National Park Service - Southwest Alaska Network
Inventory & Monitoring Program

# Inventory of Breeding Birds in Aniakchak National Monument and Preserve

Final Report

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**Acronyms:**

| | |
|---|---|
| ANIA | Aniakchak National Monument and Preserve |
| ASC | Alaska Science Center |
| GIS | Geographic Information System |
| GPS | Global Positioning System |
| KATM | Katmai National Park and Preserve |
| LACL | Lake Clark National Park and Preserve |
| NED | National Elevation Dataset |
| NPS | National Park Service |
| SWAN | Southwest Alaska Network |
| USGS | U. S. Geological Survey |

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Cover images (clockwise, from upper left): Lisa Pajot conducts a point count survey in the upper Wiggly Creek drainage (photo J. Morse); a male rock ptarmigan *Lagopus mutus* (photo B. Thompson); Surprise Lake in Aniakchak Caldera (photo D. Ruthrauff); Bill Thompson on the slopes of Pinnacle Mountain overlooking Meshik Lake (photo T. Hamon); a male snow bunting *Plectrophenax nivalis* (photo B. Thompson); marbled godwit *Limosa fedoa beringiae* (photo D. Ruthrauff).

## Abstract

As part of the National Park Service's Inventory and Monitoring Program, biologists from the U. S. Geological Survey's Alaska Science Center and the National Park Service conducted an inventory of breeding birds in Aniakchak National Monument and Preserve (ANIA) during spring 2008. To survey for birds, two, two-person crews conducted counts at 136 points across eight, 10-km x 10-km (6.2-mi x 6.2-mi) random plots; another two-person crew conducted extensive area searches at six locations believed to contain unique habitats or landforms. We detected 67 species in ANIA, including 21 species of conservation concern. We detected seven species not previously recorded in Aniakchak (gadwall [*Anas strepera*], golden eagle [*Aquila chrysaetos*], merlin [*Falco columbarius*], marbled godwit [*Limosa fedoa*], downy woodpecker [*Picoides pubescens*], horned lark [*Eremophila alpestris*], and hoary redpoll [*Carduelis hornemanni*]). The most commonly detected species was golden-crowned sparrow (*Zonotrichia atricapilla*), followed by Wilson's warbler (*Wilsonia pusilla*) and hermit thrush (*Catharus guttatus*). These three species were also the most widely distributed species at locations where we conducted point counts. We defined survey points as low (<120 m), middle (120–320 m), or high (321–625 m) elevation based on the distribution of vegetation cover, and similarly categorized the 13 most commonly detected species based on the mean elevation of sample points at which they were detected. The habitat types and associated bird communities were similar to those observed during inventories conducted in Katmai and Lake Clark National Parks and Preserves during 2004–2006, but the elevation classes, associated habitat types, and bird communities occurred within narrower and lower elevation ranges in ANIA. Because the avifauna of this region is poorly described, this inventory significantly contributes to our knowledge of the breeding bird community in the region and establishes baseline information on species status for any future monitoring efforts.

## Executive Summary

The National Park Service (NPS) is the custodian for over 200,000 $km^2$ (77,220 $mi^2$) of protected lands within Alaska. In order to more effectively protect and manage these vast holdings, NPS formed four Inventory and Monitoring networks: the Arctic, Central, Southeast, and Southwest Alaska Networks. The Southwest Alaska Network (SWAN) of national parks includes five units totaling slightly more than 38,000 $km^2$ (14,670 $mi^2$): Alagnak Wild River Corridor, Aniakchak National Monument and Preserve (ANIA), Katmai National Park and Preserve (KATM), Kenai Fjords National Park, and Lake Clark National Park and Preserve (LACL). These units encompass nearly 20% of all NPS lands within Alaska, and cover a diverse spectrum of geography and landforms in a landscape largely dominated by massive, glacier-covered mountains.

ANIA, perched along the Alaska Peninsula between the Gulf of Alaska and the Bering Sea, is one of the more remote and infrequently visited units within NPS. ANIA's physical location predisposes it to extreme weather events, and the region's rugged terrain is the result of numerous volcanic eruptions. In combination with the area's remote setting, these factors have limited scientific investigation, particularly pertaining to the region's avian resources. Consequently, the overall lack of knowledge concerning the distribution and abundance of breeding birds in ANIA is a management priority.

Within the framework of the NPS's Inventory and Monitoring Program, biologists from the U. S. Geological Survey's Alaska Science Center and NPS designed and implemented an inventory tailored to survey birds across ANIA. Plot access was via helicopter, and three, two-person crews spent from one-half day to five nights within sample plots. The inventory was conducted during late May–early June 2008, a period selected to maximize our ability to detect a wide range of breeding bird species. Following the random plot selection procedures employed in previous inventory efforts in KATM and LACL, sample points were allocated in proportion to the extent of ecological subsections within each park, and two crews conducted surveys at 136 points across eight, 10-km x 10-km (6.2-mi x 6.2 mi) random plots. A third crew conducting focal area searches visited 6 locations believed to contain unique habitats or landforms within 3 plots and an adjacent area. Employing these methodologies, 10 plots were surveyed for birds in ANIA.

We detected 67 species in ANIA, including seven species not previously recorded in this park unit: gadwall (*Anas strepera*), golden eagle (*Aquila chrysaetos*), merlin (*Falco columbarius*), marbled godwit (*Limosa fedoa beringiae*), downy woodpecker (*Picoides pubescens*), horned lark (*Eremophila alpestris*), and hoary redpoll (*Carduelis hornemanni*). Results from this inventory, combined with summaries of previous bird records, documented the occurrence of 108 species in ANIA. We detected 21 species of conservation concern during this inventory, and based on the records of previous observers, an additional 15 species of conservation concern occur in these parks. Only three species of

conservation concern, willow ptarmigan (*Lagopus lagopus*), rock ptarmigan (*L. mutus*), and golden-crowned sparrow (*Zonotrichia atricapilla*), were commonly observed, being detected on 8 (80%), 7 (70%), and 10 (100%) of 10 sample plots, respectively.

In the course of documenting new species in ANIA, we also documented their breeding status. The seven species added to the park list all likely breed in ANIA, with one especially noteworthy confirmation of this fact: on 4 June 2008, crews found the first active marbled godwit nest ever discovered for this rare Alaska breeder. This subspecies is restricted to a breeding range on the central Alaska Peninsula and numbers approximately 2,000 individuals, and this nest represents a rare ornithological first that underscores many of the basic benefits of the Inventory and Monitoring Program.

Excluding two species that were almost exclusively detected in a large flock at one point each (red-necked phalarope and bank swallow), the species most commonly detected during counts at the 136 points were all passerines. Golden-crowned sparrow ($n$ = 143 individuals detected), Wilson's warbler (*Wilsonia pusilla*; $n$ = 141), hermit thrush (*Catharus guttatus*; $n$ = 143), orange-crowned warbler (*Vermivora celata*; $n$ = 72), and fox sparrow (*Passerella iliaca*; $n$ = 50) were the most commonly detected species overall. These same five species were also widely distributed; they were the only species to be detected at all ten survey plots.

We used the Viereck classification system to characterize vegetation cover at the 136 sample points and to assess bird-habitat associations. We combined Viereck classifications into five ecologically meaningful categories: tall shrub, low shrub, dwarf shrub, bare ground, and herbaceous habitats. To facilitate describing the distribution of birds with respect to habitat, we created three elevation categories based on the distributional patterns of vegetation cover: low (<120 m), middle (120–320 m), and high (320–625 m) elevation. Similarly, the 13 most commonly detected species were assigned to an elevation category based on the mean elevation of the sample points at which they were detected.

Sites within the low elevation category were dominated by low and tall shrub habitats, and these sites were used by species like hermit thrush and orange-crowned warbler. Middle elevation sites were primarily comprised of low and dwarf shrub habitats, and common species using these habitats included rock ptarmigan and golden-crowned sparrow. High elevation sites were characterized by high percent cover of dwarf shrub and bare ground habitat and supported species like semipalmated plover (*Charadrius semipalmatus*) and snow bunting (*Plectrophenax nivalis*). High elevation sites also had extensive snow cover, but the apparently late spring conditions did not seem to impact bird behavior or delay breeding activities. The habitat types and associated bird communities in ANIA were similar to those detected during inventories in KATM and LACL in 2004–2006, with the notable exception that ANIA essentially contains no forest

habitats. Despite the general similarities, the elevation classes were narrower and lower in elevation at ANIA than KATM and LACL, and the associated habitat types and bird communities likewise occurred within narrower and lower elevation ranges. This is likely due to the region's extreme weather; high winds and increased precipitation probably force these habitat types to assume more prostrate forms at comparatively lower elevations.

This inventory represents the first systematic ground survey of breeding birds in ANIA, and complements similar inventories recently conducted throughout Alaska. Given the dearth of information regarding the state's avifauna in general, this inventory significantly augments our understanding of the distribution and abundance of Alaska's birds. Faced with numerous potential conservation threats outside of park boundaries (e.g., effects from oil and mineral extraction, global climate change), NPS holdings serve as regions of relative stability for wildlife populations. With the increased knowledge provided by these studies, managers can better promote the conservation and appreciation of birds both within and beyond park boundaries.

**TABLE OF CONTENTS**

## LIST OF FIGURES

## LIST OF TABLES

**APPENDIX**

## Introduction

The National Park Service (NPS) manages 390 land units covering nearly 340,000 $km^2$ (over 130,000 $mi^2$) of protected lands throughout the United States and associated territories. Nearly two-thirds of these lands are distributed across 16 parks, preserves, and monuments within Alaska. In order to more effectively manage Alaska's vast holdings, NPS formed four networks based on proximity and ecological similarity: the Arctic, Central, Southeast, and Southwest Alaska Networks (National Park Service 2006a).

The Southwest Alaska Network (SWAN) of national parks includes five units totaling slightly more than 38,000 $km^2$ (14,670 $mi^2$; Figure 1). SWAN units encompass approximately 2% of Alaska's total land area, and nearly 20% of all NPS lands within Alaska (National Park Service 2006b). SWAN parks cover a diverse spectrum of geographic features and landforms, but the overall defining characteristic of this network is its impressive mountains. From the fjord-dominated landscapes of Kenai Fjords National Park (KEFJ) to the sulphurous moonscape of Katmai National Park and Preserve's (KATM) Valley of Ten Thousand Smokes, SWAN sits atop a tectonic confluence that largely defines the region (Nowacki et al. 2002).

Perhaps nowhere in SWAN is this geologic history more tangible than in Aniakchak National Monument and Preserve (ANIA). Straddling the Aleutian Range between the Gulf of Alaska and the Bering Sea, ANIA is a landscape of contrasts. Lower elevation sites consist of gently sloping terrain and expansive bays along the Gulf of Alaska coast. Rolling meadows, wetlands, and ericaceous habitats dominate these sites; the Meshik River drains regions northwest to Bristol Bay, whereas the Aniakchak River drains regions to the southeast and the Gulf of Alaska. At higher elevations, gentle terrain gives way to rugged, snow-clad mountains and, most spectacularly, Aniakchak Crater, a 10-km wide, 1-km deep crater created by a massive volcanic eruption in 1645 B.C. (National Park Service 2008). Still volcanically active, at least 10 eruptive events have been documented since the formation of the crater, the most recent in 1931. The slopes of Aniakchak Crater rise gently on the western flanks from Bristol Bay, but the region surrounding the crater's eastern slopes are comprised of steep, rugged mountains.

The Aleutian Range rises prominently along the Alaska Peninsula, and both the elevational relief and physical location of the mountains between two massive bodies of water induce a notoriously wet, foggy, and cool climate. Large low pressure systems form in the western Pacific region and come in contact with the mountains as they travel east, generating wind and moisture. Warm waters from the Gulf of Alaska interact with cold Bering Sea waters, and these factors combine to create extreme weather conditions. High winds and lashing rains are common during the summer season, and thick fog and low clouds are the norm. Because of its remote location and generally foul weather, ANIA is one of the least-visited units in the NPS system (National Park Service 2008).

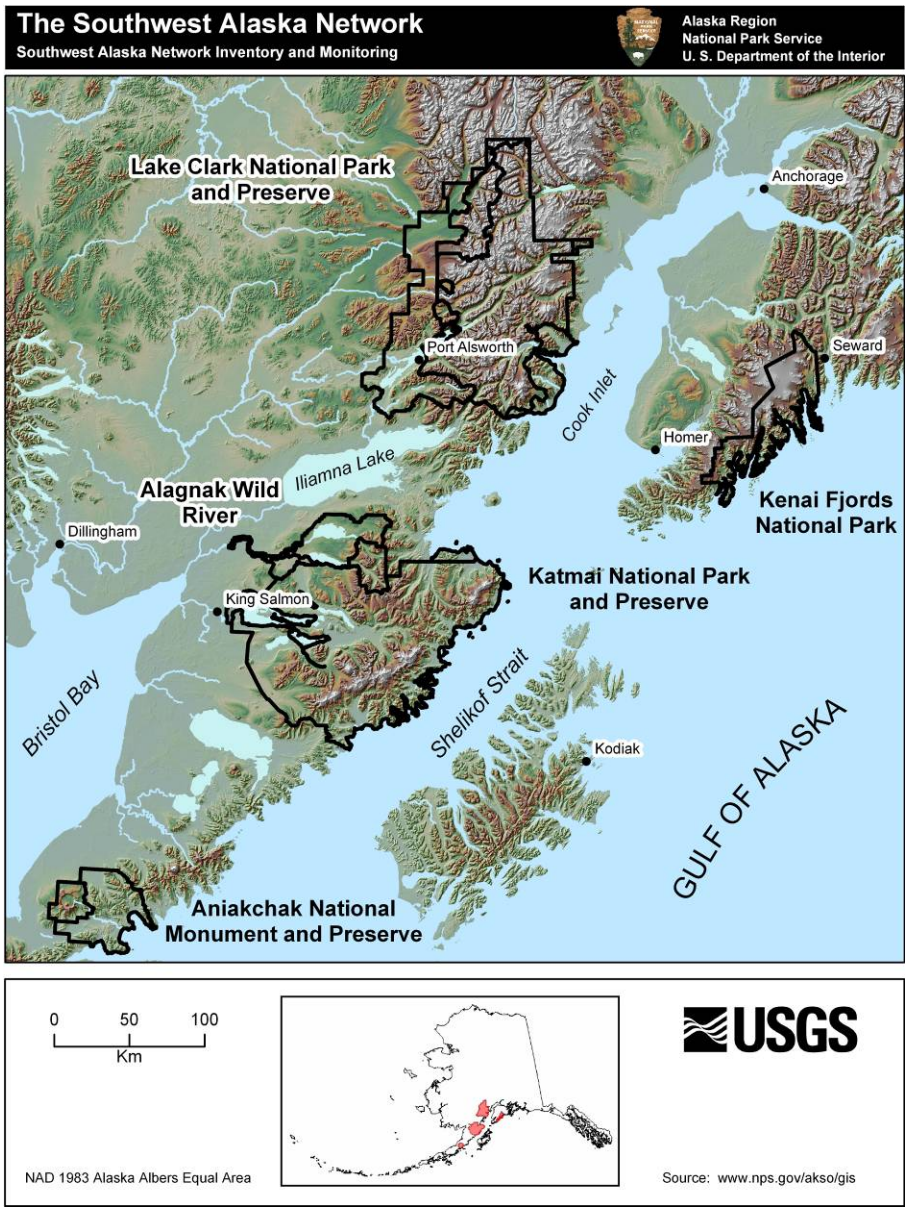


Figure 1. Location of parks within the Southwest Alaska Network.

The primary mission of NPS is to conserve unimpaired the natural and cultural resources and values of the National Park system for the enjoyment of present and future generations. To attain this mission, the Service must have credible scientific information to better manage, maintain, and protect park resources. Many parks are currently unable to achieve this mission due to a lack of basic and credible scientific knowledge about park resources (National Park Service 2006b).

In 2001, the SWAN initiated biological inventories of vertebrate animals and vascular plants in the network's parks to document occurrence, distribution, and where possible, relative abundance. Landbirds were ranked among the top eight

priorities for biological inventories in SWAN (Kedzie-Webb 2001). The inventories will lay the groundwork for park managers to develop effective monitoring programs, make informed management decisions concerning species or their habitats, and to educate the public. To this end, NPS-SWAN tasked the U.S. Geological Survey (USGS) to conduct an inventory of breeding birds in ANIA. This inventory focused on species of breeding landbirds to achieve the primary goal of documenting as many bird species as possible that occur within ANIA during the breeding season, and to describe the distribution and relative abundance of landbirds within ANIA.

## Background and Study Rationale

Scientific research in ANIA has primarily focused on the region's geology or fisheries, but the region likely supports an intriguing avifauna by virtue of its proximity to marine waters, relatively broad range of elevations, and geographic position along major migratory pathways. The Aleutian Islands and the Alaska Peninsula mark a major migration route for birds coming and going between both Asia and North America (Gill et al. 1981, Alaska Shorebird Group 2008), and the broad Meshik River valley likely serves as a channel for birds passing across the peninsula.

Few data on landbird distributions or populations in ANIA are available. To date, no Monument- or Preserve-wide systematic inventory of landbird resources has been completed in ANIA. With the exception of a fall landbird banding site at Mother Goose Lake maintained by the Alaska Peninsula/Becharof National Wildlife Refuge in the 1990s (e.g., Dewhurst et al. 1995, Eskelin and Dewhurst 1996, etc.), bird investigations in the region have primarily focused on seabird surveys encompassing ANIA's coast (e.g., Bailey and Faust 1984, Van Pelt and Piatt 2005). Thus, basic information is lacking on breeding bird communities at inland and at higher elevations. ANIA potentially supports breeding populations of several species of conservation concern (e.g., marbled godwit [*Limosa fedoa beringiae*], short-eared owl [*Asio flammeus*], Kittlitz's murrelet [*Brachyramphus brevirostris*]). Baseline surveys provide the basis of an informed natural resource program, and the status, distribution, and habitat affinities of breeding birds in ANIA is poorly documented. Recent breeding bird inventories conducted in KEFJ (Van Hemert et al. 2006), KATM, and Lake Clark National Park and Preserve (LACL; Ruthrauff et al. 2007) provide an excellent framework for similar work in ANIA, and directed field investigations will define the context and significance of ANIA's avian resources.

## Objectives

The NPS Alaska Region Science Strategy states that scientific data should guide management decisions for preserving NPS core values in each park (National Park Service 2006b). In response to NPS needs for more information on their avian resources, biologists from the U.S. Geological Survey's (USGS) Alaska

Science Center (ASC) and NPS conducted an inventory of breeding birds of ANIA. In this study, we addressed two principal objectives:

1. Use targeted field investigations to document as many bird species as possible that occur within ANIA during the breeding season.
2. Describe the distribution, habitat associations, and relative numbers of bird species occurring within ANIA during the breeding season.

To accomplish these objectives, we:

1. Collected existing information on bird species distributions in ANIA and consulted with NPS staff and other experts with knowledge of ANIA to choose bird survey plots in accessible areas that maximized the number of bird species detected during the breeding season.
2. Conducted bird surveys throughout accessible areas of ANIA to establish baseline information on the distribution and relative numbers of bird species present during the breeding season.
3. Collected habitat data at each bird survey point to describe habitat associations for common species.

## Methods

### Sampling Effort

Sample selection relied on the plot selection process already established for ANIA during the inventory in KATM and LACL; for a detailed description of the plot selection process, see Ruthrauff et al. (2007). In brief, the survey area selection process employed a stratified random sampling design based on ecological subsections. We identified potential sampling units by using an existing Alaska-wide Geographic Information System (GIS) grid composed of 10-km x 10-km (6.2-mi x 6.2-mi) plots that has been used in other recent landbird surveys in the state (e.g., Handel and Cady 2004, Tibbitts et al. 2005, Ruthrauff et al. 2007).

We delineated the sampling frame in a GIS by using digital map layers and procedures that allowed polygons to be included in the frame if they were: 1) within park boundaries, 2) > 100 m (327 ft) above sea level, 3) < 50 degree slope, and 4) unglaciated. Elevation and slope attributes were derived from the National Elevation Dataset (1:24,000 scale) and park boundary (1:63,360) and glacier coverage (1:60,000) from the NPS ECOMAP efforts (ECOMAP 1993, Tande and Michaelson 2001). Following these protocols, nine 10-km x 10-km plots were randomly selected in ANIA. In order to satisfy the goals of the current inventory, we modified the selection criteria to also include lands <100 m elevation.

We placed additional focus on areas of perceived high species diversity or unique species assemblages (hereafter, "focal areas"). In order to maximize our ability to detect a wide-range of bird species, we solicited expert opinion regarding: a) areas of special interest for breeding birds (e.g., areas of unusually rich diversity, rare or elusive species, unusual habitats) and, b) areas permitting relatively easy access. We consulted with Susan Savage, Wildlife Biologist for the U.S. Fish and Wildlife Service's Alaska Peninsula / Becharof National Wildlife Refuge. Ms. Savage has extensive experience in the region, particularly in ANIA, and recommended a handful of focal areas of particular interest, selected either because they contained unique habitats (e.g., remnant stands of balsam poplar *Populus balsamifera*) or because they represented rarely visited landforms (e.g., mountainous regions northeast of Aniakchak Caldera, the Garden Wall). We digitized these focal areas in a GIS to assist with our plot selection process (Figure 2).

In addition to relying upon Ms. Savage's suggestions, we also incorporated a recently completed Ducks Unlimited vegetation map of the region to identify and visit unique habitats in ANIA (U.S. Fish and Wildlife Service and Ducks Unlimited 2008). To the extent possible, observers surveyed areas that fell both within our pre-defined random plot selection boundaries and within those focal areas identified by Ms. Savage and habitat mapping efforts. Finally, crews focused efforts away from the Aniakchak Caldera and the Aniakchak River valley because previous ground-based bird work in ANIA was largely concentrated in these areas (e.g., Meyer 1987, Savage et al. 1993).

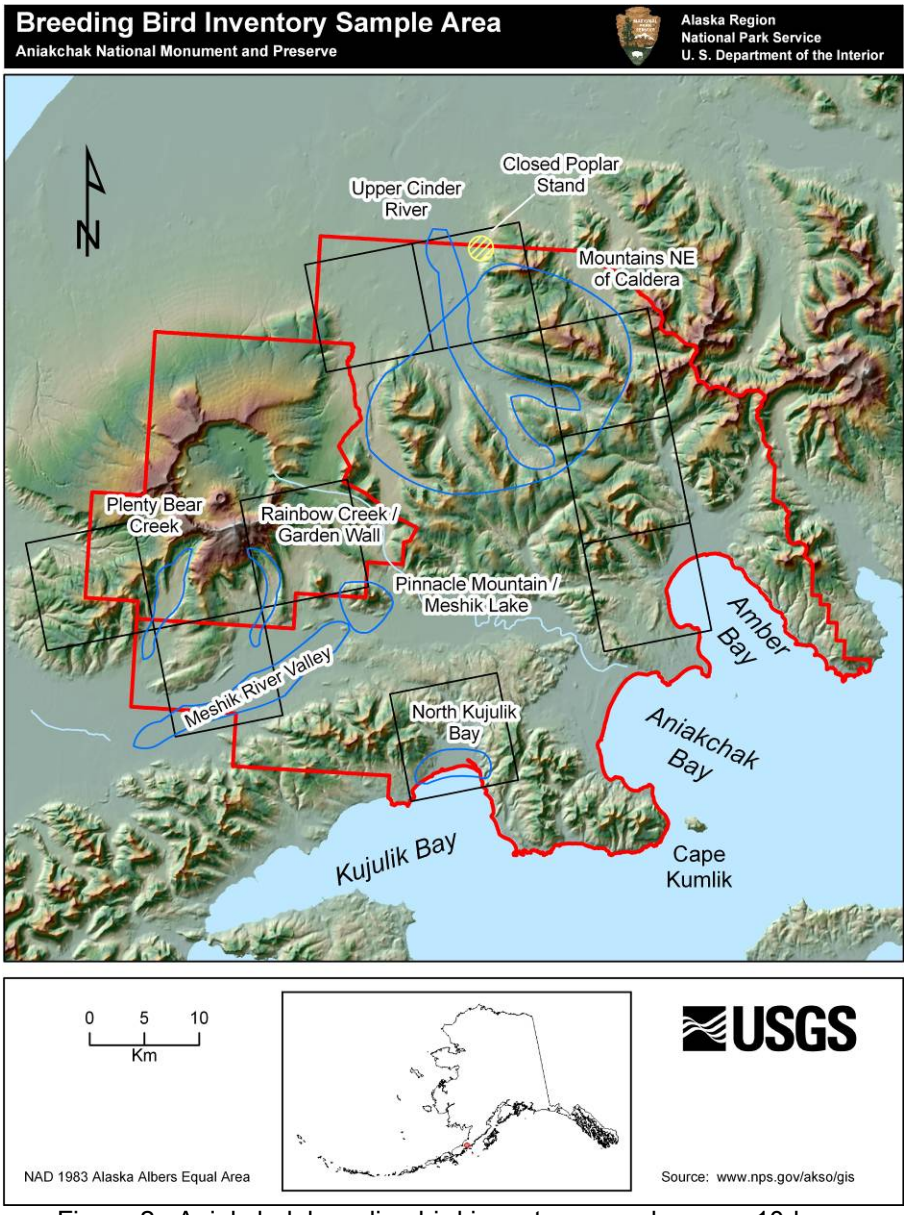


Figure 2. Aniakchak breeding bird inventory sample area. 10-km x 10-km sample plot boundaries are in black, focal areas of special bird interest (Susan Savage, pers. comm.) are in blue, remnant stands of balsam poplar are circled in yellow (U.S. Fish and Wildlife Service and Ducks Unlimited 2008), and the Monument and Preserve boundary is in red.

*Schedule of surveys*

Surveys were conducted by three, two-person teams. Two of the teams conducted point-count surveys (see below), whereas the third team conducted bird surveys in focal areas. Sample locations were accessed via helicopter, and surveys were conducted on foot. Based on our consultations with biologists familiar with the phenology of area, we scheduled our work from late-May through early-June, a period of time typically with decreased snow cover but

conspicuous bird activity. Nearly all previous avifaunal investigations in ANIA occurred after mid-June, but conspicuous bird behaviors (e.g., singing, flight displays) decrease as the breeding season progresses (Ralph et al. 1995, Nebel and McCaffery 2007). By focusing our inventory in late May and early June, we attempted to maximize our ability to detect a wide range of bird species.

*Survey methodology*

We used point count and distance sampling methodologies (point transects; Fancy and Sauer 2000, Buckland et al. 2001) to survey birds, following protocols that have been standardized for Alaska (Tibbitts et al. 2005, Handel and Cady 2004). All bird species were recorded and enumerated at each sampling point. Survey methods incorporated detection probability through distance sampling (Buckland et al. 2001) and recording time interval of first detection (Farnsworth et al. 2002). Survey points were placed across major landscape gradients such as coastlines, river valleys, and ridgelines. Sample points were located at least 500 m apart to avoid double-counting individual birds. In addition, teams recorded the approximate location and identity of any previously undetected species encountered during travel between survey points.

We recorded topographic data at sample points, including elevation, slope, and aspect, and all points were georeferenced using a GPS unit. Point-count survey crews classified habitat within a 150-m radius of the sample point to the Viereck classification system (Viereck et al. 1992). When >1 habitat type existed within the circle, the percent of the circle occupied by each habitat type was recorded. Crews took digital photographs toward each cardinal direction to supplement habitat data collected at each sample point.

The third survey crew conducted extensive searches in focal areas suggested by Ms. Savage or identified by the Ducks Unlimited vegetation map. This crew pursued, identified, and enumerated all bird species encountered in these pre-identified areas, recorded GPS locations for a subset of individuals and species encountered, and collected trackline locations on their GPS unit to record their movements. All crews typically camped for at least one night in each plot or focal area, and maintained a checklist of all bird species encountered during their stay, including any evidence of breeding.

Species List, Species of Conservation Concern

ANIA's NPSpecies bird list was compiled by Susan Savage and certified in 2007. This list is a comprehensive summary of historical bird observations in or near ANIA, and served as the baseline for our inventory. This list details the occurrence of 143 species, 101 of which were classified as "Present in Park." Given that our work comprised the first systematic survey within ANIA boundaries, we used this opportunity to confirm the occurrence, abundance, and residency of birds in ANIA with respect to this list.

Additionally, within ANIA we identified species of conservation concern as defined by one of five conservation organizations: Audubon Alaska (Stenhouse and Senner 2005), Partners in Flight (Rich et al. 2004), U.S. Fish and Wildlife Service (U.S. Fish and Wildlife Service 2002), Alaska Shorebird Group (Alaska Shorebird Group 2008), and Boreal Partners in Flight (Boreal Partners in Flight Working Group 1999). The criteria for inclusion on each organization's list varied, but species of conservation concern generally are those with threatened, declining, or small populations. Partners in Flight defines species as Stewardship or Watch List species (Rich et al. 2004). Stewardship species are those with a significant proportion of their population occurring in a single region or avifaunal biome, whereas Watch List species are those species suffering severe conservation threats.

## Data Summaries

### *Species Occurrence and Distribution*

We summarized point count survey data to compare the observed occurrence and distribution of bird species across parks, elevations, and habitats. We standardized detections for survey effort by calculating the average occurrence (number of individuals detected / number of points surveyed) of all species detected during point-count surveys. As a coarse measure of species distribution, we calculated the percentage of points at which a species was detected (number of points at which species was detected / total number of points surveyed). We summarized each species' overall observed distribution by calculating the number of sample plots or focal areas at which each species was detected, using results from all detection methods (i.e., point counts, focal area searches, etc.). Species detections by the point-count survey crews and the focal-area survey crew were combined when they overlapped at a given location.

Note that for the purposes of this report, we did not account for incomplete and variable detection probabilities of bird species in our analyses of species distribution, occurrence, and bird-habitat relationships. Detection probability is a factor of many variables (e.g., observer experience, time of day, habitat, weather), and simple presence / absence counts do not take into account false-negative error rates (Tyre et al. 2003). We likely underestimated the number of points at which a particular species occurred, thus hindering our ability to completely describe species occurrence, distribution, or species-specific habitat affinities (Tyre et al. 2003). The objective of this summary is to provide a general foundation upon which to base more detailed, species-specific habitat analyses. Subsequent analyses should model and incorporate detection probabilities (e.g., Tyre et al. 2003, MacKenzie et al. 2006) in order to more accurately describe occurrence and habitat affinities of birds within ANIA.

Given the difficulty in distinguishing between common and hoary redpolls, in the absence of confirming evidence we combined observations for all summaries as 'redpoll species'. Hoary redpolls were clearly identified by sight on one occasion, where all other observations of redpolls were not identified to species. Based on

the known distribution of both species, most redpolls were likely common redpolls (Knox and Lowther 2000a, 2000b). Throughout this document, we follow the avian nomenclature used by the American Ornithologists' Union (1998, 2008).

*Associations Between Birds, Habitats, and Elevation*

We used vegetation cover type data collected at each sample point to assess the habitat associations of birds. Based on the overall distribution of habitat types encountered, we combined similar vegetation cover types into 5 broad categories derived from the Viereck classification system (Viereck et al. 1992). Our 5 cover types were essentially groupings at Viereck level I and II: tall shrub (≥ 1.5 m tall), low shrub (1.5 m–20 cm tall), dwarf shrub (< 20 cm tall), bare ground (rocks, ash), and herbaceous (graminoids, herbs, mosses, lichens; Appendix 1). In addition, we created a cover type for snow.

Several important abiotic factors vary across elevational gradients (e.g., temperature, moisture, length of growing season), and this variation ultimately affects the distribution of vegetation types and, thus, birds. To examine the distribution of vegetation cover types and the associated bird communities, we grouped vegetation cover data and bird detections by the elevation at sample points. We defined sample points as low (<120 m), middle (120–320 m), or high (321–625 m) elevation based on the observed distributional patterns of vegetation cover types (note: 625 m was the elevation of the highest sample point). We also applied these elevation categories to species detected during point count surveys. For the purposes of this assessment, we included all species with 10 or more detections within 150 m of survey points ($n$ = 13 species). These 13 species were categorized according to the mean elevation of sample points at which the species were detected.

To assess bird-habitat associations, we summarized the percent cover of habitat types for the 13 species with ≥ 10 detections. To describe elevation-related changes in habitat cover type, we summarized the percent cover of the 5 habitat types by elevation class. Additionally, we summarized the percent cover of snow by elevation class to describe site phenology. We plotted all these summaries in box plot form, wherein we displayed the mean, median, quartiles, and 10th and 90th percentiles of habitat cover, elevation, and snowcover values. Displaying data in this format allows for easy visual comparison of broad landscape patterns.

## Results

Survey Conditions and Effort

Crews were present in the field during 30 May–8 June, 2008. All plots and focal areas were accessed via Robinson R44 helicopter staging out of Port Heiden, from which straight-line distances to plots ranged between 30 and 65 km. The weather during the study period was characteristic of spring conditions on the

Alaska Peninsula. Daily weather ranged from snow, to driving rain with strong wind, to warm, sunny conditions. Temperatures during surveys ranged from -1°–18° C, and approximately 40% of counts were conducted during periods of active precipitation (e.g., fog, hail, rain, or snow).

The two point-count survey crews conducted surveys at 136 points across eight 10-km x 10-km sample plots, traversing over 80 km of terrain in the process (Figure 3). This sample effort entailed nearly 23 hours of survey time. Crews surveyed an average of 9.8 points/day, slightly higher than our daily averages during previous efforts in KATM and LACL (9.3 points/day; Ruthrauff et al. 2007). The third survey crew conducted focal area searches at 6 discrete sites, covering approximately 25 km of terrain by foot (Figure 3). In the course of these surveys, crews also collected observations of all mammal species encountered (Appendix 2).

Comparison of Figures 2 and 3 reveals that crews were unable to visit all the pre-selected survey plots. Inclement weather, extensive snow cover at higher elevations, and steep terrain precluded visitation of certain plots, so adjacent plots were visited in their place. Due to these constraints, we sampled eight sample plots instead of nine as originally intended.

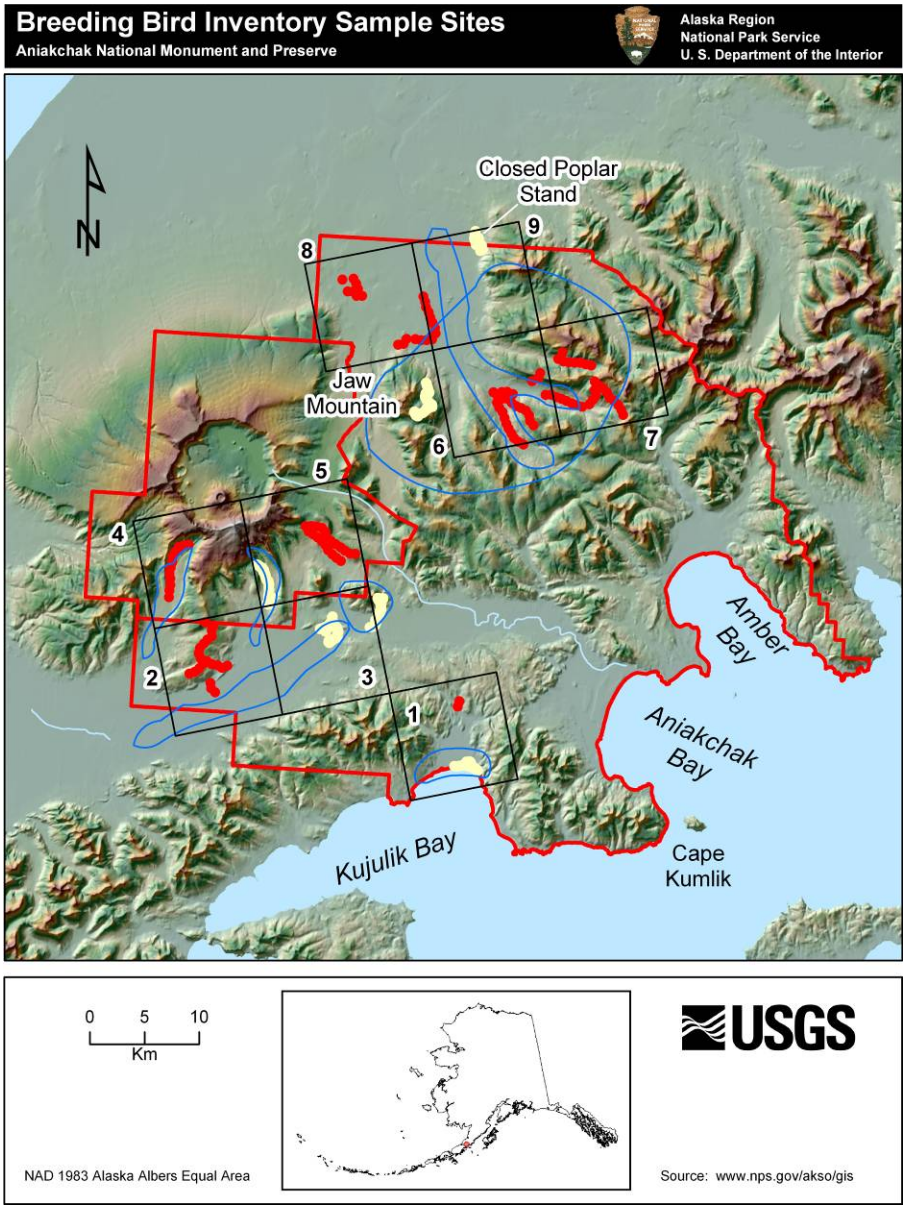


Figure 3. Aniakchak breeding bird sample sites. Point-count survey points are depicted by red circles, focal-area survey crew locations are shown by yellow circles, sample plot boundaries are in black, focal areas of special interest are in blue, and the Monument and Preserve boundary is in red.

## Species Lists

We detected 67 species (excluding unidentified redpolls [*Carduelis* spp.]) during our inventory, including twenty-two species of passerine, thirteen waterfowl, eleven shorebirds, six raptors, three gulls, two ptarmigan, two alcids, and one species each of loon, cormorant, crane, tern, jaeger, owl, kingfisher, and woodpecker (Table 1). We detected seven species not previously recorded in ANIA (gadwall, golden eagle, merlin, marbled godwit, downy woodpecker, horned lark, and hoary redpoll). The presence of the marbled godwit was underscored by the discovery on June 4 2008 of a four-egg nest near ANIA's

northwest boundary (N 57.06, W 157.98, WGS84 datum; Figure 4). This nest represents the first active nest discovered for this rare subspecies.

Table 1. Birds of Aniakchak National Monument and Preserve. 'X' indicates a species detected during the inventory of breeding birds during 2008 and 'P' indicates a species recorded by previous observers. Species of conservation concern are shown in bold font (see Table 2).

| Common Name | Scientific Name | Detection Status |
|---|---|---|
| *Waterfowl* | | |
| **Emperor Goose** | *Chen canagica* | P |
| **Brant** | *Branta bernicla* | P |
| Canada Goose | *Branta canadensis* | P |
| Tundra Swan | *Cygnus columbianus* | P, X |
| Gadwall | *Anas strepera* | X |
| American Wigeon | *Anas americana* | P, X |
| Mallard | *Anas platyrhynchos* | P, X |
| Northern Shoveler | *Anas clypeata* | P |
| Northern Pintail | *Anas acuta* | P, X |
| Green-winged Teal | *Anas crecca* | P, X |
| Greater Scaup | *Aythya marila* | P, X |
| **Steller's Eider** | *Polysticta stelleri* | P |
| **Common Eider** | *Somateria mollissima* | P |
| Harlequin Duck | *Histrionicus histrionicus* | P, X |
| Surf Scoter | *Melanitta perspicillata* | P |
| White-winged Scoter | *Melanitta fusca* | P, X |
| **Black Scoter** | *Melanitta nigra* | P, X |
| Long-tailed Duck | *Clangula hyemalis* | P |
| Bufflehead | *Bucephala albeola* | P |
| Common Goldeneye | *Bucephala clangula* | P |
| Barrow's Goldeneye | *Bucephala islandica* | P, X |
| Common Merganser | *Mergus merganser* | P, X |
| Red-breasted Merganser | *Mergus serrator* | P, X |
| *Ptarmigan* | | |
| **Willow Ptarmigan** | *Lagopus lagopus* | P, X |
| **Rock Ptarmigan** | *Lagopus mutus* | P, X |
| *Loons and Grebes* | | |
| **Red-throated Loon** | *Gavia stellata* | P, X |
| Common Loon | *Gavia immer* | P |
| Red-necked Grebe | *Podiceps grisegena* | P |
| *Seabirds: Procellarids, Cormorants* | | |
| Northern Fulmar | *Fulmarus glacialis* | P |
| Fork-tailed Storm-Petrel | *Oceanodroma furcata* | P |
| Double-crested Cormorant | *Phalacrocorax auritus* | P, X |
| **Red-faced Cormorant** | *Phalacrocorax urile* | P |
| Pelagic Cormorant | *Phalacrocorax pelagicus* | P |
| *Raptors* | | |
| Bald Eagle | *Haliaeetus leucocephalus* | P, X |
| Northern Harrier | *Circus cyaneus* | P, X |
| **Rough-legged Hawk** | *Buteo lagopus* | P, X |
| **Golden Eagle** | *Aquila chrysaetos* | X |
| Merlin | *Falco columbarius* | X |
| **Gyrfalcon** | *Falco rusticolus* | P, X |
| **Peregrine Falcon** | *Falco peregrinus* | P |

| Common Name | Scientific Name | Detection Status |
|---|---|---|
| *Cranes* | | |
| Sandhill Crane | *Grus canadensis* | P, X |
| *Shorebirds* | | |
| **Pacific Golden-Plover** | *Pluvialis fulva* | P, X |
| Semipalmated Plover | *Charadrius semipalmatus* | P, X |
| **Black Oystercatcher** | *Haematopus bachmani* | P, X |
| Spotted Sandpiper | *Actitis macularius* | P |
| **Wandering Tattler** | *Tringa incana* | P |
| Greater Yellowlegs | *Tringa melanoleuca* | P, X |
| **Lesser Yellowlegs** | *Tringa flavipes* | P |
| **Whimbrel** | *Numenius phaeopus* | P |
| **Marbled Godwit** | *Limosa fedoa beringiae* | X |
| **Ruddy Turnstone** | *Arenaria interpres* | P |
| **Black Turnstone** | *Arenaria melanocephala* | P |
| **Surfbird** | *Aphriza virgata* | P |
| **Sanderling** | *Calidris alba* | P |
| Semipalmated Sandpiper | *Calidris pusilla* | P |
| **Western Sandpiper** | *Calidris mauri* | P |
| Least Sandpiper | *Calidris minutilla* | P, X |
| **Rock Sandpiper** | *Calidris ptilocnemis* | P, X |
| **Dunlin** | *Calidris alpina* | P, X |
| **Short-billed Dowitcher** | *Limnodromus griseus* | P, X |
| Wilson's Snipe | *Gallinago delicata* | P, X |
| Red-necked Phalarope | *Phalaropus lobatus* | P, X |
| *Gulls, Terns, and Jaegers* | | |
| Black-legged Kittiwake | *Rissa tridactyla* | P, X |
| Bonaparte's Gull | *Larus philadelphia* | P |
| Mew Gull | *Larus canus* | P, X |
| Glaucous-winged Gull | *Larus glaucescens* | P, X |
| **Arctic Tern** | *Sterna paradisaea* | P, X |
| Parasitic Jaeger | *Stercorarius parasiticus* | P, X |
| Long-tailed Jaeger | *Stercorarius longicaudus* | P |
| *Seabirds: Alcids* | | |
| Common Murre | *Uria aalge* | P |
| Thick-billed Murre | *Uria lomvia* | P |
| Pigeon Guillemot | *Cepphus columba* | P, X |
| **Marbled Murrelet** | *Brachyramphus marmoratus* | P, X |
| **Kittlitz's Murrelet** | *Brachyramphus brevirostris* | P |
| Ancient Murrelet | *Synthliboramphus antiquus* | P |
| Horned Puffin | *Fratercula corniculata* | P |
| Tufted Puffin | *Fratercula cirrhata* | P |
| *Owls* | | |
| **Short-eared Owl** | *Asio flammeus* | P, X |
| *Kingfishers* | | |
| Belted Kingfisher | *Ceryle alcyon* | P, X |
| *Woodpeckers* | | |
| Downy Woodpecker | *Picoides pubescens* | X |
| *Passerines* | | |
| Northern Shrike | *Lanius excubitor* | P |
| Black-billed Magpie | *Pica hudsonia* | P, X |
| Common Raven | *Corvus corax* | P, X |
| Eurasian Skylark | *Alauda arvensis* | P |
| Horned Lark | *Eremophila alpestris* | X |
| Tree Swallow | *Tachycineta bicolor* | P, X |
| Bank Swallow | *Riparia riparia* | P, X |

| Common Name | Scientific Name | Detection Status |
|---|---|---|
| Black-capped Chickadee | *Poecile atricapillus* | P, X |
| Winter Wren | *Troglodytes troglodytes* | P |
| American Dipper | *Cinclus mexicanus* | P, X |
| Golden-crowned Kinglet | *Regulus satrapa* | P |
| **Gray-cheeked Thrush** | *Catharus minimus* | P, X |
| Hermit Thrush | *Catharus guttatus* | P, X |
| American Robin | *Turdus migratorius* | P, X |
| American Pipit | *Anthus rubescens* | P, X |
| Orange-crowned Warbler | *Vermivora celata* | P, X |
| Yellow Warbler | *Dendroica petechia* | P, X |
| Wilson's Warbler | *Wilsonia pusilla* | P, X |
| American Tree Sparrow | *Spizella arborea* | P, X |
| Savannah Sparrow | *Passerculus sandwichensis* | P, X |
| Fox Sparrow | *Passerella iliaca* | P, X |
| White-crowned Sparrow | *Zonotrichia leucophrys* | P, X |
| **Golden-crowned Sparrow** | *Zonotrichia atricapilla* | P, X |
| **Lapland Longspur** | *Calcarius lapponicus* | P, X |
| **Snow Bunting** | *Plectrophenax nivalis* | P, X |
| Gray-crowned Rosy-Finch | *Leucosticte tephrocotis* | P |
| Common Redpoll | *Carduelis flammea* | P |
| **Hoary Redpoll** | *Carduelis hornemanni* | X |
| Redpoll Species | *Carduelis* spp. | P, X |
| Total species detected during inventory: | | 67 |
| Total species (*Carduelis* spp. not included): | | 108 |

Figure 4. The discovery of this four-egg marbled godwit nest on 4 June 2008 represents the first active nest ever documented for this subspecies. The nest was discovered in wet graminoid herbaceous habitat near the northwest Monument border in plot 8 (red dot in inset).

We detected 21 species of conservation concern, including one species of waterfowl, two ptarmigan, one loon, three raptors, six shorebirds, one tern, one alcid, one owl, and five passerines (Tables 1 and 2). An additional 15 species of conservation concern have been recorded in ANIA by previous observers (Tables 1 and 2); most of these species are waterfowl that likely occur in the region during winter (e.g., emperor goose, Steller's and common eiders) or shorebirds that primarily occur as migrants (e.g., wandering tattler, ruddy turnstone, surfbird).

Table 2. Species of conservation concern recorded in Aniakchak National Monument and Preserve. 'X' indicates a species detected during the inventory of breeding birds in 2008 and 'P' indicates a species recorded by previous observers.

| | Conservation status determined by program[2]: | | | | |
|---|---|---|---|---|---|
| Common name[1] | Audubon | NALCP[3] | USFWS | ASCP | LCPA |
| Emperor Goose | P | | | | |
| Brant | P | | | | |
| Steller's Eider | P | | | | |
| Common Eider | P | | | | |
| Black Scoter | P, X | | | | |
| Willow Ptarmigan | | P, X | | | |
| Rock Ptarmigan | | P, X | | | |
| Red-throated Loon | P, X | | P, X | | |
| Red-faced Cormorant | P | | P | | |
| Rough-legged Hawk | | P, X | | | |
| Golden Eagle | X | | | | |
| Gyrfalcon | P, X | P, X | | | P, X |
| Peregrine Falcon | P | P | P | | |
| Pacific Golden-Plover | P, X | | P, X | | |
| Black Oystercatcher | P, X | | | P, X | |
| Wandering Tattler | P | | | | |
| Lesser Yellowlegs | | | | P | |
| Whimbrel | | | P | P | |
| Marbled Godwit | X | | X | X | |
| Ruddy Turnstone | P | | | | |
| Black Turnstone | P | | P | P | |
| Surfbird | | | P | P | |
| Sanderling | | | | P | |
| Western Sandpiper | | | | P | |
| Rock Sandpiper | | | P, X | | |
| Dunlin | P, X | | | P, X | |
| Short-billed Dowitcher | | | P, X | P, X | |
| Arctic Tern | | | P, X | | |
| Marbled Murrelet | P, X | | P, X | | |
| Kittlitz's Murrelet | | | P | | |
| Short-eared Owl | P, X | **P**, **X** | | | |
| Gray-cheeked Thrush | | | | | P, X |
| Golden-crowned Sparrow | | | | | P, X |
| Lapland Longspur | | P, X | | | |
| Snow Bunting | | P, X | | | |

| Common name[1] | Conservation status determined by program[2]: | | | | |
|---|---|---|---|---|---|
| | Audubon | NALCP[3] | USFWS | ASCP | LCPA |
| Hoary Redpoll | | X | | | X |

[1]See Table 1 for scientific names.
[2]Audubon = Audubon Alaska Watchlist (Stenhouse and Senner 2005), NALCP = North American Landbird Conservation Plan (Rich et al. 2004), USFWS = U.S. Fish and Wildlife Service's Birds of Conservation Concern (U.S. Fish and Wildlife Service 2002), ASCP = Alaska Shorebird Conservation Plan (Alaska Shorebird Group 2008), LCPA = Landbird Conservation Plan for Alaska (Boreal Partners in Flight working Group 1999).
[3]Bold refers to Watch List Species, normal font to Stewardship Species (Rich et al. 2004).

## Elevational Distribution of Birds

As defined by our elevation categories, we conducted 54 (40% of total), 48 (35%), and 34 (25%) point-count surveys at low, middle, and high elevation sites, respectively. We classified seven, four, and two species as low, middle, and high elevation species, respectively (Figure 5). Species of conservation concern in these categories were golden-crowned sparrow (low elevation), willow and rock ptarmigan (middle elevation), and snow bunting (high elevation).

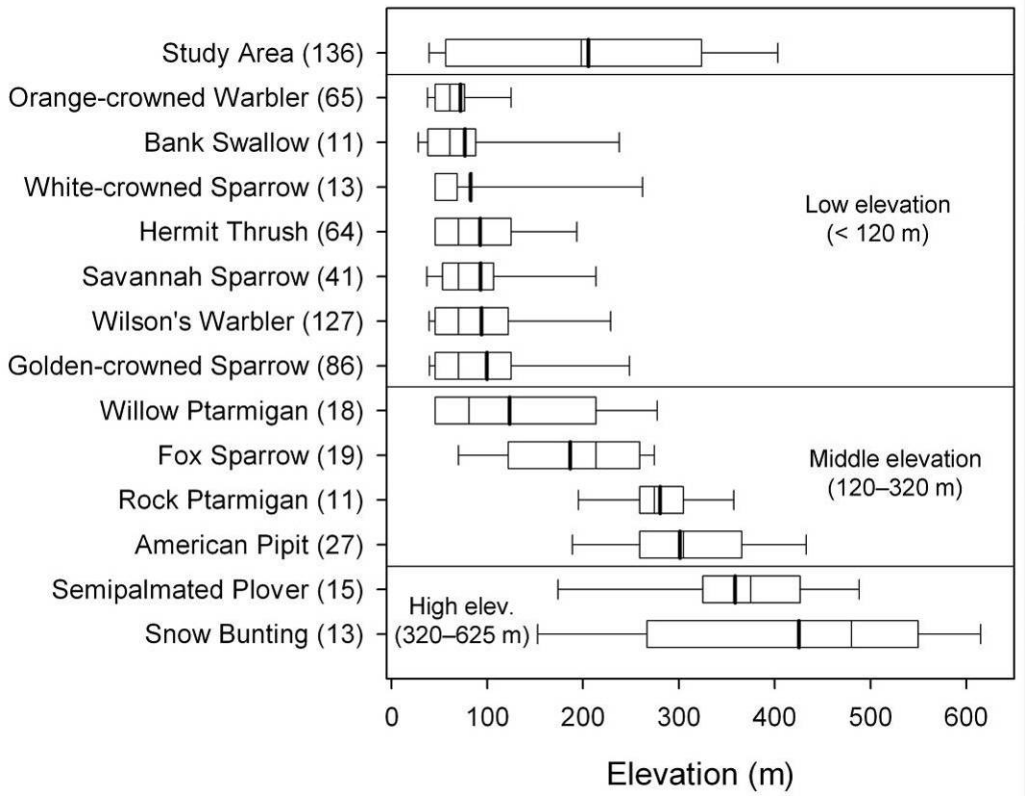


Figure 5. Elevational distribution of species commonly detected during the inventory of breeding birds in Aniakchak National Monument and Preserve, 2008. Box plots show median (thin vertical line), mean (thick vertical line), quartiles (open box), and 10th and 90th percentiles of values (whiskers). Number of detections is shown in parentheses for each species.

The two species detected at sites with the highest mean elevation, semipalmated plover (358 ± 28.2 SE m; Figure 4) and snow bunting (425 ± 47.5 SE m), were detected over a wider range of elevations than most of the other species (45–500 m and 150–625 m for semipalmated plover and snow bunting, respectively). This broad range is likely an artifact of inclement weather, because the lower values for both species were recorded during a period of foul weather (4 and 5 June) during which snow fell overnight. It is likely that the storm briefly forced these high-elevation species away from breeding sites to lower elevations where they were subsequently detected. In general, most species were detected over a range of approximately 300 m elevation.

### Frequency of Occurrence

Frequency of occurrence summaries are based on detections made at the eight plots where we conducted 136 point count surveys. We detected 1,277 birds of 47 species in ANIA (Table 3). Overall we detected 9.38 (± 1.56 SE) individuals of 4.58 (± 0.21 SE) species per point (Table 3). The five most-commonly detected species were represented by four passerines (bank swallow, golden-crowned sparrow, Wilson's warbler, and hermit thrush) and one shorebird (red-necked phalarope). It should be noted that nearly all the individual bank swallows (150 of 187; 80%) and red-necked phalaropes (105 of 126; 83%) were detected as large flocks at one point only. Thus, these two species were abundant but not widely distributed across sites where we conducted point count surveys (% detection values of 8.8% and 3.7% for bank swallow and red-necked phalarope, respectively). The average number of individuals per point drops from 9.38 to 7.25 (± 0.4 SE) when these two large flocks are removed from the analysis. Excluding these two species, golden-crowned sparrow had the greatest average occurrence (1.05 birds/point; Table 3) followed closely by Wilson's warbler (1.04 birds/point) and hermit thrush (0.84 birds/point).

Table 3. Occurrence of birds on point counts during the inventory of breeding birds in Aniakchak National Monument and Preserve, 2008.

| Common Name[1] | Total Detected | Average Occurrence[2] | # Points on Which Detected | % Detection[3] |
|---|---|---|---|---|
| American Wigeon | 1 | 0.007 | 1 | 0.7 |
| Mallard | 1 | 0.007 | 1 | 0.7 |
| Harlequin Duck | 3 | 0.022 | 1 | 0.7 |
| Red-breasted Merganser | 2 | 0.015 | 1 | 0.7 |
| Willow Ptarmigan | 46 | 0.338 | 32 | 23.5 |
| Rock Ptarmigan | 26 | 0.191 | 22 | 16.2 |
| Bald Eagle | 8 | 0.059 | 6 | 4.4 |
| Northern Harrier | 5 | 0.037 | 4 | 2.9 |
| Rough-legged Hawk | 4 | 0.029 | 3 | 2.2 |
| Merlin | 1 | 0.007 | 1 | 0.7 |
| Sandhill Crane | 5 | 0.037 | 4 | 2.9 |
| Pacific Golden-Plover | 2 | 0.015 | 1 | 0.7 |
| Semipalmated Plover | 33 | 0.243 | 25 | 18.4 |
| Black Oystercatcher | 1 | 0.007 | 1 | 0.7 |
| Greater Yellowlegs | 6 | 0.044 | 5 | 3.7 |
| Marbled Godwit | 1 | 0.007 | 1 | 0.7 |
| Least Sandpiper | 8 | 0.059 | 8 | 5.9 |

| Common Name[1] | Total Detected | Average Occurrence[2] | # Points on Which Detected | % Detection[3] |
|---|---|---|---|---|
| Rock Sandpiper | 18 | 0.132 | 14 | 10.3 |
| Dunlin | 4 | 0.029 | 2 | 1.5 |
| Short-billed Dowitcher | 4 | 0.029 | 4 | 2.9 |
| Wilson's Snipe | 10 | 0.074 | 8 | 5.9 |
| Red-necked Phalarope | 126 | 0.926 | 5 | 3.7 |
| Mew Gull | 6 | 0.044 | 4 | 2.9 |
| Glaucous-winged Gull | 8 | 0.059 | 2 | 1.5 |
| Parasitic Jaeger | 1 | 0.007 | 1 | 0.7 |
| Downy Woodpecker | 2 | 0.015 | 2 | 1.5 |
| Black-billed Magpie | 8 | 0.059 | 6 | 4.4 |
| Common Raven | 16 | 0.118 | 13 | 9.6 |
| Horned Lark | 3 | 0.022 | 3 | 2.2 |
| Tree Swallow | 10 | 0.074 | 2 | 1.5 |
| Bank Swallow | 187 | 1.375 | 12 | 8.8 |
| American Dipper | 2 | 0.015 | 1 | 0.7 |
| Gray-cheeked Thrush | 6 | 0.044 | 5 | 3.7 |
| Hermit Thrush | 114 | 0.838 | 59 | 43.4 |
| American Robin | 10 | 0.074 | 9 | 6.6 |
| American Pipit | 45 | 0.331 | 34 | 25.0 |
| Orange-crowned Warbler | 72 | 0.529 | 45 | 33.1 |
| Yellow Warbler | 4 | 0.029 | 4 | 2.9 |
| Wilson's Warbler | 141 | 1.037 | 61 | 44.9 |
| American Tree Sparrow | 11 | 0.081 | 7 | 5.1 |
| Savannah Sparrow | 45 | 0.331 | 34 | 25.0 |
| Fox Sparrow | 50 | 0.368 | 33 | 24.3 |
| White-crowned Sparrow | 15 | 0.110 | 9 | 6.6 |
| Golden-crowned Sparrow | 143 | 1.051 | 74 | 54.4 |
| Lapland Longspur | 21 | 0.154 | 17 | 12.5 |
| Snow Bunting | 32 | 0.235 | 14 | 10.3 |
| Redpoll Species | 10 | 0.074 | 9 | 6.6 |
| Total # Individuals: | 1,277 | 9.38 ± 1.56 SE | | |
| Total # Species: | 47 | 4.58 ± 0.21 SE | | |

[1]See Table 1 for scientific names.
[2]Average Occurrence = number of individuals detected / number of points surveyed.
[3]% Detection = number of points on which detected / number of points surveyed.

The species with the highest average occurrence also tended to have the highest percent detection values at plots where we conducted point count surveys. Golden-crowned sparrow, Wilson's warbler, and hermit thrush had the three highest observed percent detection values (54.4%, 44.9%, and 43.4%, respectively). Excluding species that were primarily detected as large flocks (i.e., bank swallows and red-necked phalaropes), comparing the ratio of total detections to the number of points on which a species was detected yields a coarse measure of the abundance of species across points at which they were actually detected. For instance, 141 Wilson's warblers were detected at 61 points (Table 3), yielding an average of 2.3 Wilson's warblers detected per point. By this same measure, golden-crowned sparrow and hermit thrush were also abundant at the points at which they were detected, both averaging 1.93 birds per point.

### Species Distribution

Summaries of species distribution across sample sites are based on all observations collected during survey visits that spanned half a day to six nights

(note: crews typically spent two days and nights at each site, but the focal-area survey crew spent six nights at their first camp site near Meshik Lake due to logistical expedience). When more than one crew visited a plot, observations were combined to produce one list of observations for that particular site. Thus, with the exception of the focal-area survey conducted on the slopes of Jaw Mountain on 7 June, all the observations conducted by the focal-area survey crew were combined with those of point-count survey crews in the corresponding sample plot. For example, Rainbow Creek was visited by the focal-area survey crew on 3 June, which fell within sample plot 5, where a point-count survey crew conducted surveys at 21 points during 2–3 June. All of the species observations for these combined efforts appear under sample plot 5 (Appendix 3). Note, too, that all crews were present at plot 3 during 30 May–2 June, awaiting suitable weather to deploy teams by helicopter. No point count surveys were conducted in this plot due to inclement weather, and the observation summaries in Appendix 3 comprise the observations of all three crews.

The observed distribution of species across ANIA was similar to their frequency of occurrence (Table 3, Appendix 3) in that commonly detected species were typically widely distributed and infrequently detected species had restricted distributions. For instance, the five species with the most detections during point count surveys (excluding bank swallow and red-necked phalarope; Table 3) were the only five species to be detected at all 10 plots or focal areas (Appendix 3). American tree sparrow, on the other hand, was recorded on only two sample plots and was rarely detected during point count surveys ($n$ = 11). Certain species, however, contradicted this general pattern. Semipalmated plover was observed on 8 (80%) sample plots, yet we detected only 33 individuals during point count surveys.

### Bird-habitat Associations

We summarized the percent cover of the five simplified habitat types and snow within a 150 m radius of each point count survey location by study area and elevational category (Figure 6). Overall, dwarf shrub was the most common habitat encountered on sample points, detected at nearly 64% of all points, and comprised the greatest percent cover (average of 28.1% ± 2.9 SE, Figure 6). Dwarf shrub was most expansive at middle and high elevation points, whereas tall and low shrub habitats were more expansive at low elevation points. Herbaceous cover types were also more expansive at low elevation points. Bare ground was the least common habitat encountered, present at just over 26% of all points and with an average cover of 11.9% ± 2.1 SE cover (Figure 6). Bare ground was present at over half of all high elevation points, however. We encountered snow on over one-quarter of all survey points. Similarly, snow cover was greatest at high elevation sites, present at over 70% of points and comprising over 20% ground cover at these sites.

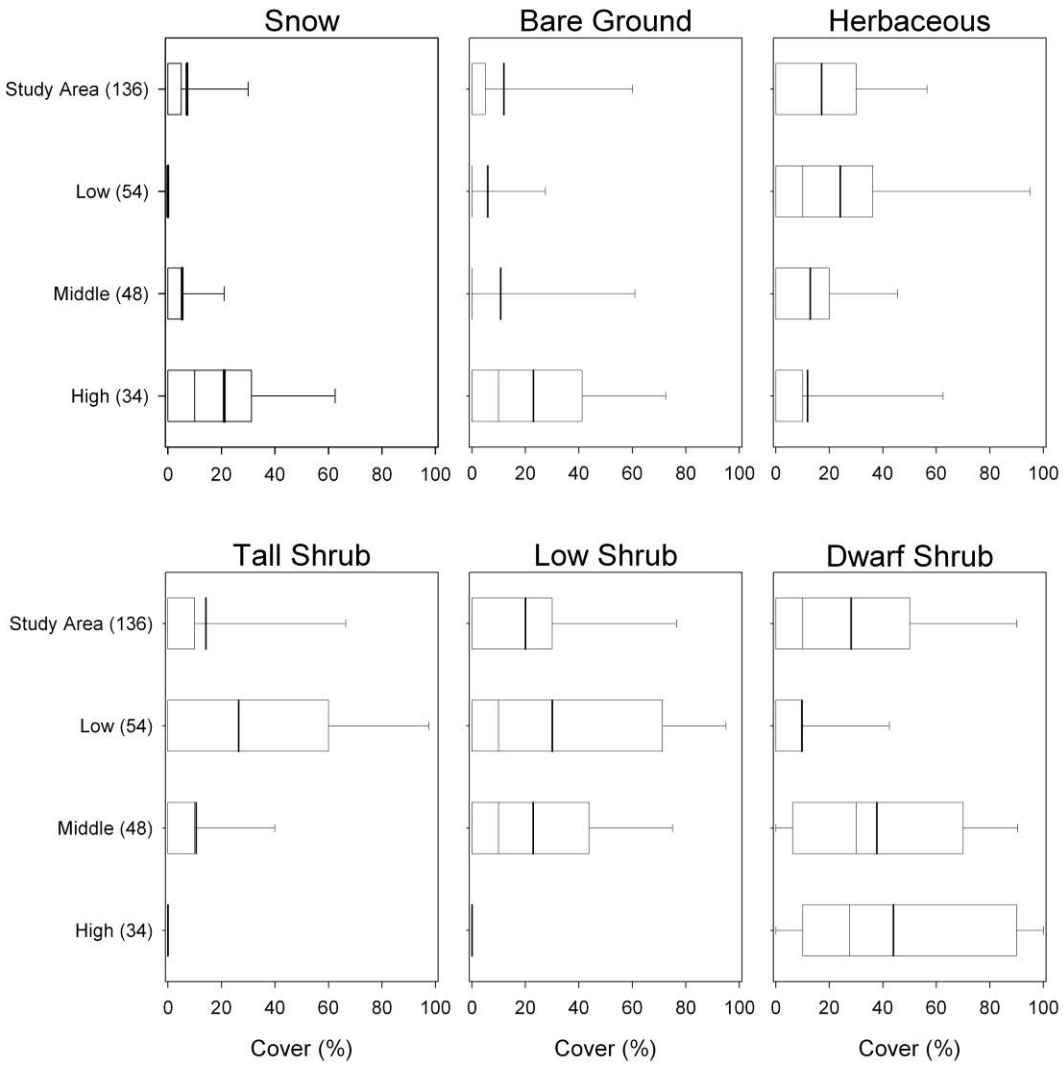


Figure 6. Percent cover of habitats and snow by study area and elevational category at survey points during the inventory of breeding birds in Aniakchak National Monument and Preserve, 2008. Box plots show median (thin vertical line), mean (thick vertical line), quartiles (open box), and 10th and 90th percentiles of values (whiskers). Number of points surveyed in each category in parentheses.

To assess patterns of bird habitat use, we summarized the percent cover of habitats at points at which the 13 most-commonly detected species were recorded (Figure 7); species are arranged by elevation as in Figure 5.

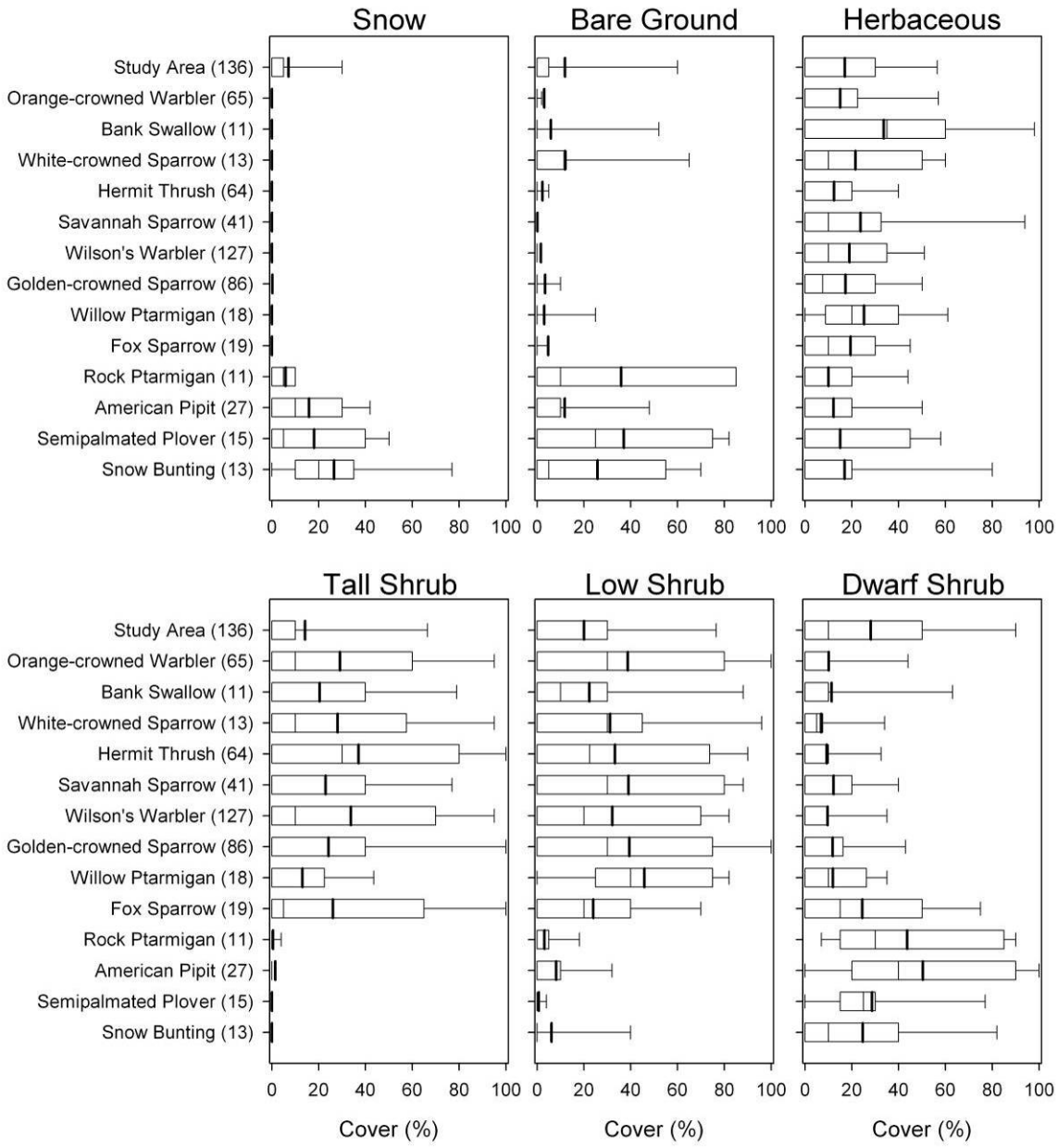


Figure 7. Percent cover of habitats at sample points during the inventory of breeding birds in Aniakchak National Monument and Preserve, 2008. Box plots show median (thin vertical line), mean (thick vertical line), quartiles (open box), and 10th and 90th percentiles of values (whiskers). Number of detections is shown in parentheses for each species. Species ordered from top to bottom based on increasing values of mean elevation at sample points where they were detected (see Figure 5).

### *Bare Ground*

Bare ground was a prominent feature at high elevation sample points (mean 22.9% [± 4.9 SE] cover; Figure 6), and it decreased in cover at lower elevations (10.7% [± 3.6 SE] and 5.9% [± 2.4 SE] at middle and low elevations,

respectively). The numerous eruptions of Aniakchak Caldera have produced a landscape blanketed in volcanic ash, and much of the bare ground in ANIA derives from volcanic activity (Figure 8). Rock ptarmigan, semipalmated plover, and snow bunting were the species most strongly associated with bare ground in ANIA (Figure 7).

Figure 8. Volcanically-derived bare ground at plot 8 in northwest Aniakchak National Monument and Preserve, 4 June 2008.

*Herbaceous*

In contrast to bare ground, herbaceous habitat decreased in average percent cover as elevation increased (Figure 6). Most species did not demonstrate a strong association with herbaceous habitats; the average percent cover for most species ranged from 10% (rock ptarmigan) to 25% (willow ptarmigan; Figure 7). Bank swallows, however, were detected at points with an average percent cover of herbaceous habitats of 33%, perhaps because wet herbaceous sites provide improved aerial foraging opportunities for this water-associated passerine (Garrison 1999). In ANIA, herbaceous habitat was typically characterized by graminoids, forbs, and mosses at mesic sites across all elevation classes (Figure 9).

Figure 9. Herbaceous, graminoid- and moss-dominated habitat at 549 m (1,795 ft) elevation overlooking the Ray Creek drainage at plot 7, Aniakchak National Monument and Preserve, 7 June 2008.

*Tall Shrub*

Tall shrub habitat was most expansive at low elevation points, averaging 26.4% (± 4.9 SE) cover at these sites (Figure 6). Tall shrub habitats were still present at middle elevation sites (10.5% [±3.1 SE]), but altogether absent at high elevation points. Accordingly, most species associations with tall shrub habitats were restricted to low elevation species. Hermit thrush, Wilson's warbler, orange-crowned warbler, and white-crowned sparrow were all detected at points with an average of at least 28% cover of tall shrub (Figure 7). One middle elevation species, fox sparrow, was also detected at points with extensive tall shrub cover (mean of 26.1% [±8.2 SE] cover). In ANIA, tall shrub habitat was dominated by willow (*Salix*) species along many river drainages (Figure 10), and alder (*Alnus*) was common along the low slopes of hills and mountains.

Figure 10. *Salix*-dominated tall shrub habitat in the upper Cinder River drainage, plot 6, Aniakchak National Monument and Preserve, 6 June 2008.

*Low Shrub*

Low shrub habitat was comprised almost entirely of willows, and, rarely, small alder. Dwarf birch (*Betula* spp.), a common component of low shrub habitats throughout much of Alaska is absent in ANIA. Low shrub habitat was common at low and middle elevation points (mean of 30.0% [±4.9 SE] and 22.9% [±4.1 SE] cover at low and middle elevation points, respectively; Figure 6), but, as with tall shrub, was entirely absent at high elevation points. Low shrub habitat was typically encountered in moist, flat terrain along river or creek drainages (Figure 11). Many of the same species associated with tall shrub habitats were also associated with low shrub habitats (Figure 7). In addition to the species listed above under tall shrub, savannah and golden-crowned sparrows were strongly associated with expansive low shrub cover (mean percent cover values > 39% for each).

Figure 11. *Salix*-dominated low shrub habitat, plot 8, Aniakchak National Monument and Preserve, 4 June 2008. The seasonal phenology was likely delayed compared to other years as evidenced by the lack of leaves on the surrounding willows.

*Dwarf Shrub*

Dwarf shrub habitat was the most expansive type throughout the survey area (Figure 6). It comprised the largest habitat component at high and middle elevation points (mean of 43.9% [± 6.7 SE] and 37.7% [5.5 SE] cover, respectively), and was also present at low elevation points (9.6% [± 2.7 SE]; all Figure 6). Areas supporting dwarf shrub habitat tended to be well-drained terrain dominated by continuous mats of ericaceous shrubs (Figure 12) or sparse *Dryas* cover. Low elevation species did not show a strong association with dwarf shrub habitats, but most middle and high elevation species were strongly associated with dwarf shrub habitats. Two middle elevation species in particular, rock ptarmigan and American pipit, seemed to occur most often in dwarf shrub habitats, with mean percent cover values of 43.6% (±9.6 SE) and 50.3% (±7.0 SE), respectively (Figure 7).

Figure 12. Dwarf shrub habitat consisting primarily of expansive *Empetrum nigrum* mats on a ridge overlooking the upper Cinder River drainage, plot 6, Aniakchak National Monument and Preserve, 5 June 2008.

## Snow Cover, Seasonal Phenology, and Survey Timing

In order to detect as many bird species as possible, we attempted to time our inventory during the period of peak bird detectability. As a proxy of seasonal conditions, we summarized the percent snowcover across the study site and by elevation class (Figure 6), and at points where the most-common bird species were detected (Figure 7). Snow covered a relatively limited area across the survey area (7.1% [±1.4 SE] cover), but comprised a large amount at high elevation points (21% [±4.3 SE] cover; Figure 13). In general, species were not associated with snow cover, but American pipit, semipalmated plover, and snow bunting all occurred at points with relatively extensive snow cover (all >15% cover, Figure 7), most likely due to these species' high-elevation distributions rather than an actual preference for snow-covered surroundings.

Figure 13. Conditions on 7 June 2008 at plot 7 in Aniakchak National Monument and Preserve. Snowcover was nearly complete at many high elevation locations, and emergent vegetation at all elevations was not yet in leaf.

## Discussion

This inventory represents the first systematic ground survey of birds within ANIA and complements previous work conducted in SWAN (Van Hemert et al. 2006, Ruthrauff et al. 2007) and across Alaska (Swanson and Nigro 2003, Tibbitts et al. 2005). All of these inventories have greatly enhanced our understanding of the distribution and abundance of birds in Alaska. The intrinsic value of avian resources within national parks will increase as habitat loss and degradation continue outside park boundaries. Effective conservation efforts require accurate information concerning the status of the resource, and these inventories fill substantial, basic knowledge gaps for many bird species across the region.

### Detection of Breeding Birds

We detected 67 species during this inventory, seven of which were not previously confirmed in ANIA. Prior to this inventory, 101 species were believed to occur in ANIA (NPSpecies 2008), of which we detected 60 (59%). The confirmed presence of seven new species represented a substantial 6.5% increase in the number of species confirmed in ANIA. For comparison, more intensive efforts in KATM (*n* = 486 point count surveys conducted) and LACL (*n* = 417 point count surveys conducted; both Ruthrauff et al. 2007) yielded the detection of three and two species new to each park, respectively. Thus, this inventory was successful in achieving its primary goal of documenting as many bird species as possible that occur within ANIA during the breeding season.

Many of the species previously documented in ANIA that we did not detect during this inventory were either seabirds restricted to the coast (e.g., murres, murrelets, puffins, cormorants) or waterfowl and shorebirds that probably occur in the region only as migrants (e.g., ruddy and black turnstone, brant) or outside the breeding season (e.g., Steller's and common eider, emperor goose). Thus, the timing of our surveys and our focus on breeding landbirds prevented us from detecting additional species. The few dedicated bird studies that have occurred in the region have focused on seabirds (e.g., Bailey and Faust 1984, Van Pelt and Piatt 2005), so our emphasis on landbirds was an effort to maximize our ability to detect new species and fill information gaps on breeding landbirds in the region.

The number of species detected at a given location was likely the result of observer effort, weather conditions, and habitat type. For instance, we detected the greatest number of species in plot 3 where all three crews were present for three nights, and where the focal-area survey crew then spent an additional three nights. By simple virtue of having numerous observers present for a relatively long duration, opportunities to detect unique bird species increased. Additionally, the crews camped along the Meshik River near Meshik Lake while at plot 3, and the presence of these waterbodies likely attracted numerous species. Jaw Mountain, in contrast, was visited for half a day, and all search efforts occurred well away from any water sources at elevations > 250 m. Correspondingly, the number of species detected at this location was comparatively low.

In general, species of conservation concern were not commonly detected nor widely distributed at ANIA. With the exception of willow and rock ptarmigan and golden-crowned sparrow, most species of conservation concern were not commonly detected during point count surveys (e.g., rough-legged hawk, Pacific golden-plover, black oystercatcher, marbled godwit, dunlin, short-billed dowitcher, and gray-cheeked thrush all with < 10 individuals detected; Table 3), nor were they widely distributed (e.g., black scoter, red-throated loon, black oystercatcher, dunlin, marbled murrelet, short-eared owl, and hoary redpoll all detected at only 1 site; Appendix 3). This is not particularly surprising, given that these species are considered species of conservation concern because their populations are believed to be threatened, declining, or simply small overall.

It is instructive to assess the ability of the two different survey methodologies (focal-area and point-count surveys) in detecting bird species. Because the three crews visited different locations for varying amounts of time, it is difficult to simply compare survey effort and correlate these efforts with species detections. However, two of the seven species (gadwall and hoary redpoll) that were confirmed in ANIA during this inventory were detected using only the focal-area survey methodology; downy woodpecker was detected by both the focal-area survey crew and a point-count survey crew, and marbled godwit, golden eagle, merlin, and horned lark were detected by one or more point-count survey crews. Thus, depending upon study goals, focal-area surveys may be an effective way to supplement count data gathered under more rigorous sampling protocols by

focusing field efforts in areas of interest that may not have been included in randomly selected plots. Crews conducting focal-area surveys also do not need the extensive training required for performing point count surveys.

### Seasonal Phenology and Inventory Timing

In general, our ability to assess whether the spring conditions that we observed were typical is limited due to the dearth of information on this topic for this region. However, we believe that the pervasive snow cover at high elevation sites was likely anomalous. Combining our observations of extensive snow cover at high elevation sites with our observations of willow and alder still in bud (prior to leaf out) across the study area lead us to conclude that the region likely experienced a late spring. Furthermore, one author (DRR) was present at the village of Ugashik (approximately 80 km northeast of Aniakchak Caldera) during the second week of May each of the previous two springs. Upon completion of the inventory in ANIA in 2008, DRR again returned to Ugashik and noted that the leaves on the willows and alders in the village were less emerged by 9 June 2008 than by 10 May in either of the two previous years. Thus, we believe that the region experienced a late spring in 2008. Locals in the villages of Port Heiden and Ugashik also supported these observations.

The impact of a late spring on our inventory work is difficult to assess in the absence of additional information (e.g., repeat visits later in the season, comparison of similar information across years). However, the inventory yielded the detection of seven new species in ANIA, and approximately two-thirds of all bird detections were of singing birds or of birds engaged in conspicuous flight displays. These facts lead us to conclude that most breeding bird species were likely present and engaged in breeding activity. We discovered seven nests from seven species (marbled godwit, rock ptarmigan, common raven, bank swallow, American dipper, savannah sparrow, and golden-crowned sparrow) during the inventory, further indicating that normal breeding activity had commenced despite apparently late spring conditions.

### Comparison with Other Studies

When comparing our results with those of similar survey efforts, the species list for ANIA is most similar to that of KATM. Given that KATM is considerably larger and has a longer history of ornithological study than ANIA, it is not surprising that more species have been detected in KATM (164) than ANIA (108). Perhaps of more influence on species diversity, however, is KATM's more varied geography and diversity of habitats (Ruthrauff et al. 2007). Nonetheless, ANIA's species list is largely a subset of KATM's; 95% of ANIA's confirmed species are also confirmed as present in KATM. By virtue of their close proximity, ANIA and KATM share similar habitats and are subject to similar biogeographical influences, and these influences promote the occurrence of many of the same species in both parks.

In addition to their similar species lists, the average occurrence of species detected during point count surveys was similar between ANIA and KATM. The five-most commonly detected species during point count surveys in ANIA (red-necked phalarope and bank swallow not included) were among the most commonly detected species in KATM as well. Two species (American pipit and American tree sparrow) were more commonly detected in KATM than ANIA, but otherwise five species (golden-crowned sparrow, Wilson's warbler, hermit thrush, orange-crowned warbler, and fox sparrow) were among the most commonly detected species in both parks.

A surprising result from the current inventory was the relative absence of American tree sparrows in ANIA. American tree sparrow was the fifth most-commonly detected species in KATM, and occurred on 57% of study plots (Ruthrauff et al. 2007). Given these results from the region, we anticipated that American tree sparrow would be one of the more common species in ANIA. However, American tree sparrows were detected on only eleven occasions (sixteenth most-common overall, Table 3) at two plots (Appendix 3) in ANIA. In KATM, American tree sparrows were commonly associated with both low and dwarf shrub habitats, and these habitats were widely distributed at ANIA. It is possible that the species simply had not fully arrived by the time we completed our surveys. This seems unlikely, however, because the species was abundant at the two plots where it was detected in ANIA (plots 8 and 9), and the species was also abundant at Ugashik upon completion of the inventory. Thus, despite the abundance of apparently suitable habitat, ANIA does not appear to support high densities of American tree sparrows.

Because of the KATM and LACL inventory's focus on montane regions, it is difficult to compare point-count survey results across inventories. Avian species diversity and breeding abundance is typically low at higher elevations (see discussion in Ruthrauff et al. 2007), and 345 of 885 (39%) point-count surveys in KATM and LACL were conducted at high elevation points compared to 34 of 136 (25%) during the ANIA inventory effort. Thus, Ruthrauff et al. (2007) conducted relatively more counts at low diversity, low density points compared to this effort. Nonetheless, the total number of species detected per point (4.58, 4.03, and 4.36 for ANIA, KATM, and LACL, respectively) and individuals detected per point (7.25 [note: this is the value calculated when removing the two large flocks of bank swallows and red-necked phalaropes from analysis; see Results], 6.42, and 6.89 for ANIA, KATM, and LACL, respectively) are similar across regions. ANIA's values were slightly higher than either at KATM or LACL, but had we conducted a similar proportion of counts at high elevation points, ANIA's values would likely be lower.

### Elevational Gradients and Patterns of Habitat Use

Just as comparing species assemblages across regions is insightful, it is instructive to compare the elevational categories and attendant habitat communities in ANIA to those elsewhere. Similar to results from Ruthrauff et al.

(2007), we detected more individuals of more species at low and middle elevation points compared to high elevation ones. Low and middle elevation points were characterized by tall shrub, low shrub, and herbaceous habitats. High elevation points contained no tall or low shrub habitat and were instead characterized by dwarf shrub and bare ground habitat. Elevational and latitudinal vegetation patterns are largely determined by temperature and moisture gradients (Pielou 1994, Arris and Eagleson 1989), factors which in turn define the length and intensity of the growing season. In general, the duration and intensity of the growing season decreases with both elevation and latitude (Billings 1973, Krebs 1985), promoting the growth of prostrate shrubs at the expense of trees (Sturm et al. 2001).

Simply by virtue of ANIA's lower latitude then, one might predict that the habitat communities at ANIA would distribute themselves across broader elevational gradients compared to KATM and LACL. This was not the case, however. The low, middle, and high elevation categories in KATM and LACL as defined by Ruthrauff et al. (2007) were 100–350 m, 351–600 m, and 601–1,620 m, respectively. In both studies, the elevational categories were created based on the observed distributional patterns of vegetation cover types, and these patterns occurred over a more compressed elevational profile in ANIA (<120 m, 120–320 m, and 321–625 m for low, middle, and high, respectively). In general, the vegetation communities in ANIA were dwarfed compared with those in KATM and LACL. For instance, in contrast to KATM and LACL's towering, seemingly impenetrable alder thickets, ANIA's tall shrub habitats were rarely over 2 m tall and were easily traversed. In general, only low, wind-blasted prostrate shrubs (e.g., *Dryas* spp., *Empetrum nigrum*) and sparse herbaceous vegetation occurred at elevations above 350 m in ANIA, whereas tall shrub was still a very common habitat cover at middle elevation sites in KATM and LACL (Ruthrauff et al. 2007).

As noted above, it is more properly temperature and moisture gradients that define vegetation patterns than elevation and latitude, and these are the factors that likely influenced the distribution of the vegetation communities in lower elevations in ANIA. As mentioned in the Introduction, the ANIA region is notorious for extreme weather. As low pressure systems track across the mountainous Alaska Peninsula, Gulf of Alaska waters interact with frigid Bering Sea waters to create wet, windy, cool conditions. These forces likely exert an influence similar to increasing in elevation or latitude, creating high moisture loads and near-constant winds that force vegetation communities to lower elevations and more prostrate forms. Indeed, these influences were immediately obvious during our first three nights in the field while camped near Meshik Lake (elevation 35 m), where obvious wind scouring and krumholtz-style dwarf shrubs were common throughout the broad valley. Furthermore, the presence of certain common vegetation at this location (e.g., *Dryas octopetala*, *Saxifraga oppositifolia*) bears evidence of the extreme weather typical of the region; these plants typically occur at higher elevations elsewhere in Alaska (Hultén 1968).

Despite the fact that the elevational categories were compressed in ANIA compared to KATM and LACL, the same bird species used similar vegetation cover types across these regions. With the exception of bank swallow, the habitat associations of all the species in Figure 7 were also assessed by Ruthrauff et al. (2007) in their Appendix 7, and most species used similar habitat types in both studies. For instance, golden-crowned sparrows were detected at points with extensive tall and low shrubs in ANIA, KATM, and LACL, and American pipits occurred at points with dwarf shrub and bare ground habitats across all parks.

The mean elevation at which species were detected differed between ANIA and KATM-LACL (Ruthrauff et al. 2007). Even though Ruthrauff et al. (2007) did not sample at points below 100 m elevation, in general we detected species at lower elevations in ANIA than in either KATM or LACL. This is likely not just an artifact of sampling from points <100 m elevation in ANIA, because even species that were only detected at high elevations in ANIA (e.g., American pipit, semipalmated plover) were detected at lower mean elevations in ANIA than KATM or LACL. For instance, the mean elevation at points where rock ptarmigan were detected in ANIA was 280.5 ±14.2 SE m, whereas the mean elevation was 716.8 ±28.5 SE m at points across KATM and LACL. Thus, similar habitat types occurred at lower elevations in ANIA than either KATM or LACL, and this in turn pushed the bird species to lower elevations.

### Breeding Range and Status

In conjunction with results from previous surveys (e.g., Ruthrauff et al. 2007, Susan Savage pers. comm.), this inventory further refined the Alaska breeding range for several species. Ruthrauff et al. (2007) extended the known breeding range of wandering tattler, surfbird, and Baird's sandpiper south to high-elevation locations in central KATM, but these three species were conspicuously absent in ANIA. This supports the truncation of their breeding ranges at more northerly sites along the Alaska Peninsula. Additionally, the detection of seven species new to ANIA's NPSpecies list helps better define the breeding range for these relatively common species across a poorly-studied portion of their range. All of the aforementioned seven species are likely breeding in ANIA.

One of the inventory's more noteworthy results was the discovery of a marbled godwit nest within ANIA boundaries. Previous observers in the region discovered nests only after the eggs had hatched (North et al. 1996, Mehall-Niswander 1997), making this nest the first active nest ever discovered for this rare Alaska-breeding subspecies. Marbled godwits in Alaska number only about 2,000 individuals and their breeding range is restricted to low-lying regions between Port Heiden and Ugashik (Alaska Shorebird Group 2008). Although the majority of this subspecies breeds outside of the ANIA boundary (R. Gill pers. comm.), this nest represents a rare ornithological first and unequivocally confirms the breeding status in ANIA of a bird whose breeding range was largely unknown less than 30 years ago (Gibson and Kessel 1989).

## Summary and Recommendations for Future Study

This inventory greatly augments our understanding of the status, abundance, and distribution of breeding birds in ANIA, and the similar methodologies employed across other regions of Alaska (e.g., the Arctic Network of National parks and preserves [Tibbitts et al. 2005], Yukon-Charley Rivers National Preserve [Swanson and Nigro 2003], KEFJ [Van Hemert et al. 2006], KATM, and LACL [both Ruthrauff et al. 2007]) provide a consistent foundation upon which to direct future monitoring efforts. This methodology successfully detects and describes broad-scale patterns of distribution and abundance, and could potentially function well as a tool for monitoring populations of common species. However, this methodology presents great logistical and financial challenges and requires highly-trained observers with unique sets of Alaska-specific field skills. These limitations should be considered within the context of future monitoring goals.

Many of Ruthrauff et al.'s (2007) recommendations for future study hold true for ANIA. Specifically, bird observations from other seasons of the year are generally lacking for ANIA. The majority of bird records for ANIA cover the period from late June through late August, the period of time during which travel to and from the region is most reliable. This inventory effort effectively filled an information gap regarding ANIA's breeding bird community, but accurate information on the occurrence and distribution of birds during other parts of the annual cycle would be invaluable. Recording the occurrence of species within these parks during the non-breeding season (i.e., spring and fall migrants, residents during the non-breeding season) would more accurately document ANIA's avian resources and enable managers to make more informed management decisions.

National parks in Alaska tend not to suffer the impacts that affect many parks in other states. Currently, visitation rates are relatively low and direct human impacts moderate, and this is especially true for ANIA. Given ANIA's remote setting, capricious weather, and cost-prohibitive access, this fact is unlikely to change in the future. The region, however, is not immune to change. Proposed off-shore oil leases and open-pit mines in the Bristol Bay region demonstrate how regional events outside of park boundaries can potentially affect resources within. This is further underscored by the numerous potential threats posed to high-latitude regions by global climate change (ACIA 2004).

In general, however, Alaska is unique in that it still supports expansive regions of relatively pristine habitat. Additionally, the majority of Alaska's bird species are migratory, and the primary conservation threats to these species typically lie outside the state. In this sense, land managers in Alaska are fortunate. However, basic life history information on distribution and abundance is lacking for many of Alaska's bird species, and recent inventory efforts on NPS lands have successfully addressed some of these basic questions. With the increased knowledge provided by these studies, managers can better promote the conservation and appreciation of birds both within and beyond park boundaries.

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Figure 14. Campsite in plot 4 near Plenty Bear Creek, 5 June 2008.

**Literature Cited**

ACIA, *Impacts of a Warming Arctic: Arctic Climate Impact Assessment*. Cambridge University Press, 2004.

Alaska Shorebird Group. 2008. Alaska shorebird conservation plan. Version II. Alaska Shorebird Group, Anchorage, AK.

American Ornithologists' Union. 1998. Checklist of North American birds, 7th ed. American Ornithologists' Union, Washington, D. C.

American Ornithologists' Union. 2008. Forty-ninth supplement to the American Ornithologists' Union *Check-list of North American Birds*. Auk 125:758–768.

Arris, L. L., and P. S. Eagleson. 1989. Evidence of a physiological basis for the boreal-deciduous ecotone in North America. Vegetatio 82:55–58.

Bailey, E. P., and N. H. Faust. 1984. Distribution and abundance of marine birds breeding between Amber and Kamishak bays, Alaska, with notes on interactions with bears. Western Birds 15:161–174.

Billings, W. D. 1973. Arctic and alpine vegetations: similarities, differences, and susceptibility to disturbance. BioScience 23:697–704.

Boreal Partners in Flight Working Group. 1999. Landbird conservation plan for Alaska biogeographic regions, Version 1.0. Unpubl. Rep., U.S. Fish and Wildlife Service, Anchorage, AK. 45 pp.

Buckland, S. T., D. R. Anderson, K. P. Burnham, J. L. Laake, D. L. Borchers, and L. Thomas. 2001. Introduction to distance sampling. Oxford University Press, New York, NY.

Dewhurst, D. A, T. E. Eskelin, and J. A. Melton. 1995. Passerine breeding and fall migration monitoring at Mother Goose Lake, Alaska Peninsula National Wildlife Refuge, Alaska, June–September 1994. Unpubl. Rep., U.S. Fish and Wildlife Service, King Salmon, AK.

ECOMAP. 1993. National hierarchical framework of ecological units. U.S. Forest Service, Washington, DC.

Eskelin, T. D., and D. A. Dewhurst. 1996. Landbird breeding and fall migration at Mother Goose Lake, Alaska Peninsula National Wildlife Refuge, Alaska, June–September 1995. Unpubl. Rep., U.S. Fish and Wildlife Service, King Salmon, AK.

Fancy, S. G., and J. R. Sauer. 2000. Recommended methods for inventorying and monitoring landbirds in National Parks. Available online: http://science.nature.nps.gov/im/monitor/protocols/npsbird.doc.

Farnsworth, G. L., K. H. Pollock, J. D. Nichols, T. R. Simons, J. E. Hines, and J. R. Sauer. 2002. A removal model for estimating detection probabilities from point-count surveys. Auk 119:414–425.

Feldhamer, G. A., B. C. Thompson, and J. A. Chapman (Eds.). 2003. Wild mammals of North America. Biology, management, and conservation. 2nd edition. The Johns Hopkins Press, Baltimore and London, 1,216 pp.

Garrison, B. A. 1999. Bank Swallow (*Riparia riparia*). The Birds of North America Online (A. Poole, Ed.) Cornell Lab of Ornithology, Ithaca, NY. Retrieved from the Birds of North America Online: http://bna.birds.cornell.edu/bna/species/414.

Gibson, D. D., and B. Kessel. 1989. Geographic variation in the Marbled Godwit and description of an Alaska subspecies. Condor 91:436–443.

Gill, R. E., Jr., M. R. Petersen, and P. D. Jorgensen. 1981. Birds of the northcentral Alaska Peninsula, 1976–1980. Arctic 34:286–306.

Handel, C. M., and M. N. Cady. 2004. Alaska Landbird Monitoring Survey: protocol for setting up and conducting point count surveys. Sponsored by Boreal Partners in Flight. Unpublished protocol. USGS Alaska Science Center, Anchorage, AK. http://www.absc.usgs.gov/research/bpif/Monitor/alms/ALMSprotocol_2004.pdf.

Hultén, E. 1968. Flora of Alaska and neighboring territories. Stanford University Press, Stanford, CA.

Kedzie-Webb, S. 2001. Biological inventory study plan, Southwest Alaska Network. National Park Service, Anchorage, AK.

Knox, A. G., and P. E. Lowther. 2000a. Common Redpoll (*Carduelis flammea*), The Birds of North America Online (A. Poole, Ed.). Cornell Lab of Ornithology, Ithaca, NY. Retrieved from the Birds of North America Online: http://bna.birds.cornell.edu/bna/species/543.

Knox, A. G., and P. E. Lowther. 2000b. Hoary Redpoll (*Carduelis hornemanni*). The Birds of North America Online (A. Poole, Ed.). Cornell Lab of Ornithology, Ithaca, NY. Retrieved from the Birds of North America Online: http://bna.birds.cornell.edu/bna/species/544.

Krebs, C. J. 1985. Ecology: the experimental analysis of distribution and abundance. Third edition, Harper & Row, New York, NY.

MacKenzie, D. I., J. D. Nichols, J. A., Royle, K. H. Pollock, L. L. Bailey, and J. E. Hines. 2006. Occupancy estimation and modeling: inferring patterns and dynamics of species occurrence. Elsevier Inc., Boston, MA.

Mehall-Niswander, A. 1997. Time budget and habitat use of Marbled Godwits (*Limosa fedoa beringiae*) breeding on the Alaska Peninsula. M.S. thesis, Oregon State University, Corvallis, OR.

Meyer, K. 1987. Bird surveys of Aniakchak Caldera. Unpubl. Rep., National Park Service, King Salmon, AK.

National Park Service. 2006a. Inventory and Monitoring Networks in Alaska. Available online: http://www1.nature.nps.gov/im/units/akro/Networks/Networks.htm.

National Park Service. 2006b. National Park Service Alaska Region Science Strategy. Available online: http://www.nps.gov/akso/strategy.pdf.

National Park Service. 2008. Aniakchak National Monument and Preserve. Available online: http://www.nps.gov/ania/.

Nebel, S., and B. J. McCaffery. 2007. Vocalization activity of breeding shorebirds: documentation of its seasonal decline and applications for breeding bird surveys. Canadian Journal of Zoology 81:1702-1708.

North, M. R., D. Dewhurst, and S. S. Tucker. 1996. First nest discovered for Alaska subspecies of Marbled Godwit. Northwestern Naturalist 77:17–18.

Nowacki, G., P. Spencer, M. Flemming, T. Brock, and T. Jorgenson. 2002. Unified Ecoregions of Alaska: 2001. Open-file Report 02-297 and map and digital dataset. (Map) USGS Series. Digital data available online: www.adgc.usgs.gov/data/projects/fhm.

NPSpecies. 2008. Certified organisms. The National Park Service Biodiversity Database. Secure online version. https://science1.nature.nps.gov/npspecies/web/main/start. (Publicly accessible webpage: http://inp2300fcspeco1/Portal/SpeciesReport.mvc/Species)

Pielou, E. C. 1994. A naturalist's guide to the Arctic. University of Chicago Press, Chicago. 327 pp.

Ralph, C. J., S. Droege, and J. R. Sauer. 1995. Managing and monitoring birds using point counts: standards and applications. Pp. 161-168 *in* Monitoring

bird populations by point counts (C. J. Ralph, J. R. Sauer, and S. Droege, eds.). Gen. Tech. Rep. PSW-GTR-149, Albany, CA. Pacific Southwest Research Station, Forest Service, U.S. Department of Agriculture.

Rich, T. D., C. J. Beardmore, H. Berlanga, P. J. Blancher, M. S. W. Bradstreet, G. S. Butcher, D. W. Demarest, E. H. Dunn, W. C. Hunter, E. E. Inigo-Elias, J. A. Kennedy, A. M. Martell, A. O. Panjabi, K. V. Rosenberg, C. M. Rustay, J. S. Wendt, and T. C. Will. 2004. Partners in Flight North American Landbird Conservation Plan. Cornell Lab of Ornithology, Ithaca, NY.

Ruthrauff, D. R., T. L. Tibbitts, R. E. Gill, Jr., and C. M. Handel. 2007. Inventory of montane-nesting birds in Katmai and Lake Clark National Parks and Preserves. Unpubl. Rep. for National Park Service. U.S. Geological Survey, Alaska Science Center, Anchorage, AK.

Savage, S., D. Dewhurst, K. Brennen, and L. Hasselbach. 1993. Annotated bird list: Aniakchak Caldera and surrounds. Unpubl. Rep., National Park Service, King Salmon, AK.

Stenhouse, I. J., and S. E. Senner. 2005. Alaska WatchList 2005. Audubon Alaska, Anchorage, AK. 5 pp.

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

Swanson, S. A., and D. A. Nigro. 2003. A breeding landbird inventory of Yukon-Charley Rivers National Preserve, Alaska, June 1999 and 2000. Unpubl. Rep. YUCH-03-001. National Park Service, Fairbanks, AK.

Tande, G., and J. Michaelson. 2001. Ecological subsections of Aniakchak National Monument and Preserve, Alaska. Available online: www.nps.gov/akso/gis/.

Tibbitts, T. L., D. R. Ruthrauff, R. E. Gill, Jr., and C. M. Handel. 2005. Inventory of montane-nesting birds in the Arctic Network of National Parks, Alaska. Arctic Network Inventory and Monitoring Program, USDI National Park Service. NPS/AKARCN/NRTR-2006/02. Fairbanks, AK.

Tyre, A. J., B. Tenhumberg, S. A. Field, D. Niejalke, K. Parris, and H. P. Possingham. 2003. Improving precision and reducing bias in biological surveys: estimating false-negative error rates. Ecological Applications 13:1790–1801.

U.S. Fish and Wildlife Service. 2002. Birds of conservation concern 2002. Division of Migratory Bird Management, Arlington, VA.

U.S. Fish and Wildlife Service and Ducks Unlimited. 2008. Alaska Peninsula / Becharof National Wildlife Refuges Earth Cover Classification. U.S Fish and Wildlife Service, Anchorage, AK.

Van Hemert, C., C. M. Handel, M. N. Cady, and J. Terenzi. 2006. Summer inventory of landbirds in Kenai Fjords National Park. Unpubl. Rep. for National Park Service. U.S. Geological Survey, Alaska Science Center, Anchorage, AK.

Van Pelt, T. I., and J. F. Piatt. 2005. Population status of Kittlitz's Murrelet along the southern coast of the Alaska Peninsula. USGS Science Support Program. Final Report for U.S. Fish and Wildlife Service, USGS Alaska Science Center, Anchorage, AK.

Viereck, L. A., C. T. Dyrness, A. R. Batten, and K. J. Wenzlick. 1992. The Alaska vegetation classification. Gen. Tech. Rep. PNW-GTR-286. U.S.D.A. Forest Serv., Pacific Northwest Research Station, Portland, OR.

## Appendix

Appendix 1. Vegetation classification (after Viereck et al. 1992) used during the inventory of breeding birds in Aniakchak National Monument and Preserve, 2008.

| Level I | Level II | Level III |
|---|---|---|
| I. Forest | A. Needleleaf (conifer) forest | 1. Closed needleleaf forest<br>2. Open needleleaf forest<br>3. Needleleaf woodland |
| | B. Broadleaf forest | 1. Closed broadleaf forest<br>2. Open broadleaf forest<br>3. Broadleaf woodland |
| | C. Mixed forest | 1. Closed mixed forest<br>2. Open mixed forest<br>3. Mixed woodland |
| II. Scrub | A. Dwarf tree scrub | 1. Closed dwarf tree scrub<br>2. Open dwarf tree scrub<br>3. Dwarf tree scrub woodland |
| | B. Tall scrub | 1. Closed tall scrub<br>2. Open tall scrub |
| | C. Low scrub | 1. Closed low scrub<br>2. Open low scrub |
| | D. Dwarf scrub | 1. Dryas dwarf scrub<br>2. Ericaceous dwarf scrub<br>3. Willow dwarf scrub |
| III. Herbaceous | A. Graminoid herbaceous | 1. Dry graminoid herbaceous<br>2. Mesic graminoid herbaceous<br>3. Wet graminoid herbaceous |
| | B. Forb herbaceous | 1. Dry forb herbaceous<br>2. Mesic forb herbaceous<br>3. Wet forb herbaceous |
| | C. Bryoid herbaceous | 1. Bryophyte (mosses)<br>2. Lichens |
| | D. Aquatic herbaceous | 1. Freshwater aquatic herbaceous<br>2. Brackish water aquatic herbaceous<br>3. Marine aquatic herbaceous |
| *IV. Non-vegetated* | *A. Snow* | *1. Complete snow cover* |
| | *B. Water* | *1. Creek, river, lake, pond* |
| | *C. Rock* | *1. Scree slope, boulder field, ash* |

[1]Italicized categories were added to the classification to accommodate specific situations encountered during the inventory.

Appendix 2: Mammals (class *Mammalia*)[1] recorded during the inventory of breeding birds in Aniakchak National Monument and Preserve, 2008.

Wolf (*Canis lupis*): Fresh wolf tracks were detected in four of ten plots. All tracks were found at lower elevations along waterways (Cinder [plot 6] and Meshik [plot 3] rivers; Wiggly Creek [plot 7]) or coastal estuaries (plot 1).

Red fox (*Vulpes vulpes*): Red fox were observed in three plots (2, 5, and 8). At plot 2, an individual was observed hunting and successfully capturing Arctic ground squirrels. Tracks or scat were observed in an additional three sample plots (1, 3, and 9).

River Otter (*Lontra canadensis*): River otters were seen in one plot (8), and tracks and scat were found along the Meshik River (plot 3) and Cinder River (plot 6).

Brown Bear (*Ursus arctos*): Brown bears were widely distributed, and evidence of bears was found in all plots. Live animals were seen in plots 2 (1 adult, 1 sow with spring cub), 4 (1 adult), and 7 (sow with yearling, and sow with three 2.5 year-olds; all in Ray Creek drainage).

Moose (*Alces alces*): Moose were also detected at numerous study locations. We saw moose in three plots (6, 9, and 10), and saw tracks, scat, or signs of browse in five others.

Caribou (*Rangifer tarandus*): Caribou were observed in three plots. Three adults were seen in plot 5, two adults in plot 9, and a cow and calf in plot 10. Sign of caribou were seen in all other plots except plot 1.

Arctic Ground Squirrel (*Spermophilus parryii*): Arctic ground squirrels were the most-commonly observed mammal during the inventory, and were detected in all plots. Squirrels were more common on well-drained soils away from large river drainages, and were also common at high elevations.

Beaver (*Castor canadensis*): We did not observe any live beaver, but dams, lodges, and signs of browse were common along waterways, observed in five plots.

Snowshoe Hare (*Lepus americanus*): One snowshoe hare was observed on 3 June near thick willow shrubs along the lower end of Rainbow Creek in plot 5. This observation is extralimital and represents the first observation of snowshoe hare in Aniakchak (B. Thompson, pers. comm.). The hare was observed at N 56.802, W 158.066 (WGS84 datum).

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[1]Common and scientific names follow Feldhamer et al. (2003). See Figure 3 for plot locations.

Appendix 3. Species occurrence by10-km x 10-km sample plot or focal area (Figure 3) during the inventory of breeding birds in Aniakchak National Monument and Preserve, 2008.

| | Plot or Focal Area ID | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Common Name | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | Jaw Mtn | # of Detections |
| Tundra Swan | | X | | | | | | | | | 1 |
| Gadwall | | | X | | | | | | | | 1 |
| American Wigeon | | X | X | | | X | X | | | | 4 |
| Mallard | X | X | X | | X | X | X | X | | | 7 |
| Northern Pintail | | | X | | | | | X | | | 2 |
| Green-winged Teal | | | X | | | X | X | | | | 3 |
| Greater Scaup | | | X | | | | | | | | 1 |
| Harlequin Duck | | | X | | | X | X | | | | 3 |
| White-winged Scoter | X | | | | | | | | | | 1 |
| Black Scoter | X | | | | | | | | | | 1 |
| Barrow's Goldeneye | | | X | | | | | | | | 1 |
| Common Merganser | | | X | | | | | | | | 1 |
| Red-breasted Merganser | X | | X | | | X | X | | | | 4 |
| Willow Ptarmigan | | X | X | X | X | X | X | X | X | | 8 |
| Rock Ptarmigan | | X | X | X | X | X | X | | | X | 7 |
| Red-throated Loon | | X | | | | | | | | | 1 |
| Double-crested Cormorant | | | | X | | | | | | | 1 |
| Bald Eagle | X | X | X | | | X | X | X | | | 6 |
| Northern Harrier | | | | | X | X | | X | X | | 4 |
| Rough-legged Hawk | X | | | | | X | | | | | 2 |
| Golden Eagle | | | | | | X | X | | | | 2 |
| Merlin | | X | | | | | | | | | 1 |
| Gyrfalcon | | X | | | | | X | | X | | 3 |
| Sandhill Crane | | X | X | | X | | | X | | | 4 |
| Pacific Golden-Plover | | | X | | | | | X | | | 2 |
| Semipalmated Plover | X | X | | X | X | X | X | X | | X | 8 |
| Black Oystercatcher | X | | | | | | | | | | 1 |
| Greater Yellowlegs | X | | X | | | X | | X | | | 4 |
| Marbled Godwit | | | | | | X | | X | | | 2 |
| Least Sandpiper | X | X | X | | X | | X | X | | | 6 |
| Rock Sandpiper | X | X | | X | X | | X | | | X | 6 |
| Dunlin | | X | | | | | | | | | 1 |
| Short-billed Dowitcher | | X | X | | | | X | X | | | 4 |
| Wilson's Snipe | X | X | X | X | | | | X | X | | 6 |
| Red-necked Phalarope | | X | X | | | | X | X | | | 4 |
| Black-legged Kittiwake | X | | | | | | | | | | 1 |
| Mew Gull | X | | | | | X | | X | | | 3 |
| Glaucous-winged Gull | X | X | X | | | | | | | | 3 |
| Arctic Tern | X | | X | | | | | | | | 2 |
| Parasitic Jaeger | | X | X | | | | | | | | 2 |
| Pigeon Guillemot | X | | | | | | | | | | 1 |
| Marbled Murrelet | X | | | | | | | | | | 1 |

| Common Name | Plot or Focal Area ID | | | | | | | | | | # of Detections |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | Jaw Mtn | |
| Short-eared Owl | | | | | | | | | X | | 1 |
| Belted Kingfisher | | | X | | | | | | | | 1 |
| Downy Woodpecker | | | | | | | | | X | | 1 |
| Black-billed Magpie | | X | X | X | | X | X | | X | | 6 |
| Common Raven | X | X | | | X | X | X | X | X | | 7 |
| Horned Lark | | X | | | X | | | | | | 2 |
| Tree Swallow | | X | X | | | | | X | | | 3 |
| Bank Swallow | X | X | X | X | X | X | X | X | | | 8 |
| Black-capped Chickadee | | | X | | X | X | X | X | X | | 6 |
| American Dipper | | | | | | | X | | | | 1 |
| Gray-cheeked Thrush | | | X | | X | | | X | X | | 4 |
| Hermit Thrush | X | X | X | X | X | X | X | X | X | X | 10 |
| American Robin | | X | X | X | X | | X | X | X | | 7 |
| American Pipit | | X | X | X | X | X | X | | | X | 7 |
| Orange-crowned Warbler | X | X | X | X | X | X | X | X | X | X | 10 |
| Yellow Warbler | | X | X | | X | X | | | X | | 5 |
| Wilson's Warbler | X | X | X | X | X | X | X | X | X | X | 10 |
| American Tree Sparrow | | | | | | | | X | X | | 2 |
| Savannah Sparrow | X | X | X | X | X | X | X | X | X | X | 10 |
| Fox Sparrow | X | X | X | X | X | X | X | X | X | X | 10 |
| White-crowned Sparrow | | | X | | | X | X | X | | | 4 |
| Golden-crowned Sparrow | X | X | X | X | X | X | X | X | X | X | 10 |
| Lapland Longspur | | X | X | | X | | X | X | | | 5 |
| Snow Bunting | | | X | X | | X | X | | | X | 5 |
| Hoary Redpoll | | | | | X | | | | | | 1 |
| Redpoll Species | X | X | X | X | X | X | X | | X | X | 9 |
| # Species Detected | 26 | 34 | 41 | 17 | 25 | 29 | 31 | 30 | 18 | 11 | |