Alaska

Landbird Conservation Plan

BOREAL Partners in Flight


Red-breasted Nuthatch

Alaska Landbird Conservation Plan

Version II

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Editors

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Table of Contents

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The Alaska Landbird Conservation Plan – Version II is the result of an extensive team effort. The bulk of the plan was written by Colleen Handel and Iain Stenhouse on behalf of BPIF. Colleen Handel also acted as the technical liaison and chief editor. Deborah Perkins contributed to the species accounts in Appendix I. All other authors contributed to the specific sections on each Bird Conservation Region. Draft versions of the plan and sections thereof were reviewed by BPIF committee members, and others, including Lynn Fuller, Mary Rabe, and David Tessler. Daniel Gibson and Robb Kaler provided specific comments on subspecies or avian groups present in Alaska.

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Summary

Alaska is a land of extremes. With almost 500 naturally occurring bird species recorded in the state, the diversity of its avifauna is certainly no exception. Species inhabiting primarily terrestrial habitats, known collectively as "landbirds," constitute the largest and most ecologically diverse component of the Alaskan 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 merge in Alaska. Individuals travel from all corners of the world to breed in Alaska.

Although Alaska has only one endemic landbird species, the McKay's Bunting, it 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.

Due to its remote nature, vast size, and small human population, Alaska's habitats remain largely pristine. The state's ever-growing population and economy, however, present many challenges that could seriously affect wildlife populations, including landbirds. Although threats in Alaska are often considered to be less significant than those occurring outside of the region, where habitats are threatened by more rapidly increasing anthropogenic pressures, they carry far-reaching consequences nonetheless. As such, effective landbird conservation in Alaska demands a broad landscape-scale approach.

To ensure the conservation of landbirds over such a massive and diverse landscape, we must integrate efforts in habitat management, population monitoring, research, education, and outreach at local, regional, continental, and international scales. Information on distribution and habitat requirements of landbirds should be incorporated into land-use planning decisions. Synthesizing reliable and useful information on distribution and population trends of landbirds is a critical, time-sensitive task. Such information needs to be provided in a form that is readily available to land managers and policy decision makers.

This plan aims to: identify species of concern, priority habitats, and critical information needs; highlight major conservation issues and threats to landbirds; and recommend appropriate conservation actions across Alaska. We initially take a state-wide approach to examine landbird conservation in Alaska with a broader perspective (regional, continental, and global), then take a detailed look at the specific issues, information needs, and conservation actions required in each Bird Conservation Region (BCR) in Alaska.

The Alaska Landbird Conservation Plan – Version II and future updates can be viewed and downloaded at: http://alaska.usgs.gov/science/biology/bpif/conservation/index.php

Photo © Bill Thompson

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Alaska: A State-wide Perspective on Landbird Avifauna, Habitats, and Conservation Priorities

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. 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. 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 decreases. The causes of population declines in birds are numerous, but habitat loss, modification, degradation, and fragmentation almost always play a major role. Threats to habitats come 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). These changes may be particularly severe in arctic, alpine, and boreal regions, which encompass much of the State of Alaska (IPCC 2007).

In late 1990, the National Fish and Wildlife Foundation brought together federal agencies, 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; http://www.partnersinflight.org) was launched as a voluntary, international coalition of government agencies, conservation groups, academic institutions, private businesses, and citizens 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 through cooperative efforts in the areas of monitoring, research, management, education, and international cooperation.


American Tree Sparrow

Photo © Bill Thompson

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) recommend 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 PIF North American Landbird Conservation Plan (Rich et al. 2004), which was intended to be a blueprint for continental habitat conservation under the North American Bird Conservation Initiative (NABCI; http://www.nabci-us.org), a tri-national effort involving the United States, Canada, and Mexico.

Under the PIF umbrella, Boreal Partners in Flight (BPIF; http://alaska.usgs.gov/science/biology/bpif/) is a coalition of biologists, land managers, teachers, and birders working together to help conserve bird populations throughout 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 because these regions share many of the same species, habitats, and conservation issues.

BPIF has more than 100 members, including representatives from all the major federal land and resource managers in Alaska and Canada, state and provincial agencies, universities, Alaska Native corporations, and local environmental consulting firms. Non-governmental organizations, such as the Alaska Natural Heritage Program, the Alaska Bird Observatory, and Audubon Alaska (state office of the National Audubon Society), also play key roles.

Purpose and Scope of the Plan

BPIF produced the first Alaska Landbird Conservation Plan (Version 1.0) in 1999 as a framework to guide conservation planning for landbirds in Alaska (Boreal Partners In Flight Working Group 1999). Like that original plan, Version II 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), as well as other recent statewide conservation plans that address specific avian taxa, such as the Alaska Shorebird Plan (Alaska Shorebird Group 2008), or regional conservation assessments, such as the All-Bird Conservation Plan for Bird Conservation Region 4 (Sharbaugh 2007).

Specifically, the Alaska Landbird Conservation Plan – Version II is designed to provide research biologists, site managers, and natural resource decision makers with an effective synthesis of priorities and objectives 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, non-governmental organizations, and academic institutions.

The plan tackles all of this at two scales: (a) a state-wide perspective on the Alaskan landbird avifauna, its habitats, and conservation priorities; then (b) a finer-scale approach that focuses on landbirds in each of the Bird Conservation Regions (BCRs) in Alaska.


Wilson's Warbler

Photo © Milo Burcham


Common Redpoll

Photo © Milo Burcham

The goals of this plan are to:

1. Introduce the region and the Alaska avifauna;
2. Highlight the major conservation issues and threats to landbirds across the state;
3. Identify species of concern, priority habitats, and critical information needs in each Bird Conservation Region; and
4. Recommend conservation actions in each Bird Conservation Region.

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

The Alaska Landbird Conservation Plan includes all landbird species regularly occurring in Alaska (following Gibson et al. 2012), including species in the following taxonomic Orders: Galliformes (grouse and ptarmigan), Accipitriformes (eagles and hawks), Falconiformes (falcons), Columbiformes (pigeons and doves), Strigiformes (owls), Caprimulgiformes (nightjars), Piciformes (woodpeckers), Apodiformes (swifts and hummingbirds), Coraciiformes (kingfishers), and Passeriformes (songbirds).

The Alaskan 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, dominant Alaska's interior landscape. The Yukon River, the third longest river in the U.S., flows over more than 2,800 km in Alaska and drains a watershed of 855,000 km2. Mountains are also a characteristic feature of the Alaskan landscape. Seventeen of the 20 highest peaks in the U.S. are found in Alaska. Mount McKinley, located in Denali National Park and Preserve, is North America's tallest mountain at 6,200 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 boreal forest in the United States. The maritime climate of southeastern Alaska is characterized by warm winters, cool summers, heavy precipitation, and intermittent strong wind, while interior Alaska has warm summers, very cold winters, little wind, and light precipitation. Winter temperatures in the interior often drop to -43°C. Cool summers, cold winters, moderate winds, and light precipitation are typical of western and northwestern Alaska. The town of Barrow, at the northernmost point in Alaska, sees 67 days of continuous darkness in winter and 84 days of continuous sunlight in summer.

Approximately 88% of Alaska (>1.2 million km^2) is publicly owned (ADFG 2011a). 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%. Federal holdings in Alaska include: the two largest forest units in the country, the Tongass and the Chugach National Forests; 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 a 93,000 km^2 parcel on Alaska's North Slope, known as the National Petroleum Reserve–Alaska, as well as many other public lands including 9,000 km^2 in the National Landscape Conservation System (USDOI 2011a, 2011b). The Department of Defense is responsible for more than 7,200 km^2 across numerous military installations (Hull and Leask 2000).

The State of Alaska manages around 364,000 km^2, with legislative authority for the management of about 46,000 km^2 of State Parks, Wildlife Sanctuaries, Game Management Units, and Critical Habitat Areas falling to the Alaska Department of Fish and Game (Hull and Leask 2000, ADFG 2011b). All other state lands are managed by the Alaska Department of Natural Resources. Private lands constitute about 12% of Alaska, with the largest

Mount Forraker in the foothills of Denali National Park. Photo © Bill Thompson component, some 178,000 km^2, belonging to the 13 Alaska Native Regional Corporations and 225 Alaska Native Village Corporations (Linxwiler 2007).

Alaska's human population has more than doubled in the last 40 years, from about 300,000 in 1970 to almost 700,000 in 2009 (U.S. Census Bureau 2010). The majority of the population lives in south-coastal Alaska, with more than 279,000 people in the Municipality of Anchorage, as of 2008 (U.S. Census Bureau 2010). Approximately 15% of the state's population self-identifies as belonging to Native Alaskan peoples, including Aleut, Athabascan, Haida, Inupiaq, Tlingit, Tsimshian, and Yup'ik (U.S. Census Bureau 2010). The harvest or extraction of natural resources, such as seafood, timber, oil, gas, and minerals, and their export are still the major revenue-producing industries in Alaska, although tourism is an increasingly important element in the state's economy.

Bird Conservation Regions in Alaska

Bird Conservation Regions (BCRs) are ecologically distinct regions across North America recognized to share similar bird communities, habitats, and resource management issues (NABCI 2000). They are designed to function as the primary units within which ecological issues are resolved. The five BCRs in Alaska are introduced here (Figure 1). Later we discuss the habitats, species of concern, management issues, and desired research and conservation actions for each BCR in detail. The following brief descriptions are adapted from NABCI (2000):

BCR 1 – Aleutian/Bering Sea Islands encompasses the Aleutian Island chain and the Bering Sea islands. The Aleutian chain is volcanic in origin, with a strongly maritime-influenced climate. Vegetation at higher elevations consists of dwarf shrubs, mainly willow and crowberry. Meadows and marshes of herbs, sedges, and grasses are plentiful, and some islands have ericaceous bogs. Although sea ice is an important feature of the Bering Sea islands, it does not extend south to the Aleutian Islands, where permafrost is generally absent.

BCR 2 – Western Alaska 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,

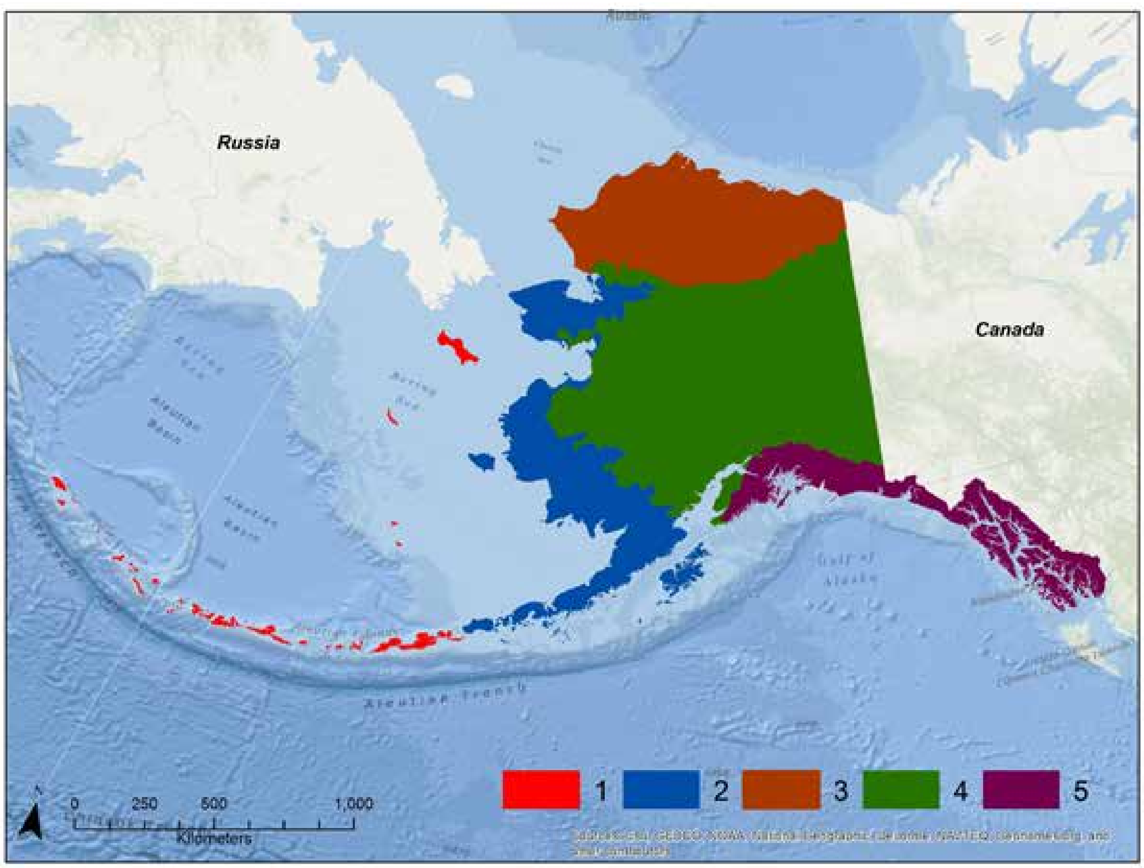

Figure 1: Bird Conservation Regions (BCR) in Alaska: 1 = Aleutian/Bering Sea Islands, 2 = Western Alaska, 3 = Arctic Plains and Mountains, 4 = Northwestern Interior Forest, 5 = Northern Pacific Rainforest.

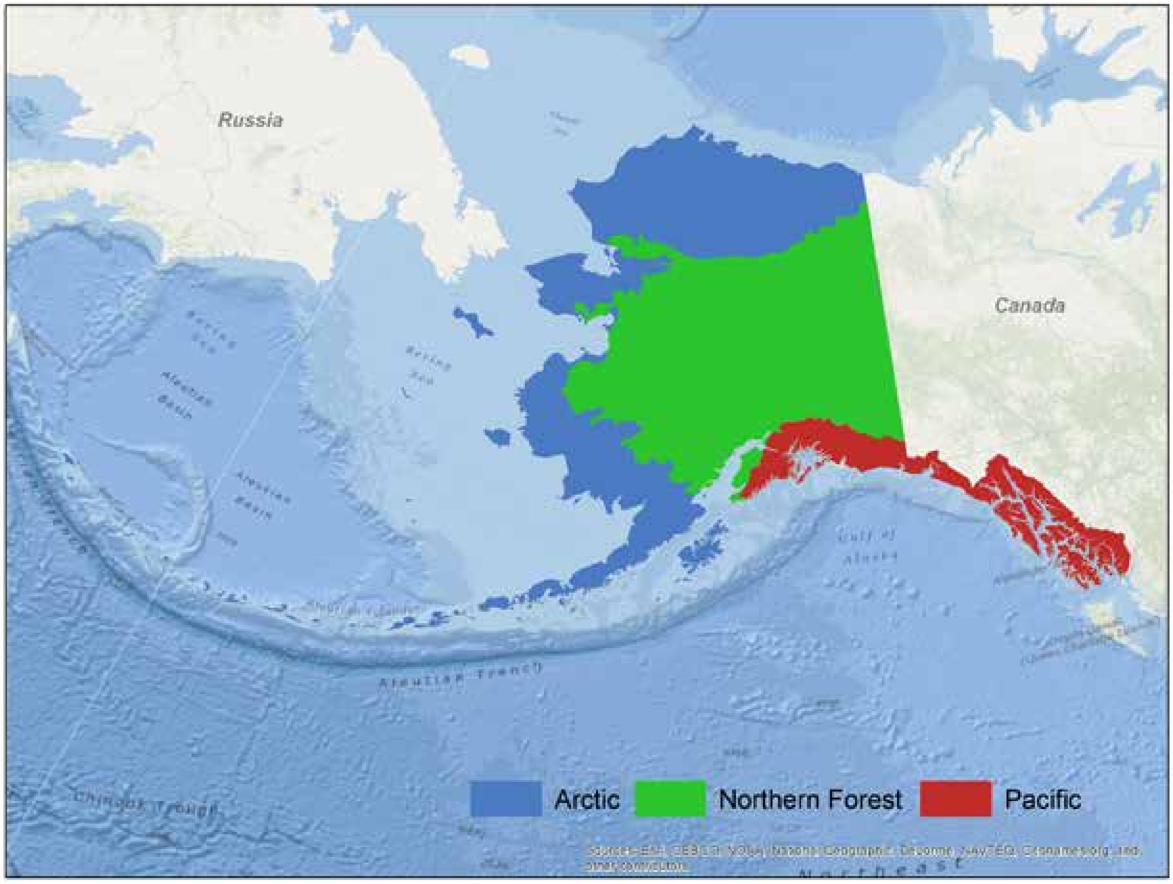

Figure 2: Avifaunal Biomes in Alaska.

and rivers dot the landscape. Tall shrub communities are found along rivers and streams, and low shrub communities occupy uplands. Forests of spruce and hardwoods penetrate the region on the eastern edge. Permafrost is continuous in this region, except in southern parts.

BCR 3 – Arctic Plains and Mountains encompasses low-lying, coastal tundra and drier uplands of the arctic mountains 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 is rarely far from shore.

BCR 4 – Northwestern Interior Forest 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, poplars, and birch. 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 scrub communities are common throughout mountainous regions, and the highest elevations are generally devoid of vegetation.

BCR 5 – Northern Pacific Rainforest encompasses the coastal temperate rainforest of the western Gulf of Alaska. This region's maritime climate is characterized by heavy precipitation and mild temperatures. The region is dominated by forests of hemlock and spruce in the far north, with fir and coastal redwood becoming more important south of Alaska. Broadleaf forests are found along large mainland river drainages.

At the continental scale, BCRs are sometimes grouped into broader avifaunal biomes (Figure 2; Rich et al. 2004). The Arctic Avifaunal Biome encompasses three BCRs (BCR 1, BCR 2, and BCR 3); the Northern Forest Avifaunal Biome encompasses six BCRs (including BCR 4); and the Pacific Avifaunal Biome encompasses three BCRs (including BCR 5).

Landbirds in Alaska

The Alaska avifauna is an extremely diverse assemblage of 501 naturally-occurring species, representing 20 avian Orders and 64 Families (Gibson et al. 2014). Among these, 249 regularly occur, 52 are rare, 141 are casual visitors, and 59 are considered accidental records. Alaska has such an outstanding avifauna for several reasons, mainly biogeographic in nature: 1) Alaska has numerous relict populations, as a result of its geologic and glacial paleohistory; 2) Alaska is at the juncture of two major global regions, the Palearctic and the Nearctic, and features Asian, Beringian, and North American components, resulting in a high rate of casual and accidental records; 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) as a result of its numerous remote regions and isolated islands, Alaska supports many unique subspecies of birds.

Populations of landbirds that exist in isolated regions or on remote islands, widely separated from other populations, often show local adaptations to specific conditions, resulting in the evolution of subspecies. Furthermore, landbird species with extremely broad ranges may also show graded (or clinal) variation across their ranges, particularly latitudinal or longitudinal differences. These conditions are clearly evident in Alaska, and it is not surprising that Alaska is home to many recognized subspecies of landbirds. Although Alaska has only one endemic species of landbird, the McKay's Bunting, the list of landbird populations restricted wholly or in large part to Alaska is impressive. For example, there are seven subspecies of Pacific Wren, eight subspecies of Fox Sparrow, and five subspecies of Rock Ptarmigan recognized in Alaska (Gibson and Kessel 1997). Most of these subspecies are confined to small Aleutian or Bering Sea islands.

Spruce Grouse

Photo © Milo Burcham

Landbirds make up the largest and most ecologically diverse component of Alaska's avifauna—268 naturally-occurring species, representing 12 avian Orders and 43 Families (Table 1). Among these, 116 regularly occur, 27 are rare, 88 are casual visitors, and 37 are considered accidental records (Gibson et al. 2014). More than half of the regularly occurring landbird species breed within the state. Of these 135 breeding species, only 34 (25%) remain in Alaska in substantial numbers throughout the boreal winter, mostly in south-coastal and southeastern Alaska. The other landbirds (breeders and non-breeders) are migrants which travel to Alaska from other regions of North America, Asia, and Europe. Four major global flyways (the East Asia, Central Pacific, Pacific Coast, and Mississippi flyways) merge in Alaska. Fifty-seven percent of the landbird species breeding in Alaska have some portion of their population that winters south of the U.S. border with Mexico. Clearly, effective conservation for these migratory species relies on a coordinated, collaborative approach across their entire ranges.

The Alaska landbird avifauna includes a few major avian groups, distinguished by their ecological requirements, life-history characteristics, foraging ecology, and migration strategies. These major landbird groups include grouse and ptarmigan, raptors, and passerines. The following sections briefly describe each of these groups of landbirds in Alaska:

Grouse and Ptarmigan

Seven species have been documented in Alaska (Gibson et al. 2014), including three forest dwellers (Ruffed, Spruce, and Sooty Grouse), one which 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 breed in Alaska, and although some may make short-distance migrations, they are all year-round residents in the state. Demographic measures of many northern populations of grouse and ptarmigan exhibit cyclic fluctuations with significant increases and declines occurring at nearly predictable intervals of 8-10 years, aiding biologists in setting harvest limits for hunting regulations. These cyclic patterns require that feeding, nesting, and brood-rearing habitats remain relatively stable despite human activities and natural disturbances. Management concerns for grouse and ptarmigan in Alaska are diverse and include habitat changes due to spruce bark beetle infestations and wildfire, accumulation of toxins and other contaminants in northern areas, climate change, and disturbance owing to mining, oil and gas development, recreational activities, and development of transportation routes.

Photo © Milo Burcham

Raptors

Thirty-one species, including 18 species of diurnal raptors (Orders Accipitriformes and Falconiformes) and 13 species of owls (Order Strigiformes), have been documented in Alaska (Gibson et al. 2014). Among these, 23 are known to breed within the state. Many of these species are migratory or nomadic, spending nearly 50% of their lives outside of Alaska, often in habitats that are rapidly being altered by anthropogenic influences. Resident species 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 sets 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, they serve as sentinels to the health of those systems. Learning about the status and trends of raptor populations is not easy, however, often requiring specific methodologies that do not transfer to other landbirds.

Woodpeckers

Nine species of woodpeckers (Picidae) have been documented in Alaska (Gibson et al. 2014), seven of which breed in the state. Among the breeding species, four are year-round residents (Downy, Hairy, Three-toed, and Black-backed Woodpecker), one remains year-round only in southeastern Alaska (Northern Flicker), and two winter well south of the state (Yellow-bellied and Red-breasted Sapsucker). The two other documented species (Wryneck, Great Spotted Woodpecker) are Eurasian vagrants. As forest dwellers, populations of these species suffer negative effects directly through the habitat loss and fragmentation that result from urbanization, industrialization, commercial timber harvest, insect kills, and wildfires. They also suffer indirectly through alteration of forest structure, which is caused by specific forest management practices, and through habitat degradation, mediated by climate change.

Passerines

This group constitutes the largest component of the landbird avifauna, with 197 species from 30 Families being documented in Alaska (Gibson et al. 2014). Among these, 77 species from 24 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. Most major threats result in the loss, fragmentation, or degradation of important landbird habitats.

Species reliant on boreal forest habitats are under considerable pressure, with a great many of them showing clear population declines, or lacking enough information to establish a population trend (Sharbaugh 2007). As a group, aerial insectivores are also showing striking and significant declines across the board (Nebel et al. 2010). The majority (up to 60%) of Alaska landbirds 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. Alaska's only endemic species, the McKay's Bunting, is in this broad avian group. It exhibits a small population, single breeding site, and restricted wintering range, and, as such, is the most likely candidate for extinction among Alaska's landbirds.

Photo © John Schoen

Table 1: The Orders and Families of regularly-occurring landbird species considered in the Alaska Landbird Conservation Plan – Version II (after Gibson et al. 2014).

Order	Family	
Galliformes	Phasianidae	Grouse and Ptarmigan
Accipitriformes	Pandionidae	Ospreys
	Accipitridae	Hawks, Eagles, and allies
Columbiformes	Columbidae	Pigeons and Doves
Cuciliformes	Cuculidae	Cuckoos
Strigiformes	Strigidae	Typical Owls
Caprimulgiformes	Caprimulgidae	Nightjars
Apodiformes	Apodidae	Swifts
	Trochilidae	Hummingbirds
Coraciiformes	Alcedinidae	Kingfishers
Piciformes	Picidae	Woodpeckers
	Tyrannidae	Tyrant Flycatchers
	Laniidae	Shrikes
	Vireonidae	Vireos
	Corvidae	Crows and Jays
	Alaudidae	Larks
	Hirundinidae	Swallows
	Paridae	Chickadees
	Sittidae	Nuthatches
	Certhiidae	Creepers
	Troglodytidae	Wrens
	Cinclidae	Dippers
Falconiformes	Falconidae	Falcons
Passeriformes	Regulidae	Kinglets
	Phylloscpidae	Leaf Warblers
	Turdidae	Thrushes
	Sturnidae	Starlings
	Motacillidae	Wagtails and Pipits
	Bombycillidae	Waxwings
	Calcariidae	Longspurs and Snow Buntings
	Parulidae	Wood Warblers
	Emberizidae	Sparrows and Buntings
	Cardinalidae	Cardinals and allies
	Icteridae	Blackbirds, Orioles, and allies
	Fringillidae	Finches

Downy Woodpecker

Photo © Milo Burcham

Continental Priorities

The PIF conservation planning process has several significant goals including: (1) assessing the vulnerability of landbird species and populations to various types of threat; and (2) identifying priority species in most need of conservation attention at the Continental level (Rich et al. 2004). 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 (Panjabi et al. 2005).

Each species is evaluated on six factors relating to biological vulnerability and two measures of area importance. The six biological vulnerability factors considered are: population size, population trend, extent of breeding distribution, threats to breeding population, extent of nonbreeding distribution, and threats to nonbreeding population (see Appendices III and IV). 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.

Based on these factor scores, a combined score is calculated to provide an overall status assessment of each species at the global or continental scale. This information is used to identify Species of Continental Importance, which includes two tiers: species that require continent-wide conservation attention, known as the Watch List species (Table 2), and those that merit special conservation actions within their core ranges, known as Stewardship species (Table 3; Rich et al. 2004).

Stewardship responsibility is designated at the scale of Avifaunal Biomes, which comprise multiple Bird Conservation Regions. In Alaska, the Arctic Avifaunal Biome, which comprises BCRs 1, 2, and 3, supports three Watch List species and all nine of the biome's Stewardship species. The Alaskan portion of the Northern Forest Avifaunal Biome, which comprises six BCRs continentally, including BCR4, hosts regularly breeding populations of five Watch List species and 11 of the biome's 26 Stewardship species. The Alaskan portion of the Pacific Avifaunal Biome, which comprises BCR5 and two other BCRs along the Pacific coast, hosts seven Watch List species and nine of the biome's 12 Stewardship species.

A third category of conservation concern, developed by Berlanga et al. (2010), includes species that have declined by 50% or more in the last 40 years based on data from the North American Breeding Bird Survey or Christmas Bird Count. These species are known as Common Birds in Steep Decline (Table 4), and are found in nearly every habitat type across the United States, including Alaska, and Canada. The 15 species designated in Alaska include four Watch List and three Stewardship species.

Small populations are generally considered to be more vulnerable to extinction than large ones, even among those species not immediately at risk. Thus, population size is a central measure in most species-assessment schemes. PIF includes global population size as one of several factors assessed to determine species of high conservation importance, using a simple scale to assess relative risk (Panjabi et al. 2005).

Table 2: PIF Watch List species occurring regularly in Alaska, their primary habitat type, their Avifaunal Biome(s), and the proportion of the global breeding and wintering populations found in each biome (from Rich et al. 2004). Note that these biomes extend well beyond Alaska; thus, Alaska overlaps with only a small portion of each one.

Species	Primary Habitat	Biome	Breeding Population	Wintering Population
Sooty Grouse[1]	coniferous forest	Pacific	75 %	75 %
Short-eared Owl	tundra	Arctic	13 %	<1 %
Black Swift	various	Pacific	29 %	0 %
Rufous Hummingbird	shrubland	Pacific	61 %	0 %
Olive-sided Flycatcher	coniferous forest	Northern Forest	61 %	0 %
		Pacific	15 %	0 %
Smith's Longspur	shrub/successional	Arctic	57 %	0 %
		Northern Forest	39 %	0 %
McKay's Bunting	tundra	Arctic	100 %	>99 %
Rusty Blackbird	coniferous forest	Northern Forest	89 %	1 %

[1] Percentages were calculated for Blue Grouse, which has since been split into two species, Sooty and Dusky grouse (Banks et al. 2006). Given known geographic range (Zwickel and Bendell 2005), these figures are underestimates for Sooty Grouse.

Table 3: PIF Stewardship species occurring regularly in Alaska, their primary habitat type, the avifaunal biome(s) with global stewardship responsibility, and the proportion of the global breeding and wintering populations found in each biome (Rich et al. 2004). Note that these biomes extend well beyond Alaska; thus, Alaska overlaps with only a small portion of each one.

Species	Primary Habitat	Biome	Breeding Population	Wintering Population
Spruce Grouse	coniferous forest	Northern Forest	98 %	98 %
Willow Ptarmigan	tundra	Arctic	76 %	19 %
Rock Ptarmigan	tundra	Arctic	99 %	78 %
Bald Eagle	wetland	Pacific	60 %	39 %
Yellow-bellied Sapsucker	mixed forest	Northern Forest	93 %	<1 %
Rough-legged Hawk	tundra	Arctic	99 %	<1 %
Snowy Owl	tundra	Arctic	100 %	2 %
Red-breasted Sapsucker	coniferous forest	Pacific	78 %	78 %
Black-backed Woodpecker	coniferous forest	Northern Forest	94 %	94 %
Gyrfalcon	tundra	Arctic	97 %	11 %
Peregrine Falcon	various	Arctic	76 %	4 %
Alder Flycatcher	shrubland	Northern Forest	94 %	0 %
Pacific-slope Flycatcher	shrubland	Pacific	91 %	0 %
Northern Shrike	shrubland	Northern Forest	96 %	26 %
Gray Jay	coniferous forest	Northern Forest	91 %	91 %
Steller's Jay	coniferous forest	Pacific	54 %	54 %
Chestnut-backed Chickadee	coniferous forest	Pacific	90 %	90 %
Boreal Chickadee	coniferous forest	Northern Forest	92 %	92 %
Pacific Wren	coniferous forest	Pacific	26 %	50 %
Varied Thrush	coniferous forest	Pacific	33 %	72 %
Bohemian Waxwing	coniferous forest	Northern Forest	98 %	55 %
Lapland Longspur	tundra	Arctic	>99 %	<1 %
Snow Bunting	tundra	Arctic	100 %	4 %
Fox Sparrow	shrubland	Pacific	8 %	52 %
Lincoln's Sparrow	wetland	Northern Forest	91 %	<1 %
Golden-crowned Sparrow	shrubland	Pacific	12 %	85 %
Pine Grosbeak	coniferous forest	Northern Forest	90 %	88 %
White-winged Crossbill	coniferous forest	Northern Forest	97 %	86 %
Hoary Redpoll	shrubland	Arctic	100 %	6 %

Spatially restricted species and subspecies are also 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 a good number of landbird populations (species and subspecies) for which it hosts a large proportion of the regional, continental, or global population (Boreal Partners in Flight 1999). Thus, Alaska has a considerably greater responsibility for the conservation of these species (Table 3) and subspecies. Although they may not qualify as high priorities, due to the lack of information on any major or imminent threats, sufficient monitoring efforts should be made to maintain at least baseline data on population sizes, resource requirements, population trends, and limiting factors.

PIF maintains a database of global, continental, and regional population estimates that includes most North American landbird species, based on relative abundance counts from Breeding Bird Survey routes (Blancher et al. 2007). Estimates of population size are admittedly crude, and have well-recognized analytical limitations

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(Rosenberg and Blancher 2005, Thogmartin et al. 2006, Thogmartin 2010). These are the most accurate global population estimates available for most species, however, and provide an important approximation of relative population sizes for general conservation planning (Rosenberg and Blancher 2005, Thogmartin et al. 2006).

Table 4: Species considered Common Birds in Steep Decline regularly occurring in Alaska, their primary habitat type, and their estimated decline (percentage of population considered lost since the mid-1960s; Berlanga et al. 2010).

Species	Primary Habitat	Decline
Ruffed Grouse	coniferous forest	61 %
Sooty Grouse	boreal forest	≥50 %
Snowy Owl	tundra	≥50 %
Short-eared Owl	tundra/grasslands	71 %
Rufous Hummingbird	coniferous forest	63 %
Belted Kingfisher	stream banks	53 %
Northern Flicker	open woodlands	52 %
Horned Lark	tundra/grasslands	56 %
Bank Swallow	bluffs/stream banks	56 %
Boreal Chickadee	boreal forest	≥50 %
Snow Bunting	tundra	64 %
Wilson's Warbler	forest/shrub	≥50 %
Brewer's Sparrow	shrub	58 %
Rusty Blackbird	boreal forest	84 %
Pine Siskin	coniferous forest	71 %

Unfortunately, there are few BBS routes across the state. Thus, it is not possible to generate informative population estimates or trends using BBS data for most Alaska landbirds. Furthermore, many of the Alaska landbird species appearing on the Watch List (Table 2), or considered Stewardship species (Table 3), are northern species for which there is little known about population status or trend. Expert opinion is highly valued and heavily relied upon in species-status-assessments in Alaska.

Based on the available information, three groups of conservation priority species are identified for Alaska: (1) species with a high continental conservation concern that occur in Alaska (Table 2); (2) species and subspecies for which Alaska has a high stewardship responsibility (≥25% of the global or continental population; Table 3, Appendix III); and (3) common species whose populations have declined by 50% or more since the mid-1960s (Table 4).

Conservation Issues in Alaska

Due to the remote nature, vast size, and small human population of Alaska, its habitats are largely pristine. The state's ever-growing population and economy, however, present many challenges that could seriously affect landbird populations. None of these is unique to the region but each could have significant impact on global or continental landbird populations because Alaska provides important habitat for so many species. Although threats in Alaska are often considered to be less significant than those occurring outside of the region, where habitats are threatened by more rapidly increasing anthropogenic pressures, they carry far-reaching consequences, nonetheless.

The following list of threats to landbirds in Alaska is based on the Conservation Measures Partnership's taxonomy of direct threats (http://www.conservationmeasures.org/initiatives/threats-actions-taxonomies/threats-taxonomy). 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 serious and pervasive threats in Alaska (such as pollution and climate change), while others are still limited in scope or restricted in scale across the state (such as residential and industrial development, and invasive species). Many of these threats 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. Erickson et al. (2005) estimated that from 500 million to possibly over one billion birds are killed annually in the U.S. due to anthropogenic sources. Collisions with buildings and windows account for an estimated 58.2% of the annual mortality and depredation by domestic and feral cats accounts for another 8.5%. 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
This category includes threats from farming and ranching as a result of expansion and intensification of agriculture,

The Matanuska-Susitna Valley is at the heart of a growing agricultural economy in Alaska. Photo © iStock - wibberelvin silviculture, mariculture, and aquaculture, all of which are currently 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 plants and insect pests, and potential range expansion of the Brown-headed Cowbird, an agriculture-reliant brood parasite (Lowther 1993). In Alaska, there are approximately 700 farms that encompass roughly 3,500 km^2 (USDA National Agriculture Statistics Service 2007 Census). Farming operations are concentrated in valleys of south-coastal 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-coastal Alaska, on the Seward Peninsula, Nunivak Island, and Kodiak Island (State of Alaska 2010). Smaller ranches occur on several islands in the Bering Sea, north Gulf of Alaska, and Aleutian Island archipelago. There are a few small dairy, poultry, and small-animal farms, primarily in south-coastal Alaska. Aquaculture and mariculture are very limited in the state and are expected to have few effects on landbird populations.

Energy Production and Mining

This category includes effects on habitats and wildlife specifically 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), 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 the Alaska Resources Development Council, the mining industry in Alaska currently produces zinc, lead, gold, silver, and coal, as well as construction minerals such as sand, gravel, and rock. There are five major mines operating in Alaska, in interior, western, and southeastern parts of the state, and active mining claims encompass about 15,000 km^2 of land. Impacts on landbirds from mining industries pertain

Wind farm on Fire Island off Anchorage in the Upper Cook Inlet. Photo © iStock - Jodi Jacobson.

primarily to direct loss, degradation, and disturbance of habitat, but also include the introduction of toxic chemicals and disruption of other ecosystem dynamics such as predator-prey relationships.

An emerging industry in the state involves development of alternative sources of energy, including hydroelectric power and wind farms. There are several active hydroelectric projects in south-coastal and southeastern Alaska and one proposed for the Susitna River in interior Alaska. Impacts to landbirds from these would be 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 less than 0.01% of all mortality due to anthropogenic sources in the U.S. (Erickson et al. 2005).

Transportation and Service Corridors
This category includes the effects of habitat alteration and fragmentation due to transportation corridors and the associated disturbance to birds. Alaska's network of roads, railroads, shipping lanes, flight paths, and utility lines is currently limited, but impacts will increase as the transportation network expands to support a growing human population. An increase in the extensive network of roads connecting oil and gas production facilities (National Research Council 2003) that dissect large expanses of tundra on Alaska's North Slope, and an increase in logging roads across private and public timber management areas in southeastern, south-coastal, and interior Alaska (e.g., USDA 2008a) may affect local landbird populations. Roads can have several general effects on wildlife: 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). Avian mortality due to collision with power lines, vehicles, communications towers, and airplanes is estimated to constitute 22.5% of all mortality due to anthropogenic sources in the U.S. (Erickson et al. 2005). Common Ravens, Bald Eagles, and other raptors are particularly susceptible to electrocution from power lines.

Biological Resource Use
This category includes threats from the consumptive use (commercial or subsistence) of "wild" biological resources including hunting, trapping, fishing, and logging. Commercial logging probably has the greatest impact on Alaska's landbirds by virtue of its landscape-level alterations

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of habitat in terms of age, composition, and structure. Although much of Alaska's vast interior boreal forest region is largely intact, 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). Most (61%) of the harvested volume comes from Native and private lands, with lesser amounts from national forests (17%) and state and other public lands (22%).

The leading species harvested are Sitka spruce (*Picea sitchensis*), western hemlock (*Tsuga heterophylla*), and cedars (*Chamaecyparis nootkatensis, Thuja plicata*) in southeastern Alaska and white spruce (*Picea glauca*) and paper birch (*Betula papyrifera*) 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 may have 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 owls, grouse, and ptarmigan, but accurate data on harvest levels and direct impacts on populations are largely 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

Habitats required by many landbirds overlap with preferred human-use areas. Photo © iStock - christiannafzger

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 is minimal.

Human Intrusions and Disturbance
This category includes threats tied to human disturbance while working, camping, or sightseeing in terrestrial environments. 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 $1.7 billion in revenue from over 1.8 million visitors per year (Alaska Department of Commerce 2007). As an increasing number of visitors and residents alike focus their recreation in wilderness settings, additional and mounting pressures will be placed on landbirds in sensitive natural habitats. Most recreational activities are concentrated, however, within relatively narrow corridors defined by accessibility through motorized transport (automobiles, trucks, all-terrain vehicles, boats, airplanes, snow machines). Habitats can be altered indirectly by development through associated 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-coastal Alaska, interior Alaska, and the Aleutian Islands. Disturbance from research and other work activities occurs at a small scale throughout the state.

Natural System Modifications
This category includes threats from actions that convert or degrade habitat in order to manage natural systems, often to improve human welfare. 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). 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 (AICC 2010) 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

Fire is an important ecological process in northern biomes, particularly in the boreal forest. Photo © iStock milehightraveler

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

Invasive and other Problematic Species and Genes

This category includes threats resulting 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 Alaskan forests. Native species that sustain unnatural increases in abundance because of anthropogenic disturbance can also be problematic, such as Common Ravens that prey on eggs and nestlings on the North Slope (Powell and Backensto 2008). Although there is debate about anthropogenic or other causes of the range expansion of Barred Owls into western North America (Monahan and Hijmans 2007, Livezey et al. 2008), evidence suggests that their recent intrusion into southeastern Alaska and British Columbia is having a negative impact on the much smaller Western Screech-Owl (Elliott 2006, Kissling and Lewis 2009).

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 (*Dendroctonus rufipennis*), for example, can have serious effects on forest habitat structure and composition on 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 disease organisms and human-altered genes. Current strains of avian influenza circulating in Asia and Eastern Europe 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 potentially transmit virulent diseases to nearctic or neotropical species in areas where their ranges overlap (Peterson et al. 2007). Should strains carrying a significant threat to humans arise, landbirds could also suffer indirectly in attempts to mitigate outbreaks by reducing population sizes (i.e., culling). 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 Northwestern Crows. Although it is unknown if this disease is being caused by a pathogen, contaminant, or some other factor, such an epizootic can have far-reaching impacts not only on the affected species but also on community dynamics. Currently there is little known threat to landbirds in Alaska from genetically modified organisms such as crops, insects, trees, or salmon.

Pollution

This category includes the introduction of harmful materials and/or energy into the environment, and includes many types of pollution, including water- and air-borne toxicants (such as sewage, oil, fertilizers, heavy metals, PCBs), solid wastes (such as garbage), and excess energy (such as 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 its geographic location and the long-range transport of contaminants from industrial regions in Asia (Arctic Monitoring and Assessment Programme 2005). Bald Eagles nesting in the Aleutian Islands have shown elevated levels of elemental mercury and several organochlorines; these were correlated with exposure both through point sources from past military activities and through long-distance transport from Asia (Anthony et al. 1999, 2007).

Because of their status as apex predators, raptors are particularly susceptible to bioaccumulation of contaminants. Recent studies of the Rusty Blackbird, whose continental population has been declining rapidly range-wide (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). There is little information available on contaminant levels among other landbird species in Alaska.

Geological Events

Located at the northern junction between the North American plate and the Pacific plate, right 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 (USGS 2009a). In fact, earthquakes are a regular, almost daily, occurrence in Alaska, with as many as 24,000 being detected in a single year (AEIC 2006). 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-coastal Alaska, by up to 15 m in some places (USGS 2009b), and subsequent and far-reaching habitat changes. For example, natural plant succession on the Copper River Delta rapidly advanced after the earthquake, which caused an uplift of 2-3.5 m above sea level, resulting in a large expanse of coastal wetlands shifting 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

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

dramatic effects on both terrestrial and marine habitats (DeGange 2010). Depending on the duration of the event and the meteorological conditions at the time, the impact of volcanic eruptions on the surrounding landscape may be highly localized and acute, or far-reaching and chronic. 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 tidal waves, or tsunamis, which can cause the sudden and severe erosion of sensitive coastal habitats, such as beaches and marshes, or the slower degradation of drier interior habitats, such as agricultural fields and shrub lands, due to an infusion of salt water and a resulting salinization of soils (Kume et al. 2009).

Alaska is also recognized for its many glaciers. Today, there are thought to be over 100,000 glaciers across the state, with approximately 5% of Alaska currently under ice fields (USFS 2002). Many of Alaska's glaciers appear to have been in rapid retreat (Koppes and Hallet 2002) or thinning (Arendt et al. 2002) over at least the last century, but some glaciers have shown advancement over the same period (Trabant et al. 2003). 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. 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 and Severe Weather

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 2007). 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 (Rupp et al. 2000, 2001; McGuire et al. 2003; Chapin et al. 2004; Edwards et al. 2005; Juday et al. 2005).

Small changes in temperature or precipitation in the arctic, alpine, and boreal forest biomes are projected

Climate change models predict increasing stochasticity in weather patterns.

to result in large changes in species composition and biodiversity during the next century (Sala et al. 2000). 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, Handel et al. 2009), but little is understood about the mechanisms and ecological processes involved.

Changes in temperature and precipitation will likely cause shrubs and boreal forests to expand farther north and higher in elevation, displacing tundra- and alpine-breeding species of wildlife (Tape et al. 2006). A recent massive decline of the Alaska yellow-cedar (insert latin name ?) 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), and 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) and wetland drying (Klein et al. 2005, Riordan et al. 2006). Changes in the presence and types of wetlands will likely affect prey distributions for boreal and tundra-nesting landbirds.

Photo © Milo Burcham

For many species, the timing of migration and breeding is coupled to the life cycles of their prey species. 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 (Vissar et al. 2006). 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 decline (Butler 2000) and the highest rates of mortality in some migratory landbird populations are during migration (Sillett and Holmes 2002). The distribution and abundance of predators and parasites may also change in response to habitat and climatic conditions. Given the extent of potential impacts, threats to Alaska's birds posed by global climate change will likely be complex and profound.

Conservation Strategies for Alaska

To ensure the conservation of landbirds in Alaska, we must integrate 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 ecological 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 will be 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 decision making. The identification of important habitat types 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, are a useful first step, but, once identified, sites often require further conservation action. In many cases, pressure may need to be brought to bear to improve the protection, conservation status, and management of key sites for landbirds in Alaska.

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. The development of bird-habitat models relies on the continued collection of data that reflects habitat requirements of particular species. Once established, however, predictive habitat models could be used to build simulation models to forecast the potential effects of broader environmental and climate change scenarios (Hauer et al. 2010).

The development and evaluation of best management practices (BMPs) in forest management (Gende et al. 1997, 1998, Kissling and Garton 2007, Sperry et al. 2008, Matsuoka et al. 2010a), wind energy development (USFWS 2010), 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. 2006).

Opportunities for habitat restoration may be limited across the state. In southeastern Alaska, however, there is considerable potential to hasten the recovery of highly productive old-growth rainforest that has been heavily logged.

Objectives

1. Identify important landbird habitats in Alaska during breeding, non-breeding, and migration, and, where appropriate, nominate them for formal protection or recognition in conservation networks for significant sites.

2. Coordinate, promote, initiate, and participate in flyway-wide initiatives that broadly define landbird habitat needs.

3. Develop habitat-based models to predict seasonal distribution and abundance of landbirds in Alaska.

4. Model the potential impact of changing environmental conditions on landbird habitats in Alaska.

5. Develop and evaluate best management practices for industrial and development sectors.

6. Identify landbird habitats prone to human disturbance and develop mitigation prescriptions to reduce negative impacts.

Population Monitoring

Many landbird species throughout the world are in decline. Determining and monitoring population sizes is critical to evaluating long-term population trends. In the U.S. and Canada, the traditional method of assessing population trends is an analysis of data from the two longest running bird survey programs in North America—the Patuxent Wildlife Research Center's Breeding Bird Survey (BBS; www.pwrc.usgs.gov/BBS/index.html) and the National Audubon Society's Christmas Bird Count (CBC; http://birds.audubon.org/christmas-bird-count). Neither of these survey schemes is well-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 generally do not provide enough information to assess population trends across such a vast landscape with few roads. Thus, the development of effective monitoring programs in northern areas is a high priority (Dunn et al. 2005).

Standardized point-counts are a well-recognized, reliable method for monitoring landbirds (Ralph and Scott 1981). There are many different methods for adjusting point count surveys 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 birds in such a landscape (Handel and Cady 2004). This point-count survey method uses a systematic sampling design with a random start point, and includes a variable circular plot methodology to account for variation in detection probability. This method has also been used effectively to estimate population sizes of some landbird species in some areas of Alaska (Handel et al. 2009). Techniques for collecting and analyzing point count data are continually being assessed and improved, and research should also focus on jointly analyzing disparate data sets to increase power for detecting population trends.

Point counts 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 (Jacobsen and

Hodges 1999, Zwiefelhofer 2007). Where possible, these surveys should also be adjusted for incomplete detectability (Bowman and Schempf 1999, Martin et al. 2009a, 2009b, Booms et al. 2010). Migration counts can also be an effective tool for monitoring species which 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).

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 (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 (see DellaSala et al. 1996, Matsuoka et al. 2011).

Given the requirement of relatively large sample sizes, monitoring demographic parameters should be conducted in focused studies, rather than part of broader research programs (DeSante et al. 2004). 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. 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.

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

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 models to better understand limiting factors at the population level.
7. Develop better estimates of subsistence harvest of non-game 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. For each, we include a brief explanation of the general information need and then provide a specific research objective related to this need.

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

In particular, developing models of landbird distribution and abundance relative to habitat at the regional and statewide scales (Cotter and Andres 2000) is critical for 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 in order to develop robust models in a timely fashion (Booms et al. 2009). 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).

Range-wide approach for understanding priority species: For priority species, we need targeted research to identify critical habitats and resource requirements for conservation, identify appropriate population units for management, to understand limiting factors in order to develop management strategies that alleviate their influence, and to estimate trends in population sizes to gauge progress towards meeting population goals. Because many of our priority species have large ranges, or non-breeding ranges that are outside of Alaska, a collaborative approach for research and conservation is particularly appropriate (Faaborg et al. 2010a).

Such an approach helps weigh the relative importance of events occurring in different locations or periods of the annual cycle for a species, and has been particularly useful in making rapid progress in understanding the conservation needs of the Rusty Blackbirds across their range (Greenberg and Matsuoka 2010).

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


Long-term banding programs can provide critical information on habitat use and movements of birds. Photo © Lucas DiCicco.

Recent advances in stable isotopes, satellite transmitters, and geolocators, make these tools particularly useful on this front (McIntyre et al. 2008, 2009; Hobson et al. 2010). Satellite telemetry may have the added benefit of allowing for the estimation of survival rates (McIntyre et al. 2006b).

Objectives

1. Identify the cause(s) of population declines in priority landbird species in Alaska.

2. Use established and developing techniques and technologies (such as genetics, banding, telemetry, stable isotope analysis) to identify unique populations of landbirds in Alaska and link habitats used throughout their annual cycles.

3. Encourage long-term studies that measure landbird breeding phenology and track environmental conditions simultaneously.

4. Encourage long-term studies to assess the impacts of pervasive, broad-scale conservation issues, such as environmental pollutants and global climate change, on landbirds in Alaska.

5. Develop quantitative population models, measure key demographic parameters, and analyze population dynamics to estimate the long-term effects of subsistence harvest, depressed productivity, and other factors that may affect the viability of landbird populations.

Ruby-crowned Kinglet

Photo © Milo Burcham

Public Outreach and Information Dissemination

BPIF seeks to inform government agencies, industries, non-governmental 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.

Objectives

1. Raise the profile of Alaska's landbirds by supporting annual bird festivals held throughout Alaska, such as the Spring Migration Celebrations and Sandhill Crane Festivals held in Fairbanks, the Alaska Bald Eagle Festivals held in Haines, and the Alaska Hummingbird Festivals held in Ketchikan.

2. Encourage the synthesis and reporting of results of Alaskan landbird studies to scientific audiences via oral or poster presentations at regional meetings, such as the Alaska Bird Conference, and national meetings, such as the North American Ornithological Conference, The Wildlife Society Conference, and annual meetings of the American Ornithologists' Union, Cooper Ornithological Society, a Wilson Ornithological Society, and Association of Field Ornithologists.

3. Host presentations and workshops in remote villages to improve communication with rural Alaskans about landbird resources and their conservation.

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 range-wide 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 U.S., 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 still work to identify opportunities and play a role in their implementation.

Objectives

1. Foster cooperative research efforts throughout North America, and elsewhere along landbird migratory flyways.

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 Rusty Blackbird International Technical Working Group).

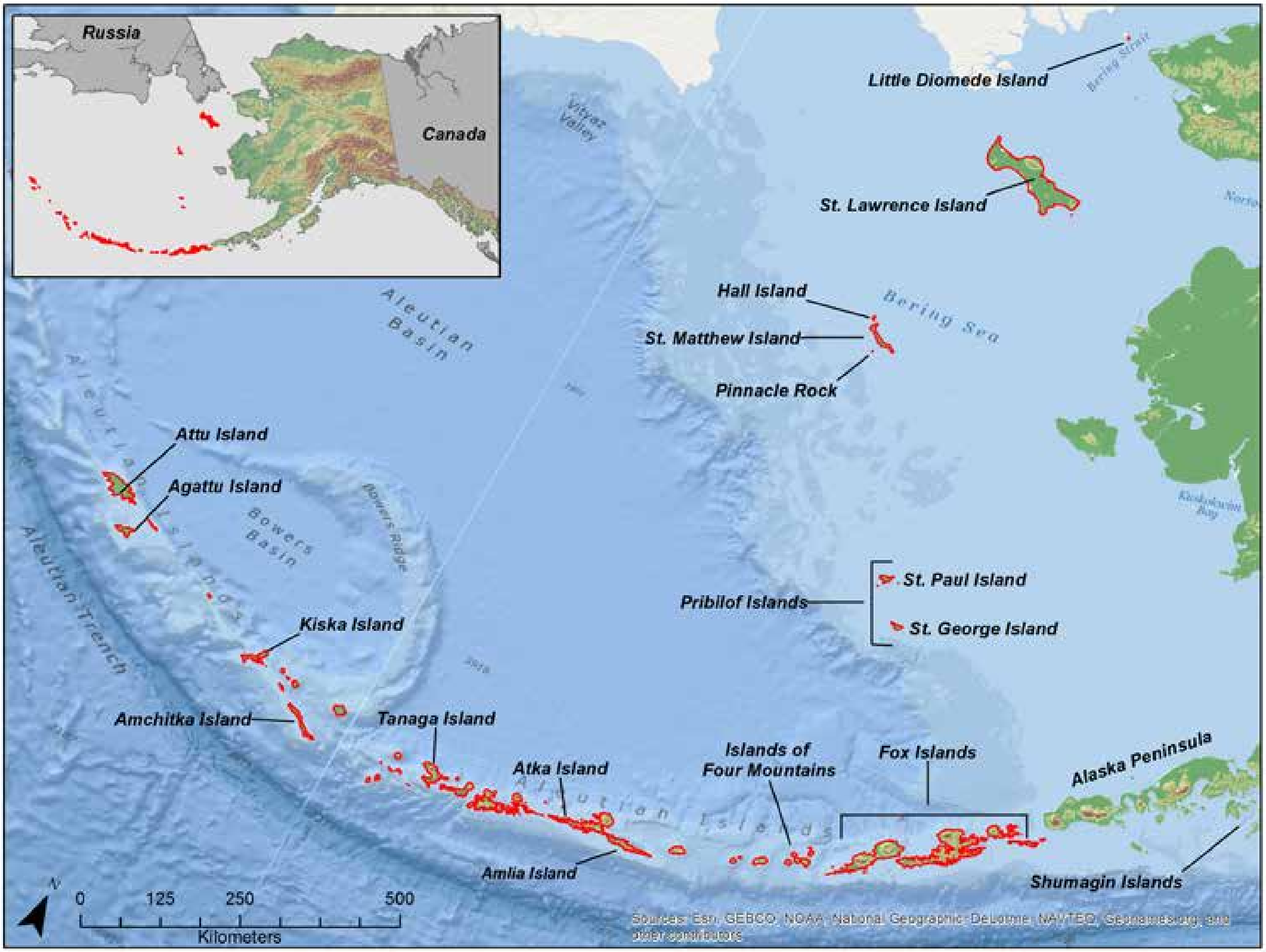
4. Cooperate with neighboring countries to standardize population monitoring protocols, enhance the investigation of ecological factors affecting landbird populations, and identify conservation issues that occur at a regional scale.

Boreal Chickadee

Photo © Milo Burcham

Bird Conservation Region 1 – Aleutian and Bering Sea Islands

Authors: James A. Johnson, Lucas H. DeCicco, Steven M. Matsuoka, and Heather M. Renner



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, because of its physical isolation from major faunal regions in Asia and North America, exhibits the highest level of endemism in Alaska (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 Wisconsin glacial maximum c. 14,000 years BP and ice fields are still present on the highest peaks. 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 of longitude, span 475 km of latitude, and link the North American and Asian continents. The Bering Sea islands are mostly isolated islands, including (from south to north) 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 St. Lawrence Island, which is privately owned, 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 and dwarf-mat 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. 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 at Gambell, on St. Lawrence Island, range from about -13 °C in winter to 6 °C in summer (National Climatic Data Center 2012). Sea ice forms in the Bering Sea each winter, occasionally as far south as the Pribilof Islands (Stabeno et al. 2007).

Landbird Avifauna

The region's landbird avifauna is characterized by a small number of species but a high level of endemism. Overall, 27 species of landbirds, representing 6 avian orders and 15 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; Gibson and Byrd 2007; 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 Paleoatropical 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). Endemism is high in the region with one endemic species (McKay's Bunting), and 10 additional endemic, or near endemic, subspecies, all of which are resident or only partially migratory.

Priority Species and Subspecies

As part of the Arctic Avifaunal Biome, the Aleutian and Bering Sea islands support significant populations of several species of continental importance (Rich et al. 1994). The endemic McKay's Bunting, a Continental Watch List species, is known to breed only on St. Matthew and Hall islands, although small numbers have been reported during summer on St. Lawrence and the Pribilof islands (Matsuoka and Johnson 2008). This region also regularly supports significant numbers of several Continental Stewardship species as either resident or migrant breeders, including Rock Ptarmigan, Rough-legged Hawk, Snowy Owl, Gyrfalcon, Peregrine Falcon, Lapland Longspur, and Snow Bunting (Preble and McAtee 1923; Fay and Cade 1959, Winker et al. 2002; Gibson and Byrd 2007). Short-eared Owls and Hoary Redpolls also occur within this region but in much lower numbers than the other Watch List and Stewardship species.

Of particular regional importance are the eight endemic landbird subspecies that are known to occur in this BCR. 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 Rock Ptarmigan (*atkhensis*, *evermanni*, and *townsendi*), two subspecies of Pacific Wren (*kiskensis* and *meligerus*), and one subspecies of Song Sparrow (*maxima*; Gibson and Byrd 2007). The Bering Sea islands support endemic subspecies of Gray-crowned Rosy-Finch (*umbrina*) and Pacific Wren (*alascensis*), in addition to the global breeding population of the McKay's Bunting (Winker et al. 2002).


McKay's Bunting

Photo © Peter Morris

Three other subspecies are endemic to Beringia, but not solely restricted to BCR 1. The sanaka Song Sparrow is resident throughout the Fox Islands and the Islands of Four Mountains but occurs east to the Shumagin and Semidi islands south of the Alaska Peninsula. The townsendi Snow Bunting is a near-endemic to the region, occupying all Aleutian and Bering Sea islands as well as the Commander Islands in Russia. The range of the kamtschaticus Common Raven includes Bering Sea and Aleutian islands and extends to eastern Russia. The griseonucha Gray-crowned Rosy-Finch occurs throughout the Aleutian Islands and east to the Semidi Islands. An assessment of avifaunal systematics in the region is incomplete, however, particularly on St. Lawrence Island. Thus, it is likely that the degree of endemism described here is 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 support the entire known breeding population of McKay's Bunting (Matsuoka and Johnson 2008). As such, these islands are recognized by Birdlife International as a globally-significant Important Bird Area (IBA). Several endemic subspecies of landbirds have limited ranges in the Aleutian (Gibson and Byrd 2007) or Pribilof (Preble and McAtee 1923) islands. The *evermanni* subspecies of Rock Ptarmigan was restricted to Attu Island until recently but 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 Atka, possibly Amlia). For Pacific Wren, the meligerus subspecies is restricted to the Near Islands (Attu and Agattu), kiskensis is resident from the Rat Islands (Kiska) east to islands off the Alaska Peninsula (Amak and Amagat), 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 Atka, possibly Amlia). The umbrina subspecies

Table 5: Seasonal occurrence of species (and subspecies) within the Aleutian and Bering Sea Islands BCR of Alaska recognized as of continental importance (Watch List or Stewardship species; Rich et al. 2004), a Common Bird in Steep Decline (Berlanga et al. 2010), or of regional stewardship importance. 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	Common Bird in Steep Decline	Regional Stewardship	Seasonal Occurrence
Rock Ptarmigan (*atkhensis, evermanni, townsendi*)	Stewardship			Resident
Rough-legged Hawk	Stewardship			Breeding
Snowy Owl	Stewardship	●		Resident
Short-eared Owl	**Watch List**	●		Breeding
Gyrfalcon	Stewardship			Resident
Peregrine Falcon	Stewardship			Resident
Common Raven (*kamtschaticus*)			●	Resident
Bank Swallow		●		Breeding
Pacific Wren (*alascensis, meligerus, kiskensis*)			●	Resident
Lapland Longspur	Stewardship			Breeding
Snow Bunting	Stewardship	●		Resident
McKay's Bunting	**Watch List**			Breeding
Song Sparrow (*maxima, sanaka*)			●	Resident
Gray-crowned Rosy-Finch (*umbrina, girseonucha*)			●	Resident
Hoary Redpoll	Stewardship			Resident

Photo © Lucas DiCicco

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 (Preble and McAtee 1923, Fay and Cade 1959, Gibson and Byrd 2007, Matsuoka and Johnson 2008) are varied and largely intact. Coastal cliffs provide important nesting substrates for Gyrfalcons, Peregrine Falcons, Common Ravens, Gray-crowned Rosy-Finches and McKay's Buntings. 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 Rough-legged Hawks, Rock Ptarmigan, the ubiquitous Lapland Longspur, and Song Sparrows. Artificial habitats, particularly abandoned equipment and structures in the Aleutians, are used for nesting by Gray-crowned Rosy-Finches and Snow Buntings. 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. Introduction of mammalian predators, particularly Norway rats (*Rattus norvegicus*) and foxes (*Vulpes* sp.), is the greatest conservation concern in the region. 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 2006).

Increases in trans-Pacific shipping traffic, including the opening of new shipping routes through the Northeast Passage and Northwest Passage, heighten concerns for catastrophic fuel spills and rat invasions. The region has also experienced particularly high rates of climate warming, which is predicted to increase in the future and result in rapid ecological changes (Stabeno et al. 2007, Post et al. 2009).

A small human population (State of Alaska 2010), combined with the protected status of most lands in the region, minimizes levels of urbanization and development compared to other regions of Alaska. Economic incentives, however, are expected to increase road-building, mineral mining, and energy development in the region, particularly on St. Lawrence Island (Kawerak and the Bering Strait Development Council 2009). 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. 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.

Future work in BCR 1 should focus on these primary conservation objectives:

- Protect endemic and other natural populations of landbirds on the islands by restoring populations to historic distributions (prior to introduction of mammalian predators) and by minimizing future impacts from introduced mammals, fuel spills, and other types of disturbance.
- Determine 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 and Stewardship species and endemic taxa.

Priority Conservation Issues and Actions

Introduced and Invasive Species

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 ground squirrels (*Spermophilus parryii*), European hare (*Lepus europaeus*), sheep (*Ovis* sp.), goats (*Capra* sp.), cattle (*Bos* sp.), horses (*Equus* sp.), caribou (*Rangifer tarandus arcticus*), reindeer (*R. t. asiaticus*), and bison (Bos sp.). 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. Since then, Norway rat populations have 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 ashore at harbors.

Reindeer were also introduced on other Bering Sea islands, including St. Lawrence (1900), the Pribilofs (1911), and St. Matthew (1944), where they continue to occur in free-ranging herds 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


Northern Wheatear

Photo © Lucas DiCicco


Bluethroat

Photo © Lucas DiCicco

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 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.
- Remove or reduce numbers of rats, foxes, and other introduced mammals from selected islands and 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.
- Determine factors that influence differential breeding densities of McKay's Buntings on St. Matthew and Hall islands.
- Determine 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.

The grassy slopes of Hall Island in the central Bering Sea. Photo © Heather Renner

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, such as the Northwest Passage and Northeast Passage, 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, including freighters, barges, cargo vessels, and passenger ships have wrecked on the Aleutian Islands. 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).

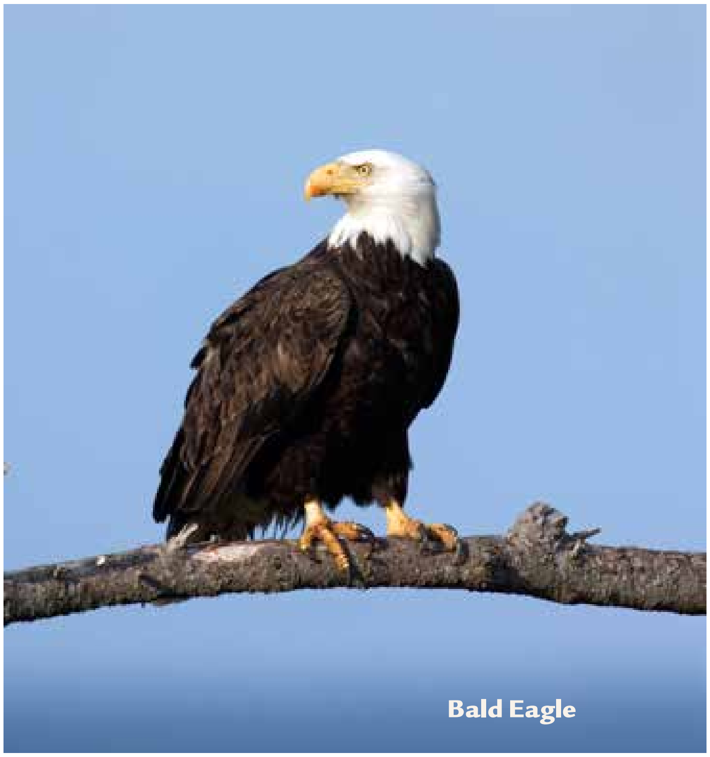
Fuel spills are less likely to have severe, direct effects on landbirds than on more aquatic species; however, the many passerines that forage along wrack lines and intertidal areas, especially during winter, are vulnerable. Bald Eagles and other raptors that opportunistically feed on animals killed 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 throughout the region, 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.
- Determine levels of mercury and other contaminants for high-risk species (e.g. Bald Eagle, McKay's Bunting).

The M/V Selendang Ayu ran aground and broke up off of Unalaska Island in 2004. Photo courtesy of Alaska Department of Fish and Game.



Bald Eagle

Photo © Daniel Poleschook

Climate Change and Severe Weather

This region is experiencing increased summer and winter air temperatures and decreased cover of sea ice (Overland and Stabeno 2004, Stabeno et al. 2007). These 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 colonized St. Matthew Island (Post et al. 2009) prior to 1995 and appear to have already replaced arctic foxes on the island. Subarctic shrubs are increasing in extent and height in response to a longer growing season (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 on St. George Island (Roby and Brink 1986). Such changes may also alter predation pressures and 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:

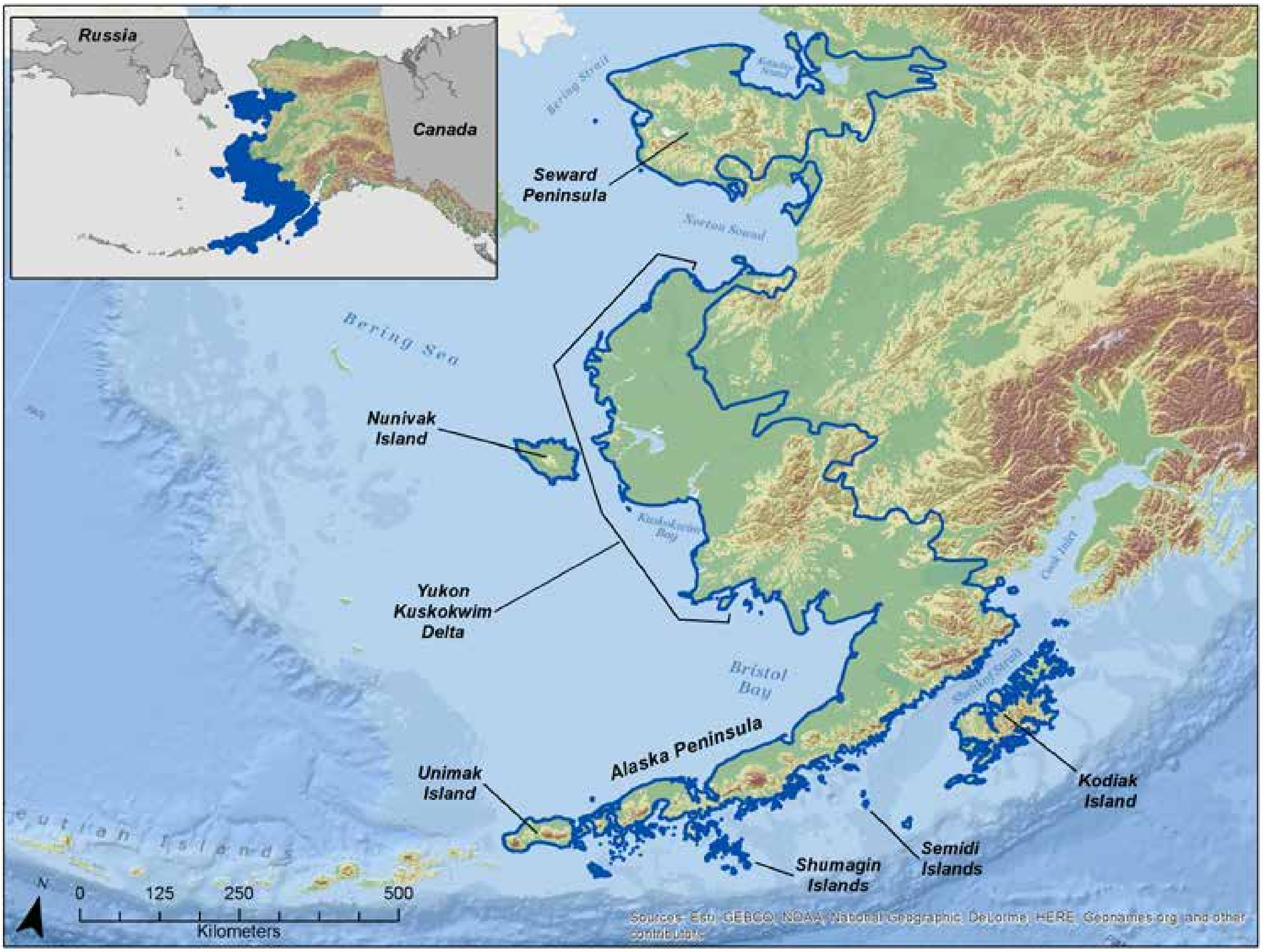
- Conduct long-term, periodic monitoring to track status and demography of continentally important and regionally endemic landbird populations to assess how climate-mediated changes ultimately affect population dynamics. Studies should include breeding chronology (e.g. arrival, nest initiation, and fledging dates), measures of habitat phenology, composition, and structure, and predator-prey relationships.
- Determine whether the recent colonization of St. Matthew Island by red foxes is negatively affecting the status of breeding McKay's Buntings.
- Encourage the acquisition and analysis of high-resolution remotely-sensed imagery to develop current landcover classifications and species-habitat models 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.

Gray-crowned Rosy-Finch

Photo © Brian Guzetti

Bird Conservation Region 2 – Western Alaska

Authors: 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 north 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 Wisconsin glacial maximum c. 14,000 years BP, and some remain so today, much of the region was encompassed by the vast refugium known as Beringia (Hopkins 1982). 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 myriad 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 2012). Rain and dense fog are common during summer months and windy conditions persist throughout the year (Williamson & Peyton 1962, Kessel 1989, Peterson et al. 1991).

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 U.S.

Landbird Avifauna

There are 85 species representing 7 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 of these species, except McKay's Bunting, are known or suspected to breed in the region, at least peripherally. Thirty species are considered permanent residents but individuals of at least 17 other species remain regularly during winter in southern parts of the region (Gabrielson & Lincoln 1959; Kessel & Gibson 1978; Gill et al. 1981; Kessel 1989; Petersen et al. 1991; Gibson & Kessel 1997). The remaining species migrate out of the region along one of several continental or

Landscape photograph by Stacey Studebaker 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

As part of the Arctic Avifaunal Biome, BCR 2 regularly supports several Partners in Flight Species of Continental Importance (Rich et al. 2004; Appendix II). Three of four Watch List species breed across the region and are Nearctic (Short-eared Owl, Rusty Blackbird) or Neotropical (Olive-sided Flycatcher) migrants. A fourth Watch List species, the Alaska-endemic McKay's Bunting, breeds solely on St. Matthew and Hall islands (BCR 1) and is almost entirely restricted to western Alaska during winter (Kessel & Gibson 1978; Winker et al. 2002; Matsuoka & Johnson 2008). This region also supports populations of 10 Stewardship species (Table 6). Nine Stewardship species are largely resident in the region

Table 6: Seasonal occurrence of species (and subspecies) within the Western Alaska BCR recognized as of continental importance (Watch List or Stewardship species; Rich et al. 2004), a Common Bird in Steep Decline (Berlanga et al. 2010), or of regional stewardship importance. 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	Common Bird in Steep Decline	Regional Stewardship	Seasonal Occurrence
Willow Ptarmigan	Stewardship			Resident
Rock Ptarmigan	Stewardship			Resident
Rough-legged Hawk	Stewardship			Breeding
Golden Eagle			●	Breeding
Great Horned Owl (*algistus*)			●	Resident
Snowy Owl	Stewardship	●		Resident
Short-eared Owl	**Watch List**	●		Breeding
Belted Kingfisher		●		Breeding
Gyrfalcon	Stewardship		●	Breeding
Peregrine Falcon	Stewardship			Breeding
Olive-sided Flycatcher	**Watch List**			Breeding
Horned Lark		●		Breeding
Bank Swallow		●		Breeding
Boreal Chickadee		●		Resident
Pacific Wren (*semidiensis, helleri*)			●	Resident
Lapland Longspur	Stewardship			Breeding
Snow Bunting	Stewardship	●		Breeding
McKay's Bunting	**Watch List**		●	Wintering
Blackpoll Warbler			●	Breeding
Wilson's Warbler		●		Breeding
Fox Sparrow (*unalaschcensis, insularis*)			●	Breeding
Song Sparrow (*insignis*)			●	Resident
Rusty Blackbird	**Watch List**	●	●	Breeding
Hoary Redpoll	Stewardship			Resident


Peregrine Falcon

Photo © Ken Archer

throughout the year (Willow Ptarmigan, Rock Ptarmigan, Snowy Owl, Gyrfalcon, Hoary Redpoll). Both Snowy Owls and Hoary Redpolls, however, also occur irregularly across the eastern Palearctic and northern Nearctic during winter (Parmelee 1992; Knox & Lowther 2000) and some juvenile Gyrfalcons have been documented wandering from natal areas on the Seward Peninsula to the eastern Palearctic (Kessel 1989; McIntyre et al. 2009).

Two Stewardship species are Nearctic migrants (Rough-legged Hawk, Lapland Longspur) and one exhibits an intermediate migration pattern, with part of the population migrating to Nearctic wintering areas and the remainder wintering in southern areas of BCR 2 (Snow Bunting).

Two populations of the Peregrine Falcon breeding in BCR 2 have disparate migration patterns: the more northern breeding anatum migrates to Neotropical wintering areas as far south as Chile, whereas pealei is resident year-round in southern portions of BCR 2 (White et al. 2002).

Nine species that regularly occur in the region have been designated as Common Birds in Steep Decline (Berlanga et al. 2010; Table 6). In addition to four Watch List and Stewardship species (Snowy Owl, Short-eared Owl, Snow Bunting, Rusty Blackbird) these include four Nearctic and Neotropical migrants (Belted Kingfisher, Horned Lark, Bank Swallow, Wilson's Warbler) and one boreal-forest-associated resident (Boreal Chickadee). Local stewardship status is also warranted for two additional species. The Golden Eagle is present in low numbers during the breeding season where fell-fields, rock outcrops, and riverine cliffs occur. Conservation concern for this species is focused on potential cumulative threats along its migration pathways and on its wintering grounds (Smith et al. 2008). 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 (Sauer et al. 2013).

Six subspecies, representing Great Horned Owl, Pacific Wren, Fox Sparrow, and Song Sparrow, are endemic to the region for all or a portion of the annual cycle (Table 6). These populations are therefore recognized as regionally important for 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 & 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 or a male-biased sex ratio in the population.

Within this BCR, the *algistus* subspecies of Great Horned Owl is an uncommon resident typically associated with coniferous forest and, to a lesser degree, riparian deciduous habitats (Kessel 1989, Petersen et al. 1991, Houston et al. 1998). This population is not well studied, and therefore information relative to the conservation and management of important areas is lacking. Two insular Pacific Wren subspecies, *semidiensis* and *helleri*, are resident to the Semidi Islands and Kodiak Island, respectively, and the *insignis* subspecies of Song Sparrow occurs on Kodiak Island. Two migratory subspecies of the Fox Sparrow also occur—*unalaschensis* on the western Alaska Peninsula and nearby island groups, and *insularis* on Kodiak Island (Gibson and Kessel 1997). 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. 2010, 2011). Coastal tundra habitats on the Seward Peninsula and Yukon-Kuskokwim Delta 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. 2009; 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).

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. 2013).

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

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 2013). 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 by directional climate change, industrial 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.

The U.S. Fish and Wildlife Service recently initiated the Western Alaska Landscape Conservation Cooperative (LCC), a multi-agency partnership to enhance conservation of the region's ecosystems and biota (https://westernalaskalcc.org). The Western Alaska LCC may be an important cooperator for achieving landbird objectives in the region.

Future work in this BCR should focus on these primary conservation objectives:

- 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 and protect 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 such as 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 LCC to address information needs and conservation measures for priority landbirds, particularly those vulnerable to effects of climate change. Identify and protect areas likely to serve as continental refugia for landbirds in boreal and tundra biomes.
- Work with biologists and conservation groups in temperate and tropical regions to conserve 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.

Researchers gather baseline inventory data on the current distribution of landbirds across the region, which is particularly needed in remote areas. Photo © Chris Harwood.

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 stampede to mine for gold in stream and beach placer deposits and underground quartz lode deposits on the Seward Peninsula (Koschmann & 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 (Tetra Tech 2013), Donlin Creek Deposit (Donlin Gold 2012), and Pebble Deposit (Pebble Partnership 2012).

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 new 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 & REAP 2013). 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 18% of the city's electricity (AEA & REAP 2013). As of December 2013, there were 20 completed wind projects in BCR 2, with 6 more in the design or construction phase (http://www.akenergyauthority.org/programwindprojects.html). The region's largest project in Nome (19 turbines, 3 MW) is considerably smaller than the average wind farm in the contiguous U.S. (45 turbines; Loss et al. 2013).

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. However, the turbines should be constructed away from bird concentration areas and migration pathways to minimize the risk that birds collide with the turbines (URS Corporation 2009; U.S. Fish and Wildlife Service 2012). Such collisions are estimated to kill 140,000–573,000 birds per year in the contiguous U.S. (Loss et al. 2013; Smallwood 2013) and 13,000–149,000 birds per year in Canada (Zimmerling et al. 2013), with raptors comprising 14% of these mortalities (Smallwood 2013). Although avian mortality from wind farms is generally much less than from other human-related sources (Calvert et al. 2013, Loss et al. 2013), 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 2011), 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,b). Recent evaluations of bird mortality at wind farms in the U.S. and Canada have primarily been at inland sites (Loss et al. 2013; Smallwood 2013; Zimmerling et al. 2013), so findings


McKay's Bunting

Photo © Peter Morris

from these studies likely have limited application to western Alaska. After construction, wind facilities in coastal Alaska should be monitored to understand their impacts on birds, particularly the McKay's Bunting.

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.
- 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 for transportation and service. For example, one potential road currently being considered by the State of Alaska to access the Ambler Mineral Deposit in the "Roads to Resources" program would traverse the southern Brooks Range from the Dalton Highway to Ambler; this road would then possibly continue to Kotzebue or the Seward Peninsula (ADOTPF 2013).

Rough-legged Hawk

Photo © Ken Archer

Shipping and barge traffic would also likely increase along the region's coasts, rivers, or lakes to service large industrial operations. Barge traffic on the Kuskokwim River alone is projected to increase 28-fold with the construction and operation of the Donlin Mine (Donlin Gold 2012). Such changes would 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 would also lead to degradation of habitats adjacent to roads from increases in habitat edges, hunting pressure, noise, and dust (McClure et al. 2013). Riparian habitats would suffer degradation from increased disturbance and erosion due to shipping traffic. Many species of invasive non-native plants, which are easily introduced into transportation corridors by 'hitch-hiking' on equipment, are rapidly becoming naturalized across Alaska and spreading rapidly across the landscape, posing a serious threat to ecosystem dynamics (Carlson & 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 to minimize impacts on landbird populations during both construction and operation phases.
- Work with land managers to reduce 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 & Lincoln


Horned Lark

Photo © Ken Archer

1959, Harwood 1999, 2001). Some areas within the region, such as the Kuskokwim River, have naturally high levels of mercury (Matz 2012). Thus, even small to modest increases in mercury from point sources or from atmospheric deposition could increase mercury exposures to toxic levels (Evers et al. 2005, Edmonds et al. 2010). For example, the Red Devil Mine, an abandoned cinnabar mine (1993–1971) 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 2012).

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 wrack lines and intertidal areas, especially during winter, are vulnerable to toxic exposure. Within BCR 2, McKay's Buntings and endemic subspecies of Song Sparrow and Pacific Wren are 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).

Introduced and Invasive Species

Due to its unique migratory connectivity 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 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 and Severe Weather

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.

Photo © Ken Archer

Significant ecological changes are projected to include: (1) changes in coastal habitats resulting from increases in sea level, frequency and intensity of storm surges, 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, thermal erosion, and expansion of forests and shrublands into tundra areas (Jorgenson 2012). 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. 2011; 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.

Because ecosystem processes are projected to change broadly across Alaskan landscapes in response to directional climate change (Martin et al. 2009; Reynolds and Wiggins 2012), 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).

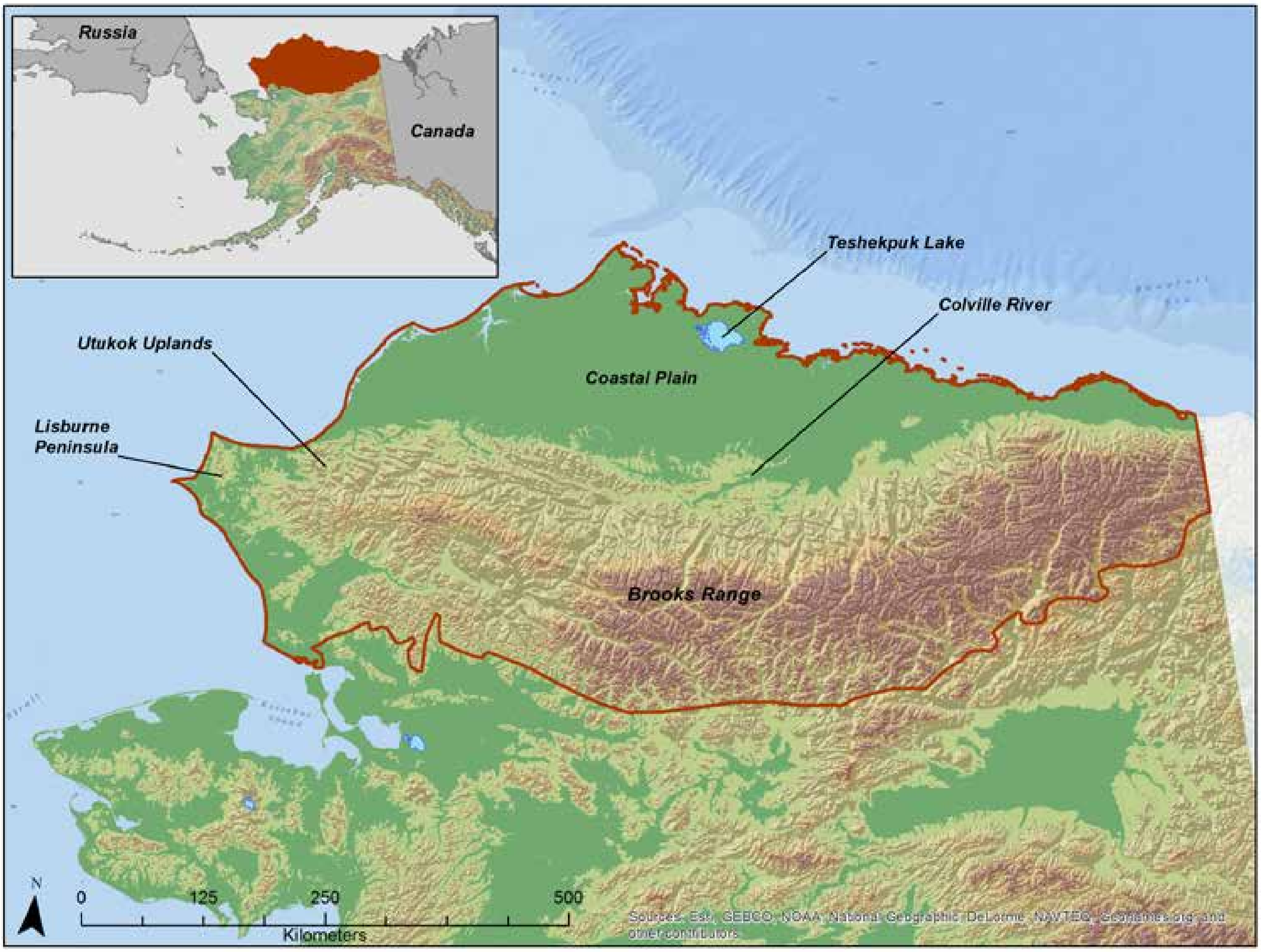
Ecological stress from climate change, such as the drought-induced reductions in plant growth observed in interior Alaska (Verbyla 2008, Beck et al. 2011), might be less in western Alaska compared to adjacent continental regions. This resiliency might particularly benefit boreal songbirds. Indeed, recent 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. 2013). Thus, from a continental perspective, BCR 2 will likely provide an important broad-scale climate-change refugium for boreal birds (Stralberg et al. 2013). 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 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.
- Support efforts to reduce carbon emissions.

Bird Conservation Region 3 – Arctic Plains and Mountains

Authors: Travis L. Booms, Debbie A. Nigro, Lucas H. DeCicco, and Melanie J. Flamme



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 Mountain 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 U.S. 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, cut banks, cliffs, and isolated islands of balsam poplars. On the south-facing foothills, interior boreal forest, which reaches its northern extent and penetrates this region through river valleys, hosts the highest 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 2012). 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 22 families and 5 orders (Maher 1959; Kessel and Schaller 1960; Irving 1960; Hines 1963; Johnson and Herter 1989; Swanson 1997, 1998, 2001; Guldager 2004; Tibbitts et al. 2006; ANWR 2010; 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 non-existent at the eastern boundary.

Priority Species

Five species in this region are listed as Watch List species of continental importance for the Arctic avifaunal biome: Short-eared Owl, Olive-sided Flycatcher, Smith's Longspur, Rusty Blackbird, and McKay's Bunting (Table 7; Rich et al. 2004). The Short-eared Owl, which has suffered a significant long-term continental population decline (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. 2006). Smith's Longspur, considered vulnerable because of its small population size and uncertainty in population trend (American Bird Conservancy 2012), occurs in the tundra-shrub zone throughout the Brooks Range. For this species, BCR 3 represents an important and large portion of its breeding range (Kendall 2006; Briskie 2009; Wild and Powell

This region includes a vast expanse of coastal tundra habitat and rugged mountains. Photo © Ken Archer

2009). Both the Rusty Blackbird, whose population has been steeply declining (Greenberg and Matsuoka 2010), and the Olive-sided Flycatcher, which was recently classified as Threatened in Canada (COSEWIC 2007), occur in low numbers along the southern edge of this region bordering the boreal forest. The Alaska-endemic McKay's Bunting has an extremely small population size and a highly restricted breeding distribution (St. Matthew and Hall islands in the Bering Sea; Matsuoka and Johnson 2008); a small portion of its winter range occurs within BCR 3 along the Chukchi Sea coast (Montgomerie and Lyon 2011).

Nine species in this region are considered Stewardship species of continental importance for the Arctic avifaunal biome, including Willow Ptarmigan, Rock Ptarmigan, Rough-legged Hawk, Snowy Owl, Gyrfalcon, Peregrine Falcon, Lapland Longspur, Snow Bunting, and Hoary Redpoll (Table 7; Rich et al. 2004). These species rely heavily on the tundra, shrub, and cliff habitats characteristic of this biome.

This region regularly supports eight species that have been listed as Common Birds in Steep Decline because of estimated losses of >50% of their populations during the past 40 years (Table 7; Berlanga et al. 2010). These include four species designated as Watch List or Stewardship species (Short-eared Owl, Snowy Owl, Snow Bunting, Rusty Blackbird).

Among the other species, Horned Larks and Wilson's Warblers occur broadly in low abundance across tundra and shrub habitats throughout BCR 3, Bank Swallows occur uncommonly in riparian habitat in the Brooks Range, and Boreal Chickadees are strongly tied to boreal forest and, thus, are comparatively rare except along the southern edge of the region.

Table 7: Seasonal occurrence of species within the Arctic Plains and Mountains BCR of Alaska recognized as of continental importance (Watch List or Stewardship species; Rich et al. 2004), a Common Bird in Steep Decline (Berlanga et al. 2010), or of regional stewardship importance. 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	Common Bird in Steep Decline	Regional Stewardship	Seasonal Occurrence
Willow Ptarmigan	Stewardship			Resident
Rock Ptarmigan	Stewardship			Resident
Rough-legged Hawk	Stewardship			Breeding
Golden Eagle			●	Breeding
Snowy Owl	Stewardship	●		Resident
Short-eared Owl	**Watch List**	●		Breeding
Gyrfalcon	Stewardship			Breeding
Peregrine Falcon	Stewardship			Breeding
Olive-sided Flycatcher	**Watch List**			Breeding
Horned Lark		●		Breeding
Bank Swallow		●		Breeding
Boreal Chickadee		●		Resident
Gray-headed Chickadee			●	Resident
Lapland Longspur	Stewardship			Breeding
Smith's Longspur	**Watch List**			Breeding
Snow Bunting	Stewardship	●		Breeding
McKay's Bunting	**Watch List**			Wintering
Wilson's Warbler		●		Breeding
Rusty Blackbird	**Watch List**	●		Breeding
Hoary Redpoll	Stewardship			Breeding

A species not listed in the national plan, but of particularly high stewardship importance for Alaska and especially BCR 3 because of its nearly endemic status, almost complete lack of information, and unknown population status, is the Gray-headed Chickadee (Table 7). This largely Old World species is represented in North America by a distinct subspecies (*lathami*), which is restricted to Alaska and northwest Canada (Hailman and Haftorn 1995; Gibson and Kessel 1997; Sinclair et al. 2003). BCR 3 includes a significant portion of the subspecies' range and likely hosts the majority of its population. Although the Golden Eagle is not listed as a Stewardship species nationally, it occurs widely throughout this region, is facing potentially significant cumulative conservation threats on it wintering grounds, and also warrants priority status in this region.

Photo © Ken Archer

Important Landbird Areas

Several habitats in this region are particularly important to priority species. Wet and lowland tundra in the coastal plain provide important breeding and foraging areas for Lapland Longspurs, Short-eared Owls, and Snowy Owls (Johnson and Herter 1989; Parmelee 1992, Hussell and Montgomerie 2002, Wiggins et al. 2006). 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 (Kendall 2006; Wiggins et al. 2006; Wild and Powell 2009). 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. Riparian habitats, including poplar groves, tall willows, and year-round open water, support a diversity of migratory and resident birds, including Gray-headed Chickadees. Finally, coastal habitats support concentrations of migratory birds that are preyed upon by hunting raptors and also provide important wintering habitat for McKay's Buntings.


Tundra habitat. Photo © Ken Archer

Several specific geographic areas in this region are of notable importance to landbirds of continental and regional importance and, thus, deserve special attention and protection. Two areas are recognized by BirdLife International as continentally significant Important Bird Areas for landbirds: tundra habitat around Teshekpuk Lake and east to Dease Inlet, which supports high breeding densities of Short-eared Owls, and a long stretch of the Lower Colville River, where bluffs support extraordinary numbers of nesting Peregrine Falcons, Gyrfalcons, and Rough-legged Hawks (Cecil et al. 2009; http://netapp.audubon.org/IBA/State/US-AK; R. Ritchie, pers. comm.).

The western uplands of BCR 3 also support high concentrations of nesting raptors, particularly on the Lisburne Peninsula (Booms et al. 2009) 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 database with which to assess long-term population changes. 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.

Photo © Ken Archer

Primary Conservation Objectives

The key conservation objective for this region is to protect the unique array of Arctic habitats, and the unique 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 2007).

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; Guldager 2004; Tibbitts et al. 2006).

Some longer-term studies have provided some information on distribution, abundance, productivity and population trends for raptors (e.g., Ritchie et al. 2003; T. Swem, unpubl. data). Recently a few studies have focused on understanding the distribution, breeding ecology, and population status of Smith's Longspur (Wild and Powell 2009; H. Craig, unpubl. data). For most species within this region, however, there is a dearth of information regarding basic distribution, abundance, habitat requirements, population trends, phenology, and ecology necessary to support basic conservation decisions.

Primary conservation objectives for BCR 3 include:

- Improve knowledge of distribution, abundance, basic life history, habitat requirements, migratory connectivity, and population trends for the highest priority species in the region (Short-eared Owl, Smith's Longspur, Gray-headed Chickadee).
- Establish region-wide long-term monitoring programs for Stewardship raptor species; refine and implement statewide protocols that are rigorous, repeatable, and statistically valid, especially relative to movements and demography of these species.
- Acquire detailed information on the seasonal occurrence, distribution, and abundance of Stewardship species in areas being considered for development, especially areas that may contain biologically unique, valuable, or vulnerable populations.
- Assess how species 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 and state-administered lands. 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 (NRC 2003). Infrastructure (roads, pipelines, gravel pads containing structures, gravel extraction pits, power lines and poles) 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, planning efforts by the State of Alaska Department of Transportation and Public Facilities to develop a road to Umiat to provide access to oil and gas resources west of the Dalton Highway are currently underway (see http://foothillsroad.alaska.gov). Mining, by comparison with oil and gas development,

Prudhoe Bay is the largest oilfield in North America, measuring approximately 15 miles by 40 miles.

Photo © Ken Archer

is currently very limited and localized within the region. Primary impacts to landbird populations from mining may include direct loss of 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.

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 and work to protect these areas.
- 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 suitable for local landbirds after resource extraction is complete.

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 U.S. 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, ravens, and gulls, 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 and protect them from development.
- Survey areas slated for development to quantify occurrence and abundance of landbirds before development. Use these data to guide the planning process and develop appropriate mitigation measures.

Human development may increase the density of native predators like this red fox. Photo © Ken Archer

- Balance community expansion with habitat protection by guiding placement of expansion in areas with the lowest potential impacts to landbirds and their habitats and permanently protecting areas of highest value 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.
- 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 automobiles, trucks, and ATVs) 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 ensure that current restrictions on motorized land vehicles are maintained for the Dalton Highway Corridor Management Area and implemented for 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 to manage access to remote areas to minimize overuse 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 negatively affect landbirds through destruction or degradation of habitat, direct oiling of some individuals, poisoning of predators/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 Macdonald 2005, AMAP/UNEP 2013). Little monitoring of contaminant levels in terrestrial wildlife, other than Peregrine Falcons (Ambrose et al. 2000) and arctic fox (*Alopex 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).

The Alaska pipeline in bisects the Arctic Plains and Mountains.

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). Of particular concern for raptors and other birds in the Arctic region are 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 (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.
- Continue to monitor contaminant loads in Arctic and American Peregrine Falcons and expand 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.

Photo © Ken Archer

Invasive and Other Problematic Species

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

Sport hunting regulations on ptarmigan and Snowy Owls are liberal (20–50 per day or no bag limit, and long or unending open seasons) and the effects of harvest on these populations are unknown.

Actions

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

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 Smith's Longspurs and Short-eared Owls during non-breeding seasons.

Actions

- Explicitly link the breeding and wintering areas of priority species to identify areas important to Alaska's birds during the non-breeding 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 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).

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, especially resident Arctic specialists such as ptarmigan, Snowy Owls, and Gyrfalcons; (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 for priority landbird species across the region.
- Encourage the Arctic Landscape Conservation Cooperative (and other appropriate programs within state and federal governments) to create, maintain, and make available:
- A network of automated weather stations across the region that provides real-time and archived climate information for the scientific community.
- 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.
- Preserve large areas of intact habitat 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.

Arctic plain and mountain landscape. Photo © Ken Archer.

Bird Conservation Region 4 – Northwestern Interior Forest

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The Alaska portion of the Northwestern Interior Forest Bird Conservation Region (BCR) encompasses 733,000 km^2 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 highest peak in North America (Mt. McKinley at 6,194 m, known locally as Denali). 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. 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, 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 -30° C during January and the average maximum summer temperature increases to 21 °C during July (WRCC 2012). 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 18 °C, and annual average precipitation of 27 cm. The entire region receives extended daylight during the summer (up to 20 h) and reduced day length 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, but black spruce 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 often occur; alpine shrublands and alpine herbaceous tundra grow at higher elevations above tree line.

Mount McKinley at the heart of Denali National Park. Photo © John Schoen

Table 8: Seasonal occurrence of species within the Northwestern Interior Forest BCR of Alaska recognized as of continental importance (Watch List or Stewardship species; Rich et al. 2004), a Common Bird in Steep Decline (Berlanga et al. 2010), or of regional stewardship importance. 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	Common Bird in Steep Decline	Regional Stewardship	Seasonal Occurrence
Ruffed Grouse		●		Resident
Spruce Grouse	Stewardship			Resident
Golden Eagle			●	Breeding
Short-eared Owl	**Watch List**	●		Breeding
Rufous Hummingbird	**Watch List**	●		Breeding
Belted Kingfisher		●		Breeding
Black-backed Woodpecker	Stewardship			Resident
Northern Flicker		●		Breeding
American Kestrel			●	Breeding
Olive-sided Flycatcher	**Watch List**			Breeding
Yellow-bellied Flycatcher	Stewardship			Breeding
Alder Flycatcher	Stewardship			Breeding
Northern Shrike	Stewardship			Resident
Gray Jay	Stewardship			Resident
Horned Lark		●		Breeding
Bank Swallow		●		Breeding
Boreal Chickadee	Stewardship	●		Resident
Gray-headed Chickadee			●	Resident
Bohemian Waxwing	Stewardship			Resident
Smith's Longspur	**Watch List**			Breeding
Snow Bunting		●		Breeding
Wilson's Warbler		●		Breeding
Brewer's Sparrow		●		Breeding
Lincoln's Sparrow	Stewardship			Breeding
Rusty Blackbird	**Watch List**	●		Breeding
Pine Grosbeak	Stewardship			Resident
White-winged Crossbill	Stewardship			Resident
Pine Siskin		●		Breeding

Much of this BCR is held in public lands, including many parks and preserves, wild and scenic rivers, and wildlife refuges. The U.S. 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. These federal and state lands constitute about 40% of the total land area of this BCR.

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; Scher 1989; West 1994; 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 in size from the sturdy Common Raven (1 kg) to the tiny Black-capped Chickadee (12 g). Five species of finches are nomadic throughout the Northwestern Interior Forest.

Priority Species and Subspecies

As part of the Northern Forest Avifaunal Biome, the Northwestern Interior Forest BCR supports a large complement of species of continental importance (Rich et al. 2004; Table 8). These include five Continental Watch List species: three (Short-eared Owl, Olive-sided Flycatcher, and Rusty Blackbird) breed throughout the region, one (Smith's Longspur) is restricted to the Tanana-Yukon highlands, and one (Rufous Hummingbird) occurs in low numbers in the Cook Inlet area. This region also supports significant breeding populations of 11 Continental Stewardship species designated for this biome. Six of these species are common throughout the BCR (Spruce Grouse, Alder Flycatcher, Gray Jay, Boreal Chickadee, Bohemian Waxwing, Lincoln's Sparrow), three occur regularly but uncommonly (Northern Shrike, Pine Grosbeak, White-winged Crossbill), and one is rare but regular in occurrence, particularly in recently burned forests (Black-backed Woodpecker). The eleventh species, Yellow-bellied Flycatcher, has been recorded in small numbers and as a rare breeder in riparian corridors in eastern interior Alaska (Benson et al. 2000, Martin et al. 2006; Handel et al. 2009; Gibson 2011). These records are at the far western extent of the species' distribution and perhaps represent an expansion of the larger breeding population in the southern Yukon Territory.


Pine Grosbeak
Photo © Milo Burcham


Rusty Blackbird
Photo © Jeff Nadler Photography

This region regularly supports populations of 13 species designated as Common Birds in Steep Decline (Table 8), which have suffered significant continental population declines over the past 40 years (Berlanga et al. 2010). These include four species that are also Watch List or Stewardship species for this region (Short-eared Owl, Rufous Hummingbird, Boreal Chickadee, Rusty Blackbird). The others occur in a wide array of habitats including forest and woodlands (Ruffed Grouse, Northern Flicker, Pine Siskin), riparian habitats (Belted Kingfisher, Bank Swallow), grasslands and alpine tundra (Horned Lark, Snow Bunting), and shrub thickets (Wilson's Warbler, Brewer's Sparrow).

Three additional species warrant local stewardship status in BCR 4 (Table 8). The Golden Eagle occurs regularly throughout this region and faces potentially cumulative

Olive-sided Flycatcher

Photo © Tom Munson courtesy Idaho Fish & Game

conservation threats along its migration pathways and on its wintering grounds (Smith et al. 2008). 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 northwest Canada (Hailman & Haftorn 1995; Gibson & Kessel 1997; Sinclair et al. 2003). This population is of special concern due to its limited range and small population size. Although this subspecies has received scant attention to date, it has been found to occur 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). Local stewardship status is also warranted for aerial insectivores as a group (e.g., swallows, flycatchers) because of their strong reliance on wetland habitats, which are undergoing rapid and severe hydrological changes.

Important Landbird Areas

In their entirety, boreal forests and wetlands of the Northwestern Interior BCR are of national, continental, and global significance to landbirds because of the boreal-dependent populations they support, particularly during breeding and migration. 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.

Only four sites in this region—Anchor River, Kahiltna Flats, Sheep Mountain, and Swanson Lakes—have been recognized to date as Important Bird Areas (IBAs) by the National Audubon Society based primarily on the presence of landbird species. These state-level IBAs have all been proposed as sites of global significance, but have yet to be confirmed by BirdLife International. The sites are all recognized for their populations of Blackpoll Warbler

Wilson's Warbler

Photo © Lucas DiCicco

Northern Shrike

Photo © Ryan Brady

and Olive-sided Flycatcher, among other species, except Sheep Mountain, where the Blackpoll Warbler is the only landbird included in the designation. Most other IBAs within this BCR are wetlands designated on the basis of the waterfowl or shorebird populations they support. One of these, the Upper Tanana Valley IBA, serves as a globally significant migration corridor for waterfowl and landbirds from southern regions of the Americas to breeding areas in Alaska and western Siberia (Kessel 1984, Cooper & Ritchie 1995, McIntyre & Ambrose 1999, Benson & Winker 2001). Riparian habitats along many other riverine IBAs also provide abundant food and nest sites for breeding landbirds.

Three of the five Watch List species in this BCR (Short-eared Owl, Olive-sided Flycatcher, Rusty Blackbird) are strongly associated with boreal wetlands in scattered woodlands or other open habitats, although the Short-eared Owl also regularly uses alpine tundra (Sharbaugh 2007,;Matsuoka et al. 2010; Gibson 2011). Smith's Longspur nests primarily in mesic to moist dwarf shrub tundra in the Tanana-Yukon Highlands (Gibson 2011); Rufous Hummingbird, at the northern extent of its breeding range in the Cook Inlet area (Scher 1989; West 1994), is associated with forest openings. Habitats used most commonly by the Stewardship species in this biome include coniferous forest (6 species), boreal wetlands (3 species), and shrub thickets (1 species; Sharbaugh 2007). 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 urban and agricultural areas.

Primary Conservation Objectives

The Northwestern Interior Forest BCR is profoundly important to landbird populations because it not only comprises the only area of boreal forest in the United States but also 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 attendant 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 continued warming suggest that, within the next few decades, Alaska's boreal forest will undergo significant changes in structure and dynamics to an extent unprecedented during the last 6,000 years (Chapin et al. 2010; Wolken et al. 2011).

One of the most important conservation objectives 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 desperate need for basic information on basic 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 should be identified to protect vulnerable populations and preserve biodiversity. Vast expanses of land, limited access, and broad distributions of birds all combine to increase the level of difficulty in

Rufous Hummingbird

achieving these objectives. 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.

Future work in this BCR should focus on these primary conservation objectives:

- Increase our understanding of the annual cycle, basic breeding ecology, habitat associations, phenological relationships, and migratory connectivity of landbird species in the region, particularly priority species.
- Establish an inventory system and a long-term ecological monitoring program to understand current distribution patterns and to track changes in populations over time.
- Develop a clearinghouse of existing information, such as early surveys of Olive-sided Flycatchers by Wright (1997), which can be used as a baseline and a guide for gathering future comparative data.
- Identify and protect key habitats and specific areas 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

Seven out of every ten Alaskans live within BCR 4. The vast majority of residents are clustered in or near the major metropolitan areas of Anchorage and Fairbanks, and about 75% of the human population in BCR 4 is concentrated in south-central Alaska around Cook Inlet. Avian habitats are being lost or altered markedly through increases in road networks, housing developments, motorized recreation, and associated commercial development.

The human population in Alaska has increased by 15% during the last decade, growing from 626,932 in 2001 to 722,718 in 2011 (U.S. Census Bureau 2012). Growth has been concentrated in the metropolitan areas of the state, with the population around Anchorage and on the Kenai Peninsula increasing by 12%, and the Fairbanks North Star Borough population rising by 18%. The most rapid growth has occurred in the Matanuska-Susitna Borough, where the human population has doubled. This explosive

A rapidly increasing human population expands our environmental footprint. Photo © iStock - JonnyNoTrees

Recreational use of the land poses conservation concerns.

growth 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.

Actions

- Identify important landbird habitat, particularly wetlands and corridors, in rapidly developing areas and work with land managers to protect 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 of the importance of snags for cavity nesters and how to landscape residential and business property to provide natural habitats beneficial to 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, mud boggers, jet boats, and other watercraft. Some landbird species may even be sensitive to lower levels of disturbance from other types of recreation.

Actions

- 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 & 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 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.
- Work with fire-management agencies and the public to use methods for constructing fire breaks that minimize loss and degradation of natural habitat.

Transportation and Service Corridors

The State of Alaska's "Roads to Resources" initiative 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. Similar concerns accompany expansion of existing transportation networks throughout the region.

Actions

- Identify critical 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.
- 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.

Dalton Highway. Photo © Dennis Green, Alaska State Office

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 nitrogen-fixing species such as alder. 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 and conversion of wood to pellets for household use is likely to increase. In addition to harvest of large trees and firewood, there has been new 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).

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 received industry requests to harvest ~300,000–400,000 tons of biomass or ~8,000–10,000 acres of trees annually across the Tanana Valley (from the U.S.-Canadian border west to the village of Tanana). Given these estimates, local harvest on State lands in the Fairbanks area could increase up to seven-fold.

Although biomass production is often referred to as a "sustainable" energy source, there is limited knowledge about associated effects on wildlife populations in the region (McGuire 2012). The successional trajectory of boreal forest vegetation and wildlife communities after timber harvest can be quite different from the trajectory following large-scale disturbances from wildfire, to which they are adapted (Viereck 1973; Kasischke et al. 2002).

Timber harvest and wildfire disturb the soil layer differently and result in structurally different residual vegetation (Collins & Schwartz 1998; Schieck & Song 2006). 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.

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 vital areas.
- Identify and inventory habitat associations within proposed biomass harvest areas. Monitor areas after harvest to determine 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 quality avian habitat while balancing the need for sustainable alternative energy.

Energy Production and Mining

Unparalleled 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 the wealth of natural resources in this region. Constantly evolving technologies have increased industrial capacity to access these resources on a scale that can affect large swaths of previously unaltered habitat. Increasing oil prices have not only increased the profitability of extracting less accessible reserves but also prompted the development of alternative sources of energy.

Extraction of minerals has long been associated with the history of northern regions. The Klondike Gold Rush of 1897 brought thousands of prospectors to the heart of this region to seek their fortune, 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. Access to remote mining claims may also affect habitat within transportation corridors by blazing trails, building roads, introducing invasive species, and increasing levels of associated disturbance.

Coal mining in Seward. Photo © Claudine Van Massenhove

There are currently several large mines operating in this region (for gold and coal) and a few additional large mines have been proposed. 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. They often entail increased risks to wildlife populations because extraction techniques expose large areas to potentially catastrophic results. 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 introduction of invasive species and predators, 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. Dam construction could flood large tracts of habitat with direct impacts on riparian and forest birds. Fluctuating water levels, 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. Placement of wind turbines in migration corridors may present a direct collision hazard to migrating birds.

Actions

- Identify critical habitat for priority species in areas proposed for energy production and mining. Work with stakeholders to minimize impacts. 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 infrastructure.

Invasive and Other Problematic Species

New species can enter an ecosystem through association with humans or through dispersal as environmental parameters 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 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

Although the Black-billed Magpie is a native species, urban expansion is causing this nest predator to increase. Photo © iStock - Silfox

of introduced and native species of birds associated with urban and agricultural development, such as European Starling, Rock Pigeon, Common Raven, Black-billed Magpie, and Red-winged Blackbird, may result in displacement of other native species of birds.

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 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 Red-winged Blackbirds on declining Rusty Blackbird populations and effects of European Starlings on cavity-nesting birds.

Climate Change and Severe Weather

Climate change may be the most important factor in determining the future of bird populations in the Northwestern Interior Forest BCR. There has been significant winter-warming in the boreal forests throughout Eurasia and 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. This increase has 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 (Silapaswan et al. 2001, Sturm et al. 2001, Stow et al. 2004, Tape et al. 2006, Walker et al. 2006); (2) shrinkage and loss of water bodies within wetlands (Riordan 2005, Klein et al. 2005); (3) advance of tree line northwards and upslope (Lloyd & Fastie 2003); (4) an increase in the frequency and severity of outbreaks of plant pests and pathogens (leafminers, sawflies, aphids, leaf rollers, spruce budworm, spruce beetle, alder blight; Werner et al. 2006); (5) an increase in the intensity and frequency of forest fires and the length of the fire season (Kasischke & Turetsky 2006); and (6) an increase in permafrost thawing and thermokarst in boreal forests, causing dramatic changes to the ecosystem (Jorgenson & Osterkamp 2005). In turn, these ecosystem shifts may have profound effects on the availability and suitability of habitat for northern bird populations.

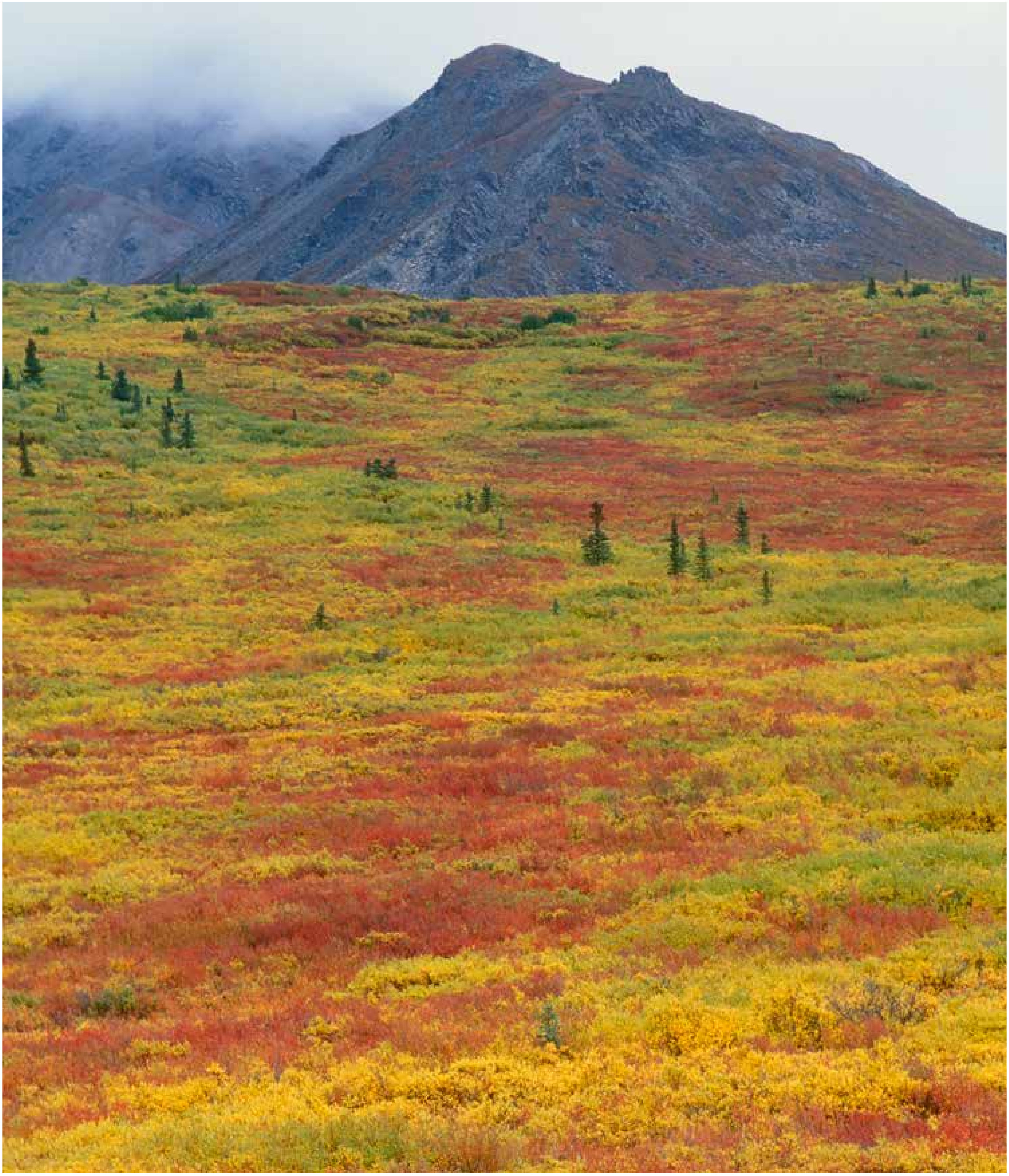
Loss of wetlands and other changes in hydrology may further exacerbate population declines in four of the Watch List species within this region (Short-eared Owl, Olive-sided Flycatcher, Rusty Blackbird, Smith's Longspur), all of which are reliant upon wetlands or mesic habitats. Recent bioclimatic niche 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 of them (Stralberg et al. 2013). Differential shifts in avian distribution may result in restructuring of avian communities.

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. 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).

Monitoring landbirds is critical to developing conservation actions. Photo © Chris Harwood

Actions

- Create an accurate habitat map for the region as a baseline against which to measure change in wetlands, change in forest structure, transition of tundra to shrub, and loss of alpine habitat.
- 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 dynamic models of habitat change across the landscape 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.
- Create a system of protected areas across the region sufficient to buffer against habitat loss.
- 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 between 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.
- Support efforts to reduce greenhouse gas emissions.



Denali National Park and Preserve is a crown jewel in the nation's National Park system. Photo © Milo Burcham

Bird Conservation Region 5 – Northern Pacific Rainforest

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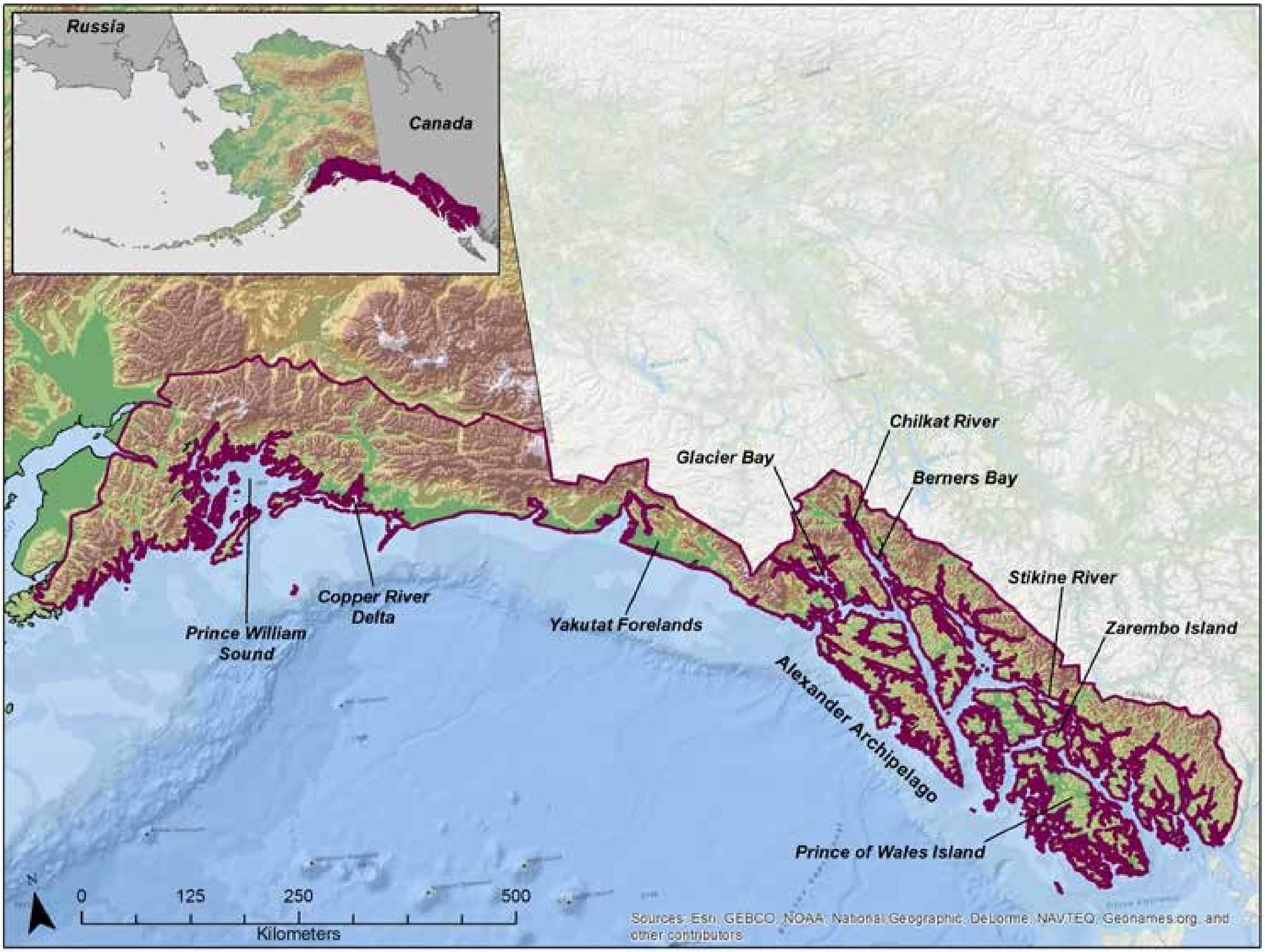

The North Pacific Rainforest Bird Conservation Region (BCR) encompasses temperate rainforests along the coast from Alaska to Northern California. The Alaskan portion encompasses roughly 167,000 km^2 and extends about 1,500 km from the southern half of the Kenai Peninsula, through Prince William Sound, and southward along the coast of southeast Alaska through 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 U.S. Forest Service, U.S. Fish and Wildlife Service, National Park Service, and the State of Alaska. In particular, the Tongass and Chugach National Forests manage over 90,000 km^2.

Habitats range from temperate coniferous rainforests at low elevations to rocky peaks, ice fields, and tundra habitats above treeline. Lush coastal forests of western hemlock (*Tsuga heterophylla*), Sitka spruce (*Picea sitchensis*), western redcedar (*Thuja plicata*), and Alaska cedar (*Callitropis nootkatensis*) blanket lower elevations in southeast 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

At 2,800 km², the Copper River Delta is the largest contiguous wetland on the Pacific coast. Photo © Milo Burcham

Table 9: Seasonal occurrence of species (and subspecies) within the North Pacific Rainforest BCR of Alaska recognized as of continental importance (Watch List or Stewardship species; Rich et al. 2004), a Common Bird in Steep Decline (Berlanga et al. 2010), or of regional stewardship importance. 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	Common Bird in Steep Decline	Regional Stewardship	Seasonal Occurrence
Ruffed Grouse		●		Resident
Spruce Grouse (*isleibi*)			●	Resident
Rock Ptarmigan (*dixoni*)			●	Resident
Sooty Grouse	**Watch List**	●		Resident
Bald Eagle	Stewardship			Resident
Northern Goshawk (*laingi*)			●	Resident
Red-tailed Hawk (*alascensis*)			●	Breeding
Band-tailed Pigeon	**Watch List**			Breeding
Short-eared Owl	**Watch List**	●		Breeding
Black Swift	**Watch List**			Breeding
Rufous Hummingbird	**Watch List**	●		Breeding
Belted Kingfisher		●		Resident
Red-breasted Sapsucker	Stewardship			Breeding
Hairy Woodpecker (*sitkensis*)			●	Resident
Northern Flicker		●		Breeding
Olive-sided Flycatcher	**Watch List**			Breeding
Pacific-slope Flycatcher	Stewardship			Breeding
Steller's Jay	Stewardship			Resident
Horned Lark		●		Breeding
Bank Swallow		●		Breeding
Chestnut-backed Chickadee	Stewardship			Resident
Boreal Chickadee		●		Resident
Pacific Wren	Stewardship			Resident
Ruby-crowned Kinglet (*grinnelli*)			●	Breeding
Hermit Thrush (*osgoodi*)			●	Breeding
Varied Thrush	Stewardship			Resident
Snow Bunting		●		Resident
Wilson's Warbler		●		Breeding
Fox Sparrow (*townsendi, sinuosa, annectens, chilcatensis*)	Stewardship			Resident
Song Sparrow (*kenaiensis, caurina, rufina*)			●	Resident
Lincoln's Sparrow (*gracilis*)			●	Breeding
Golden-crowned Sparrow	Stewardship			Breeding
Rusty Blackbird	**Watch List**			Breeding
Pine Siskin		●		Resident

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 ssp. 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 Alaskan 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 further inland (National Climatic Data Center 2012).

The steep islands and mountainous mainland of this region create ideal conditions for orographic lift and abundant precipitation, which ranges from 120 cm to >250 cm annually (National Climatic Data Center 2012). At lower elevations and latitudes, most of this precipitation occurs as rain, but at higher elevations and in 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 by 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; Heinl and Piston 2009). Overall, 120 species of landbirds, representing 35 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 U.S. that occur nowhere else in Alaska. Approximately 20 of these species are at or near the northerly extent of their ranges, including MacGillivray's Warbler, Band-tailed Pigeon, Western Screech-Owl, Barred Owl, Black Swift, Red-breasted Sapsucker, and Sooty Grouse. A few species, including 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 Northern Goshawk, Pacific Wren, Northwestern Crow, Rufous Hummingbird, Pacific-slope Flycatcher, Chestnut-backed Chickadee, Varied Thrush, Hermit Thrush, and Townsend's Warbler (Gabrielson and Lincoln 1959; Kessler and Kogut 1985; Armstrong 2008; Heinl and Piston 2009). Also conspicuous are the avian icons of traditional Tlingit, Haida, and Tsimshian cultures, the Bald Eagle and Common Raven. Interior species and species that favor deciduous habitats, such as Western Tanager and Warbling Vireo, 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

Comprising the northern extent of the Pacific Avifaunal Biome, BCR 5 supports a large number of species of continental importance, including seven Watch List species and nine Stewardship species (Table 9; Rich et al. 2004). Two of the Watch List species (Sooty Grouse, Rufous Hummingbird) breed regularly and are restricted almost exclusively to BCR 5 within Alaska, and thus are of highest priority in this region. Two other Watch


Pacific Wren

Photo © Milo Burcham

List species (Olive-sided Flycatcher, Rusty Blackbird) breed regularly in BCR 5 but are more abundant in the Northwestern Interior Forest (BCR 4) and thus are of slightly lower priority. The remaining three Watch List species occur rarely within this BCR and are thus of localized priority where they do occur. Among these, the Short-eared Owl, which breeds more commonly in boreal and arctic habitats, is a rare breeder, migrant, and winter visitant primarily along lowland meadows on the mainland of BCR 5; the Band-tailed Pigeon and Black Swift are both at the northern periphery of their ranges in southeast Alaska, where they likely breed in suitable habitat along mainland river systems (Kessel and Gibson 1978, Johnson et al. 2008, Heinl and Piston 2009). BCR 5 also supports significant populations of nine Continental Stewardship species, including seven species that are resident throughout the region or in portions of it (Bald Eagle, Steller's Jay, Chestnut-backed Chickadee, Pacific Wren, Varied Thrush, Fox Sparrow, Golden-crowned Sparrow) and two species that breed in southeast Alaska and migrate south to winter (Red-breasted Sapsucker, Pacific-slope Flycatcher).


Stellar Jay

Photo © Milo Burcham

Twelve species within BCR 5 have been designated as Common Birds in Steep Decline because of significant population declines during the past 40 years (Table 9; Berlanga et al. 2010). In addition to three Watch List species (Short-eared Owl, Rufous Hummingbird, Rusty Blackbird), these include three regularly breeding resident species (Ruffed Grouse, Belted Kingfisher, Pine Siskin), two regularly breeding summer migrants (Northern Flicker, Wilson's Warbler), one resident boreal-forest associate occurring uncommonly in this BCR (Boreal Chickadee), two breeding summer migrants occurring primarily in the northern portions of this BCR (Horned Lark, Bank Swallow), and one species occurring more commonly during winter than as a breeder in this region (Snow Bunting).

Similar to the Aleutian and Bering Sea Islands BCR, the North Pacific Rainforest BCR supports a large number of endemic or nearly endemic subspecies due to its geography, paleohistory, and relatively mild climate (Swarth 1936; Dickerman and Gustafson 1996; Gibson and Kessel 1997; Heinl and Piston 2009). An additional nine species merit regional stewardship status because of the importance of BCR 5 to their restricted subspecific populations (Table 9). 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; Zwickel and Bendell 2005; Montgomerie et al. 2008; Barry and Tallmon 2010). Several taxa that breed in BCR 5 nest only along the coast of southeast Alaska and British Columbia, most of them dark-plumaged races characteristic of the Pacific coastal rainforest (Swarth 1936; Arcese et al. 2002; Weckstein et al. 2002; Heinl and Piston 2009).

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 BCR 5. 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 southeast 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


Great Horned Owl

Photo © Lucas DiCicco

al. 2006; DellaSala 2011). Endemic subspecies, such as the Prince of Wales Spruce Grouse and 'Queen Charlotte' Northern Goshawk, depend on these old growth forest habitats, 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; Van Hemert et al. 2006; Johnson et al. 2008). 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 southeast 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 Warbling Vireo, Northern Waterthrush, MacGillivray's Warbler, Common Yellowthroat, Yellow Warbler, Western Tanager, and Vaux's Swift. 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 Savannah Sparrows, Lincoln's Sparrows, and Rusty Blackbirds.

Other habitats of interest include non-forested alpine areas, which are important for species such as American Pipit and Willow, Rock, 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 Western Screech-Owls, Bald Eagles 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 Northern Harrier and Short-eared Owl (Isleib and

Photo © Milo Burcham

Gray-cheeked Thrush

Kessel 1973) and host mid-summer flowers important for breeding Rufous Hummingbirds.

Three sites in this region—Berners Bay, Chilkat Bald Eagle Preserve, and the Stikine River Delta—have been recognized as Important Bird Areas by the National Audubon Society, based on the presence of landbird species. These state-level IBAs have all been proposed as sites of global or continental significance, but have yet to be confirmed by BirdLife International. Among other priority species, these sites are all recognized for their concentrations of breeding or wintering Bald Eagles.

Primary Conservation Objectives

A few areas within BCR 5 have had formally reported descriptions of local avifauna, 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 southeast Alaska (Johnson et al. 2008). The avifauna of much of BCR 5 has not been documented by ornithologists, however, and most sites have had very little survey or inventory work done (Heinl and Piston 2009).

Landbird conservation in BCR 5 should focus on these primary objectives:

- 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.
- 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.
- 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 determine 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 southeast Alaska and develop measures to mitigate negative effects on landbirds, particularly on 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 and this pressure is most intense in the southern portion of the region. The Tongass National Forest, with 87% of its productive old growth forest still intact, has both the majority of the available timber producing lands (1.4 million ha, compared to 120,000 ha on the Chugach National Forest) and the most active timber sale program, although significant harvest also occurs on Native Corporation lands. Between 2000 and 2006, an average of 900 ha was harvested annually in the Tongass and, as of 2008, approximately 334,000 ha of productive old growth forest had been harvested (USDA Forest Service 2008). Stands with higher volume of larger trees, and at lower elevations, were targeted during past harvests (USDA Forest Service 2008), and thus these important avian habitats have been reduced or degraded disproportionately. Although the rate of harvest has dropped dramatically since the 1990s, the industry could be reinvigorated via growing enthusiasm for certain forest products, such as wood pellets.

Young growth stands that regenerate after clearcut 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). 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). These young growth forests have lower species diversity and support lower densities of snags and the associated cavity-nesting species than old growth forests (Kessler and Kogut 1985; Matsuoka et al. 2012).

Actions

- Support the transition of the timber industry toward harvesting more young growth forest on timber production lands rather than concentrating harvest in the remaining old growth forest.
- 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 birds when designing habitat restoration treatments in young growth stands.
- Maintain and fully implement the reserve system and conservation strategy as described in the Tongass Land and Resource Management Plan (USDA Forest Service 2008) and monitor its effectiveness.
- Participate in the current planning process for revising the Chugach National Forest Plan. Provide information on the value of different forest habitats for landbirds, particularly priority species and subspecies.

Commercial logging is the greatest source of habitat disturbance for birds in this region. Photo © iStock - BenDC

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. Even the highest density sites in BCR 5, however, are still low compared to most areas of the contiguous U.S. Unused or lightly used roads are quickly recolonized by alder and rapidly revert to impassable conditions without regular maintenance.

Actions
- Continue implementation of planned road closures in the Tongass National Forest.
- Design and implement studies to examine the relationship between road densities, hunting pressure, and the impacts of harvest on hunted landbird species.

Introduced and Invasive Species
BCR 5 is on Alaska's leading edge of species' invasions 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 southeast Alaska since 2006 (Heinl and Piston 2009). The cavity-nesting starling is particularly threatening to native forest

Photo © Bill Thompson

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 1993). Starlings and collared doves both appear to be restricted to areas of human development at this time, but their effect on native bird species has not yet been assessed.

Rapid 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 particularly harmful to many neotropical migrant songbirds, has been expanding its range rapidly in association with the clearing of forests (Smith et al. 2000); although cowbirds still occur rarely in BCR 5, they likely now breed in this region (Kessel and Gibson 1978, Heinl and Piston 2009). 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 owls (e.g., Spotted Owls in western U.S.; Kelly et al. 2003; Dugger et al. 2011) and could potentially affect smaller forest owls in BCR 5 (such as Western Screech-Owls, Northern Saw-whet Owls; Kissling and Lewis 2009, 2010). Barred Owls prey on a wide variety of smaller bird species, and may compete with other raptors such as 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 (Nawrocki et al. 2011). 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 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 southeast Alaska, its recent spread to neighboring British Columbia (Morshed et al. 2011) highlights the need for surveillance in this region.

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 or 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 southeast Alaska. Hydroelectric facilities have been proposed all across the region, although many developments in southeast Alaska are small in scale compared with those in other parts of the country. In

Monitoring is needed to assess the effects of invasive songbird species on native landbirds. Photo © Lucas DiCicco 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 lumber. This emerging market may lead to a resurgence of the timber industry in southeast 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. Several large mine developments, such as the Kensington mine near Juneau, are currently in operation and exploration is still underway in some areas. 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 southeast 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. The history of mining in the U.S. justifies concern over potential habitat destruction and contamination that could occur as a result of these developments.

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; dispose of tailings beneath ground to minimize surface footprint; and monitor water quality to ensure that downstream pollution does not affect aquatic and riparian habitats important to landbirds.
- Manage 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). Currently, about 70 million liters (500,000 barrels) of crude oil are 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 (Prince William Sound Regional Advisory Council, 2013, http://www.pwsrcac.org). 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 winter 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 Common Raven, Northwestern 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. Although safeguards against such catastrophic spills were subsequently instituted in the region, landbirds associated with coastal habitats in this region 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 (Dillman et al. 2007). In addition, global climate patterns render this exposed coastal region susceptible to deposition of atmospheric contaminants transported long distances from other source regions (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 U.S. 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, such as the Bald Eagle, and establish protocols for periodic monitoring.
- Determine the sources and effects on landbirds of contaminants found in high concentrations in this region.
- Support efforts to remove debris fields from the shoreline.

Climate Change and Severe Weather

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). 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). Changes in climatic drivers will interact with biophysical factors, such as insects, disease, and invasive species, to effect complex changes on plant succession and wildlife populations (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 southeast 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 (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 southeast 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 Cristensen 2010, 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 2010) 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

Stikine River Delta in southeast Alaska is an area that is vulnerable to rising sea levels. Photo credit TBD

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). During the last 50 years, however, glacier surface elevations have decreased across 95% of the glacier-covered areas analyzed across southeast Alaska and northwest 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 flow, geomorphic processes, and water quality (Moore et al. 2009), with attendant ecological effects on associated community assemblages. Changes in temperature and precipitation will also directly alter the hydrological regimes and nutrient concentrations in streams of southeast Alaska, with potentially complex effects on the anadromous salmonid populations that form a key component of the wetland ecosystems of the region (Bryant 2009). Spawning salmon exert strong influences on many biotic processes in riparian systems, and forests of southeast 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, sea level change is very difficult to predict (Bryant 2009). Increasing temperatures projected to occur may cause drying of wetlands, although this effect may be counterbalanced by future increases in precipitation. 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).

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 and incidentally transmitted to humans, is thought to be limited by temperature and mosquito (Culex tarsalis) abundance (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.

Photo © Ken Archer

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 habitats 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).
- Identify specific areas that are important during breeding, migration, and wintering for priority species, endemic populations, and overall landbird diversity. Develop spatially explicit projections for how such areas may shift under future climate scenarios and create a system of protected areas to buffer populations against rapid climatic changes.
- Evaluate genetic diversity within landbird populations across archipelagoes in the region relative to paleohistorical climatic cycles to build an understanding of potential impacts of contemporary climate change on extant populations.
- Conduct long-term monitoring across the region to assess the status and distribution of continentally and regionally important landbird populations relative to climatic changes.
- Track range expansion and monitor ecological effects of more southerly species of birds, mammals, plants, insects, and pathogens moving into southeast Alaska.
- Establish or maintain patterns of connectivity for priority species between breeding areas, migration corridors, and wintering areas to understand how climatic changes in other portions of their ranges may influence population trajectories.
- Educate the public to promote understanding of potential impacts of climate change at the ecosystem level.
- Support efforts to reduce greenhouse gas emissions.

Literature Cited

Alaback, P.B. 1982. Dynamics of understory biomass in Sitka spruce–western hemlock forests of southeast Alaska. Ecology 63: 1932-1948.

Alaska Department of Commerce. 2007. Alaska Visitor Statistics Program: Alaska Visitor Volume and Profile – Fall/Winter 2006-07. Alaska Office of Tourism Development, Anchorage, AK. 105 pp. [available at: http://www.dced.state.ak.us/oed/toubus/research.htm]

Alaska Department of Fish & Game (ADFG). 2006. Our Wealth Maintained: A Strategy for Conserving Alaska's Diverse Wildlife and Fish Resources. Alaska Department of Fish and Game, Juneau, AK. 842 pp. [available at: http://www.sf.adfg.state.ak.us/statewide/ngplan/NG_outline.cfm]

Alaska Department of Fish & Game (ADFG). 2011a. Protected Areas [Online]. Alaska Department of Fish & Game. [available at: http://www.adfg.alaska.gov/index.cfm?adfg=protectedareas.main]

Alaska Department of Fish & Game (ADFG). 2011b. About Us [Online]. Alaska Department of Fish & Game. [available at: http://www.adfg.alaska.gov/index.cfm?adfg=about.main]

Alaska Department of Transportation & Public Facilities (ADOTPF). 2013. Roads to Resources Program. Alaska Department of Transportation & Public Facilities, Juneau, AK. 17 pp. [available at: http://www.dot.alaska.gov/comm/documents/R2R_Joint_Transp_Comm_012213.pdf]

Alaska Earthquake Information Center (AEIC). 2006. Alaska Earthquake Facts [Online]. Geophysical Institute, University of Alaska-Fairbanks [available at: http://www.aeic.alaska.edu/html_docs/faq.html#How_many_earthquakes_do_we_have_in]

Alaska Energy Authority and Renewable Energy Alaska Project (AEA & REAP). 2013. Renewable Energy Atlas of Alaska: A Guide to Alaska's Clean, Local, and Inexhaustible Energy Resources. Alaska Energy Authority and Renewable Energy Alaska Project, Anchorage, Alaska. 36 pp. [available at: http://www.akenergyauthority.org/PDF%20files/2013-RE-Atlas-of-Alaska-FINAL.pdf]

Alaska Interagency Coordination Center (AICC). 2010. Alaska Interagency Wildland Fire Management Plan 2010. State of Alaska, Juneau, AK, and U.S. Department of the Interior, Washington, DC. 57 pp. [available at: http://fire.ak.blm.gov/content/admin/awfcg/C.%20Documents/Alaska%20Interagency%20Wildland%20Fire%20Management%20Plan/Alaska%20Interagency%20Wildland%20Fire%20Managment%20Plan%202010.pdf]

Alaska Shorebird Group. 2008. Alaska Shorebird Conservation Plan. Version II. Alaska Shorebird Group, Anchorage, AK. 91 pp. [available at: http://alaska.fws.gov/mbsp/mbm/shorebirds/plans.htm]

Albert, D.M. & Schoen, J.W. 2013. Use of historical logging patterns to identify disproportionately logged ecosystems within temperate rainforests of southeastern Alaska. Conservation Biology 27: 774-784.

Allen, J.L., Wesser, S., Markon, C.J. & Winterberger, K.C. 2006. Stand and landscape level effects of a major outbreak of spruce beetles on forest vegetation in the Copper River Basin, Alaska. Forest Ecology & Management 227: 257-266.

Altman, B. & Sallabanks, R. 2000. Olive-sided Flycatcher (Contopus cooperi). The Birds of North America, no. 502 (A. Poole & F. Gill, Eds.). The Birds of North America, Inc., Philadelphia, PA. [available at: http://bna.birds.cornell.edu/bna/species/502]

AMAP. 1998. AMAP Assessment Report: Arctic Pollution Issues. Arctic Monitoring & Assessment Programme (AMAP), Oslo, Norway. 871 pp. [available at: http://amap.no/documents/index.cfm?dirsub=/AMAP%20Assessment%20Report%20-%20Arctic%20Pollution%20Issues]

AMAP. 2011. Combined Effects of Selected Pollutants and Climate Change in the Arctic Environment. [R. Kallenborn, K. Borgå, J.H. Christensen, M. Dowdall, A. Evenset, J.Ø. Odland, A. Ruus, K. Aspmo Pfaffhuber, J. Pawlak, and L.-O. Reiersen.] AMAP Technical Report No. 5. Arctic Monitoring and Assessment Programme, Oslo. 108 pp. [available at: http://www.amap.no/documents/doc/combined-effects-of-selected-pollutants-and-climate-change-in-the-arctic-environment/747]

AMAP/UNEP. 2013. Technical Background Report for the Global Mercury Assessment 2013. Arctic Monitoring and Assessment Programme, Oslo, Norway/UNEP Chemicals Branch, Geneva, Switzerland. 269 pp. [available at: http://www.amap.no/documents/doc/technical-background-report-for-the-global-mercury-assessment-2013/848]

Ambrose, R.E., Matz, A., Swem, T. & Bente, P. 2000. Environmental contaminants in American and Arctic Peregrine Falcon eggs in Alaska, 1979-1995. Unpublished Technical Report NAES-TR-00-02. U.S. Fish & Wildlife Service, Fairbanks, AK. 67 pp. [available at: http://www.fws.gov/alaska/fisheries/contaminants/pdf/Peregrine%20Report.pdf]

American Bird Conservancy. 2012. List of the Birds of the United States with Conservation Rankings. American Bird Conservancy, The Plains, VA. [available at: http://www.abcbirds.org/abcprograms/science/conservationchecklist/index.html]

Andres, B.A. & Browne, B.T. 2007. The Birds of Yakutat, Alaska. Technical Paper R10-TP-141. U.S. Forest Service - Alaska Region, Juneau, AK. 54 pp.

Andres, B.A., Browne, B.T. & Brann, D.L. 2005. Composition, abundance, and timing of post-breeding migrant landbirds at Yakutat, Alaska. Wilson Bulletin 117: 270-279.

Andres, B.A., Stotts, M.J. & Stotts, J.M. 2004. Breeding birds of Research Natural Areas in southeastern Alaska. Northwestern Naturalist 85: 95-103.

Anthony, R.G., Miles, A.K., Estes, J.A. & Isaacs, F.B. 1999. Productivity, diets, and environmental contaminants in nesting Bald Eagles from the Aleutian Archipelago. Environmental Toxicology & Chemistry 18: 2054-2062.

Anthony, R.G., Miles, A.K., Ricca, M.A. & Estes, J.A. 2007. Environmental contaminants in Bald Eagle eggs from the Aleutian Archipelago. Environmental Toxicology & Chemistry 26: 1843-1855.

Arcese, P., Sogge, M.K., Marr, A.B. & Patten, M.A. 2002. Song Sparrow (Melospiza melodia). The Birds of North America Online (A. Poole, Ed.). Cornell Lab of Ornithology, Ithaca, NY. [available at: http://bna.birds.cornell.edu/bna/species/704]

Arctic Climate Impact Assessment (ACIA). 2004. Impacts of a Warming Arctic: Arctic Climate Impact Assessment. ACIA Overview Report. Cambridge University Press, New York. 140 pp. [available at: http://www.amap.no/documents/doc/impacts-of-a-warming-arctic-2004/786]

Arctic Climate Impact Assessment (ACIA). 2005. Arctic Climate Impact Assessment. Cambridge University Press, New York. 1,042 pp. [available at: http://www.acia.uaf.edu/pages/scientific.html]

Arctic Council. 2009. Arctic Marine Shipping Assessment 2009 Report. Second printing. Arctic Council, Tromsø, Norway. 189 pp. [available at: http://www.arctic.gov/publications/AMSA.html]

Arctic Monitoring & Assessment Programme. 1998. Arctic Pollution Issues[Online]. [available at: http://amap.no]

Arctic Monitoring and Assessment Programme (AMAP). 2005. AMAP Assessment 2002: Heavy Metals in the Arctic. Arctic Monitoring and Assessment Programme, Oslo, Norway. 281 pp.

Arctic National Wildlife Refuge (ANWR). 2010. Bird List [Online]. U.S. Fish & Wildlife Service. [available at: http://arctic.fws.gov/pdf/birdlist.pdf]

Armstrong, R.H. 2008. Guide to the Birds of Alaska - 5th edition. Alaska Northwest Books, Portland, OR. 360pp.

Arendt, A.A., Echelmeyer, K.A., Harrison, W.D., Lingle, C.S. & Valentine, V.B. 2002. Rapid wastage of Alaska glaciers and their contribution to rising sea level. Science 297: 382-386

Avery, M.L. 1995. Rusty Blackbird (Euphagus carolinus). The Birds of North America, no. 200 (A. Poole & F. Gill, Eds.). The Academy of Natural Sciences, Philadelphia, PA, and the American Ornithologists' Union, Washington, DC. [available at: http://bna.birds.cornell.edu/bna/species/200]

Bailey, E.P. 1974. Winter banding of passerines on the Alaska Peninsula. Bird-Banding 45: 307-314.

Bailey, E.P. 1993. Introduction of Foxes to Alaskan Islands: History, Effects on Avifauna, and Eradication. U.S. Fish & Wildlife Service Resource Publication 193. U.S. Department of Interior, Washington DC. 62 pp.

Banks, R.C., Cicero, C., Dunn, J.L., Kratter, A.W., Rasmussen, P.C., Remsen Jr., J.V., Rising, J.D. & Stotz, D.F. 2006. Forty-seventh supplement to the American Ornithologists' Union check-list of North American birds. Auk 123: 926–936.

Barnard, W.H., Mettke-Hofmann, C. & Matsuoka, S.M. 2010. Prevalence of hematozoa infections among breeding and wintering Rusty Blackbirds. Condor 112: 849-853.

Barrett, T.M. & Christensen, G.A. (Eds.). 2011. Forests of Southeast and South-central Alaska, 2004-2008. General Technical Report PNW-GTR-835. U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station, Portland, OR. 155 pp.

Barry, P., & Tallmon, D.A. 2010. Genetic differentiation of a subspecies of Spruce Grouse (Falcipennis canadensis isleibi) in an endemism hotspot. Auk 127:617-625.

Beck, P.S.A., Juday, G.P., Alix, C., Barber, V.A., Winslow, S.E., Sousa, E.E., Heiser, P., Herriges, J.D. & Goetz, S.J. 2011. Changes in forest productivity across Alaska consistent with biome shift. Ecology Letters 14: 373–379.

Beier, C.M., Sink, S.E., Hennon, P.E., D'Amore, D.V. & Juday, G.P. 2008. Twentieth-century warming and the dendroclimatology of declining yellow-cedar forests in southeastern Alaska. Canadian Journal of Forest Research 38: 1319-1334.

Benson, A.-M. & Winker, K. 2001. Timing of breeding range occupancy among high-latitude passerine migrants. Auk 118: 513-519.

Benson, A.-M., Pogson, T.H. & Doyle, T.J. 2000. Updated geographic distribution of eight passerine species in central Alaska. Western Birds 31: 100-105.

Benson, A.-M., Andres B.A., Johnson W.N., Savage S. & Sharbaugh, S.M. 2006. Differential timing of Wilson's Warbler migration in Alaska. Wilson Journal of Ornithology 118: 547-551.

Berg, E.E., Henry, J.D., Fastie, C.L., DeVolder, A.D. & Matusoka, S.M. 2006. Spruce beetle outbreaks on the Kenai Peninsula, Alaska, and Kluane National Park and Reserve, Yukon Territory: Relationship to summer temperatures and regional differences in disturbance. Forest Ecology & Management 227: 219-232.

Berlanga, H., Kennedy, J.A., Rich, T.D., Arizmendi, M.C., Beardmore, C.J., Blancher, P J., Butcher, G.S., Couturier, A.R., Dayer, A.A., Demarest, D.W., Easton, W.E., Gustafson, M., Inigo-Elias, E., Krebs, E.A., Panjabi, A.O., Rodriguez Contreras, V., Rosenberg, K.V., Ruth, J.M., Santana Castellon, E., Ma. Vidal, R., & Will, T. 2010. Saving Our Shared Birds: Partners in Flight Tri-National Vision for Landbird Conservation. Cornell Lab of Ornithology, Ithaca, NY. 52 pp. [available at: http://www.savingoursharedbirds.org]

Bettinetti R., Quadroni, S., Galassi, S., Bacchetta, R., Bonardi, L. & Vailati, G. 2008. Is meltwater from Alpine glaciers a secondary DDT source for lakes? Chemosphere 73: 1027-1031.

Blais, J.M., Schindler, D.W., Muir, D.C.G., Sharp, M., Donald, D., Lafrenière, M., Braekevelt, E. & Strachan, W.M.J. 2001. Melting glaciers: a major source of persistent organochlorines to subalpine Bow Lake in Banff National Park, Canada. AMBIO 30: 410-415. [available at: http://dx.doi.org/10.1579/0044-7447-30.7.410]

Blancher, P. J., Rosenberg, K.V., Panjabi, A.O., Altman, B., Bart, J., Beardmore, C.J., Butcher, G.S., Demarest, D., Dettmers, R., Dunn, E.H., Easton, W., Hunter, W.C., Iñigo-Elias, E.E., Pashley, D.N., Ralph, C.J., Rich, T.D., Rustay, C.M., Ruth, J.M. & Will, T.C. 2007. Guide to the Partners in Flight Population Estimates Database.

Version: North American Landbird Conservation Plan 2004. Partners in Flight Technical Series No 5. Partners in Flight, City??, State??. 26 pp. [available at: http://www.partnersinflight.org]

Bockheim J.G., O'Brien, J.D., Munroe, J.S. & Hinkel, K.M.. 2003. Factors Affecting the Distribution of Populus balsamifera on the North Slope of Alaska, USA. Arctic, Antarctic, and Alpine Research 35: 331-340.

Booms, T.L., Huettmann, F. & Schempf, P.F. 2010. Gyrfalcon nest distribution in Alaska based on a predictive GIS model. Polar Biology 33: 347-358.

Booms, T.L., Lindgren, M. & Huettmann, F. 2011. Linking Alaska's predicted climate, Gyrfalcon, and ptarmigan distributions in space and time: a unique 200-year perspective. Pp. 177–190 in Gyrfalcons and Ptarmigan in a Changing World (R.T. Watson, T.J. Cade, M. Fuller, G. Hunt & E. Potapov, Eds.). The Peregrine Fund, Boise, ID. [available at: http://peregrinefund.org/subsites/conference-gyr/proceedings/116-Booms.pdf]

Booms, T., Schempf, P., McCaffery, B., Lindberg, M.S. & Fuller, M. 2010. Detectability of cliff-nesting raptors during helicopter and fixed-wing surveys in western Alaska. Journal of Raptor Research 44: 175-187.

Boon, A.C.M., Sandbulte, M.R., Seiler, P., Webby, R.J., Songserm, T., Guan, Y. & Webster, R.G. 2007. Role of terrestrial wild birds in ecology of influenza A virus (H5N1). Emerging Infectious Diseases 13: 1720-1724.

Boreal Partners in Flight Working Group. 1999. Landbird Conservation Plan for Alaska Biogeographic Region, Version 1.0. Unpublished report. U.S. Fish and Wildlife Service, Anchorage, AK. 116 pp. [available at http://alaska.usgs.gov/science/biology/bpif/conservation/conservation.pdf]

Bowman, T.D & Schempf, P.F. 1999. Detection of Bald Eagles during aerial surveys in Prince William Sound, Alaska. Journal of Raptor Research 33: 299-304.

Brewer R. 2006. The Selendang Ayu Oil Spill: Lessons Learned. Conference proceedings August 16-19, 2005 – Unalaska, Alaska. Alaska Sea Grant College Program, University of Alaska - Fairbanks, Fairbanks, AK. 45 pp.

Briskie, J.V. 1993. Smith's Longspur (Calcarius pictus). In The Birds of North America, no. 34 (A. Poole, P. Stettenheim & F. Gill, Eds.). The Academy of Natural Sciences, Philadelphia, PA, and the American Ornithologists' Union, Washington, DC. [available at: http://bna.birds.cornell.edu/bna/species/034]

Bryant, M.D. 2009. Global climate change and potential effects on Pacific salmonids in freshwater ecosystems of southeast Alaska. Climatic Change 95: 169-193.

Buckelew, S., Byrd, V., Howald, G., MacLean, S. & Sheppard, J. 2011. Preliminary Ecosystem Response Following Invasive Norway Rat Eradication on Rat Island, Aleutian Islands, Alaska. Pp. 275-279 in Island Invasives: Eradication and Management. (C.R. Veitch, M.N. Clout & D.R. Towns, Eds). IUCN, Gland, Switzerland.

Bureau of Land Management (BLM). 2012. National Petroleum Reserve–Alaska. Final Integrated Activity Plan/Environmental Impact Statement. Volume 2. U.S. Department of Interior, Bureau of Land Management, Anchorage, AK. 683 pp. [available at: https://www.blm.gov/epl-front-office/projects/nepa/5251/41003/43153/Vol1_NPR-A_Final_IAP_FEIS.pdf]

Butler, R. W. 2000. Stormy seas for some North American songbirds: Are declines related to severe storms during migration? Auk 117: 518-522.

Byrd G.V. & Daniel, L. 2008. Preassessment Data Report No. 9: Bird Species Found Oiled, December 2004-January 2005, at Unalaska Island Following the M/V Selendang Ayu Oil Spill. U.S. Fish & Wildlife Service, Alaska Maritime National Wildlife Refuge, Homer, AK. 11 pp.

Byrd, G.V., Reynolds, J.H. & Flint, P.L. 2009. Persistence rates and detection probabilities of bird carcasses on beaches of Unalaska Island, Alaska, following the wreck of the M/V Selendang Ayu. Marine Ornithology 37: 197-204.

Cabe, P.R. 1993. European Starling (Sturnus vulgaris), The Birds of North America Online (A. Poole, Ed.). Cornell Lab of Ornithology, Ithaca, NY. [available at: http://bna.birds.cornell.edu/bna/species/048]

Cahill, A.E., Aiello-Lammens, M.E., Fisher-Reid, M.C., Hua, X., Karanewsky, C.J., Ryu, H.Y., Sbeglia, G.C., Spagnolo, F., Waldron, J.B., Warsi, O. & Wiens, J.J. 2013. How does climate change cause extinction? Proceedings of Royal Society B 280: 20121890. [available at: http://dx.doi.org/10.1098/rspb.2012.1890]

Calvert, A.M., Bishop, C.A., Elliot, R.D., Krebs, E.A., Kydd, T.M., Machtans, C.S. & Robertson, G.J. 2013. A synthesis of human-related avian mortality in Canada. Avian Conservation and Ecology 8(2): 11. [available at: http://www.ace-eco.org/vol8/iss2/art11/]

Carlson, M.L. & Shephard, M. 2007. Is the spread of non-native plants in Alaska accelerating? Pp. 117-133 in Meeting the Challenge: Invasive Plants in Pacific Northwest Ecosystems (T.B. Harrington & S.H. Reichard, Eds.). USDA Forest Service, Pacific Northwest Research Station, General Technical Report PNW-GTR-694, Portland, OR.

Cecil, J., Sanchez, C., Stenhouse, I.J. & Hartzler, I. 2009. United States of America. Pp. 369-382 in Important Bird Areas Americas – Priority Sites for Biodiversity Conservation (C. Devenish, D.F. Diaz Fernández, R.P. Clay, I. Davidson & I. Yépez Zabala, Eds.). BirdLife Conservation Series no. 16. BirdLife International, Quito, Ecuador. [available at: http://www.birdlife.org/action/science/sites/american_ibas/americas-ibas-downloads.html]

Chapin III, F.S., Yarie, J., Van Cleve, K. & Viereck, L.A. 2006b. The conceptual basis of LTER studies in the Alaskan boreal forest. Pp. 3-11 in Alaska's Changing Boreal Forest (F.S. Chapin III, M.W. Oswood, K. Van Cleve, L.A. Viereck & D.L. Verbyla, Eds.). Oxford University Press, New York, NY.

Chapin III, F.S., Hollingsworth, T., Murray, D.F., Viereck, L.A. &

Walker, M.D. 2006a. Floristic diversity and vegetation distribution in the Alaskan boreal forest. Pp. 81-99 in Alaska's Changing Boreal Forest (F.S. Chapin III, M.W. Oswood, K. Van Cleve, L.A. Viereck & D.L Verbyla, Eds.). Oxford University Press, New York, NY.

Chapin III, F.S., Callaghan, T.V., Bergeron, Y., Fukuda, M., Johnstone, J.F., Juday, G. & Zimov, S.A. 2004. Global change and the boreal forest: Thresholds, shifting states or gradual change? Ambio 33: 361-365.

Chapin III, F.S., McGuire, A.D., Ruess, R.W., Hollingsworth, T.N., Mack, M.C., Johnstone, J.F., Kasischke, E.S., Euskirchen, E.S., Jones, J.B., Jorgenson, M.T., Kielland, K., Kofinas, G.P., Turetsky, M.R., Yarie, J., Lloyd, A.H. & Taylor, D.L. 2010. Resilience of Alaska's boreal forest to climatic change. Canadian Journal of Forest Research 40: 1360-1370.

Christensen, J.H., Hewitson, B., Busuioc, A., Chen, A., Gao, X., Held, I., Jones, R., Kolli, R.K., Kwon, W.-T., Laprise, R., Magaña Rueda, V., Mearns, L., Menéndez, C.G., Raisanen, J., Rinke, A., Sarr, A. & Whetton, P. 2007. Regional climate projections. Pp. 847-940 in Climate change 2007: The physical science basis. Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change, (S. Solomon, D. Qin, M. Manning, Z. Chen, M. Marquis, K.B. Averyt, M. Tignor & H.L. Miller, Eds.). Cambridge University Press, New York, NY. [available at: https://www.ipcc.ch/pdf/assessment-report/ar4/wg1/ar4-wg1-chapter11.pdf]

Clark, R.J. 1975. A field study of the Short-eared Owl (Asio flammeus) in North America. Wildlife Monographs 47: 1-67.

Collins, W.B. & Schwartz, C.C. 1998. Logging in Alaska's boreal forest: creation of grasslands or enhancement of moose habitat. Alces 34: 355-374.

Cook, J.A., Dawson, N.G. & MacDonald, S.O. 2006. Conservation of highly fragmented systems: the north temperate Alexander Archipelago. Biological Conservation 133: 1-15.

Cooper, B.A. & Ritchie, R.J. 1995. The altitude of bird migration in east-central Alaska: a radar and visual study. Journal of Field Ornithology 66: 590-608.

Coordinated Bird Monitoring Working Group. 2004. Monitoring Avian Conservation: Rationale, Design, and Coordination. Report prepared for the International Association of Fish and Wildlife Agencies. 28 pp. [available at: http://www.drbradandres.com/uploads/MonitorCoordMonWorkGrp2004.pdf]

Corbett, J.J., Lack, D.A., Winebrake, J.J., Harder, S., Silberman, J.A. & Gold, M. 2010. Arctic shipping emissions inventories and future scenarios. Atmospheric Chemistry and Physics 10: 9689.

COSEWIC. 2000. COSEWIC Assessment and Update Status Report on the Northern Goshawk Laingi Subspecies (Accipiter gentilis laingi) in Canada. Committee on the Status of Endangered Wildlife in Canada, Ottawa, ON. 41 pp. [available at: http://www.sararegistry.gc.ca/virtual_sara/files/cosewic/sr_northern_goshawk_e.pdf]

COSEWIC. 2007. COSEWIC Assessment and Status Report on the Olive-sided Flycatcher (Contopus cooperi) in Canada. Committee on the Status of Endangered Wildlife in Canada, Ottawa, ON. 32 pp. [available at: http://www.sararegistry.gc.ca/virtual_sara/files/cosewic/sr_olivesided_flycatcher_0808_e.pdf].

COSEWIC. 2008. COSEWIC Assessment and Update Status Report on the Short-eared Owl Asio flammeus in Canada. Committee on the Status of Endangered Wildlife in Canada. Ottawa, ON. 30 pp. [available at: http://www.sararegistry.gc.ca/virtual_sara/files/cosewic/sr_shorteared_owl_0808_e.pdf]

Cotter, P.A. & Andres, B.A. 2000. Breeding bird habitat associations on the Alaska Breeding Bird Survey. U.S. Geological Survey, Biological Resources Division Information and Technology Report USGS/BRD/ITR-2000-0010. 53 pp. [available from: National Technical Information Service, 5285 Port Royal Road, Springfield, VA 22161]

Crick, H.Q.P. 2004. The impact of climate change on birds. Ibis 146 (suppl. 1): 48-56.

Crow, J.H. 1971. Earthquake-initiated Changes in the Nesting Habitat of the Dusky Canada Goose. Pp. 130-136 in The Great Alaska Earthquake of 1964: Biology (Committee on the Alaska Earthquake, Division of Earth Sciences, National Research Council). National Academy of Sciences, Washington, DC.

Cumming, S.G., Lefevre, K., Bayne, E., Fontaine, T., Schmiegelow, F. & Song, S.J. 2010. Toward conservation of Canada's boreal forest avifauna: Design and application of ecological models at continental extents. Avian Conservation & Ecology 5: 8. [available at: http://www.ace-eco.org/vol5/iss2/art8/]

DeGange, A. 2010. U.S. Geological Survey Western Region: Kasatochi Volcano Coastal and Ocean Science. U.S. Geological Survey Fact Sheet 2010-3028. U.S. Geological Survey, Anchorage, AK. [available at: http://pubs.usgs.gov/fs/2010/3028]

DellaSala, D.A. (Ed.). 2011. Temperate and Boreal Rainforests of the World: Ecology and Conservation. Island Press, NY. 294 pp.

Dellasala, D.A., Hagar, J.C., Engel, K.A., McComb, W.C., Fairbanks, R.L. & Campbell, E.G. 1996. Effects of silvicultural modifications of temperate rainforest on breeding and wintering bird communities, Prince of Wales Island, southeast Alaska. Condor 98: 706-721.

DeSante, D.F., Kaschube, D.R., Sillett, T.S., Matsuoka, S.M. & Schmutz, J.A. 2004. Evaluating the First 10 Years of the Monitoring Avian Survival and Productivity Program in Alaska and Adjacent Canada. Unpublished final report. Institute for Bird Populations, Point Reyes Station, CA. ??? pp.

DeWilde, L. & Chapin III, F.S. 2006. Human impacts on the fire regime of interior Alaska: interactions among fuels, ignition sources, and fire suppression. Ecosystems 9: 1342-1353.

Dickerman, R.W. & Gustafson, J. 1996. The Prince of Wales Spruce Grouse: a new subspecies from southeastern Alaska. Western Birds 27: 41-47.

Dillman, K.L., Geiser, L.H. & Brenner, G. 2007. Air quality biomonitoring with lichens: the Tongass National Forest. U.S. Department of Agriculture, Forest Service, Tongass National Forest, Petersburg, AK. ??? pp.

Donlin Gold. 2012. Donlin Gold: Project Summary. Donlin Gold, Anchorage, AK. 43 pp. [available at: http://www.donlingold.com/wordpress/wp-content/uploads/2011/01/Donlin_PD_Book_2012.pdf]

Dugger, K.M., Anthony, R.G. & Andrews, L.S. 2011. Transient dynamics of invasive competition: Barred Owls, Spotted Owls, habitat, and the demons of competition present. Ecological Applications 21: 2459-2468.

Dunn, E.H., Altman, B.L., Bart, J., Beardmore, C.J., Berlanga, H., Blancher, P.J., Butcher, G.S., Demarest, D.W., Dettmers, R., Hunter, W.C., Iñigo-Elias, E.E., Panjabi, A.O., Pashley, D.N., Ralph, C.J., Rich, T.D., Rosenberg, K.V., Rustay, C.M., Ruth, J.M. & Will, T.C. 2005. High Priority Needs for Range-wide Monitoring of North American Landbirds. Partners in Flight Technical Series, no. 2. Partners in Flight, City??, State??. [available at: http://www.partnersinflight.org/pubs/ts/02-MonitoringNeeds.pdf]

Ebbert, S.E. & Byrd, G.V. 2002. Eradications of Invasive Species to Restore Natural Biological Diversity of Alaska Maritime National Wildlife Refuge. Pp 102-109 in Turning the Tide: The Eradication of Invasive Species. (C.R. Veitch & M.N. Clout, eds). Occasional Paper of the IUCN Species Survival Commission No. 27. IUCN, Gland, Switzerland, and Cambridge, UK.

Edmonds, S.T., Evers, D.C., Cristol, D., Mettke-Hofmann, C., Powell, L.L., McGann, A.J., Armiger, J.W., Lane, O.P., Tessler, D.F., Newell, P., Heyden, K. & O'Driscoll, N.J. 2010. Geographic and seasonal variation in mercury exposure of the declining Rusty Blackbird. Condor 112: 789-799.

Edwards, M.E., Brubaker, L.B., Lozhkin, A.V. & Anderson, P.M. 2005. Structurally novel biomes: A response to past warming in Beringia. Ecology 86: 1696-1703.

Efford, M.G. & Dawson, D.K. 2009. Effect of distance-related heterogeneity on population size estimates from point counts. Auk 126: 100-111.

Elliott, K. 2006. Declining numbers of Western Screech-Owl in the lower mainland of British Columbia. British Columbia Birds 14: 2-11.

Emison, W.B. & White, C.M. 1988. Foods and weights of the Rock Ptarmigan on Amchitka, Aleutian Islands, Alaska. Great Basin Naturalist 48: 533-540.

Erickson, W.P., Johnson, G.D. & Young Jr., D.P. 2005. A summary and comparison of bird mortality from anthropogenic causes with an emphasis on collisions. Pp. 1029-1042 in Bird Conservation Implementation and Integration in the Americas: Proceedings of the Third International Partners in Flight Conference. 2002 March 20-24; Asilomar, California, Vol. 2 (C.J. Ralph & T.D. Rich, Eds.). General Technical Report PSW-GTR-191. USDA Forest Service, Pacific Southwest Research Station, Albany, CA. [available at: http://www.fs.fed.us/psw/publications/documents/psw_gtr191/]

Erwin, C.A., Rozell, K.B. & DeCicco, L.H. 2004. Update on the status and distribution of Wilson's Phalarope and Yellow-bellied Sapsucker in Alaska. Western Birds 35: 42-44.

Evers, D.C., Burgess, N.M., Champoux, L., Hoskins, B., Major, A., Goodale, W.M., Taylor, R.J., Poppenga, R. & Daigle, T. 2005. Patterns and interpretation of mercury exposure in freshwater avian communities in northeastern North America. Ecotoxicology 14: 193-221.

Faaborg, J., Holmes, R.T., Anders, A.D., Bildstein, K.L., Dugger, K.M., Gauthreaux, S.A., Heglund, P., Hobson, K.A., Jahn, A.E., Johnson, D.H., Latta, S.C., Levey, D.J., Marra, P.P., Merkord, C.L., Nol, E., Rothstein, S.I., Sherry, T.W., Sillett, T.S., Thompson, F.R. & Warnock, N. 2010a. Recent advances in understanding migration systems of New World landbirds. Ecological Monographs 80: 3-48.

Faaborg, J., Holmes, R.T., Anders, A.D., Bildstein, K.L., Dugger, K.M., Gauthreaux, S.A., Heglund, P., Hobson, K.A., Jahn, A.E., Johnson, D.H., Latta, S.C., Levey, D.J., Marra, P.P., Merkord, C.L., Nol, E., Rothstein, S.I., Sherry, T.W., Sillett, T.S., Thompson, F.R. & Warnock, N. 2010b. Managing migratory landbirds in the New World: Do we know enough? Ecological Applications 20: 398-418.

Fay, F.H. & Cade, T.J. 1959. An ecological analysis of the avifauna of St. Lawrence Island, Alaska. University of California Publications in Zoology 63: 73-150.

Flannigan, M.D., Amiro, B.D., Logan, K.A., Stocks, B.J. & Wotton, B.M. 2005. Forest fires and climate change in the 21st Century. Mitigation and Adaptation Strategies for Global Change 11: 847-859.

Fritts, E.I. 2007. Wildlife and People at Risk: A Plan to Keep Rats Out of Alaska. Alaska Department of Fish & Game, Juneau, AK. 190 pp.

Gabrielson, I.N. & Lincoln, F.C. 1959. The Birds of Alaska. Stackpole Co., Harrisburg, PA, and Wildlife Management Institute, Washington, DC. 922 pp.

Gende, S.M. & Willson, M.F. 2001. Passerine densities in riparian forests of southeast Alaska: potential effects of anadromous spawning salmon. Condor 103: 624-629

Gende, S.M., Willson, M.F. & Jacobson, M. 1997. Reproductive success of Bald Eagles (Haliaeetus leucocephalus) and its association with habitat or landscape features and weather in southeast Alaska. Canadian Journal of Zoology 75: 1595-1604.

Gende, S.M., Willson, M.F., Marston, B.H., Jacobson, M.J. & Smith W.P. 1998. Bald Eagle nesting density and success in relation to distance from clearcut logging in southeast Alaska. Biological Conservation 83: 121-126.

Gibson, D.D. 2011. Nesting Shorebirds and Landbirds of Interior Alaska. Unpublished report to U.S. Geological Survey, Alaska Science Center, Anchorage, AK. 231 pp.

Gibson D.D. & Byrd, G.V. 2007. Birds of the Aleutian Islands, Alaska. Series in Ornithology No. 1. Nuttall Ornithological Club, Cambridge, MA, and American Ornithologists' Union, Washington, DC.

Gibson, D.D. & Kessel, B. 1992. Seventy-four new avian taxa documented in Alaska 1976–1991. Condor 94: 454-467.

Gibson, D.D. & Kessel, B. 1997. Inventory of the species and subspecies of Alaska birds. Western Birds 28: 45-95.

Gibson, D.D., DeCicco, L.H., Gill Jr., R.E., Heinl, S.C., Lang, A.G., Tobish Jr., T.G., & Withrow, J.J. 2014. Checklist of Alaska Birds, 20th edition. University of Alaska Museum, Fairbanks, AK. 14 pp. [available at: http://www.universityofalaskamuseumbirds.org/products/checklist.pdf]

Gill Jr., R.E., Petersen, M.R. & Jorgenson, P.D. 1981. Birds of the Northcentral Alaska Peninsula. Arctic 34: 286-306.

Greenberg, R., Demarest, D.W., Matsuoka, S.M., Mettke-Hofmann, C., Avery, M.L., Blancher, P.J., Evers, D., Hamel, P.D., Hobson, K.A., Luscier, J., Niven, D.K., Powell, L.L & Shaw, D. 2011. Understanding declines in Rusty Blackbirds. Studies in Avian Biology: in press.

Greenberg, R., Demarest, D.W., Matsuoka, S.M., Mettke-Hofmann, C., Evers, D.C., Hamel, P.B., Luscier, J. Powell, L.L., Shaw, D., Avery, M.L., Hobson, K.A., Blancher, P.J. & Niven, D.K. 2011. Understanding declines in Rusty Blackbirds. Pp. 107-126 in J.V. Wells (Ed.). Boreal birds of North America: a hemispheric view of their conservation links and significance. Studies in Avian Biology (no. 41), University of California Press, Berkeley, CA.

Greenberg, R. & Droege, S. 1999. On the decline of the Rusty Blackbird and the use of ornithological literature to document long-term population trends. Conservation Biology 13: 553-559.

Greenberg, R. & Matsuoka, S.M. 2010. Rusty Blackbird: Mysteries of a declining species. Condor 112: 770-777.

Guldager, N. 2004. Assess Landbird Diversity, Density and Habitat within Gates of the Arctic National Park and Preserve. Unpublished Progress Report – PMIS #98917. National Park Service, Fairbanks, AK. 14 pp.

Guthrie, R.D. 2004. Radiocarbon evidence of mid-Holocene mammoths stranded on an Alaskan Bering Sea island. Nature 429: 746-749.

Hailman, J.P. & Haftorn, S. 1995. Gray-headed Chickadee (Poecile cinctus), The Birds of North America Online (A. Poole, Ed.). Cornell Lab of Ornithology, Ithaca, NY. [available at: http://bna.birds.cornell.edu/bna/species/196]

Halbrook, J.M., Morgan, T.A., Brandt, J.P., Keegan, C.E., Dillon, T. & Barrett, T.M. 2009. Alaska's Timber Harvest and Forest Products Industry, 2005. General Technical Report PNW-GTR-787. U.S. Forest Service, Pacific Northwest Research Station, Portland, OR. 30 pp. [available at: http://www.fs.fed.us/pnw/pubs/pnw_gtr787.pdf]

Hamilton, T.D., Reed, K.M. & Thorsen R.M. 1986. Glaciation in Alaska: The Geologic Record. Alaska Geological Society, Anchorage, AK. 265 pp.

Handel, C.M., Pajot, L.M., Matsuoka, S.M., Van Hemert, C., Terenzi, J., Talbot, S.L., Mulcahy, D.M., Meteyer, C.U. & Trust, K.A. 2010. Epizootic of beak deformities among wild birds in Alaska: An emerging disease in North America? Auk 127: 882-898.

Handel, C.M. & Cady, M.N. 2004. Alaska Landbird Monitoring Survey: Protocol for Setting Up and Conducting Point Count Surveys. Unpublished report to Boreal Partners in Flight. U.S. Geological Survey - Alaska Science Center, Anchorage, AK. 40 pp. [available at: http://alaska.usgs.gov/science/biology/bpif/monitor/alms/ALMSprotocol_2004.pdf]

Handel, C.M., Swanson, S.A., Nigro, D.A. & Matsuoka, S.M. 2009. Estimation of avian population sizes and species richness across a boreal landscape in Alaska. Wilson Journal of Ornithology 121: 528-547.

Hannah, K.C. 2004. Status Review and Conservation Plan for the Rusty Blackbird (Euphagus carolinus) in Alaska. Alaska Bird Observatory, Fairbanks, AK. 30 pp. [available at: http://www.nbii.gov/images/uploaded/153635_1235416195148_ABORUBLReport.pdf]

Harwood, C.M. 1999. 1998 Lower Kuskokwim River Watershed Breeding Bird Survey. Unpublished memorandum. U.S. Fish & Wildlife Service, Yukon Delta National Wildlife Refuge, Bethel, AK.

Harwood, C. M. 2000. 1999 Lower Kuskokwim River Watershed Breeding Bird Survey. Unpublished memorandum. U. S. Fish & Wildlife Service, Yukon Delta National Wildlife Refuge, Bethel, AK.

Harwood, C. M. 2001. 2000 Lower Yukon River Watershed Breeding Bird Survey (BBS). Unpublished memorandum. U.S. Fish & Wildlife Service, Yukon Delta National Wildlife Refuge, Bethel, AK.

Harwood, C. M. 2002a. 2001 Lower Kuskokwim River Watershed Breeding Bird Survey (BBS). Unpublished memorandum. U. S. Fish & Wildlife Service, Yukon Delta National Wildlife Refuge, Bethel, AK.

Harwood, C. M. 2002b. 2002 Lower Yukon River Watershed Breeding Bird Survey (BBS). Unpublished memorandum. U. S. Fish and Wildlife Service, Yukon Delta National Wildlife Refuge, Bethel, AK. 14 pp.

Hauer, G., Cumming, S.G., Schmiegelow, F., Adamowicz, W., Weber, M. & Jagodzinski, R. 2010. Tradeoffs between forestry resource and conservation values under alternate policy regimes: A spatial analysis of the western Canadian boreal plains. Ecological Modelling 221: 2590-2603.

Haufler, J.B., Mehl, C.A. & Yeats, S. 2010. Climate Change: Anticipated Effects on Ecosystem Services and Potential Actions by the Alaska Region, U.S. Department of Agriculture, Forest Service, Ecosystem Management Research Institute, Seeley Lake, MT. 53 pp. [available at: http://www.fs.usda.gov/Internet/FSE_DOCUMENTS/fsbdev2_038171.pdf]

Healy, S. & Calder, W.A. 2006. Rufous Hummingbird (Selasphorus rufus). The Birds of North America Online (A. Poole, Ed.). Cornell Lab of Ornithology, Ithaca, NY. [available at: http://bna.birds.cornell.edu/bna/species/053doi:10.2173/bna.53]

Heinl, S.C. & Piston, A.W. 2009. Birds of the Ketchikan Area, Southeast Alaska. Western Birds 40: 54-144.

Hennon, P.E., D'Amore, D.V., Wittwer, D.T. & Caouette, J.P. 2008. Yellow Cedar Decline: Conserving a Climate-Sensitive Tree Species as Alaska Warms. Pp. 233-245 in Integrated Restoration of Forested Ecosystems to Achieve Multiresource Benefits: Proceedings of the 2007 National Silviculture Workshop (Deal, R.L., Ed.). General Technical Report PNW-GTR -733. U.S. Forest Service, Pacific Northwest Research Station, Portland, OR.

Hennon, P.E., D'Amore, D.V., Schaberg, P.D., Wittwer, D.T. & Shanley, C.S. 2012. Shifting climate, altered niche, and a dynamic conservation strategy for yellow-cedar in the North Pacific coastal rainforest. BioScience 62: 147-158.

Hines, J.Q. 1963. Birds of the Noatak River, Alaska. Condor 65: 410-425.

Hinzman, L.D., Viereck, L.A., Adams, P.C., Romanovsky, V.E. & Yoshikawa, K. 2006. Climate and permafrost dynamics of the Alaskan boreal forest. Pp. 39-61 in Alaska's Changing Boreal Forest (F.S. Chapin III, M.W. Oswood, K. Van Cleve, L.A. Viereck & D.L Verbyla, Eds.). Oxford University Press, New York, NY.

Hinzman, L.D., Bettez, N.D., Bolton, W.R., Chapin, F.S., Dyurgerov, M.B., Fastie, C.L., Griffith, B., Hollister, R.D., Hope, A., Huntington, H.P., Jensen, A.M., Jia, G.J., Jorgenson, T., Kane, D.L., Klein, D.R., Kofinas, G., Lynch, A.H., Lloyd, A.H., McGuire, A.D., Nelson, F.E., Oechel, W.C., Osterkamp, T.E., Racine, C.H., Romanovsky, V.E., Stone, R.S., Stow, D.A., Sturm, M., Tweedie, C.E., Vourlitis, G.L., Walker, M.D., Walker, D.A., Webber, P.J., Welker, J.M., Winker, K.S. & Yoshikawa, K. 2005. Evidence and implications of recent climate change in northern Alaska and other Arctic regions. Climatic Change 72: 251-298.

Hobson, K.A., Greenberg , R., Van Wilgenburg ,S.L. & Mettke-Hofmann, C. 2010. Migratory connectivity in the Rusty Blackbird: Isotopic evidence from feathers of historical and contemporary specimens. Condor 112: 778-788.

Hoekstra, P.F., Braune, B.M., O'Hara, T.M., Elkin, B., Solomon, K.R. & Muir, D.C.G. 2003. Organochlorine contaminant and stable isotope profiles in arctic fox (Alopex lagopus) from the Alaskan and Canadian Arctic. Environmental Pollution 122: 423-433.

Hoffman, S.W. & Smith J.P. 2003. Population trends of migratory raptors in western North America, 1977-2001. Condor 105: 397-419.

Holsten, E., Hennon, P., Trummer, L., Kruse, J., Schultz, M. & Lundquist, J. 2008. Insects and Diseases of Alaskan Forests. USDA Forest Service Publication No. R10-TP-140. USDA Forest Service, Alaska Region, Juneau, AK. 246 pp.

Hood, E., Fellman, J., Spencer, R.G.M., Hernes, P.J., Edwards, R., D'Amore, D. & Scott, D. 2009. Glaciers as a source of ancient and labile organic matter to the marine environment. Nature 462: 1044-10477.

Hopkins, D.M. (Ed.). 1967. The Bering Land Bridge. Stanford University Press, Stanford, CA. 501 pp.

Hopkins, D.M. 1982. Aspects of the paleogeography of Beringia during the Late Pleistocene. Pp. 3-28 in Paleoecology of Beringia (D.M. Hopkins, J.V. Matthews, Jr., C.E. Schweger & S.B. Young, eds.). Academic Press, New York, NY.

Hopkins, D.M., Matthews J.V., Schweger, C.E. & Young, S.B. 1982. Paleoecology of Beringia. Academic Press, New York, NY. 489 pp.

Houston, C.S., Smith, D.G. & Rohner, C. 1998. Great Horned Owl (Bubo virginianus). In The Birds of North America Online (A. Poole, Ed.). Cornell Lab of Ornithology, Ithaca, NY. [available at: http://bna.birds.cornell.edu/bna/species/372]

Howell, S.N.G. & Webb, S. 1995. A Guide to the Birds of Mexico and Northern Central America. Oxford University Press, New York, NY. 851 pp.

Hull, T. & Leask, L. 2000. Dividing Alaska, 1867-2000: Changing Land Ownership and Management. Institute of Social and Economic Research, University of Alaska, Anchorage, AK. 14 pp. [available at: http://www.iser.uaa.alaska.edu/Home/ResearchAreas/comm_gov.html]

Hunter, W.F. & Baldwin, P.H. 1962. Nesting of the Black Swift in Montana. Wilson Bulletin 74: 409-416.

Hussell, D.J. & Montgomerie, R. 2002. Lapland Longspur (Calcarius lapponicus). The Birds of North America Online (A. Poole, Ed.). Cornell Lab of Ornithology, Ithaca, NY. [available at: http://bna.birds.cornell.edu/bna/species/656]

Institute of Social and Economic Research. 2006. Understanding Alaska: People, Economy, and Resources. Institute of Social and Economic Research, University of Alaska, Anchorage, AK. 21 pp. [available at: http://www.alaskaneconomy.uaa.alaska.edu/Publications/UA_summ06_04size.pdf]

Intergovernmental Panel on Climate Change (IPCC). 2007. Climate Change 2007: Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change (M.L. Parry, O.F. Canziani, J.P. Palutikof, P.J. van der Linden & C.E. Hanson, Eds.). Cambridge University Press, Cambridge, UK. 976 pp. [available at: http://www.ipcc.ch/ipccreports/ar4-wg1.htm]

Ip, H.S., Flint, P.L., Franson, J.C., Dusek, R.J., Derksen, V.D., Gill Jr., R.E., Ely, C.R., Pearce, J.M., Lanctot, R.B., Matsuoka, S.M., Irons, D.B., Fischer, J.B., Oates, R.M., Petersen, M.R., Fondell, T.F., Rocque, D.A., Pedersen, J.C. & Rothe, T.C. 2008. Prevalence of influenza A viruses in wild migratory birds in Alaska: Patterns of variation in detection at the crossroads of international flyways. Virology Journal 5: 71.

Irving, L. 1960. Birds of Anaktuvuk Pass, Kobuk, and Old Crow: A Study in Arctic Adaptation. U.S. National Museum Bulletin 217. 409 pp.

Isleib, M.E. & Kessel, B. 1973. Birds of the North Gulf Coast-Prince William Sound Region, Alaska. Biological Papers of the University of Alaska 14. University of Alaska, Fairbanks, AK. 149 pp.

Iverson, G.C, Hayward, G.D., Titus, K., DeGayner, E., Lowell, R.E., Crocker-Bedford, D.C., Schempf, P.F. & Lindell, J. 1996. Conservation Assessment for the Northern Goshawk in Southeast Alaska. General Technical Report PNW-GTR-387. U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station, Portland, OR. 101 pp.

Jackson, J.A., Ouellet, H.R. & Jackson, B.J. 2002. Hairy Woodpecker (Picoides villosus), The Birds of North America Online (A. Poole, Ed.). Cornell Lab of Ornithology, Ithaca, NY. [available at: http://bna.birds.cornell.edu/bna/species/702]

Jacobson, M.J. & Hodges. J.I. 1999. Population trend of adult Bald Eagles in southeast Alaska, 1967-97. Journal of Raptor Research 33: 295-298.

Johnson, J.A., Andres, B.A. & Bissonette, J.A. 2008. Birds of the Major Mainland Rivers of Southeast Alaska. General Technical Report PNW-GTR-739. U.S. Forest Service, Pacific Northwest Research Station, Portland, OR. 88 pp.

Johnson, J.A., DeCicco, L.H. & Matsuoka, S.M. 2009. The Short-eared Owl: Notes on Capture and Harnessing Methods, Plumage and Molt Characteristics, and General Ecology During the 2009 Breeding Season, Nome, Alaska. Unpublished report, U.S. Fish and Wildlife Service, Anchorage, AK. ??? pp.

Johnson, J.A., Matsuoka, S.M., Ruthrauff, D.R., Litzow, M.A. & Dementyev, M.N. 2004. Additions to the avifauna of St. Matthew Island, Bering Sea. Western Birds 35: 50-52.

Johnson, S.R. & Herter, D.R. 1989. The Birds of the Beaufort Sea. British Petroleum Exploration Inc. Anchorage, AK. 372 pp.

Jorgenson, T. 2012. Conceptual models of landscape change. Pp. 21-32 in Shared Science Needs: Report from the Western Alaska Landscape Conservation Cooperative Science Workshop (J.H. Reynolds & H.V. Wiggins, Eds.). Western Alaska Landscape Conservation Cooperative Anchorage, AK. 142 pp. [available at: https://westernalaskalcc.org/about/LCC%20Document%20Library/Science%20Needs%20Workshop%20Report.pdf]

Jorgenson, M.T. & Osterkamp, T.E. 2005. Response of boreal ecosystems to varying modes of permafrost degradation. Canadian Journal of Forest Research 35: 2100-2111.

Jorgenson, T., Yoshikawa, K., Kanevskiy, M., Shur, Y., Romanovsky, V., Marchenko, S., Grosse, G., Brown, J. & Jones, B. 2008. Permafrost Characteristics of Alaska. Institute of Northern Engineering, University of Alaska Fairbanks, Fairbanks, AK. [available at: http://www.cryosphericconnection.org/resources/alaska_permafrost_map_dec2008.pdf]

Juday, G.P., Ott, R.A., Valentine, D.W. & Barber, V.A. 1998. Forests, climate stress, insects, and fire. Pp. 23-49 in Proceedings of a Workshop on Implications of Global Change in Alaska and the Bering Sea Region (G. Weller & P.A. Anderson, Eds.). Center for Global Change and Arctic System Research, University of Alaska, Fairbanks, AK.

Juday, G.P., Barber, V., Vaganov, E., Rupp, S., Sparrow, S., Yarie, J., Linderholm, H., Berg, E., D'Arrigo, R., Duffy, P., Eggertsson, O., Furyaev, V.V., Hogg, E.H., Huttunen, S., Jacoby, G., Kaplunov, V.Ya., Kellomaki, S., Kirdyanov, A.V., Lewis, C.E., Linder, S., Naurzbaev, M.M., Pleshikov, F.I., Runesson, U.T., Savva, Yu.V., Sidorova, O.V., Stakanov, V.D., Tchebakova, N.M., Valendik, E.N., Vedrova, E.F. & Wilmking, M. 2005. Forests, Land Management, and Agriculture. Pp. 781-862 in Arctic Climate Impact Assessment (C. Symon, L. Arris & B. Heal, Eds.). Cambridge University Press, NY.

Kaler, R.S.A., Ebbert, S.E., Braun, C.E. & Sandercock, B.K. 2010. Demography of a reintroduced population of Evermann's Rock Ptarmigan in the Aleutian Islands. Wilson Journal of Ornithology 122: 1-14.

Kasischke, E. & Turetsky, M.R. 2006. Changes in the fire regime across the North American boreal region – Spatial and temporal patterns of burning across Canada and Alaska. Geophysical Research Letters 33: L09703. doi:10.1029/2006GL025677.

Kasischke, E.S., Williams, D. & Barry, D. 2002. Analysis of the patterns of large fires in the boreal forest region of Alaska. International Journal of Wildland Fire 11: 131-144.

Kawerak & Bering Strait Development Council. 2009. Bering Strait Comprehensive Economic Development Strategy 2009-2013. Kawerak, Inc., Nome, AK. 106 pp.

Kelly, E.G., E. D. Forsman, E.D. & Anthony, R.G. 2003. Are Barred Owls displacing Spotted Owls? Condor 105:45-53.

Kendall, S. 2006. Smith's Longspur Ecology: Pilot Studies in the Arctic National Wildlife Refuge, Alaska, June 2006. Unpublished Report. U.S. Fish & Wildlife Service, Fairbanks, AK. 27 pp.

Kessel, B. 1984. Migration of Sandhill Cranes (Grus canadensis) in east-central Alaska, with routes through Alaska and Canada. Canadian Field-Naturalist 98: 279-292.

Kessel, B. 1989. Birds of the Seward Peninsula, Alaska. University of Alaska Press, Fairbanks, AK. 330 pp.

Kessel, B. & Cade, T.J. 1958. Birds of the Colville River, Northern Alaska. Biological Papers of the University of Alaska No. 2. Anchorage, AK. 83 pp.

Kessel, B. & Gibson, D.D. 1978. Status and Distribution of Alaska Birds. Studies in Avian Biology No. 1. Cooper Ornithological Society, Lawrence, KS. 100 pp.

Kessel, B. & Gibson, D.D. 1994. A Century of Avifaunal Change in Alaska. Pp. 4-13 in A Century of Avifaunal Change in Western North America (J.R. Jehl, Jr. and N.K. Johnson, Eds.). Studies in Avian Biology No. 15, Cooper Ornithological Society, Lawrence, KS.

Kessel, B. & Schaller, G.B. 1960. Birds of the Upper Sheenjek Valley, Northeastern Alaska. Biological Papers of the University of Alaska No. 4. Anchorage, AK. 58 pp.

Kessler, W.B. & Kogut, T.E. 1985. Habitat orientations of forest birds in southeastern Alaska. Northwest Science 59: 58-65.

Kissling, M.L. & Garton, E.O. 2007. Forested buffer strips and breeding bird communities in southeast Alaska. Journal of Wildlife Management 72: 674-681.

Kissling, M.L. & Lewis, S.B. 2009. Distribution, Abundance, and Ecology of Forest Owls in Southeast Alaska. Unpublished report. U.S. Fish & Wildlife Service, Juneau, AK, and Alaska Department of Fish & Game, Division of Wildlife Conservation, Douglas, AK. 215 pp. [available at: http://alaska.fws.gov/fisheries/fieldoffice/juneau/pdf/07-ForestOwls-1_Kissling&Lewis_FinalReport.pdf]

Kissling, M.L. & Lewis, S.B. 2010. Factors influencing the detectability of forest owls in southeastern Alaska. Condor 112: 539-548.

Kissling, M.L., Lewis, S.B. & Pendleton, G. 2010. Factors influencing the detectability of forest owls in southeastern Alaska. Condor 112: 539-548.

Klein, D.R. 1968. The introduction, increase, and crash of reindeer on St. Matthew Island. Journal of Wildlife Management 32: 350-367.

Klein, D.R. 1987. Vegetation recovery patterns following overgrazing by reindeer on St. Matthew Island. Journal of Range Management 40: 336-338.

Klein, E., Berg, E.E. & Dial, R. 2005. Wetland drying and succession across the Kenai Peninsula lowlands, south-central Alaska. Canadian Journal of Forest Research 35: 1931-1941.

Knox, A.G. & Lowther, P.E. 2000. Hoary Redpoll (Acanthis hornemanni). In The Birds of North America Online (A. Poole, Ed.). Cornell Lab of Ornithology, Ithaca, NY. [available at: http://bna.birds.cornell.edu/bna/species/544]

Koppes, M.N. & Hallet, B. 2002. Influence of rapid glacial retreat on the rate of erosion by tidewater glaciers. Geology 30: 47-50.

Koschmann, A.H. & Bergendahl, M.H. 1968. Principal Gold-producing Districts of the United States. U.S. Geological Survey Professional Paper 610. U.S. Government Printing Office, Washington DC. 238 pp.

Kume, T., Umetsu, C. & Palanisami, K. 2009. Impact of the December 2004 tsunami on soil, groundwater, and vegetation in the Nagapattinam district, India. Journal of Environmental Management 90: 3147-3154.

Lance, E. W. & Howell, S. 2000. Survey of songbirds during a spruce beetle (Dendroctonus rufipennis) outbreak on the Kenai Peninsula, Alaska. Northwestern Naturalist 81: 1-10.

Landers, D.H., Simonich, S.L, Jaffe, D.A., Geiser, L.H., Campbell, D.H, Schwindt, A.R., Schreck, C.B, Kent, M.L, Hafner, W.D., Taylor, H.E., Hageman, K.J., Usenko, S., Ackerman, L.K., Schrlau, J.E., Rose, N.L, Blett, T.F. & Erway, M.M. 2008. The Fate, Transport, and Ecological Impacts of Airborne Contaminants in Western National Parks (USA). EPA/600/R-07/138. U.S. Environmental Protection Agency, Office of Research & Development, National Health and Environmental Effects Research Laboratory, Western Ecology Division, Corvallis, OR. 350 pp.

Larsen, C.F., Motyka, R.J., Arendt, A.A., Echelmeyer, K.A. & Geissler, P.E. Glacier changes in southeast Alaska and northwest British Columbia and contribution to sea level rise. Journal of Geophysical Research 112: F01007.

Larsen, C.F, Motyka, R.J., Freymueller, J.T.,Echelmeyer, K.A., Ivins, E.R. 2004. Rapid uplift of southern Alaska caused by recent ice loss. Geophysical Journal International 158: 1118-1133.

Lawler, J.J., Shafer, S.L., White, D., Kareiva, P., Maurer, E.P., Blaustein, A.R. & Bartlein, P.J. 2009. Projected climate-induced faunal change in the Western Hemisphere. Ecology 90: 588-597.

Lehman, P. 2005. Fall bird migration at Gambell, St. Lawrence Island, Alaska. Western Birds 36: 2-55.

Lenoir, J., Gégout, J.C. Marquet, P.A., de Ruffray, P. & Brisse, H. 2008. A significant upward shift in plant species optimum elevation during the 20th century. Science 320: 1768-1771.

Lewis, S.B., Titus, K. & Fuller, M.R. 2006. Northern Goshawk diet during the nesting season in southeast Alaska. Journal of Wildlife Management 70: 115-1160.

Li, Y.F. & Macdonald, R.W. 2005. Sources and pathways of selected organochlorine pesticides to the Arctic and the effect of pathway divergence on HCH trends in biota: a review. Science of the Total Environment 342: 87-106.

Liebezeit, J., Rowland, E., Cross, M. & Zack, S. 2012. Assessing Climate Change Vulnerability of Breeding Birds in Arctic Alaska. A report prepared for the Arctic Landscape Conservation Cooperative. Wildlife Conservation Society, Bozeman, MT. 167 pp. [available at: http://arcticlcc.org/products/publications-and-reports/show/climate-change-vulnerability-of-breeding-birds-in-arctic-alaska-final-report]

Liebezeit, J.R., Kendall, S.J., Brown, S., Johnson, C.B., Martin, P., McDonald, T.L., Payer, D.C., Rea, C.L., Streever, B., Wildman, A.M. & Zack, S. 2009. Influence of human development and predators on nest survival of tundra birds, Arctic Coastal Plain, Alaska. Ecological Applications 19: 1628-1644.

Linxwiler, J.D. 2007. The Alaska Native Claims Settlement Act at 35: Delivering On the Promise. Oral Presentation at the 53rd Annual Rocky Mountain Mineral Law Institute, July 19-21, Vancouver, BC. [available at: http://www.iser.uaa.alaska.edu/Home/8a.html]

Livezey, K.B., Root, T.L., Gremel, S.A. & Johnson, C. 2008. Natural range expansion of Barred Owls? A critique of Monahan and Hijmans (2007). Auk 125: 230-232.

Loss, S.R., Will, T. & Marra, P.P. 2013. Estimates of bird collision mortality at wind facilities in the contiguous United States. Biological Conservation 168: 201-209.

Lowther, P.E. 1993. Brown-headed Cowbird (Molothrus ater). The Birds of North America, no. 47 (A. Poole & F. Gill, Eds.). The Birds of North America, Inc., Philadelphia, PA. [available at: http://bna.birds.cornell.edu/bna/species/047]

Lowther, P.E. & Collins, C.T. 2002. Black Swift (Cypseloides niger). The Birds of North America, no. 676 (A. Poole & F. Gill, Eds.). The Birds of North America, Inc., Philadelphia, PA. [available at: http://bna.birds.cornell.edu/bna/species/676]

Lloyd, A.H. & Fastie, C.L. 2003. Recent changes in treeline forest distribution and structure in interior Alaska. Ecoscience 10: 176-185.

MacDonald, S.O. & Cook, J.A. 2007. The Mammals and Amphibians of Southeast Alaska. Museum of Southwestern Biology - Special Publication 8. University of New Mexico, Albuquerque, NM. 191 pp.

Macdonald, R.W., Harner, T. & Fyfe, J. 2005. Recent climate change in the Arctic and its impact on contaminant pathways and interpretation of temporal trend data. Science of the Total Environment 342: 5-86.

Macdougall-Shackleton, S.A., Johnson, R.E. & Hahn, T.P. 2000. Gray-crowned Rosy-Finch (Leucosticte tephrocotis). The Birds of North America Online (A. Poole, Ed.). Cornell Lab of Ornithology, Ithaca, NY. [available at: http://bna.birds.cornell.edu/bna/species/559]

MacLean, S.F. 1980. The Detritus-Based Ecosystem. Pp. 411-457 in An Arctic Ecosystem: The Coastal Tundra at Barrow, Alaska (J. Brown, P.C. Miller, L.L. Tieszen & L.F. Bunnell, Eds). U.S. International Biome Program Synthesis Series 12. Dowden, Hutchinson, and Ross, Inc., Stroudsburg, PA. 571 pp.

Maher, W.J. 1959. Habitat distribution of birds breeding along the upper Kaolak River, northern Alaska. Condor 61: 351-368.

Maley J. M. & Winker, K. 2010. Diversification at high latitudes: speciation of buntings in the genus Plectrophenax inferred from mitochondrial and nuclear markers. Molecular Ecology 19: 785-797.

Mann, D.H. & Streeveler, G.P. 2008. Post-glacial relative sea level, isostasy, and glacial history in Icy Strait, southeast Alaska, USA. Quaternary Research 69: 201-216.

Mars, J.C. & Houseknecht, D.W. 2007 Quantitative remote sensing study indicates doubling of coastal erosion rate in past 50 years along a segment of the Arctic coast of Alaska. Geology 35: 583-586.

Martin, J., Nichols, J.D., McIntyre, C.L., Hines, J.E. & Ferraz, G. 2009b. Perturbation analyses for patch occupancy dynamics. Ecology 90: 10-16.

Martin, J., McIntyre, C.L., Hines, J.E., Nichols, J.D., Schmutz, J.A. & MacCluskie, M.C. 2009a. Dynamic multistate site occupancy to evaluate hypotheses relevant to conservation of Golden Eagles in Denali National Park, Alaska. Biological Conservation 142: 2726-2731.

Martin, P.D., Jenkins, J.L., Adams, F.J., Jorgenson, M.T., Matz, A.C., Payer, D.C., Reynolds, P.E., Tidwell, A.C. & Zelenak, J.R. 2009. Wildlife response to environmental Arctic change: predicting future habitats of Arctic Alaska. Report of the Wildlife Response to Environmental Arctic Change (WildREACH): Predicting Future Habitats of Arctic Alaska Workshop, 17-18 November 2008. U.S. Fish & Wildlife Service, Fairbanks, AK. 138 pp. [available at: http://www.fws.gov/alaska/pdf/wildreach_workshop_report.pdf]

Martin, P.R., Bonier, F. & Gibson, D.D. 2006. First nest of the Yellow-bellied Flycatcher for Alaska, with notes on breeding biology. Western Birds 37: 8-22.

Matsuoka, S.M. & Handel, C.M. 2007. Nesting ecology of boreal forest birds following a massive forest disturbance by spruce beetles. Journal of Wildlife Management 71: 51-63.

Matsuoka, S.M., Handel, C.M. & Ruthrauff, D.R. 2001. Densities of breeding birds and changes in vegetation in an Alaskan boreal forest following a massive disturbance by spruce beetles. Canadian Journal of Zoology 79: 1678-1690.

Matsuoka, S.M. & Johnson, J.A. 2008. Using a multimodel approach to estimate the population size of McKay's Buntings. Condor 110: 371-376.

Matsuoka, S.M., Johnson, J.A. & DellaSala, D.A. 2012. Succession of bird communities in young temperate rainforests following thinning. Journal of Wildlife Management 76: 919-931.

Matsuoka, S.M., Handel, C.M. & Ruthrauff, D.R. 2001. Densities of breeding birds and changes in vegetation in an Alaskan boreal forest following a massive disturbance by spruce beetles. Canadian Journal of Zoology 79: 1678-1690.

Matsuoka, S.M., Shaw, D. & Johnson, J.A. 2010a. Estimating the abundance of nesting Rusty Blackbirds in relation to wetland habitats in Alaska. Condor 112: 825-833.

Matsuoka, S.M., Holsten, E.H., Shephard, M.E., Werner, R.A. & Burnside, R.E. (Eds.). 2006. Special issue: Spruce beetles and forest ecosystems of south-central Alaska. Forest Ecology and Management 227: 193-283.

Matsuoka, S.M., Shaw, D., Sinclair, P.H., Johnson, J.A., Corcoran, R.M., Dau, N.C., Meyers, P.M. & Rojek, N.A. 2010b. Nesting ecology of the Rusty Blackbird in Alaska and Canada. Condor 112: 810-824.

Matz, A. 2012. Mercury, Arsenic, and Antimony in Aquatic Biota from the Middle Kuskokwim River Region, Alaska, 2010–2011. Interim report prepared for the Bureau of Land Management, Alaska State Office. U.S. Fish & Wildlife Service, Fairbanks, AK. 44 pp. [available at: http://www.blm.gov/pgdata/etc/medialib/blm/ak/aktest/fisheries.Par.17988.File.tmp/Interim_Mercury_Arsenic%20_Antimony_FT_Technical_Report_Dec2012v2.pdf]

Matz, A., Swem, T., Johnson, P., Booms, T. & White, C. 2011. Potential for climate change to increase contaminants exposure and effects in Gyrfalcons. Pp. 161-176 in Gyrfalcons and Ptarmigan in a Changing World, Vol. 1 (R.T. Watson, T.J. Cade, M. Fuller, G. Hunt & E. Potapov, Eds.). The Peregrine Fund, Boise, ID. [available at: http://dx.doi.org/10.4080/gpcw.2011.0115]

McCabe, G.J., Clark, M.P. & Serreze M.C. 2001. Trends in northern hemisphere surface cyclones frequency and intensity. Journal of Climate 14: 2763-2768.

McCaffery, B.J. 1996. Distribution and Relative Abundance of Gray-cheeked Thrush (Catharus minimus) and Blackpoll Warbler (Dendroica striata) on Yukon Delta National Wildlife Refuge, Alaska. Unpublished Report. U.S. Fish & Wildlife Service, Bethel, AK. ???pp.

McCaffery, B.J. & McIntyre, C. 2005. Disparities between results and conclusions: do Golden Eagles warrant special concern based on migration counts in the western United States? Condor 107: 469-473.

McClure, C.J.W., Ware, H.E., Carlisle, J., Kaltenecker, G. & Barber, J.R. 2013. An experimental investigation into the effects of traffic noise on distributions of birds: avoiding the phantom road. Proceedings of the Royal Society B 280: 1471-2954. [DOI: 10.1098/rspb.2013.2290]

McGuire, B. 2012. Assessment of the Bioenergy Provisions in the 2008 Farm Bill. The Voice of Fish & Wildlife Agencies, Washington, DC. 51 pp. [Available at: http://www.fishwildlife.org/files/08_22_12_bioenergy_report_web_final.pdf]

McGuire, A.D., Sturm, M. & Chapin, F.S. 2003. Arctic transitions in the land–atmosphere system (ATLAS): background, objectives, results, and future directions. Journal of Geophysical Research 108: 8166.

McIntyre, C.L. & Ambrose, R.E. 1999. Raptor migration in autumn through the Upper Tanana River Valley, Alaska. Western Birds 30: 33-38.

McIntyre, C.L., Collopy, M.W. & Lindberg, M.S. 2006b. Survival probability and mortality of migratory juvenile Golden Eagles from interior Alaska. Journal of Wildlife Management 70: 717-722.

McIntyre, C.L., Douglas, D.C. & Adams, L.G. 2009. Movements of juvenile Gyrfalcons from western and interior Alaska following departure from their natal areas. Journal of Raptor Research 43: 99-109.

McIntyre, C.L., Douglas, D.C. & Collopy, M.W. 2008. Movements of Golden Eagles (Aquila chrysaetos) from interior Alaska during their first year of independence. Auk 125: 214-224.

McIntyre, C.L., Collopy, M.W., Kidd, J.G., Stickney, A.A. & Paynter, J. 2006a. Characteristics of the landscape surrounding Golden Eagle nest sites in Denali National Park and Preserve, Alaska. Journal of Raptor Research 40: 46-51.

Melvin, S.M., Smith, D.G., Holt, D.W. & Tate, G.R. 1989. Small Owls. Pp. 88-96 in Proceedings of the Northeast Raptor Management Symposium and Workshop (B.G. Pendleton, Ed.). National Wildlife Federation, Washington, DC. 353 pp.

Monahan, W.B. & Hijmans, R.J. 2007. Distributional dynamics of invasion and hybridization by Strix spp. in western North America. Ornithological Monographs 63: 55-66.

Montgomerie, R. & Holder, K. 2008. Rock Ptarmigan (Lagopus muta). The Birds of North America Online (A. Poole, Ed.).Cornell Lab of Ornithology, Ithaca, NY. [available at: http://bna.birds.cornell.edu/bna/species/051]

Montgomerie, R. & Lyon, B. 2011. McKay's Bunting (Plectrophenax hyperboreus). The Birds of North America Online (A. Poole, Ed.). Cornell Lab of Ornithology, Ithaca, NY. [available at: http://bna.birds.cornell.edu/bna/species/199]

Moore, R.D., Fleming, S.W., Menounos, B., Wheate, R., Fountain, A., Stahl, K., Holm, K. & Jakob, M. 2009. Glacier change in western North America: influences on hydrology, geomorphic hazards and water quality. Hydrological Processes 23: 42-61.

Morshed, M., Tang, P., Petric, M., Krajden, M., Roth, D., Henry, B., Isaac-Renton, J. & the BCCDC West Nile Virus Team. 2011. West Nile virus finally debuts in British Columbia 10 years after its introduction to North America. Vector-Borne and Zoonotic Diseases 11: 1221-1224.

Murie, O.J. 1959. Fauna of the Aleutian Islands and Alaska Peninsula. North American Fauna 61: 1-364.

National Climatic Data Center. 2012. Climate Data Online: Map & Application Search. Monthly data, 1936–1988, Gambell Airport, Alaska. [available at: http://www.ncdc.noaa.gov/oa/ncdc.html]

National Geographic Society. 1987. Field Guide to the Birds of North America, 2nd edn. National Geographic Society, Washington, DC. 464 pp.

National Research Council. 2003. Cumulative Environmental Effects of Oil and Gas Activities on Alaska's North Slope. National Academies Press, Washington DC. 288 pp. [available at: http://www.nap.edu/openbook.php?record_id=10639&page=R1]

Nawrocki, T., Klein, H., Carlson, M., Flagstad, L., Conn, J., DeVelice, R., Grant, A., Graziano, G., Million, B. & Rapp, W. 2011. Invasiveness Ranking of 50 Non-native Plant Species for Alaska. Alaska Natural Heritage Program, University of Alaska, Anchorage, AK. 32 pp. [available at: http://aknhp.uaa.alaska.edu/botany/akepic/publications/]

Nebel, S., Mills, A., McCracken, J.D. & Taylor, P.D. 2010. Declines of aerial insectivores in North America follow a geographic gradient. Avian Conservation & Ecology 5: 1-14. [available at: http://www.ace-eco.org/vol5/iss2/art1/]

Neff, J.M., Owens, S.S.S. & McCormick, D.M. 1995. Shoreline oiling conditions in Prince William Sound following the Exxon Valdez oil spill. Pp. 312-346 in Exxon Valdez Oil Spill: Fate and Effects in Alaskan Waters (P.G. Wells, J.N. Butler & J.S. Hughes, Eds.). ASTM Special Technical Publication 1219. American Society for Testing and Materials, Philadelphia, PA

Nelson, A.R. 2012 Ecology of Prince of Wales Spruce Grouse. M. Sc. Thesis. University of Alaska, Fairbanks, AK. 85 pp.

Nichols, J.D., Thomas, L. & Conn, P.B. 2009. Inferences About Landbird Abundance from Count Data: Recent Advances and Future Directions. Pp. 201-235 in Modeling Demographic Processes in Marked Populations (D.L. Thomson, E.G. Cooch, and M.J. Conroy, Eds.). Springer, New York, NY.

Niven, D.K., Sauer, J.R., Butcher, G.S. & Link, W.A. 2004. Christmas Bird Count provides insights into population change in land birds that breed in the boreal forest. American Birds The 104th Christmas Bird Count: 10-20. [available at: http://web4.audubon.org/bird/cbc/pdf/104_BOREALpp10-20-lr.pdf]

North American Bird Conservation Initiative (NABCI). 2000. Bird Conservation Region Descriptions: A Supplement to the NABCI Bird Conservation Regions Map [Online]. U.S. North American Bird Conservation Initiative Committee, Washington, DC. [available at: http://www.nabci-us.org/aboutnabci/bcrdescrip.pdf]

North American Bird Conservation Initiative (NABCI) Monitoring Subcommittee. 2007. Opportunities for Improving Avian Monitoring. U.S. North American Bird Conservation Initiative Report, U.S. Fish & Wildlife Service, Arlington, VA. 50 pp. [available at: http://www.nabci-us.org/aboutnabci/monitoringreportfinal0307.pdf]

Nowacki, G. & Kramer, M.G. 1998. The Effects of Wind Disturbance on Temperate Rain Forest Structure and Dynamics of Southeast Alaska. General Technical Report PNW-GTR-421. U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station, Portland, OR. 25 pp

Nowacki, G., Shephard, M, Krosse, P., Pawuk, W., Fisher, G., Baichtal, J., Brew, D., Kissinger, E. & Brock, T. 2001. Ecological Subsections of Southeast Alaska and Neighboring Areas of Canada. Technical Publication R10-TP-75. U.S. Forest Service - Alaska Region, Anchorage, AK. 306 pp.

Noyes, P.D., McElwee, M.K., Miller, H.D, Clark, B.W., Van Tiem, L.A., Walcott, K.C, Erwin, K.N. & Levin, E.D. 2009. The toxicology of climate change: environmental contaminants in a warming world. Environment International 35: 971-986.

NUKA Research & Planning Group. 2012. Southeast Alaska Vessel Traffic Study, Revision 1. NUKA Research & Planning Group, LLC, Seldovia, AK. [available at: http://dec.alaska.gov/spar/perp/docs/Southeast%20Alaska%20Vessel%20Traffic%20Study.pdf]

Overland, J.E. & Stabeno, P.J. 2004. Is the climate of the Bering Sea warming and affecting the ecosystem? Eos 85: 309-316.

Overland, P.J., Bond, N.A. & Salo, S.A. 2004. On the recent warming of the southeastern Bering Sea shelf. Deep-Sea Research 54: 2599-2618.

Panjabi, A.O., Blancher, P.J., Dettmers, R. & Rosenberg, K.V. 2012. The Partners in Flight Handbook on Species Assessment, Version 2012. Partners in Flight Technical Series No. 3. Rocky Mountain Bird Observatory, Brighton, CO. 35 pp. [available at: http://www.rmbo.org/pubs/downloads/Handbook2012.pdf]

Panjabi, A.O., Dunn, E.H., Blancher, P.J., Hunter, W.C., Altman, B., Bart, J., Beardmore, C.J., Berlanga, H., Butcher, G.S., Davis, S.K., Demarest, D.W., Dettmers, R., Easton, W., Gomez de Silva Garza, H., Iñigo-Elias, E.E., Pashley, D.N., Ralph, C.J., Rich, T.D., Rosenberg, K.V., Rustay, C.M., Ruth, J.M., Wendt, J.S. & Will, T.C. 2005. The Partners in Flight Handbook on Species Assessment. Version 2005. Partners in Flight Technical Series No. 3. Rocky Mountain Bird Observatory, Brighton, CO. 30 pp. [available at http://www.rmbo.org/pubs/downloads/Handbook2005.pdf]

Parmelee, D.F. 1992. Snowy Owl (Bubo scandiacus). The Birds of North America Online (A. Poole, Ed.). Cornell Lab of Ornithology, Ithaca, NY. [available at: hhtp://bna.birds.cornell.edu/bna/species/010doi:102173/bna.10]

Payette, S. 1992. Fire as a Controlling Process in the North American Boreal Forest. Pp. 145-169 in A Systems Analysis of the Global Boreal Forest (H.H. Shugart, R. Leemans, & G.B. Bonan, Eds.). Cambridge University Press, Cambridge, UK.

Pebble Partnership. 2012. The Pebble Environment: A Scientific Overview of Environmental and Social Data in Southwest Alaska. The Pebble Partnership, Anchorage, AK. 50 pp. [available at: http://corporate.pebblepartnership.com/files/documents/Pebble_environment.pdf]

Peterson, A.T., Benz, B.W. & Papes¸ M. 2007. Highly pathogenic H5N1 avian influenza: entry pathways into North America via bird migration. PLoS ONE 2: e261. [available at: http://www.plosone.org/article/info%3Adoi%2F10.1371%2Fjournal.pone.0000261]

Peterson, M.R., Weir, D.N. & Dick, M.H. 1991. Birds of the Kilbuck and Ahklun Mountain Region, Alaska. North American Fauna 76: 1-158. [available at: http://www.fwspubs.org/doi/abs/10.3996/nafa.76.0001]

Piatt, J.F., Lensink, C.J., Butler, W., Kendziorek, M. & Nysewander, D.R. 1990. Immediate impact of the 'Exxon Valdez' oil spill on marine birds. Auk 107: 387-397.

Post, E., Forchhammer, M.C., Bret-Harte, M.S., Callaghan, T.V., Christensen, T.R., Elberling, B., Fox, A.D., Gilg, O., Hik, D.S., Høye, T.T., Ims, R.A., Jeppesen, E., Klein, D.R., Madsen, J., McGuire, A.D., Rysgaard, S., Schindler, D.E., Stirling, I., Tamstorf M.P., Tyler, N.J., van der Wal, R., Welker, J., Wookey, P. A., Schmidt, N.M. & Aastrup, P. 2009. Ecological dynamics across the Arctic - associated with recent climate change. Science 325: 1355–1358.

Powell, A.N. & Backensto, S.A. 2008. Productivity and Locations of Common Ravens (Corvus corax) Nesting on Alaska's North Slope. Unpublished final report to U.S. Geological Survey. Alaska Cooperative Fish and Wildlife Research Unit, Fairbanks, AK. 32 pp.

Powell, L.L., Hodgman, T.P., Glanz, W.E., Osenton, J.D. & Fisher, C.M. 2010. Nest-site selection and nest survival of the Rusty Blackbird: Does timber management adjacent to wetlands create ecological traps? Condor 112: 800-809.

Preble, E.A. & McAtee, W.L. 1923. A biological survey of the Pribilof Islands, Alaska. I. Birds and mammals. North American Fauna 46: 1-128.

Ralph, C.J. & Scott, J.M. 1981. Estimating Numbers of Birds. Studies in Avian Biology No. 6. Cooper Ornithological Society, Lawrence, KS. 730 pp.

Ramey, A.M., Ely, C.R., Schmutz, J.A., Pearce, J.M. & Heard, D.J. 2012. Molecular detection of hematozoan infections in Tundra Swans relative to migration patterns and ecological conditions at breeding grounds. PLoS ONE 7(9):e45789.

Reeves, A.B., Pearce, J.M., Ramey, A.M., Ely, C.R., Schmutz, J.A., Flint, P.L., Derksen, D.V., Ip, H.S. & Trust, K.A. 2013. Genomic analysis of avian influenza viruses from waterfowl in western Alaska, USA. Journal of Wildlife Diseases 49: 600-610.

Reynolds, J.H. & Wiggins, H.V. (Eds.). 2012. Shared Science Needs: Report from the Western Alaska Landscape Conservation

Cooperative Science Workshop. Western Alaska Landscape Conservation Cooperative Anchorage, AK. 142 pp. [available at: https://westernalaskalcc.org/about/LCC%20Document%20Library/Science%20Needs%20Workshop%20Report.pdf]

Rich, T.D., Beardmore, C.J., Berlanga, H., Blancher, P.J., Bradstreet, M.S.W., Butcher, G.S., Demarest, D.W., Dunn, E.H., Hunter, W.C., Iñigo-Elias, E.E., Kennedy, J.A., Martell, A.M., Panjabi, A.O., Pashley, D.N., Rosenberg, K.V., Rustay, C.M., Wendt, J.S. & Will, T.C. 2004. Partners in Flight North American Landbird Conservation Plan. Cornell Lab of Ornithology, Ithaca, NY. 89 pp. [available at: http://www.partnersinflight.org/cont_plan/].

Ridgely, R.S., Allnutt, T.F., Brooks, T., McNicol, D.K., Mehlman, D.W., Young, B.E. & Zook, R.J. 2003. Digital Distribution Maps of the Birds of the Western Hemisphere, Version 1.0. NatureServe, Arlington, VA. [available at: http://www.natureserve.org/library/birddistribmapsproject.pdf]

Riordan, B. 2005. Use of remote sensing to examine changes of closed-basin surface water area in interior Alaska from 1950–2002. M.S. Thesis. University of Alaska Fairbanks. 122 pp.

Riordan, B., Verbyla, D. & McGuire A.D. 2006. Shrinking ponds in subarctic Alaska based on 1950–2002 remotely sensed images. Journal of Geophysical Research 111: G04002. [available at: http://www.lter.uaf.edu/dev2009/pdf/1055_Riordan_Verbyla.pdf]

Ritchie, R.J., Wildman, A.M. & Yokel, D.A. 2003. Aerial Surveys of Cliff-nesting Raptors in the National Petroleum Reserve - Alaska, 1999 with comparisons to 1977. BLM/AK/ST-03/016+6501=023, Technical Note 413. Bureau of Land Management, Denver, CO. 66 pp.

Robertson, B.A. & Hutto, R.L. 2007. Is selectively harvested forest an ecological trap for Olive-sided Flycatchers? Condor 109: 109-121.

Roby, D.D. & Brink, K.L. 1986. Decline of breeding Least Auklets on St. George Island, Alaska. Journal of Field Ornithology 57: 58-59.

Rocque, D.A. & Winker, K. 2004. Biomonitoring of contaminants in birds from two trophic levels in the North Pacific. Environmental Toxicology and Chemistry 23: 759-766.

Rogers, J. 2005. Identifying McKay's Buntings. Birding 37: 618–626.

Rosenberg, K.V. & Blancher, P.J. 2005. Setting Numerical Population Objectives for Priority Landbird Species. Pp. 57-67 in Bird Conservation and Implementation in the Americas: Proceedings of the Third International Partners in Flight Conference. 2002 March 20-24; Asilomar, California, Vol. 1 (C.J. Ralph & T.D. Rich, Eds.). General Technical Report PSW-GTR-191. U.S. Forest Service, Pacific Southwest Research Station, Albany, CA. [available at: http://www.fs.fed.us/psw/publications/documents/psw_gtr191/]

Roth, D., Henry, B., Mak, S., Fraser, M., Taylor, M., Li, M., Cooper, K., Furnell, A., Wong, Q., Morshed, M. and members of the British Columbia West Nile Virus Surveillance Team. 2010. Emerging Infectious Diseases 16: 1251-1258.

Rupp, T.S., Chapin III, F.S. & Starfield, A.M. 2000. Response of subarctic vegetation to transient climatic change on the Seward Peninsula in north-west Alaska. Global Change Biology 6: 541-555.

Rupp, T.S., Chapin III, F.S. & Starfield, A.M. 2001. Modeling the influence of topographic barriers on treeline advance at the forest-tundra ecotone in northwestern Alaska. Climate Change 48: 399-416.

Ruthrauff, D.R., Tibbitts, T.L., Gill, Jr., R.E. & Handel, C.M. 2007. Inventory of Montane-nesting Birds in Katmai and Lake Clark National Parks and Preserves. Unpublished final report for National Park Service NPS/AKRSWAN/NRTR-2007/02. U.S. Geological Survey, Alaska Science Center, Anchorage, AK. 88 pp. [available at: http://alaska.usgs.gov/science/biology/shorebirds/pdfs/RuthrauffD_2007_SWAN_MontaneBirdsFinalReport_642374.pdf]

Ruthrauff, D.R., Tibbitts, T.L., Gill, R.E., Jr., Dementyev, M.N. & Handel, C.M. 2012. Small population size of the Pribilof Rock Sandpiper confirmed through distance-sampling surveys in Alaska. Condor 114: 544-551.

Sala, O.E., Chapin III, F.S., Armesto, J.J., Berlow, E., Bloomfield, J., Dirzo, R., Huber-Sanwald, E., Huenneke, L.F., Jackson, R.B., Kinzig, A., Leemans, R., Lodge, D.M., Mooney, H.A., Oesterheld, M., Poff, N.L. Sykes, M.T., Walker, B.H., Walker, M. & Wall D.H. 2000. Global biodiversity scenarios for the year 2100. Science 287: 1770-1774.

Salafsky, N., Salzer, D., Stattersfield, A.J., Hilton-Taylor, C., Neugarten, R., Butchart, S.H.M., Collen, B., Cox, N., Master, L.L., O'Connor, S. & Wilkie, D. 2008. A standard lexicon for biodiversity conservation: unified classifications of threats and actions. Conservation Biology 22: 897-911.

Sauer, J.R., Hines, J.E. & Fallon, J. 2008. The North American Breeding Bird Survey, Results and Analysis 1966-2007. Version 5.15.2008. USGS Patuxent Wildlife Research Center, Laurel, MD. [available at: http://www.mbr-pwrc.usgs.gov/bbs/bbs.html]

Sauer, J.R., Link, W.A., Fallon, J.E., Pardieck, K.L. & Ziolkowski Jr., D.J. 2013. The North American Breeding Bird Survey 1966-2011: summary analysis and species accounts. North American Fauna 79: 1-32 + app. [available at: http://www.fwspubs.org/toc/nafa//79]

Savage, S. 2007. Incidental Avian Observations (1986-2005) Northern Alaska Peninsula with an Emphasis on Field Season 2004-2005. Unpublished report. U.S. Fish & Wildlife Service, Alaska Peninsula/Becharof National Wildlife Refuge Complex, King Salmon, AK. 64 pp.

Scenarios Network for Alaska Planning (SNAP). 2008. Preliminary Report to the Governor's Sub-cabinet on Climate Change. SNRAS Publication Number MP 2008-06. University of Alaska, Fairbanks. 24 pp. [available at: http://www.uaf.edu/files/snras/MP_08_06.pdf]

Scenarios Network for Arctic Planning (SNAP) & EWHALE Lab. 2012. Predicting Future Potential Climate-biomes for the Yukon, Northwest Territories, and Alaska: A Climate-linked Cluster Analysis Approach to Analyzing Possible Ecological Refugia and Areas of Greatest Change. Unpublished report. University of Alaska Fairbanks, Fairbanks, AK. 105 pp. [available at: http://www.snap.uaf.edu/attachments/Cliomes-FINAL.pdf]

Scher, R.L. 1989. Field Guide to Birding in Anchorage. Available from Anchorage Chapter of National Audubon Society, Anchorage, AK.

51 pp.

Scheuhammer, A.M. 1987. The chronic toxicity of aluminium, cadmium, mercury, and lead in birds: a review. Environmental Pollution 46: 263-295.

Schieck, J. & Song, S.J. 2006. Changes in bird communities throughout succession following fire and harvest in boreal forests of western North America: Literature review and meta-analyses. Canadian Journal of Forest Research 36: 1299-1318.

Schmutz, J.A., Trust, K.A. & Matz, A.C. 2009. Red-throated Loons (Gavia stellata) breeding in Alaska, USA, are exposed to PCBs while on their Asian wintering grounds. Environmental Pollution 157: 2386-2393.

Schroeder, M.A. & Boag, D.A. 1991. Spruce Grouse populations in successional lodgepole pine. Ornis Scandinavica 22: 186-191.

Sharbaugh, S.M. 2007. Bird Conservation Region 4 All-Bird Conservation Plan. Unpublished report. Alaska Bird Observatory, Fairbanks, AK. 110 pp. [available at: http://www.pcjv.org/alaska/pdfs/BCR4report.pdf]

Silapaswan, C.S., Verbyla, D.L. & McGuire, A.D. 2001. Land cover change on the Seward Peninsula: the use of remote sensing to evaluate the potential influences of climate warming on historical vegetation dynamics. Canadian Journal of Remote Sensing 27: 542-554.

Sillett, T.S. & Holmes, R.T. 2002. Variation in survivorship of a migratory songbird throughout its annual cycle. Journal of Animal Ecology 71: 296-308.

Simons, T.R., Pollock, K.H., Wettroth, J.M., Alldredge, M.W., Pacifici, K. & Brewster, J. 2009. Sources of Measurement Error, Misclassification Error, and Bias in Auditory Avian Point Count Data. Pp. 237-254 in Modeling Demographic Processes in Marked Populations (D.L. Thomson, E.G. Cooch & M.J. Conroy, Eds.). Environmental and Ecological Statistics 3, Springer Science and Business Media, New York, NY.

Sinclair, P.H., Nixon, W.A., Eckert, C.D. & Hughes, N.L. (Eds.). 2003. Birds of the Yukon Territory. University of British Columbia Press, Vancouver, BC. 595 pp.

Smallwood, J.A., Causey, M.F., Mossop, D.H., Klucsarits, J.R., Robertson, B., Robertson, S., Mason, J., Maurer, M.J., Melvin, R.J., Dawson, R.D., Bortolotti, G. R., Parrish Jr., J.W. & Breen, T.F. 2009. Why are American Kestrel (Falco sparverius) populations declining in North America? Evidence from nest-box programs. Journal of Raptor Research 43: 274-282.

Smallwood, K.S. 2013. Comparing bird and bat fatality-rate estimates among North American wind-energy projects. Wildlife Society Bulletin 37: 19–33.

Smallwood, K.S. & Karas, B. 2009. Avian and bat fatality rates at old-generation and repowered wind turbines in California. Journal of Wildlife Management 73: 1062-1071.

Smith, E.P. 2002. BACI Design. Pp. 141-148 in Encyclopedia of Environmetrics, Vol. 1 (A.H. El-Shaarawi & W.W. Piegorsch, eds.). John Wiley & Sons, Chichester, UK. [available at: http://people.stat.sfu.ca/~cschwarz/Stat-650/Notes/Handouts.readings/smith-2002-EES-baci.pdf]

Smith, L.C., Sheng, Y., MacDonald, G.M. & Hinzman, L.D. 2005. Disappearing arctic lakes. Science 308: 1429.

Smith, J.N.M., Cook, T.L., Rothstein, S.I., Robinson, S.K. & Sealy, S.G. (Eds.). 2000. Ecology and Management of Cowbirds and Their Hosts. University of Texas Press, Austin, TX.

Smith, J.P., Farmer, C.J., Hoffman, S.W., Kaltenecker, G.S., Woodruff, K.Z. & Sherrington, P. 2008. Trends in autumn counts of migratory raptors in western North America, 1983-2005. Pp. 217-252 in State of North America's Birds of Prey (K.L. Bildstein, J.P. Smith, E. Ruelas Inzunza & R.R. Veit, Eds.). Series in Ornithology, no. 3. Nuttall Ornithological Club, Cambridge, MA, and American Ornithologists' Union, Washington, D.C.

Soja, A.J., Tchebakova, N.M., French, N.H.F., Flannigan, M.D., Shugart, H.H., Stocks, B.J., Sukhinin, A.I., Parfenova, E.I., Chapin III, F.S. & Stackhouse Jr., P.W. 2007. Climate-induced boreal forest change: Predictions versus current observations. Global and Planetary Change 56: 274-296.

Sperry, D.M., Kissling, M. & George, T.L. 2008. Avian nesting survival in coastal buffer strips on Prince of Wales Island, Alaska. Condor 110: 740-746.

Spindler, M.A. & Kessel, B. 1980. Avian populations and habitat use in interior Alaska taiga. Syesis 13: 61-104.

Stabeno, P.J., Bond, N.A. & Salo, S.A. 2007. On the recent warming of the southeastern Bering Sea shelf. Deep-Sea Research II 54: 2599-2618.

State of Alaska. 2010. Exploring Viable Markets for Remote Alaska Producers' Value-added Shelf-stable Red Meat Products-Phase I. Unpublished report. State of Alaska, Department of Natural Resources, Division of Agriculture, Palmer, Alaska. 64 pp. [available at: http://dnr.alaska.gov/ag/Marketing/RedMeatMarketResearch.pdf]

State of Alaska. 2010. Alaska Population Digest: 2009 Estimates. Department of Labor & Workforce Development, Research and Analysis Section, Juneau, AK. 77 pp. [available at: http://laborstats.alaska.gov/pop/estimates/pub/popdigest.pdf]

State of Alaska. 2013. Alaska Population Overview: 2012 Estimates. Alaska Department of Labor and Workforce Development, Research and Analysis Section, Juneau, AK. 128 pp. [available at: http://laborstats.alaska.gov/pop/estimates/pub/popover.pdf]

Stout, J.H. & Trust, K.A. Elemental and organochlorine residues in Bald Eagles from Adak, Alaska. Journal of Wildlife Diseases 38: 511-517.

Stout, J.H., Trust, K.A., Cochrane, J.F., Suydam, R.S. & Quakenbush, L.T. 2002. Environmental contaminants in four eider species from Alaska and Arctic Russia. Environmental Pollution 119: 215-225.

Stow, D.A., Hope, A., McGuire, D., Verbyla, D., Gamon, J., Huemmrich, F., Houston, S., Racine, C., Sturm, M., Tape, K., Hinzman, L., Yoshikawa, K., Tweedle, C., Noyle, B., Silapaswan, C., Douglas, D., Griffith, B., Jia, G., Epstein, H., Walker, D., Daeschner, S., Petersen, A., Zhou, L. & Myneni, R. 2004. Remote sensing of vegetation and land-cover change in Arctic tundra ecosystems. Remote Sensing of Environment 89: 281-308.

Stralberg, D., Jonsomjit, D., Howell, C.A., Snyder, M.A., Alexander, J.D., Wiens, J.A. & Root, T.L. 2009. Re-shuffling of species with climate disruption: a no-analog future for California birds? PLoS ONE 4: e6825.

Stralberg, D., Matsuoka, S.M., Solymos, P., Bayne, E.M., Schmiegelow, F.K.A., Cumming, S.G., Song, S.J., Fontaine, T.C. & Handel, C.M. 2013. Modeling Avifaunal Responses to Climate Change Across North America's Boreal-Arctic Transition Zone. Final report to the Arctic Landscape Conservation Cooperative. Boreal Avian Modelling Project, Edmonton, Alberta. 97 pp.

Sturm, M., Racine, C. & Tape, K. 2001. Increasing shrub abundance in the Arctic. Nature 411: 546-547.

Swanson, S. 1997. Avian Productivity in Tundra and Riparian Shrub Habitats near Anaktuvuk Pass, Alaska. Unpublished Report GAAR-97-004. National Park Service, Fairbanks, AK. 13 pp.

Swanson, S. 1998. 1998 Bird Off-Road Point Count Surveys and Analysis of Species Richness Data, 1993-1998: Gates of the Arctic National Park and Preserve. Unpublished Report GAAR-98-006. National Park Service, Fairbanks, AK. 13 pp.

Swanson, S. 2001. 2001 Bird Off-Road Point Count Surveys: Gates of the Arctic National Park and Preserve. Unpublished Report GAAR-01-02. National Park Service, Fairbanks, AK. 7 pp.

Swanson, J.D. & Barker, M.H.W. 1992. Assessment of Alaska reindeer populations and range conditions. Rangifer 12: 33-43.

Swarth, H.S. 1936. Origins of the fauna of the Sitkan District, Alaska. Proceedings of the California Academy of Sciences 23: 59-78

Tape, K., Sturm, M. & Racine, C. 2006. The evidence for shrub expansion in northern Alaska and the Pan-Arctic. Global Change Biology 12: 686-702.

Tetra Tech. 2013. Preliminary Economic Assessment Report on the Arctic Project, Ambler Mining District, Northwest Alaska. Report to Nova Copper, Document 1297650100-RE-R0002-03.1. Tetra Tech, Vancouver, BC. 546 pp. [available at: http://www.novacopper.com/i/pdf/reports/2013_Arctic_PEA_FINAL.pdf]

Thilenius, J.F. 1990. Plant succession on earthquake uplifted coastal wetlands, Copper River Delta, Alaska. Northwest Science 64: 259-262.

Thogmartin, W.E. 2010. Sensitivity analysis of North American bird population estimates. Ecological Modelling 221: 173-177.

Thogmartin, W.E., Howe, F.P., James, F.C., Johnson, D.H., Reed, E.T., Sauer, J.R. & Thompson, F.R. 2006. A review of the population estimation approach of the North American Landbird Conservation Plan. Auk 123: 892-904.

Thomas, C.P.; North, W.B.; Doughty, T.C. & Hite, D.M. 2009. Alaska North Slope Oil and Gas A Promising Future or an Area in Decline? Addendum Report. US Department of Energy, National Energy Technology Lab, Fairbanks, AK. DOE/NETL-2009/1385. [available at: http://www.netl.doe.gov/technologies/oil-gas/publications/AEO/ANS_Potential.pdf]

Tibbitts, T.L., Ruthrauff, D.R., Gill, Jr., R.E. and Handel, C.M. 2006. Inventory of Montane-nesting Birds in the Arctic Network of National Parks, Alaska. Arctic Network Inventory and Monitoring Program Report NPS/AKRARCN/NRTR-2006/2. U.S. Department of Interior, National Park Service, Fairbanks, AK. 156 pp. [available at: http://home.nps.gov/gaar/naturescience/upload/NPS_AKRARCN_NRTR-2005-01-2.pdf]

Trabant, D.C, March, R.S. & Thomas, D.S. 2003. Hubbard Glacier, Alaska: Growing and Advancing in Spite of Global Climate Change and the 1986 and 2002 Russell Lake Outburst Floods. Fact Sheet 001-03. U.S. Geological Survey, Anchorage, AK. [available at: http://pubs.usgs.gov/fs/fs-001-03/fs-001.03.pdf]

Trombulak, S.C. & Frissell, C.A. 2000. Review of ecological effects of roads on terrestrial and aquatic communities. Conservation Biology 14: 18-30.

URS Corporation. 2009. Alaska Wind Energy Development: Best Practices Guide to Environmental Permitting and Consultation. Report to the Alaska Energy Authority. URS Corporation, Anchorage, AK. 20 pp. + app. [available at: http://www.akenergyauthority.org/Reports%20and%20Presentations/2009WindBestPracticesGuide.pdf].

U.S. Census Bureau. 2012. State and County Quick Facts. U.S. Department of Commerce, Washington, DC. [available at: http://quickfacts.census.gov/qfd/states/02000.html]

U.S. Census Bureau. 2010. Annual Estimates of the Resident Population for the United States, Regions, States, and Puerto Rico: April 1, 2000 to July 1, 2009 (NST-EST2009-01). U.S. Census Bureau, Population Division, Washington DC. [available at: http://www.census.gov/popest/states/NST-ann-est.html]

U.S. Department of Agriculture (USDA). 2008a. Tongass National Forest Land and Resource Management Plan Amendment, 2008 Final Environmental Impact Statement: Record of Decision. Unpublished report. R10-MB-603a. U.S. Forest Service, Alaska Region, Juneau, AK. 83 pp. [available at: http://tongass-fpadjust.net/Documents/Record_of_Decision.pdf]

U.S. Department of Agriculture (USDA). 2008b. Tongass National Forest Land and Resource Forest Management Plan. Unpublished report. R10-MB-603b. U.S. Forest Service, Alaska Region, Juneau, AK. 468 pp. [available at: http://tongass-fpadjust.net/Documents/2008_Forest_Plan.pdf]

U.S. Department of the Interior (USDOI). 2011a. BLM Alaska National Landscape Conservation System Units [Online]. U.S. Department of the Interior [available at: http://www.blm.gov/ak/st/en/prog/nlcs.html]

U.S. Department of the Interior (USDOI). 2011b. National Petroleum Reserve – Alaska [Online]. U.S. Department of the Interior [available at: http://www.blm.gov/ak/st/en/prog/energy/oil_gas/npra.html]

U.S. Fish & Wildlife Service (USFWS). 2000. Management Plan for Alaskan Raptors. Unpublished report. U.S. Fish & Wildlife Service, Migratory Bird Management, Juneau, AK. 73 pp.

U.S. Fish & Wildlife Service (USFWS). 2010a. Wind Turbine Guidelines Advisory Committee Recommendations. U.S. Fish & Wildlife Service, Arlington, VA. 162 pp. [available at: http://www.fws.gov/habitatconservation/windpower/Wind_Turbine_Guidelines_Advisory_Committee_Recommendations_Secretary.pdf]

U.S. Fish & Wildlife Service (USFWS). 2010b. Prince of Wales Spruce Grouse. Species Assessment and Listing Priority Assignment Form. Unpublished report. U.S. Fish & Wildlife Service, Anchorage, AK. 28 pp. [availale at: http://alaska.fws.gov/fisheries/endangered/pdf/pow_spgr_species_assessment.pdf]

U.S. Fish & Wildlife Service (USFWS). 2012. U.S. Fish and Wildlife Service Land-based Wind Energy Guidelines. OMB Control No. 1018-0148. U.S. Fish & Wildlife Service, Arlington, WV. 71 pp. [available at: http://www.fws.gov/windenergy/docs/weg_final.pdf]

U.S. Forest Service (USFS) 2002. Icefields and Glaciers. Tongass National Forest: Forest Facts. USDA Forest Service, Washington, DC. [available at: http://www.fs.fed.us/r10/tongass/forest_facts/resources/geology/icefields.htm]

U.S. Geological Survey (USGS). 2009a. Alaska: Earthquake History [Online]. Earthquake Hazards Program, U.S. Geological Survey. [available at: http://earthquake.usgs.gov/earthquakes/states/alaska/history.php]

U.S. Geological Survey (USGS). 2009b. Historic Earthquakes [Online]. Earthquake Hazards Program, U.S. Geological Survey. [available at: http://earthquake.usgs.gov/earthquakes/states/events/1964_03_28.php]

Van Cleve, K., Chapin III, F.S., Dyrness, C.T. & Viereck, L.A. 1991. Element cycling in taiga forests: state-factor control. BioScience 41: 78-88.

Van Hemert, C. & Handel, C.M. 2010. Beak deformities in Northwestern Crows: evidence of a multispecies epizootic. Auk 127: 746-751.

Van Hemert, C., Handel, C.M., Cady, M.N. & Terenzi, J. 2006. Summer Inventory of Landbirds in Kenai Fjords National Park. U.S. Geological Survey, Anchorage, AK. 96 pp. [available at: http://science.nature.nps.gov/im/units/swan/assets/docs/reports/inventories/VanHemertC_2006_KEFJ_Landbird2005InventoryFinalReport_620339.pdf]

Van Hemert, C., Pearce, J., Oakley, K. & Whalen, M. 2013. Wildlife Disease and Environmental Health in Alaska. USGS Fact Sheet 2013–3027. U.S. Geological Survey, Anchorage, AK. 4 pp. [available at: http://pubs.usgs.gov/fs/2013/3027/]

Verbyla, D. 2008. The greening and browning of Alaska based on 1982–2003 satellite data. Global Ecology and Biogeography 17: 547-555.

Viereck, L.A. 1973. Wildfire in the taiga of Alaska. Quaternary Research 3: 465-495.

Visser, M.E., Both, C. & Lambrechts, M.M. 2004. Global climate change leads to mis-timed avian reproduction. Advances in Ecological Research 35: 89-110.

Visser, M.E., Holleman, L.J.M. & Gienapp, P. 2006. Shifts in caterpillar biomass phenology due to climate change and its impact on the breeding biology of an insectivorous bird. Oecologia 147: 164-172.

Walker, M.D., Wahren, C.H., Hollister, R.D., Henry, G.H.R., Ahlquist, L.E., Alatalo, J.M., Bret-Harte, M.S., Calef, M.P., Callaghan, T.V., Carroll, A.B., Epstein, H.E., Jonsdottir, I.S., Klein, J.A., Magnusson, B., Molau, U., Oberbauer, S.F., Rewa, S.P., Robinson, C.H., Shaver, G.R., Suding, K.N., Thompson, C.C., Tolvanen, A., Totland, O., Turner, P.L., Tweedie, C.E., Webber, P.J. & Wookey, P.A. 2006. Plant community responses to experimental warming across the tundra biome. Proceedings of the National Academy of Sciences 103: 1342-1346.

Walsh, J.E. 2012. Climate change projections and uncertainties for Alaska. Pp. 15-20 in Shared Science Needs: Report from the Western Alaska Landscape Conservation Cooperative Science Workshop (J.H. Reynolds & H.V. Wiggins, Eds.). Western Alaska Landscape Conservation Cooperative Anchorage, AK. 142 pp. [available at: https://westernalaskalcc.org/about/LCC%20Document%20Library/Science%20Needs%20Workshop%20Report.pdf]

Walters, E.L., Miller, E.H. & Lowther, P.E. 2002. Red-breasted Sapsucker (Sphyrapicus ruber). The Birds of North America Online, no. 663a (A. Poole, Ed.). Cornell Lab of Ornithology Ithaca, NY. [available at: http://bna.birds.cornell.edu/bna/species/663a]

Weckstein, J.D., Kroodsma, D.E. & Faucett, R.C. 2002. Fox Sparrow (Passerella iliaca). The Birds of North America Online (A. Poole, Ed.).Cornell Lab of Ornithology Ithaca, NY. [available at: http://bna.birds.cornell.edu/bna/species/715]

Werner, R.A., Raffa, K.F. & Illman, B.L. 2006. Dynamics of phytophagus insects and their pathogens in Alaskan boreal forests. Pp. 133-146 in Alaska's Changing Boreal Forest (F.S. Chapin III, M.W. Oswood, K. Van Cleve, L.A. Viereck & D.L. Verbyla, Eds.). Oxford University Press, New York, NY.

Werner, R. A., Holsten, E. H., Matsuoka, S. M. & Burnside, R.E. 2006. Spruce beetles and forest ecosystems in south-central Alaska: a review of 30 years of research. Forest Ecology & Management 227: 195-206.

West, G.C. 1994. A Birder's Guide to the Kenai Peninsula, Alaska. Pratt Museum and Birchside Studios, Homer, AK. 154 pp.

Western Regional Climate Center (WRCC). 2010. Period of Record Monthly Climate Summary for Barrow Weather Service Office (WSO) Airport, Kuparuk, Umiat, Prudhoe Bay, and Wainwright, Alaska. Historic Climate Information. Western U.S. Historical Summaries (Individual Stations), Historical Climate Information, Reno, NV.

Western Regional Climate Center (WRCC). 2012. Period of Record Monthly Climate Summary for Alaska. Historic Climate Information. Western U.S. Historical Summaries (Individual Stations), Historical Climate Information, Reno, NV. [available at: http://www.wrcc.dri.edu/summary/Climsmak.html]

White, C.M., Clum, N.J., Cade, T.J. & Hunt, W.G. 2002. Peregrine Falcon (Falco peregrinus). In The Birds of North America Online (A. Poole, Ed.). Cornell Lab of Ornithology, Ithaca, NY. [available at: http://bna.birds.cornell.edu/bna/species/660]

Wiens, J.A., Crist, T.O., Day, R.H., Murphy, S.M. & Hayward, G.D. 1996. Effects of the Exxon Valdez oil spill on marine bird communities in Prince William Sound, Alaska. Ecological Applications 6: 828-841

Wiggins, D. 2004. Black Swift (Cypseloides niger): a technical conservation assessment [Online]. U.S. Forest Service, Rocky Mountain Region. [available at: http://www.fs.fed.us/r2/projects/scp/assessments/blackswift.pdf]

Wiggins, D.A., Holt, D.W. & Leasure, S.M. 2006. Short-eared Owl (Asio flammeus). The Birds of North America Online, no. 62 (A. Poole, Ed.). Cornell Lab of Ornithology, Ithaca, NY. [available at: http://bna.birds.cornell.edu/bna/species/062]

Wild, T.C. & Powell, A. 2009. Smith's Longspur ecology studies in Northern Alaska 2008-2009 Progress Report. Unpublished Report. University of Alaska - Fairbanks, Fairbanks, AK. 34 pp.

Williamson, F.S.L. & Peyton, L.J. 1962. Faunal relationships of birds in the Iliamna Lake area, Alaska. Biological Papers of the University of Alaska 5. Institute of Arctic Biology, Fairbanks, AK. 73 pp.

Winer, G.S., Feeley, T.C. & Cosca, M.A. 2004. Basaltic volcanism in the Bering Sea: geochronology and volcanic evolution of St. Paul Island, Pribilof Islands, Alaska. Journal of Volcanology and Geothermal Research 134: 277-301.

Winker K., Gibson, D.D., Sowls, A.L., Lawhead, B.E., Martin, P.D., Hoberg, E.P. & Causey, D. 2002. The Birds of St. Matthew Island, Bering Sea. Wilson Bulletin 114: 491-509.

Wolken, J.M., Hollingsworth, T.N., Rupp, T.S., Chapin III, F.S., Trainor, S.F., Barrett, T.M., Sullivan, P.F., McGuire, A.D., Euskirchen, E.S., Hennon, P.E., Beever, E.A., Conn, J.S., Crone, L.K., D'Amore, D.V., Fresco, N., Hanley, T.A., Kielland, K., Kruse, J.J., Patterson, T., Schuur, E.A.G., Verbyla, D.L. & Yarie, J. 2011. Evidence and implications of recent and projected climate change in Alaska's forest ecosystems. Ecosphere 2: 124. doi:10.1890/ES11-00288.1.

Wright, J.M. 1997. Preliminary Study of Olive-sided Flycatchers, July 1994-April 1997. Unpublished final research report. Endangered species conservation fund Federal Aid studies SE-3-3, 4 and 5. Alaska Department of Fish & Game, Juneau, AK. 34 pp.

Wright, J.M. 1979. Reindeer Grazing in Relation to Bird Nesting on the Northern Seward Peninsula. M.S. thesis. University of Alaska, Fairbanks. 109 pp.

Wurtz, T.L., Ott, R.A. & Maisch, J.C. 2006. Timber Harvest in Interior Alaska. Pp. 302-308 in Alaska's Changing Boreal Forest (F.S. Chapin III, M.W. Oswood, K. Van Cleve, L.A. Viereck & D.L Verbyla, Eds.). Oxford University Press, New York, NY.

Yoshikawa, K. & Hinzman, L.D. 2003. Shrinking thermokarst ponds and groundwater dynamics in discontinuous permafrost near Council, Alaska. Permafrost & Periglacial Processes 14: 151-160.

Zimmerling, J.R., Pomeroy, A.C., d'Entremont, M.V. & Francis, C.M. 2013. Canadian estimate of bird mortality due to collisions and direct habitat loss associated with wind turbine developments. Avian Conservation and Ecology 8(2): 10. [available at: http://dx.doi.org/10.5751/ACE-00609-080210]

Zwickel, F.C. & Bendell, J.F. 2005. Blue Grouse (Dendragapus obscurus). The Birds of North America Online, no. 15 (A. Poole, Ed.). Cornell Lab of Ornithology, Ithaca, NY. [available at: http://bna.birds.cornell.edu/bna/species/015]

Zwiefelhofer, D. 2007. Comparison of Bald Eagle (Haliaeetus leucocephalus) nesting and productivity at Kodiak National Wildlife Refuge, Alaska, 1963-2002. Journal of Raptor Research 41: 1-9.

Appendix I

Brief accounts of species of Continental Importance occurring in Alaska

The following eight species are identified on the top-tier of the PIF Watch List as being Species of Continental Importance for the U.S. and Canada (Rich et al. 2004). 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 the highest priority for conservation action at regional, national, and international scales (Rich et al. 2004).

Sooty Grouse (*Dendragapus fuliginosus*) — In Alaska, this popular game bird (formerly considered a subspecies group of the Blue Grouse; Banks et al. 2006) is restricted to mainland and insular southeastern Alaska (except Prince of Wales Island), where it is generally found in coniferous and mixed forests (Zwickel and Bendell 2005). Breeding densities vary greatly. Old-growth forest appears to be their preferred habitat and they appear to be negatively affected by forest management practices. Although they show initial increases in logged clearcuts, density declines once dense conifer growth shades out understory vegetation, and they are absent in young, even-age forest stands (Zwickel and Bendell 2005). Despite intensive study over the past 60 years (although little to none in Alaska), ability to predict population levels and trends remains poor. In Alaska, the BBS is not adequate for monitoring population trend and more specialized surveys are needed. Forest management practices, such as habitat fragmentation due to logging-road development, are probably the major threats to this species in Alaska, although the impact and extent of these are unknown. This species is an important prey item of the Queen Charlotte Goshawk, for which the Canadian population is listed under Canada's Species at Risk Act (COSEWIC 2000). Thus, managing for Sooty Grouse may indirectly benefit the management of other priority species in the region (Lewis et al. 2006).

Short-eared Owl (*Asio flammeus*) — This species is nomadic and difficult to census (Wiggins et al. 2006) but a rough population estimate for Alaska is 150,000 individuals, or >20% of the continental population. The Short-eared Owl has a broad distribution and has suffered a precipitous continent-wide decline over the last 40 years (Sauer et al. 2008). Alaska-breeding populations winter in North American prairie regions, where native grasslands have largely been converted or fragmented by agriculture (J. Johnson and T. Booms, unpubl. data). Owls arrive in Alaska in mid-May to early June, and breed in lowland habitats throughout the state. Erratic fluctuations in breeding distribution present a challenge for population monitoring in Alaska (USFWS 2000). In general, detailed life-history information is lacking, but the decline in continental numbers is likely due to large-scale loss of critical grassland and coastal wetland habitats. Other limiting factors include vehicle collisions (Clark 1975), predation, prey abundance (Melvin et al. 1989), and possible contaminants accumulated in prey on agriculturally-dominated wintering areas. The effects

Easterm Yellow Wagtail

of climate change on breeding habitats should also be considered (Sinclair et al. 2003). Basic research on migratory movements, habitat use, reproductive ecology, and productivity is required if we are to understand the cause(s) of the decline and effectively manage this species.

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 non-breeding season is virtually non-existent (Lowther and Collins 2002). In fact, 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 little behavior of this species is 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 are apparently common although the cause is unknown, but may be 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, and behavior is required.

Rufous Hummingbird (*Selasphorus rufus*) — This little migrant has the most northern breeding range of any hummingbird and arrives 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 2006). Rufous Hummingbirds winter in southern Texas and Mexico. Overall, the species is considered to be relatively secure, with the global population estimated at around 7 million individuals (Rich et al. 2004), but BBS data show a significant decline in western North America (Healy and Calder 2006). In Alaska, however, the BBS is not adequate for monitoring population trend and more specialized surveys are needed. Basic research on breeding biology, foraging ecology, habitat use, and productivity is required if we are to understand the cause(s) of the decline and effectively manage this species.

Olive-sided Flycatcher (*Contopus cooperi*) — Alaska supports an estimated 300,000 birds, around 25% of the global population, and BBS data provide strong evidence for a significant, continent-wide population decline (Sauer et al. 2008). The breeding range of this species extends across the coniferous forest region of North America, with the steepest declines indicated in the west. They winter primarily in the mountains of northern and western South America. They regularly breed at low densities throughout the boreal and coastal forests of Alaska (Kessel and Gibson 1978). Males return to breeding sites in Central 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 2000). Nest success is high in wetlands and recent burns (61-65%), but much lower in recent harvested areas (30-33%; Wright 1997, Altman and Sallabanks 2000, Robertson and Hutto 2007), which are thought to act as an ecological trap (Robertson and Hutto 2007). 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 its broad breeding range, however, and declines may be related to habitat loss on the wintering range or on migration. 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 was listed as Threatened in Canada in 2007, under the Species At Risk Act (COSEWIC 2007).

Smith's Longspur (*Calcarius pictus*) — One of the least-studied landbirds in North America, Smith's Longspur is known to breed in two areas in Alaska, the Brooks Range and the northern foothills and uplands of east-central Alaska (Kessel and Gibson 1978). They winter in the grasslands of the southern Great Plains in the central U.S. (Briskie 1993). Given its isolated breeding grounds, this species is not covered by the BBS and is rarely seen on the CBC. As a result, the best population estimate is an educated guess of around 75,000 birds (Briskie 1993). Analysis of CBC data, however, suggests a declining trend in wintering populations in BCRs 25 and 26 (Niven et al. 2004). The proportion of the global population occurring in Alaska is unknown, but likely to be considerable. No long-term data are available to determine population trends. Clearly, dedicated and long-term monitoring initiatives are required to confirm the distribution, population size, and population trend of Smith's Longspurs in Alaska, and some of this research has recently begun in Alaska. The isolation of their breeding areas may protect this species during summer from most human disturbance, except perhaps oil and gas exploration and extraction, but they are likely highly susceptible to land-use changes on their wintering grounds, which are heavily managed for agricultural uses. Climate change in both the wintering and breeding grounds may have considerable impacts on this species, the extent of which is unknown. Basic research across their range on systematics, breeding biology, behavior, phenology, foraging ecology, habitat use, and population dynamics is required.

McKay's Bunting (*Plectrophenax hyperboreus*) – The only endemic landbird species in Alaska. The state supports the entire global population, estimated at 31,000 individuals (Matsuoka and Johnson 2008). McKay's Bunting breeds on the remote St. Matthew Island and its smaller satellite, Hall Island, in the central Bering Sea. Small numbers also appear irregularly on St. Lawrence Island and the Pribilof Islands, but breeding has not been confirmed at these sites (Montgomerie and Lyon 2011). McKay's Buntings also have a limited wintering range along the coast of western Alaska, from the Seward Peninsula south to the Alaska Peninsula (Montgomerie and Lyon 2011). There are no major imminent threats, but given the small population size and its extremely limited range, McKay's Bunting is extremely vulnerable to disruptions to their breeding islands, such as the introduction of invasive species (e.g. rats), or 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.

Rusty Blackbird (*Euphagus carolinus*) – This species' dramatic 90% population decline over the last 40 years (Greenberg and Droege 1999) has until quite recently been the best known aspect of its ecology (Greenberg and Matsuoka 2010). Alaska supports an estimated 600,000 birds, or ~30% of the global population, which breeds across North America's boreal forest (Avery 1995). Alaska breeding populations winter in the Mississippi Alluvial Valley (Hobson et al. 2010). In Alaska, Rusty Blackbirds arrive on breeding territories in early May and breed at low densities south of the Brooks Range (ADFG 2006) with densities particularly high in riparian areas along the lower Yukon and Kuskokwim rivers (Harwood 2002). The species almost always breeds in association with freshwater wetlands, particularly ponds and lakes (Spindler and Kessel 1980), presumably due to specialized food requirements for large aquatic invertebrates (Matsuoka et al. 2010a). They tend to breed solitarily or in small groups and nest in small spruce (Picea spp.) or willow shrubs (Salix spp.) adjacent to open water (Matsuoka et al. 2010b). Post-breeding flocks build from mid-July with the peak of fall migration in early September. The species is not often encountered on BBS routes or off-road point counts in Alaska (Hannah 2004), but targeted area searches in wetland habitats have been found to be quite accurate in estimating breeding densities (Matsuoka et al. 2010a). Continued wetland-drying across boreal Alaska associated with climate warming (Klein et al. 2005, Riordan et al. 2006) will likely contribute to future declines in this and possibly other boreal-wetland birds (Matsuoka et al. 2010a). Breeding populations are vulnerable to exposure to high levels of methylmercury, which are much lower in Alaskan birds compared to those breeding in eastern North America, where atmospheric deposition of industrial pollution is far greater problem (Edmonds et al. 2010). Nest survival is low for nests placed in stands regenerating from recent clearcuts near wetlands (Powell et al. 2010). However, nesting success overall tends be high in Alaska (56%) and New England (62%) indicating that chronic low nest survival is not a likely mechanism for the species' decline. Research is needed to understand where and why deficits in adult or juvenile survival are limiting population growth in the species (Matsuoka et al. 2010b). Research is also needed on the wintering grounds to identify, characterize, and protect the remaining areas that still support large flocks, to understand how past and ongoing blackbird control efforts may be negatively affecting the species, and to understand why wintering birds have a high incidence of blood parasites, a sign of high stress (Avery 1995, Barnard et al. 2010, Greenberg and Matsuoka 2010).

Insert Appendix II

Insert Appendix III

Appendix IV

Variables and criteria used for assessing the status and vulnerability of landbirds at the global, continental, and state levels (from Panjabi et al. 2005).

Population Size (PS) indicates vulnerability due to the total number of adult individuals in the population. Evaluation of PS is based on the assumption that species with small populations are more vulnerable to extirpation or extinction than species with large populations. Scores were assigned using population estimates derived primarily from abundance data collected by the North American Breeding Bird Survey (BBS), extrapolated after various adjustments to range size outside of BBS coverage; but other data on abundance were used when appropriate (Rich et al. 2004, Rosenberg and Blancher 2005).

5 Breeding population <50,000

4 Breeding population ≥50,000 and <500,000

3 Breeding population ≥500,000 and <5,000,000

2 Breeding population ≥5,000,000 and <50,000,000

1 Breeding population ≥50,000,000

Breeding Distribution (BD) indicates vulnerability due to the geographic extent of a species' breeding range. The underlying assumption is that species with narrowly distributed breeding populations are more vulnerable than species with widely distributed populations. BD is assessed at a truly global scale, such that the entire range of the species is considered in the evaluation.

BD is calculated by determining the area (km2) or, for coastal breeders, length (km) of linear coastline occupied by breeding-aged individuals during the breeding season, using range maps for the species from well-known field guides (e.g. National Geographic Society 1987, Howell and Webb 1995), as well as other sources (e.g., NatureServe). In future versions of the database, distribution scores will make use of area measurements from digital range maps such as those available from NatureServe (Ridgely et al. 2003). Comparisons to date indicate that most distribution scores will not change.

5 <500,000 km^2, or very restricted coastal areas or interior uplands

4 ≥500,000 and <1,000,000 km^2, or ≤1,600 km of coast

3 ≥1,000,000 and <2,000,000 km^2, or >1,600 to ≤5,000 km of coast

2 ≥2,000,000 and <4,000,000 km^2, or >5,000 to ≤8,000 km of coast

1 ≥4,000,000 km^2, or >8,000 km of coast

Non-breeding Distribution (ND) indicates vulnerability due to the geographic extent of a species' non-breeding range, with the assumption that species narrowly distributed in the non-breeding season are more vulnerable than widely-distributed species. ND is assessed at a truly global scale.

For landbirds, range size does not consider migratory periods, or phenomena such as migratory bottlenecks. Instead, evaluation of ND is based on the non-breeding range of a species when populations are relatively sedentary. However, for some birds that are known to be concentrated during migration, ND scores reflect the smallest area (km2), or for coastal species amount of linear coastline (km) occupied by the population at any given time during the non-breeding season.

ND is calculated by determining the area (km2), or amount of linear coastline (km), occupied by the population during the portion of the non-breeding season when birds are relatively sedentary, using range maps for the species from well-known field guides (e.g., National Geographic Society 1987, Howell and Webb 1995), as well as other sources (e.g., Ridgely et al. 2003).

1. 5 <500,000 km2, or very restricted coastal areas or interior uplands
1. 4 ≥500,000 and <1,000,000 km2, or ≤1,600 km of coast
1. 3 ≥1,000,000 and <2,000,000 km2, or >1,600 to ≤5,000 km of coast
1. 2 ≥2,000,000 and <4,000,000 km2, or >5,000 to ≤8,000 km of coast
1. 1 ≥4,000,000 km2, or >8,000 km of coast

Threats to Breeding (TB) indicates vulnerability due to the effects of current and probable future extrinsic conditions that threaten the ability of populations to survive and successfully reproduce in breeding areas within North America. Evaluation of TB includes threats to breeding habitats, as well as other factors that interfere with reproduction (e.g., competition with exotic species).

Scoring of TB involves assessing the expected change over the next 30 years in the suitability of breeding conditions necessary for maintaining healthy populations of a species. Threats to suitable breeding conditions 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, or any other factor that reduces the suitability of breeding conditions. To date, climate change has been considered a threat only for mountain-top species and a few others for which this is an obvious threat, but has not been used in scoring threats for most species due to lack of good information on probable effects on global population size (as opposed to effects on distribution).

Threats scores are assigned by the PIF Science Committee and the sources of all scores are maintained in the database. Although threat scores are the most subjective of the species assessment criteria, they are calibrated among taxa and subject to review. In practice, PIF has found close agreement among experts on the most appropriate threat scores.

The categorical variable TB is derived according to a multiple-choice list of scenarios that place the species into one of the broad, relative threats categories in the table below. In order for a species to be placed in a particular category, it must meet the criteria defined for that category and meet one or more of the examples listed under the possible scenarios that follow each definition. It is important to understand that in order for a species to be assigned a given score, one or more of the example conditions listed must actually be affecting the species at present, or be expected to do so within the next 30 years. In other words, simply being susceptible to threats, without actually being affected by such threats in the foreseeable future, is not enough to warrant a high threat score.

5 Extreme deterioration in breeding conditions is occurring; species is in danger of major range contraction, or has a low probability of successful reintroduction.

4 Severe deterioration in the future suitability of breeding conditions is expected.

3 Slight to moderate decline in the future suitability of breeding conditions is expected.

2 Future breeding conditions expected to remain stable; no known threats.

1 Future breeding conditions expected to be enhanced by human activities or land-uses.

Threats to Non-breeding (TN) indicates vulnerability due to the effects of current and future extrinsic conditions that threaten the ability of North American breeding populations to survive over the non-breeding season. Unlike TB, evaluation of TN considers vulnerability throughout the non-breeding range of North American breeding populations. However, it is still a "continental" score in that it refers to threats faced by North American populations. Evaluation of TN includes threats to habitat as well as other factors affecting survival outside the breeding season. Threats during the migration season are included, but for landbirds, TN is almost exclusively based on the portion of the non-breeding season in which birds are relatively sedentary. Scoring is the same as described for TB above.

1. 5 Extreme deterioration in non-breeding conditions is occurring; species is in danger of major range contraction, or has a low probability of successful reintroduction.
1. 4 Severe deterioration in the future suitability of non-breeding conditions is expected.
1. 3 Slight to moderate decline in the future suitability of non-breeding conditions is expected.
1. 2 Future non-breeding conditions expected to remain stable; no known threats.
1. 1 Future non-breeding conditions expected to be enhanced by human activities or land-uses.

Population Trend (PT) indicates vulnerability due to the direction and magnitude of recent changes in population size. Like the threats scores, PT actually reflects trends only within North America, even for species with ranges that extend beyond the continent. It is therefore a continental, rather than a global, score. Species that have declined by 50% or more over 30 years are considered most vulnerable, whereas species with increasing trends are least vulnerable.

The primary source of trends is the BBS, but Christmas Bird Count (CBC) or specialized data sources are used where these were the best available breeding or non-breeding data on North American population trends. In some cases, particularly for extirpated or possibly extinct species, historical trends are considered. Where empirical data do not exist, PT is assigned by expert opinion, using the qualitative definitions below as guidelines.

Trends from the longest period available are used (from 1966-2001 for BBS in the current version of the database). On the assumption that rate of change has been reasonably constant over the long term, PT scores are calculated based on the annual rates of change that would produce population size change of a particular size over 30 years.

PT scores include consideration of data quality when possible. Species for which trends are uncertain, either because of highly variable data or poor sample size, receive a score of 3. This intermediate score is assigned on the reasoning that uncertain trends should invoke more concern than stable trends (for which PT=2). Any species that receives a PT score of 3 is reviewed by experts to determine whether a more appropriate score can be assigned.

1. 5 Large decrease (≥ 50% over 30 years; ≤-2.28% per year)
1. 4 Moderate decrease (15-49% over 30 years; <-0.54 to -2.28% per year)
1. 3 Uncertain trend
1. 2 Moderate increase (15-49% over 30 years; 0.47 to 1.36% per year)
   OR stable (<15% change over 30 years; -0.54 to 0.47% per year)
1. 1 Large increase (≥ 50% over 30 years; ≥1.36% per year)