

Oil and fuel spills and the release of mining wastes have the potential to degrade habitats and poison landbirds and a variety of wetland fauna in the region. Of particular concern are the proposed mines on the eastern border of the region and the potential risk of accidental discharge of fuel, tailings, and other toxic materials, such as mercury or arsenic. Such spills, if they were to occur at the mining facilities or along associated transportation corridors, have the potential to contaminate important riparian habitats along major drainages (Kobuk, Kuskokwim, Kvichak, Nushagak) that support high densities of breeding raptors, Olive-sided Flycatchers, Blackpoll Warblers, Rusty Blackbirds, and other landbird species (Gabrielson and Lincoln 1959, Harwood 1999, 2001). Some areas within the region, such as the Kuskokwim River, have naturally high levels of mercury (Matz et al. 2014). Thus, even small to modest increases in mercury from point sources or from atmospheric deposition could increase mercury exposures

Photo © Rachel Richardson

Shrubs are encroaching onto coastal tundra, altering avian communities and predator-prey dynamics.

to toxic levels (Evers et al. 2005, Edmonds et al. 2010). For example, the Red Devil Mine, an abandoned cinnabar mine (1933–1971) along the middle Kuskokwim River, has left behind a lasting legacy of contamination of mercury, arsenic, and antimony that is still detected in the area's fish and aquatic insects (Matz et al. 2014).

Coastal habitats in the North Pacific Ocean and the southern Bering Sea, which remain ice-free year round, are particularly vulnerable to fuel spills through shipping traffic and fishing vessels. Shipping traffic through the Bering Sea is projected to increase with continued warming of the Arctic Ocean. New routes such as the Northwest and Northeast passages are projected to account for 5% of global trade volume by 2050 (Arctic Council 2009). Increased shipping traffic, along with expanded exploration and development for offshore petroleum reserves in the Bering and Chukchi seas, will increase risk of fuel spills as well as air pollution in the region (Corbett et al. 2010). Oil spills are less likely to have severe effects on landbirds compared with marine species, but many passerines that forage along or above wrack lines and intertidal areas, especially during winter, are vulnerable to toxic exposure. Within BCR 2, McKay's Buntings, endemic subspecies of Song Sparrow and Pacific Wren, and Bank Swallows may be particularly at risk. Bald Eagles and other raptors that scavenge on animals killed by oil spills are also vulnerable to feather oiling and secondary exposure to toxicants.

Actions

- Ensure landbirds are addressed in environmental response plans for oil spills and loss of containment for toxic materials associated with resource development and transportation.
- Monitor levels and potential effects of mercury and other contaminants for high-risk species (e.g., Rusty Blackbird, Blackpoll Warbler, and other species associated with aquatic habitats).

Invasive & Problematic Species, Pathogens, & Genes
Due to its unique connectivity through migrant landbirds to Oceania, Asia, Africa, and other continents, BCR 2 may be particularly vulnerable to new or emerging avian diseases, especially those that respond to rapidly changing climatic conditions (Van Hemert et al. 2013). Shifts in vector populations, range expansion of host species, or increased challenges to avian immune function could contribute to the spread of infectious pathogens and parasites in this region. A recent study of avian hematozoan infections found higher prevalence

Horned Lark

Photo © Ken Archer

and diversity of parasites in the Bristol Bay lowlands of western Alaska than at other sites in Alaska, and concluded that patterns of infection were best explained by climatic factors (Ramey et al. 2012). Although the highly pathogenic strain of avian influenza, of grave human health concern, has not yet been detected in Alaska, the occurrence of a multitude of low pathogenic strains in western Alaska (Reeves et al. 2013) highlights the need for continued surveillance in this region.

Actions

- Establish routine surveillance for avian diseases at potential gateways into the region, particularly in contact zones where different continental populations of migratory birds and other wildlife co-occur.

Climate Change
Arctic, subarctic, and boreal regions are experiencing the most rapid rates of warming in the world (Christensen et al. 2007) and are therefore projected to be global epicenters of the ecological changes brought by climate change through the end of the 21st century (ACIA 2004, Lawler et al. 2009). Temperatures in western Alaska increased 1.5 °C over the past 60 years, and both temperature and precipitation are expected to increase through the end of the century (Walsh 2012). Such climatic changes are projected to alter major ecosystem processes and thereby affect landbird habitats and communities across the region.

Significant ecological changes are projected to include: (1) changes in coastal habitats resulting from increases in sea level, frequency and intensity of storm surges,

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and levels of salt water intrusion; (2) changes in riparian habitats and floodplain processes due to increases in precipitation, glacial melting, permafrost thaw, and timing of snow melt; and (3) widespread changes in both lowland and upland habitats through increases in permafrost thaw and associated thermokarst processes, lake drainage, and expansion of trees and shrubs into coastal tundra (Rupp et al. 2000, 2001, Naito and Cairns 2015, Jorgenson et al. 2018). Habitat changes are likely to favor landbirds associated with shrubs and forests at the expense of species associated with tundra and species that are sensitive to changes in hydrologic cycles. Based on these criteria, species of particular management interest considered to be most susceptible to climate-induced changes in this region include the resident Rock Ptarmigan, Willow Ptarmigan, and Gyrfalcon; the overwintering McKay's Bunting; and the migratory Rusty Blackbird (Booms et al. 2011a, Reynolds and Wiggins 2012). The Lapland Longspur should also be considered a sentinel species of climate change because of its reliance on coastal meadow habitats.

Ecosystem processes are projected to change broadly across Alaska landscapes in response to climate change (Martin et al. 2009c, Reynolds and Wiggins 2012). Thus, bird conservation objectives should be framed from a continental, population-level perspective to aid species' abilities to adapt to rapid ecological change, rather than from a more narrow perspective to maintain current local or even regional population levels. Identifying and protecting geographic areas within Alaska with relatively stable and favorable climates (climate refugia) for priority or climate-sensitive species might be an important conservation strategy. Within this context, BCR 2 may be a particularly important region for Alaska birds, as future shifts in the region's climate envelope are expected to be more moderate than the larger shifts projected in northern and interior Alaska (SNAP and EWHALE Lab 2012).

Ecological stress from climate change, such as the drought-induced reductions in plant growth observed in interior Alaska (Verbyla 2008, Beck et al. 2011b), might be less in western Alaska compared to adjacent continental regions. This resiliency might particularly benefit boreal songbirds. Indeed, recent climate-based species distribution models suggest that western Alaska is likely to be one of the few geographic areas in northern North America that will maintain favorable climatic conditions for many species of boreal-breeding landbirds throughout the 21st century (Stralberg et al. 2015). Thus, from a continental perspective, BCR 2 will likely provide important broad-scale climate-change refugia for boreal birds, although how communities may reshuffle is highly uncertain (Stralberg et al. 2018, Bateman et al. 2020b). Identifying and protecting multiple potential refugia for landbirds at a finer geographic scale within the region may facilitate their adaptation to rapid ecological change across North America.

Actions

- Gather baseline inventory data on the current distribution of landbirds across the region, particularly in remote areas at interfaces with adjacent BCRs and in habitat-transition zones that are rapidly changing.
- Develop models of current habitat associations for all regularly occurring species of landbirds in the region, but particularly priority species.
- Support development of dynamic models of habitat change across the landscape relative to major ecosystem drivers (e.g., permafrost, hydrology, soil nutrients, fire, salt water intrusion, coastal erosion and deposition) and climatic factors. Ensure that models encompass broad latitudinal, elevational, and coastal-inland gradients in permafrost and climatic conditions.
- Identify specific geographic areas within the region that are currently of great importance during breeding, migration, and wintering for priority species and areas that are likely to provide critical refugia for tundra- and boreal-associated species as climate is projected to change.
- Establish a series of long-term monitoring stations to track the status and distribution of continentally and regionally important landbird populations relative to climate-induced changes. Such studies should include demography, migratory connectivity, phenology, habitat quality, predator-prey relationships, and pathogens.
- Engage the public in local community projects to monitor phenological changes in landbirds and their habitats to promote understanding of impacts of climate change on ecosystems.

Photo © James Saghafi

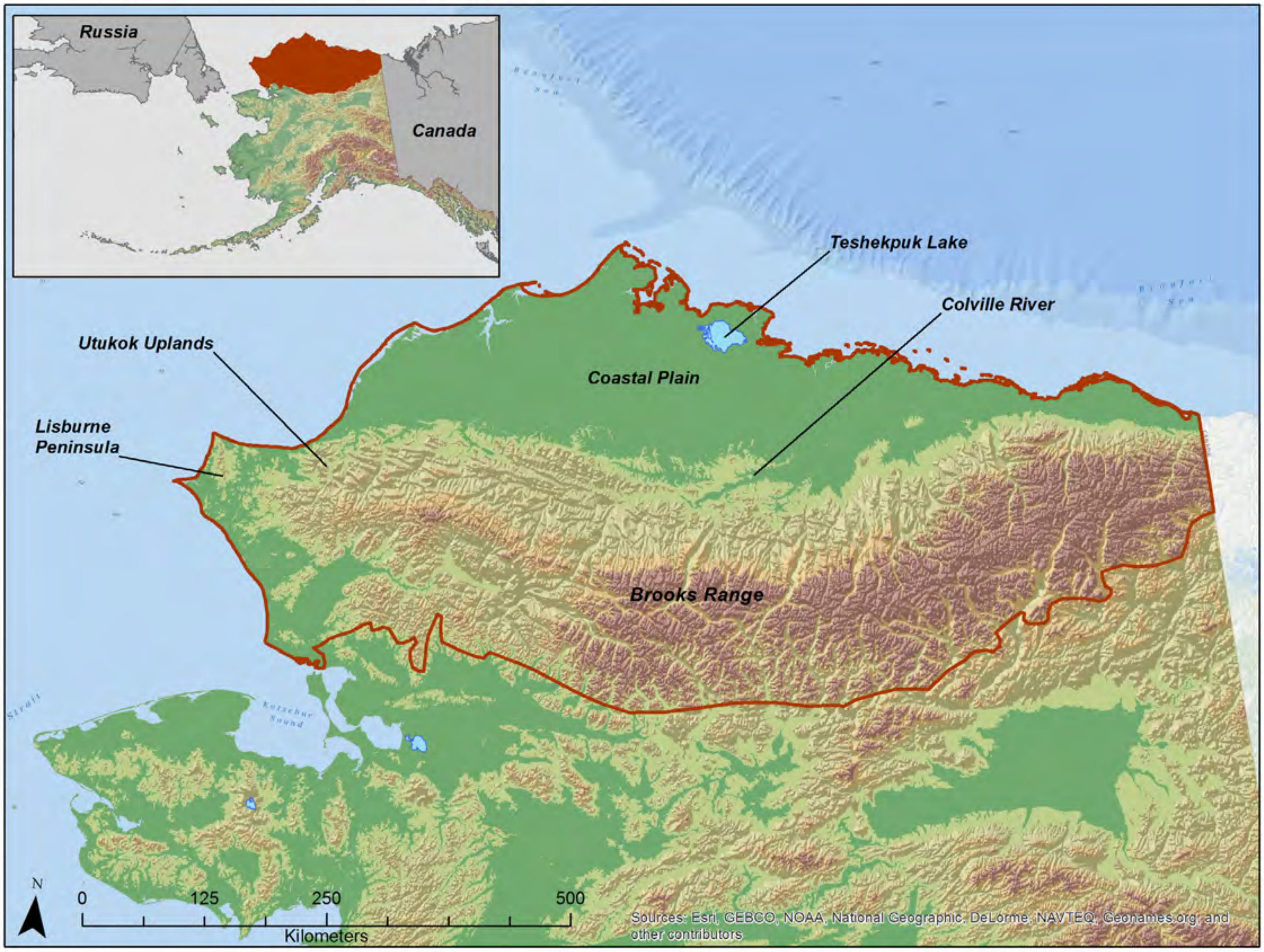
The transition zone between the boreal forest and coastal tundra is undergoing rapid ecological change.

Photo © Robert Gill, Jr.

The Arctic Plains and Mountains BCR includes vast expanses of coastal tundra, the northernmost fringes of boreal forest, and montane habitats across the rugged Brooks Range.

Bird Conservation Region 3 – Arctic Plains and Mountains

Travis L. Booms, Debbie A. Nigro, Lucas H. DeCicco, Melanie J. Flamme, and Colleen M. Handel



The Arctic Plains and Mountains Bird Conservation Region (BCR) encompasses 240,000 km^2 of northern Alaska and includes the vast Arctic Coastal Plain, Arctic foothills, and rugged Brooks Range. Within Alaska, the conservation area is bounded by the Chukchi Sea to the west, Beaufort Sea to the north, Canadian border to the east, and the southern foothills of the Brooks Range. Nearly 70% (212,400 km^2) of BCR 3 is federally managed by the National Park Service, Bureau of Land Management, and US Fish and Wildlife Service combined.

The Arctic Coastal Plain, which dominates this region, features wet polygonal tundra and meandering north-flowing rivers. Although highly important for breeding shorebirds and waterfowl, the coastal plain supports relatively few landbird species. The northern foothills of the Brooks Range are dominated by upland tundra and low rolling hills with long sinuous rivers lined with willow thickets (*Salix* spp.), cut banks, cliffs, and isolated islands of balsam poplars (*Populus balsamifera*). On the south-facing foothills, interior boreal forest, which reaches its northern extent and penetrates this region through river valleys, hosts the greatest diversity of landbirds within this region. Rocky alpine tundra dominates the majority of higher elevations throughout the Brooks Range and tundra–shrub communities occur widely at lower elevations.

The climate of this region is characterized by long, cold, and dark winters contrasting with short summers that are cool along the Arctic Coastal Plain but warmer in the interior. Warmest temperatures generally occur during July, when average monthly maximums vary from about 8 °C along the coast to 16 °C in the interior (WRCC 2016). Coldest temperatures generally occur during February, when average monthly minimums range from about −26 to −32 °C across the region. Annual precipitation is less than 30 cm for most of this Arctic desert biome.

Landbird Avifauna

Fifty-six species of landbirds occur regularly in the region, representing 23 families and 5 orders (Maher 1959, Kessel and Schaller 1960, Irving 1960, Hines 1963, Johnson and Herter 1989, Swanson 1997, 1998, 2001, Tibbitts et al. 2006, DeGroot and McMillan 2012; https://www.fws.gov/refuge/arctic/birdlist.html; Appendix II). Only 13 species are year-round residents and many species are at the northern periphery of their boreal-forest distribution. A few Palearctic species arrive from a westerly direction, likely migrating along the southern (Arctic Warbler) or northern (Eastern Yellow Wagtail) slope of the Brooks Range. These species are more abundant in the western half of the region, becoming rare or nonexistent at the eastern boundary.

Priority Species

The Arctic Plains and Mountains BCR hosts two Watch List species, considered of highest continental importance for conservation: the Snowy Owl and Olive-sided Flycatcher (Table 6; Panjabi et al. 2020). The Snowy Owl, recently uplisted to Vulnerable on the IUCN Red List of Threatened Species (BirdLife International 2020), is an iconic, nomadic species of the circumpolar Arctic tundra, typically nesting in dry, windswept coastal areas with high relief wherever small microtines are cyclically plentiful (Johnson and Herter 1989, Holt et al. 2020). This owl is one of the few year-round avian residents in the Arctic although it is also known for its irruptive southward migrations (Holt et al. 2020). In contrast, the Olive-sided Flycatcher occurs during summer in low numbers along the southern edge of this region bordering the boreal forest, where it is strongly associated with forest openings and edges (Altman and Sallabanks 2020). This flycatcher, a species of Special Concern in Canada (COSEWIC 2018), has experienced long-term population declines both continentally (Sauer et al. 2013) and within Alaska (Handel and Sauer 2017). The Alaska-endemic McKay's Bunting has an extremely small population size and a highly restricted breeding distribution (virtually all on St. Matthew and Hall islands in the Bering Sea; Matsuoka

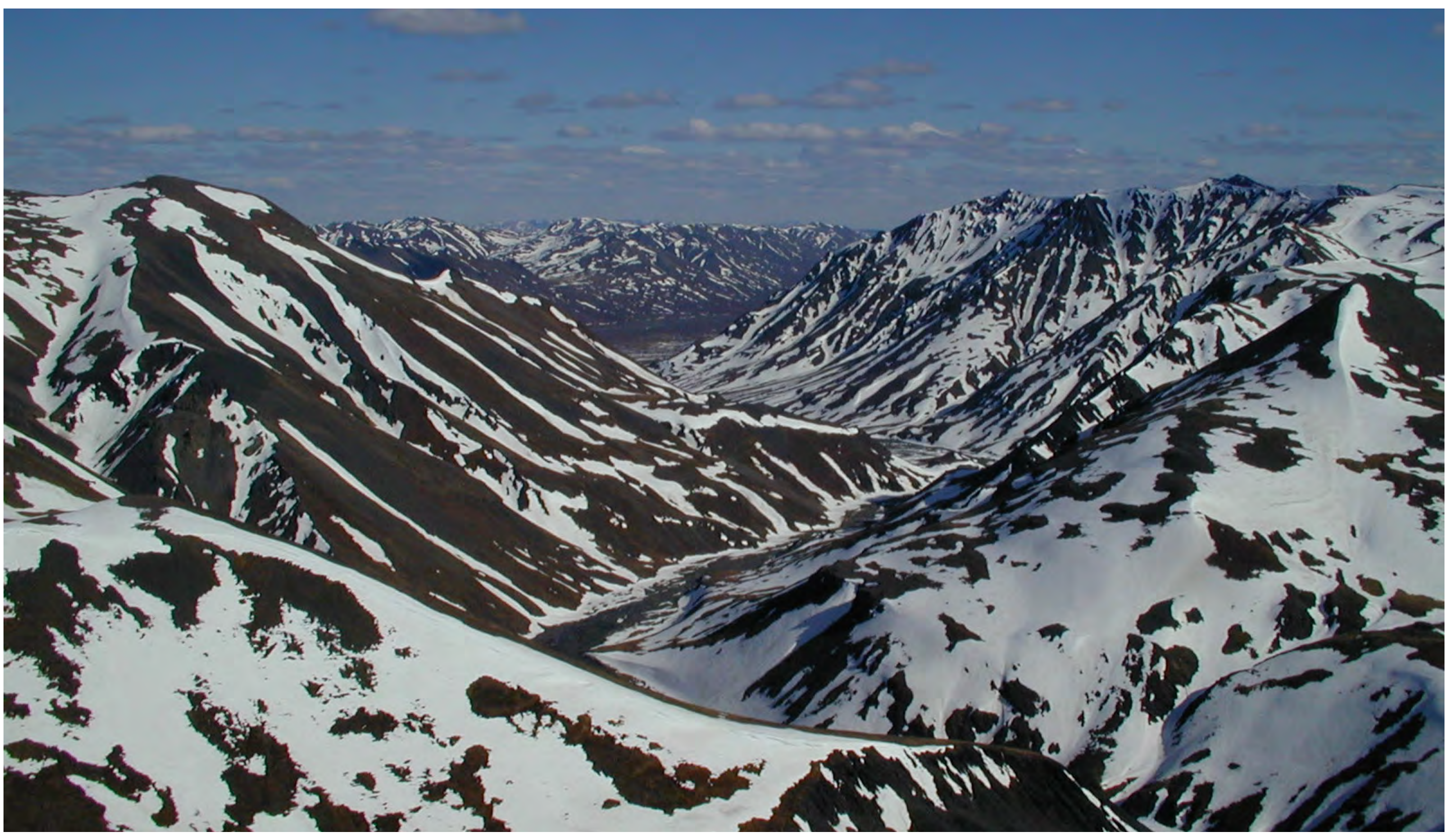


Photo © Robert Gill, Jr.

The Brooks Range serves as a formidable ecological barrier between interior and Arctic Alaska.

Table 6. Seasonal occurrence of species and subspecies within the Arctic Plains and Mountains BCR of Alaska recognized as of continental importance (Watch List or Common Birds in Steep Decline [CBSD]; Panjabi et al. 2020) or as a Continental or Regional Stewardship species. Some species that occur primarily during the breeding season may also occur in small numbers during winter in southern parts of the region.

Species	Continental Status	Continental Stewardship	Regional Stewardship	Seasonal Occurrence
Willow Ptarmigan		●		Year-round
Golden Eagle			●	Breeding
Snowy Owl	Watch List			Year-round
Short-eared Owl	CBSD			Breeding
Peregrine Falcon			●	Breeding
Olive-sided Flycatcher	Watch List			Breeding
Horned Lark	CBSD			Breeding
Gray-headed Chickadee (*lathami*)			●	Year-round
Arctic Warbler	CBSD	●		Breeding
Northern Wheatear		●		Breeding
Gray-cheeked Thrush		●		Breeding
Common Redpoll	CBSD	●		Breeding
Lapland Longspur			●	Breeding
Smith's Longspur			●	Breeding
Snow Bunting	CBSD			Breeding
Fox Sparrow		●		Breeding
American Tree Sparrow	CBSD	●		Breeding
White-crowned Sparrow		●		Breeding
Golden-crowned Sparrow		●		Breeding
Orange-crowned Warbler		●		Breeding
Wilson's Warbler	CBSD	●		Breeding

and Johnson 2008). A small portion of its winter range occurs along the Chukchi Sea coast at the northern edge of BCR 2 (Montgomerie and Lyon 2020), but the neighboring coastline of BCR 3 has not been explored well enough in winter to determine if McKay's Buntings also occur there.

This Arctic region regularly supports seven continentally important species that have been designated as Common Birds in Steep Decline because of estimated losses of >50% of their populations since 1970 (Table 6; Panjabi et al. 2020). These include the Short-eared Owl, Horned Lark, Arctic Warbler, Common Redpoll, Snow Bunting, American Tree Sparrow, and Wilson's Warbler. The Short-eared Owl, designated a species of Special Concern in Canada (COSEWIC 2008), occurs throughout the region and can be an abundant breeder at times, especially during years with high lemming populations (Johnson and Herter 1989, Wiggins et al. 2020). Horned Larks occur broadly in low abundance across xeric dwarf shrub mat tundra and fellfields, predominantly in the foothills and uplands (Gabrielson and Lincoln 1959, Johnson and Herter 1989, Kessel 1989, Tibbitts et al. 2006). The Arctic Warbler is a largely Palearctic species whose breeding range extends into the western and central portions of the Brooks Range within the Arctic BCR and nests mainly in stands of low- to medium-height willow thickets, often along streams (Lowther and Sharbaugh 2020). The Common Redpoll is one of the most common and ubiquitous breeding passerines in this BCR, where it can be found nesting in a broad array of habitats ranging from coastal tundra to boreal forest (Knox and Lowther 2020). Redpolls use a diverse array of shrub habitats for nesting, and their irruptive migrations are related to catkin seed production (Troy 1983, Kessel 1989). Snow Buntings can be found nesting on the ground or in crevices at high elevations in cliffs and block-fields

Photo © Ken Archer

of the Brooks Range as well as along the coastline in artificial habitats such as buildings, empty gas drums, and bird houses (Gabrielson and Lincoln 1959, Kessel and Gibson 1978, Johnson and Herter 1989, Tibbitts et al. 2006). American Tree Sparrows, largely absent from Arctic coastal lowlands, are most commonly found in low shrub thickets in the foothills and uplands along both the north and south sides of the Brooks Range (Gabrielson and Lincoln 1959, Johnson and Herter 1989, Tibbitts et al. 2006). Wilson's Warblers are associated with medium to tall shrub thickets throughout the region but are more common along the south than north slopes of the Brooks Range (Gabrielson and Lincoln 1959, Johnson and Herter 1989, Kessel 1989, Tibbitts et al. 2006).

The Arctic BCR supports significant segments of the global and North American breeding populations of seven additional Continental Stewardship species, including Willow Ptarmigan, Northern Wheatear, Gray-cheeked Thrush, Fox Sparrow, White-crowned Sparrow, Golden-crowned Sparrow, and Orange-crowned Warbler (Table 6; Panjabi et al. 2020). The Willow Ptarmigan is broadly distributed during summer across the region except at high elevations and can also be found in small numbers during winter. Abundance of ptarmigan is tightly linked to snow depth and shrub cover, and these willow browsers are thought to migrate from wintering grounds south of the Brooks Range to Arctic breeding areas, where they become ubiquitous in river valleys in the spring (Christie et al. 2014). The remaining Continental Stewardship species are largely absent from the Arctic Coastal Plain and are more abundant on the south than on the north side of the Brooks Range. The Northern Wheatear nests most commonly at higher elevations in block-fields adjacent to dwarf shrub mat tundra whereas the other species are strongly associated with shrub thickets of low to medium height (Johnson and Herter 1989, Kessel 1989, Tibbitts et al. 2006).

Five species have been designated as important for Regional Stewardship due to specific conservation concerns or endemic status: Golden Eagle, Peregrine Falcon, Gray-headed Chickadee, Lapland Longspur, and Smith's Longspur (Table 6). The Golden Eagle occurs widely throughout this region, nesting predominantly on inaccessible cliffs (Gabrielson and Lincoln 1959, Johnson and Herter 1989, Kochert and Steenhof 2002). Recent tracking data revealed that habitats within the Arctic BCR may also be particularly important for immature Golden Eagles (McIntyre et al. 2008, 2009, McIntyre and

Lewis 2017). Although the most recent surveys suggest that populations of these long-lived raptors are currently stable continentally, there is concern about whether the populations have the demographic resiliency to absorb any additional mortality and remain stable (Millsap et al. 2013). This species is facing significant cumulative conservation threats on its wintering grounds, and information is needed on all stages of its life cycle.

Within BCR 3, the Peregrine Falcon typically nests on cliffs and bluffs along riparian corridors, with intensity of use related to topography, prey habitat, and productivity (Johnson and Herter 1989, Bruggeman et al. 2016, 2018, Swem and Matz 2018). During the mid-twentieth century, Peregrine Falcon populations suffered dramatic declines globally due to exposure to organochlorine pesticides (White et al. 2020). In response to protection under the Endangered Species Act of 1970 and subsequent conservation efforts, populations have largely recovered and stabilized, including the Arctic population that breeds across this BCR (Swem and Matz 2018, Franke et al. 2019). This falcon is highly sensitive to disturbance at the eyrie, especially in remote areas (White et al. 2020), and it is thus important to identify and protect key nesting areas (Bruggeman et al. 2015).

The Gray-headed Chickadee is of particularly high stewardship importance for BCR 3. This largely Old World species is represented in North America by a distinct subspecies (*lathami*), which is restricted to northern Alaska and northwestern Canada (Gibson and Kessel 1997, Sinclair et al. 2003, DeCicco et al. 2017, Hailman and Haftorn 2020). BCR 3 includes a significant portion of the subspecies' range and likely hosts the majority of its population. Recent surveys across this region revealed that the species has disappeared from areas in which it was previously common and that it is no longer observed annually in its North American range (Booms et al. 2020). Additional research is needed to locate any extant population in this region and to determine and address causes of its decline.

The Lapland Longspur is the iconic songbird of Arctic tundra, especially across the coastal plain, favoring wet, hummocky meadows with a dwarf shrub component (Johnson and Herter 1989, Kessel 1989, Hussell and Montgomerie 2020). Although there is little information available on North American population trends for this circumpolar species, recent studies in Europe demonstrated a significant decline for this and other tundra-associated species, likely related to climatic changes (Lehikoinen et al. 2019). Given the Lapland Longspur's abundance and strong preference for low-stature tundra vegetation, it can serve as a sentinel of ecological change at the northern edge of the continent.

Photo © Lucas DeCicco

The Smith's Longspur, once considered of conservation concern because of its small population size, limited Arctic distribution, and poor information on its population trend (Dunn et al. 1999), occurs patchily in the tundra-shrub zone throughout the Brooks Range (Johnson and Herter 1989, Tibbitts et al. 2006, McFarland et al. 2017). For this species, BCR 3 represents an important and large portion of its breeding range (Wild et al. 2015, Briskie 2020). Because of the unique configuration of sedge and shrub habitats Smith's Longspurs require for nesting, the species is considered particularly vulnerable to the climate-related changes to upland vegetation forecast for this region (Wild et al. 2015, McFarland et al. 2017).

Important Landbird Areas

Several habitats in this region are particularly important to continental and regional species of conservation concern as well as other Arctic breeders. Wet and lowland tundra in the coastal plain provide important breeding and foraging areas for Short-eared Owls, Snowy Owls, and Lapland Longspurs (Johnson and Herter 1989, Holt et al. 2020, Hussell and Montgomerie 2020, Wiggins et al. 2020). Mixed moist and upland tundra and dwarf shrubs in the foothills and Brooks Range are key habitats for Smith's Longspurs and Short-eared Owls (Johnson and Herter 1989, Craig et al. 2015, Wild et al. 2015, McFarland et al. 2017, Wiggins et al. 2020). Cliff habitats (rocky cliffs, outcrops, lake bluffs, and cut-banks) that occur throughout the upland plains, foothills, and lower mountain ranges provide important nesting habitat for raptors, and sparsely vegetated habitats at high elevations are important for Northern Wheatears, Snow Buntings, and Horned Larks (Johnson and Herter 1989, Tibbitts et al. 2006). Riparian habitats, including tall willows, poplar groves, and year-round open water, support a diversity of migratory and resident birds, including Willow Ptarmigan, Gray-headed Chickadees, Arctic Warblers, and Wilson's Warblers (Johnson and Herter 1989, Christie et al. 2014). Shrub thickets of various heights and cover support the highest densities and diversity of songbirds, particularly on the southern slopes of the Brooks Range as they grade into the interior boreal forest (Tibbitts et al. 2006). Finally, coastal habitats provide breeding habitat for Snow Buntings.

Several specific geographic areas in this region are of notable importance to landbirds of continental and regional concern and thus deserve special attention and protection. Tundra habitat around Teshekpuk Lake and east to Dease Inlet has been recognized by the National Audubon Society in partnership with BirdLife International as a Global Important Bird Area (IBA) in part because of its high summer densities of Short-eared Owls, Golden Eagles, Willow Ptarmigan, and Lapland Longspurs (Cecil et al. 2009, Liebezeit et al. 2011; https://netapp.audubon.org/iba/Reports/2781). The Lower Colville River has been recognized as a Continental IBA primarily because of the extraordinary numbers of Gyrfalcons, Peregrine Falcons, and Rough-legged Hawks that nest along its bluffs (Ritchie et al. 2003, Swem and Matz 2018; https://netapp.audubon.org/iba/Reports/3097). Finally, the Colville River Delta has been recognized as a Continental IBA in part because of the high densities of raptors that forage over the lowland tundra and nest along cliffs of the upper region of the delta (https://netapp.audubon.org/iba/Reports/2784).

The western uplands of BCR 3 also support high concentrations of nesting raptors, particularly on the Lisburne Peninsula (Booms et al. 2010a) and along drainages of the Kukpowruk, Kokolik, and Utukok rivers (also known as the Utukok Uplands). Raptors along the Colville River have been studied and monitored for over six decades and, as such, provide an important legacy

Lapland Longspur

Photo © Rachel Richardson

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database with which to assess long-term population changes (Swem and Matz 2018). A similar although less consistent monitoring effort in the Utukok Uplands (see Ritchie et al. 2003) also provides valuable information about continental and regional raptor population trends. For smaller landbirds, especially Gray-headed Chickadees, key riparian habitats can be found in isolated clumps along many rivers, especially the Kongakut, Canning, Ivishak, Sagavanirktok, Itkillik, Colville, Noatak, and Nimiuktuk Rivers (Booms et al. 2020; T. Booms, unpubl. data).

Primary Conservation Objectives

The key conservation objective for this region is to protect the unique array of Arctic habitats and the landbird populations that they support at this northern edge of the North American continent. Although there is a relatively small resident human population here, the region has a marked industrial footprint concentrated near the coast. More importantly, this Arctic region is undergoing some of the most rapid climatic changes of any biome on earth (IPCC 2014).

The state of knowledge about landbirds in this rapidly changing region varies markedly among species and across geographic areas. Much of the region lacks even basic surveys for most landbird species, although a few early field efforts produced localized avifaunal summaries (e.g., Kessel and Cade 1958, Maher 1959, Kessel and Schaller 1960, Irving 1960, Hines 1963, Johnson and Herter 1989) and more recent efforts produced more extensive inventories of avifauna across national parks of northwestern Alaska (Swanson 1997, 1998, 2001, Tibbitts et al. 2006, DeGroot and McMillan 2012).

Some long-term studies have provided information on distribution, abundance, productivity and population trends for raptors (e.g., Ritchie et al. 2003, Swem and Matz 2018). Recently, a few studies have focused on understanding the distribution, breeding ecology, and population status of Smith's Longspur (Wild et al. 2015, McFarland et al. 2017). In addition, a series of surveys was recently conducted across northern Alaska to search for the rare Gray-headed Chickadee in areas where it had historically been documented, with results suggesting a range contraction and decline in population size, prompting a call for additional monitoring and research (Booms et al. 2020). For most species within this region, however, there is a dearth of even basic information regarding distribution, abundance, habitat requirements, population trends, phenology, and ecology necessary to support conservation decisions.

The following objectives may facilitate conservation of landbirds in BCR 3:

- Improve knowledge of distribution, abundance, basic life history, habitat requirements, migratory connectivity, and population trends for the most poorly understood priority species in the region (Snowy Owl, Short-eared Owl, Gray-headed Chickadee).
- Determine and address causes of the population decline and range contraction of the Gray-headed


Photo © Rachel Richardson

Chickadee after locating any extant populations within the region.

- Establish region-wide long-term monitoring programs for priority raptor species; refine and implement statewide protocols that are rigorous, repeatable, and statistically valid, especially relative to movements and demography of these species.
- Increase regional sampling efforts for long-term monitoring of passerines, including all species of continental and regional importance.
- Acquire detailed information on the seasonal occurrence, distribution, and abundance of species of continental and regional importance in areas being considered for development, especially areas that may contain biologically unique, valuable, or vulnerable populations.
- Assess how landbirds are affected by different types of habitat modifications, participate in the planning process for potential large-scale habitat alterations, and determine how to mitigate negative impacts.
- Identify species, habitats, and geographic areas particularly vulnerable to climate-induced changes and develop conservation actions to protect them.

Priority Conservation Issues and Actions

Energy Production and Mining

Resource extraction, particularly of oil, gas, and minerals, is the most important industrial activity within this region that currently poses threats to landbirds. The Prudhoe Bay Oil Field, encompassing more than 860 km^2 of the Arctic Coastal Plain, is the largest oilfield in North America and is flanked by other large areas that are currently being explored for development, such as the National Petroleum Reserve–Alaska, Arctic National Wildlife Refuge, and state-administered lands. Offshore oil and gas exploration and development in the Beaufort and Chukchi seas would also require construction of onshore support facilities and pipelines (Northern Economics 2009). Conservation issues associated with this type of development are second only to those of climate change in Arctic Alaska.

Direct impacts of site-specific development on landbirds may be relatively minor and difficult to quantify, but more pervasive, cumulative impacts will likely increase as oil and gas resources in the National Petroleum Reserve–Alaska and elsewhere are developed (National Research Council 2003). Infrastructure (roads, pipelines, gravel pads containing structures, gravel extraction pits,

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Infrastructure for oilfields on the Arctic Coastal Plain is concentrated along the coast.

airstrips, power lines and poles, communication stations, and fiber optic lines) to support resource extraction will likely expand greatly in this region, causing direct loss of habitats, fragmentation, habitat degradation, possible contamination, and potentially direct mortality to some landbirds (BLM 2012). For example, the proposed Arctic Strategic Transportation and Resources (ASTAR) project, a large network of roads connecting oil and gas production facilities and Native communities, would dissect vast expanses of tundra on Alaska's North Slope (https://dggs.alaska.gov/pubs/project/1557). A seismic survey program proposed for exploring the northern Arctic National Wildlife Refuge for oil and gas development includes a grid of 63,000 km of seismic and mobile-camp trails, which are projected to cause long-lasting direct, indirect, and cumulative impacts to the vegetation, hydrology, permafrost, microtopography, and local ecosystems, particularly when exacerbated by climate change (Raynolds et al. 2020).

Mining, by comparison with oil and gas development, is currently very limited and localized within the region. Primary impacts to landbird populations from mining may include direct loss of or changes in habitat at the mine site and from road development; disturbance from high-frequency trucking; sound-scape impacts; discharges of fugitive dust and toxic contaminants from transported minerals to surrounding land, air, and water at the mine and along the transport route; and cumulative impacts of associated infrastructure.

A joint record of decision was recently issued to approve construction of a new 200-mile-long gravel access road and its attendant infrastructure across the southern Brooks Range foothills; this project was proposed by the Alaska Industrial Development and Export Authority to provide industrial access to vast areas of the Ambler Mining District in northwestern Alaska (USDOI and USACE 2020). The selected alternative crosses 26 miles of the Gates of the Arctic National Park and Preserve (USDOI and USDOT 2020).

Actions

- Survey areas being considered for development to quantify occurrence and abundance of landbirds. Identify habitats and specific areas that are of particular importance to high priority landbird species for potential protection.
- Work cooperatively with public land managers, private land owners, and resource development companies to concentrate resource extraction and infrastructure in areas with lowest potential impacts to landbirds and their habitats and to minimize the overall footprint of development.
- Identify and quantify effects of resource development and associated infrastructure (especially cumulative effects) on landbirds and identify useful mitigation measures.
- Quantify the effects of mining development on landbird species by comparing pre- and post-mining bird-survey data and assessing contaminant loads of species and habitats close to mine sites and along the roads used to transport extracted mining materials.
- Provide guidance to land managers and resource development companies for restoring natural habitats for landbirds after resource extraction is complete.

Photo © Dirk Derksen

Infrastructure development may increase the density of native predators such as the Common Raven.

Transportation and Service Corridors

New roads and service corridors to support resource extraction and community development will fragment and degrade habitats and provide easier human access to currently remote lands.

Actions

- Work cooperatively with public land managers, private land owners, and resource development companies to concentrate transportation and service corridors in areas with lowest impacts to landbirds and their ecosystems and minimize the overall footprint of roads and corridors.

- Identify and quantify cumulative effects (e.g., infrastructure, soundscapes, contamination, litter) of roads and service corridors on landbirds and their habitats and provide recommendations to minimize impacts.
- Work cooperatively with public land managers, private land owners, and resource development companies to minimize negative impacts on landbirds and their habitats from off-road vehicle use.

Residential and Commercial Development

The footprint of some existing human communities in BCR 3 is expected to double in size by 2050 (BLM 2012), if oil and gas development increases as predicted (Thomas et al. 2009). This will likely lead to an increase in the filling of wetlands, general loss of natural habitat, expansion of landfills, and an increase in other human activities that cause disturbance to landbirds. A decrease in sea ice has prompted the US Coast Guard to consider building a deep water port at Barrow, which would include the construction of support facilities, likely on wetland habitats. Solid wastes (garbage) associated with development provide a supplemental food resource for predators, including foxes (*Vulpes* spp.), ravens, and gulls (*Larus* spp.), which may increase their population sizes and their impacts on nesting landbirds.

Actions

- Identify habitats and specific areas that are of particular importance to high priority landbird species.
- Survey areas slated for development to quantify occurrence and abundance of landbirds before development. Use these data to guide the planning process and suggest mitigation alternatives.
- Balance community expansion with habitat protection by identifying areas of highest value to landbirds for potential protection and suggesting alternatives for expansion in areas with the lowest potential impacts to landbirds.
- Quantify effects of community expansion (especially cumulative effects) on landbirds and identify useful mitigation measures.
- Quantify the effects of development, including landfills, on abundance and distribution of potential predators (foxes, ravens, and gulls), determine their impacts on landbird populations, and work with land management agencies and developers to mitigate those effects.

Photo © Robert Gill, Jr.

The Trans-Alaska pipeline bisects the Arctic Plains and Mountains BCR.

- Work with land owners to assess the efficacy of land exchanges or conservation easements to help preserve valuable habitats.

Human Intrusions and Disturbance

Off-road vehicle use (especially of automobiles, trucks, and all-terrain vehicles) can easily and permanently degrade habitats in this region. Even snow machines are likely to damage habitat wherever snow cover is insufficient. Most of the region is currently roadless and motorized access is limited, although road networks may increase with additional resource and community development. Recreational floating of rivers in this region is popular and increasing, especially in the Arctic National Wildlife Refuge. Recreational uses of other rivers, especially the Colville, will likely increase if roads are developed, assuming public access is allowed. While it is important to maintain recreational opportunities, overuse of some areas could lead to disturbance of cliff-nesting raptors and other sensitive landbirds.

Actions

- Work with policymakers and management agencies to identify alternatives for and assess impacts of motorized land vehicles along the Dalton Highway Corridor Management Area and any new roads.
- Create educational materials clearly describing and visually depicting habitat damage caused by off-road vehicles in other areas and effectively communicate this information to public and private stakeholders.
- Quantify the effects of high levels of recreational floating and river trips on landbirds, especially cliff-nesting raptors.
- Work with public land managers on management alternatives for access to remote areas by floating and other recreational activities. Educate recreational users about how to minimize disturbance to the landscape and sensitive wildlife species.

Pollution

Oil spills may affect landbirds through destruction or degradation of habitat, direct oiling of some individuals, poisoning of predators and scavengers of oiled fauna, and alteration or contamination of invertebrate prey. Mercury, persistent organic pollutants, radioactivity, and other contaminants, emitted into the environment from both natural and anthropogenic sources, can be transported long distances through atmospheric and oceanic pathways to the Arctic, where they pose threats to the health of both wildlife and humans (Li and

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Macdonald 2005, AMAP/UNEP 2013). Little monitoring of contaminant levels in terrestrial wildlife, other than Peregrine Falcons (Ambrose et al. 2000) and arctic foxes (*Vulpes lagopus*) (Hoekstra et al. 2003), has been conducted in this region, although some studies have focused on marine-associated species (e.g., Stout et al. 2002, Schmutz et al. 2009).

Recent studies suggest that climate change will significantly alter contaminant pathways and mobility, which will likely result in increases in contaminants in the Arctic environment (Macdonald et al. 2005, AMAP 2011). The potential liberation of sequestered persistent pollutants from thawing permafrost, increased methylation of mercury in wetlands created by thawing permafrost, and increased deposition of persistent organic pollutants through changes in atmospheric and oceanic transport are of particular concern for raptors and other birds in the Arctic region (Matz et al. 2011).

In addition, landbirds may accumulate environmental contaminants elsewhere during their annual cycle and transport toxic compounds in their tissues to Arctic breeding grounds, as has been postulated for Red-throated Loons (*Gavia stellata*) wintering in Asia and breeding in northern Alaska (Schmutz et al. 2009).

Actions

- Work with management and permitting agencies to ensure appropriate measures are implemented to prevent oil spills. When spills occur, quantify the direct, indirect, and cumulative effects on landbirds and use that information to mitigate future impacts.

Say's Phoebe

Photo © Rachel Richardson

Photo © Rachel Richardson

- Continue to monitor contaminant loads in Peregrine Falcons and expand the program to include other landbird species sensitive to bioaccumulation (e.g., other raptors and insectivores) and species used as subsistence foods (e.g., ptarmigan).
- Support research to understand global contaminant pathways and potential impacts of climate change on contaminant levels in terrestrial and marine Arctic ecosystems.

Invasive & Problematic Species, Pathogens, & Genes

Invasive species can cause significant changes in community structure and thus pose a major threat to the mostly pristine native floral and faunal communities of the region. Invasive weeds are spreading north along the Dalton Highway, increasing the possibility of invasive species spreading beyond road systems. Structures associated with oil and gas infrastructure, roads, and service corridors can provide artificial nesting platforms for ravens and some raptor species, which may be significant predators on landbird adults, eggs, and young.

Actions

- Monitor occurrence of potential invasive plant species at human access points (roads, oil and gas infrastructure, and villages) and aggressively remove invasive species when found.
- Work with management and permitting agencies, wildland fire-fighting crews and agencies, Department of Transportation, and resource extraction companies to develop and implement effective measures to prevent the introduction and spread of invasive species.
- Monitor use of artificial structures by potential avian predators, quantify effects on local landbird populations, and provide guidance to resource developers and management and permitting agencies on how to minimize such impacts.

Biological Resource Use

Hunting regulations on ptarmigan and Snowy Owls are liberal (20–50 per day and no bag limit, respectively, both with long open seasons) and the effects of harvest on these populations are poorly understood (Merizon and Carroll 2019).

Actions

- Assess sustainability of allowable take of ptarmigan and Snowy Owls in this region and suggest regulation alternatives if the allowable take is deemed unsustainable. Assist with public outreach if bag limits or seasons need to be amended.
- Evaluate inter- and intra-seasonal movements of ptarmigan to identify the geographic areas over which hunting may affect populations.

Photo © Lucas DeCicco

Species nesting at high elevations and latitudes are highly vulnerable to effects of climate change.

Agriculture

Intensive agricultural practices, conversion of natural habitats to farmlands, and fragmentation of natural grassland habitats in southern Canada and the contiguous United States are likely significant threats to Short-eared Owls and Smith's Longspurs during nonbreeding seasons.

Actions

- Explicitly link the breeding and wintering areas of priority species to identify areas important to Alaska's birds during the nonbreeding season.
- Partner with entities in southern Canada and other states to determine the effects of agricultural practices on priority species and identify likely causes of decline (particularly for Short-eared Owls) in known wintering areas.
- Provide support for conservation initiatives on the wintering grounds of priority species and educate the general public, private land owners, and public land managers in areas where priority species winter about the importance of these areas.

Climate Change

Model projections of anthropogenic climate change suggest that the climate, flora, and fauna across the circumpolar Arctic will undergo dramatic alterations during the 21st century (see review in ACIA 2005). Rising temperatures, changing habitat, and increasing coastal erosion have already been documented within Arctic Alaska (Sturm et al. 2001, Hinzman et al. 2005, Tape et al. 2006, Walker et al. 2006, Mars and Houseknecht 2007). Although little is understood about potential effects of climate change on landbird populations in this ecoregion, preliminary vulnerability assessments suggest that many landbird species, such as various shrub-nesting sparrows, will likely benefit from climate-related ecosystem changes whereas other species, such as the Gyrfalcon, may be highly vulnerable because of their narrow ecological niches (Liebezeit et al. 2012). Differential shifts in avian distribution in response to changes in climate, habitat, and food resources may result in restructuring of ecological communities across the region (cf. Stralberg et al. 2009, Bateman et al. 2020b). Expansion of shrubs in river valleys of the North Slope has already reached a tipping point along a trajectory towards homogeneity in cover of tall shrubs (Naito and Cairns 2015), which will have profound implications for diversity of landbirds in the region.

The aspects of climate change that will likely have the most significant impacts on landbirds in this region include: (1) changes in hydrology, permafrost, and temperature regimes that alter the abundance and distribution of different habitat types, especially wetlands, shrublands, coastal tundra, and alpine tundra; (2) increased severity of storms, especially in the spring and summer months, which may negatively affect productivity and survival of landbirds; (3) changes in phenology, which may lead to trophic mismatches that reduce the survival and productivity of landbirds; (4) introduction or accelerated life cycles of pathogens and parasites, which may reduce the survival and abundance of landbirds; (5) increased competition due to arrival of new avian or non-avian species, which may cause some landbird populations to increase and others to decline; and (6) changes in natural disturbance patterns, including storms, wind, insect, and fire dynamics, which may alter habitat type and structure and thus landbird community composition. Multiple factors will likely interact on landbird populations in complex ways.

If current climate models are at least moderately accurate in their predictions of the future (and data to date support their general predictions thus far), it is important to realize that the current species-specific paradigms under which most conservation and management organizations operate may be ineffective in the face of climate-change-induced alterations to the abundance, distribution, and persistence of landbird populations. Therefore, the current emphasis on conserving species may need to shift to conserving the ability for species to adapt to a rapidly changing environment.

Actions

- Compile data on current distribution, abundance, population status, phenology, and habitat requirements of priority landbird species across the region.
- Develop detailed, spatially explicit, and ground-truthed maps of vegetation and habitats in BCR 3.
- Develop spatially explicit, predictive models to identify landbird species and habitats that are particularly vulnerable to effects of climate change. Identify geographic areas likely to serve as areas of high diversity or refugia during rapid climatic changes.
- Monitor changes in permafrost (thermokarst) as a mechanism of habitat change.
- Identify large areas of intact habitat for potential protection that are likely to provide species sufficient space and opportunity to move with or adapt to changing environments.
- Identify a few charismatic landbird species that are likely to be substantially affected by climate change and use these species as "poster children" to educate the public about ecological effects of climate change.


Photo © Robert Gill, Jr.

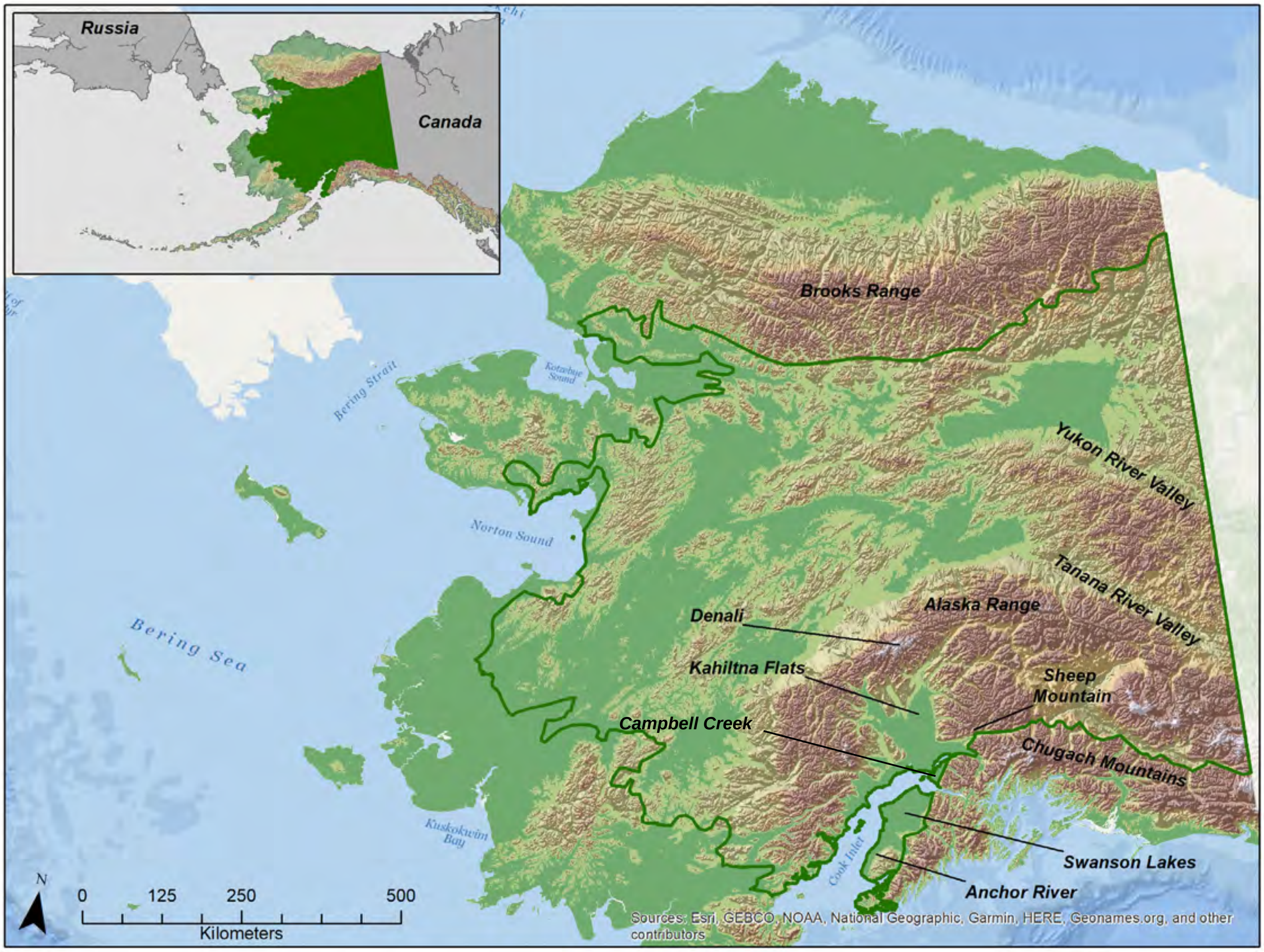
Berries from dwarf shrubs provide an important food resource for many birds on Arctic tundra.

Photo © Milo Burcham

Denali National Park and Preserve is a crown jewel in the nation's national park system.

Bird Conservation Region 4 – Northwestern Interior Forest

Susan M. Sharbaugh, Colleen M. Handel, Lucas H. DeCicco, Julie C. Hagelin, and Maureen L. de Zeeuw



The Alaska portion of the Northwestern Interior Forest Bird Conservation Region (BCR) encompasses 733,000 km² and spans approximately 10° of latitude and 15° of longitude. It accounts for nearly half the land area of Alaska and is larger than the state of Texas. Elevations range from sea level along Upper Cook Inlet and eastern Norton Sound to the mountaintop of Denali, the highest peak in North America (6,194 m). The region is bordered by the Brooks Range to the north, Chugach Mountains to the south, and subarctic tundra to the west. Within the region, a mix of mountain ranges, rolling highlands, river valley bottoms, boreal forest, muskeg, and shrub tundra provides an array of breeding habitats for birds that overwinter at lower latitudes of the Americas, Asia, and Africa.

Glaciation has shaped the avian landscape of this region. During the Pleistocene, the ice-free refugium of Beringia extended east through what is now interior Alaska and into the Yukon Territory (Hopkins 1967), providing a corridor for exchange of species with Asia and an area of genetic isolation from other parts of North America (Pruett and Winker 2008). The influence of this unique ecoregion is still reflected in relict vegetation patterns and present-day species' distribution. The Cook Inlet Basin was covered by ice during the Pleistocene, and repeated retreats and advances of the ice sheet gave rise to the numerous lakes, ponds, and wetlands in this area. Permafrost is found in almost all areas of this region but its extent and thickness vary from continuous (90–95%) in the southern foothills of the Brooks Range,

Arctic Warbler

Photo © Ken Archer

to discontinuous (50–90%) in interior Alaska, to sporadic (10–50%) or isolated in patches (0–10%) south of the Alaska Range (Hinzman et al. 2006).

Climate varies markedly across this region (Hinzman et al. 2006). Interior Alaska is a land of extremes due to its dry continental climate and claims the record high (38 °C) and low (−62 °C) temperatures for the state. The average minimum winter temperature in Fairbanks reaches −28° C during January and the average maximum summer temperature increases to 22 °C during July (WRCC 2016). Precipitation is limited by the mountain ranges; the annual average is 27 cm. The Cook Inlet region has a more moderate, maritime climate, with average minimum temperatures during January in Anchorage of −15 °C, average maximum temperatures during July of 19 °C, and annual average precipitation of 37 cm. The entire region receives extended daylight during the summer (up to 20 h) and reduced daylength during the winter (minimum 4 h).

Climate is the single most important factor in determining the structure and functioning of the boreal forest and in differentiating it from other biomes (Chapin et al. 2006b). Other factors including topography, parent materials, and time since disturbance (predominantly from fire and thermokarst) are also important drivers of vegetation patterns.

There are three basic types of forested communities: those on south-facing uplands, those on north-facing uplands, and those in lowlands (Chapin et al. 2006a). Forest composition in the lowlands depends on drainage. Well-drained, permafrost-free soils on active floodplains support the growth of large white spruce (*Picea glauca*), but black spruce (*P. mariana*) forests are the norm on poorly drained permafrost-dominated soils. This region also supports vast stretches of non-forested habitat. In the lowlands, extensive nutrient-poor acidic bogs lying above shallow permafrost are too wet to support trees. As the soil dries out on the margins, black spruce forests become established. There are also extensive nonacidic wetlands (fens) that are fed by upwelling groundwater and dominated by herbaceous plants. On drier areas below tree line, large areas of shrub

Photo © John Schoen

Denali, the highest peak in North America, lies at the heart of Denali National Park and Preserve.

Table 7. Seasonal occurrence of species and subspecies within the Northwestern Interior Forest BCR of Alaska recognized as of continental importance (Watch List or Common Birds in Steep Decline [CBSD]; Panjabi et al. 2020) or as a Continental or Regional Stewardship species. Some species that occur primarily during the breeding season may also occur in small numbers during winter in southern parts of the region.

Species	Continental Status	Continental Stewardship	Regional Stewardship	Seasonal Occurrence
Willow Ptarmigan		●		Year-round
Rufous Hummingbird	Watch List			Breeding
Golden Eagle			●	Breeding
Northern Goshawk		●		Breeding
Bald Eagle		●		Year-round
Northern Hawk Owl		●		Year-round
Short-eared Owl	CBSD			Breeding
American Kestrel			●	Breeding
Olive-sided Flycatcher	Watch List			Breeding
Western Wood-Pewee	CBSD			Breeding
Horned Lark	CBSD			Breeding
Bank Swallow	CBSD			Breeding
Gray-headed Chickadee (*lathami*)			●	Year-round
Arctic Warbler	CBSD	●		Breeding
Northern Wheatear		●		Breeding
Gray-cheeked Thrush		●		Breeding
Varied Thrush	CBSD	●		Breeding
Bohemian Waxwing	CBSD			Breeding
Gray-crowned Rosy-Finch		●		Year-round
Common Redpoll	CBSD	●		Year-round
Snow Bunting	CBSD			Year-round
Fox Sparrow		●		Breeding
American Tree Sparrow	CBSD	●		Breeding
Dark-eyed Junco		●		Year-round
White-crowned Sparrow		●		Breeding
Golden-crowned Sparrow		●		Breeding
Rusty Blackbird	CBSD			Breeding
Orange-crowned Warbler		●		Breeding
Blackpoll Warbler	CBSD			Breeding
Townsend's Warbler		●		Breeding
Wilson's Warbler	CBSD	●		Breeding

often occur; alpine shrublands and alpine herbaceous tundra grow at higher elevations above tree line.

About 86% of the lands in this BCR are publicly owned (51% federal, 35% state); among these, 45% (42% federal, 3% state) are protected areas and the remaining are slated for multiple use (Matsuoka et al. 2019). The protected lands include many parks and preserves, wild and scenic rivers, and wildlife refuges. The US Fish and Wildlife Service manages more than 150,000 km^2 across 11 national wildlife refuges in this region. The National

Park Service oversees more than 90,000 km^2 that encompass all or portions of seven national parks and preserves. The Bureau of Land Management administers more than 10,000 km^2 across eight units of the National Landscape Conservation System, and oversees much additional public land still under consideration for conveyance. The Department of Defense administers about 7,000 km^2 across seven major military installations. The State of Alaska manages almost 30,000 km^2 in parks, refuges, critical habitat areas, and recreation areas.

Landbird Avifauna

Situated near the northern extent of the North American landmass, the Northwestern Interior Forest region is of global importance as the endpoint of many continental and intercontinental flyways (Sharbaugh 2007). Migrants flow into this area through the Yukon and Tanana river valleys from the continental interior, along the southern coast of Alaska and across the Gulf of Alaska from the Pacific coast region, and across the Pacific Ocean from Asia and Africa. The draw is abundant food, vast areas of relatively unaltered habitat, and a lower risk of predation at higher latitudes. There are 100 landbird species representing 30 families and 8 orders that breed regularly in BCR 4 (Gabrielson and Lincoln 1959, Spindler and Kessel 1980, Scher 1989, West 1994, Kessel 1998, Ruthrauff et al. 2007, Gibson 2011; Appendix II). Although most species migrate south after breeding, individuals of 46 species regularly experience the limited day length and low ambient temperatures of the northern winter in at least parts of this region. Fully or partially resident birds include 6 species of grouse and ptarmigan, 6 diurnal birds of prey, 5 owls, 1 kingfisher, 4 woodpeckers, and 24 passerines (Appendix II). Overwintering passerines range greatly in size from the Common Raven (1 kg) to the Black-capped Chickadee (11 g). Five species of finches are nomadic throughout the Northwestern Interior Forest.


Olive-sided Flycatcher

Photo © Tom Munson courtesy of Idaho Fish and Game


Rusty Blackbird

Photo © Jeff Nadler Photography

Priority Species and Subspecies

The Northwestern Interior Forest BCR supports a large complement of Partners in Flight species of continental importance (Panjabi et al. 2020; Table 7). Two Watch List species occur here: the Olive-sided Flycatcher, which breeds in low densities across open forested portions of this BCR, and the Rufous Hummingbird, whose northern range extent occurs in the Cook Inlet area (Scher 1989, West 1994). This region also regularly supports populations of 13 species designated as Common Birds in Steep Decline, which have suffered significant continental population declines over the past 40 years. These include the Short-eared Owl and 12 species of passerines from 11 families.

Five of the Common Birds in Steep Decline are designated as Continental Stewardship species in this region because of the large proportion of the North American population that Alaska supports (Arctic Warbler, Varied Thrush, Common Redpoll, American Tree Sparrow, Wilson's Warbler). This BCR also supports significant breeding populations of 13 other Continental Stewardship species. In total, these stewardship species include the Willow Ptarmigan, 3 raptors (Bald Eagle, Northern Goshawk, Northern Hawk Owl), and 14 passerines from 6 families,

Photo © Dirk Derksen

including the largely Palearctic Northern Wheatear and Arctic Warbler.

Three additional species warrant regional stewardship status in BCR 4 due to specific conservation concerns: the Golden Eagle, American Kestrel, and Gray-headed Chickadee (Table 7). The Golden Eagle occurs regularly throughout this region and faces potentially cumulative conservation threats along its migration pathways and on its wintering grounds (Smith et al. 2008). Although recent surveys suggest that populations of these long-lived raptors are currently stable continentally, there is concern about whether the populations have the demographic resiliency to absorb any additional mortality and remain stable (Millsap et al. 2013). Recent tracking studies have shed important light on annual movements and timing as well as sources of mortality (McIntyre 2012, Davidson et al. 2020).

Within Alaska, the cavity-nesting American Kestrel occurs almost exclusively in the boreal region and its population has been widely reported to be declining across North America (Smith et al. 2008, Smallwood et al. 2009). The Gray-headed Chickadee, largely an Old World species, is represented in North America by a distinct subspecies (*lathami*) that is restricted to Alaska and northwestern Canada (Gibson and Kessel 1997, Sinclair et al. 2003, DeCicco et al. 2017, Hailman and Haftorn 2020). This population is of special concern due to its limited range and small population size. This subspecies occurs as a rare breeder in northwestern and northern interior Alaska and as a casual visitant in eastern interior Alaska during fall and winter (Gibson 2011). Recent surveys across its range in Alaska suggest a significant population decline and range contraction (Booms et al. 2020).

Aerial insectivores merit special attention within BCR 4 (e.g., swallows, flycatchers) because of their widespread North American population declines (Nebel et al. 2010, Smith et al. 2015, Spiller and Dettmers 2019) and their strong reliance within this BCR on wetland habitats, many of which are undergoing rapid and severe hydrological changes (Riordan et al. 2006, Jorgenson et al. 2001, 2013, Roach et al. 2011, 2013).

Important Landbird Areas

The Northwestern Interior Forest BCR provides important breeding habitat for large numbers of landbird species


Photo © Lucas DiCicco

Photo © Ryan Brady

because of its large size and diverse mix of wetlands, forest, and alpine habitats. The boreal forest ecosystem functions as a complex, dynamic mosaic of habitat types that are constantly changing through the natural processes of fire and succession (Payette 1992).

Knowledge of the distribution and abundance of landbirds within this vast, largely unexplored region is relatively poor, making it difficult to evaluate the importance of specific areas to their populations. Furthermore, little is understood about the geographic scale at which important areas should be designated to incorporate natural ecosystem dynamics. As a result of these uncertainties, and the fact that breeding birds are widely dispersed across boreal landscapes, few areas within this BCR have been identified as specifically important for landbird populations.

Eight sites in this region have been recognized as Important Bird Areas (IBAs) by the National Audubon Society in partnership with BirdLife International based in part on their importance to landbirds. Among these, the Upper Tanana River Valley in interior Alaska has been designated a Global IBA primarily for the concentrations of Trumpeter Swans (*Cygnus buccinator*) and Sandhill Cranes (*Grus canadensis*) it supports, but it also serves as a major migration corridor for raptors and waterfowl between southern regions of the Americas and breeding areas in Alaska and western Siberia (Kessel 1984, Cooper and Ritchie 1995, McIntyre and Ambrose 1999, Benson and Winker 2001; https://netapp.audubon.org/iba/Reports/2967). The Swanson Lakes area on the Kenai Peninsula (https://netapp.audubon.org/iba/Reports/1003) and the Kahiltna Flats–Petersville Road site in interior Alaska (https://netapp.audubon.org/iba/Reports/984) are both recognized as Global IBAs for their high breeding concentrations of Trumpeter Swans, but these rich forested wetlands also support significant breeding populations of passerines of concern, including the Olive-sided Flycatcher, Gray-cheeked Thrush, Varied Thrush, Bohemian Waxwing, Rusty Blackbird, Golden-crowned Sparrow, and Blackpoll Warbler.

Five sites have been identified as IBAs at the state level primarily for their landbird populations. Among these, the Yukon–Charley Rivers site in eastern interior Alaska supports high breeding concentrations and a large number of passerine species of conservation concern, including the Olive-sided Flycatcher, Gray-cheeked Thrush, Varied Thrush, Fox Sparrow, and American Tree Sparrow, among others (Handel et al. 2009; https://netapp.audubon.org/iba/Reports/4542). The Alaska Range Foothills is recognized as supporting one of the highest nesting densities of Golden Eagles in North America (McIntyre 2002, McIntyre et al. 2006a, Katzner et al. 2020; https://netapp.audubon.org/iba/Reports/3226). Sheep Mountain lies along a major raptor migration corridor between the Talkeetna and Chugach mountains and supports significant breeding densities of a diverse assemblage of passerines of conservation concern (https://netapp.audubon.org/iba/Reports/1084). The Campbell Creek site in the Anchorage bowl (https://netapp.audubon.org/iba/Reports/1082) and the Anchor River site on the Kenai Peninsula (https://netapp.audubon.org/iba/Reports/1086) are both rich forested riparian corridors that support significant breeding concentrations of diverse landbirds, including many species of conservation concern.

Boreal wetlands in scattered woodlands or other open habitats in this BCR provide important breeding habitat

Photo © Milo Burcham

Photo © Lila Tauzer

for one Watch List species, the Olive-sided Flycatcher, and several other continentally important species, including the Northern Hawk Owl, Arctic Warbler, Bohemian Waxwing, Rusty Blackbird, and Common Redpoll (Sharbaugh 2007, Matsuoka et al. 2010a, 2010b, Gibson 2011, Avery 2020). Bald Eagles are strongly associated with forested habitats adjacent to large bodies of water (Buehler 2020), and Bank Swallows can be found nesting in subterranean soil primarily along shores of lacustrine waters (Gibson 2011). Coniferous and mixed forests provide important nesting habitat for the Northern Goshawk, Varied Thrush, Townsend's Warbler, and Dark-eyed Junco, whereas deciduous forest stands are preferred by the Western Wood-Peewee (Gibson 2011, Squires et al. 2020). The other Watch List species in this BCR, the Rufous Hummingbird, is associated with forest openings in the Cook Inlet area, which is the northern extent of its breeding range (Scher 1989, West 1994).

Among other species of continental concern, the Short-eared Owl can be found nesting and foraging in dwarf shrub meadows as well as alpine tundra, but Horned Larks, Northern Wheatears, Snow Buntings, and Gray-crowned Rosy-Finches are most often found at higher elevations using dwarf shrub mat tundra, inland cliffs, and block-fields (Sharbaugh 2007, Matsuoka and Johnson 2008, Gibson 2011). The Golden Eagle occurs widely throughout this BCR, nesting predominantly on inaccessible cliffs (Gabrielson and Lincoln 1959, Kochert and Steenhof 2002). Denali National Park and Preserve, in the heart of this BCR, supports one of the highest breeding densities of Golden Eagles in North America (Kochert and Steenhof 2002), and nesting success there has been found to be linked in a complex pattern to abundance of their cyclical prey (McIntyre and Schmidt 2012, Schmidt et al. 2018).

Dwarf, medium, and tall shrub thickets at all elevations support continentally important populations of several other species, including the Willow Ptarmigan, Arctic Warbler, Gray-cheeked Thrush, American Tree, White-crowned, Golden-crowned, and Fox sparrows, and Arctic, Orange-crowned, and Blackpoll warblers (Sharbaugh 2007, Gibson 2011). Many of these shrub-associated species have recently suffered significant population declines across the region (Kessel and Gibson 1994, Handel and Sauer 2017).

Among all 100 species of landbirds regularly occurring in BCR 4, most use primarily coniferous forest (23 species), alpine tundra (21 species), and shrub thickets (18 species; Sharbaugh 2007). Fewer species are primarily associated with mixed forest (14 species), boreal wetlands (11 species), deciduous forest (6 species), and riparian substrates (6 species). European Starlings are strongly associated with limited urban and agricultural areas.

Primary Conservation Objectives

The Northwestern Interior Forest BCR comprises the vast majority of boreal forest in the United States and supports a unique array of breeding species migrating from Asia, Africa, and North and South America. This BCR is the largest in Alaska and supports the greatest landbird biodiversity. This region also supports the largest and most rapidly growing human population in the state, with all the associated pressures from commercial and residential development (Chapin et al. 2010). At a global scale, the boreal forest region is one of the biomes expected to change most rapidly with climate change (Christensen et al. 2007). Projections of temperature and precipitation suggest that, within the next few decades, Alaska's boreal forest will undergo significant changes

Photo © Dirk Derksen

Spruce Grouse

Photo © Dirk Derksen

in structure and dynamics to an extent unprecedented during the last 6,000 years (Chapin et al. 2010, Wolken et al. 2011, Matsuoka et al. 2019).

One of the most important conservation objectives to consider for this region is to obtain basic information on the array of landbird species that rely on habitats within this region during critical phases of their annual cycle. There is need for information on natural history, seasonal distribution, population size, habitat requirements, and migratory connectivity. Given the rapid habitat alterations arising from climate change and other human activities (Hinzman et al. 2005, Chapin et al. 2010), monitoring programs should be established to track and understand changes in landbird populations. In addition, a network of key geographic areas across the boreal landscape could be identified to protect vulnerable populations and preserve biodiversity. Vast expanses of land, limited access, and broad distributions of birds all combine to make achieving these objectives more difficult. The additional constraints of limited staffing and budgets (especially for long-term projects) make focusing on attainable goals and collaborative efforts especially important. Educating the public and establishing international partnerships are essential for success.

The following objectives may facilitate conservation of landbirds in BCR 4:

- Increase our understanding of the annual cycle, limiting factors, breeding ecology, habitat associations, phenological relationships, and migratory connectivity of landbird species in the region, particularly priority species.
- Establish a long-term ecological monitoring program to understand current distribution patterns and track changes in populations over time.
- Develop a clearinghouse of existing information, such as early survey data and unpublished reports, which can be used as a baseline and a guide for gathering future comparative data.
- Identify key habitats and specific areas for potential protection that are of particular importance to high priority species or are particularly resilient to climate change and may provide important refugia.

- Work with resource managers, industrial developers, urban planners, and the public to develop and implement best-management practices for protecting landbird populations and important landbird habitats.
- Develop education and outreach programs about landbird ecology and habitats for the general public, the media, and policy-makers.
- Work closely in all aspects of research, monitoring, planning, and outreach with biologists in the Canadian portion of BCR 4 and establish additional national and international partnerships, such as the International Rusty Blackbird Working Group, to address questions that transcend state and national boundaries.

Priority Conservation Issues and Actions

Residential and Commercial Development

About seven out of every ten Alaskans live within BCR 4 (State of Alaska 2020). The vast majority of residents are clustered in or near the major metropolitan areas of Anchorage and Fairbanks, and about 80% of the human population in BCR 4 is concentrated in south-central Alaska around Cook Inlet. Avian habitats are being lost or altered through increases in road networks, housing developments, motorized recreation, and commercial development.

After a period of very rapid growth between 1939 and 2009 (+3.6%/year), the human population in Alaska has remained relatively stable during the past decade (+0.3%/year) and now totals about 731,000 residents (State of Alaska 2020). The majority of people living in Alaska (59%) are migrants to the state. Historically, human population growth has been concentrated in the metropolitan areas of the state. During the past decade, however, the Municipality of Anchorage has had zero net growth and populations in interior Alaska around Fairbanks have decreased (-0.2%/year). Statewide, population growth during the past decade, though slower than previously, has been highest in the Matanuska–Susitna Borough (+1.9%/year) and on the Kenai Peninsula (0.6%/year). Rapid growth in these two regions since the 1970s and 1960s, respectively, has put pressure on community infrastructure and the planning process. Great care needs to be taken to ensure that development continues with minimal degradation of avian habitats, with special attention to wetlands and avian movement corridors. In addition, mortality may increase in urban areas through window strikes and predation by domestic cats.

Photo © iStock - JonnyNoTrees

BCR 4 hosts Anchorage (shown here) and Fairbanks, Alaska's two largest cities, and supports 70% of the state's population.

Actions

- Identify important landbird habitat, particularly wetlands and corridors, in rapidly developing areas and work with land managers on alternatives for protection of these vital areas.
- Develop accurate habitat maps and make them available to land managers, development companies, planning commissions, and land owners.
- Gather basic data on the annual cycle of breeding birds to construct a timeline of sensitive periods to reduce the impact of construction and development.
- Increase public awareness about the importance of snags for cavity nesters and how to incorporate natural habitats in landscape design for residential and business property to benefit local birds.
- Increase public awareness about window strikes and domestic cats as potential sources of bird mortality and how to mitigate such impacts.

Human Intrusion and Disturbance

Continued residential growth and development increases the pressures on recreational areas within driving distance of population centers. Relatively pristine areas will quickly deteriorate with overuse by all-terrain vehicles, dirt bikes, jet boats, and other watercraft. Some landbird species may even be sensitive to lower levels of disturbance from other types of recreation.

Actions

- Educate the public about the value of landbirds and natural ecosystems.
- Increase public awareness of the direct and indirect effects of recreational vehicles and other types of disturbance on landbirds and associated impacts on their habitats.

Natural System Modifications

A significant, ancillary effect of increasing human development within this region arises from suppression of wildfire to protect human life and property. Fire is the principal disturbance agent in interior Alaska (Viereck 1973, Kasischke et al. 2002), and Alaska has been zoned into areas designated to receive different levels of fire suppression, based on distance to human habitation (DeWilde and Chapin 2006). In addition, areas with human development are more likely to be subject to human-caused fires, which differ from natural lightning-caused fires in size, fuel types, and seasonal occurrence. Thus, expanding networks of human development

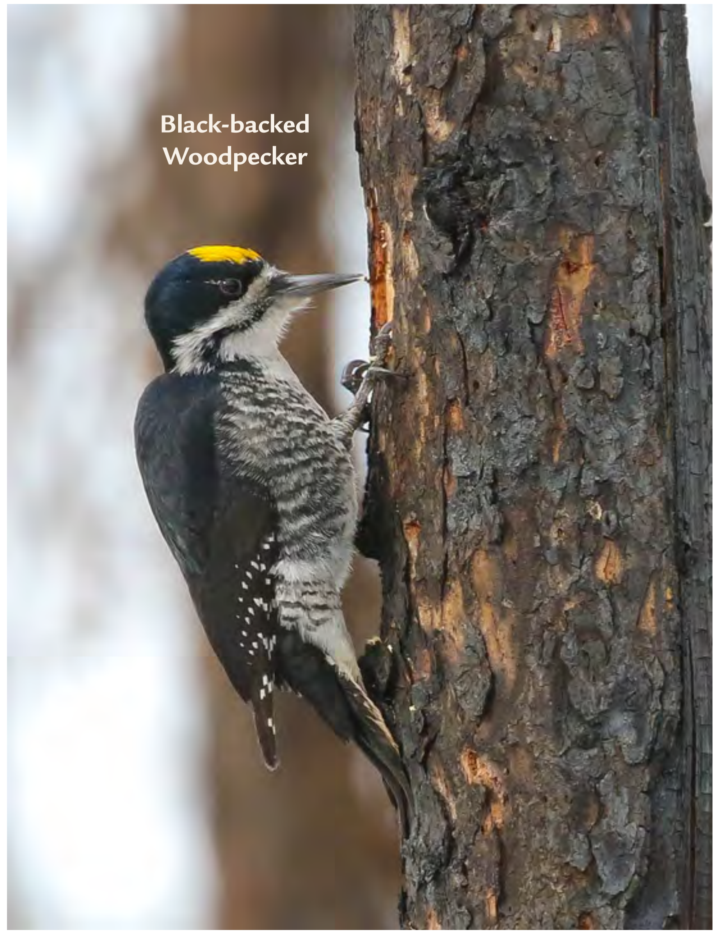


Photo © Dirk Derksen

The Black-backed Woodpecker is a fire specialist.

will alter ecosystem dynamics and change the age and physical structure of the boreal forest both by increasing areas of fire suppression and by changing the timing and nature of fires that do occur (Chapin et al. 2010). The increase in the number of forest fires near populated areas has increased the need for the construction of fire breaks. Fragmentation of habitat increases when wide swaths of forest are removed. If these breaks are placed in areas of permafrost, further degradation of the habitat is possible.

Actions

- Work with natural resource agencies to develop fire-management policies that preserve natural fire dynamics within the boreal forest ecosystem while minimizing danger to human life and property.
- Promote awareness of fire-suppression issues among planners and resource developers.
- Develop protocols for prescribed burning to mimic wildlfires in timing and intensity.

Transportation and Service Corridors

The State of Alaska's Roads to Resources initiative (Longan and Glenn 2015) has the potential to fragment large swaths of avian breeding habitat that have been inaccessible to motor vehicles. Three of the four proposed roads are in BCR 4 (road to Ambler, road to Tanana, and the Klondike Industrial Use Highway).

Roads increase human impacts on the environment in many ways. In addition to the basic habitat loss and fragmentation through construction, roads alter hydrology, alter native vegetation composition, facilitate the spread of exotic and invasive species, add road dust to vegetation near the road, increase hunting pressure on game species, increase mortality from vehicle collisions, increase noise pollution, introduce physical structures such as power poles, power lines, bridges, and buildings that can serve as artificial avian habitat, and promote new human settlement and associated disturbance (Trombulak and Frissell 2000, Longcore et al. 2012, Loss et al. 2013b, 2014a, 2014b, 2014c). Similar concerns accompany expansion of existing transportation networks throughout the region.

Actions

- Identify important landbird habitats within proposed road corridors. Work with land owners, developers, and land managers to reduce impacts on landbird populations.
- Gather information within vs. away from existing roadside corridors to examine impacts of roads on breeding and migration of local birds.
- Work with land managers to reduce off-road activities along new transportation corridors.

Photo courtesy of US Geological Survey

High-voltage powerlines pose a hazard to landbirds.

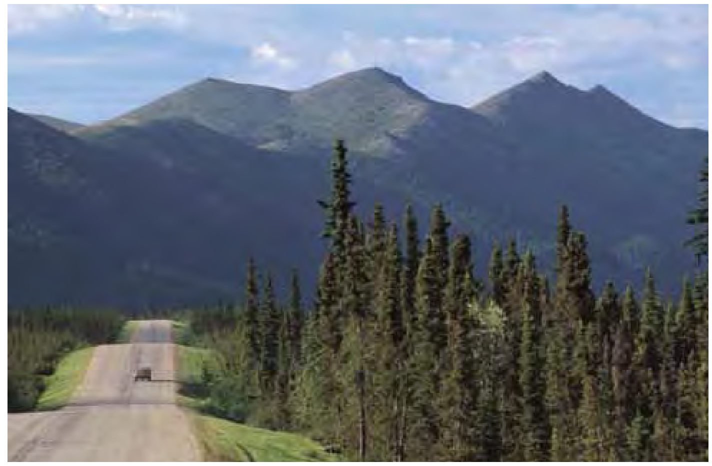


Photo © Dennis Green, Alaska State Office

The Dalton Highway connects interior Alaska to the North Slope.

- Work with road construction and maintenance crews to reduce the introduction and establishment of invasive species. Monitor area for presence of non-native species of plants and animals.

Biological Resource Use

Commercial timber harvest in BCR 4 has focused to date on large, riparian white spruce (Wurtz et al. 2006). Riparian areas are conducive to tree growth due to the lack of permafrost and presence of more productive soils. This habitat is important to many landbird species and the impact of large-scale harvest has not been assessed.

As petroleum prices continue to rise, harvest of firewood for household use is likely to increase. There is also recent interest in the use of multiple timber species for large-scale production of biofuels, generally pelletized wood or other organic materials to produce heat and electricity (Lowell et al. 2015). Biomass harvest has the potential to impact markedly the boreal forest within BCR 4, which has historically experienced relatively low-level timber harvest. The Alaska Department of Natural Resources, Division of Forestry, has recently drafted a 5-year contract for industrial harvest of ~140,000 green tons of biomass total or ~600 acres (~240 ha) of trees annually across the Tanana Valley, from the US–Canadian border west to the village of Tanana, and is planning for additional annual harvest of ~2,100 green tons to support biomass systems for the Alaska Gateway School District (Douse and Meany 2020).

Although biomass production is often referred to as a sustainable energy source, there is limited knowledge about associated effects of production on wildlife populations throughout the US (McGuire 2012). The successional trajectory of boreal forest vegetation and subsequent changes in wildlife communities after timber harvest can be quite different from those following large-scale disturbances from wildfire (Viereck 1973, Kasischke et al. 2002). Bird communities postharvest have been found to differ the most from those postfire during the first 10 years after disturbance, primarily due to the presence in postfire stands of large dead and dying trees and subsequent insect infestations attractive to cavity-nesting species such as woodpeckers; significant differences persist during the next 11–30 years but community structure tends to converge after that (Schieck and Song 2006). Timber harvest can also result in a disclimax vegetation structure dominated by bluejoint reedgrass (*Calamagrostis canadensis*) unless soils are scarified to mimic the natural disturbance of the organic layer that occurs through wildfire (Collins and Schwartz 1998). Interactive effects of climate change on ecosystem dynamics introduce further uncertainty about how the boreal forest may respond to different types of disturbance (Soja et al. 2007).

The emerging biomass industry presents a unique opportunity for biologists and natural resource managers to work together to establish best management practices that maintain quality habitat for landbirds and other wildlife while balancing public needs for a source of sustainable alternative energy (Paragi et al. 2020).

Actions

- Work with natural resource managers to minimize loss of mature white spruce stands in riparian corridors.
- Ensure that harvest practices retain dead and decaying trees for cavities, perches, and foraging and no-harvest buffers around forested lakes and wetlands.
- Identify areas within prospective harvest boundaries important to priority landbird species. Work with land managers to reduce impacts to these areas.
- Identify and inventory habitat associations within proposed biomass harvest areas. Monitor areas after harvest to document temporal progression of changes to vegetation and associated impacts on landbird populations.
- Work with natural resource managers to establish best management practices aimed at maximizing avian habitat quality while balancing the need for sustainable wood harvests and alternative energy (cf. http://forestry.alaska.gov/forestpractices#reforestation).

Photo © Annie Ruggles

Deciduous forest in interior Alaska

Energy Production and Mining

Underground treasures of minerals, oil, and gas have historically driven exploration and settlement of the Far North. Local economies are now highly dependent on extraction of natural resources in this region. Constantly evolving technologies have increased industrial capacity to access these resources on a scale that can affect large areas of previously unaltered habitat. Future increases in oil prices will not only increase the profitability of extracting less accessible reserves but also prompt the development of alternative sources of energy.

The history of northern regions has long been associated with the extraction of minerals. The Klondike Gold Rush of 1897 brought thousands of prospectors to the heart of this region, and small-scale placer mining continues to this day. Degradation of riparian habitat, accumulation of silt in downstream water bodies, and loss of permafrost in adjacent areas due to heavy equipment are a few of the impacts on habitat associated with localized mining (LaPerriere and Reynolds 1997).

Access to remote mining claims may also affect habitat within transportation corridors by building trails and roads, introducing invasive species, and increasing levels of associated disturbance.

There are currently several large mines operating in this region for gold and coal and a few additional large mines have been proposed (http://dnr.alaska.gov/mlw/mining/largemine/). Large industrialized mines present a larger footprint of direct disturbance to wildlife habitat, including removal of natural vegetation and underlying rock from very large areas (e.g., 5–40 km^2), construction of large tailings ponds, atmospheric emissions of mercury, discharge of pollutants, and creation of mine tailings and waste (Jain et al. 2016, Khamkhash et al. 2017). They often entail increased risks to wildlife populations because extraction techniques expose large areas to potentially catastrophic results, such as acid mine drainage, thermal pollution, mine tailings dam spills, and direct and indirect effects of toxic pollutants (e.g., Wright et al. 2017, Byrne et al. 2018). Secondary impacts from large mines arise from new access roads, airstrips, ports, housing projects, power plants, power transmission lines, water treatment plants, and other associated infrastructure.

Increasing oil prices and new technology have stimulated renewed interest in coal-bed methane and natural gas production in this region. Projects that were once financially untenable are now possible and exploration for such resources has recently begun in several areas within the region. Development of gas fields with the associated infrastructure of roads and pipelines would reduce and fragment habitat, facilitate increased densities of predators associated with human habitation and infrastructure, and increase the amount of human disturbance in previously inaccessible areas.

Hydropower has been viewed as a relatively inexpensive and green alternative energy source and is currently being investigated at a large scale within this region (AEA 2019), although the proposed construction of the Susitna Dam in interior Alaska was recently vetoed. The construction of dams could flood large tracts of habitat with direct impacts on riparian and forest birds. Transmission lines, associated roads, other infrastructure, and increased human use of the area would subsequently affect the local bird populations. Another developing source of alternative energy in the region is wind power (AEA 2019). Placement of wind turbines in migration corridors may present a direct collision hazard to

Photo © Claudine Van Massenhove

Coal mined in interior Alaska is transported via rail to this transfer facility at the port of Seward, in BCR 5, for export.

migrating birds. Avian mortality from collision with wind turbines, however, is relatively low, estimated at only 140,000 to 328,000 birds annually in the US (Loss et al. 2013a). Raptors are particularly vulnerable to collisions with rotors, but appropriate siting of turbines can reduce mortality (Smallwood et al. 2009, Ferrer et al. 2012).

Actions

- Identify important landbird habitat and diversity hotspots to evaluate potential impacts of development on priority species in areas proposed for energy production and mining. Work with stakeholders to minimize impacts and to incorporate exclusion zones into mining plans to protect habitat.
- Collaborate with stakeholders to promote industry environmental compliance.
- Incorporate natural habitat recovery into post-mining reclamation plans.
- Work with hydroelectric companies to establish in-stream flow agreements to provide appropriate water levels at critical times.
- Monitor establishment of invasive species and potential predators along access roads and transmission lines.
- Identify migration routes to inform land managers of potential conflict with wind power turbines and transmission lines.
- Monitor impacts of existing mining and energy infrastructure on landbirds.

Invasive & Problematic Species, Pathogens, & Genes
New species can enter an ecosystem through association with humans or through dispersal as environmental conditions change. A warming climate reduces barriers that have precluded range expansion. Several species of invasive plants have expanded along transportation corridors throughout the region, some non-native ornamental shrubs have invaded natural habitats, and the aggressive American waterweed (*Elodea canadensis*) has become established in many lakes, rivers, and streams via floatplanes and watercraft (Carlson and Shephard 2007, Wolken et al. 2011). Invasive plants displace native species and alter ecosystem dynamics.

Several invasive species of insects, including sawflies (Hymenoptera) and aphids (Homoptera), have become widespread throughout the region and can cause severe defoliation of trees during periodic outbreaks (Holsten et al. 2008). There is an increased threat of movement

Photo © Martin Renner

Avian keratin disorder, a disease of unknown etiology that causes gross beak abnormalities, was first discovered in the Northwestern Interior Forest BCR in Black-capped Chickadees.

of other problematic insects, plants, and pathogens into interior Alaska from southern parts of the continent as temperatures continue to increase (Holsten et al. 2008, Wolken et al. 2011). Densities of nesting birds in this region may change significantly in response to insect outbreaks and other major disturbances as a result of altered vegetation structure and food resources (Matsuoka et al. 2001). Finally, increasing populations of introduced and native species of birds associated with urban and agricultural development, such as the European Starling, Rock Pigeon, Common Raven, Black-billed Magpie, and Brown-headed Cowbird, may result in displacement of other native species of birds or demographic impacts.

A recent epizootic of a disease termed avian keratin disorder, whose epicenter and first discovery were in the Northwestern Interior Forest BCR, is currently affecting a broad array of species in Alaska and a significant segment of the populations of both Black-capped Chickadees and American Crows (Handel et al. 2010, Van Hemert and Handel 2010). This disorder is characterized by gross beak abnormalities and other lesions. Recent evidence suggests that it may be caused by a novel picornavirus, which has now been found in multiple species in Alaska and more recently elsewhere in North America (Zylberberg et al. 2016, 2018, 2021). Such an epizootic can have far-reaching impacts not only on the affected species but also on community dynamics. Blood parasites, additional stressors, have also been found in Alaska chickadees and Rusty Blackbirds (Barnard et al. 2010, Wilkinson et al. 2015). Emerging infectious diseases in wildlife have increasingly been linked to climate-related environmental changes (Van Hemert et al. 2014), so we should continue surveillance efforts for the occurrence of pathogens and parasites and their impacts on landbird populations.

Actions

- Work with land managers, resource developers, and the public to minimize the introduction of invasive plants along transportation corridors, in waterways, and from ornamental plantings.
- Encourage residential landscaping that uses native species and increase public awareness of the impact of invasive species.
- Work to remove established invasive species in critical habitats.
- Monitor the spread of invasive insects, parasites, and pathogens and encourage research to understand their potential impacts on landbird populations.
- Monitor the spread of introduced, urban- and agriculture-associated bird species and encourage research on their impacts on native birds. Examine the potential effects of European Starlings on cavity-nesting birds.

Climate Change

Climate change may be the most important factor affecting bird populations in the Northwestern Interior Forest BCR. There has been significant winter-warming in the boreal forests throughout western North America (~0.5–2 °C per decade from 1966 to 1995; Hinzman et al. 2006). The mean annual winter temperature in interior Alaska has increased by 4 °C since the 1950s.

Rising temperatures have had a large impact on the region's boreal forest and tundra ecosystems. Concurrent with this increase in temperature, scientists have measured: (1) infilling and expansion of shrubs across tundra habitats (Tape et al. 2006, Walker et al. 2006, Myers-Smith et al. 2011, Brodie et al. 2019); (2) shrinkage and loss of water bodies within wetlands (Klein et al. 2005, Riordan et al. 2006, Roach et al. 2011, 2013); (3) advance of tree line northwards and upslope (Lloyd and Fastie 2003, Dial et al. 2007); (4) an increase in the frequency and severity of outbreaks of plant pests and pathogens such as spruce beetles (*Dendroctonus rufipennis*), birch leafminers (*Fenusa pusilla*), and alder blight (Werner et al. 2006a); (5) an increase in the intensity and frequency of wildfires and the length of the fire season (Kasischke and Turetsky 2006, Kasischke et al. 2010); (6) an increase in permafrost thawing and thermokarst in boreal forests, causing dramatic changes to the ecosystem (Jorgenson and Osterkamp 2005, Jorgenson et al. 2013, Lara et al. 2016); and (7) a regional decline in forest productivity consistent with a biome shift (Beck et al. 2011b). In turn, these ecosystem shifts may have profound effects on the availability and suitability of habitat for northern bird populations (Mizel et al. 2016).

Photo © Dirk Derksen

Many species, such as the American Robin, are becoming more common during winter in response to a warming climate.

Loss of wetlands and other changes in hydrology may further exacerbate population declines in four of the Watch List species within this region (Short-eared Owl, Olive-sided Flycatcher, Rusty Blackbird, Smith's Longspur), which are reliant upon wetlands or mesic habitats. Recent bioclimatic niche models across the boreal–Arctic transition zone of North America project population declines for over half of the boreal passerines currently breeding in Alaska and significant shifts in distribution for most (Stralberg et al. 2015, 2017). Differential shifts in avian distribution will likely result in restructuring of avian communities. Furthermore, this region is projected to provide continentally significant habitat for landbird populations expanding northward from boreal forests in southern Canada and climate-change refugia for others (Stralberg et al. 2017, 2018, Bateman et al. 2020b).

In addition to landscape-level changes to habitat, climate change may also have an impact on phenology of plants and insects. Mismatched shifts in the timing of leaf-out and insect emergence in the spring relative to timing of breeding and migration of birds have been shown to have a significant effect on avian productivity (Visser et al. 2004). Aerial insectivores associated with wetland habitats are of particular concern within this region because of the rapid alterations of wetlands and hydrology and the effects of changing weather on their breeding phenology and success (Irons et al. 2017, Cox et al. 2019). Changes in climatic conditions may also affect the distribution of pathogens, which may provide a mechanism for local extinction of host populations (Cahill et al. 2013).

Actions

- Create an accurate habitat map for the region as a baseline against which to measure change in wetlands, change in forest structure and composition, transition of tundra to shrub, and loss of other alpine habitats.
- Gather baseline inventory data on the current distribution of landbirds across the region, particularly in remote areas with sparse data.
- Develop models of habitat associations for all regularly occurring species of landbirds in the region, but particularly priority species.
- Establish baseline data on the impact of fire and permafrost dynamics on habitat structure and avian communities at a landscape scale.
- Support development of predictive models of the distribution and seasonal abundance of insect prey for aerial insectivores relative to major ecosystem drivers and climatic factors.
- Identify specific geographic areas within the region that currently are of great importance during breeding, migration, and wintering for priority species and for overall landbird diversity. Develop spatially explicit projections for how such geographic areas may shift under future climate scenarios and identify stable areas that may serve as climate-change refugia.
- Establish a series of long-term monitoring stations to track status and distribution of continentally and regionally important landbird populations relative to climatic changes including pertinent aspects of demographic processes, migration, phenology, habitat quality, predator-prey relationships, and pathogens.
- Track range expansion and monitor ecological effects of more southerly species of plants, insects, birds, mammals, and pathogens into interior Alaska.
- Identify patterns of connectivity for priority species among breeding areas in the region, migration corridors, and wintering areas to understand how climatic changes in other portions of their range may influence population trajectories.
- Engage the public with local projects to monitor phenological changes in their own backyards. Promote the understanding of the impact of climate change on ecosystems.

Photo © John Schoen

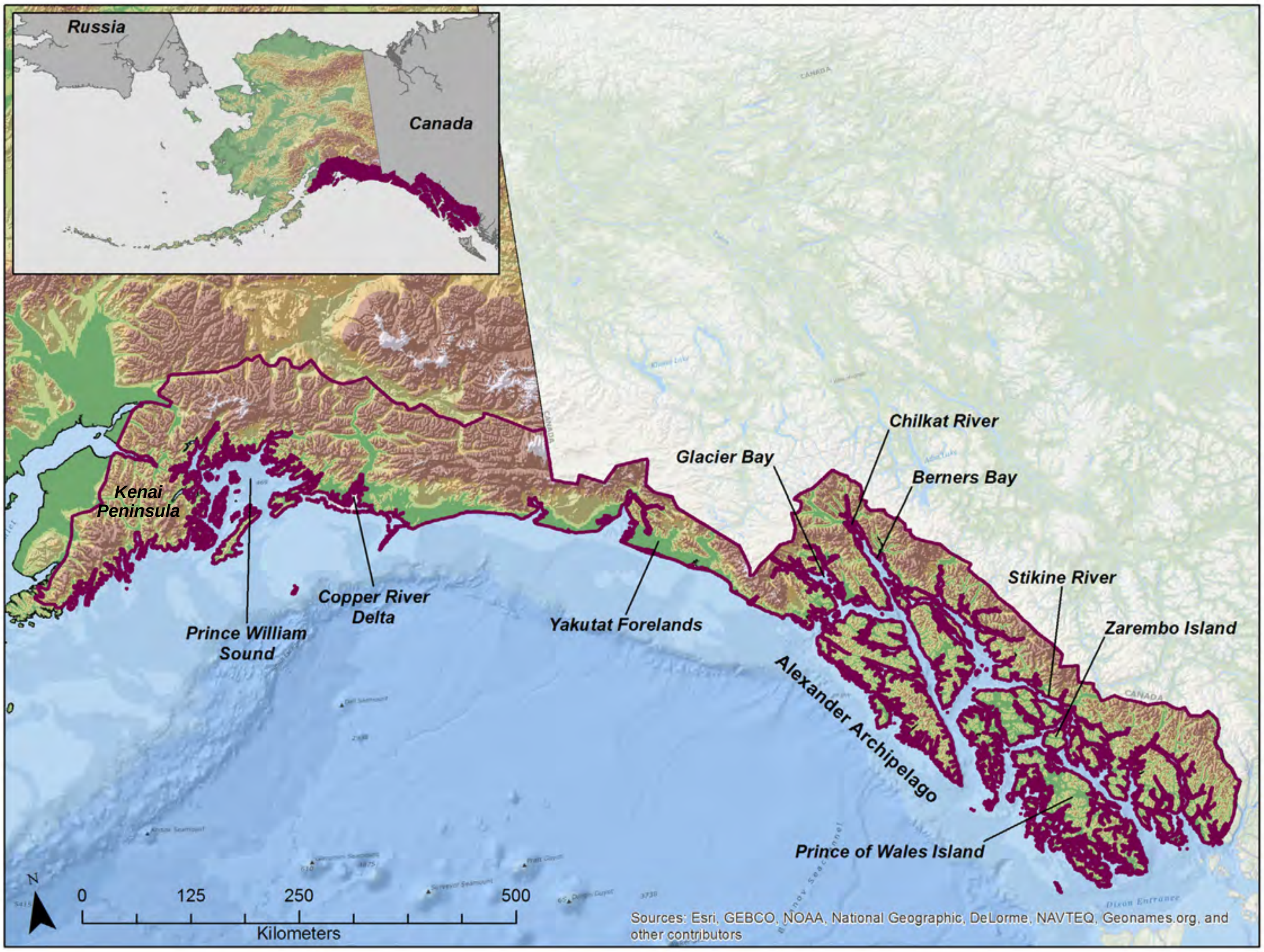
The Black-billed Magpie, a significant nest predator, is expanding its range northward in interior Alaska.

Photo © Milo Burcham

At 2,800 km^2, the Copper River Delta is the largest contiguous wetland on the Pacific coast.

Bird Conservation Region 5 – Northern Pacific Rainforest

Melissa N. Cady, Matthew D. Kirchhoff, Stephen B. Lewis, Michelle L. Kissling, Cheryl E. Carrothers, Caroline Van Hemert, and Colleen M. Handel



The Northern Pacific Rainforest Bird Conservation Region (BCR) encompasses temperate rainforests along the coast from Alaska to Northern California. The Alaska portion encompasses roughly 167,000 km^2 and extends about 1,500 km from the southern half of the Kenai Peninsula, through Prince William Sound, and southward along the coast of southeastern Alaska across the Alexander Archipelago.

The narrow strip of coastal mainland and more than 2,000 islands are bounded on the seaward side by the Gulf of Alaska and the North Pacific Ocean. The landward boundary includes the Kenai, Chugach, St. Elias, and Coast mountain ranges. More than 75% of BCR 5 comprises public lands, including those managed by the USDA Forest Service, US Fish and Wildlife Service, National Park Service, and State of Alaska. In particular, the Tongass National Forest and Chugach National Forest manage over 90,000 km^2 combined.

Habitats range from temperate coniferous rainforests at low elevations to rocky peaks, ice fields, and tundra habitats above treeline (Smith 2016). Lush coastal forests of western hemlock (*Tsuga heterophylla*), Sitka spruce (*Picea sitchensis*), western redcedar (*Thuja plicata*), and Alaska cedar (*Callitropsis nootkatensis*) blanket lower elevations in southeastern Alaska, whereas the forests transition to Sitka spruce and mountain hemlock (*Tsuga mertensiana*) in Prince William Sound. Boggy wetlands, or muskegs, are interspersed throughout the forests wherever drainage

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is poor. Riparian areas, avalanche or landslide chutes, receding glaciers, and other areas of soil disturbance support stands of red alder (*Alnus rubra*) and Sitka alder (*A. viridis sinuata*). Large mainland river systems that intersect the coastal mountains provide corridors to drier interior habitats. Floodplains associated with these rivers support immense freshwater wetlands and deciduous forests. Mixed stands of black cottonwood (*Populus balsamifera trichocarpa*), red alder, willows (*Salix* spp.), and sometimes paper birch (*Betula papyrifera*) or quaking aspen (*Populus tremuloides*) occur along riparian areas and more recently deglaciated sites. Higher elevations and interior sites have large areas of bare rock and alpine tundra habitats characterized by dwarf shrubs, mosses, lichens, and sedges.

The climate is strongly influenced by the warm Alaska current, which moderates temperatures and provides a constant source of moisture. Summer temperatures are cool (7 to 19 °C) and winter temperatures are mild (−12 to 4 °C) across this coastal region relative to those at the same latitudes farther inland (NOAA NCEI 2020).

The steep islands and mountainous mainland of this region create ideal conditions for orographic lift and abundant precipitation, whose long-term mean ranges from 156 cm to >500 cm annually per borough (NOAA NCEI 2021). At lower elevations and latitudes, most of this precipitation occurs as rain, but at higher elevations and more northerly sites, more than 15 m of snow may fall annually. Fire is rare and the primary source of natural disturbance is wind, with minor contributions from avalanches and landslides.

Landbird Avifauna

The unique glacial history, geographic complexity and rich array of habitats contribute to the high avian diversity and heterogeneity across this region (Swarth 1936, Johnson et al. 2008, Heinl and Piston 2009, Smith et al. 2016). Overall, 119 species of landbirds, representing 34 families and 10 orders, regularly occur in this region. Spanning the most southerly 7° of latitude in the state, BCR 5 is home to many species common in the Pacific Northwest or elsewhere in the contiguous US that occur nowhere else in Alaska. Approximately 20 of these species are at or near the northerly extent of their ranges, including the Sooty Grouse, Band-tailed Pigeon, Black Swift, Western Screech-Owl, Barred Owl, Red-breasted Sapsucker, and MacGillivray's Warbler. A few species, including the Gyrfalcon, Willow Ptarmigan, and Rock Ptarmigan, reach the southerly extent of their ranges in this area.

The most common species are those adapted to the coniferous forests and coastal environments typical of the Pacific Northwest, including the Rufous Hummingbird, Northern Goshawk, American Crow, Pacific-slope Flycatcher, Chestnut-backed Chickadee, Pacific Wren, Hermit Thrush, Varied Thrush, and Townsend's Warbler

Photo © Melissa Cady

Birds are an integral part of Native history, art, and culture in southeastern Alaska.

(Gabrielson and Lincoln 1959, Kessler and Kogut 1985, Heinl and Piston 2009, Armstrong 2015). Also conspicuous are the avian icons of traditional Tlingit, Haida, and Tsimshian cultures, the Bald Eagle and Common Raven. Species common in interior Alaska and those that favor deciduous habitats, such as the Warbling Vireo and Western Tanager, also occur along and near the mainland, particularly along trans-boundary river corridors (Johnson et al. 2008, Heinl and Piston 2009).

Priority Species and Subspecies

The Northern Pacific Rainforest BCR supports a large number of Partners in Flight species of continental importance, including four Watch List species and seven Common Birds in Steep Decline (Table 8; Panjabi et al. 2020). Among the Watch List species, the Rufous Hummingbird is of highest priority here because it breeds regularly and is restricted almost exclusively to this BCR within Alaska. The Olive-sided Flycatcher also breeds regularly in BCR 5 but is more abundant in the Northwestern Interior Forest (BCR 4). The remaining two Watch List species occur rarely within this BCR and are thus of localized priority where they do occur. The Black Swift is at the northern periphery of its range in southeastern Alaska, where it likely breeds in suitable habitat along mainland river systems (Gabrielson and Lincoln 1959, Kessel and Gibson 1978, Johnson et al. 2008, Heinl and Piston 2009). The Snowy Owl, a circumpolar Arctic breeder known for its irruptive southward migrations (Holt et al. 2020), occurs across this BCR as a rare to uncommon winter visitant (Gabrielson and Lincoln 1959, Isleib and Kessel 1973, Heinl and Piston 2009).

Seven species within BCR 5 have been designated as Common Birds in Steep Decline because of significant population declines during the past 40 years (Table 8; Panjabi et al. 2020). The Short-eared Owl, which breeds more commonly in boreal and Arctic habitats, is a rare breeder and winter visitant but locally common spring and fall migrant primarily along lowland meadows on the mainland of BCR 5 (Isleib and Kessel 1973, Johnson et al. 2008, Heinl and Piston 2009). The Varied Thrush, Common Redpoll, and Pine Siskin are common breeders across the BCR but their abundance is lower and more variable during winter, the Western Wood-Peewee is an uncommon breeder and migrant, and the Wilson's Warbler is a common breeder and migrant throughout the region (Isleib and Kessel 1973, Kessel and Gibson 1978, Johnson et al. 2008, Heinl and Piston 2009). The Bohemian Waxwing, a common breeder in BCR 4, occurs here primarily as an uncommon migrant and winter visitant (Kessel and Gibson 1978, Johnson et al. 2008, Heinl and Piston 2009).


Rufous Hummingbird

Photo © Milo Burcham

Three of the Common Birds in Steep Decline in this region are also designated as Continental Stewardship species because of the large proportion of the North American population that Alaska supports (Varied Thrush, Common Redpoll, Wilson's Warbler). This BCR also hosts significant populations of 13 other Continental Stewardship species. Together, these 16 species represent 10 families from 5 orders of birds, including 2 Nearctic migrants (Red-breasted Sapsucker, Golden-crowned Sparrow), 3 longer-distance migrants (Orange-crowned, Townsend's, and Wilson's warblers), and 11 species that are resident throughout the region or in portions of it (Table 8).


Pine Siskin

Photo © Lucas DeCicco

Table 8. Seasonal occurrence of species and subspecies within the North Pacific Rainforest BCR of Alaska recognized as of continental importance (Watch List or Common Birds in Steep Decline [CBSD]; Panjabi et al. 2020) or as a Continental or Regional Stewardship species. Some species that occur primarily during the breeding season may also occur in small numbers during winter in southern parts of the region.

Species	Continental Status	Continental Stewardship	Regional Stewardship	Seasonal Occurrence
Spruce Grouse (*isleibi*)			●	Year-round
Willow Ptarmigan		●		Year-round
Rock Ptarmigan (*dixoni*)			●	Year-round
Sooty Grouse		●		Year-round
Black Swift	Watch List			Breeding
Rufous Hummingbird	Watch List			Breeding
Northern Goshawk (*laingi*)		●	●	Year-round
Bald Eagle		●		Year-round
Red-tailed Hawk (*alascensis*)			●	Breeding
Snowy Owl	Watch List			Wintering
Northern Hawk Owl		●		Year-round
Short-eared Owl	CBSD			Breeding
Red-breasted Sapsucker		●		Breeding
Hairy Woodpecker (*sitkensis*)			●	Year-round
Olive-sided Flycatcher	Watch List			Breeding
Western Wood-Pewee	CBSD			Breeding
Chestnut-backed Chickadee		●		Year-round
Pacific Wren		●		Year-round
Ruby-crowned Kinglet (*grinnelli*)			●	Breeding
Hermit Thrush (*nanus*)			●	Breeding
Varied Thrush	CBSD	●		Year-round
Bohemian Waxwing	CBSD			Year-round
Gray-crowned Rosy-Finch		●		Year-round
Common Redpoll	CBSD	●		Year-round
Pine Siskin	CBSD			Year-round
Fox Sparrow (*townsendi, sinuosa, annectens, chilcatensis*)			●	Breeding
Dark-eyed Junco		●		Year-round
Golden-crowned Sparrow		●		Breeding
Song Sparrow (*kenaiensis, caurina, rufina*)			●	Year-round
Lincoln's Sparrow (*gracilis*)			●	Breeding
Orange-crowned Warbler		●		Breeding
Townsend's Warbler		●		Breeding
Wilson's Warbler	CBSD	●		Breeding

Northern Goshawk

Photo © Dirk Derksen

Similar to the Aleutian and Bering Sea Islands BCR, the Northern Pacific Rainforest BCR supports a large number of endemic or nearly endemic subspecies due to the region's geography, paleohistory, and relatively mild climate (Swarth 1936, Dickerman and Gustafson 1996, Gibson and Kessel 1997, Heinl and Piston 2009). Ten species merit regional stewardship status because of the importance of BCR 5 to these subspecies (Table 8). The numerous islands of the Alexander Archipelago and Prince William Sound host a number of endemic populations, particularly among resident birds that are less mobile, such as grouse and ptarmigan (Dickerman and Gustafson 1996, Barry and Tallmon 2010, Gibson and Withrow 2015, Montgomerie and Holder 2020, Zwickel and Bendell 2020). Several taxa that breed in this BCR nest only along the coasts of southeastern Alaska and British Columbia, most of them dark-plumaged races characteristic of the Pacific coastal rainforest (Swarth 1936, Heinl and Piston 2009, Arcese et al. 2020, Weckstein et al. 2020).

Of particular conservation concern is the Queen Charlotte subspecies of Northern Goshawk (*A. g. laingi*), which is largely restricted to old-growth forests in southeastern Alaska and coastal British Columbia and is classified as Threatened in Canada due to its small population size, limited distribution, and habitat loss and fragmentation from forest harvest and other commercial activities (COSEWIC 2013).

Important Landbird Areas

This coastal region of Alaska supports one of the largest, least disturbed expanses of temperate rainforest in the world (DellaSala 2011). These forests, especially old-growth stands with plentiful snags, are among the most important habitats for landbirds in this BCR. The complex coastline and abundant old-growth trees are an important resource for many species, including Bald Eagles, which nest in higher densities on the islands of southeastern Alaska than anywhere else (Gende et al.1997). The Alexander Archipelago, which contains thousands of small islands as well as some of the largest in North America (e.g., Prince of Wales Island), is recognized as a "hotspot" of biodiversity because of its high degree of endemism among small mammals, birds, and invertebrates (Cook et al. 2006, DellaSala 2011).

Endemic subspecies, such as the Prince of Wales Spruce Grouse (*F. c. isleibi*) and Queen Charlotte Northern Goshawk, depend on these old-growth forest habitats,

Photo © Stephen Hayes

as do many other typical temperate rainforest species such as Sooty Grouse, Red-breasted Sapsucker, Steller's Jay, Pacific-slope Flycatcher, Chestnut-backed Chickadee, Pacific Wren, Golden-crowned Kinglet, and Townsend's Warbler (Isleib and Kessel 1973, Kessler and Kogut 1985, DellaSala et al. 1996, Iverson et al. 1996, Andres et al. 2004, Lewis et al. 2006, Van Hemert et al. 2006, Johnson et al. 2008, COSEWIC 2013, Walters et al. 2020). Stands of large-diameter trees are particularly important for species such as cavity-nesting owls, woodpeckers, chickadees, nuthatches, and creepers. Such stands have sustained the largest proportional loss of any habitat in southeastern Alaska as a result of historic logging (Albert and Schoen 2013).

Mainland river corridors and associated riparian areas, which provide conduits to interior regions through coastal mountain ranges, serve as hotspots of avian diversity and abundance (Kessler and Kogut 1985, Van Hemert et al. 2006, Johnson et al. 2008). The large, trans-boundary river valleys support deciduous forest and shrub habitats not otherwise common in BCR 5. These areas are important for species such as Vaux's Swift, Warbling Vireo, Northern Waterthrush, MacGillivray's Warbler, Common Yellowthroat, Yellow Warbler, and Western Tanager. Large coastal wetlands, such as those found at the mouths of the Stikine, Nuka, and Resurrection rivers, Yakutat Forelands, Mendenhall Wetlands, Berner's Bay, and the Copper River Delta, also provide critical habitat and host a variety of landbird species, including the Savannah Sparrow, Lincoln's Sparrow, and Rusty Blackbird.

Other habitats of interest include non-forested alpine areas, which are important for species such as American Pipit and Rock, Willow, and White-tailed ptarmigan. Lowland riparian areas, especially salmon-spawning (*Oncorhynchus* spp.) streams, are also important for a wide variety of bird species (Gende and Willson 2001), including Bald Eagles, Western Screech-Owls, and American Dippers. Recently deglaciated areas and deciduous scrub and forelands habitats are relatively uncommon across the landscape, but support species such as Alder Flycatcher and Gray-cheeked Thrush. Regenerating harvested stands provide habitat for shrub-loving species, such as Orange-crowned and Wilson's warblers, but the value of this habitat declines for these species after approximately 25 years. Muskegs also provide foraging habitat for species such as the Northern Harrier and Short-eared Owl (Isleib and Kessel 1973) and host mid-summer flowers important for breeding Rufous Hummingbirds.

Three sites in this region—the Stikine River Delta, Berners Bay, and the Chilkat Bald Eagle Preserve—have been recognized as Important Bird Areas (IBAs) by the National Audubon Society in partnership with BirdLife International, based on their importance to landbirds as well as waterfowl, shorebirds, and seabirds. The Stikine River Delta (https://netapp.audubon.org/iba/Reports/3098) has been recognized as a Global IBA and the other two sites as state-level IBAs (https://netapp.audubon.org/iba/Reports/2712, https://netapp.audubon.org/iba/Reports/2827). All three sites are recognized for their concentrations of breeding or wintering Bald Eagles, which are particularly attracted to abundant spring concentrations of spawing eulachon (*Thaleichthys pacificus*).

Photo © Milo Burcham

Primary Conservation Objectives

Naturalists first documented birds in a series of explorations of the region from the mid-1700s through the mid-1900s (see Gabrielson and Lincoln 1959, Isleib and Kessel 1973, Johnson et al. 2008 for reviews). Comprehensive studies of the local avifauna have since been conducted in a few areas within the Northern Pacific Rainforest BCR, including the North Gulf Coast–Prince William Sound Region (Isleib and Kessel 1973), Kenai Fjords National Preserve (Van Hemert et al. 2006), Yakutat area (Andres and Browne 2007), Ketchikan area (Heinl and Piston 2009), and areas along the major mainland rivers of southeastern Alaska (Johnson et al. 2008). Much has yet to be learned about landbirds within large, remote expanses of the region, however, particularly relative to their seasonal occurrence and how their distribution is influenced by proximity to the mainland and its major river corridors (Heinl and Piston 2009).

The following objectives may facilitate conservation of landbirds in BCR 5:

- Fill gaps in our knowledge of the distribution, abundance, phenology, population trends, migratory connectivity, and habitat requirements of landbirds, especially for priority species and subspecies.
- Identify important habitats for landbirds and work with land managers on alternative harvest management scenarios, particularly large-tree old growth in riparian and nearshore areas.
- Support a long-term ecological monitoring program to track changes in distribution and abundance of landbirds, especially priority species and subspecies, relative to changes in habitat structure and function following timber harvest.
- Mitigate the effects of habitat change on landbird populations, especially those due to forest management practices (both historic and current) and climate change.
- Examine the effectiveness of adaptive silvicultural practices, such as young-growth management to improve degraded habitat for the benefit of landbirds.
- Document the occurrence and genetic diversity of endemic populations, identify and protect their key habitats, develop monitoring strategies to understand their status and demography, and identify and protect potential refugia relative to projected climate change.
- Monitor potential northward expansion of invasive birds, plants, and pathogens into southeastern Alaska and develop measures to mitigate negative effects on landbirds, particularly priority species and subspecies.
- Educate the public, resource developers, and land managers about the value of landbirds as important components of ecosystems in this region.

Priority Conservation Issues and Actions

Biological Resource Use

Timber harvest within old-growth forests on both public and private lands is the greatest source of habitat disturbance for birds in BCR 5. This pressure has been most intense in the southern portion of the region and on forests supporting the oldest and largest trees. The largely pristine Chugach National Forest (2.2 million ha) in the northern part of the region has designated no lands for commercial production and only a small amount (~4,000 ha) for harvest of fuelwood and saw timber for personal use during the next 10–15 years (USDA Forest Service 2020). In contrast, the Tongass National Forest (6.8 million ha), which dominates southeastern Alaska, has a long history of commercial timber harvest dating back to the 1950s. Significant logging has more recently been

Photo © Lucas DiCicco

Monitoring is needed to assess how climate change and land management practices are affecting landbird populations.

Photo © Lucas DiCicco

undertaken on State and Native Corporation lands in the region (Sullender and Smith 2016, USDA Forest Service 2016c).

As of 2004, ~12% (~320,000 ha) of all productive old-growth forest in southeastern Alaska had been harvested (Albert and Schoen 2013). As of 2014, ~183,000 ha of productive forest had been harvested on non-National Forest Service lands compared with ~187,000 ha on the Tongass National Forest (USDA Forest Service 2016c). Stands with a higher volume of larger trees and at lower elevations were targeted disproportionately during past harvests, with extremely large trees (>1 m diameter) being almost completely removed from the landscape (Albert and Schoen 2013, Albert et al. 2016, USDA Forest Service 2016b). Logging was not evenly distributed across the region, with 40% of all large-tree productive old-growth forest being harvested on North Prince of Wales Island (Albert et al. 2016, Albert 2019).

Young-growth stands that regenerate after clear-cut logging provide different structural habitats for birds than the old-growth stands they replace. These harvested stands function as shrub habitats for the first few decades but eventually transition to a relatively depauperate plant community underneath the canopy (Alaback 1982, Kessler and Kogut 1985, Albert et al. 2016). It may take more than 150 years for a regenerating forest to regain structural diversity similar to that of old growth. Understory vegetation and the species composition of mosses, lichen, and fungi may take even longer to re-establish. Where timber production is the primary goal, young-growth stands will seldom develop the structural characteristics important to bird species associated with old growth within the harvest rotation period (90–125 years; DellaSala et al. 1996, Matsuoka et al. 2012).

These young-growth forests have lower species diversity and support lower densities of snags and the associated cavity-nesting species than old growth (Kessler and Kogut 1985, Kissling 2003, Kissling and Garton 2006, 2008, Matsuoka et al. 2012). The Queen Charlotte Northern Goshawk, classified as a threatened subspecies in Canada (COSEWIC 2013) and a sensitive subspecies for the Tongass National Forest (USDA Forest Service 2016d), preferentially selects nesting sites in mature, high-volume stands with large trees and relatively closed, multi-layered canopies, characteristics rarely found in young-growth stands (Iverson et al. 1996, COSEWIC 2013). In addition, key prey species for goshawks, including grouse and red squirrels (*Tamiascieurus hudsonicus*), occur in reduced abundance in areas with even-aged silvicultural practices (Lewis et al. 2006). Forest management plans have traditionally failed to provide adequate protection of the large patches of old growth required for breeding and the post-fledging period (Reynolds et al. 1992, COSEWIC 2013, Smith 2013).

The endemic Prince of Wales Spruce Grouse also prefers high-volume old growth over homogeneous, second-growth forest and avoids clear-cuts (Russell 1999). Thus, timber management prescriptions could be designed to minimize impacts to avian species of concern, preserve the remaining stands of large-tree old growth, and maximize the diversity of vertical and horizontal plant structure following harvest. It is also important to maintain large, contiguous forest tracts, protect riparian forest corridors, and provide adequate forest buffers to mitigate effects of habitat loss (Kissling 2003, Sperry et al. 2008). Land management planning based on risk assessment for multiple species may be beneficial because relying on an assessment for the most sensitive single species (such as the Northern Goshawk) can substantially underestimate the risk of wildlife extinction across a planning area (Smith and Zollner 2005).

In 2012, the Forest Service adopted a new rule to guide land management planning across the National Forest System, with the intention of involving the public more and promoting a more collaborative approach to management (USDA Forest Service 2016a). In accordance with this new planning process, the Tongass National Forest and Chugach National Forest recently released updated land and resource management plans that provide prescriptions promoting the conservation of migratory bird species and the ecosystems upon which they depend (USDA Forest Service 2016d, 2020). In the Tongass plan, an important major objective of the selected alternative is to accelerate the transition to young-growth management (with concordantly limited old-growth harvest) within a span of 10 to 15 years (USDA Forest Service 2016d). Similar approaches to harvest on state and private lands, if possible to adopt, could help protect the highly valuable wildlife habitat that old growth provides.

In October of 2020, the US Department of Agriculture adopted the Alaska Roadless Rule (85 Federal Register 68688), which exempted the Tongass National Forest from the national 2001 Roadless Rule, a provision that had prohibited road construction, road reconstruction,

Photo © Colin Arisman

Commercial logging, such as this on Prince of Wales Island, is the greatest source of habitat disturbance for birds in the region.

Photo © Rachel Richardson

and timber harvests within Inventoried Roadless Areas, ~55% of the forest. The contentious Alaska Roadless Rule, which is currently under review, has great repercussions not only for the potential impacts from construction of additional roads (see below) but also for the large, contiguous forest tracts of rare and valuable wildlife habitat that could possibly be harvested through amendments to the current land and resource management plan (Hanley et al. 2005, Albert 2019).

Actions

- Investigate alternatives for harvesting more young-growth forest on timber production lands rather than concentrating harvest in the remaining old-growth stands.
- Design and implement studies to better understand the avian demographic processes in different habitat types and responses of birds to successional changes in forest structure.
- Identify silvicultural treatments in young growth that will benefit bird diversity and consider benefits to the avian community when designing habitat restoration treatments in young-growth stands.
- Maintain and implement the reserve system and conservation strategy as described in the Tongass and Chugach land and resource management plans (USDA Forest Service 2016d, 2020) and monitor their effectiveness.
- Provide information to land management agencies and private landowners within the BCR on the value of different forest habitats for landbirds, particularly priority species and subspecies.

Transportation and Service Corridors

Roads, and the managed landscapes made accessible by them, have been shown to contribute to changes in the species composition, abundance, and distribution of birds. In particular, such changes favor species that are edge- or shrub-adapted at the expense of those that are old-growth-obligate species. In addition, roads may create specific immediate hazards to local birds. For example, Nelson (2010) identified road-related mortality (vehicle strikes and road hunters) as the largest source of mortality for the endemic subspecies of Spruce Grouse on Prince of Wales Island.

Due to the networks of logging roads found on most islands in the Alexander Archipelago, BCR 5 has some of the highest road densities in rural Alaska. Prince of Wales Island alone has over 4,500 km of road (https://www.fhwa.dot.gov/tribal/tribalprgm/govts/pow.htm). Unused or lightly used roads, however, are quickly recolonized by alder and rapidly revert to impassable conditions without regular maintenance.

Recent adoption of the Alaska Roadless Rule (85 Federal Register 68688, 29 October 2020) opened 3.8 million ha of Inventoried Roadless Areas (IRAs) on the Tongass National Forest to road construction, road reconstruction, and timber harvest. Large IRAs currently contain a large proportion of contiguous old-growth stands that remain in the Tongass (Albert 2019). How the Alaska Roadless Rule will be implemented on the Tongass is uncertain, given that the IRAs were designated to be protected from these activities by the Forest's current land and resource management plan (USDA Forest Service 2016d).

Actions

- Evaluate the benefits to landbirds under the current level of protection of IRAs in the Tongass National Forest per the 2016 land and resource management plan.
- Assess the effects on landbirds of road closures and restoration in the Tongass National Forest.
- Evaluate the alternatives of using existing roads for logging second-growth stands vs. building new roads into pristine drainages.
- Design and implement studies to examine the relationship between road densities, hunting pressure, and the impacts of harvest on hunted landbird species.


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Barred Owl

Photo courtesy of US Fish and Wildlife Service

Invasive & Problematic Species, Pathogens, & Genes
BCR 5 is on Alaska's leading edge of intrusions of invasive species from the south. The non-native European Starling has continued to expand its North American range rapidly and is already well established in many communities in this region; Eurasian Collared Doves have been consistently reported in several communities in southeastern Alaska since 2006 (Heinl and Piston 2009). The cavity-nesting starling is particularly threatening to native forest birds because it is a strong competitor for nest sites and will aggressively evict woodpeckers, swallows, and even much larger-bodied birds from nest cavities (Cabe 2020). Starlings and collared doves both appear to be restricted to areas of human development at this time, but their effects on native bird species have not yet been assessed within Alaska.

Northward range expansions of two native North American species also pose threats to other landbirds within BCR 5. The Brown-headed Cowbird, an obligate brood parasite that can reduce reproductive output of songbird hosts, has been expanding its range in association with the clearing of forests (Smith et al. 2000). Although cowbirds still occur rarely in BCR 5, they now breed in this region (Gibson and Withrow 2015).

Barred Owls likely pose greater conservation issues for landbirds than traditionally defined invasive species in BCR 5. First documented in Alaska in 1977 (Kessel and Gibson 1978), Barred Owls have become increasingly common in recent years (Kissling and Lewis 2009). They are known to affect other large owls (e.g., Spotted Owls in the western US; Kelly et al. 2003, Dugger et al. 2011) and could potentially affect smaller forest owls in BCR 5, such as Western Screech-Owls and Northern Saw-whet Owls (Kissling and Lewis 2009, Kissling et al.

2010). Barred Owls prey on a wide variety of smaller bird species, and may compete with other raptors such as the Northern Goshawk for prey (Kissling and Lewis 2009). As secondary cavity-nesters, they may also compete with other species for nest sites.

Several species of invasive plants, such as reed canarygrass (*Phalaris arundinacea*), knotweed (*Fallopia* spp.), orange hawkweed (*Hieracium aurantiacum*), white sweetclover (*Melilotus alba*), and European mountain ash (*Sorbus aucuparia*), already occur in this region; these aggressive competitors limit the growth and density of native vegetation (Wolken et al. 2011). Most of these are currently associated with urbanized areas and roadsides but could significantly alter forest structure and function, riparian habitats, and wetlands if they expand beyond regions of human settlement. Many of the non-native plant species known or expected to occur in Alaska have been ranked according to the potential threat they pose to the native flora and ecosystems, based on their ability to become established in natural areas and the ecological damage they can cause (Carlson et al. 2008). Such quantitative rankings should be used to prioritize efforts to eradicate or mitigate the effects of invasive plants in natural areas.

Due to its connectivity to the lower mainland, BCR 5 may also be subject to new or emerging avian diseases, especially those that respond to changing climatic conditions. In particular, shifts in insect vector populations or northward range expansion of host species could contribute to the spread of infectious disease in this region. Although avian diseases such as West Nile virus have not yet been detected in southeastern Alaska, its recent spread to neighboring British Columbia (Morshed et al. 2011) highlights the need for surveillance in this region. Large clusters of American Crows have been found throughout southeastern Alaska with clinical signs of avian keratin disorder and the disease appears to have spread southward to British Columbia and Washington from Alaska (Van Hemert and Handel 2010).

Photo © Stephen Hayes


Photo © Charlie Finn

Large clusters of American Crows have been found throughout the Northern Pacific Rainforest BCR with gross beak abnormalities characteristic of avian keratin disorder.

Actions

- Monitor the occurrence of invasive songbird species (particularly starlings and cowbirds) within the region, assess their effects on native nesting birds, and support plans to mitigate negative impacts.
- Monitor site occupancy of forest owls throughout the region to document changes in distribution and abundance of Barred Owls, assess their effects on small owls, and identify actions needed to protect small-owl populations.
- Support ongoing eradication efforts for invasive plants and contribute to continued assessments of potential threats they pose to natural ecosystem functioning.
- Monitor and report avian diseases as part of existing research efforts.

Energy Production and Mining

Energy production continues to interest state and local governments in southeastern Alaska. Hydroelectric facilities have been proposed across the region, although many developments in southeastern Alaska are small in scale compared with those in other parts of the country (Peluso and Culliney 2016, USDA Forest Service 2016b). In addition to dams and more traditional impoundments, some developments rely on a steady supply of water from high mountain lakes that is piped underground or along the surface to generation stations below, a system with negligible impacts to fisheries resources. Regardless, hydroelectric development and transmission lines may contribute to loss of habitat and to mortality from collisions and electrocution.

Another alternative energy source of great interest to land managers in BCR 5 is biomass. There is growing pressure to develop an economical wood-chip industry to use readily available, fast-growing young growth or low-value wood that could be salvaged as a byproduct of harvest of higher-value timber (Lowell et al. 2015, USDA Forest Service 2016b). This emerging market may lead to a resurgence of the timber industry in southeastern Alaska if energy prices, subsidies, and entrepreneurial spirits converge; such harvest would likely have significant effects on landbirds in the region through alterations of habitat.

Mining is also a growing industry in this coastal region (USDA Forest Service 2016b). Two large mine developments, including the Kensington gold mine near Juneau and the Greens Creek mine (silver, zinc, gold, and lead) on Admiralty Island, are currently in operation in southeastern Alaska and exploration is still underway in other areas (Peluso 2016). There are dozens of mining claims and mines under development in British Columbia, upstream of the lower Stikine River and its delta, which is well known as a hotspot for bird diversity in southeastern Alaska (Johnson et al. 2008). Claims on Bokan Mountain on southern Prince of Wales Island, once an active and productive uranium mine, may now be developed for rare earth elements. Habitat destruction and contamination from acid mine drainage and leakage from tailings are of particular concern from large commercial mining activities (Jain et al. 2016, Peluso 2016), as evidenced by a recent mine tailings embankment breach in British Columbia, which contaminated downstream Alaska waters with copper (Byrne et al. 2018). Bald Eagles, American Dippers, and other species associated with riparian corridors are the species most at risk from such pollution.


Red-breasted Nuthatch

Photo © Milo Burcham

Actions

- Stay engaged with planning processes for resource development; educate managers, developers, and the public about potential effects on landbirds.
- Survey areas slated for development to quantify landbird occurrence and abundance prior to development and use these data to guide the planning process.
- Conduct research to assess the effects of resource development on landbirds and important habitats; identify useful mitigation measures.
- Support management efforts to reduce the attraction of leaching ponds (often toxic) to birds; to dispose of tailings beneath ground to minimize the surface footprint; and to monitor water quality to ensure that downstream pollution does not affect aquatic and riparian habitats important to landbirds.
- Provide guidance for mining camps and facilities to reduce garbage and other attractants to landbird predators.

Pollution

This narrow coastal region, with its plethora of islands, inlets, and rocky fjords, is dominated by the marine environment and thus highly vulnerable to marine sources of pollution. Within protected waterways, vessels of all types are abundant, ranging in size from small recreational skiffs, to moderately sized fishing boats and passenger vessels, to cargo barges, large ferries, cruise ships, and oil tankers (NUKA 2012). Since 2015, about

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79 million liters (500,000 barrels) of crude oil have been transported per day from the North Slope of Alaska along the 1300-km Trans-Alaska Pipeline System to the deep-water port of Valdez in Prince William Sound, where it is loaded onto supertankers (https://www.alyeska-pipe.com/TAPS).

In 1989 the grounding of the supertanker *Exxon Valdez* in Prince William Sound caused what was then the largest oil spill ever to occur in North America, with crude oil spreading across ~800 km of shoreline in the Sound, along the outer coast of the Kenai Peninsula, and beyond (Neff et al. 1995). The avian species most consistently impacted by oiling were those that forage on or close to shore and either nest on beaches or are wintering or permanent residents there (Wiens et al. 1996). These include landbird species such as the Bald Eagle, which suffered relatively high losses (Piatt et al. 1990), as well as the Common Raven, American Crow, Black-billed Magpie, Steller's Jay, Peregrine Falcon, and Sharp-shinned Hawk (Wiens et al. 1996), all of which typically forage along the shoreline and are likely to scavenge oiled carcasses. Safeguards against such catastrophic spills, including the use of double-hulled tankers, were subsequently instituted in the region. Landbirds associated with coastal habitats, however, remain vulnerable to impacts from all types of oil spills associated with marine traffic.

Although air quality within this sparsely populated region is considered good, localized air pollution does originate from marine vessels, mining operations, and various industrial and urban sources (Schirokauer et al. 2014). In addition, global climate patterns render this exposed coastal region susceptible to deposition of atmospheric contaminants transported long distances from outside sources (Landers et al. 2008). For example, a variety of airborne pollutants have been detected in relatively high concentrations in conifer needles in Glacier Bay National Park and the Stikine LeConte Wilderness Area, both sites considered pristine wildernesses. The combination of high concentrations in needles and dense forest foliage raises the concern that high loading of contaminants into the ecosystem may occur from canopy leachates and forest litter fall (Landers et al. 2008). Atmospheric deposition of mercury from coal burning in Asia is another major pollution concern.

Climate change may intensify the effects of contaminants by enhancing their environmental distribution and toxicity (Noyes et al. 2009). Atmospheric deposition of contaminants, including several pesticides that have since been banned in the US and many other countries, occurred when glaciers were still increasing in volume (Bettinetti et al. 2008). Glacial recession and changes in ice fields related to climate change have the potential to enhance productivity (Hood et al. 2009) or release formerly sequestered contaminant loads into streams and lakes (Blais et al. 2001, Bettinetti et al. 2008), potentially affecting species that are dependent on riparian and lacustrine systems, such as the American Dipper, Osprey, and Bald Eagle.

Recent recovery of debris along Alaska's coast from the 2011 tsunami in Japan has raised concerns about radiation contamination or other hazardous materials washing ashore in Alaska. Entrapment or entanglement of species that forage along the shoreline is likely a larger threat associated with such debris fields.

Actions

- Continue to support long-term monitoring programs for atmospheric pollutants.
- Support efforts to minimize risk of fuel spills in the marine environment and to minimize atmospheric emissions from marine vessels and localized industrial and urban point sources.
- Identify landbird species that would make good sentinels to monitor the occurrence and effects of

pollution in the environment and establish protocols for periodic monitoring.

- Identify sources of major contaminants in the region and assess their effects on landbirds.
- Support efforts to remove debris fields from the shoreline.

Climate Change

Climate change is likely to have significant effects on landbird populations in this region, particularly through impacts on habitat. Projected changes include continued shrinkage of glaciers and ice fields as well as increases in air temperature, length of growing season, precipitation, rates of evapotranspiration, and intensity of storms (SNAP 2008, Haufler et al. 2010, Wolken et al. 2011, Larsen et al. 2015, Shanley et al. 2015). The magnitude of these changes will vary between glacial-fed and non-glacial watersheds and across the steep elevational gradients that occur throughout the mountainous region (Wolken et al. 2011, Larsen et al. 2015). Changes in climate drivers, coupled with changes in the dominant biophysical factors in this region such as snow and ice cover, insects, disease, and invasive species, are projected to cause complex changes in plant succession and wildlife populations, with significant social consequences and feedbacks (Wolken et al. 2011).

Habitats are already being affected significantly by climatic changes. Concentrated mortality of Alaska cedar (also commonly known as yellow-cedar) has recently been documented in several thousand locations across southeastern Alaska, affecting over 200,000 ha of forest (Hennon et al. 2012). "Yellow-cedar decline," which began in the late 1800s and accelerated during the 20th century, has been attributed to root-freezing injury during spring in areas of reduced snowpack caused by warmer temperatures (Beier et al. 2008, Hennon et al. 2008, 2012). This slow-growing tree, which can live more than 1,000 years and is naturally resistant to insects and pathogens, has ecological, cultural, and economic importance in southeastern Alaska (Hennon et al. 2012). Though not known to be an important tree for cavity-nesting birds, decay-resistant cedars may remain standing long after death and the ecological effects of such massive stand mortality on forest birds are unknown. Loss of live cedars may lead to changes in nesting and foraging habitat, protective cover, prey abundance, fire dynamics, and other characteristics that may have cascading effects on the bird community. An increase in length of the growing season may also increase rates of parasitism by hemlock dwarf mistletoe (*Arceuthobium tsugense*), which impedes growth and causes mortality of western hemlock (Barrett and Christensen 2011, Wolken et al. 2011). Many other temperature-sensitive insect pests and invasive plant species affect the structure and functioning of these coastal forests (Barrett and Christensen 2011), and it is likely that such effects will be exacerbated with projected changes in climate.

High elevations of the continental land mass of BCR 5 are currently dominated by ice fields and glaciers, many of which terminate in lakes or at tidewater (Larsen et al. 2007). These features are strongly linked to climatic factors, including temperature, cloud cover, and precipitation, but the direction and extent of change in glacier mass balance can be quite variable across this region (Moore et al. 2009, Larsen et al. 2015). During the last 50 years, however, glacier surface elevations have decreased across 95% of the glacier-covered areas analyzed across southeastern Alaska and northwestern British Columbia, with some glaciers thinning up to 640 m (Larsen et al. 2007). In addition to the creation or loss of successional habitat that occurs as glaciers retreat or advance, changes in glacier mass can cause significant physical effects downstream, including changes in stream

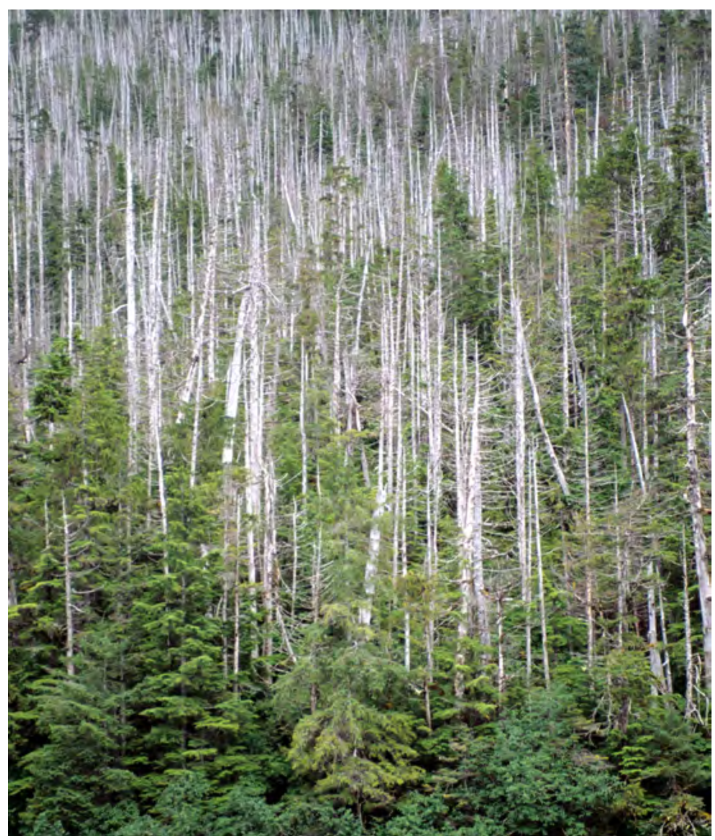

Photo courtesy of Melissa Cady, USDA Forest Service

Large tracts of Alaska cedar have suffered mass mortality from root-freezing injury resulting from reduced snowpack.

Photo © Dirk Derksen

flow, geomorphic processes, and water quality (Moore et al. 2009), with concomitant ecological effects on associated community assemblages. The rate of glacier mass loss across the region is higher among land- and lake-terminating glaciers than tidewater glaciers, and Alaska's glacier melt is contributing significantly to global sea level rise (Larsen et al. 2015).

A recent analysis of a suite of global climate models for the northern Pacific coastal temperate rainforest projects increases in mean annual temperature from a current average of 3.2 °C to 4.9–8.7 °C; 3–18% increases in mean annual precipitation; and 22–58% decreases in total precipitation as snow by the 2080s (Shanley et al. 2015). These projected changes are expected to result in a cascade of ecosystem-level alterations of snowline and stream flow, shrinking alpine habitats, and elevational advance of tree line, causing shifts in wildlife habitat and distribution, an increase in the incidence and severity of insects and disease in lowland forests, an increase in flooding and disturbance events, and adverse effects on species with rare niches and limited dispersal capabitility (Shanley et al. 2015).

Changes in temperature and precipitation will also directly alter the hydrological regimes and nutrient concentrations in streams of southeastern Alaska, with potentially complex effects on the anadromous salmonid populations that form a key component of the ecosystems of the region (Bryant 2009, Shanley et al. 2015). Spawning salmon exert strong influences on many biotic processes in riparian systems, and forests of southeastern Alaska bordering salmon streams have been found to support significantly higher densities of forest passerines compared to non-salmon streams (Gende and Willson 2001).

Rising sea levels could inundate coastal wetlands, but given the active geology of the area, including isostatic rebound of recently deglaciated areas and potential for uplift or subsidence associated with earthquakes, local sea level change is very difficult to predict (Bryant 2009). Projected increases in mean annual precipitation suggest that lowland coastal forests will remain wet, despite increases in temperature, but that disturbance events will become more frequent (Shanley et al. 2015).

Several changes in habitat structure have already been documented in conjunction with recent climatic warming in this region, including colonization of alpine tundra by mountain hemlock, invasion of meadows by shrubs, and increased browsing of vegetation at low elevations by Sitka black-tailed deer (*Odocoileus hemionus sitkensis*), facilitated by declines in snow accumulation (Juday et al. 1998). Coastal areas have also experienced a marked increase in the frequency and intensity of storms and gale-force winds (Juday et al. 1998), which have a strong influence on vegetation structure. Catastrophic winds are one of the major sources of forest disturbance along the coast, often causing large-scale blowdowns that drastically alter the age and composition of forest stands (Nowacki and Kramer 1998). Projected increases in air temperature and length of the growing season will also increase growth rates of stem-decay fungi, which are expected to exacerbate susceptibility of decayed trees to wind breakage (Wolken et al. 2011). Notably, the community structure of coastal Alaska forests is projected to change as air temperature increases, with a gradual decline in Sitka spruce across the region and replacement by boreal spruce species (Ma et al. 2019).

How such changes in the structure and composition of vegetation will influence landbird populations in this region is largely unknown. Coastal mountain ranges currently serve as a geographic barrier between coastal and boreal populations of birds, although analysis of past, current, and future conditions suggests that the perceived biogeographic barrier may be easily weakened as climate changes (Stralberg et al. 2017). High-elevation, mountain specialists, such as the White-tailed Ptarmigan, are likely the species most vulnerable to climate change in this region and across the Holarctic (Jackson et al. 2015, Scridel et al. 2018). It is imporant to understand the vulnerability and adaptability of individual species and populations across the region, including distributional, demographic, and phenological effects, and to identify and protect potential refugia as distributions change (Stralberg et al. 2019).

Changes in temperature and precipitation may also affect the distribution of pathogens (Cahill et al. 2013), which may be particularly problematic for the endemic bird populations that have long been isolated in this region. West Nile virus, which causes significant avian mortality and poses threats to human health, has been spreading rapidly west and north across North America and has recently been detected in Washington (2002), Alberta (2003) and British Columbia (2009) (Morshed et al. 2011). Transmission of this vector-borne flavivirus, which is transmitted between birds by mosquitoes (*Culex* spp.) and incidentally transmitted to humans, is thought to be limited by temperature and abundance of *C. tarsalis* mosquitoes (Roth et al. 2010). It is uncertain what threshold conditions must be met for spread of this disease into Alaska, but it could severely impact populations of various corvids and other highly susceptible species if it reaches this region.

Actions

- Support development of regional climate models to project climatic changes at a finer geographic scale across the region.
- Gather data on current distribution of landbirds across the region and develop models of habitat associations for all regularly occurring species of landbirds, but particularly for priority species and subspecies and for the habitats, such as alpine tundra, most vulnerable to climate change.
- Develop dynamic models of habitat change across the landscape relative to major ecosystem drivers (e.g., glaciers, snowpack, wind, temperature, precipitation, salmonids, deer, insects, pathogens).
- Conduct long-term monitoring across the region to assess changes in the status, distribution, and demography of landbirds relative to climatic factors.
- Identify specific areas within the region that are important during breeding, migration, and winter for priority species, endemic populations, and overall landbird diversity. Develop spatially explicit projections for how such areas may shift under future climate scenarios and design a system of protected areas that could buffer populations against rapid climatic changes.
- Document migratory connectivity for priority species among breeding areas, migration corridors, and wintering areas to assess how climate change may influence key habitats and demographic processes in other regions.
- Evaluate genetic diversity within landbird populations in the region relative to paleohistorical climate and evaluate potential impacts of contemporary climate change on extant populations.
- Track range expansion and monitor ecological effects of more southerly species of birds, mammals, plants, insects, and pathogens moving into southeastern Alaska.
- Educate the public to promote understanding of potential impacts of climate change.

Photo © Daniel Fehringer, Ducks Unlimited

The Stikine and other mainland rivers may become increasingly important as corridors for landbird migration and dispersal.

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Appendix I

Brief accounts of Partners in Flight Watch List species occurring in Alaska

Iain J. Stenhouse, Deborah E. Perkins, Stephen B. Lewis, Steven M. Matsuoka, and Colleen M. Handel

The following five species are on the Partners in Flight (PIF) Watch List of continental importance for the United States and Canada (Rosenberg et al. 2016, Panjabi et al. 2020). All of these species regularly occur in Alaska, except the Black Swift, which is perhaps peripheral, although the range of this species in Alaska is not fully known. The PIF Watch List identifies species with the greatest range-wide concerns and which are in most need of conservation attention. These species are all considered to have multiple causes for concern across their range and are ranked as the highest priority for conservation action at regional, national, and international scales (Panjabi et al. 2020).

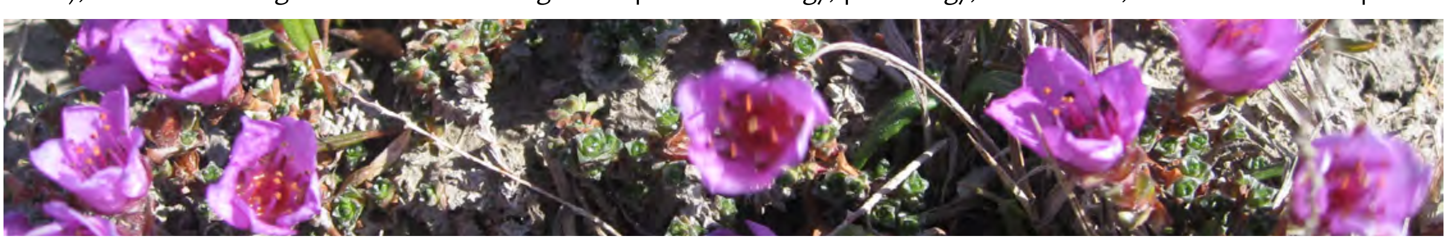
Black Swift (*Cypseloides niger*)—This species is a fairly common summer resident, probable breeder, and common fall migrant in select river valleys of southeastern Alaska (Johnson et al. 2008). Black Swifts winter in northern and western South America, but knowledge of their behavior and ecology during the nonbreeding season is virtually nonexistent (Beason et al. 2012, Lowther et al. 2020). BBS data show a significant decline (−6.8%/year; Sauer et al. 2017) but the sheer lack of information on this species is perhaps the greatest cause for conservation concern. They are known to use remote and inaccessible breeding sites with sheer cliffs, often behind waterfalls, but behavior of this species is poorly known except for what has been observed at the few known nest sites across their range. Swifts appear to be a relatively long-lived species, lay a fixed clutch size of one egg, and have an unusually prolonged and late breeding season with extremely slow nestling growth rates (Wiggins 2004). There is little information on the factors influencing Black Swift population viability, but the main threats appear to be lack of late summer water-runoff, which affects the suitability of nesting sites, and decreased local food supplies (Wiggins 2004). Nest failures appear to be common and likely most often related to heavy precipitation events (Hunter and Baldwin 1962). Although Black Swifts are apparently restricted to nesting in relatively rare, wet cliff faces, a lack of nesting sites does not appear to be controlling local population growth. Basic research on distribution, systematics, phenology, breeding biology, foraging ecology, habitat use, behavior, and limiting factors is required.

Rufous Hummingbird (*Selasphorus rufus*)—These tiny migrants have the most northern breeding range of any hummingbird and arrive early (late April) in Alaska. They breed throughout south-coastal and southeastern Alaska, where their nesting habitats are diverse and include early successional spruce/hemlock, old growth and scrub, deciduous woodlands, muskeg forests, and riparian shrubs. The highest densities occur in scrub or early successional habitats. Secondary succession caused by logging, fires, and other disturbances can increase food availability for this species (Healy and Calder 2020). Rufous Hummingbirds winter in southern Texas and Mexico. Overall, the species is considered to be relatively secure, with the global population estimated at around 22 million individuals (Panjabi et al. 2020), but BBS data show a significant continental decline of −1.4%/year continentally (Sauer et al. 2017) and ALMS data indicate a significant decline of −7.5%/year in off-road areas of Alaska (Handel and Sauer 2017). The timing of spring migration appears to be advancing in response to climate warming, and birds may be shifting migration routes inland and breeding ranges northward (Courter 2017); such climate-related range expansion is predicted to occur (Winker and Gibson 2018). Autumn migration is segregated temporally and spatially by age and sex, possibly in response to differential flowering morphology (Rousseau et al. 2020). Studies on distribution, breeding biology, habitat use and movements relative to plant phenology, migratory connectivity, and demography are required to understand the causes of the population decline and effectively manage this species.

Snowy Owl (*Bubo scandiacus*)—These iconic large owls of Arctic regions occupy a northern circumpolar range, nesting in tundra habitats throughout this area, often adjacent to coastal Arctic seas (Holt et al. 2020). In the US, Snowy Owls breed exclusively in Alaska (USFWS 2000), mostly limited to sites across the northern part of the state (Holt et al. 2020). Snowy Owls winter in various places across the Arctic tundra (Gessaman 1972, USFWS 2000) as well as on or near sea ice (Gilchrist and Robertson 2000, Therrien et al. 2011) but also may move south to temperate areas of North America (Holt et al. 2020). Snowy Owls are a difficult species to enumerate across broad spatial areas because of their nomadic tendencies and the remote nature of their range. In 2004, the global population was estimated at 290,000 owls (Rich et al. 2004) but alternative methodologies have been presented recently that give far lower figures of approximately 28,000 mature individuals (Marthinsen et al. 2009, Potapov and Sale 2013), causing the species to be uplisted to Vulnerable on the IUCN Red List of Threatened Species (Birdlife International 2020). The North American population has recently been estimated at 15,000 (Panjabi et al. 2020), and a recent analysis of Christmas Bird Count data indicates that the population has declined at a rate of −1.5%/year since 1966. (Meehan et al. 2018). Snowy Owls' nomadic and irruptive movements, variable breeding density, and highly variable reproductive success are largely attributable to the variable abundance of lemmings (*Lemmus* spp. and *Dicrostonyx* spp.), their primary prey (Gilg et al. 2006, Therrien et al. 2014a, 2014b, Holt et al. 2020). These relationships are not fully understood, however, and the owls' movements remain unpredictable (Holt et al. 2020). Research to understand factors that drive their movements as well as coordinated surveys across the range during lemming highs are needed to clarify their population numbers and conservation needs.

Olive-sided Flycatcher (*Contopus cooperi*)—Alaska supports an estimated 418,000 birds, around 22% of the global population (Panjabi et al. 2020), and BBS data provide strong evidence for a continent-wide population decline of −2.6%/year (Sauer et al. 2017). The breeding range of this species extends across the coniferous forest region of North America, with the steepest declines indicated in the west. They regularly breed at low densities throughout the boreal and coastal forests of Alaska (Kessel and Gibson 1978). Males return to breeding sites in interior Alaska in mid- to late May, with most females returning 1–2 weeks later, and they remain through late August. During breeding, they are usually associated with open habitats, such as muskegs, meadows, burns, and logged areas, and with wetland areas, such as streams, lakes, ponds, and bogs (Altman and Sallabanks 2020). Nest success is high in wetlands and recent burns (61–65%), but much lower in recently harvested areas (30–33%; Wright 1997, Robertson and Hutto 2007, Altman and Sallabanks 2020), which are thought to act as an ecological trap (Robertson and Hutto 2007, Robertson 2012). Fire suppression may have negatively affected breeding habitat by reducing forest openings and the amount of uneven canopy structure. No consistent threat or impact is immediately obvious across their broad breeding range, however, and declines may be related to habitat loss on the wintering range or on migration. They winter primarily in the mountains of northern and western South America. Primary wintering habitat appears to be mature evergreen forest of low- to mid-elevation in the Northern and Central Andes, one of the most heavily deforested habitats in South America. This species had previously been classified in Canada as Threatened due to its substantial long-term population decline (COSEWIC 2007) but this designation was recently changed to Special Concern because the rate of decrease slowed during the past decade (COSEWIC 2018). Studies on breeding biology, food resources, and migratory connectivity are underway in Alaska (Hagelin et al. 2015, Haberski et al. 2016).

McKay's Bunting (*Plectrophenax hyperboreus*)—The only endemic landbird species in Alaska, the state supports its entire global population, estimated at 31,000 individuals (Matsuoka and Johnson 2008). Virtually the entire population of McKay's Buntings breeds on the remote St. Matthew and Hall islands, in the central Bering Sea, but small numbers appear irregularly in summer on St. Lawrence Island (with evidence of breeding) and the Pribilof Islands (Johnson et al. 2013, Lehman 2019, Montgomerie and Lyon 2020). McKay's Buntings also have a limited wintering range mainly along the coast of western Alaska, from the Seward Peninsula south to the Alaska Peninsula (Montgomerie and Lyon 2020). There are no major imminent threats, but given the species' small population size and extremely limited range, the McKay's Bunting is extremely vulnerable to disruptions to its breeding islands, such as through the introduction of invasive species (e.g., rats) or alteration of wintering habitats. There is a pressing need to identify important wintering areas and the species' vulnerability to mortality from wind energy developments in coastal villages in western Alaska. Basic research on systematics, breeding biology, phenology, habitat use, and behavior is required.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Appendix II

Landbird species substantiated as regularly and naturally occurring in Alaska[1], their migration strategy[2], and their relative abundance[3] in each Bird Conservation Region (BCR).

Species[4]	Scientific Name	Migration Strategy	Relative Abundance				
			BCR 1	BCR 2	BCR 3	BCR 4	BCR 5
Ruffed Grouse	*Bonasa umbellus*	R		R		C	R
Spruce Grouse	*Falcipennis canadensis*	R		U	R	C	U
Willow Ptarmigan	*Lagopus lagopus*	R	+	C	C	C	U
Rock Ptarmigan	*Lagopus muta*	R	C	C	C	C	C
White-tailed Ptarmigan	*Lagopus leucura*	R		+		U	U
Sooty Grouse	*Dendragapus fuliginosus*	R					C
Sharp-tailed Grouse	*Tympanuchus phasianellus*	R				U	
Band-tailed Pigeon*	*Patagioenas fasciata*	A		+	+		R
Eurasian Collared-Dove	*Streptopelia decaocto*	R		+		+	R
Mourning Dove*	*Zenaida macroura*	B		+		+	R
Common Nighthawk*	*Chordeiles minor*	A	+	+	+	+	R
Black Swift	*Cypseloides niger*	A					R
Vaux's Swift	*Chaetura vauxi*	A				+	U
Anna's Hummingbird	*Calypte anna*	N		+		+	R
Rufous Hummingbird	*Selasphorus rufus*	A	+	+		R	C
Osprey	*Pandion haliaetus*	A	+	R	+	R	R
Golden Eagle	*Aquila chrysaetos*	B	R	U	U	C	R
Northern Harrier	*Circus hudsonius*	B	+	U	U	U	U
Sharp-shinned Hawk	*Accipiter striatus*	R, B	+	R	+	C	U
Northern Goshawk	*Accipiter gentilis*	R, N	+	R	+	U	U
Bald Eagle	*Haliaeetus leucocephalus*	R, N	C	U	R	U	C
Swainson's Hawk*	*Buteo swainsoni*	A		+	+	R	+
Red-tailed Hawk	*Buteo jamaicensis*	B		R	+	C	U
Rough-legged Hawk	*Buteo lagopus*	N	U	C	C	U	R
Western Screech-Owl*	*Megascops kennicottii*	R				+	R
Great Horned Owl	*Bubo virginianus*	R		U	+	C	C
Snowy Owl	*Bubo scandiacus*	R, N	R	U	U	+	U
Northern Hawk Owl	*Surnia ulula*	R		U	+	C	U
Northern Pygmy-Owl*	*Glaucidium gnoma*	R					R

Species[4]	Scientific Name	Migration Strategy	Relative Abundance				
			BCR 1	BCR 2	BCR 3	BCR 4	BCR 5
Barred Owl	*Strix varia*	R					U
Great Gray Owl	*Strix nebulosa*	R		R	+	R	R
Short-eared Owl	*Asio flammeus*	B	U	C	U	C	U
Boreal Owl	*Aegolius funereus*	R	+	R	+	C	U
Northern Saw-whet Owl	*Aegolius acadicus*	R, N	+	+		R	U
Belted Kingfisher	*Megaceryle alcyon*	B	R	U	+	C	C
Yellow-bellied Sapsucker*	*Sphyrapicus varius*	N				+	R
Red-breasted Sapsucker	*Sphyrapicus ruber*	N		+		+	C
American Three-toed Woodpecker	*Picoides dorsalis*	R		R	+	U	U
Black-backed Woodpecker	*Picoides arcticus*	R		+	+	R	+
Downy Woodpecker	*Dryobates pubescens*	R		R	+	U	U
Hairy Woodpecker	*Dryobates villosus*	R		+	+	U	U
Northern Flicker	*Colaptes auratus*	B	+	+	+	C	U
American Kestrel	*Falco sparverius*	B		+	+	C	+
Merlin	*Falco columbarius*	R, A	+	U	R	U	R
Gyrfalcon	*Falco rusticolus*	R, N, P	R	U	U	U	R
Peregrine Falcon	*Falco peregrinus*	R, A	U	R	R	R	U
Olive-sided Flycatcher	*Contopus cooperi*	A	+	R	R	U	U
Western Wood-Pewee	*Contopus sordidulus*	A	+	+	+	U	U
Yellow-bellied Flycatcher*	*Empidonax flaviventris*	A	+		+	R	+
Alder Flycatcher	*Empidonax alnorum*	A	+	U	+	C	U
Least Flycatcher*	*Empidonax minimus*	A		+	+	+	+
Hammond's Flycatcher	*Empidonax hammondii*	A			+	C	U
Pacific-slope Flycatcher	*Empidonax difficilis*	A					C
Say's Phoebe	*Sayornis saya*	B	+	U	U	U	R
Northern Shrike	*Lanius borealis*	R, N	+	U	U	U	U
Cassin's Vireo*	*Vireo cassinii*	A				+	R
Warbling Vireo	*Vireo gilvus*	A				+	U
Canada Jay	*Perisoreus canadensis*	R		U	R	C	R
Steller's Jay	*Cyanocitta stelleri*	R				R	C
Black-billed Magpie	*Pica hudsonia*	R	+	U	+	C	U
American Crow	*Corvus brachyrhynchos*	R		U		U	C

Species[4]	Scientific Name	Migration Strategy	Relative Abundance				
			BCR 1	BCR 2	BCR 3	BCR 4	BCR 5
Common Raven	*Corvus corax*	R	U	C	C	C	C
Eurasian Skylark*	*Alauda arvensis*	P	R			+	
Horned Lark	*Eremophila alpestris*	B	+	U	C	C	R
Bank Swallow	*Riparia riparia*	A	U	U	R	C	R
Tree Swallow	*Tachycineta bicolor*	B	+	C	R	C	C
Violet-green Swallow	*Tachycineta thalassina*	A	+	R	R	C	U
Northern Rough-winged Swallow*	*Stelgidopteryx serripennis*	A			+		R
Barn Swallow	*Hirundo rustica*	A	+	+	+	+	C
Cliff Swallow	*Petrochelidon pyrrhonota*	A	+	U	U	C	U
Black-capped Chickadee	*Poecile atricapillus*	R		U	+	C	U
Chestnut-backed Chickadee	*Poecile rufescens*	R				R	C
Boreal Chickadee	*Poecile hudsonicus*	R		U	R	C	R
Gray-headed Chickadee*	*Poecile cinctus*	R		R	R	R	
Red-breasted Nuthatch	*Sitta canadensis*	R, N	+	R		R	U
Brown Creeper	*Certhia americana*	R, B		R		R	U
Pacific Wren	*Troglodytes pacificus*	R	U	U	+	R	C
American Dipper	*Cinclus mexicanus*	R	U	C	R	U	C
Golden-crowned Kinglet	*Regulus satrapa*	R, B	+	R		R	C
Ruby-crowned Kinglet	*Regulus calendula*	B	+	U	R	U	C
Arctic Warbler	*Phylloscopus borealis*	P	+[5]	C	U	C	
Bluethroat	*Cyanecula svecica*	P	+[5]	R	R		
Siberian Rubythroat*	*Calliope calliope*	P	R	+			
Northern Wheatear	*Oenanthe oenanthe*	P	R[5]	U	U	U	R
Mountain Bluebird*	*Sialia currucoides*	B		+	+	R	+
Townsend's Solitaire	*Myadestes townsendi*	B		+	R	R	R
Gray-cheeked Thrush	*Catharus minimus*	A	R[5]	C	C	C	R
Swainson's Thrush	*Catharus ustulatus*	A	+	R	R	C	C
Hermit Thrush	*Catharus guttatus*	B	+	R	+	U	C
Eyebrowed Thrush*	*Turdus obscurus*	P	R		+		
American Robin	*Turdus migratorius*	B	+	C	C	C	C
Varied Thrush	*Ixoreus naevius*	N	+	C	R	C	C
European Starling	*Sturnus vulgaris*	R	+	+	+	R	R

Species[4]	Scientific Name	Migration Strategy	Relative Abundance				
			BCR 1	BCR 2	BCR 3	BCR 4	BCR 5
Bohemian Waxwing	*Bombycilla garrulus*	R, N	+	R	R	C	U
Cedar Waxwing	*Bombycilla cedrorum*	B		+		+	U
Eastern Yellow Wagtail	*Motacilla tschutschensis*	P	R[5]	C	U	+	+
White Wagtail*	*Motacilla alba*	P	R	R	+	+	+
Red-throated Pipit	*Anthus cervinus*	P	R	R	+	+	+
American Pipit	*Anthus rubescens*	B	U	C	C	C	C
Brambling	*Fringilla montifringilla*	P	R	+	+	+	+
Pine Grosbeak	*Pinicola enucleator*	R, N	+	U	+	U	U
Gray-crowned Rosy-Finch	*Leucosticte tephrocotis*	R, N	C	U	R	U	U
Purple Finch*	*Haemorhous purpureus*	N	+	+	+	+	R
Common Redpoll	*Acanthis flammea*	R, N	U	C	U	C	U
Hoary Redpoll	*Acanthis hornemanni*	R, N	R	C	C	R	+
Red Crossbill	*Loxia curvirostra*	R, N	+	R		R	C
White-winged Crossbill	*Loxia leucoptera*	R, N	+	U	R	U	C
Pine Siskin	*Spinus pinus*	B	+	R	+	R	C
Lapland Longspur	*Calcarius lapponicus*	N	C	C	C	C	R
Smith's Longspur	*Calcarius pictus*	N			U	R	+
Snow Bunting	*Plectrophenax nivalis*	R, N	C	C	U	U	R
McKay's Bunting	*Plectrophenax hyperboreus*	R	C[6]	R[6]		+	+
Rustic Bunting*	*Emberiza rustica*	P	R	+		+	+
Chipping Sparrow	*Spizella passerina*	A	+		+	U	U
Brewer's Sparrow*	*Spizella breweri*	A				R	+
Fox Sparrow	*Passerella iliaca*	B	+	C	U	C	C
American Tree Sparrow	*Spizelloides arborea*	N	+	C	C	C	R
Dark-eyed Junco	*Junco hyemalis*	R, B	+	U	R	C	C
White-crowned Sparrow	*Zonotrichia leucophrys*	B	+	C	C	C	R
Golden-crowned Sparrow	*Zonotrichia atricapilla*	N	+	C	U	U	C
White-throated Sparrow*	*Zonotrichia albicollis*	N		+	+	+	R
Savannah Sparrow	*Passerculus sandwichensis*	B	C	C	C	C	C
Song Sparrow	*Melospiza melodia*	R, B	C	C		U	C
Lincoln's Sparrow	*Melospiza lincolnii*	A	+	U	+	C	C
Swamp Sparrow*	*Melospiza georgiana*	B				+	R

Species[4]	Scientific Name	Migration Strategy	Relative Abundance				
			BCR 1	BCR 2	BCR 3	BCR 4	BCR 5
Red-winged Blackbird	*Agelaius phoeniceus*	B	+	+	+	U	U
Brown-headed Cowbird*	*Molothrus ater*	B	+	+	+	+	R
Rusty Blackbird	*Euphagus carolinus*	N	+	U	R	U	R
Northern Waterthrush	*Parkesia noveboracensis*	A	+	C	R	C	U
Tennessee Warbler*	*Leiothlypis peregrina*	A	+	+		+	R
Orange-crowned Warbler	*Leiothlypis celata*	A	+	C	U	C	C
MacGillivray's Warbler	*Geothlypis tolmiei*	A			+	+	U
Common Yellowthroat	*Geothlypis trichas*	A		+		+	U
American Redstart	*Setophaga ruticilla*	A	+		+	+	U
Yellow Warbler	*Setophaga petechia*	A	+	C	R	C	C
Blackpoll Warbler	*Setophaga striata*	A	+	C	+	U	R
Palm Warbler*	*Setophaga palmarum*	A	+	+	+	+	+
Yellow-rumped Warbler	*Setophaga coronata*	B	+	C	R	C	C
Townsend's Warbler	*Setophaga townsendi*	A	+	+	+	C	C
Wilson's Warbler	*Cardellina pusilla*	A	+	C	U	C	C
Western Tanager	*Piranga ludoviciana*	A	+	+	+	+	U
Black-headed Grosbeak*	*Pheucticus melanocephalus*	A	+	+		+	R

[1]Substantiated through archived specimens, photos, videotapes, or audio recordings; list excludes species recorded only as casual or accidental in Alaska (Gibson et al. 2021).

[2]Migration Strategy: A = Neotropical migrant with majority of winter range south of US/Mexico border, B = Neotropical migrant with majority of winter range north of US/Mexico border, N = Nearctic migrant, with entire or almost entire winter range in the US and Canada, P = Palearctic or Paleotropical migrant, with entire winter range in Asia, R = resident species, non-migratory or very weakly migratory. Some species may have different strategies for northern and southern parts of their breeding range.

[3]Relative Abundance: C = common (species occurs regularly in all or nearly all appropriate habitats and/or region regularly hosts large numbers of the species), U = uncommon (species occurs regularly but uses very little of suitable habitat and/or region hosts relatively small numbers of the species), R = rare (species occurs regularly within region but in very small numbers; at perimeter of region, in season, or scarce resident), + = casual or accidental (species does not occur annually; beyond periphery of annual range). Regional abundance refers to that during summer breeding season for migratory species, or maximum seasonal abundance for residents and nonbreeding migrants; abundance for breeding species may be greater than indicated during migration periods, particularly within southerly portions of some BCRs. Assessment of status is based on published and unpublished records since 1950.

[4]Species marked with * are considered rare at the statewide level.

[5]Significant trans-Beringian migrant through BCR 1.

[6]McKay's Bunting breeds and winters in BCR 1; also winters along the coast of BCR 2.

Appendix III

Continental assessment scores, conservation status, stewardship priority, and population estimates for regularly occurring and rare (*) landbirds in Alaska. Data are from the Avian Conservation Assessment Database (Panjabi et al. 2020) and Partners in Flight Population Estimates Database (Stanton et al. 2019, Will et al. 2020) available at pif.birdconservancy.org.

Species[1]	Assessment Scores[2]							Continental Conservation Status	Continental Stewardship	US & Canada Population Estimate[3]	% Global Population in North America[3]	% North American Population in Alaska[3]
	PS	BD	ND	TB	TN	PT	Combined					
Ruffed Grouse	2	1	1	2	3	2	8			18,000,000	100%	4%
Spruce Grouse	2	1	1	2	2	2	7			11,000,000	100%	12%
Willow Ptarmigan	2	1	1	2	2	3	8		●	13,000,000	30%	50%
Rock Ptarmigan	2	1	1	2	2	3	8			4,000,000	50%	15%
White-tailed Ptarmigan	3	2	2	3	3	3	11			2,000,000	100%	?
Sooty Grouse	3	3	3	3	3	4	13		●	2,000,000	100%	34%
Sharp-tailed Grouse	3	2	2	3	3	2	10			760,000	100%	<1%
Band-tailed Pigeon*	2	2	2	3	3	5	12	CBSD		1,500,000	24%	<1%
Eurasian Collared-Dove	1	1	1	1	1	1	4			8,700,000	4%	<1%
Mourning Dove*	1	1	1	1	1	3	6			130,000,000	89%	<1%
Common Nighthawk*	2	1	1	3	3	5	11	CBSD		22,000,000	94%	<1%
Black Swift	4	2	2	4	3	5	15	Watch List		89,000	51%	<1%
Vaux's Swift	3	2	3	3	3	4	13			420,000	48%	<1%
Anna's Hummingbird	2	3	2	1	1	1	7			8,800,000	91%	1%
Rufous Hummingbird	2	2	4	4	3	5	14	Watch List		22,000,000	100%	21%
Osprey	3	1	1	2	2	1	7			400,000	32%	4%
Golden Eagle	4	1	1	3	3	2	10			63,000	49%	6%
Northern Harrier	3	1	1	3	3	4	11			820,000	100%	5%
Sharp-shinned Hawk	3	1	1	2	2	1	7			410,000	41%	6%
Northern Goshawk	4	1	1	3	3	2	10		●	210,000	49%	34%
Bald Eagle	4	1	1	2	3	1	9		●	200,000	100%	35%
Swainson's Hawk*	3	1	3	3	4	1	11			820,000	92%	<1%
Red-tailed Hawk	3	1	1	1	1	1	6			2,800,000	90%	1%
Rough-legged Hawk	3	1	1	2	2	2	8			300,000	50%	19%

Species[1]	Assessment Scores[2]							Continental Conservation Status	Continental Stewardship	US & Canada Population Estimate[3]	% Global Population in North America[3]	% North American Population in Alaska[3]
	PS	BD	ND	TB	TN	PT	Combined					
Western Screech-Owl*	4	2	2	3	3	4	13			140,000	77%	<1%
Great Horned Owl	2	1	1	2	1	3	8			3,800,000	67%	7%
Snowy Owl	5	1	1	3	2	5	14	Watch List		15,000	52%	?
Northern Hawk Owl	4	1	1	3	2	3	11		●	130,000	50%	53%
Northern Pygmy-Owl*	4	2	2	3	3	2	11			130,000	71%	1%
Barred Owl	3	1	1	2	2	1	7			3,500,000	100%	<1%
Great Gray Owl	4	1	1	3	3	1	9			58,000	50%	10%
Short-eared Owl	3	1	1	3	3	5	12	CBSD		600,000	26%	22%
Boreal Owl	3	1	1	3	3	3	10			500,000	30%	?
Northern Saw-whet Owl	3	1	1	3	2	1	8			2,000,000	99%	2%
Belted Kingfisher	3	1	1	2	2	4	10			1,800,000	99%	12%
Yellow-bellied Sapsucker*	2	1	1	2	2	1	6			14,000,000	100%	<1%
Red-breasted Sapsucker	3	3	3	3	3	1	10		●	2,800,000	100%	31%
American Three-toed Woodpecker	3	1	1	3	3	1	8			1,600,000	100%	17%
Black-backed Woodpecker	3	1	1	3	3	1	8			1,700,000	100%	1%
Downy Woodpecker	2	1	1	2	1	2	7			13,000,000	100%	1%
Hairy Woodpecker	2	1	1	2	2	1	6			8,700,000	98%	4%
Northern Flicker	2	1	1	2	2	4	9			11,000,000	94%	1%
American Kestrel	2	1	1	3	2	4	10			2,800,000	31%	1%
Merlin	3	1	1	2	2	1	7			1,600,000	50%	12%
Gyrfalcon	4	1	1	2	2	4	11			42,000	50%	20%
Peregrine Falcon	4	1	1	3	3	1	9			72,000	20%	19%
Olive-sided Flycatcher	3	1	1	3	4	5	13	Watch List		1,900,000	99%	22%
Western Wood-Pewee	2	1	2	3	3	5	12	CBSD		8,800,000	92%	2%
Yellow-bellied Flycatcher*	2	1	3	3	3	1	9			13,000,000	100%	2%
Alder Flycatcher	1	1	2	2	2	4	9			120,000,000	100%	20%
Least Flycatcher*	2	1	2	3	2	5	11	CBSD		27,000,000	100%	<1%
Hammond's Flycatcher	2	2	3	2	3	2	10			20,000,000	100%	11%
Pacific-slope Flycatcher	2	3	4	2	3	2	11			9,000,000	94%	23%

Species[1]	Assessment Scores[2]							Continental Conservation Status	Continental Stewardship	US & Canada Population Estimate[3]	% Global Population in North America[3]	% North American Population in Alaska[3]
	PS	BD	ND	TB	TN	PT	Combined					
Say's Phoebe	2	1	2	2	2	1	7			5,000,000	86%	3%
Northern Shrike	4	1	1	2	2	4	11			53,000	30%	20%
Cassin's Vireo*	2	3	3	3	3	1	9			4,600,000	91%	<1%
Warbling Vireo	1	1	3	3	3	1	8			52,000,000	98%	<1%
Canada Jay	2	1	1	3	2	2	8			27,000,000	100%	17%
Steller's Jay	3	2	2	2	2	3	10			2,700,000	90%	4%
Black-billed Magpie	2	1	1	2	2	4	9			6,000,000	100%	5%
American Crow*	2	1	1	1	1	2	6			28,700,000	100%	1%
Common Raven	2	1	1	2	1	1	6			8,300,000	28%	5%
Eurasian Skylark*	2	1	1	2	2	3	8			?	?	<1%
Horned Lark	1	1	1	2	2	5	9	CBSD		100,000,000	72%	<1%
Bank Swallow	2	1	1	3	2	5	11	CBSD		7,900,000	28%	15%
Tree Swallow	2	1	2	2	2	4	10			19,000,000	100%	5%
Violet-green Swallow	2	1	2	2	2	4	10			6,700,000	94%	6%
Northern Rough-winged Swallow*	2	1	2	2	2	4	10			20,000,000	74%	<1%
Barn Swallow	1	1	1	2	2	4	8			47,000,000	25%	<1%
Cliff Swallow	1	1	1	2	2	2	6			78,000,000	94%	1%
Black-capped Chickadee	2	1	1	2	1	2	7			43,000,000	100%	4%
Chestnut-backed Chickadee	2	3	3	3	2	4	12		●	12,000,000	100%	27%
Boreal Chickadee	2	1	1	3	2	2	8			13,000,000	100%	24%
Gray-headed Chickadee*	3	1	1	2	2	3	9			5,000	<1%	75%
Red-breasted Nuthatch	2	1	1	2	2	1	6			20,000,000	100%	1%
Brown Creeper	2	1	1	3	3	2	8			9,500,000	87%	6%
Pacific Wren	2	2	2	3	3	4	11		●	7,500,000	100%	39%
American Dipper	4	1	1	3	3	4	12			150,000	96%	7%
Golden-crowned Kinglet	1	1	1	2	2	4	8			130,000,000	98%	10%
Ruby-crowned Kinglet	1	1	1	2	2	2	6			100,000,000	100%	10%
Arctic Warbler	1	1	1	2	3	5	10	CBSD	●	8,200,000	10%	100%
Bluethroat	1	1	1	2	3	3	8			220,000	?	100%

Species[1]	Assessment Scores[2]							Continental Conservation Status	Continental Stewardship	US & Canada Population Estimate[3]	% Global Population in North America[3]	% North American Population in Alaska[3]
	PS	BD	ND	TB	TN	PT	Combined					
Northern Wheatear	3	1	1	2	2	3	9		●	260,000	10%	30%
Mountain Bluebird*	2	1	2	3	3	4	11			5,600,000	100%	<1%
Townsend's Solitaire	3	2	2	3	3	2	10			1,100,000	97%	8%
Gray-cheeked Thrush	2	1	1	2	3	3	9		●	42,000,000	90%	44%
Swainson's Thrush	1	1	2	3	3	4	10			120,000,000	100%	25%
Hermit Thrush	1	1	1	2	2	2	6			72,000,000	100%	12%
American Robin	1	1	1	1	1	2	5			370,000,000	98%	8%
Varied Thrush	2	2	3	3	2	5	12	CBSD	●	35,000,000	100%	66%
European Starling	1	1	1	1	1	4	7			93,000,000	37%	<1%
Bohemian Waxwing	2	1	1	2	2	5	10	CBSD		2,500,000	50%	22%
Cedar Waxwing	1	1	1	2	2	2	6			64,000,000	100%	<1%
Eastern Yellow Wagtail	2	2	2	2	2	3	9			1,000,000	5%	90%
White Wagtail*	1	1	1	2	2	3	7			500	<1%	100%
Red-throated Pipit	3	2	1	2	2	3	10			50	<1%	100%
American Pipit	2	1	1	2	2	4	9			18,000,000	90%	1%
Pine Grosbeak	2	1	1	3	2	4	10			5,500,000	50%	22%
Gray-crowned Rosy-Finch	4	2	2	3	2	3	12		●	200,000	100%	45%
Purple Finch*	2	1	1	2	2	4	9			6,500,000	100%	<1%
Common Redpoll	1	1	1	2	2	5	9	CBSD	●	76,000,000	30%	74%
Hoary Redpoll	2	1	1	2	2	3	8			14,000,000	50%	10%
Red Crossbill	2	1	1	3	3	2	8			9,600,000	37%	12%
White-winged Crossbill	1	1	1	3	3	1	6			40,000,000	50%	9%
Pine Siskin	2	1	1	2	2	5	10	CBSD		45,000,000	97%	9%
Lapland Longspur	1	1	1	2	2	2	6			68,000,000	50%	14%
Smith's Longspur	4	3	3	2	3	3	13			75,000	100%	16%
Snow Bunting	2	1	1	2	2	5	10	CBSD		14,000,000	50%	6%
McKay's Bunting	5	5	5	3	2	3	16	Watch List	●	31,000	100%	100%
Chipping Sparrow	1	1	2	2	2	4	9			230,000,000	98%	<1%
Brewer's Sparrow*	2	2	2	3	3	4	11			17,000,000	100%	<1%
Fox Sparrow	2	1	2	2	2	4	10		●	35,000,000	100%	45%

Species[1]	Assessment Scores[2]							Continental Conservation Status	Continental Stewardship	US & Canada Population Estimate[3]	% Global Population in North America[3]	% North American Population in Alaska[3]
	PS	BD	ND	TB	TN	PT	Combined					
American Tree Sparrow	2	1	1	2	2	5	10	CBSD	●	26,000,000	100%	36%
Dark-eyed Junco	1	1	1	2	2	4	8		●	220,000,000	100%	26%
White-crowned Sparrow	1	1	1	2	2	3	7		●	79,000,000	100%	44%
Golden-crowned Sparrow	2	2	3	2	2	4	11		●	7,500,000	100%	89%
White-throated Sparrow*	1	1	2	2	2	4	9			160,000,000	100%	<1%
Savannah Sparrow	1	1	1	2	2	4	8			170,000,000	99%	24%
Song Sparrow	1	1	1	2	2	4	8			130,000,000	98%	1%
Lincoln's Sparrow	1	1	2	3	2	2	7			88,000,000	100%	14%
Swamp Sparrow*	2	1	1	2	2	1	6			23,000,000	100%	<1%
Red-winged Blackbird	1	1	1	2	2	4	8			170,000,000	96%	<1%
Brown-headed Cowbird*	1	1	1	1	1	4	7			130,000,000	95%	<1%
Rusty Blackbird	2	1	2	3	3	5	12	CBSD		6,800,000	100%	14%
Northern Waterthrush	2	1	2	2	3	1	8			17,000,000	100%	23%
Tennessee Warbler*	1	1	2	2	3	4	10			110,000,000	100%	<1%
Orange-crowned Warbler	1	1	2	2	2	4	9		●	82,000,000	100%	38%
MacGillivray's Warbler	2	2	3	2	3	4	12			11,000,000	100%	1%
Common Yellowthroat	1	1	2	2	2	4	9			76,000,000	98%	<1%
American Redstart	2	1	2	2	3	3	10			42,000,000	100%	<1%
Yellow Warbler	1	1	1	2	2	4	8			93,000,000	96%	16%
Blackpoll Warbler	1	1	2	3	3	5	11	CBSD		60,000,000	100%	24%
Palm Warbler*	2	2	3	3	2	2	9			13,000,000	100%	<1%
Yellow-rumped Warbler	1	1	1	2	2	2	6			170,000,000	100%	17%
Townsend's Warbler	2	2	3	3	3	4	12		●	21,000,000	100%	28%
Wilson's Warbler	1	1	2	3	2	5	10	CBSD	●	81,000,000	100%	43%
Western Tanager	2	2	3	2	3	1	9			15,000,000	99%	<1%
Black-headed Grosbeak*	2	1	3	2	2	2	9			12,000,000	81%	<1%

[1] Scores not available for Siberian Rubythroat, Eyebrowed Thrush, Brambling, or Rustic Bunting, all Palearctic species.

[2] Assessment Scores are in the following categories: PS = population size (global), BD = breeding distribution (global), ND = non-breeding distribution (North American), TB = threats to breeding, TN = threats to non-breeding (North American), PT = population trends (North American), Combined = maximum combined score.

[3] ? = absolute or relative population estimate not available.


Eastern Yellow Wagtail

Appendix IV

Variables and criteria used for assessing the status and vulnerability of landbirds at the global, continental, and state levels (quoted directly or paraphrased from Panjabi et al. 2020; see that reference for more details).

Population Size (PS) indicates vulnerability due to the total number of breeding-aged adult individuals in the global population. Evaluation of PS is based on the assumption that species with small breeding populations are more vulnerable to extirpation or extinction than species with large breeding populations.

5 World breeding population <50,000

4 World breeding population ≥50,000 and <500,000

3 World breeding population ≥500,000 and <5,000,000

2 World breeding population ≥5,000,000 and <50,000,000

1 World breeding population ≥50,000,000

Breeding and Nonbreeding Distribution (BD and ND) scores indicate a species' vulnerability due to the geographic extent of its range in either the breeding or nonbreeding seasons separately. The underlying assumption is that species with narrowly distributed populations are more vulnerable to individual risks and threats than species with widely distributed populations, and that this vulnerability can vary seasonally as migratory populations re-distribute. Distribution scores are assessed at a global scale.

5 <80,000 km^2

4 ≥80,000 and <300,000 km^2

3 ≥300,000 and <1,000,000 km^2

2 ≥1,000,000 and <4,000,000 km^2

1 ≥4,000,000 km^2

Threats to Breeding and Nonbreeding (TB and TN) are scored separately and assess vulnerability due to the effects of current and probable future extrinsic conditions that threaten the ability of populations to survive and successfully reproduce during the breeding season (TB) or to survive over the nonbreeding season (TN)...To score threats, an assessment is made regarding the expected change in the suitability of breeding or nonbreeding conditions necessary for maintaining healthy populations of a species over the next 30 years. Threats are defined as any extrinsic factor that reduces the likelihood of the persistence of a population, and can include predation, poaching, parasitism, poisoning from pesticides or other environmental contaminants, habitat fragmentation/deterioration/loss, hybridization, collisions with power lines or other hazards, predicted impacts of climate change or any other factor that reduces the suitability of breeding or nonbreeding conditions.

5 Extreme deterioration in the future suitability of breeding (TB) or nonbreeding (TN) conditions is expected; species is in danger of extinction, is at risk of extirpation from substantial portions of range leading to a major range contraction, or has a low probability of successful reintroduction across a former range.

4 Severe deterioration in the future suitability of breeding (TB) or nonbreeding (TN) conditions is expected to significantly affect a majority of the population.

3 Slight to moderate decline in the future suitability of breeding (TB) or nonbreeding (TN) conditions is expected for the majority of the population.

2 Future conditions for breeding (TB) or nonbreeding (TN) populations are expected to remain stable; no significant threats.

1 Future conditions for breeding (TB) or nonbreeding (TN) are expected to significantly improve (e.g., due to widespread human activities or land-uses that benefit the species) for the majority of the population.

Population Trend (PT) indicates vulnerability due to the direction and magnitude of recent changes in population size. Like the threat scores, PT scores reflect trends for North American populations only, even for species with ranges that extend beyond the continent...Species declining by 50% or more since 1970 are considered most vulnerable, whereas species with increasing trends over this period are least vulnerable...PT scores were determined based on total population size change since 1970, and the precision and reliability of the annual trend estimate as presented in the table below.

PT Scores and Criteria					
% Total population change	90% CI excludes 0 (P ≤ 0.1) and df ≥ 14	67% CI excludes 0 (P ≤ 0.33) and df = 6–13	67% CI excludes 0, 90% CI includes 0 (0.1 < P ≤ 0.33) and df ≥ 14	67% CI includes 0 (P > 0.33) and trend is reliable	67% CI includes 0 (P > 0.33) and trend is not reliable
≤ -50%	5	4	4	3	3
-50% to -15%	4	4	4	3	3
-15% to 0%	3	3	3	2	3
0% to +50%	2	3	2	2	3
≥ + 50%	1	2	2	2	3

In the absence of long-term, quantitative, species-specific trend data, PT scores can be assigned using the qualitative descriptions provided below using the same timeframe (1970–present).

5 Significant large decrease

4 Moderate decrease; possible large decrease

3 Uncertain population change; possible small decrease; significant small decrease

2 Significant small increase; possible increase; stable

1 Significant large increase

To determine which species are most vulnerable, we summed the global scores pertinent to each season to arrive at *Combined Scores* for breeding and nonbreeding seasons...The overall Maximum Combined Score for each species is the larger of the two seasonal combined scores.

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