National Park Service - Southwest Alaska Network
Inventory & Monitoring Program

Summer Inventory of Landbirds in Kenai Fjords National Park
Final Report
Southwest Alaska Network

Caroline Van Hemert, Colleen M. Handel, Melissa N. Cady, and John Terenzi
USGS Alaska Science Center
1011 E. Tudor Road
Anchorage, Alaska 99503

September 2006

Contract Number: F2101050007
Report Number: NPS/AKRSWAN/NRTR-2006/04
Accession Number: KEFJ-00210
Funding Source: Inventory & Monitoring Program, National Park Service

File Name: VanHemertC_2006_KEFJ_LandbirdInventoryFinalReport_060930.doc

Recommended Citation:
Van Hemert, Caroline, Colleen M. Handel, Melissa N. Cady, and John Terenzi. 2006. Summer Inventory of Landbirds in Kenai Fjords National Park. Unpublished final report for National Park Service. U. S. Geological Survey, Alaska Science Center, Anchorage, Alaska.

Topics:
Inventory, Monitoring, Biological

Theme Keywords:
Alaska, birds, inventory, national parks, landbirds

Placename Keywords:
Alaska, Southwest Alaska Network, Kenai Fjords National Park, Kenai Peninsula

Initial Distribution:
Southwest Alaska Network—3 hardcopies, 1 electronic

Abstract:
As part of the National Park Service Inventory and Monitoring Program, we conducted a summer inventory of landbirds within Kenai Fjords National Park. Using a stratified random sampling design of areas accessible by boat or on foot, we selected sites that encompassed the breadth of habitat types within the Park. We detected 101 species across 52 transects, including 62 species of landbirds, which confirmed presence of 87% of landbird species expected to occur in the Park during the summer breeding season. We found evidence of breeding for three *Partners in Flight* Watch List species, Rufous Hummingbird (*Selasphorus rufus*), Olive-sided Flycatcher (*Contopus cooperi*), and Rusty Blackbird (*Euphagus carolinus*), which are of particular conservation concern due to recent population declines. Kenai Fjords National Park supports extremely high densities of Hermit Thrush, Orange-crowned Warbler, and Wilson's Warbler (*Wilsonia pusilla*) compared with other regions of Alaska. Other commonly observed species included Fox Sparrow (*Passerella iliaca*), Varied Thrush (*Ixoreus naevius*), Ruby-crowned Kinglet (*Regulus calendula*), and Yellow Warbler (*Dendroica petechia*). More than half of the landbird species we observed occurred in needleleaf forests, and several of these species were strongly associated with the coast-forest interface. Tall shrub habitats, which occurred across all elevations and in recently deglaciated areas, supported high densities and a diverse array of passerines. Two major riparian corridors, with their broadleaf forests, wetlands, and connectivity to interior Alaska, provided unique and important landbird habitats within the region.

EXECUTIVE SUMMARY

As part of the National Park Service Inventory and Monitoring Program, biologists from the U.S. Geological Survey and the National Park Service conducted a summer inventory of landbirds, which included passerines (*Passeriformes)*, raptors (*Falconiformes*), grouse and ptarmigan (*Galliformes*), owls (*Strigiformes*), hummingbirds (*Apodiformes*), kingfishers (*Coraciiformes*), and woodpeckers (*Piciformes*), in Kenai Fjords National Park during 25 May–24 June 2005. We surveyed 411 points across 52 transects with variable circular plot methodology using distance-sampling protocols. With this method, we recorded distances to birds detected in order to estimate species' densities with a correction factor for those individuals missed. Using a stratified random sampling design of areas accessible by boat or on foot, we selected sites that encompassed the breadth of habitat types that existed within the Park, including the altitudinal gradient, the north-to-south latitudinal gradient, and the coast-to-inland gradient, particularly along the Nuka River and Resurrection River valleys. Additionally, the sampling design specifically targeted unique habitat types, such as riparian corridors and wetland habitats.

We identified 101 species during the four-week survey period, including 62 species of landbirds, 15 species of waterfowl, 2 species of loons, 15 species of seabirds, and 7 species of shorebirds. Landbird species included 3 grouse and ptarmigan, 5 raptors, 2 owls, 1 hummingbird, 4 woodpeckers, and 47 passerines. We documented 61 (87%) of the 70 landbird species expected as well as one species not expected to occur in Kenai Fjords National Park during the summer breeding season. Highlights from the field season included evidence of breeding for three *Partners in Flight* Watch List species, Rufous Hummingbird (*Selasphorus rufus*), Olive-sided Flycatcher (*Contopus cooperi*), and Rusty Blackbird (*Euphagus carolinus*), which are of particular conservation concern due to recent population declines. We also detected several relatively rare species, including Gyrfalcon (*Falco rusticolus*) and Western Screech-Owl *(Megascops kennicottii)*, and one species not previously recorded in the Park, Townsend's Solitaire (*Myadestes townsendi*). We observed a pair of Golden Eagles (*Aquila chrysaetos*) frequenting a suspected nest site on cliffs in southern Taroka Arm as well as a second pair near the head of Paguna Arm in suitable nesting habitat. No observations of nesting activity had previously been reported for Golden Eagles within the Park.

Among the landbirds, Hermit Thrush (*Catharus guttatus*) and Orange-crowned Warbler (*Vermivora celata*) were the most frequently detected species, with 882 and 734 detections, respectively. Other commonly observed species included Fox Sparrow (*Passerella iliaca*), Varied Thrush (*Ixoreus naevius*), Wilson's Warbler (*Wilsonia pusilla*), Ruby-crowned Kinglet (*Regulus calendula*), and Yellow Warbler (*Dendroica petechia*), all with greater than 250 detections.

Thirteen species of passerines had sufficient numbers of detections from which to estimate breeding density across the areas sampled within the Park. Among these, Orange-crowned Warbler was the most abundant, averaging 1.9 pairs ha^{-1} (95% CI 1.4–2.8) across all areas surveyed. Yellow Warblers, Hermit Thrushes, and Fox Sparrows were moderately abundant, with densities ranging from 0.65–0.98 pairs ha^{-1}. Wilson's Warblers were about four times more abundant inland (0.60 pairs ha^{-1}; 95% CI 0.43–0.85) than along the coast (0.13 pairs ha^{-1}; 95% CI 0.06–0.30).

Densities of several species in Kenai Fjords National Park were significantly different from densities elsewhere in Alaska. Several species that were strongly associated with the North Pacific coastal rainforest occurred near the limit of their geographic range in the Park, including Chestnut-backed Chickadee (*Poecile rufescens*), Winter Wren (*Troglodytes troglodytes*), and Golden-crowned Kinglet (*Regulus satrapa*). Densities of these species in the Park were only 10–20% of those recorded in natural tracts of Tongass National Forest in southeast Alaska. The opposite pattern, however, was true for Orange-crowned and Wilson's warblers, whose densities were 10–20 times higher in the Park than in the Tongass. The geographic distribution of both of these species occurs more broadly to the north and west of the Park. Densities of most species whose ranges extend into interior Alaska were higher in Kenai Fjords than in the more northern areas. Densities of Hermit Thrush were 70–170 times higher, Orange-crowned Warblers 16–50 times higher, Wilson's Warblers 6–18 times higher, and Yellow Warblers more than 130 times higher.

Those species that occurred in significantly higher densities in Kenai Fjords National Park than in either southeast or interior Alaska were all ground- or shrub-nesting species. Densities of some of these species matched peak densities found in temperate portions of their geographic range. The relatively open canopy of forests in Kenai Fjords, coupled with high precipitation and moderate temperatures, produced a lush understory that supported high breeding densities of passerines.

We compared patterns of species richness across three ecological units, based on National Park Service-defined detailed ecological subsections. During our study we detected 52 landbird species within Fjordland Undifferentiated Sedimentary Rocks, 35 species in Coastal Lowland and Valley, and 34 species in Peninsula and Island Granitics detailed ecological subsections. After accounting for incomplete detectability of species, we estimated that the Coastal Lowland and Valley subsection likely supported 65 ($\pm$ 12 SE) species, which was significantly higher than estimated species richness for the Fjordland Undifferentiated Sedimentary Rocks subsection (57 $\pm$ 4); both of these were in turn higher than estimated species richness in the Peninsula and Island Granitics subsection (37 $\pm$ 4). Differences in species richness reflected variation in the diversity of habitat types available as well as degree of connectivity to interior biomes. The Coastal Lowland and Valley subsection contains unique riparian and wetland habitats as well as the Nuka and Resurrection river valleys, which are the only ice-free corridors to inland forests and encompass most of the broadleaf communities within the Park. These valleys hosted four landbird species that were strongly associated with broadleaf forests and several others that were detected nowhere else in the Park. The Fjordland Undifferentiated Sedimentary Rocks subsection covers a broad geographic range and encompasses a wide range of habitat types and all ice-free alpine areas within the Park. Needleleaf forests, tall shrub, and alpine meadows were the most commonly encountered habitat types in Fjordland Undifferentiated Sedimentary Rocks sample areas. Ten montane landbird species, including Rock Ptarmigan (*Lagopus muta*), American Pipit (*Anthus rubescens*), Snow Bunting (*Plectrophenax nivalis*), and Gray-crowned Rosy-Finch (*Leucosticte tephrocotis*), occurred only on these transects.

More than half of the landbird species occurred in needleleaf forests, which covered about a third of the areas sampled, and several of these species were strongly associated with the coast-forest interface. Northwestern Crow (*Corvus caurinus*), Winter Wren, Rufous Hummingbird, and Bald Eagle (*Haliaeetus leucocephalus*) were detected exclusively in near-coastal habitats, and may have relied upon the "edge" habitat in this coastal forest fringe. Tall shrub habitats covered about a quarter of areas sampled in the Park, occurring from coastal to high elevations and in recently deglaciated areas. Characteristic species included the Fox Sparrow, Hermit and Gray-cheeked (*Catharus minimus*) Thrushes, and Orange-crowned, Yellow, and Wilson's warblers. Broadleaf forests, though a small component of the Park, provided habitat for Yellow-rumped Warblers (*Dendroica coronata*), Pine Siskins (*Carduelis pinus*), Swainson's Thrushes (*Catharus ustulatus*), and American Robins (*Turdus migratorius*).

This landbird inventory provides important baseline information about the status, abundance, and habitat associations of landbird populations within Kenai Fjords National Park during the primary breeding season. Additional research is needed to determine the importance of the Park to landbirds during other parts of the annual cycle. Inadequate data exist for confirming presence, abundance, and residency status of many avian species that occur in the Park, particularly early breeding species, migrants, and winter residents. In addition, because rare or difficult-to-detect species are not sampled adequately with an inventory approach, targeted survey efforts for species of concern may be warranted. Relatively common species could be monitored easily over time and this information could serve to gauge the health of the unique and important ecosystems present within the Park.

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

INTRODUCTION

Kenai Fjords National Park is one of 15 national parks in Alaska, which jointly cover more than 200,000 km² (54 million acres) across the state. As a steward for these important areas as well as hundreds of additional park units throughout the rest of the United States, the National Park Service has been charged with the responsibility of managing nearly 325,000 km² (80 million acres) of protected lands. This stewardship includes maintaining "ecosystem integrity" by ensuring that managers have the information necessary to guide the protection of their park's natural resources (National Park Service 2006a). Toward this aim, the Inventory and Monitoring Program, which includes goals for baseline inventories and long-term monitoring programs for all biological natural resources within national parks, was formally implemented in 1991. The Inventory and Monitoring Program for Alaska began in 2000 and was implemented across four park networks, grouped by geographic proximity and similarity of ecological units.

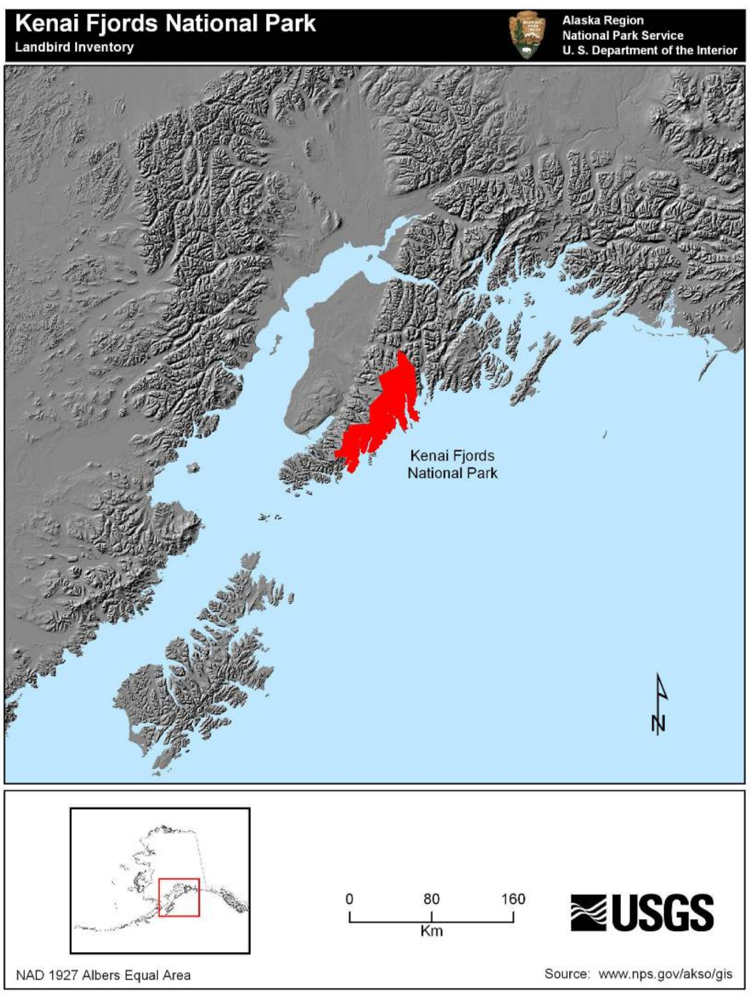


Figure 1. Location of Kenai Fjords National Park, Alaska.

Kenai Fjords National Park (hereafter referred to as the "Park") is a part of the Southwest Alaska Network, which includes Aniakchak National Park and Monument on the northern Alaska Peninsula, and parks adjacent to the northern Bering Sea and southern Cook Inlet (Lake Clark and Katmai National parks and preserves and the Alagnak Wild River corridor). This network encompasses a wide range of dramatic geological features and habitat types, and straddles the interface between Pacific maritime and continental climatic zones. The Park is located on the outer Kenai Peninsula coast, spanning over 2,500 km² (607,000 acres) of dramatic montane and coastal topography (Figure 1). Dominated by the frozen expanse of the Harding Ice Field, numerous tidewater glaciers, and deeply cut fjords, Kenai Fjords National Park is a unique gem within the National Park system.

Ecological Context

The National Park Service uses landscape-level maps as a stratification layer for their biological Inventory and Monitoring Programs. For National Park Service lands, ecological subsections based on a hierarchical system of spatial and temporal scales have been defined according to climatic, physiographic, and geologic characteristics of the landscape. These classifications thus provide a framework for developing Inventory and Monitoring sampling protocols that include broad coverage of environmental gradients (Tande and Michaelson 2001).

Two ecological subsections occur within the Park: Harding Icefield and Kenai Fjordlands. The Harding Icefield is composed of a single large icefield with snowfields and other small glaciers interspersed. Vegetation exists only on some nunataks (peaks that protrude above the icefield), and is generally restricted to sparse, discontinuous patches. The Harding Icefield is not likely to offer much, if any, landbird breeding habitat, and we did not conduct surveys within this subsection. The Kenai Fjordlands subsection encompasses a variety of geomorphic features and habitat types and is further divided into three detailed ecological subsections: Peninsula and Island Granitics, Fjordland Undifferentiated Sedimentary Rocks, and Coastal Lowland and Valley. Peninsula and Island Granitics include low mountains, islands, and sea stacks resulting from glacial erosion of granitic bedrock. Fjordland Undifferentiated Sedimentary Rocks extends from the coast to recently deglaciated areas, and comprises undifferentiated sedimentary rocks. These two detailed subsections share many vegetation characteristics and likely provide similar landbird habitat resources, primarily consisting of shrub and forest. The third category, Coastal Lowland and Valley, includes floodplain and low-lying areas of glacial rivers, fluvial valley bottoms, glacial moraines, and beaches and estuarine deltas. The Coastal Lowland and Valley subsection contains potentially important riparian habitat types and is restricted to several key river valleys in the Park (Tande and Michaelson 2001).

At a more local scale, Kenai Fjord's dynamic landscape is backed by the Kenai Mountains and contains a diverse assemblage of habitat types. The Park hosts four major ecosystems dominated by the interplay between glaciers and ocean: the arctic-alpine zone above treeline; the alder belt descending down the mountain slopes; the Hudsonian zone dominated by Sitka spruce forests in a few interior valleys; and the transcontinental coniferous forests of the Canadian zone along the shoreline. Extensive coniferous stands within Kenai Fjords comprise the most pristine northern portions of the largest extant temperate rainforest in the world.

The scenic and natural resources of Kenai Fjords are strongly valued by the public, as demonstrated by high visitation rates, particularly during the summer. Visitor use is not equally distributed across the Park, and is primarily determined by ease of access from the nearby city of Seward. For this reason, the Exit Glacier area and fjords nearest to Resurrection Bay receive the highest number of visitors each year and therefore may be of particular management interest within the Park.

Avian Background

In the 2005 avian inventory, we targeted several orders of birds generally termed "landbirds," which included passerines (*Passeriformes)*, raptors (*Falconiformes*), grouse and ptarmigan (*Galliformes*), owls (*Strigiformes*), hummingbirds (*Apodiformes*), kingfishers (*Coraciiformes*), and woodpeckers (*Piciformes*). Alaska's coastal forests, stretching from southeast Alaska to the Kenai Peninsula, support guilds of breeding landbirds that are uniquely adapted to maritime climatic conditions and rugged topography. These coastal forest bands provide habitat for more than 100 of the 135 landbird species that occur in Alaska. Nineteen of these species are believed to be experiencing global or statewide population declines, and at least 10 others are highly dependent on coastal forests for breeding or wintering habitat (Alaska Department of Fish and Game 2005). Despite the importance of these forest ecosystems, very little baseline information exists about landbird populations in this region. Lack of disturbance from logging and other high-impact human uses makes Kenai Fjords National Park an increasingly rare, intact ecosystem with potentially high importance for avian breeding habitat.

The Park straddles two major avifaunal biomes: the Pacific and the Northern Forest (Rich et al. 2004). These biomes are largely separated by the vast Harding Ice Field but are interconnected by two key valleys—along the Nuka River in the southern part of the Park and along the Resurrection River in the north. As a result of these inland corridors, the Park is likely to host a unique mixture of the distinct avifaunas characteristic of the Pacific coastal rainforests and the interior boreal forests of North America.

Few studies on landbirds were previously conducted in Kenai Fjords National Park. No Breeding Bird Survey routes or other standardized monitoring programs have been established in the Park and, prior to our 2005 efforts, no systematic Park-wide inventory of landbird resources had been completed. General information about landbird communities in this region was based on expected species occurrence, rather than documented presence. Verification of landbirds in the Park was primarily limited to incidental or amateur sources, such as observations by Park visitors and personnel, annual Audubon Christmas Bird Counts near Seward, and reports from local tour operators (National Audubon Society 1983, 1990; National Park Service 2004). Local birders compiled a bird checklist for the Park in 1988 based on birds known to occur in and around Seward, the Resurrection River valley, and the waters of Resurrection Bay. This list was revised in 1997, and expanded to include the Chiswell Islands, which fall outside the jurisdiction of the Park (National Park Service 1997).

Research projects on other taxa conducted in the Park provided some information about landbirds, but these observations were generally opportunistic rather than systematic (Bailey 1977, Bailey and Rice 1989, Day et al. 1997). In the early 1980s, landbird species' accounts were compiled for the Nuka Bay and Aialik Bay regions based on field observations made during marine mammal and vegetation surveys (Day 1981, Rice 1983). The few sources of focused landbird information were restricted to specific areas within the Park and did not encompass the breadth of habitats and environmental conditions. A brief Peregrine Falcon (*Falco peregrinus*) survey was completed along the outer Kenai Peninsula coast, including much of the Park (Janik and Schempf 1985). In the only other landbird species-specific study for Kenai Fjords, nest sites and populations of Bald Eagles (*Haliaeetus leucocephalus*) were monitored in the Park during 1986–1995 (Tetreau 1996). Recently, Park personnel collected limited avian inventory data in the Exit Glacier area (Wright 2000, 2002). Although these and other studies within the Park provided important ecological information, they were generally limited in scope. In addition, scant records existed regarding landbird distribution and habitat use, both of which are critical avian management tools.

Surveying landbirds in Kenai Fjords National Park presents unique challenges, notably due to the remote and rugged character of the glacial-fjord landscape, difficulty of access, and lack of existing knowledge about landbird occurrence in the Park. In addition, unlike many species of seabirds, landbirds generally do not congregate in large assemblages to nest or feed, and hence require more extensive survey effort over a broad geographic area. With perhaps the exception of large and charismatic species like Bald Eagles or Northwestern Crows (*Corvus caurinus*), landbirds also attract less public attention than seabirds. Less conspicuous than their marine counterparts and often more difficult to locate and study, landbirds have thus been largely overlooked in the Park. Although a single inventory cannot meet the array of informational needs for understanding ecology of breeding landbirds, it provides an important baseline for future studies and allows managers and visitors alike to better understand the avian resources within the Park.

Rationale for Study

As a geographic area prone to dramatic and rapid transformation, the Park will likely experience major environmental changes in the coming decades. On a local scale, dynamic habitat succession caused by variation in glacial cover over time will alter existing landscape features and may affect birds and other wildlife populations (Hall et al. 2005). Increased visitor use, particularly around the Exit Glacier area, also has the potential for profound impacts on local flora and fauna (National Park Service 2006b). Wildlife species may be affected not only by regional factors but also by global-scale issues, such as climate change, disease, and environmental contaminants and pollutants. In order to monitor the effects of changing environmental conditions, an initial inventory of species and populations of interest is necessary. Baseline data collected through the 2005 effort will aid in identification and quantification of future changes in landbird populations.

The information collected in an inventory will also help the Park assess the regional and global importance of the landbird species it supports. Kenai Fjords National Park likely hosts breeding populations of four species of landbirds that have been designated as Continental Watch List Species by *Partners in Flight* in the *North American Landbird Conservation Plan*, which are of urgent conservation concern because of severe population declines (Rich et al. 2004). These include the Short-eared Owl (*Asio flammeus*), Rufous Hummingbird (*Selasphorus rufus*), Olive-sided Flycatcher (*Contopus cooperi*), and Rusty Blackbird (*Euphagus carolinus*). In addition, because of its unique link to both the Pacific and Northern Forest Avifaunal Biomes, the Park likely provides habitat for breeding populations of 22 other landbirds that have been listed as Continental Stewardship Species (Table 1). These species merit special attention because of their limited geographic distribution and, in some cases, declining populations (Rich et al. 2004).

Objectives

In response to the need for basic information regarding the Park's avian resources, Alaska Science Center (U.S. Geological Survey) and National Park Service biologists conducted a landbird inventory in the Park during summer of

2005. The goal of this project was to document the distribution and abundance of landbirds with respect to habitat during the breeding season in Kenai Fjords National Park. This initial inventory effort provides scientific information on the occurrence, distribution, and habitat associations of landbirds in the Park, and can serve as baseline information for future monitoring. In accordance with the National Park Service Inventory and Monitoring Program goals, the objectives of this project were to:

1. Document through existing, verifiable data and targeted field investigations the occurrence of at least 90% of the species of landbirds likely to occur in Kenai Fjords National Park during the breeding season.
2. Describe the distribution and relative abundance of landbirds within the Park, with particular attention to *Partners in Flight* Continental Watch List Species (Short-eared Owl, Rufous Hummingbird, Olive-sided Flycatcher, and Rusty Blackbird) and Continental Stewardship Species (22 species; Rich et al. 2004) expected to occur in the Park.

To accomplish these objectives, we:

1. Summarized existing, verifiable records of all landbird species occurring within Kenai Fjords National Park during the breeding season.
2. Conducted bird surveys throughout accessible areas of the Park to establish baseline information on the distribution and abundance of landbird species in the Park during the breeding season.
3. Collected habitat data at each bird survey point that could be used to describe habitat associations for each species.
4. Identified important landbird resources of the Park and provided recommendations for future monitoring of landbird populations.

Information generated by the 2005 Kenai Fjords landbird inventory provides a resource that will be used to educate the public, identify species of special concern, determine the significance of the Park in supporting landbird populations, and make management decisions about resources and visitors. In addition to establishing general patterns of abundance and habitat use, information on the current status of populations will provide a necessary scientific basis for future population monitoring.

METHODS

Sampling Design

Lack of helicopter access limited our sampling universe to areas that could be accessed on foot from the shoreline. Given this constraint, we selected sites that encompassed the breadth of habitat types that existed within the Park. This included the altitudinal gradient from the shoreline up into alpine habitats; the north-to-south latitudinal gradient of the Park's boundaries; and the coastal-to-inland gradient, particularly along the Nuka River and Resurrection River valleys, which provided corridors to interior boreal forest habitats. Additionally, the sampling design specifically targeted unique habitat types, such as riparian corridors and wetland habitats. Due to its high level of use by the public, relative ease of access, unique wetland habitats, and rapid changes in habitat associated with glacial retreat, we also identified the Exit Glacier area as a priority for sampling.

We compiled Geographical Information System data layers for topography, glaciation, land cover, and accessibility in order to identify and stratify potential areas for surveys. Sample plots were identified using shoreline access, slope, and location relative to access points. Sites deemed accessible for sampling were divided into coastal sites (areas within 250 m of the shoreline) and inland sites (areas ≥250 m from the shoreline). Sites were then stratified by detailed ecological subsection (Tande and Michaelson 2001) and geographic location. Sites deemed of particular interest due to unique habitats or perceived probability of high species richness were selected nonrandomly. The remaining plots were chosen using simple random sampling from all sites deemed accessible. Coastal transects were started at the most accessible end of the coast-vegetation interface and continued parallel to the shoreline. Inland transects were started 250 m from the coastal access point and oriented, as much as possible, across major landscape gradients, including elevation and distance from features such as coastline, glaciers, and river valleys. In the field, observers established transects of approximately 10 survey points, spaced 500 m apart on coastal transects and 250 m apart on inland transects. In extremely difficult travel conditions, these distances were approximate, based on logistical constraints.

Field Methods

Experienced ornithologists conducted surveys of landbirds in Kenai Fjords National Park during 25 May–24 June 2005, a temporal period selected to optimize detections of species breeding both early and late in the season. We deployed three teams of two to three people for approximately four weeks of survey effort. All primary observers had at least three seasons of experience conducting surveys using methodologies similar or identical to those used in this study. Prior to the field season, all observers received additional training in field identification of local birds by sight and vocalization, distance estimation, plant identification, habitat characterization, navigation, use of Geographical Positioning System (GPS), and safety. We used a combination of motorized and non-motorized boats to reach survey locations, staging initially out of Seward, Alaska.

We conducted bird surveys at each survey point using distance sampling methodology (Buckland et al. 2001) so that we could estimate densities of birds in areas sampled within the Park. The probability of detecting a bird during a survey depends on many factors, including its distance from the survey point, habitat, weather conditions, observer's hearing ability, and behavior of the bird; thus, simple counts of birds detected can be highly biased and should not be used to compare abundance among species, habitats, or areas (Diefenbach et al. 2003 and references therein). Recording detection distances from the observer to individual birds allows one to estimate a detection function for each species, which provides an estimate of detection probability out to a given distance from the survey point, given the survey conditions. Density can then be estimated for an area by combining the mean number of birds detected per point with the probability of detection (Buckland et al. 2001).

We recorded distances to individual birds within a series of variable circular plots (Fancy and Sauer 2000), following protocols developed for the Alaska Landbird Monitoring Survey (Handel and Cady 2004). Briefly, we recorded all birds seen or heard in 10-m bands out to 100 m, in 25-m bands to 150 m, and in 50-m bands out to 400 m. Surveys at each point lasted for 10 min, with detections recorded in intervals of 0–3, 3–5, 5–8, and 8–10 min. For each species that was positively identified by sight or sound, we recorded behavior codes that documented evidence of occurrence and probable or confirmed breeding. We defined probable breeding evidence as a pair observed in suitable habitat, a singing male, or a courtship display. Confirmed breeding evidence was defined as observation of nest construction, alarm call, distraction display, nest, downy or recently fledged young, or an adult with a fecal sac or food for young. Topographic data were recorded at all survey locations, including elevation, slope, and aspect; and survey points were georeferenced using a GPS with targeted accuracy of 5 m.

Observers also described habitat characteristics within a 50-m radius of the survey point according to both *The Alaska Vegetation Classification* (Viereck et al. 1992) and the *Avian Habitat Classification for Alaska* (Kessel 1979). Where applicable, National Wetlands Inventory classification codes, described by *Classification of Wetlands and Deepwater Habitats of the United States* (Cowardin et al. 1979), were also assigned. Digital photographs taken toward each cardinal direction were used to supplement habitat data collected at each point. Distances to coastline, nearest fluviatile water, and nearest glacier were measured, estimated in the field, or estimated later using available Geographical Information System layers. A more detailed explanation of methods is in the

"Sampling Protocol for Kenai Fjords National Park Landbird Inventory" (Appendix).

Expected Species List

In order to assess the success of our objective to document approximately 90% of the landbird species within Kenai Fjords National Park, we developed an expected species list based on all available sources of local and regional information. To compile this list, we conducted an extensive literature review and assessed all prior Park observations described in the Kenai Fjords *NPSpecies* database (National Park Service 2004). We included all landbird species that had been documented in the Park or within 50 km of Park boundaries (such as in or around Seward) during the summer breeding season (Table 1). Because existing records for landbird occurrence within the Park were incomplete in most cases, we relied on a combination of historical and current documentation. Species with unverified observations were excluded, as were those whose seasonal occurrence did not overlap with the time period (summer breeding season) of the inventory.

Data Analysis

Density Estimation**—**For those species with adequate numbers of detections (minimum of 25), we used program Distance 4.1, Release 2 (Thomas et al. 2004) to analyze variable circular plot data to estimate the probability of detection as a function of distance from the survey point. We then used program Distance to estimate densities based on encounter rates (detections per point) and probability of detection. To minimize bias due to movement of birds (Buckland et al. 2001), we included only those individuals detected during the first 5 min of each count, including those present at the point as we approached, and we excluded birds flying over the study area. Most detections of birds included in the analysis were of singing males and surveys were timed to coincide with the incubation period for most passerines (C. M. Handel, unpubl. data). We recorded pairs of birds as a cluster size of one. Thus, we interpreted estimates as densities of breeding pairs. For transects along the coast, we included a multiplier to reflect that only half of each circle was surveyed. We considered transects to be the sampling units and points within transects to be replicates when estimating variance.

We expected the probability of detecting a bird to decline with distance from the observer, with the shape of the detection curve potentially being influenced by habitat and other factors (Buckland et al. 2001). Using program Distance, we evaluated the fit of six candidate models for the detection curve, each of which included a parametric key function to fit the basic shape of the curve (half-normal, hazard rate, or uniform) and an appropriate series expansion (cosine series, simple polynomial, or Hermite polynomial) to adjust the key function to improve the fit of the model (Buckland et al. 2001). We truncated 0–35% of the observations from the right-hand tail of each detection function to improve precision and reduce bias in density estimation; in a few cases we pooled detections across intervals to avoid heaping at certain distances.

For those species with adequate numbers of detections in each stratum, we evaluated the fit of separate detection functions for coastal and inland transects. We determined the best-fitting model for the detection function to be that with the lowest value for Akaike's Information Criterion corrected for small sample size (AIC_c; Buckland et al. 2001). We used goodness of fit statistics to assess adequacy of fitted models. For each of the candidate models, we then calculated a normalized Akaike weight (w_i), which can be interpreted as the weight of evidence in favor of model *i* being the actual best model, given the data and the set of models being considered (Burnham and Anderson 2002). We calculated evidence ratios to determine the strength of support for the best model versus each of the alternative models in the set (Burnham and Anderson 2002). We then used the Akaike weights to obtain model-averaged estimates of density and the variance to incorporate model selection uncertainty (Burnham and Anderson 2002). For each species we examined 95% confidence intervals (CI) of the difference between densities on coastal vs. inland transects. We used the formulas for independent estimates if separate detection functions were selected and used the delta method if a single detection function was used (Buckland et al. 2001:84*ff*). If the CIs overlapped zero, we calculated a pooled density, which was weighted by sampling effort (number of points sampled) within each stratum.

Finally, we compared densities in Kenai Fjords National Park with those estimated from similar distance-sampling surveys in coastal rainforests of the Tongass National Forest in southeast Alaska (Kissling 2003) and in northern boreal forests of the Copper River Basin (Matsuoka et al. 2001) and Yukon-Charley Rivers National Preserve (Swanson and Nigro 2003). We used the Z-test for independent estimates to compare the difference between means (Buckland et al. 2001:84*ff*). Means that differed significantly ($Z > 1.96$) and that differed by an order of magnitude or more were considered biologically significant (*sensu* Alderson 2004).

Species Richness within Detailed Ecological Subsections**—**We estimated landbird species richness from count data collected within National Park Service-assigned detailed ecological subsections, which provided coarse landscape stratification according to broad geomorphic characteristics. For each of the three detailed ecological subsection types that occur within the Park—Peninsula and Island Granitics, Fjordland Undifferentiated Sedimentary Rocks, and Coastal Lowland and Valley—we used program SPECRICH2 (Hines 1996) to estimate species richness. This program uses capture-recapture models to account for heterogeneity in species' detectability and to estimate the numbers of species that were present but not detected within each sampled area (Boulinier et al. 1998, Nichols et al. 1998). The resulting species richness estimates are less biased than simple species counts. To compare species richness between subsections, we calculated the 95% CI of the difference between the means. If the CI did not overlap zero we considered the differences between subsections to be significant. These statistics were intended to highlight patterns of landbird species richness across coarse ecological units.

***Habitat Associations*—**We evaluated habitat associations for landbirds using vegetation data that we collected at each survey location during the inventory. Based on habitat types most commonly encountered in the Park, and given the constraint of limited sample size for landbird detections, we identified six primary habitat types for analysis. We defined these categories, based on an existing classification system (Viereck et al. 1992), as: needleleaf forest, broadleaf/mixed forest, tall shrub, dwarf/low shrub, herbaceous, and aquatic herbaceous.

The six habitat types identified closely follow Viereck level II classifications, but we combined two habitat types into a single category in several cases: broadleaf forest and mixed forest; dwarf trees and tall shrub; low shrub and dwarf shrub; and graminoid herbaceous and forb herbaceous. Habitat classes were combined to reduce the number of categories with small sample sizes, and combinations were based on structural similarities relative to use by birds. The resulting six habitat types were used to assess landbird-habitat associations.

In a preliminary evaluation of landbird-habitat associations, we summarized habitat data for all points at which each species was detected. Only species with greater than 10 detections within the 50-m habitat survey radius were included in this analysis. For points with a single habitat type within a 50-m radius, percent cover of that habitat type was defined as equal to 100%. If more than one habitat type existed at a point, we estimated percent cover of each habitat type present. To display bird-habitat associations, we created box plots for each species that portray mean, median, quartiles, and 10^{th} and 90^{th} percentiles of total percent cover for each habitat type. Therefore, mean percent cover represents the average coverage of each habitat type for points at which we detected a given species. We compared these at a gross level with similar box plots constructed for each habitat across all points surveyed, which represented habitat available across the areas sampled.

We also compiled physiographic data for each point at which we detected a given species, and summarized this information in box plots. Only landbird species with greater than 10 detections within 50 m were included in analysis. For elevation and distance to nearest coastline, we created plots with mean, median, quartiles, and 10^{th} and 90^{th} percentiles for each species. These plots are intended to highlight broad patterns of landbird distribution, which may include associations with inland, coastal, montane or lowland habitats.

This preliminary analysis of bird-habitat associations does not account for incomplete detectability of species at survey points. Thus, we undoubtedly excluded points at which birds of a given species occurred but were not detected during our brief single visit. Even low rates of false negatives (i. e., failure to record a species when in fact it is present) can bias statistical estimates of the effect of habitat on distribution (Tyre et al. 2003). However, false negatives will generally underestimate the effects of habitat on occupancy unless detectability is confounded with habitat type (Tyre et al. 2003). Further modeling that accounts for zero-inflated observations would likely confirm habitat effects evident in this preliminary analysis and would also detect less obvious habitat relationships. We plan to use zero-inflated binomial models (MacKenzie et al. 2002, Tyre et al. 2003) in a subsequent more rigorous analysis of habitat associations, with points within transects as spatial replicates (i. e., multiple visits to transects) in lieu of seasonal revisits to each survey point (cf. MacKenzie 2005).

RESULTS

Occurrence of Species in the Park

During the 2005 inventory, we sampled 411 survey locations across 52 transects, spanning the geographic range of Kenai Fjords National Park (Figure 2). We surveyed 98 points on 14 coastal transects and 313 points on 38 inland transects. We detected 101 species of birds during the four-week survey period. These included 62 species of landbirds (Table 1) as well as 15 species of waterfowl, 2 species of loons, 15 species of seabirds, and 7 species of shorebirds (Table 2). The landbird species included 3 grouse and ptarmigan, 5 raptors, 2 owls, 1 hummingbird, 4 woodpeckers, and 47 passerines.

We documented 61 (87%) of 70 landbird species expected to occur in Kenai Fjords National Park during the summer breeding season. In addition to meeting one of the primary objectives of documenting approximately 90% of expected species, we also detected one landbird species not expected to be present in the Park during the survey period, Gyrfalcon *(Falco rusticolus*).

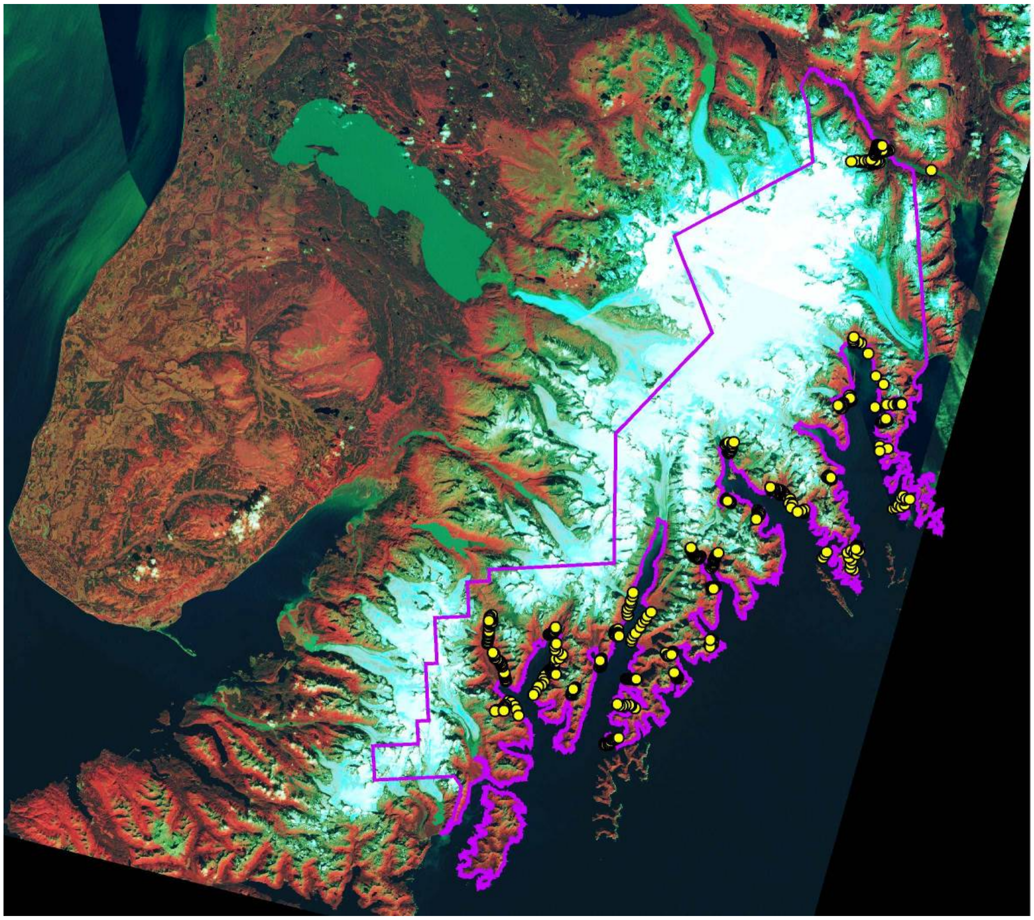


Figure 2. Sampling locations (yellow dots) for landbird inventory of Kenai Fjords National Park during 25 May–24 June 2005 (Albers Equal Area on the North American 1927 Datum).

Across the 52 transects completed, we accumulated over 4,500 detections of birds. Among the 101 species, 79 were detected during 10-min counts, and an additional 22 were observed outside of the survey points, such as at camp or while traveling between survey locations. Among the landbirds, Hermit Thrush (*Catharus guttatus*; Figure 3) and Orange-crowned Warbler (*Vermivora celata*) were the most frequently detected species, with 882 and 734 detections, respectively (Table 3). Other commonly observed species included Fox Sparrow (*Passerella iliaca*), Varied Thrush (*Ixoreus naevius*), Wilson's Warbler (*Wilsonia pusilla*), Ruby-crowned Kinglet (*Regulus calendula*), and Yellow Warbler (*Dendroica petechia*), all with greater than 250 detections during surveys.

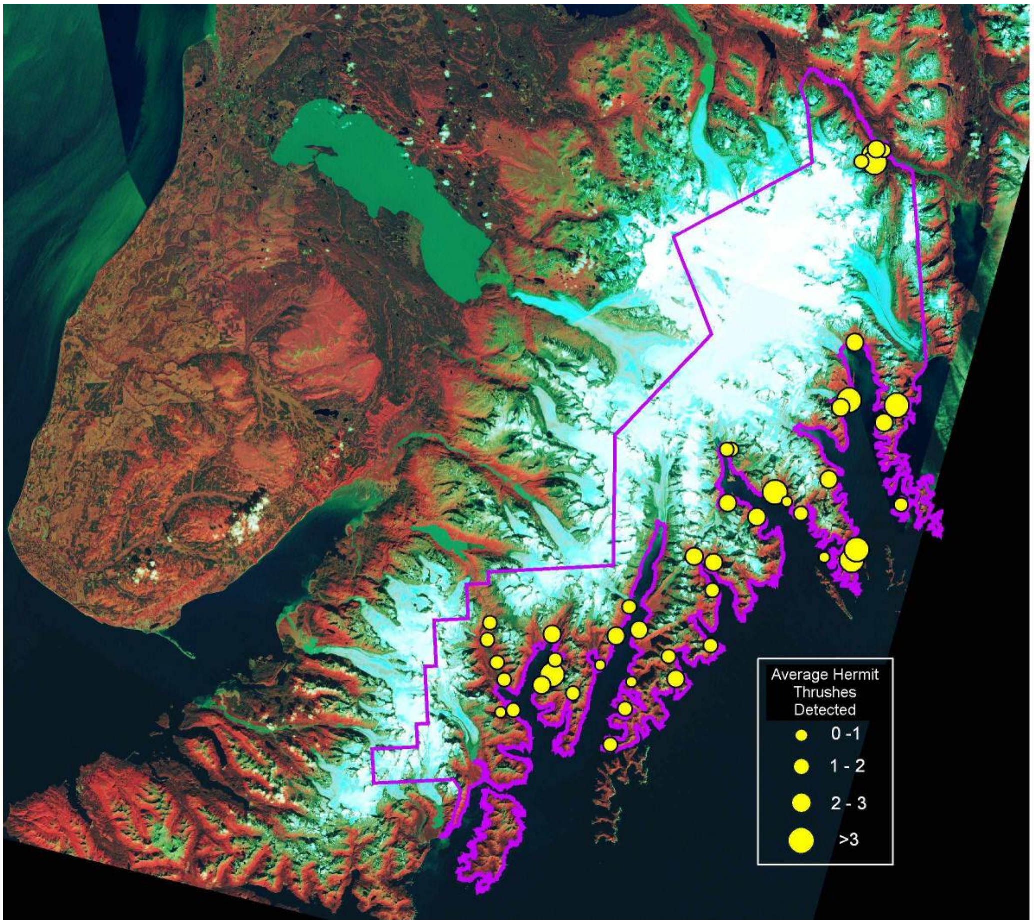


Figure 3. Average number of detections of Hermit Thrushes per survey point (yellow dots) during the landbird inventory in Kenai Fjords National Park during 25 May–24 June 2005 (Albers Equal Area on the North American 1927 Datum). Absence of a point indicates no birds were detected.

We detected Hermit Thrush (Figure 3) and Orange-crowned Warbler on the greatest number of transects surveyed (50), followed by Fox Sparrow (46), Varied Thrush (45), and Wilson's Warbler (41; Table 3). We detected most species much less frequently, however, and nearly a quarter of all landbirds observed in the Park were observed on only a single transect.

We documented three of the four *Partners in Flight* Continental Watch List Species expected to breed in the Park during the 2005 survey: Rufous Hummingbird, Olive-sided Flycatcher, and Rusty Blackbird (Table 1). These species were relatively uncommon in the Park, each detected on only 2–13% of the transects and in very low numbers. In addition to the Watch List species, we detected 21 Continental Stewardship species (Table 1). Among these, Bald Eagle, Chestnut-backed Chickadee (*Poecile rufescens*), Winter Wren (*Troglodytes troglodytes*), Varied Thrush, Fox Sparrow, and Pine Grosbeak (*Pinicola enucleator*) were relatively ubiquitous, each occurring on 46–88% of the transects surveyed (Table 3).

Densities of Landbirds

Data from point-transect surveys were sufficient to estimate densities for 13 species of passerines (Table 4). For most species we truncated observations beyond 100 m from the survey point to model detection probabilities, resulting in 23–450 detections from which to construct models (Table 5). We had adequate numbers of detections on both coastal and inland transects to test the fit of separate detection functions for four species in the two strata. For both Orange-crowned Warblers and Hermit Thrushes, the best-fitting model included different detection functions for the two strata, indicating that detectability varied for these species between coastal and inland transects (Table 6). Evidence ratios suggested that for Orange-crowned Warblers a model with two detection functions was $\geq$4.3 times more likely than any other model with a single detection function to fit the distance data; the corresponding evidence ratio for Hermit Thrushes was 4.5. For both Fox Sparrows and Varied Thrushes, distance data from coastal and inland transects were best fit by the same detection function, so we used a pooled detection function for each species. For the remaining nine species there were too few detections to model separate detection functions for coastal and inland areas, so we estimated a single detection function for each from the pooled data (Table 6).

Orange-crowned Warblers were the most abundant passerine, with model-averaged densities of 1.9 pairs ha^{-1} (95% CI 1.4–2.8) across all areas surveyed (Table 4). Yellow Warblers, Hermit Thrushes, and Fox Sparrows were moderately abundant, with densities ranging from 0.65–0.98 pairs ha^{-1} across the study area. Densities of Pine Grosbeaks were the lowest among those estimated, averaging only 0.04 pairs ha^{-1} (95% CI 0.02–0.06). Densities of Wilson's Warblers were about four times greater inland (0.60 pairs ha^{-1}; 95% CI 0.43–0.85) than along the coast (0.13 pairs ha^{-1}; 95% CI 0.06–0.30). This difference (0.47 pairs ha^{-1}; 95% CI 0.26–0.68) was statistically and biologically significant (Table 4).

Densities of several species in Kenai Fjords were significantly different from densities documented elsewhere in Alaska (Table 7). Densities of Chestnut-backed Chickadees, Winter Wrens, and Golden-crowned Kinglets (*Regulus satrapa*), all species characteristic of the Pacific Coastal rainforest, were only 10–20% of densities recorded in natural, unmanaged tracts of the Tongass National Forest in southeast Alaska (Kissling 2003). In contrast, densities of Orange-crowned and Wilson's warblers were 10–20 times higher than those found in the Tongass. Densities of most species were higher in Kenai Fjords than in more northern interior boreal forests of the Copper River Basin (Matsuoka et al. 2001) or Yukon-Charley Rivers National Preserve (Swanson and Nigro 2003). Densities of Hermit Thrushes were 70–170 times higher, Orange-crowned Warblers 16–50 times higher, Wilson's Warblers 6–18 times higher, and Yellow Warblers over 130 times higher. Densities of Varied Thrushes varied little across these areas.

Landbird Species Richness within Detailed Ecological Subsections

We detected 52 landbird species across 35 transects in the Fjordland Undifferentiated Detailed Ecological Subsection; 35 species across 7 transects in the Coastal Lowland and Valley subsection; and 34 species across 10 transects in the Peninsula and Island Granitics subsection (Table 8). Simple species counts are biased low, however, so we estimated species richness for each of the three subsections in order to account for incomplete species' detectability. We estimated species richness for landbirds to be 65 (± 12 SE) for Coastal Lowland and Valley, 57 (± 4 SE) for Fjordland Undifferentiated Sedimentary Rocks, and 37 (± 4 SE) for the Peninsula and Island Granitics ecological subsection. Pairwise comparisons suggested that the Coastal Lowland and Valley subsection supported the greatest species richness of landbirds, with a mean of 8 more species (95% CI 3–13) than the Fjordland Undifferentiated Sedimentary Rocks subsection and 28 more species (95% CI 20–36) than the Peninsula and Island Granitics subsection (Table 8). These results suggest that the Coastal Lowland and Valley subsection is of particular ecological importance within the Park. This subsection is characterized by several unique habitats, including wetlands, riparian vegetation, and deciduous forests, which are valuable for many species of landbirds. Although this subsection comprises less than 5% of the non-glaciated habitats present in the Park, the small geographic areas within this ecotype harbor notable landbird richness.

Species richness was also significantly higher within the Fjordland Undifferentiated Sedimentary Rocks subsection than in the Peninsula and Island Granitics subsection, with the Fjordland Undifferentiated Sedimentary Rocks subsection estimated to support 20 (95% CI 17–23) more species than the Peninsula and Island Granitics subsection (Table 8). The Fjordland Undifferentiated Sedimentary Rocks subsection encompasses all ice-free montane habitats in the Park and covers the greatest land area of all non-glaciated subsections.

Because we did not sample the small, inaccessible nunataks emerging from the Harding Icefield ecological subsection, we have no comparative measure of the landbird species richness in that unique habitat.

Habitat Associations

We found 45 landbird species commonly associated with needleleaf forests across the Park and a slightly different suite of 45 species commonly associated with broadleaf/mixed forests (Table 9). Only 25 species were commonly associated with tall shrub habitats, 16 with dwarf/low shrub habitats, 13 with herbaceous meadows, and 4 with aquatic herbaceous habitats within intertidal areas (Table 9). In the following sections we present representative photos, identify prominent features, and describe the avian species characteristics of each of the six main habitat types within the Park. Box plots depict the percent cover of each habitat type within a 50-m radius circle at all points surveyed. In addition, average percent cover for points at which each of the 17 most abundant landbird species was detected within 50 m is presented. These boxplots highlight disparately high or low occurrence of particular species within each available habitat but do not account for incomplete detectability of species, which can bias estimates of habitat associations.

***Needleleaf Forest*—**Needleleaf forests (Figure 4) were the primary habitat type across the study area during the inventory, with a mean of 31.8% (±1.9 SE) cover for all points sampled. Dominated by Sitka spruce (*Picea sitchensis*) near the coast and mountain hemlock (*Tsuga mertensia*) at higher elevations, needleleaf forest habitats occurred across a wide geographic and altitudinal gradient, and were present in all but alpine regions of the Park.

Figure 4. Needleleaf forest habitat in Kenai Fjords National Park during summer 2005.

Common landbird species included Chestnut-backed Chickadee, Winter Wren, Golden-crowned Kinglet, Ruby-crowned Kinglet, and Varied Thrush. Rarer species associated with needleleaf forests included Downy, Hairy, and Black-backed woodpeckers (*Picoides pubescens, P. villosus, P. arcticus*), Brown Creeper (*Certhia americana*), Red-breasted Nuthatch (*Sitta canadensis*), Rufous

Hummingbird, White-winged Crossbill (*Loxia leucoptera*), Pine Grosbeak, and Townsend's Warbler (*Dendroica townsendi*). The proportion of needleleaf forest habitat at points where we detected Hermit Thrush and Orange-crowned Warbler was similar to its availability across the study area (Figure 5). These latter two species were also commonly observed in tall shrub habitat, and no strong association was apparent for either habitat type (see below).

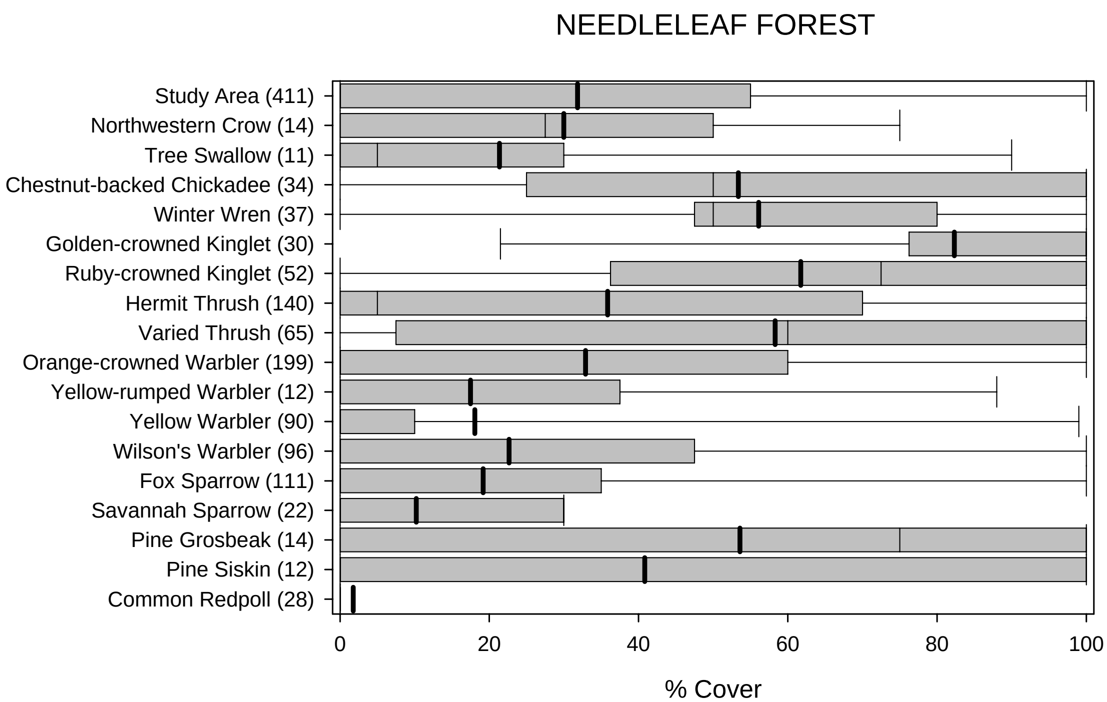


Figure 5. Percent cover of needleleaf forest habitats within 50-m radius circle at all points sampled in 2005 Kenai Fjords landbird inventory, and at points at which specific landbird species were detected within 50 m. Box plots show median (thin vertical line), quartiles (shaded box), and 10th and 90th percentiles of values (whiskers). Thick vertical line shows mean percent cover. Number of points at which each species was detected is shown in parentheses.

Broadleaf/Mixed Forest—Black cottonwood (*Populus trichocarpa*) and balsam poplar (*Populus balsamifera*) were the dominant broadleaf species present in this habitat type (Figure 6). Broadleaf and mixed forests encompassed only a small proportion of the habitats sampled (7.7% ± 1.3 SE), reflective of their relative dearth throughout the Park (Figure 7). Closely associated with riparian areas, the majority of these forests occurred near Exit Glacier on the Resurrection River floodplain, which provided a unique ecological niche within the Park.

Characteristic landbird species of broadleaf and mixed forests included Yellow-rumped Warbler (*Dendroica coronata*), Pine Siskin (*Carduelis pinus*), Swainson's Thrush (*Catharus ustulatus*), and American Robin (*Turdus migratorius*), all of which were detected at relatively low frequencies (Figure 7, Table 3).

Figure 6. Broadleaf/mixed forest in Kenai Fjords National Park during summer 2005.

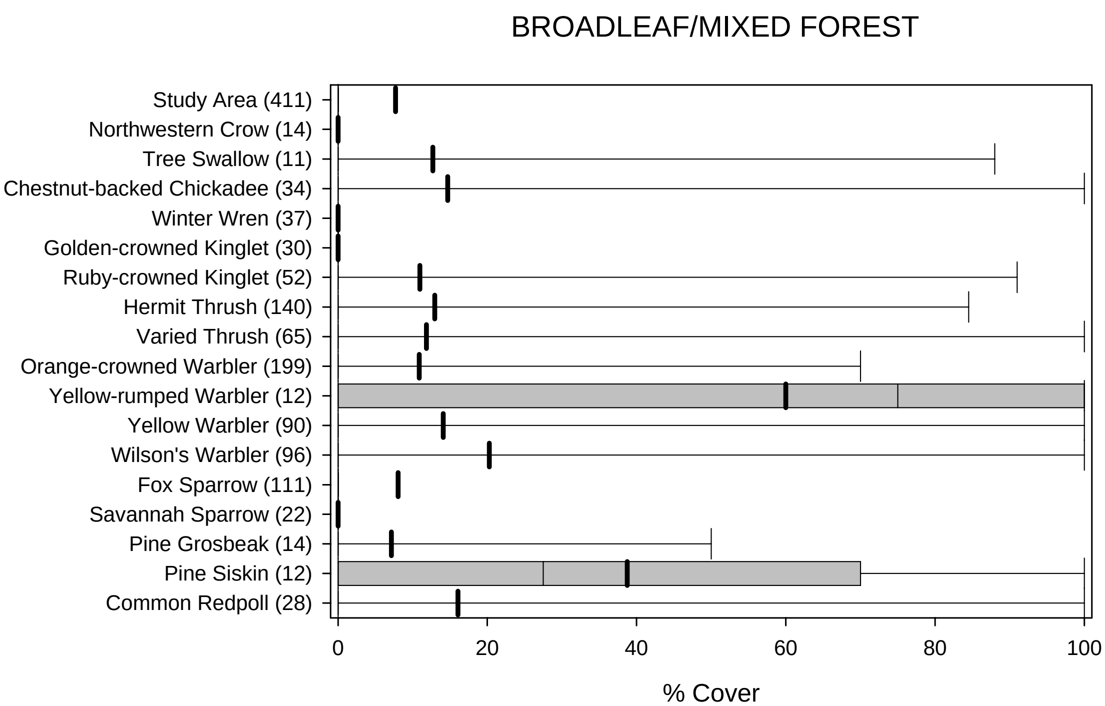


Figure 7. Percent cover of broadleaf/mixed forest habitats within 50-m radius circle at all points sampled in 2005 Kenai Fjords landbird inventory, and at points at which specific landbird species were detected within 50 m. Box plots show median (thin vertical line), quartiles (shaded box), and 10th and 90th percentiles of values (whiskers). Thick vertical line shows mean percent cover. Number of points at which each species was detected is shown in parentheses.

Tall Shrub**—**Tall shrub habitats accounted for 24.7% (±1.9 SE) of the total cover of habitats sampled in our inventory. Alder (*Alnus*) and willow (*Salix*) species were dominant across this vegetation type, which was ubiquitous throughout the Park (Figure 8). Tall shrub habitats occurred from coastal to high elevation areas and appeared commonly as an early successional stage of recently deglaciated regions.

Characteristic species included Fox Sparrow, one of the most abundant and widely dispersed landbirds within the Park. Also relatively common, but present at lower densities were Yellow Warbler, Wilson's Warbler, Common Redpoll (*Carduelis flammea*), and Gray-cheeked Thrush (*Catharus minimus*). The proportion of tall shrub habitat at points where we detected Hermit Thrush and Orange-crowned Warbler was similar to its availability across the study area, suggesting an opportunistic use of both tall shrub and needleleaf forest habitats by these species (Figure 9).

Figure 8. Tall shrub habitats in Kenai Fjords National Park during summer 2005.

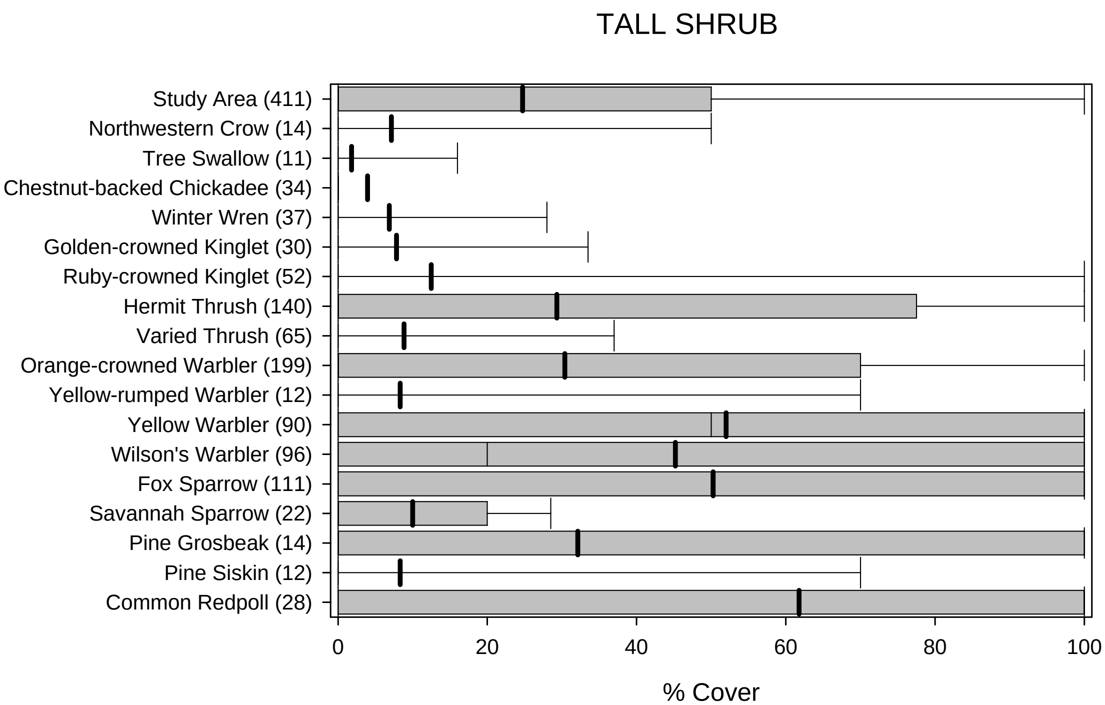


Figure 9. Percent cover of tall shrub habitats within 50-m radius circle at all points sampled in 2005 Kenai Fjords landbird inventory, and at points at which specific landbird species were detected within 50 m. Box plots show median (thin vertical line), quartiles (shaded box), and 10th and 90th percentiles of values (whiskers). Thick vertical line shows mean percent cover. Number of points at which each species was detected is shown in parentheses.

***Low and Dwarf Shrub*—**Low and dwarf shrub habitats provided a mere 3.2% (±0.8 SE) cover across sample areas. This vegetation type was generally scarce throughout the Park and occurred primarily in a small subset of alpine areas that support *Dryas* and *Ericaceous* dwarf shrub and patches of low willow thickets (Figure 10).

Of the 17 most abundant landbird species, none demonstrated a strong association with low and dwarf shrub habitat (Figure 11). Despite its low relative cover and accompanying harsh environmental conditions, this habitat type hosted a unique assemblage of montane species. Often combined with alpine herbaceous habitats, bare ground, or snow, the low and dwarf shrub habitat provided primary and secondary habitat for several species of landbirds, including Rock Ptarmigan (*Lagopus muta*), American Pipit (*Anthus rubescens*), Snow Bunting (*Plectrophenax nivalis*), and Gray-crowned Rosy-Finch (*Leucosticte tephrocotis*).

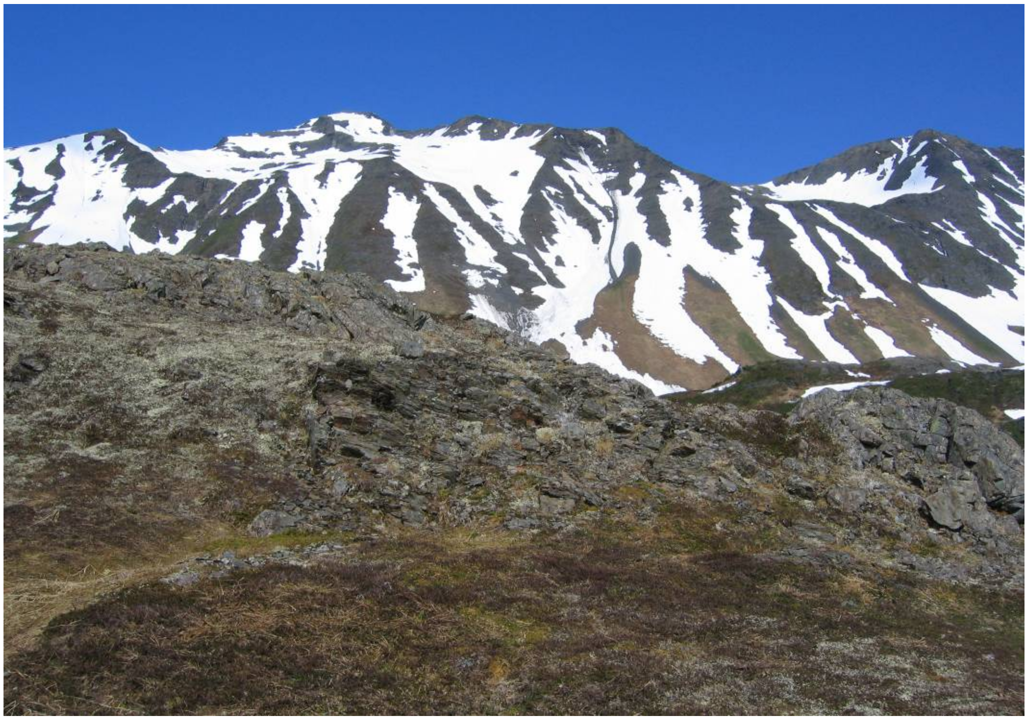


Figure 10. Low and dwarf shrub habitats in Kenai Fjords National Park during summer 2005.

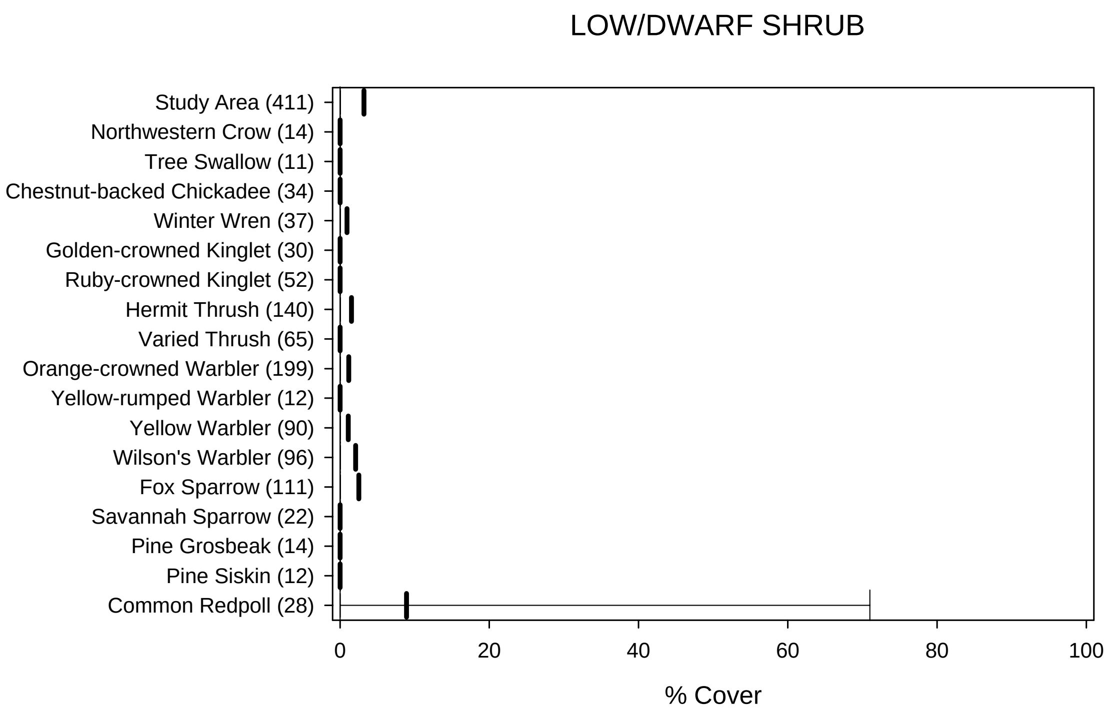


Figure 11. Percent cover of low/dwarf shrub habitats within 50-m radius circle at all points sampled in 2005 Kenai Fjords landbird inventory, and at points at which specific landbird species were detected within 50 m. Box plots show median (thin vertical line), quartiles (shaded box), and 10th and 90th percentiles of values (whiskers). Thick vertical line shows mean percent cover. Number of points at which each species was detected is shown in parentheses.

Herbaceous**—**Herbaceous habitats in Kenai Fjords, with a mean of 8.7% (±1.1 SE) total cover across sample areas, generally fell into one of thee main categories: coastal *Elymus* community, alpine meadow, or lowland meadow.

Due to the Park's extensive coastline and protected beaches of inner fjords, dry, halophytic *Elymus* was a relatively common habitat type (Figure 12). Although a number of landbird species occurred along the coastal forest fringe, few actively used shoreline herbaceous habitats. Northwestern Crows were present on many beaches in the Park, foraging in halophytic herbaceous and intertidal aquatic herbaceous zones. We detected Savannah Sparrow (*Passerculus sandwichensis*) and Lincoln's Sparrow (*Melospiza lincolnii*) sporadically in *Elymus*-dominated habitats, particularly in "edge" areas, at the interface between beach and forest or shrub. Occasionally, Fox Sparrow and Hermit Thrush were also observed foraging in this habitat type (Figure 13).

Figure 12.   *Elymus* meadow (one of several herbaceous habitat types) in Kenai Fjords National Park during summer 2005.

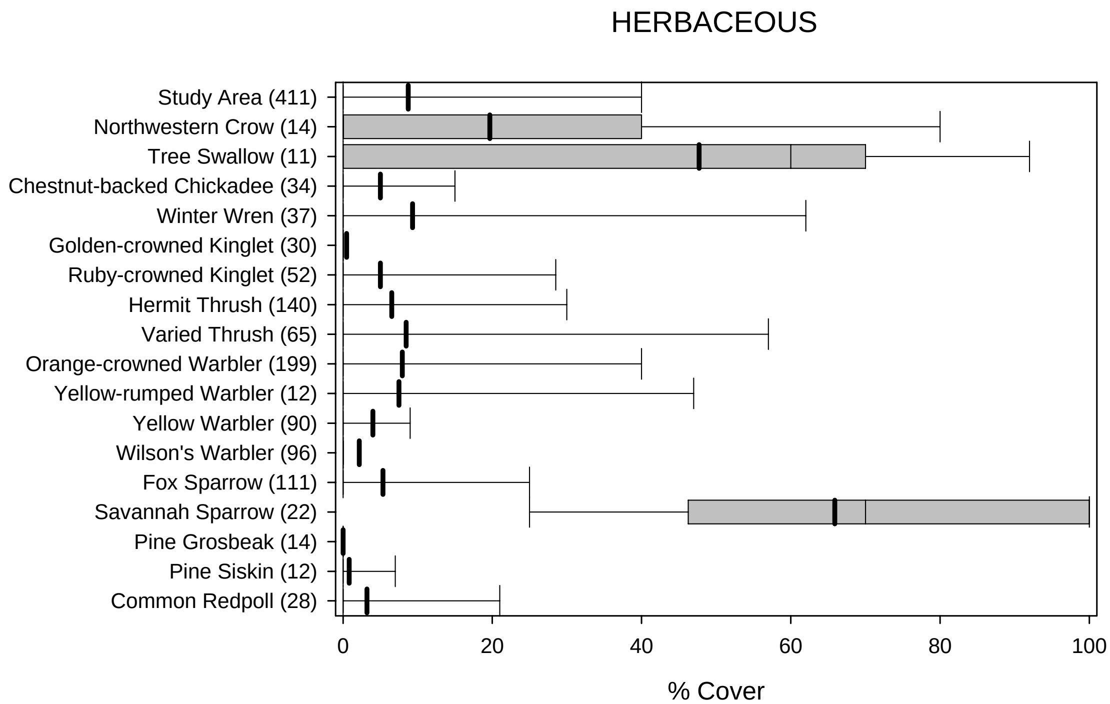


Figure 13. Percent cover of herbaceous habitats within 50-m radius circle at all points sampled in 2005 Kenai Fjords landbird inventory, and at points at which specific landbird species were detected within 50 m. Box plots show median (thin vertical line), quartiles (shaded box), and 10th and 90th percentiles of values (whiskers). Thick vertical line shows mean percent cover. Number of points at which each species was detected is shown in parentheses.

Although relatively scarce, alpine herbaceous meadows (Figure 14), in combination with dwarf and low shrub habitats, provided important habitat for a suite of montane species. Rock Ptarmigan, American Pipit, Snow Bunting, and Gray-crowned Rosy-Finch were detected in alpine herb communities in several locations throughout the Park. Due to limited access, we were unable to sample nunataks, which, where vegetated, likely provided additional habitat for these species.

Lowland and estuarine meadows (Figure 15) constituted the third component of herbaceous habitats in the Park. These habitats generally encompassed small streams or ponds, and reflected a mosaic of grass, bare ground (typically mud, sand, or gravel), and infrequent shrub patches. Characteristic landbird species included Savannah Sparrow, Lincoln Sparrow, and Tree Swallow (*Tachycineta bicolor*). These species were detected primarily in meadows with adjacent willow thickets or sparse coverage of standing dead trees (Figure 13).

Figure 14. Alpine herbaceous meadow (one of several herbaceous habitat types) in Kenai Fjords National Park during summer 2005.

Figure 15. Lowland and estuarine meadows (one of several herbaceous habitat types) in Kenai Fjords National Park during summer 2005.

Aquatic Herbaceous—Within the Park, the aquatic herbaceous habitat category referred to intertidal areas where various species of marine algae, including *Fucus*, were present (Figure 16). Coastal transects typically had at least some marine algae present, and provided 10.0% (± 1.1 SE) total coverage across sample areas.

For all landbird species, this zone provided no usable nesting habitat. However, Northwestern Crow and Bald Eagle relied on marine intertidal and subtidal areas for important foraging resources and demonstrated an apparent association with this habitat type (Figure 17, Table 9). We frequently encountered other species, including Winter Wren and Chestnut-backed Chickadee, in coastal fringe forests immediately adjacent to the intertidal zone, but they did not actually occur in aquatic herbaceous habitat.

Figure 16. Aquatic herbaceous habitat in Kenai Fjords National Park during summer 2005.

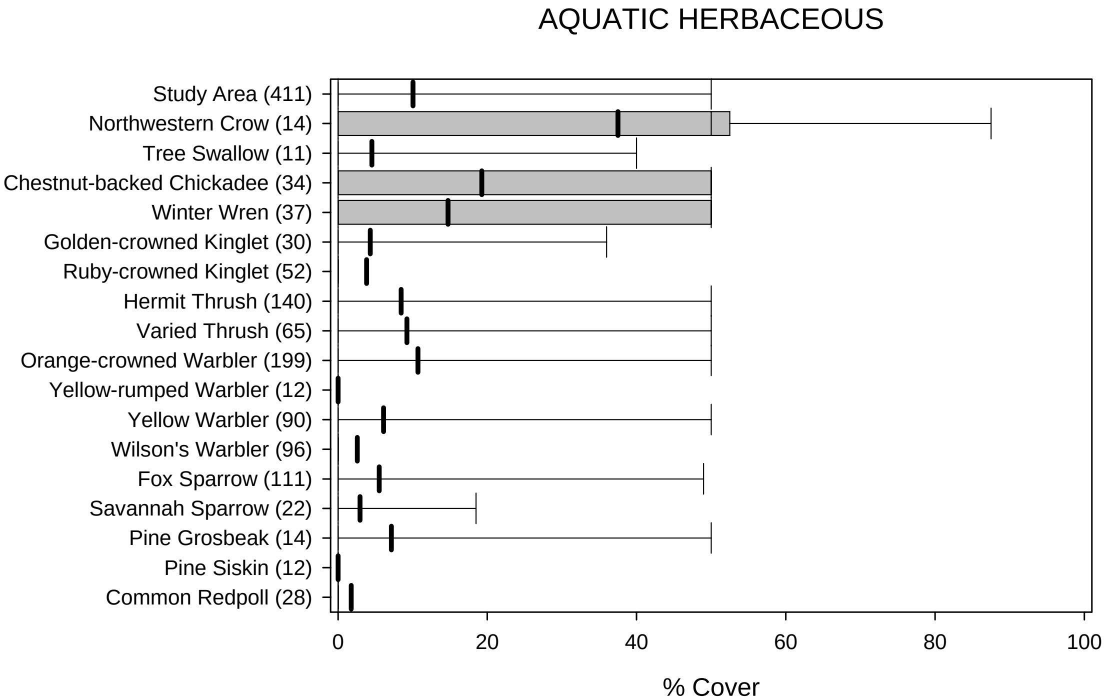
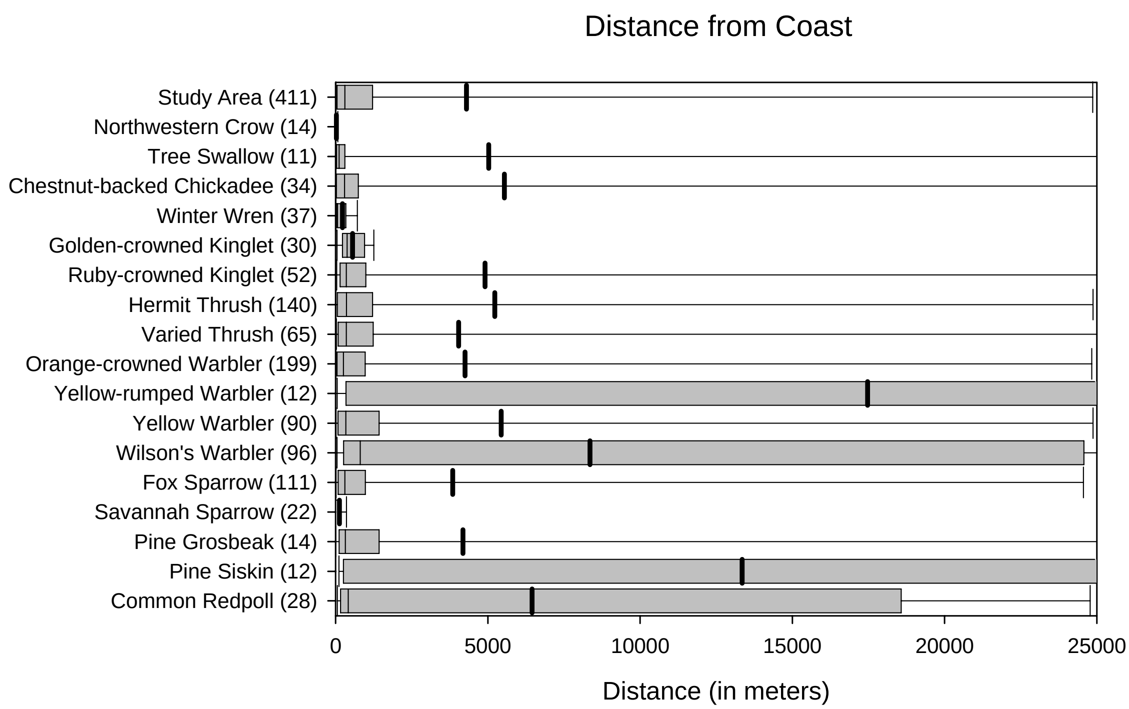


Figure 17. Percent cover of aquatic herbaceous habitats within 50-m radius circle at all points sampled in 2005 Kenai Fjords landbird inventory, and at points at which specific landbird species were detected within 50 m. Box plots show median (thin vertical line), quartiles (shaded box), and 10th and 90th percentiles of values (whiskers). Thick vertical line shows mean percent cover. Number of points at which each species was detected is shown in parentheses.

Remaining percent cover for habitat types not described above included marine and fresh water; patches of bare ground such as beaches, cliffs, and exposed bedrock; and persistent snow and ice.

Physiographic Characteristics

Several species, including Northwestern Crow, Winter Wren, and Savannah Sparrow, were strongly associated with near-coastal habitats and occurred, on average, less than 250 meters from the nearest coastline (Figure 18). Orange-crowned Warbler was also associated with near-coastal habitats, though several observations on transects near Exit Glacier indicated this species' adaptability to a range of coastal and inland habitats. Although their sample sizes were inadequate for box plot or distance analysis, we detected Song Sparrow (*Melospiza melodia*) and Rufous Hummingbird almost exclusively in forests within a few hundred meters of the coast. We also frequently observed Bald Eagles in both intertidal and coastal forest habitats (Table 9).



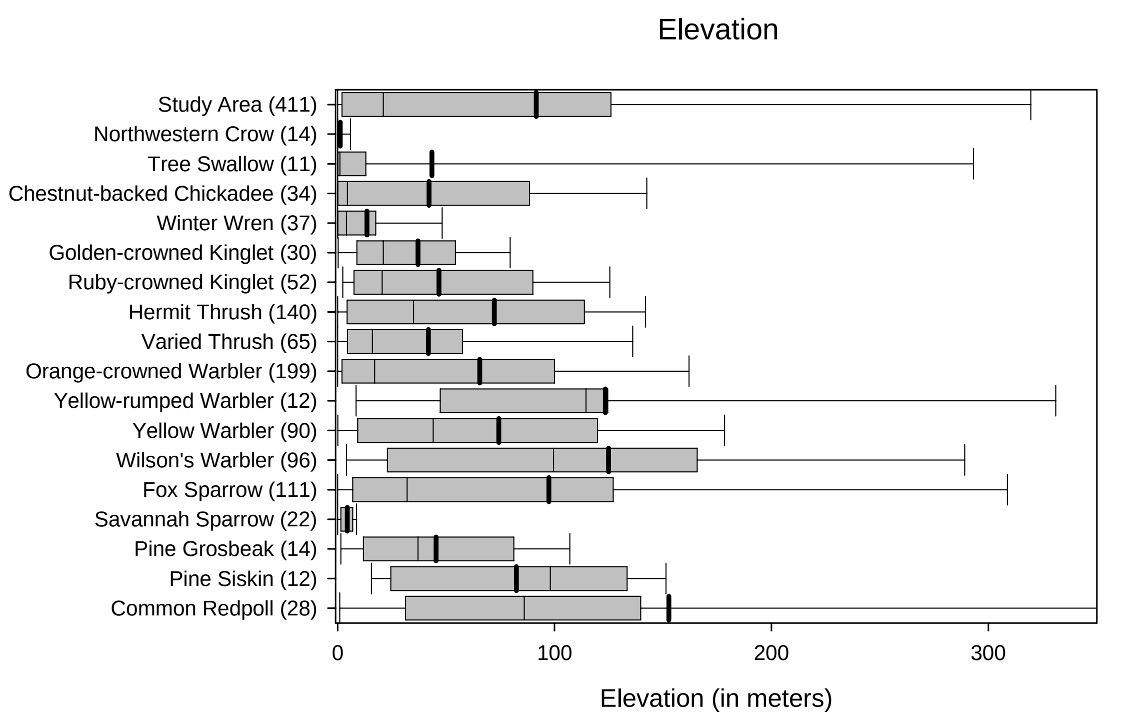


Figure 18. Distance from the nearest coastline and elevation for all points sampled in 2005 Kenai Fjords landbird inventory, and at points at which specific landbird species were detected within 50 m. Box plots show median (thin vertical line), quartiles (shaded box), and 10th and 90th percentiles of values (whiskers). Thick vertical line shows mean percent cover. Number of points at which each species was detected is shown in parentheses. Distance from coast estimated from Geographical Information System topographic layers.

Winter Wren and Northwestern Crow demonstrated an association with low elevation habitats, and typically occurred at or near the coastline (Figures 18, 19). Other coastally-distributed species naturally occurred at low elevations, including Savannah Sparrow, Song Sparrow, Rufous Hummingbird, and Bald Eagle. Most other commonly detected species demonstrated no strong association with altitudinal gradient, and were observed in suitable habitat across a range of elevations (Figure 18).

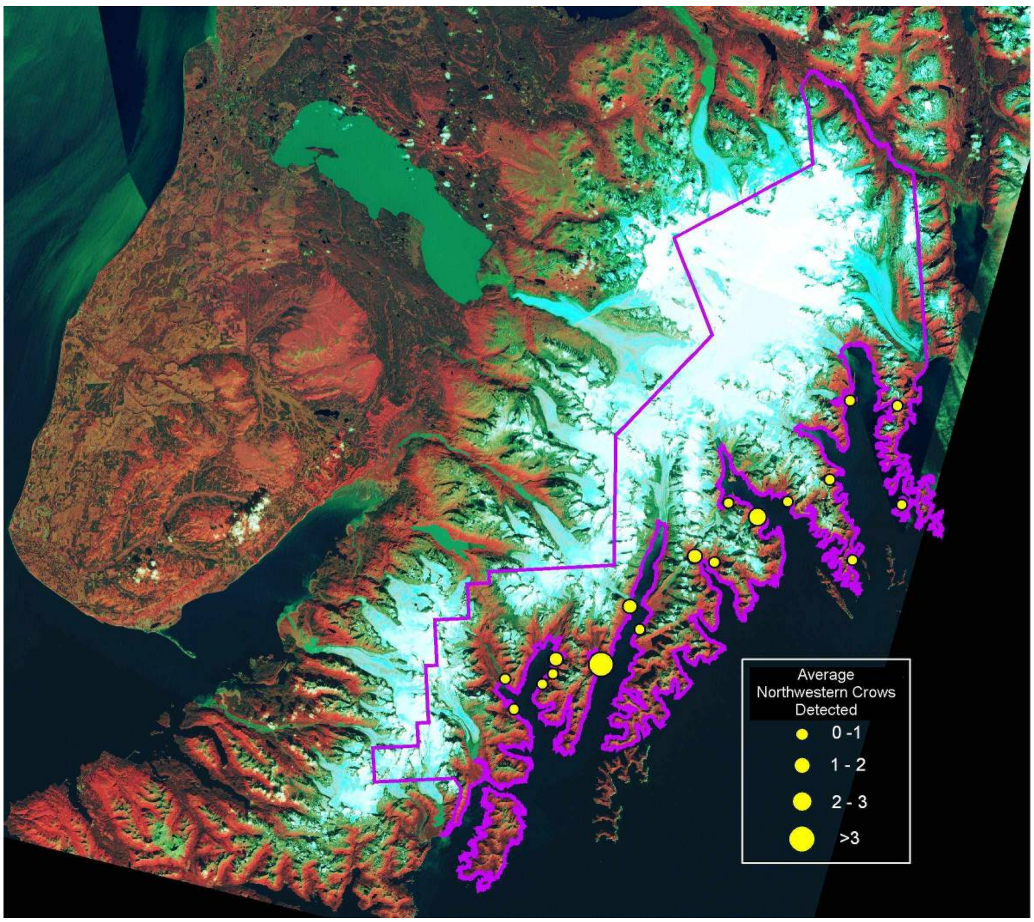


Figure 19. Average number of detections of Northwestern Crows per survey point (yellow dots) during the landbird inventory in Kenai Fjords National Park during 25 May–24 June 2005 (Albers Equal Area on the North American 1927 Datum). Absence of a point indicates no birds were detected.

We detected several species primarily inland, with large average distance from nearest coastline relative to the overall sample area for Yellow-rumped Warbler, Pine Siskin, and Wilson's Warbler (Figure 18). Both Yellow-rumped Warbler and Pine Siskin (Figure 20) were strongly associated with broadleaf and mixed forests, which occurred primarily in the Resurrection and Nuka River areas and elsewhere inland. No individuals of either species were detected immediately adjacent to the coast (Figure 18).

Among the 17 species with adequate detections for box plot analysis, none was strongly associated with high elevation (Figure 18). For species with fewer detections, however, American Pipit (Figure 21), Gray-crowned Rosy-Finch, Snow Bunting, and Rock Ptarmigan occurred exclusively in montane habitats, at elevations ranging from 400 to 1200 m.

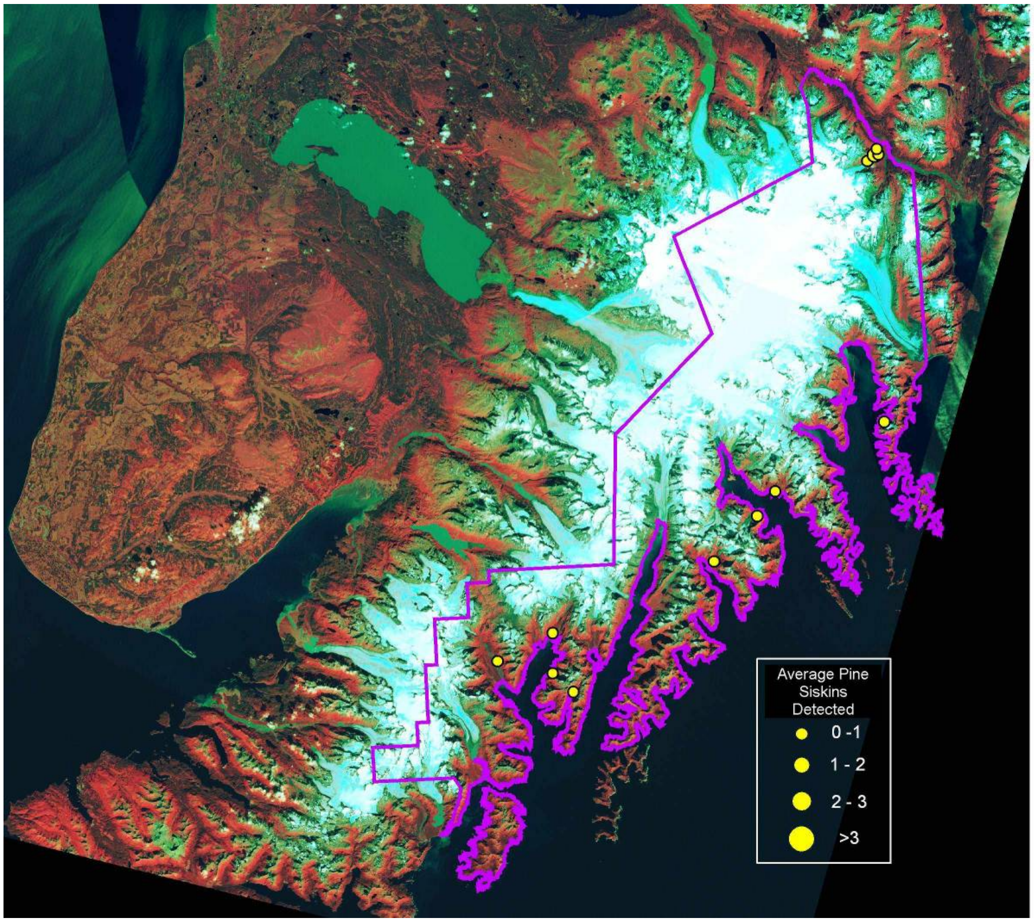


Figure 20. Average number of detections of Pine Siskins per survey point (yellow dots) during the landbird inventory in Kenai Fjords National Park during 25 May–24 June 2005 (Albers Equal Area on the North American 1927 Datum). Absence of a point indicates no birds were detected.

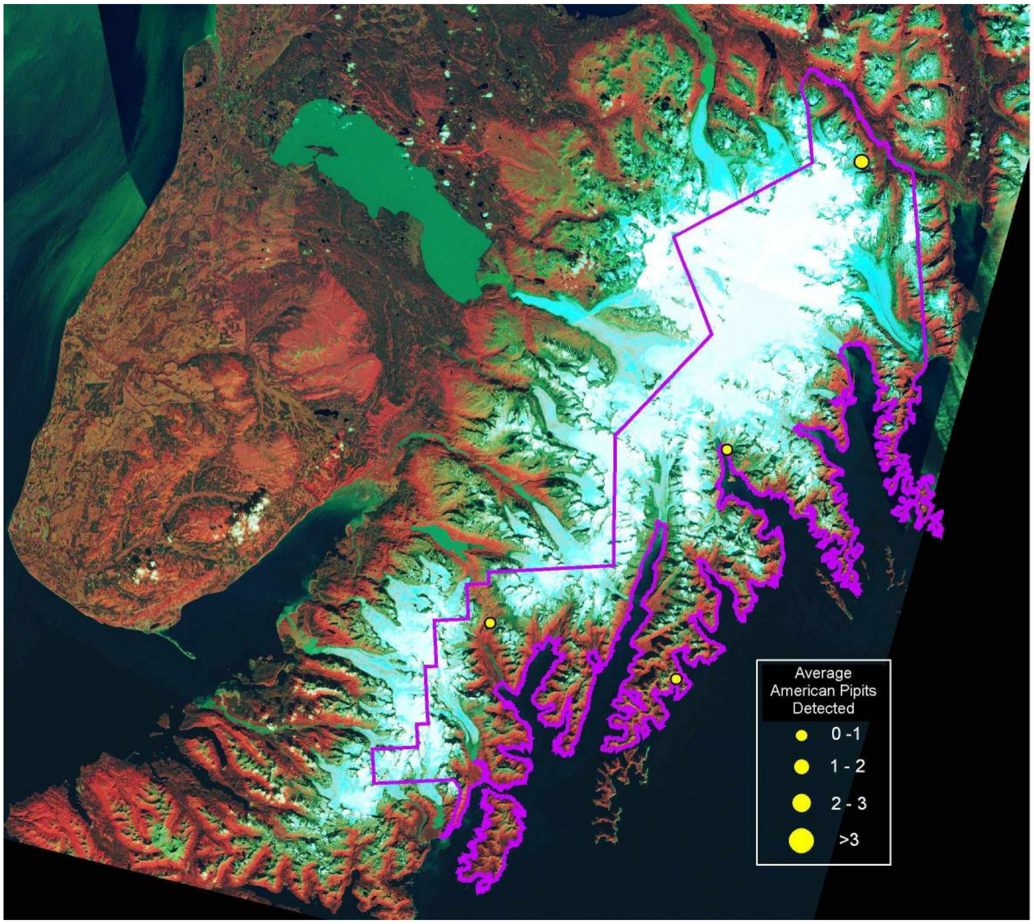


Figure 21. Average number of detections of American Pipits per survey point (yellow dots) during the landbird inventory in Kenai Fjords National Park during 25 May–24 June 2005 (Albers Equal Area on the North American 1927 Datum). Absence of a point indicates no birds were detected.

DISCUSSION

Species of Conservation Concern

The Northern Pacific forest provides continentally-important breeding habitat for the three *Partners in Flight* Continental Watch List species and 21 Continental Stewardship species detected in the Park, and Kenai Fjords likely offers valuable nesting areas. Several other landbirds not included on these lists have been identified as priority species by *Boreal Partners in Flight*, including Northwestern Crow, Gray-cheeked Thrush, and Townsend's Warbler. These species have been targeted as a priority due to conservation concerns specific to Alaska, including high responsibility for global populations and potential negative response to loss of forest cover (Boreal Partners in Flight Working Group 1999). Though management actions do not appear to be currently necessary for these relatively common species, their populations should be monitored over time and the 2005 survey will provide a baseline for doing so. If significant changes to the Park's forest protection are proposed, potential effects of habitat loss may threaten important breeding areas, and should be factored into any large-scale management decisions.

For each of the three *Partners in Flight* Continental Watch List species that we detected—Rufous Hummingbird, Olive-sided Flycatcher, and Rusty Blackbird—at least one male was observed singing, indicating the presence of a probable breeding territory within the Park. For Rufous Hummingbird and Olive-sided Flycatcher, our observations provide the first reported breeding activity within the Park. The Rufous Hummingbird was thought to rarely occur along the western North Gulf Coast (Isleib and Kessel 1973), but our four records, all on coastal transects, suggest it may be more common than previously thought. Both of our records of Olive-sided Flycatcher were on inland transects, confirming their strong association with more mainland habitats. Our sole observation of a singing Rusty Blackbird inland in the North Arm of Nuka Bay suggests that its population may have declined in the Park, in concert with the strong population declines that have been recorded throughout its range (Greenberg and Droege 1999, Niven et al. 2004, Sauer et al. 2004). We failed to detect Rusty Blackbirds at all in the Resurrection River valley, where they have been recorded regularly during the breeding season in low numbers in the past (Isleib et al. 1973). We detected the three species almost exclusively in coniferous forest habitats, with the exception of a single Olive-sided Flycatcher that was observed in tall alder shrub habitat.

Due to documented population declines in recent decades (Rich et al. 2004, Sauer et al. 2004), these Watch List species are of particular conservation interest and warrant further study, given their breeding presence in Kenai Fjords. Because of their relatively rarity, focused species-specific studies would be necessary for a more complete assessment of these species' status in the Park. Documentation of breeding status is an important preliminary step that can help identify potential study areas for future work, particularly for species with high site fidelity, such as Rufous Hummingbird (Calder 1993) or those dependent on specific habitats, such as Rusty Blackbirds on wetlands (Avery 1995).

Landbird Occurrence

Among the 70 landbird species expected to occur during the summer breeding season in the Park, seven were not detected during the 2005 inventory. Lack of detection indicated that either the species was not present at survey locations, or the species was present but simply not detected. For some species, obvious constraints in survey timing or methodology may limit the probability of detection. For example, owls, including two species expected to occur in the Park, Northern Hawk Owl (*Surnia ulula*) and Short-eared Owl, breed earlier than the ideal survey window for most landbird species and are generally difficult to detect later in the summer. Belted Kingfishers (*Ceryle alcyon*) are also relatively early nesters, which may have reduced their detection rates during the June survey period (C. Handel, pers. observ).

For species with very specific habitat requirements or distribution patterns, such as montane White-tailed Ptarmigan (*Lagopus leucurus*) or colonial-nesting Bank Swallow (*Riparia riparia*), targeted survey efforts may be necessary for detection. Montane habitats do not represent a large proportion of the Park's overall unglaciated land area and support relatively few landbird species. Therefore, we sampled alpine areas across a limited number of transects, and employed less overall survey effort in montane habitats than in lowland shrub and forests. In addition, we were limited to areas we could access via boat or foot, excluding many high alpine sites where White-tailed Ptarmigan likely occur.

Colonially-nesting bank swallows have been reported in the literature as locally common breeders in specific areas of the Park, and are usually associated with riparian banks or glacial moraines (Rice 1983, National Park Service 2004). If our randomly distributed sample plots did not include one of these colonial nesting areas, detection of Bank Swallows would be unlikely. Both White-tailed Ptarmigan and Bank Swallow have been well documented in the Park, and the lack of detection during our survey efforts is probably a factor of specific distributional patterns rather than indication of their absence from the Park (Day 1981, Rice 1983, National Park Service 2004).

In other cases, lack of detection does not have a clear temporal or distributional explanation, and suggests a species' rarity in the survey area. We did not detect White-crowned Sparrow (*Zonotrichia leucophrys*) or Blackpoll Warbler (*Dendroica striata*) during the survey period, although they have previously been observed in the Park. The outer coast of the Kenai Peninsula borders the expected breeding range for these typically more inland-distributed species (Isleib and Kessel 1973, Chilton et al. 1995, Hunt and Eliason 1999). Although both species have been documented in or near the Park during the summer breeding season, few records exist for this area, indicative of their rarity in the coastal forests of Kenai Fjords (Bailey 1976, Day 1981, National Park Service 2004). We expect that breeding populations of these species were present in the Park, but in very low numbers and likely restricted to inland areas.

We did not detect two other expected species, Merlin (*Falco columbarius*) and Peregrine Falcon, which, similar to other raptors, are typically widely spaced during the breeding season. Unlike other landbirds, such as passerines, raptors do not establish territories vocally and are generally quiet unless an observer is in the immediate vicinity of a nest. It is therefore easier to miss the presence of an individual at a survey point if the bird is stationary and silent. Merlins are suspected to nest rarely, at or near timberline in the North Gulf Coast region (Isleib and Kessel 1973). Given the expected rarity of Merlin and Peregrine Falcon within the Park, it was not surprising that we did not detect them during the 2005 inventory. In addition, most observations of Peregrine Falcon in Kenai Fjords have been reported near seabird colonies, primarily in areas that we did not target for landbird surveys.

We observed one species that was not expected to occur in the Park during the breeding season, Gyrfalcon. Gyrfalcons are known to nest in the Chugach Mountains to the north and have been observed in the interior of the Kenai Peninsula (Isleib and Kessel 1973). Although our detections confirmed the presence of this species in the Park, we did not observe any evidence of breeding. The lone bird appeared to be a vagrant individual outside of its normal summer range but Gyrfalcons could breed sporadically in very low numbers within the Park.

Regional Patterns of Abundance

Kenai Fjords National Park occurs at a pivotal location relative to regional distribution patterns for many landbirds because it lies near the northern and western extent of the North Pacific coastal rainforest but also is linked through valley corridors to interior boreal forests. As such, the Park hosts an interesting array of species, with mixtures from both biomes, and their abundance reflects the relative contributions from these two avifaunas. Chestnut-backed Chickadees, Winter Wrens, and Golden-crowned Kinglets are all strong associates of the North Pacific coastal rainforest (Willson and Comet 1996, Gende and Willson 2001, De Santo et al. 2003, Andres et al. 2004) and are near the northern limit of their geographic range in Kenai Fjords National Park (Sibley 2000). The order of magnitude differences in densities in the Park compared with those recorded in southeast Alaska (Kissling 2003) suggest that some ecological factors associated with latitudinal differences in the forest may be limiting their abundance. For example, Winter Wrens in southeast Alaska most commonly nest in cavities excavated within thick moss or decadent wood (De Santo et al. 2003). Lower breeding densities of Winter Wrens in Kenai Fjords may be related to lower availability of nest sites in the more northern coastal rainforests, which are characterized by lower precipitation and cooler temperatures (McNab and Avers 1994), less dense layers of moss, and likely slower rates of decay (C. Handel, pers. observ.). Highest breeding densities of Townsend's Warblers occur in forests with mature conifers (Wright et al. 1998); they nest selectively in the larger conifers, in which they have higher reproductive success (Matsuoka et al. 1997a,b). Thus, the uncommon occurrence of Townsend's Warblers in Kenai Fjords relative to breeding densities in southeast Alaska (1.24 pairs ha^{-1}, SE 0.24; Kissling 2003) might be linked to breeding success and related to nest-site selection.

Those species that occurred in significantly higher densities in Kenai Fjords than in either southeast Alaska or boreal forests of interior Alaska are all ground- or shrub-nesting species. Densities of Hermit Thrush in Kenai Fjords were more than twice that recorded in southeast Alaska, 70–170 times higher than recorded in boreal forests, and matched peak densities found at temperate latitudes in Nova Scotia and Arizona (0.60–0.63 pairs ha^{-1}; Jones and Donovan 1996). Similarly, densities of Orange-crowned Warblers in Kenai Fjords were 16–50 times higher than elsewhere in Alaska and were similar to those typically recorded in Oregon and California (1.0–1.8 pairs ha^{-1}; Sogge et al. 1994). In contrast, densities of both Yellow and Wilson's warblers in Kenai Fjords were orders of magnitude higher than those in either southeast Alaska or the boreal interior but orders of magnitude lower than densities found in temperate parts of their range (Ammon and Gilbert 1999, Lowther et al. 1999). For all species of this nesting guild, however, the relatively open canopy of forests in Kenai Fjords, coupled with high precipitation and moderate temperatures, produced a lush understory that supported high breeding densities.

Species Richness within Detailed Ecological Subsections

Although fewer landbird species were observed cumulatively across transects within the Coastal Lowland and Valley subsection, the estimated species richness was significantly higher in this subsection than in the Fjordland Undifferentiated Sedimentary Rocks and Peninsula and Island Granitics subsections (Table 8). Two specific physiographic features, riparian corridors and wetlands, distinguish the Coastal Lowland and Valley subsection within the Park and have been noted as important habitat characteristics for landbirds (Kessel 1998, Boreal Partners in Flight Working Group 1999). Relatively high landbird species richness in deciduous riparian habitats has been documented in southeast Alaska. Similar to patterns we observed in Kenai Fjords, broadleaf forests in southeast Alaska host unique avian communities and a suite of species that occur primarily in this habitat type (Willson and Comet 1996). In Kenai Fjords, we detected nine species of landbirds only in the Coastal Lowland and Valley subsection: Spruce Grouse (*Dendragapus canadensis*), Gyrfalcon, Western Screech-Owl *(Megascops kennicottii)*, Black-capped Chickadee (*Poecile atricapillus*), Downy Woodpecker, Hairy Woodpecker, Northern Shrike (*Lanius excubitor*), Violet-green Swallow (*Tachycineta thalassina*), and Bohemian Waxwing (*Bombycilla garrulus*). All of these species were observed in broadleaf forest or in habitats with a mosaic of canopy types, including wetlands, standing dead trees, shrub, and mixed forests. This distinction highlights the importance of relatively rare Coastal Lowland and Valley areas within the Park, and may warrant consideration for management of avian populations at a gross scale.

The Fjordland Undifferentiated Sedimentary Rocks detailed ecological subsection covers the largest non-glaciated area within the Park. Accordingly, we conducted the most surveys within this subsection, which encompasses a wide range of habitat types and all ice-free montane areas within the Park. We detected the highest cumulative number of landbird species within Fjordland Undifferentiated Sedimentary Rocks transects, including species associated with forest, shrub, and herbaceous habitats. Several montane species, Rock Ptarmigan, American Pipit, Snow Bunting, and Gray-crowned Rosy-Finch, as well as an additional six species, occurred only on Fjordland Undifferentiated Sedimentary Rocks transects. This subsection hosted significantly higher species richness than the Peninsula and Island Granitics subsection and, due to its extensive and varied land coverage, provides important landbird habitat resources within the Park.

Transects within the Peninsula and Island Granitics detailed ecological subsection supported the fewest number of landbird species, based on estimated species richness and cumulative number of species detected across transects (Table 8). This subsection contains most of the Park's steep, wave-battered sea cliffs as well as other exposed coastal zones that generally do not attract landbirds. Other avian taxa, particularly cliff-nesting seabirds, rely on these areas during the breeding season, but overall this subsection provides limited landbird habitat.

Although broad landscape features sometimes indicate the presence of important habitat resources for landbirds and other species, the classification of detailed ecological subsections occurs at a scale too broad to be useful for management of specific avian species. Coarse-level physiographic classification is generally less precise in determining important areas for breeding birds than a habitat-based approach. Each detailed ecological subsection within the Park hosts an array of different habitat types, ranging from dense coniferous rainforest to windswept alpine meadows. Landbird abundance and species richness vary greatly across this spectrum, and each habitat type provides unique resources for birds adapted to the region's extreme climatic and geographic features. In order to develop a more comprehensive understanding of avian resources, we examined patterns of habitat use by vegetation type.

Habitat Use and Patterns

Our preliminary analysis of habitat associations did not account for incomplete detection of species at the survey points. With single, brief visits to each point during a rapid inventory, failure to detect a species at a given point does not assure that the species did not use the habitat there during the breeding season. A species could have been present at the time of the survey but not detected by the observer or the species could have been absent during the brief count period but have used the area at other times as part of its breeding territory (MacKenzie

2005). In most cases, analysis without correcting for detectability will underestimate the effects of habitat on occurrence (Tyre et al. 2003). Any strong associations we've noted are likely to be valid, but it is also likely that we have failed to detect more subtle habitat associations that exist. Thus, the following preliminary interpretations of habitat associations should be viewed cautiously and final assessments should await our subsequent analyses that will account for imperfect detection.

Throughout the Park, the most abundant species were generally also the most widely distributed. These species typically occurred in a wide variety of habitats, with broad geographic and altitudinal distribution. For example, the most abundant species, Hermit Thrush and Orange-crowned Warbler, were also present on the highest number of transects surveyed across the Park (Table 3). For both species, the proportion of needleleaf forest and tall shrub where the birds were detected was similar to the availability of these habitats across the survey area, which suggests little habitat selection. In more inland areas of south-central Alaska, Hermit Thrushes often rely more heavily on birch or mixed birch-spruce forests, and Orange-crowned Warblers occur primarily in shrub habitats (Kessel 1998). By adapting to available habitat types, these generalist species are able to exploit greater potential breeding area than other thrushes or warblers in the Park.

Most landbird species have relatively specific habitat requirements, and many depend heavily on Alaska's coastal forests. Three Watch List species detected in the Park as well as at least 25 other landbirds that we observed in Kenai Fjords, including 11 Continental Stewardship species, are associated with coniferous forests. Needleleaf forests constitute the dominant habitat type across the Park and provide large areas of relatively undisturbed nesting habitat for species strongly associated with coniferous forests, including Chestnut-backed Chickadee, Winter Wren, Golden-crowned and Ruby-crowned kinglets, Varied Thrush, and Pine Grosbeak. Currently, little is known about these and other forest species' sensitivity to changes in forest structure due to anthropogenic effects (primarily logging) or environmental regime changes (such as fire or spruce beetle [*Dendroctonus rufipennis*] infestation). However, previous research suggests detrimental effects associated with loss of old growth habitat for some breeding landbirds (Boreal Partners in Flight Working Group 1999).

These effects have been most pronounced in southeast Alaska's Tongass National Forest, which has experienced at least 16% total reduction in high volume old growth forests (DeGayner 1996). In south-central Alaska, more recent logging operations have led to deforestation of areas along the Kenai Peninsula, Wrangell-St. Elias and Chugach mountains, Copper River Delta, and Kodiak and Afognak islands. In addition, a recent outbreak of the spruce beetle has resulted in loss of approximately 1.3 million ha of forest in the south-central region between 1989 and 2000 (Ross et al. 2001, Wittwer 2001, Werner et al. *in press*). The Park's forests have not been subject to logging or beetle infestation in recent decades, and this intact ecosystem may be an especially important resource if potential landbird habitat in other coastal forests is further threatened.

As a result of Kenai Fjords' extensive, rugged coastline, the forest-coast interface is a prominent landscape feature of the Park. For several landbird species, this zone may provide particularly important habitat, as indicated by apparent association with forest bands adjacent to the shoreline. Northwestern Crow, Winter Wren, and Orange-crowned Warbler, all strongly associated with near-coastal areas, likely use very different ecological niches within this zone. Large flocks of Northwestern Crows congregate along rocky beaches, particularly at low tide, feeding on marine invertebrates. Their nests are typically constructed high in spruce trees very near the coast. Winter Wrens also use the coastal forest band, but typically build nests in old growth forest snags or downed wood. In other parts of their range, Winter Wrens are frequently associated with water, particularly riparian areas, and often occur near small openings in the forest (Hejl et al. 2002). Orange-crowned Warblers typically breed in shrub thickets, often along the edge of coniferous forests or near streams (Sogge et al. 1994). In Kenai Fjords, where riparian areas and ponds are rare, the extensive coastal band may provide important "edge" habitat for these two species.

We observed Rufous Hummingbirds and Bald Eagles exclusively in habitats very near the shoreline. Bald Eagles build conspicuous nests in tall spruce and cottonwood trees adjacent to the coast, and feed along the intertidal zone and in estuarine areas (Tetreau 1996). Few records exist for breeding Rufous Hummingbirds in the western North Gulf Coast region (Isleib and Kessel 1973), but they have been reported to nest in secondary successional communities and near openings in the forest in other parts of their range (Calder 1993). Along the coast-forest interface, a shrub band typically grows between the beach and the edge of large trees, providing some of the only prominent understory associated with old growth forest in the Park. This transitional habitat zone may offer resources not available in more inland, closed forests.

Several species, including Yellow Warbler, Wilson's Warbler, Fox Sparrow, and Common Redpoll, were strongly associated with tall shrub habitats in the Park, which confirmed patterns of habitat use observed for these species in other nearby coastal areas such as Prince William Sound, the Copper River Delta, and Kodiak Island (Isleib and Kessel 1973, Boreal Partners in Flight Working Group 1999). However, this differed from the results of more inland studies in south-central Alaska. In the upper Susitna River Basin, Fox Sparrow and Common Redpoll were associated most strongly with cottonwood forest, mixed forest, and spruce woodlands and dwarf forests (Kessel 1998). Wilson's Warbler occurred in spruce woodlands in frequency similar to that in shrub thickets in this region (Kessel 1998). Major landcover differences between Kenai Fjords and the Upper Susitna taiga include the scarcity of woodlands along the coast and scarcity of shrub habitats in the interior. This variation in habitat availability appears to result in different habitat partitioning for species that occur in both regions.

Relatively rare but locally important habitat types within the Park, such as alpine meadows, dwarf shrub thickets, and lowland meadows, host species that are well adapted to specific environmental conditions. For example, Savannah Sparrow, American Dipper (*Cinclus mexicanus*), and Tree Swallow all occur in riparian zones but each occupies a unique habitat niche, utilizing specific environmental resources. Montane species thrive in relatively barren, high elevation habitats and sustain more extreme climatic conditions than lowland species. These habitat types, and, consequently their respective avian communities, occur in geographically unique areas, such as at high elevations for alpine meadows or in wetland or riparian zones for lowland meadows.

Kenai Fjords National Park's dynamic, heavily glaciated landscape experiences dramatic and frequent changes in vegetation cover. Rapid glacial recession exposes barren soils that are quickly colonized by early successional species like alder. Colonizing shrubs are often succeeded by transitional deciduous tree species, such as balsam poplar, before eventually shifting toward a climax spruce-hemlock forest (Pfeiffenberger 1995). For landbirds, these changes provide important shrub and broadleaf forest habitats in transitional areas, and, in many cases, create temporary mosaics of patchy vegetation. These "edge" habitats, which provide good nesting cover as well as open areas for foraging, are particularly valuable for flycatchers, swallows, some warblers, and other landbirds that prey on flying insects (Robertson et al. 1992, Eaton 1995, Hunt and Flaspohler 1998, Lowther 1999, Altman and Sallabanks 2000). Shrub coverage in the Park will increase as additional bare ground is exposed and stable alder/willow communities continue to become established across a wide altitudinal gradient.

The Park's extensive glacial coverage drives many landscape-level changes, but other forms of disturbance also affect availability of habitat for landbirds. Both coastal and riparian areas experience periodic flood events, which may create or modify existing wetland and estuarine areas. Many coastal meadows within the Park exhibit evidence of historical saltwater inundation, such as standing dead trees, which provide important nesting and foraging habitat for swallows, woodpeckers, and other landbirds (Robertson et al. 1992, Jackson and Oullet 2002, Jackson et al. 2002).

Areas of Special Importance

Resurrection River and Nuka River valleys, the two major riparian corridors within the Park, experience annual spring floods, which often cause changes in primary channels as well as bank and floodplain erosion or deposition (Pfeiffenberger 1995; Michael Tetreau, Kenai Fjords National Park, pers. comm.). Within the two valleys, we observed four landbird species that are strongly associated with broadleaf forests and several others that were detected nowhere else in the Park. Due to their unique habitat attributes and resulting avian communities, these riparian corridors warrant special consideration.

Nuka River Valley—The Nuka River provides one of only two non-glaciated corridors to interior forest ecosystems within the Park, and hosts several of the more typically inland- and northern-distributed avifauna. This valley encompasses a broad estuary at the river's mouth, extensive shrub habitats along the floodplain and on adjacent hillsides, large stands of old growth Sitka spruce forest, and montane meadows and high alpine lakes. The diversity of habitats within the valley is accompanied by equally diverse avian communities. More than half of all landbird species we detected in the Park were observed on transects within the Nuka River valley. Observations of Gyrfalcon, Spruce Grouse, and American Tree Sparrow (*Spizella arborea*) occurred only in this area. In addition to landbird species, we observed territorial breeding pairs of Spotted Sandpiper (*Actitis macularia*) and Semipalmated Plover (*Charadrius semipalmatus*), both streamside nesters, as well as a nesting Common Merganser (*Mergus merganser*).

Resurrection River Valley—This valley provides the only other ice-free access to inland forests, and is a particularly unique area due to the presence of Exit Glacier, which calves directly onto the Resurrection River floodplain. This dynamic ecological zone lies immediately adjacent to the expansive Harding Icefield and contains an unusual combination of needleleaf forests, broadleaf forests, alder and willow thickets, alpine meadows, newly exposed bedrock and bare soils, riparian lowlands, and wetlands. Although it covers a relatively small proportion of the Park's total area, the valley hosts a high percentage of landbird species, and offers habitat resources that occur nowhere else in the Park.

More than half of all landbird species detected across the Park were observed in the Exit Glacier and Resurrection River area, including seven species that occurred only in this limited geographic area. We observed Western Screech-Owl, Downy Woodpecker, Hairy Woodpecker, Northern Shrike, Violet-green Swallow, Black-capped Chickadee, and Bohemian Waxwing on transects within the Resurrection River valley. Highlights from the field season included detection of two species previously undocumented in the Park, Townsend's Solitaire

(*Myadestes townsendi*) and Western Screech-Owl, both of which were observed in this diverse area.

Wetlands and wetland edge habitats also occur primarily in the Resurrection valley, and support breeding populations of Alder Flycatcher (*Empidonax alnorum*), Tree Swallow, and Violet-green Swallow. In addition to landbird habitat, these wetlands provide important resources for breeding shorebirds. We detected Greater Yellowlegs (*Tringa melanoleuca*), Spotted Sandpiper, and Semipalmated Plover exhibiting territorial breeding behavior, and we also found two nests of Wilson's Snipe (*Gallinago delicata*) in this area.

The Exit Glacier and Resurrection River area is an important resource for landbird conservation as well as visitor use, and management decisions should reflect current status of avian populations. In addition to potentially increased human impacts, rapid glacial recession will lead to major landscape changes in the coming decades. Long-term monitoring programs in this area will help assess any potential effects on bird communities. Standardized methodology employed in the 2005 inventory was designed to be repeatable and can therefore be implemented in future monitoring efforts.

***Golden Eagle Nest Area*—**We observed a pair of Golden Eagles (*Aquila chrysaetos*) frequenting a suspected nest site on cliffs adjacent to an unnamed lake in southern Taroka Arm. We detected an additional 13 species of landbirds in this transect, including nesting Bald Eagles on the opposite side of the lake. A second pair of Golden Eagles was observed in the Park near the head of Paguna Arm in suitable nesting habitat. Surprisingly, both cliff bands are located within several kilometers of the coast, which is unusual for Golden Eagle breeding habitat. No observations of nesting activity have previously been reported for Golden Eagles within the Park and these probable nest sites warrant further investigation.

Recommendations for Future Study

Following an intensive literature review and our 2005 landbird inventory, apparent gaps in information about landbirds and other species in Kenai Fjords National Park illuminate the need for additional study. Inadequate data exist for confirming presence, abundance, and residency status of many avian species, particularly those that occur in the Park outside of the summer breeding season, such as early breeders, migrants, and winter residents.

Due to the lack of helicopter access, we were unable to survey birds on nunataks and were therefore limited to surveying inland areas that could be reached by hiking from shoreline access points. Future research efforts should target a sample of montane habitat types, with particular emphasis on montane-nesting shorebirds. Shorebird inventories, several of which have been recently conducted in other Southwest Alaska Network parks, require an earlier survey period than is dictated by landbird breeding phenology (Ruthrauff et al. 2005). Vegetation community studies of nunataks have been planned for future seasons within the Park and may provide an opportunity to collect basic information about birds using nunatak habitats. Although these surveys are scheduled to occur in July, after the primary breeding season, vegetation field crews could encounter nesting or migratory bird species and a basic protocol for avian observations may be useful. In addition, adequate assessment of owl distribution and population status would require survey efforts in the early spring. The detection of two owl species, Western Screech-Owl and Great Horned Owl (*Bubo virginianus*), during the 2005 landbird inventory suggested previously undocumented breeding populations within the Park, and may warrant further investigation. Historical observations of Northern Hawk Owl, Short-eared Owl, Northern Saw-whet Owl (*Aegolius acadicus*), and Boreal Owl (*Aegolius funereus*) should also be verified in order to determine the status of these species in Kenai Fjords.

Previous reports indicate that some landbird, shorebird, and waterfowl species occur regularly in the Park only during migration and wintering periods (Day 1981, National Park Service 2004). Therefore, additional studies conducted during non-breeding seasons would allow for a more complete year-round assessment of the Park's avian resources and may help identify important foraging and stopover areas.

Sampling design and protocol for the 2005 landbird inventory addressed the goal of documenting as many landbird species as possible over a limited survey window. Because rare or difficult-to-detect species are not sampled adequately with an inventory approach, additional survey efforts for species of interest may be warranted, and such efforts should be based on methods for sampling rare species (e.g., Thompson 2004).

ACKNOWLEDGMENTS

We thank Lisa Pajot, Bill Thompson, Patrick Farrell, Tim Johnson, Michelle Keagle, and Joe Harvey for their hard work in the field. We appreciate the logistical support and invaluable local information provided by National Park Service biologists and staff, particularly Alan Bennett, Ian Martin, Mike Tetreau, and Shelley Hall. Our National Park Service boat captain, Kevin Murphy, safely transported us to remote and difficult to access study plots, and the survey work would not have been possible without his help. We thank Dorothy Mortenson for her technical assistance. Cover photo by Patrick Farrell.

LITERATURE CITED

Alaska Department of Fish and Game. 2005. Our wealth maintained: A strategy for conserving Alaska's diverse wildlife and fish resources. Unpublished report. Alaska Department of Fish and Game, Juneau, Alaska. 838 p.

Alderson, P. 2004. Absence of evidence is not evidence of absence. BMJ 328:476–477.

Altman, B., and R. Sallabanks. 2000. Olive-sided Flycatcher (*Contopus cooperi*). *In* Poole, A., and F. Gill, eds. The Birds of North America, No. 502. The Birds of North America, Inc., Philadelphia, Pennsylvania.

Ammon, E. M., and W. M. Gilbert. 1999. Wilson's Warbler (*Wilsonia pusilla*). *In* Poole, A., and F. Gill, eds. The Birds of North America, No. 478. The Birds of North America, Inc., Philadelphia, Pennsylvania.

Andres, B. A., and A. J. Poe. 2001. Integrated Bird Monitoring in Harriman Fiord, Prince William Sound, Alaska. Unpublished report. USDA Forest Service, Chugach National Forest, Glacier Ranger District, Girdwood, Alaska. 26 p.

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

Avery, M. L. 1995. Rusty Blackbird (*Euphagus carolinus*). *In* Poole, A., and F. Gill, eds. The Birds of North America, No. 200. Academy of Natural Sciences, Philadelphia, and American Ornithologists' Union, Washington, D.C.

Bailey, E. P. 1977. Distribution and abundance of marine birds and mammals along the south side of the Kenai Peninsula, Alaska. Murrelet 58:58–72.

Bailey, E. P., and B. Rice. 1989. Assessment of injury to waterbirds from the *Exxon Valdez* oil spill: effects on populations of Marbled Murrelets along the Kenai Peninsula and Prince William Sound. Unpublished report. National Park Service, Seward, Alaska.

Boreal Partners in Flight Working Group. 1999. Landbird Conservation Plan for Alaska biogeographic regions, Version 1.0. Unpublished report. U.S. Fish and Wildlife Service, Anchorage, Alaska. 45 p.

Boulinier, T., J. D. Nichols, J. R. Sauer, J. E. Hines, and K. H. Pollock. 1998. Estimating species richness: the importance of heterogeneity in species detectability. Ecology 79:1018–1028.

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.

Burnham, K. P., and D. R. Anderson. 2002. Model selection and multimodel inference: a practical information-theoretic approach. Springer-Verlag, New York.

Calder, W. A. 1993. Rufous Hummingbird (*Selasphorus rufus*). *In* Poole, A., and F. Gill, eds. The Birds of North America, No. 53. Academy of Natural Sciences, Philadelphia, Pennsylvania, and American Ornithologists' Union, Washington, D.C.

Chilton, G., M. C. Baker, C. D. Barrentine, and M. A. Cunningham. 1995. White-crowned Sparrow (*Zonotrichia leucophrys*). *In* Poole, A., and F. Gill, eds. The Birds of North America, No. 183. Academy of Natural Sciences, Philadelphia, Pennsylvania, and American Ornithologists' Union, Washington, D.C.

Cowardin, L. M, V. Carter, F. C. Golet, and E. T. LaRoe. 1979. Classification of wetlands and deepwater habitats of the United States. FWS/OBS-79/31. U. S. Department of Interior, Fish and Wildlife Service, Washington, D.C.

Day, R. H. 1981. Annotated avian species list for upper Aialik Bay, Alaska. Pp. 112–125 *in* E. C. Murphy and A. A. Hoover. Research study of the reactions of wildlife to boating activity along Kenai Fjords coastline. Final report for the National Park Service. Alaska Cooperative Park Studies Unit, Biology and Resource Management Program, University of Alaska, Fairbanks, Alaska.

Day, R. H., S. M. Murphy, J. A. Wiens, G. D. Hayward, E. J. Harner, and B. E. Lawhead. 1997. Effects of the *Exxon Valdez* oil spill on habitat use by birds along the Kenai Peninsula, Alaska. Condor 99:728–742.

Day, R. H., and A. K. Prichard. 2004. Biology of wintering marine birds and mammals in the northern Gulf of Alaska. Prepared by ABR, Inc., Environmental Research and Services for *Exxon Valdez* Oil Spill Trustee Council, Anchorage, Alaska.

DeGayner, E. 1996. Tongass land management plan revision old-growth assessment panel summary. Unpublished report. On file with U.S. Department of Agriculture, Forest Service, Tongass Land Management Planning Office, 8465 Old Dairy Road, Juneau, Alaska.

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

De Santo, T. L., M. F. Willson, K. M. Bartecchi, and J. Weinstein. 2003. Variation in nest sites, nesting success, territory size, and frequency of polygyny in Winter Wrens in northern temperate coniferous forests. Wilson Bull. 115:29–37.

Diefenbach, D. R., D. W. Brauning, and J. A. Mattice. 2003. Variability in grassland bird counts related to observer differences and species detection rates. Auk 120:1168-79.

Eaton, S. W. 1995. Northern Waterthrush (*Seiurus novaeboracensis*). *In* Poole, A., and F. Gill, eds. The Birds of North America, No. 182. Academy of Natural Sciences, Philadelphia, Pennsylvania, and American Ornithologists' Union, Washington, D.C.

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.

Forsell, D. J., and P. J. Gould. 1981. Distribution and abundance of marine birds and mammals wintering in the Kodiak area of Alaska. FWS/OBS-81/13. U. S. Fish and Wildlife Service, Office of Biological Services, Washington, D.C. 81 p.

Gabrielson, I. N., and F. C. Lincoln. 1959. The birds of Alaska. Stackpole Co., Harrisburg, Pennsylvania, and Wildlife Management Institute, Washington, D.C.

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

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

Hall, D. K., B. A. Giffin, and J. Y. Chien. 2005. Change analysis of glacier ice extent and coverage for three Southwest Alaska Network (SWAN) Parks: Katmai National Park and Preserve, Kenai Fjords National Park, and Lake Clark National Park and Preserve. Unpublished report. National Park Service and NASA/Goddard Space Flight Center, Anchorage, Alaska.

Handel, C. M., and M. N. Cady. 2004. Alaska Landbird Monitoring Survey: Protocol for setting up and conducting point count surveys. Unpublished protocol. U.S. Geological Survey, Alaska Science Center, Anchorage, Alaska.

Hejl, S. J., J. A. Holmes, and D. E. Kroodsma. 2002. Winter Wren (*Troglodytes troglodytes*). *In* Poole, A., and F. Gill, eds. The Birds of North America, No. 623. The Birds of North America, Inc., Philadelphia, Pennsylvania.

Hines, J. E. 1996. SPECRICH2 Software to estimate the total number of species from species presence-absence data on multiple sample sites or occasions using mode M(h) from program CAPTURE. U. S. Geological Survey, Patuxent Wildlife Research Center, Patuxent, Maryland. Available online: http://www.mbr-pwrc.usgs.gov/software.html.

Hunt, P. D., and B. C. Eliason. 1999. Blackpoll Warbler (*Dendroica striata*). *In* Poole, A., and F. Gill, eds. The Birds of North America, No. 431. The Birds of North America, Inc., Philadelphia, Pennsylvania.

Hunt, P. D., and D. J. Flaspohler. 1998. Yellow-rumped Warbler (*Dendroica coronata*). *In* Poole, A., and F. Gill, eds. The Birds of North America, No. 376. The Birds of North America, Inc., Philadelphia, Pennsylvania.

Isleib, M. E., and B. Kessel. 1973. Birds of the North Gulf Coast–Prince William Sound region, Alaska. Biological Papers of the University of Alaska No. 14.

Jackson, J. A., and H. R. Ouellet. 2002. Downy Woodpecker (*Picoides pubescens*). *In* Poole, A., and F. Gill, eds. The Birds of North America, No. 613. The Birds of North America, Inc., Philadelphia, Pennsylvania.

Jackson, J. A., H. R. Ouellet, and B. J. S. Jackson. 2002. Hairy Woodpecker (*Picoides villosus*). *In* Poole, A., and F. Gill, eds. The Birds of North America, No. 702. The Birds of North America, Inc., Philadelphia, Pennsylvania.

Janik, C. A., and P. F. Schempf. 1985. Peale's Peregrine Falcon (*Falco peregrinus pealei*) studies in Alaska, June 12–24, 1985. Unpublished report. U. S. Fish and Wildlife Service, Juneau, Alaska.

Jones, P. W., and T. M. Donovan. 1996. Hermit Thrush (*Catharus guttatus*). *In* Poole, A., and F. Gill, eds. The Birds of North America, No. 261. Academy of Natural Sciences, Philadelphia, Pennsylvania, and American Ornithologists' Union, Washington, D.C.

Kessel, B. 1979. Avian habitat classification for Alaska. Murrelet 60:86–94.

Kessel, B. 1998. Habitat characteristics of some passerine birds in western North American taiga. University of Alaska Press, Fairbanks.

Kessel, B., and D. D. Gibson. 1978. Status and distribution of Alaska birds. Studies in Avian Biology No. 1.

Kissling, M. L. 2003. Effects of forested buffer width on breeding bird communities in coastal forests of Southeast Alaska with a comparison of avian sampling techniques. Unpublished M. S. thesis. University of Idaho, Boise.

Lowther, P. E. 1999. Alder Flycatcher (*Empidonax alnorum*). *In* Poole, A., and F. Gill, eds. The Birds of North America, No. 446. The Birds of North America, Inc., Philadelphia, Pennsylvania.

Lowther, P. E., C. Celada, N. K. Klein, C. C. Rimmer, and D. A. Spector. 1999. Yellow Warbler (*Dendroica petechia*). *In* Poole, A., and F. Gill, eds. The Birds of North America, No. 454. The Birds of North America, Inc., Philadelphia, Pennsylvania.

MacKenzie, D. I. 2005. What are the issues with presence-absence data for wildlife managers? Journal of Wildlife Management 69:849–860.

MacKenzie, D. I., J. D. Nichols, G. B. Lachman, S. Droege, J. A. Royle, and C. A. Langtimm. 2002. Estimating site occupancy rates when detection probabilities are less than one. Ecology 83:2248–2255.

Matsuoka, S. M., C. M. Handel, and D. D. Roby. 1997a. Nesting ecology of Townsend's Warblers in relation to habitat characteristics in a mature boreal forest. Condor 99:271–281.

Matsuoka, S. M., C. M. Handel, D. D. Roby, and D. L. Thomas. 1997b. The relative importance of nesting and foraging sites in selection of breeding territories by Townsend's Warblers. Auk 114:657–667.

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

McNab, W. H., and P. E. Avers. 1994. Ecological subregions of the United States: section descriptions. WO-WSA-5. U. S. Department of Agriculture, Forest Service, Washington, D. C. 267 p. Available online: http://www.fs.fed.us/land/pubs/ecoregions/ [Accessed 7 July 2006].

National Audubon Society. 1983. The Christmas Bird Count historical results [Online]. Available online: http://www.audubon.org/bird/cbc [Accessed 11 April 2006].

National Audubon Society. 1990. The Christmas Bird Count historical results [Online]. Available online: http://www.audubon.org/bird/cbc [Accessed 11 April 2006].

National Park Service. 1997. Birds of Kenai Fjords National Park, Seward, Alaska. Unpublished checklist. Alaska Natural History Association, National Park Service, Challenge Cost Share Program, with association by Kenai Fjords National Park and Chugach National Forest. Available online: http://www.npwrc.usgs.gov/resource/othrdata/checkbird/r7/kena.htm (Version 02DEC99).

National Park Service. 2004. Wildlife observation database. Unpublished data. Kenai Fjords National Park, Seward, Alaska.

National Park Service. 2006a. Natural Resource Inventory and Monitoring in National Parks. Available online: http://www.nature.nps.gov/im.

National Park Service. 2006b. Park visitation report: Kenai Fjords NP. Available online: http://www2.nature.nps.gov/stats/.

Nichols, J. D., T. Boulinier, J. E. Hines, K. H. Pollock, and J. R. Sauer. 1998. Inference methods for spatial variation in species richness and community composition when not all species are detected. Conservation Biology 12:1390–1398.

Nishimoto, M., and B. Rice. 1987. A re-survey of seabirds and marine mammals along the south coast of the Kenai Peninsula, Alaska. Unpublished report. Prepared for National Park Service. U. S. Fish and Wildlife Service, Seward, Alaska.

Niven, D. K., J. R. Sauer, G. S. Butcher, and W. A. Link. 2004. Christmas Bird Count provides insights into population change in land birds that breed in the boreal forest. American Birds 58:10–20.

Norusis, M. J., 1994. SPSS Advanced Statistics 6.1. SPSS Inc., Chicago, Illinois.

Paton, P. W., and T. H. Pogson. 1996. Relative abundance, migration strategy, and habitat use of birds breeding in Denali National Park, Alaska. Canadian Field-Naturalist. 110:599–606.

Pfeiffenberger, J. 1995. The complete guide to Kenai Fjords National Park, Alaska. Greatland Graphics, Anchorage, Alaska.

Rice, W., Jr. 1983. Bird species sightings in the Nuka Bay district. Unpublished report. National Park Service, Kenai Fjords National Park, Seward, Alaska.

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, New York.

Robertson, R. J., Stutchbury, B. J., and R. R. Cohen. 1992. Tree Swallow (*Tachycineta bicolor*). *In* Poole, A., and F. Gill, eds. The Birds of North America, No. 11. Academy of Natural Sciences, Philadelphia, Pennsylvania, and American Ornithologists' Union, Washington, D.C.

Rosenberg, D. H. 1986. Wetland types and bird use of Kenai lowlands. Unpublished report. U.S. Fish and Wildlife Service, Special Studies, Anchorage, Alaska.

Ross, D. W., G. E. Daterman, J. L. Boughton, and T. M. Quigley. 2001. Forest health restoration in south-central Alaska: a problem analysis. General Technical Report PNW-GTR-523. U. S. Department of Agriculture, Forest Service, La Grande, Oregon.

Ruthrauff, D. R., T. L. Tibbitts, R. E. Gill, Jr., and C. M. Handel. 2005. Inventory of montane-nesting birds the National Parks of southwest Alaska: a summary of the 2004 and 2005 field efforts. Unpublished report. U. S. Geological Survey, Alaska Science Center, Anchorage, Alaska.

Sauer, J. R., J. E. Hines, and J. Fallon. 2004. The North American Breeding Bird Survey, results and analysis, 1966–2003. Version 2004.1. U.S. Geological Survey, Patuxent Wildlife Research Center, Laurel, Maryland.

Sibley, D. A. 2000. The Sibley guide to birds. Alfred A. Knopf, New York.

Smith, W. P., M. J. Stotts, B. A. Andres, J. M. Melton, A. Garibaldi, and K. Boggs. 2001. Bird, mammal, and vegetation community surveys of Research Natural Areas in the Tongass National Forest. Research Paper PNW-RP-535. U. S. Dept. Agriculture, Forest Service, Pacific Northwest Research Station, Portland, Oregon.

Sogge, M. K., W. M. Gilbert, and C. van Riper III. 1994. Orange-crowned Warbler (*Vermivora celata*). *In* Poole, A., and F. Gill, eds. The Birds of North America, No. 101. Academy of Natural Sciences, Philadelphia, Pennsylvania, and American Ornithologists' Union, Washington, D.C.

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

Tande, G. F., and J. Michaelson. 2001. Ecological subsections for Kenai Fjords National Park. Final report prepared for National Park Service. Alaska Natural Heritage Program, Anchorage, Alaska.

Tetreau, M. D. 1996. Bald Eagle nest surveys in Kenai Fjords National Park, 1986 to 1990. Unpublished report. National Park Service, Kenai Fjords National Park, Seward, Alaska.

Thomas, L., J. L. Laake, S. Strindberg, F. F. C. Marques, S. T. Buckland, D. L. Borchers, D. R. Anderson, K. P. Burnham, S. L. Hedley, J. H. Pollard, and J. R. B. Bishop. 2004. Distance 4.1, Release 2. Research Unit for Wildlife Population Assessment, University of St. Andrews, United Kingdom. Available online: http://www.ruwpa.st-and.ac.uk/distance/.

Thompson, W. L., ed. 2004. Sampling rare or elusive species: concepts, designs, and techniques for estimating population parameters. Island Press, Washington, D.C.

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 14:1790–1801.

Van Pelt, T. I., and J. Piatt. 2003. Population status of Kittlitz's and Marbled Murrelets and surveys for other marine bird and mammal species in the Kenai Fjords area, Alaska. Annual report for U. S. Fish and Wildlife Service. U. S. Geological Survey, Alaska Science Center, Anchorage, Alaska.

Vequist, G. W. 1990. Between year comparison of seabird populations off the Kenai Fjords coast. Unpublished report. National Park Service, Alaska Region, Anchorage, Alaska.

Viereck, L. A., C. T. Dyrness, A. R. Batten, and K. J. Wenzlick. 1992. The Alaska vegetation classification. General Technical Report PNW-GTR-286. U. S. Department of Agriculture, Forest Service, Pacific Northwest Research Station, Portland, Oregon.

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

West, G. C., and B. B. DeWolfe. 1974. Populations and energetics of taiga birds near Fairbanks, Alaska. Auk 91:757–775.

Willson, M. F., and T. A. Comet. 1996. Bird communities of northern forests: patterns of diversity and abundance. Condor 98:337–349.

Wittwer, D. 2001. Forest insect and disease conditions in Alaska 2000. General Technical Report R10-TP-86. U. S. Department of Agriculture, Forest Service, Anchorage, Alaska.

Wright, A. 2000. Avian inventory, June 2000. Unpublished report. National Park Service, Kenai Fjords National Park, Seward, Alaska.

Wright, A. 2002. Corvid survey final report. Unpublished report. National Park Service, Kenai Fjords National Park, Seward, Alaska.

Wright, A. L., G. D. Hayward, S. M. Matsuoka, and P. H. Hayward. 1998. Townsend's Warbler (*Dendroica townsendi*). *In* Poole, A., and F. Gill, eds. The Birds of North America, No. 333. The Birds of North America, Inc., Philadelphia, Pennsylvania.

Table 1. Landbirds expected and observed in Kenai Fjords National Park during the summer breeding season. Names with an asterisk (*) are *Partners in Flight* Continental Watch List species and those only in bold are Continental Stewardship species.

Common name	Scientific name	Expected[1]	Observed
Spruce Grouse	***Falcipennis canadensis***	X	X
Willow Ptarmigan	***Lagopus lagopus***	X	X
Rock Ptarmigan	***Lagopus muta***	X	X
White-tailed Ptarmigan	*Lagopus leucura*	X	
Bald Eagle	***Haliaeetus leucocephalus***	X	X
Sharp-shinned Hawk	*Accipiter striatus*	X	X
Northern Goshawk	*Accipiter gentilis*	X	X
Golden Eagle	*Aquila chrysaetos*	X	X
Merlin	*Falco columbarius*	X	
Gyrfalcon	***Falco rusticolus***		X
Peregrine Falcon	***Falco peregrinus***	X	
Western Screech-Owl	*Megascops kennicottii*	X	X
Great Horned Owl	*Bubo virginianus*	X	X
Northern Hawk Owl	*Surnia ulula*	X	
Short-eared Owl*	***Asio flammeus***	X	
Rufous Hummingbird*	***Selasphorus rufus***	X	X
Belted Kingfisher	*Ceryle alcyon*	X	
Downy Woodpecker	*Picoides pubescens*	X	X
Hairy Woodpecker	*Picoides villosus*	X	X
Black-backed Woodpecker	***Picoides arcticus***	X	X
Northern Flicker	*Colaptes auratus*	X	X
Olive-sided Flycatcher*	***Contopus cooperi***	X	X
Western Wood-Pewee	*Contopus sordidulus*	X	X
Alder Flycatcher	***Empidonax alnorum***	X	X
Northern Shrike	***Lanius excubitor***	X	X
Steller's Jay	***Cyanocitta stelleri***	X	X
Black-billed Magpie	*Pica hudsonia*	X	X
Northwestern Crow	*Corvus caurinus*	X	X
Common Raven	*Corvus corax*	X	X
Tree Swallow	*Tachycineta bicolor*	X	X
Violet-green Swallow	*Tachycineta thalassina*	X	X
Bank Swallow	*Riparia riparia*	X	
Black-capped Chickadee	*Poecile atricapillus*	X	X
Chestnut-backed Chickadee	***Poecile rufescens***	X	X
Boreal Chickadee	***Poecile hudsonica***	X	X
Red-breasted Nuthatch	*Sitta canadensis*	X	X

Table 1 (continued).

Common name	Scientific name	Expected[1]	Observed
Brown Creeper	*Certhia americana*	X	X
Winter Wren	***Troglodytes troglodytes***	X	X
American Dipper	*Cinclus mexicanus*	X	X
Golden-crowned Kinglet	*Regulus satrapa*	X	X
Ruby-crowned Kinglet	*Regulus calendula*	X	X
Townsend's Solitaire	*Myadestes townsendi*	X	X
Gray-cheeked Thrush	*Catharus minimus*	X	X
Swainson's Thrush	*Catharus ustulatus*	X	X
Hermit Thrush	*Catharus guttatus*	X	X
American Robin	*Turdus migratorius*	X	X
Varied Thrush	***Ixoreus naevius***	X	X
American Pipit	*Anthus rubescens*	X	X
Bohemian Waxwing	***Bombycilla garrulus***	X	X
Orange-crowned Warbler	*Vermivora celata*	X	X
Yellow Warbler	*Dendroica petechia*	X	X
Yellow-rumped Warbler	*Dendroica coronata*	X	X
Townsend's Warbler	*Dendroica townsendi*	X	X
Blackpoll Warbler	*Dendroica striata*	X	
Northern Waterthrush	*Seiurus noveboracensis*	X	X
Wilson's Warbler	*Wilsonia pusilla*	X	X
American Tree Sparrow	***Spizella arborea***	X	X
Savannah Sparrow	*Passerculus sandwichensis*	X	X
Fox Sparrow	***Passerella iliaca***	X	X
Song Sparrow	*Melospiza melodia*	X	X
Lincoln's Sparrow	***Melospiza lincolnii***	X	X
White-crowned Sparrow	*Zonotrichia leucophrys*	X	
Golden-crowned Sparrow	***Zonotrichia atricapilla***	X	X
Dark-eyed Junco	*Junco hyemalis*	X	X
Snow Bunting	***Plectrophenax nivalis***	X	X
Rusty Blackbird*	***Euphagus carolinus***	X	X
Gray-crowned Rosy-Finch	*Leucosticte tephrocotis*	X	X
Pine Grosbeak	***Pinicola enucleator***	X	X
White-winged Crossbill	***Loxia leucoptera***	X	X
Common Redpoll	*Carduelis flammea*	X	X
Pine Siskin	*Carduelis pinus*	X	X

[1]Gabrielson and Lincoln 1959, Isleib and Kessel 1973, Bailey 1977, Kessel and Gibson 1978, Day 1981, Forsell and Gould 1981, National Audubon Society 1983, Rice 1983, Janik and Schempf 1985, Rosenberg 1986, Nishimoto and Rice 1987, Bailey and Rice 1989, National Audubon Society 1990, Agler et al. 1995, Tetreau 1996, University of Alaska Museum 1996, Day et al. 1997, National Park Service 1997, Agler et al. 1999, Wright 2000, Andres and Poe 2001, Wright 2002, Day and Prichard 2004, National Park Service 2004.

Table 2. Non-landbird species detected during Kenai Fjords National Park landbird inventory during 25 May–24 June 2005.

Common name	Scientific name
Canada Goose	*Branta canadensis*
Gadwall	*Anas strepera*
Mallard	*Anas platyrhynchos*
Northern Pintail	*Anas acuta*
Green-winged Teal	*Anas crecca*
Greater Scaup	*Aythya marila*
Lesser Scaup	*Aythya affinis*
Harlequin Duck	*Histrionicus histrionicus*
Surf Scoter	*Melanitta perspicillata*
White-winged Scoter	*Melanitta fusca*
Black Scoter	*Melanitta nigra*
Common Goldeneye	*Bucephala clangula*
Barrow's Goldeneye	*Bucephala islandica*
Common Merganser	*Mergus merganser*
Red-breasted Merganser	*Mergus serrator*
Pacific Loon	*Gavia pacifica*
Common Loon	*Gavia immer*
Double-crested Cormorant	*Phalacrocorax auritus*
Pelagic Cormorant	*Phalacrocorax pelagicus*
Semipalmated Plover	*Charadrius semipalmatus*
Black Oystercatcher	*Haematopus bachmani*
Spotted Sandpiper	*Actitis macularius*
Greater Yellowlegs	*Tringa melanoleuca*
Lesser Yellowlegs	*Tringa flavipes*
Least Sandpiper	*Calidris minutilla*
Wilson's Snipe	*Gallinago delicata*
Mew Gull	*Larus canus*
Herring Gull	*Larus argentatus*
Glaucous-winged Gull	*Larus glaucescens*
Black-legged Kittiwake	*Rissa tridactyla*
Arctic Tern	*Sterna paradisaea*
Common Murre	*Uria aalge*
Pigeon Guillemot	*Cepphus columba*
Marbled Murrelet	*Brachyramphus marmoratus*
Kittlitz's Murrelet	*Brachyramphus brevirostris*
Ancient Murrelet	*Synthliboramphus antiquus*
Rhinoceros Auklet	*Cerorhinca monocerata*
Horned Puffin	*Fratercula corniculata*
Tufted Puffin	*Fratercula cirrhata*

Table 3. Frequency of occurrence of landbirds observed during the inventory of Kenai Fjords National Park during 25 May–24 June 2005. Columns detail the number and proportion of transects on which each species was observed, the total number of individuals detected, and the proportion of points on which each species was detected during 10-min surveys. Four hundred eleven points on 52 transects were surveyed. Species observed only off-transect, such as between points or after the survey period, are listed as 0 total detections.

Common name	Number of transects	Proportion of transects[1]	Total number of detections	Proportion of points[1]
Spruce Grouse	1	0.02	0	0.000
Willow Ptarmigan	3	0.06	1	0.002
Rock Ptarmigan	2	0.04	1	0.002
Bald Eagle	30	0.58	54	0.105
Sharp-shinned Hawk	1	0.02	1	0.002
Northern Goshawk	1	0.02	0	0.000
Golden Eagle	3	0.06	1	0.002
Gyrfalcon	1	0.02	1	0.002
Western Screech-Owl	1	0.02	1	0.002
Great Horned Owl	1	0.02	0	0.000
Rufous Hummingbird	7	0.13	4	0.010
Downy Woodpecker	2	0.04	2	0.002
Hairy Woodpecker	1	0.02	1	0.002
Black-backed Woodpecker	2	0.04	2	0.005
Northern Flicker	1	0.02	0	0.000
Olive-sided Flycatcher	3	0.06	2	0.005
Western Wood-pewee	1	0.02	0	0.000
Alder Flycatcher	3	0.06	4	0.007
Northern Shrike	1	0.02	0	0.000
Steller's Jay	13	0.25	6	0.015
Black-billed Magpie	5	0.10	8	0.017
Northwestern Crow	21	0.40	72	0.102
Common Raven	16	0.31	15	0.036
Tree Swallow	16	0.31	28	0.049
Violet-green Swallow	1	0.02	2	0.005
Black-capped Chickadee	1	0.02	0	0.000
Chestnut-backed Chickadee	24	0.46	49	0.100
Boreal Chickadee	6	0.12	8	0.019
Red-breasted Nuthatch	4	0.08	4	0.010
Brown Creeper	3	0.06	4	0.007

Table 3 (continued).

Common name	Number of transects	Proportion of transects[1]	Total number of detections	Proportion of points[1]
Winter Wren	27	0.52	94	0.170
American Dipper	10	0.19	4	0.010
Golden-crowned Kinglet	21	0.40	42	0.090
Ruby-crowned Kinglet	39	0.75	283	0.384
Townsend's Solitaire	2	0.04	1	0.002
Gray-cheeked Thrush	9	0.17	21	0.036
Swainson's Thrush	7	0.13	19	0.034
Hermit Thrush	50	0.96	882	0.803
American Robin	10	0.19	25	0.054
Varied Thrush	45	0.87	427	0.496
American Pipit	6	0.12	19	0.022
Bohemian Waxwing	1	0.02	0	0.000
Orange-crowned Warbler	50	0.96	734	0.769
Yellow Warbler	34	0.65	266	0.316
Yellow-rumped Warbler	18	0.35	39	0.066
Townsend's Warbler	11	0.21	26	0.041
Northern Waterthrush	7	0.13	6	0.015
Wilson's Warbler	41	0.79	308	0.387
American Tree Sparrow	2	0.04	1	0.002
Savannah Sparrow	17	0.33	86	0.092
Fox Sparrow	46	0.88	515	0.557
Song Sparrow	7	0.13	13	0.027
Lincoln's Sparrow	6	0.12	10	0.015
Golden-crowned Sparrow	13	0.25	44	0.063
Dark-eyed Junco	15	0.29	25	0.049
Snow Bunting	4	0.08	3	0.007
Rusty Blackbird	1	0.02	0	0.000
Gray-crowned Rosy-Finch	3	0.06	11	0.012
Pine Grosbeak	28	0.54	77	0.148
White-winged Crossbill	3	0.06	7	0.007
Common Redpoll	22	0.42	80	0.129
Pine Siskin	12	0.23	28	0.049

[1]These values represent individuals actually detected during the survey effort, and do not incorporate incomplete detectability estimates.

Table 4. Densities (pairs ha^{-1}) of 13 species of passerines based on the model-averaged estimates from distance-sampling data. Values in parentheses are standard errors of estimates. Pooled densities were calculated for each species across all coastal and inland transects combined, with means weighted by effort (number of points sampled) in each stratum. For Wilson's Warblers we also calculated densities separately for coastal (C) and inland (I) transects, since 95% confidence intervals for the difference between the two means did not overlap zero.

Species	Mean	(SE)	LCL[1]	UCL[2]
Chestnut-backed Chickadee	0.32	(0.12)	0.16	0.65
Winter Wren	0.19	(0.058)	0.11	0.35
Golden-crowned Kinglet	0.24	(0.14)	0.08	0.71
Ruby-crowned Kinglet	0.21	(0.045)	0.14	0.32
Hermit Thrush[3]	0.67	(0.093)	0.51	0.88
Varied Thrush[3]	0.19	(0.032)	0.14	0.27
Orange-crowned Warbler	1.92	(0.35)	1.35	2.75
Yellow Warbler	0.65	(0.16)	0.40	1.06
Wilson's Warbler (C)[4]	0.13	(0.052)	0.06	0.30
Wilson's Warbler (I)[4]	0.60	(0.10)	0.43	0.85
Wilson's Warbler (P)[4]	0.54	(0.091)	0.39	0.75
Savannah Sparrow	0.41	(0.21)	0.16	1.06
Fox Sparrow	0.98	(0.56)	0.35	2.76
Pine Grosbeak	0.038	(0.009)	0.023	0.061
Common Redpoll	0.50	(0.53)	0.09	2.82

[1]Lower 95% confidence limit.
[2]Upper 95% confidence limit.
[3]Stratified estimates calculated using separate detectability functions for coastal and inland transects; means weighted by effort (number of points sampled) in each stratum.
[4]C=coastal; I=inland; P=pooled densities.

Table 5. Parameters associated with best-fitting models for detection functions for 13 species of passerines. Values in parentheses are standard errors of estimates. Separate detection functions were fit for coastal (C) and inland (I) transects for Hermit Thrush and Orange-crowned Warbler. A single detection function was fit for Wilson's Warbler but encounter rates differed between coastal (C) and inland (I) transects.

Species	Truncation distance (m)[1]	Effective detection radius (m)[2]	Number of detections[3]	Encounter rate[4]
Chestnut-backed Chickadee	100	28.1 (2.6)	32	0.09 (0.02)
Winter Wren	100	54.7 (4.1)	62	0.17 (0.04)
Golden-crowned Kinglet	70	33.2 (3.8)	23	0.06 (0.02)
Ruby-crowned Kinglet	100	78.5 (3.5)	137	0.38 (0.06)
Hermit Thrush (C)	100	73.7 (3.3)	68	1.39 (0.30)
Hermit Thrush (I)	100	77.3 (3.1)	361	1.15 (0.12)
Varied Thrush	100	100.0 (0.0)	217	0.60 (0.08)
Orange-crowned Warbler (C)	100	38.2 (5.9)	82	1.67 (0.32)
Orange-crowned Warbler (I)	100	52.4 (2.1)	368	1.18 (0.10)
Yellow Warbler	100	43.1 (3.4)	156	0.43 (0.07)
Wilson's Warbler (C)	100	52.2 (2.2)	6	0.13 (0.05)
Wilson's Warbler (I)	100	52.2 (2.2)	178	0.57 (0.07)
Savannah Sparrow	100	35.1 (7.0)	58	0.16 (0.06)
Fox Sparrow	100	46.0 (12.6)	292	0.81 (0.11)
Pine Grosbeak	100	100.0 (0.0)	43	0.12 (0.03)
Common Redpoll	60	22.1 (3.4)	24	0.07 (0.03)

[1]Distance beyond which detections were deleted from analysis.
[2]Radius around survey point for which as many birds remained undetected within the circle as were detected beyond it out to the truncation distance used in the analysis.
[3]Number of detections included in analysis.
[4]Average number of detections per point sampled.

Table 6. Summary of results from fitting six different models of detection functions (key functions plus adjustment terms) to distance-sampling data to estimate breeding densities of 13 passerine species. Best models, as indicated by the smallest Akaike's Information Criterion corrected for small sample size (ΔAIC_c = 0), are shown in bold. K is the number of parameters in each model. For those species with more than one model highlighted, the best-fitting model used only the key function and no adjustment terms. Separate detection functions were fit for coastal (C) and inland (I) transects for Hermit Thrush and Orange-crowned Warbler. Densities presented in Table 4 were estimated by averaging across all candidate models, with densities weighted by Akaike weights (see Methods). Stratified estimates were calculated for Hermit Thrush and Orange-crowned Warbler.

	Half-normal Hermite polynomial		Half-normal Cosine		Hazard-rate Simple polynomial		Hazard-rate Cosine		Uniform Simple polynomial		Uniform Cosine	
Species	ΔAIC_c	K	ΔAIC_c	K	ΔAIC_c	K	ΔAIC_c	K	ΔAIC_c	K	ΔAIC_c	K
Chestnut-backed Chickadee	2.06	1	**0.00**	**2**	2.66	3	4.49	4	3.69	3	0.71	3
Winter Wren	**0.00**	**1**	**0.00**	**1**	1.20	2	1.20	2	2.30	2	0.36	2
Golden-crowned Kinglet	**0.00**	**1**	**0.00**	**1**	0.42	2	0.42	2	2.51	3	1.31	2
Ruby-crowned Kinglet	0.15	1	0.15	1	2.17	2	2.17	2	**0.00**	**1**	0.91	1
Hermit Thrush (C)	0.88	1	0.88	1	1.27	2	1.27	2	**0.00**	**1**	1.83	2
Hermit Thrush (I)	3.91	1	3.91	1	4.01	2	4.01	2	0.80	2	**0.00**	**1**
Varied Thrush	1.95	1	1.95	1	4.04	2	4.04	2	**0.00**	**0**	**0.00**	**0**
Orange-crowned Warbler (C)	5.31	1	0.98	2	**0.00**	**2**	**0.00**	**2**	2.85	4	2.85	4
Orange-crowned Warbler (I)	6.41	1	4.56	3	1.54	2	1.54	2	**0.00**	**2**	**0.00**	**2**
Yellow Warbler	0.60	1	**0.00**	**2**	2.49	3	2.59	2	3.80	3	0.88	2
Wilson's Warbler	**0.00**	**1**	**0.00**	**1**	3.46	2	3.46	2	2.07	2	0.24	1
Savannah Sparrow	7.89	1	0.28	2	**0.00**	**2**	**0.00**	**2**	4.60	3	2.47	3
Fox Sparrow	4.89	1	2.16	2	**0.00**	**2**	**0.00**	**2**	4.58	3	2.75	2
Pine Grosbeak	2.10	1	2.10	1	4.30	2	4.30	2	**0.00**	**0**	**0.00**	**0**
Common Redpoll	3.34	1	**0.00**	**2**	0.45	2	0.45	2	5.67	3	4.29	1

Table 7. Breeding densities (pairs ha^{-1}) of passerines in Kenai Fjords National Park (this study) in comparison with those estimated from similar distance-sampling surveys in other parts of Alaska. Kenai Fjords densities of some species were statistically higher (>) or lower (<) than those in compared area, based on Z-test of difference between independently derived means (i.e., Z > 1.96; Buckland et al. 2001:84*ff*). Double symbols (>> or <<) indicate those species for which densities differed by more than an order of magnitude, and for which differences were therefore also biologically significant. Some species were detected (D) in too few numbers to derive estimates of density; others were not detected at all during the study (ND).

	Coastal rainforest				Interior boreal forest			
	Kenai Fjords		Tongass[1]		Copper River Basin[2]		Yukon-Charley[3]	
Species	Mean	(SE)	Mean (SE)	Z	Mean (SE)	Z	Mean (SE)	Z
Chestnut-backed Chickadee	0.32	(0.12)	<< 2.04 (0.32)	5.04	ND		ND	
Winter Wren	0.19	(0.058)	<< 1.48 (0.21)	5.91	ND		ND	
Golden-crowned Kinglet	0.24	(0.14)	<< 2.67 (0.47)	4.95	D		ND	
Ruby-crowned Kinglet	0.21	(0.045)	> 0.10 (0.03)	1.99	0.17 (0.02)	0.77	> 0.092 (0.011)	2.50
Hermit Thrush	0.67	(0.093)	> 0.27 (0.03)	4.09	>> 0.01 (0.01)	7.05	>> 0.004 (0.001)	7.15
Varied Thrush	0.19	(0.032)	0.23 (0.03)	0.82	> 0.08 (0.01)	3.36	0.16 (0.016)	0.97
Orange-crowned Warbler	1.92	(0.35)	>> 0.10 (0.03)	5.23	>> 0.04 (0.01)	5.42	>> 0.12 (0.014)	5.20
Yellow Warbler	0.65	(0.16)	D		D		>> 0.005 (0.001)	3.99
Wilson's Warbler	0.54	(0.091)	>> 0.05 (0.02)	5.26	>> 0.03 (0.02)	5.48	> 0.097 (0.011)	4.84
Savannah Sparrow	0.41	(0.21)	ND		D		0.13 (0.017)	1.30
Fox Sparrow	0.98	(0.56)	D		D		0.075 (0.008)	1.63
Pine Grosbeak	0.038	(0.009)	D		> 0.01 (0.01)	2.04	0.032 (0.007)	0.47
Common Redpoll	0.50	(0.53)	ND		0.20 (0.06)	0.56	0.079 (0.011)	0.79

[1]Densities estimated from 149 point transects on 14 coastal control plots in Tongass National Forest, southeast Alaska (Kissling 2003).
[2]Densities estimated from 36 point transects on four forested plots with low spruce beetle mortality in and near Wrangell-St. Elias National Park and Preserve, along eastern border of mainland Alaska and Canada (Matsuoka et al. 2001).
[3]Densities estimated from 1,415 point transects on 40 plots across all habitats on Yukon-Charley Rivers National Preserve in northeast Alaska (Swanson and Nigro 2003).

Table 8. Species richness of landbirds within detailed ecological subsections during inventory of Kenai Fjords National Park during 25 May–24 June 2005.

Detailed Ecological Subsection	Area within Park (km²)	Number of transects surveyed	Number of points surveyed	Number of species detected[1]	Species richness estimated Mean (SE)[2]
Harding Icefield[3]	1,462	0	0	N/A[4]	N/A
Coastal Lowland and Valley	56	7	46	35	65 (11.7)
Fjordland Undifferentiated Sedimentary Rocks	1,043	35	265	52	57 (4.4)
Peninsula and Island Granitics	142	10	82	34	37 (3.9)

[1] Cumulative number of species encountered within each detailed ecological subsection, summed across transects.
[2] Species richness estimate calculated with program SPECRICH2, which accounts for incomplete species' detectability.
[3] Harding Icefield is technically classified as an ecological subsection within the Park, not a detailed ecological subsection.
[4] N/A = not applicable because not surveyed.

Table 9. Habitats with which landbird species were most commonly associated during inventory of Kenai Fjords National Park in summer 2005. Abundance codes[1] are based on 2005 results and other verifiable observations within the Park (see references in Table 1) and apply to the summer breeding season only.

A = Abundant: Species occurs repeatedly in proper habitats, with available habitat heavily utilized, and/or the region regularly hosts great numbers of the species.

C = Common: Species occurs in nearly all proper habitats, but some areas of presumed suitable habitat are occupied only sparsely or not at all, and/or the region regularly hosts large numbers of the species.

U = Uncommon: Species occurs regularly, but utilizes some or very little of the suitable habitat, and/or the region regularly hosts relatively small numbers of the species.

R = Rare: Species occurs regularly within the region, but may not occur annually; usually in very small numbers.

CA = Casual: Species has been recorded no more than a few times, but irregular observations are likely over a period of years.

+ Probable breeding activity observed during 2005 landbird inventory.

++ Confirmed breeding activity observed during 2005 landbird inventory.

Common name	Abundance in Kenai Fjords	Needleaf forest	Broadleaf/mixed forest	Tall shrub	Dwarf/low shrub	Herbaceous	Aquatic herbaceous
Spruce Grouse	U	●	●				
Willow Ptarmigan +	U			●	●		
Rock Ptarmigan +	C				●	●	
Bald Eagle ++	C	●	●			●	●
Sharp-shinned Hawk	U	●	●				
Northern Goshawk	R	●	●				
Golden Eagle ++	R				●		
Gyrfalcon	CA				●		
Western Screech-Owl	CA	●	●				
Great Horned Owl	R	●	●				
Rufous Hummingbird +	U	●	●				
Downy Woodpecker +	U	●	●				
Hairy Woodpecker	U	●	●				

Table 9 (continued).

Common name	**Abundance in Kenai Fjords**	**Needleaf forest**	**Broadleaf / mixed forest**	**Tall shrub**	**Dwarf / low shrub**	**Herbaceous**	**Aquatic herbaceous**
Black-backed Woodpecker	**R**	•	•				
Northern Flicker	**R**	•	•				
Olive-sided Flycatcher +	**R**	•	•	•			
Western Wood-Pewee +	**R**	•	•				
Alder Flycatcher +	**U**		•	•		•	
Northern Shrike +	**R**		•	•			
Steller's Jay +	**C**	•	•				
Black-billed Magpie +	**C**	•	•				
Northwestern Crow ++	**A**	•				•	•
Common Raven +	**U**	•	•	•			
Tree Swallow ++	**C**	•	•			•	
Violet-green Swallow	**U**	•	•			•	
Black-capped Chickadee	**R**	•	•				
Chestnut-backed Chickadee +	**C**	•	•				
Boreal Chickadee +	**U**	•	•	•			
Red-breasted Nuthatch	**U**	•	•				
Brown Creeper +	**R**	•					
Winter Wren +	**C**	•					
American Dipper +	**U**	•		•			
Golden-crowned Kinglet +	**C**	•	•				
Ruby-crowned Kinglet +	**C**	•	•				
Townsend's Solitaire +	**CA**	•	•				
Gray-cheeked Thrush +	**U**		•	•			
Swainson's Thrush +	**U**		•				
Hermit Thrush ++	**A**	•	•	•	•		
American Robin +	**U**	•	•	•			
Varied Thrush ++	**C**	•	•	•			
American Pipit ++	**C**				•	•	
Bohemian Waxwing	**R**		•				
Orange-crowned Warbler ++	**A**	•	•	•	•		
Yellow Warbler +	**A**	•	•	•			

Table 9 (continued).

Common name	Abundance in Kenai Fjords	Needleaf forest	Broadleaf/mixed forest	Tall shrub	Dwarf/low shrub	Herbaceous	Aquatic herbaceous
Yellow-rumped Warbler ++	U	●	●				
Townsend's Warbler +	U	●	●				
Northern Waterthrush +	R	●	●	●			
Wilson's Warbler ++	C	●	●	●	●		
American Tree Sparrow +	CA			●	●		
Savannah Sparrow +	C			●	●	●	
Fox Sparrow ++	A	●	●	●	●	●	●
Song Sparrow +	U	●		●			●
Lincoln's Sparrow +	U			●	●	●	
Golden-crowned Sparrow +	C			●	●		
Dark-eyed Junco +	U	●	●	●			
Snow Bunting +	U				●	●	
Rusty Blackbird +	R			●		●	
Gray-crowned Rosy-Finch +	U				●	●	
Pine Grosbeak +	C	●	●	●			
White-winged Crossbill +	U	●	●				
Common Redpoll +	C	●	●	●	●		
Pine Siskin ++	U	●	●				

[1]Abundance code definitions derived from *Kenai Fjords National Park Birdlist* (National Park Service 1997).

Appendix: Sampling Protocol for Kenai Fjords Landbird Inventory
Kenai Fjords National Park
Southwest Alaska Network
Alaska

Colleen M. Handel, Melissa N. Cady, and Caroline Van Hemert
USGS Alaska Science Center
1011 E. Tudor Road
Anchorage, Alaska 99503

January 2006

Contract Number: F2101050007

Funding Source:
Inventory & Monitoring Program, National Park Service

Appendix (continued).

OVERVIEW

The goal of this project, in accordance with the National Park Service Inventory and Monitoring Program, is to document the occurrence of landbirds in Kenai Fjords National Park (KEFJ) during the breeding season. This initial inventory effort will also provide information on landbird abundance, distribution and habitat associations within KEFJ. To collect this information, we will conduct bird surveys throughout accessible areas of the Park during the breeding season in 2005 to document the species on the list of expected landbirds and to add any species not previously recorded for KEFJ.

Plot Site Selection—Site selection was designed to encompass the breadth of habitat types that exist within KEFJ. This includes the altitudinal gradient from the shoreline up into alpine habitats; the north-to-south latitudinal gradient of the park's boundaries; and the coastal-to-inland gradient, particularly along the Nuka River and Resurrection River valleys, which provide corridors to interior boreal forest habitats. Additionally, sample areas specifically target unique habitat types, such as riparian corridors and wetland habitats. Due to its high level of use by the public, relative ease of access, unique wetland habitats, and rapid changes in habitat associated with glacial retreat, the Exit Glacier area was also included as a priority.

We compiled GIS data layers for topography, glaciation, land cover, and accessibility in order to identify and stratify potential areas for surveys. Sample plots were identified using shoreline access, slope, and location relative to access points. "Accessibility" was determined by several criteria: <65° slope; <3 kilometers from shore, road, or trail; and shoreline access via skiff. Sites deemed accessible for sampling were divided into coastal sites (areas within 250 m of the shoreline) and inland sites (areas ≥250 m from shoreline). Site selection was then stratified by detailed ecological subsection (Tande and Michaelson 2001) and geographic location. All plots were assigned unique identifying numbers and priority levels from 1 to 4, with 1 being the highest priority, and 4 the lowest. Sites deemed of particular interest due to unique habitats or perceived likelihood of high species diversity were selected nonrandomly and assigned a priority value of 1 or 2. The remaining plots were chosen randomly from all sites deemed accessible. Target sample size was 45 survey sites; approximately two-thirds of the sampling effort would be focused on inland sites (30 sites). The remaining one-third of sampling effort would be directed toward coastal sites (15 sites).

Survey Route Location within Plots—Inland point count routes will be placed across major landscape gradients including elevation and distance from features such as coastline, glaciers, and river valleys. Survey points will be 500 m apart on coastal transects and 250 m apart on inland transects. Each sample site will have approximately 10 survey points, depending on site accessibility and travel conditions.

Schedule of Surveys—Surveys will be conducted by three two- to three-person teams, which will include both USGS biologists and NPS personnel. A combination of motorized and non-motorized boats will be used for access to survey locations, staging initially out of Seward, Alaska. On 2 June, 2005, The M/V *Serac* will drop two crews with supplies, kayaks, and a motorized *Zodiac* inflatable boat near initial survey locations at the southern end of the Park. These two crews will independently survey locations in North Arm and Beauty Bay until 7 June, at which point the M/V *Serac* will return to the area. From 7-18 June the M/V *Serac* will move the two crews northeast along the outer coast to new survey locations in and around McCarty and Northwestern Fjords. Simultaneously (from approximately 2-18 June), one crew of three will survey sites in Aialik Bay and Northwestern Fjord. All boat-based field work will be completed by 18 June at which time all crews will return to Seward. One crew will stay in Seward several additional days to survey remaining plots in the Exit Glacier area.

Survey Methodology—Birds will be surveyed with variable circular plot methodology using distance-sampling protocols (Fancy and Sauer 2000, Buckland et al. 2001) that have been standardized for Alaska (Handel and Cady 2004). All landbird species (see Appendix A) will be recorded and enumerated at each sampling station. The presence of all non-landbird species will be recorded but they will not be enumerated if doing so would detract from the detection of landbirds. Survey methods will incorporate detection probability through distance sampling (Buckland et al. 2001) and recording time interval of first detection (Farnsworth et al. 2002). Approximate location and identity of species previously undetected will be recorded as the survey team traverses between survey points. Each crew will maintain a checklist of all species encountered each day, including any evidence of breeding.

Topographic and Habitat Data—Topographic data will be recorded at survey locations, including elevation, slope, and aspect; all survey points will be georeferenced using a GPS. Habitat within a 50-m radius of the survey point will be classified according to both *The Alaska Vegetation Classification* (Viereck et al. 1992) and the *Avian Habitat Classification for Alaska* (Kessel 1979). Where applicable, National Wetlands Inventory (NWI) classification codes described by *Classification of Wetlands and Deepwater Habitats of the United States* (Cowardin et al. 1979) will also be assigned. When more than habitat type exists within the circle, the percent of the circle occupied by each habitat type will be recorded. Digital photographs taken toward each cardinal direction will be used to supplement habitat data collected at each point. Distance to coastline, nearest fresh water, and glacier will be estimated using available GIS layers.

Record-keeping—For each survey plot, observers will fill out one *Bird Survey Data Booklet* and one *Habitat Data Booklet* (see Appendix B), using a dark pencil to record. Descriptions of the data booklets as well as guidelines for observers are located below, in the respective bird and habitat data sections of this protocol packet.

CONDUCTING THE BIRD SURVEYS

Please fill out one *Bird Data Booklet* (Appendix B) for each survey transect. The following information provides detailed instructions for route selection, data collection, and bird survey guidelines.

Survey Route Specifications

Crews should use the map and schedule provided to determine where to survey from day to day. Inland sites are ranked by Priority from 1 to 4 (see Appendix C). If not all assigned sites can be completed in the time allowed, crews should focus on completing the highest priority sites first. Inland and coastal plots as shown on the sample universe map are intended as a guide to direct crews to a wide variety of habitats and geographic locations within KEFJ. Boundaries of inland and coastal plots need not be adhered to strictly, but crews should choose alternate sites to survey only if necessary due to weather or other logistical constraints. Although the targeted distance between points is 250 m, if extremely steep or difficult terrain makes 250 m impossible to travel in under 20 minutes, then shorter distances between points may be used. However, points should not be placed closer than 100 m apart, and effort should be made to maximize the geographic area surveyed while also attempting to minimize travel time.

The first count of the day is targeted to start between 0415 and 0500 Alaska Standard Time. However, a later start time may sometimes be necessary if the terrain cannot be traversed safely before sunrise. The last count of the day should be completed no later than 6 hours after the targeted start time, since bird activity declines markedly after that time in most areas. Thus, all counts should be completed no later than 1100.

Routes must be run only under conditions of good visibility, little or no precipitation, and light winds. Occasional light drizzle or a very brief shower may not affect bird activity but fog, steady drizzle, or prolonged, heavy rain should be avoided as much as possible. Weather codes are described on the data sheets (Appendix B) and observers should record weather data at the beginning and end of the count each day. In particular, it is important to note any points at which detectability of birds seems to be affected by weather (e.g., wind, precipitation).

If weather does not meet minimum standards for point counts, crews should instead keep a daily checklist for that day. Crews may choose to look for birds near their campsite, or on the way to their next site. However, they are not constrained to particular locations or times for these checklists. It is not necessary to record habitat data for these checklists, but GPS locations for observation areas should be recorded, especially if new species are recorded.

Survey Details

Only birds detected by the official observer for a given point count should be recorded for distance estimation. A second person may be present but must not interfere by asserting his or her own detections. However, the field assistant may help with species identification if the observer has detected a bird but needs help identifying it. It is best for the observer to record his or her own observations on the forms, since relaying the information to another person could result in making transcription errors or missing other birds during the conversation. Field assistants may fill out habitat data if they can do so quietly while the primary observer is collecting bird data.

An alternative protocol that can be used if two trained observers are available is the double-observer method. Under this protocol, two observers conduct point counts simultaneously on separate data sheets. If the double-observer method is used, it is important that detections of birds be independent, i.e., that one observer does not influence which birds are detected by the second observer. Observers should not discuss any sightings until the count has been completed. After the count, birds detected by both observers should be circled. No additions or deletions should be made to the data sheets after the count. It is expected that all observers will miss some birds; how many are missed is immaterial as long as we can estimate the proportion being detected. Having both observers count simultaneously will allow us to estimate detection functions and also determine for each species the outermost distance within which most observers detect a large proportion of the individuals.

The survey point should be approached with as little disturbance to the birds as possible. Immediately upon arriving at the survey point the observer will note the time and begin the count. A second person can also be the timekeeper.

Observations of birds, including species, time interval, behavior code, and distance interval, should be recorded as soon as they are detected rather than at the completion of the survey interval. It may help to map the approximate locations of counter-singing males first and then determine distance interval of each. Those occurring in obvious associations (flocks, pairs, family groups) within the same distance interval should be recorded as a single observation. At the end of each day species codes should be verified for accuracy against the list; several species have codes similar to each other and could cause confusion.

Duration of Count and Time Intervals—Standard counts are to be precisely 10 min long. Please denote the time interval in which each bird is first detected: 0-3 min, 3-5 min, 5-8 min, or 8-10 min. This will allow comparison of detection rates with roadside Breeding Bird Surveys, which are 3-min counts, and with previous 5- and 8-min Off-Road counts. It will also allow estimation of detection probabilities based on time of detection.

Distance Estimation—For each observation, measure or estimate the *horizontal* distance to the bird when it was first detected. Note that this is *not* the angular distance to the bird itself, which can be much greater than the horizontal distance if the bird is at the top of a tall tree or on a steep slope. If a bird is flushed by the observer, either when the observer arrives or during the count, distance should be recorded relative to its take-off position.

Observers should record exact distances whenever possible. Otherwise, denote distances in 10-m bands out to 100 m from the survey point, in 25-m bands from 101-150 m, and in 50-m bands from 151-400 m. Birds detected at greater distances can be denoted as > 400 m. In areas with closed habitats or very high densities of birds, the same initial distance bands will be used out to 150 m. Then, birds beyond 150 m will be lumped as > 150 m.

The most important observations are those closest to the observer; effort should not be wasted trying to measure distance to individuals far away if it means that closer individuals are being missed. Most observations at greater distances will be truncated during analysis. Birds that are not actively using the survey area but are only flying over should also be recorded. The horizontal distance to the point at which they were first detected should be estimated. Distances can be determined by using a rangefinder focused on the bird, a reference tree, or other distinctive feature, or by measuring paces to the location after the count is over.

Which Birds to Count—Count all individuals of all species seen or heard at any time during the survey period. Observers should not attempt to guess what species or numbers they may be missing. Try to keep track of any individuals known or strongly suspected to have been previously counted at another survey point. Please mark birds that have been previously counted as "P" on both the map and the list, in addition to their respective behavior codes. Birds detected at more than one point can be used in distance analysis.

A bird that is detected during the count but not identified may be identified after the count if more careful observation is required and the bird is still present. A flock that is present at some time during the count may also be followed after the count to determine its species composition and size. Visual identifications should be made whenever possible, and are always preferable to identification by song or call alone. Absolutely no method of attracting birds should be used during the count.

Excluding Species from Count or Restricting Radius—Certain non-landbird species (e.g., seabirds on nesting cliffs) may be so abundant that to count them completely would lead to inadequate surveys of landbirds. In such cases observers may choose one of two alternatives: 1) count the abundant non-landbird species only within a restricted radius (e.g., ≤ 150 m) and ignore those beyond that distance or, 2) exclude the abundant species completely from the point count surveys. If either of these alternatives is used, it should be noted on the survey details form and the entire grid should be surveyed the same way. The first alternative is preferable, as it still allows for density estimation. If a species is excluded from the survey completely, at a minimum note whether it is present or absent at each point in the notes section.

Using the Circular Map—The circular map and list of symbols are provided on the datasheets (Appendix B) in order to minimize the probability of counting the same bird twice at a survey point. The center of the circle is the position of the observer (the survey "point"). Concentric circles represent distances of 50, 100 and 150 m around the observer. After starting the count, the observer should immediately begin recording the birds detected and sketching the position of individuals on the circular map. The 4-letter species code will accompany the appropriate behavior code or symbol at the approximate position of the bird.

Please use the 4-letter codes provided on the *Daily Team Checklist*; if the species is not listed, spell out the name completely. If a bird is unidentified to species, spell out the closest identification, e.g., unidentified sparrow. If an observer is fairly certain but not positive about a species' identification, a question mark should be placed after the species code.

Next to each species' alpha-code, observers will indicate the time interval and the distance band in which it was first detected. Time intervals should be denoted with a superscript of ^{3}, ^{5}, ^{8} or ^{10} for the 0-3, 3-5, 5-8, and 8-10 min intervals, respectively. Distance should be denoted by subscript according to the *outer* distance of the band in which it was first detected. For example, if you see a Varied Thrush at 4:05 min at a distance of 24 m, it should be denoted as

VATH^{5}_{30}, since it was heard in the 3-5 min interval and within the 21-30 m distance band. When possible, record exact distances to birds, and identify those distances by adding an asterisk after the distance or otherwise demarcating it as an exact distance.

Please use the behavior codes provided. These are simple characters that help determine the age and sex of each bird detected. If an individual exhibits several behaviors during the count period, you may record the behaviors in the order observed. In the final tally, record only the behavior that best indicates the age and sex of the bird (e.g., singing rather than calling). Observers should be familiar with the 4-letter species and detection codes before the actual survey.

In the final data compilation the only important position factor is the actual distance band, but sketching within the four quadrants of the map is helpful when high numbers of birds are present. Recording movements can also be helpful, but be careful to count an individual only once if it has moved during the survey. Also, it is important to clearly distinguish between birds that move from one place to another in a count radius versus those that fly over a count area and are not currently occupying the habitat.

Transferring Observations to List—As soon as each survey has been completed, the species, time interval, number of individuals, behavior code, and distance interval (outer band) should be transcribed from the map to the list. The position and time interval of each bird when it was first detected should be recorded, regardless of its subsequent movements during the survey. For cases where a bird is mapped exhibiting several behaviors, only the behavior that best indicates the age and sex of the bird needs to be recorded on the list. For example, if a Yellow Warbler is first detected calling and later heard singing, it would be recorded as singing since this behavior allows us to classify this individual with certainty as an adult male. Keeping track of the type of detection will allow monitoring of the number of breeding pairs more effectively.

Species Detected Between Survey Points—Any species that are detected only *between* the survey periods should be listed in the notes section underneath the circular map. At the end of each transect, list these observations in the "Other Species Detected Outside of Point Counts" section.

Daily Team Checklist—In the back of each *Bird Data Booklet* (Appendix B) is a daily team checklist used to tally all species detected in a given plot. At the end of each day, compile information on all birds and mammals detected within the survey block during point-count surveys; while traveling to, from, and between points; and during time at camp. Include observations of all species of birds and mammals from all team members during their observations in that area. For each species that has been positively identified by sight or sound, use the list of codes to describe evidence of occurrence and possible or confirmed breeding. This checklist will provide the basis for species certification and distribution within KEFJ. On days when weather conditions preclude point counts, the daily team checklist should still be completed.

BIRD SURVEY DATA BOOKLET INSTRUCTIONS

Complete one *Bird Survey Data Booklet* (Appendix B) per route.

Route number: This is the four digit number that uniquely identifies each plot. Inland plots are numbered >1000, and coastal plots <100. Transect numbers are identified on the map and are assigned to each team in the schedule.

Plot name: User-assigned name for the plot, noting some recognizable geographic feature for reference.

Spacing between pts (m): Record the spacing between survey points on the transect for each sample plot. Spacing between points should be 250 m on inland transects and 500 m on coastal transects, unless constrained by difficult travel (described above).

Double observer method used: If two observers conduct counts simultaneously at the same points on this grid, circle yes. Fill out a separate form for each observer. Weather information should be identical for both observers.

Daily Weather—Record data at start and end of each transect.

Route number: Four digit number that uniquely identifies each plot.

Plot name: User-assigned name for the plot.

Date: Record the survey date in month-day-year format.

Time: Record in 24-hr format the start time of the first point count and the end time of the last point count conducted each day.

Temp: Record the ambient air temperature at the start and end of point counts each day. Circle whether recorded in degrees Celsius or Fahrenheit.

Wind: Record Beaufort code at the start and end of point counts each day.

Sky: Record code for sky condition at the start and end of point counts each day.

Other species detected outside of point counts: List all species seen between points or elsewhere in the plot (which may include those seen at camp and while travelling to survey location). This list should only include species not already recorded on the actual point count.

Species counted within restricted radius: List non-landbird species or groups that are counted only within a restricted radius because they are too numerous to allow adequate count of landbird species (e.g., seabirds nesting on cliff). Record outermost distance band (in meters) within which the listed species were counted.

Species excluded from survey: List non-landbird species or groups that are completely excluded from point counts because they are too numerous to allow adequate count of landbird species, even with restricted-radius count. In the notes section on the map form for each point, record presence of each species that is detected at that point.

Notes: List any other details that may be important to interpretation of the data.

Map of Birds Detected During Survey—Complete one map for each point surveyed.

Route #: Four digit number that uniquely identifies each plot.

Point #: Record the number (1-12) of the point being surveyed.

Observer: Give name or initials of observer conducting survey. Make sure complete name is given in "Survey Details" section on the front of the booklet.

Date: Record survey date in month-day-year format.

Time start: Record survey start time to the nearest minute in 24-hr format.

Circular map: Map the approximate locations of all birds detected using 4-letter species codes and behavior symbols provided on code sheets. The center of the circle is the position of the observer (survey point). Distance bands are shown for 50, 100, and 150 m. Note distance and time interval for first detection of each bird.

Species between this and previous point: List species observed between this and previous point that have not yet been detected during a point count. These species will be added to the list of "Other Species Detected Ouside of Point Counts" if they are not detected elsewhere during the surveys of this transect.

Non-landbird species present but not counted: Note the presence of any non-landbird species detected during the count that are not being enumerated during the standard count because their extreme abundance precludes adequate landbird counts.

Mammals: Note any mammals detected during counts or between points as well as type of detection (visual, tracks, sign, dam).

Notes: Record any information pertinent to bird survey, such as inclement weather or wind. Note any nests, downy or newly volant young, mate-feeding, adults carrying food or fecal sacs, or any other behavior that confirms or suggests breeding birds in the area.

List of Birds Detected During Survey—Complete one entry for each individual, pair, or flock of birds detected during count.

Species: Record 4-letter code of species detected as described above (in "Conducting the Point Count" section).

Time: Record time interval during which bird was first detected.

#: Record number of individuals detected.

Beh: Use behavior codes to note how bird was detected. If bird is detected by more than one method, use the code that gives the best information about the age and sex of the bird (e.g., a male that calls and then sings should be listed as singing). Birds flying on a direct heading high over the survey area that are not actively using or associated with the habitat near the point should be listed as flyovers. If bird is known or suspected to have been counted from a previous point based on its position, record it on the map and the list with the detection code of "P" for previous point.

Dist: Record the distance interval in which each bird was first detected during the count. If a bird was flushed from the point as the observer approached, record the distance between the survey point and the original position of the bird. Note that the intervals are designated as the outermost bound of the interval.

Exact: Record the exact distance to a bird or its location if it can be measured.

COLLECTING HABITAT DATA

Please fill out one *Habitat Data Booklet* (Appendix B) for each transect you survey. This information can be collected at the same time that the bird survey is conducted, but habitat data collection should not interfere with the bird survey. The information collected on these forms will be used to characterize habitat according to classifications outlined by Viereck et al. (1992), Kessel (1979), and Cowardin et al. (1979).

Photographing Points

Points should be photographed for reference as conditions allow. Digital cameras are preferred, using the highest possible resolution given the disk space available (minimum 2-3 megapixels per sq in). Set digital cameras to date- and time-stamp each photograph. Photos will be used to document habitat surrounding the point and thus should capture the immediate surrounding habitat (out to a 50-m radius) rather than the general landscape of the area. Note the photo number and direction in which each photograph is taken. Take one photograph of the center point including background habitat from each cardinal direction (beginning with N, then E, S, and W), approximately 5 m away from the point. Have a field partner stand in the north-facing photo for scale and to help keep track of photo sets. It is important to record distinguishing information on the data sheet that describes the content of each photo, such as specific topographic features or details that are visible in the foreground.

If photos and GPS locations are taken at about the same time, the photos can later be linked to the locations in a GIS database. Observers should mark waypoints using a GPS at each survey location as soon as possible relative to the time when photos are taken. Also, in order to calibrate photos for interface with GIS, observers will take a photo of the GPS at the first point at the beginning of each day.

These settings should be used for each GPS unit:

Position format:	Decimal degrees (hddd.ddddd)
Map datum:	NAD 27
Units:	Metric
Heading:	True north

Determining the Number of Habitats to Record at a Point

Observers will be recording habitat data within a circle with a *radius* of 50 m around each survey point. Some information about the area can be determined by walking through it during the survey, but observers may also need to walk around the circle to get an unbiased view of the habitat that it contains.

The "Habitat Questionnaire" on the back of the booklet will help determine whether the habitat within the circle should be classified as one or more types. It will help observers distinguish among unvegetated, wetland, and different non-wetland habitats. Based on answers to the questionnaire, follow the instructions provided, which will indicate how many "Vegetation/Classification" forms should be filled out (usually only one per point). Each distinct habitat type will be described on a separate "Vegetation/Classification" form. Each habitat should be numbered and the percent of the 50-m radius circle occupied by that habitat estimated.

The first step in determining the number of habitats within the survey circle is to view the area in the context of the surrounding landscape. Look at the size of each "patch" of habitat that occurs at least partly within the circle. The minimum size a patch must be to be considered a separate habitat will depend on several factors: (1) whether or not it is a wetland, (2) whether it can be considered an understory of a higher canopy layer, and (3) whether or not it is part of a larger, regularly occurring mosaic. The following guidelines are intended to help determine the number of habitats present at a given site:

- Any wetland at least 10 m wide should be considered a separate habitat.
- A non-wetland patch must be at least 400 m^2 in size (circle of 11-m radius; 0.1 acre) before it should be described as a separate habitat.
- Shrub or herb layers under sparse tree canopy layers should NOT be described as separate habitats. If woody plants are present, the habitat should generally be classified by the tallest canopy of woody plants present.
- A habitat "mosaic" is "a fairly regular pattern of two cover types interspersed together at a fine enough grain that it seems inappropriate to classify it as two separate things" (Hutto et al. 2002:16). Such a mosaic should be classified as a single habitat and named by the highest canopy layer that meets the minimum percent cover criterion for each classification system.
- If there is a clear boundary between two habitat patches that are large relative to the survey circle and large enough to host a different bird community, these should be described as separate habitats.

Identifying Wetland Habitats

Wetland habitats will be classified according to criteria of the NWI Classification (Cowardin et al. 1979). Use the separate NWI Key provided on the NWI Reference Sheet to determine the wetland classification (see Appendix D). Wetland presence is determined by frequent or persistent saturation or inundation with water. In the absence of visible bodies of water, wetland status will be determined by the presence or lack of obligate and/or facultative wetland indicator plant species.

As defined by NWI (USFWS 2004), obligate wetland indicator plant species almost always occur in wetlands (estimated probability > 99%). If there is no other evidence of wetland habitat, an NWI designation can be made based on the presence of obligate wetland indicator plants alone. Facultative wetland indicator plants usually occur in wetlands (67–99% estimated probability), but are occasionally found in non-wetland areas. Presence of a few facultative wetland indicator plants alone is not enough to warrant wetland designation. If facultative wetland plants are very abundant, or if there are several facultative wetland species occurring together, then it is *likely*, but not certain, that a wetland is present.

Observers will have to use their best judgment in the field to determine whether or not wetland habitats are present. The obligate and facultative wetland indicator plant lists provided on the NWI Reference Sheet are in no way comprehensive lists, but provide the most common species likely to be encountered. These lists were derived from the 1988 list of regional wetland indicators for Alaska (USFWS 2004).

Habitat Mosaics Versus Distinct Habitats

The following figures illustrate various distributions of two different vegetation types. These should be used as a guide to determine when to lump versus split vegetation types into different habitats. The larger circle outlined in black represents the 50-m radius circle inside which habitat data are collected. The white background represents meadow habitat in these examples. The grey circles in these figures represent patches of trees. The grey circles are proportional to the minimum patch size that can constitute a separate habitat, and these figures are drawn to scale.

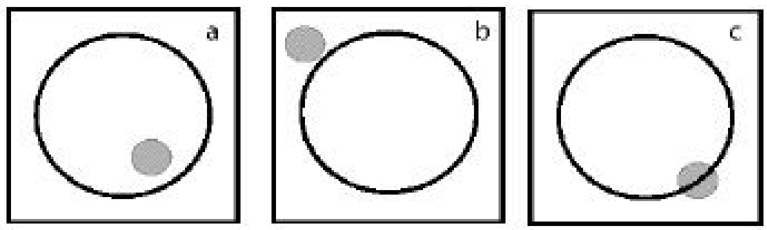


Fig. 1. Examples of discrete patches of forest in large tract of meadow in relation to 50-m survey circle. See text for which should be classified as separate habitats.

The 50-m radius circle depicted in Fig. 1a should be described as two separate habitats because the patch of trees meets the minimum patch size requirement for terrestrial habitats, falls at least partly inside the circle, and is not part of a larger landscape mosaic of interdigitated habitats. While the forest habitat type in Fig. 1b meets the minimum patch size requirement, none of it falls within the 50-m radius circle, so only the meadow habitat represented in white inside the circle should be described. Similar to Fig. 1a, the grey forest habitat in Fig. 1c meets the minimum patch size, and part of it falls within the circle, so this circle should be described as two separate habitat types. The percent of the 50-m radius circle occupied by the forest habitat will be very small, since only a tiny portion of it falls inside the circle.

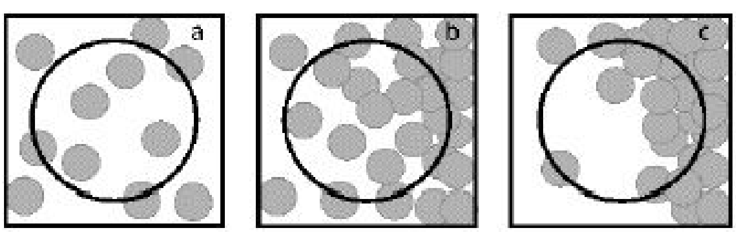


Fig. 2. Examples of two vegetation types forming a single habitat mosaic (a-b) between two separate habitat types (c), shown in relation to 50-m circle.

Fig. 2 depicts different configurations of two vegetation types. Fig. 2a represents what Hutto et al. (2002) describe as a "habitat mosaic," where two vegetation types are interdigitated at a fine scale to form a mosaic across the landscape. Such mosaics should be described as one habitat. Fig. 2b represents a similar situation where two vegetation types (e.g., patches of trees and meadow) are heterogeneously distributed along a gradient between two different habitat types (forest and meadow). Because there is no clear boundary between the two types inside the 50-m radius circle, this mosaic should be described as one habitat type. Fig. 2c depicts a clearer boundary between forest and meadow and should be described as two separate habitats.

Some wetland habitats and disturbed areas pose particular problems when designating separate habitats within a circle. Wide shorelines (such as large tidal flats or lakes with marshy edges) should be classified as separate habitats if they are at least 10 m wide. A disturbed area (such as road margin, logged forest, or area affected by a fire) should be classified as a separate habitat if it is at least 400 m^2 in size (circle of 11-m radius; 0.1 acre). Several examples are given below.

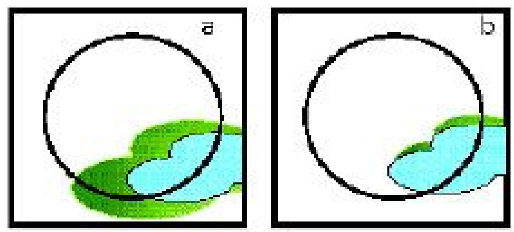


Fig. 3. Examples of water bodies with vegetated margins of varying widths in 50-m survey circle.

Fig. 3 depicts water bodies that fall within the 50-m radius circle. If a water body comprises two distinctly different wetland types that are >10 m wide, then the parts should be described separately. Therefore Fig. 3a would be assigned three different habitats (the water itself, its vegetated margin, and the surrounding non-wetland habitat). Fig. 3b would be assigned only two habitat types because the vegetated wetland associated with the water body is <10 m wide.

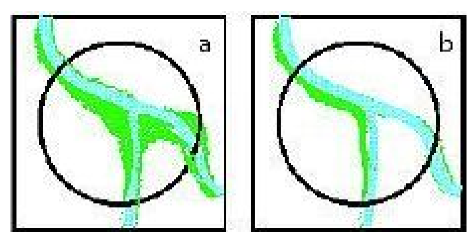


Fig. 4. Examples of streams with vegetated wetlands along banks crossing 50-m survey circle.

Fig. 4 depicts a similar situation in which a stream with associated wetlands runs through a 50-m radius circle. The associated wetland in Fig. 4a is >10 m wide in some areas and should be described separately, leading to three habitat descriptions for this circle (water, streamside vegetation, surrounding non-wetland vegetation). The wetlands along the stream in Fig. 4b are less than 10 m wide, so should be lumped in with the riverine habitat description, resulting in two habitat types.

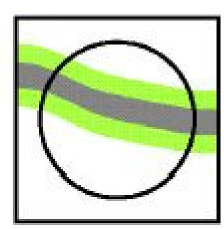


Fig. 5. Example of roadside with disturbed vegetation crossing 50-m survey circle.

Fig. 5 depicts a road crossing the 50-m radius circle. The disturbed area associated with the road on either side has markedly different vegetation, and meets the minimum patch size requirement (>400 m^2) for non-wetlands, so should therefore be described separately from the surrounding habitat. If the canopy is broken, the road itself will be one habitat (unvegetated bare soil), the roadside vegetation will be a second, and the remaining vegetation will be a third. A small trail cutting through the circle should NOT be described as a separate habitat.

Only in instances when there are distinctly different vegetation types, when there are large unvegetated surfaces, or when a wetland is present, should more than one habitat be described. When in doubt, observers should lump rather than split and describe as few habitats as possible. If observers are consistently recording more than one habitat per point, and are not in a disturbed or wetland area, then they are probably assessing habitat at a finer scale than we intended. It will be necessary to step back and try to assess the habitat at a grosser scale.

HABITAT DATA BOOKLET INSTRUCTIONS

Habitat Data Cover Page—Complete one *Habitat Data Booklet* for each route (Appendix B).

Route number: As indicated previously, a four digit number that uniquely identifies each plot. Inland plots are >1000, and coastal plots are <100. Transect numbers are identified on the map and are assigned to each team in the schedule.

Route name: User-assigned name for the route, noting some recognizable geographic feature. It is important to assign unique names to plots and avoid place names of large geographic areas, such as "Aialik Bay." An example of a useful name for a plot is "Quicksand Cove."

Date: Date the survey point locations were recorded.

Observer: List the first and last names of the observer(s), listing primary observer first.

Point Data—Complete one entry for each point.

Route #: Four digit number that uniquely identifies each plot.

Point #: Number of survey point (1-12). Points should be numbered sequentially in the order in which they are completed. Surveys should not exceed 12 points in one day.

# of Habitats: Record the number of different habitats described at each point. Most inland points should only have one habitat type, while most coastal points will have at least two due to the interface of terrestrial and marine habitats.

GPS type and number: Assign each GPS unit a unique identification number for storage and retrieval of waypoints. Record the type (model) and number of the GPS unit used for each sample block.

GPS datum: Confirm that the GPS is set to record all waypoints in NAD 27.

Waypt #: Waypoint number of actual survey point location stored in GPS unit. Use this as reference for downloading data to computer.

Latitude and longitude: Record field-averaged coordinates of the actual survey point in decimal degrees from GPS unit in NAD 27.

Location error (m): Record error in meters listed on GPS unit for field-averaged coordinates. Try to reduce error to less than 10 m if possible.

Elevation: List the elevation in meters, at the survey point itself. This can be measured with an altimeter or GPS or estimated from a topographic map. If necessary, record elevation in feet and convert later but it is essential to label units if doing so.

Aspect: List the direction in degrees from true north that the slope at the survey point is facing. If it is flat, write NA; do not leave blank.

Slope: At the survey point, estimate or measure slope (in degrees) with a hypsometer or a compass. Estimate the average slope over a distance of approximately 20 m. If it is flat, slope = 0; do not leave blank.

Topographic position: Record the position of the point relative to the largest topographic features in your area. Features should be recorded at a scale such that they will be recognized on a topographic map with 200-ft contour intervals. See *Topography Reference Sheet* for details (Appendix E).

Local features: Record notable local topographic features within the 50-m radius circle that are considered important enough to affect bird occurrence. See *Topography Reference Sheet* for definitions (Appendix E).

Photos—Record the photo number(s) and direction(s) in which photos were taken from the survey point. See "Collecting Habitat Data" instructions for more information on providing georeferenced digital photographs.

Habitat Questionnaire—Complete this questionnaire to determine the number and types of habitats present within the 50-m radius circle. See "Collecting Habitat Data" section for details regarding the use of this questionnaire.

Habitat Description

Complete one form for each unique habitat described within the 50-m radius circle.

Route #: Four digit number that uniquely identifies each plot.

Date: Date habitat data are collected for this point.

Point #: Survey point number.

Habitat #: If more than one major habitat type exists within the 50-m survey circle, indicate which one is being described relative to the total number of habitats for this circle. For example, the first habitat described at a point that has two distinct habitat types would be noted as 1 of 2.

% of circle: Record the percent of the 50-m radius circle occupied by this habitat. If there is only one habitat present, record 100. If more than one habitat is present in the circle, the percent recorded at each habitat should sum to 100 for all of the different habitats at the point. An aerial photo may help to estimate the coverage.

Vegetation—Complete this section for each habitat in which the vegetation cover is > 2%. It is only necessary to measure and record vegetation layers that contribute to habitat classifications. Because Viereck (1992) and Kessel (1979) habitat classifications are based on the highest layer of vegetation present, lower layers need not be recorded on the data sheets. For example, a forest classification requires data exclusively for the tree layer; understory shrub or herbaceous layers may be omitted. On the datasheets, list species in descending order of dominance and use scientific names when possible. If names are abbreviated, they should include the first three letters of the genus and the species name.

Table 1. Modified Braun-Blanquet cover-abundance scale used to describe cover of vegetation within each layer.

Cover class code	Cover-abundance
0	None
1	Rare, one or few individuals,
2	More than a few individuals,
3	1-5% cover
4	6-25% cover
5	26-50% cover
6	51-75% cover
7	76-100% cover

Note that some variables require an estimate of the % cover to the nearest 5% whereas others request the cover class codes from the scale provided on the data sheet. This scale (Table 1) is modified from the Braun-Blanquet cover-abundance scale, and fits the National Vegetation Classification guidelines (Jennings et al. 2004).

Single-stemmed Trees >3 m—In this section, record information about trees >3 m tall that are primarily single-stemmed in growth form (e.g., include birches but exclude most species of alders and willows).

% tree canopy cover: Estimate canopy cover for all single-stemmed trees greater than 3 m in height. Canopy cover is defined as the vertical projection of the perimeter of a tree canopy to the ground, ignoring small gaps between foliage on each tree. This can be estimated ocularly and should be expressed as a percentage. If cover is >5%, round to the nearest 5%.

% coniferous: Estimate the proportion of the canopy cover above 3 m that is coniferous (needleleaf), rounding to the nearest 5%. Note that this is the relative percent, not absolute percent, of the canopy cover. For example, total canopy cover could be 25%, and 90% of this might be coniferous.

Tree layer species: List, in descending order of percent canopy cover, up to four species of single-stemmed trees taller than 3 m that dominate the tree canopy layer. Trees are defined here as woody plants that generally grow from a single stem, have a more or less definitely formed crown of foliage, and have a height of at least 3 m (Viereck and Little 1972, Viereck et al. 1992). Willows or alders of tree size but with multiple trunks should be described below in the "Shrubs" section. For each species, estimate tree canopy cover to the nearest 5%. Check the box showing the average height of the canopy. If a single species forms two distinct sublayers, list it twice, with the layer contributing the greater canopy cover listed first. Tree layer height may be estimated using a clinometer or hypsometer. Also estimate the size class (diameter at breast height, DBH) into which the largest tree of each species falls. List the cover class code to describe the percent cover of the largest trees within this habitat.

Single-stemmed Saplings, Seedlings or Dwarf Trees <3 m—Mature trees with a single stem but less than 3 m in height are considered dwarf trees (e. g., black spruce in a bog or mountain hemlock at timberline). Saplings are defined as young woody plants with a single stem <13 cm in DBH. For up to two distinct layers, in descending order of height, list the dominant species in each, the percent cover of the layer (to the nearest 5%), the average height (to nearest 0.1 m), and the average DBH class.

Shrubs (Multiple-stemmed, Woody Plants)—Shrubs are defined as woody plants with multiple stems. For each shrub layer in descending order of height, give the average height (to 0.1 m), cover class, and dominant species in the layer. Several species of dwarf shrubs have multiple growth forms across their range and thus may be difficult to categorize as shrubs or herbs. Please consult Table 2 to determine the growth form under which to categorize some of the more common Alaska species (following Viereck et al. 1992).

Table 2. Default growth form to record for species with multiple growth forms.

Scientific Name (synonym)	Common Names	Growth Form
Artemisia tilessi	Tilesius' wormwood	Herb
Cornus canadensis	dwarf dogwood, bunchberry	Herb
Dasiphora floribunda (*Potentilla fruticosa*)	shrubby cinquefoil	Shrub
Dryas octopetala	eightpetal mountain-avens, Alaska mountain-avens, Kamtschatca mountain-avens	Shrub
Linnaea borealis	twinflower	Shrub
Lycopodium sp.	clubmoss	Herb
Rubus arcticus	dwarf nagoonberry	Herb
Rubus chamaemorus	cloudberry	Herb
Rubus pedatus	five-leaved bramble, strawberryleaf raspberry, creeping raspberry	Herb

Non-woody Plants—List the cover class code as delineated in Table 1 to indicate the percent ground covered by graminoids, herbs, ferns, and horsetails. List up to three dominant species for each category, if known.

Ground Cover—List the cover class code to indicate the percent ground covered by mosses and hepatics, lichens, litter, ephemeral snow or ice, or bare (unvegetated) ground. As indicated in the *Habitat Questionnaire*, any patch of unvegetated substrate >400 m^2 in size should be recorded and described as a separate habitat. If vegetation is covered by ice or snow, observers should differentiate between persistent ice or snow cover (that will stay in place for many years, at least during breeding season), versus ice or snow that is ephemeral and not likely to be present year round.

Classification—Indicate which one of the five categories best fits the habitat being described on this sheet. It will be necessary to collect data on vegetation layers before completing this section.

NWI: If this is a wetland habitat, provide National Wetlands Inventory (NWI) classification code based on the NWI key provided (Appendix D).

Kessel: Indicate the alphanumeric code for Kessel's (1979) habitat classification based on key provided (Appendix F).

Viereck: Provide the alphanumeric code down to the lowest level possible for the Viereck et al. (1992) classification system.

LITERATURE CITED

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.

Cowardin, L. M, V. Carter, F. C. Golet, and E. T. LaRoe. 1979. Classification of wetlands and deepwater habitats of the United States. FWS/OBS-79/31. U.S. Department of the Interior, Fish and Wildlife Service, Washington, D.C.

Fancy, S. G., and J. R. Sauer. 2000. Recommended methods for inventorying and monitoring landbirds in National Parks. Available on NPS website: http://science.nature.nps.gov/im/monitor/protocols/npsbird.doc. Last updated May 5, 2005.

Farnsworth, G. L., K. H. Pollock, J. D. Nichols, T. R. Simons, J. E. Hines, and J. R. Sauer. 2002. A removal model for estimation detection probabilities from point-count surveys. The Auk 119(2): 414-425.

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, Alaska.

Hutto, R. L., J. Hoffland, J. S. Young, and A. Cilimburg. 2002. USDA Forest Service Northern Region Landbird Monitoring Program Field Methods. Ongoing revisions from the Division of Biological Sciences, University of Montana, Missoula, MT 59812. http://biology.dbs.umt.edu/landbird/methMan.htm.

Jennings, M., O. Loucks, R. Peet, D. Faber-Langendoen, A. Damman, M. Barbour, D. Glen-Lewin, D. Grossman, R. Pfister, S. Talbot, J. Walker, G. Hartshorn, G. Waggoner, M. Abrams, A. Hill, D. Roberts, D. Tart, M. Rejmanek, and M. Walker. 2004. Guidelines for describing associations and alliances of the U. S. National Vegetation Classification. The Ecological Society of America Vegetation Classification Panel. Draft Version 3.1, March 24, 2004.

Kessel, B. 1979. Avian habitat classification for Alaska. The Murrelet 60:86-94.

Tande, G. F., and J. Michaelson. 2001. Ecological subsections for Kenai Fjords National Park. Final report prepared for National Park Service. Alaska Natural Heritage Program, Anchorage, Alaska.

Appendix (continued).

U.S. Fish and Wildlife Service. 2004. National Wetlands Inventory Homepage: http://www.nwi.fws.gov/. Last updated May 14, 2004.

Viereck, L. A., and E. L. Little. 1972. Alaska trees and shrubs. U.S. Forest Service [Supt. of Docs., U.S. Govt. Print. Off.], Washington, D.C.

Viereck, L. A., C. T. Dyrness, A. R. Batten, and K. J. Wenzlick. 1992. The Alaska Vegetation Classification. General Technical Report PNW-GTR-286. USDA Forest Service, Pacific Northwest Research Station, Portland, OR.

Appendix (continued).

APPENDIX A: Landbird List for Species Occurring in Alaska

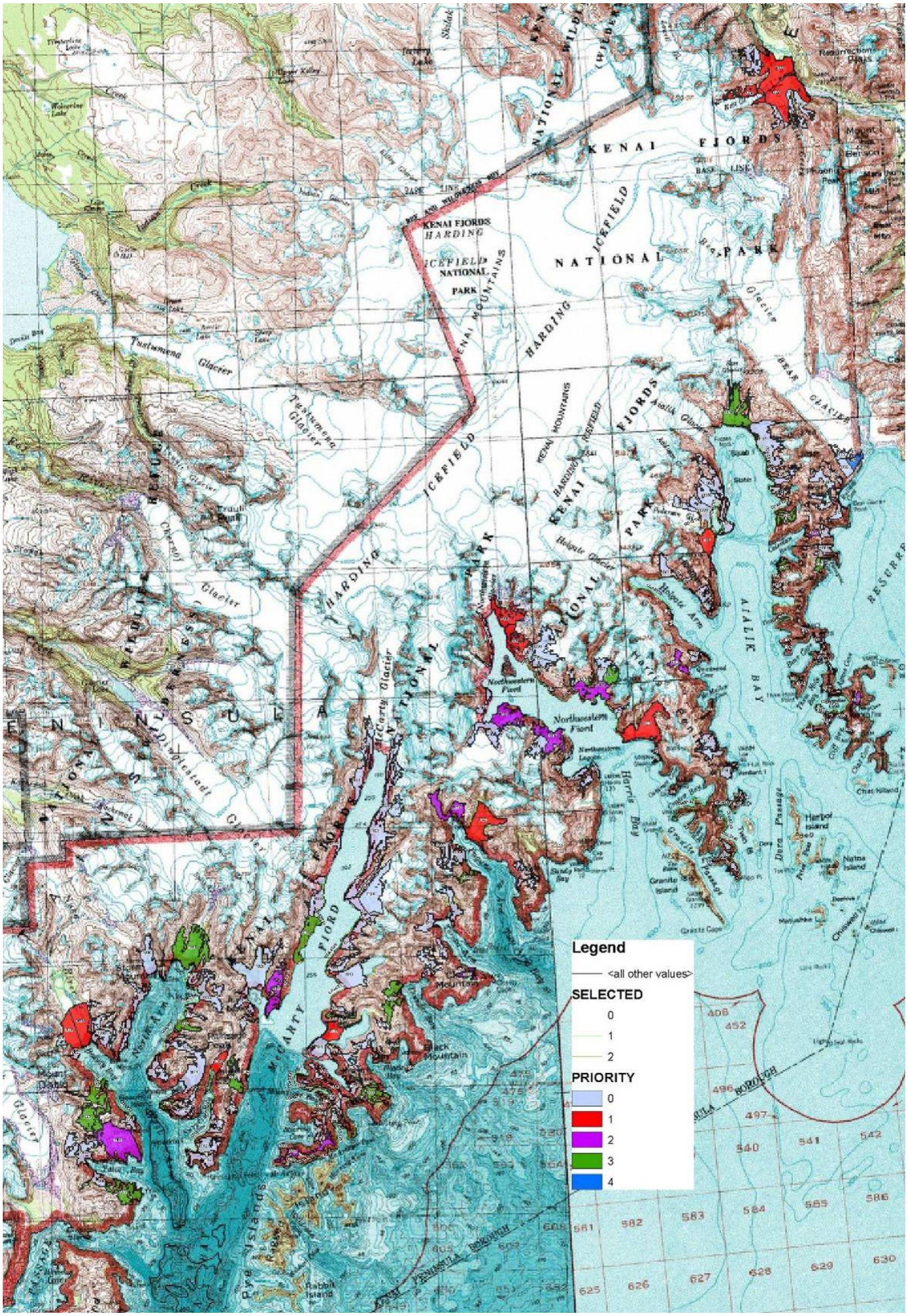
Osprey
Bald Eagle
White-tailed Eagle
Northern Harrier
Sharp-shinned Hawk
Northern Goshawk
Swainson's Hawk
Red-tailed Hawk
Rough-legged Hawk
Golden Eagle
American Kestrel
Merlin
Peregrine Falcon
Gyrfalcon
Spruce Grouse
Blue Grouse
Willow Ptarmigan
Rock Ptarmigan
White-tailed Ptarmigan
Ruffed Grouse
Sharp-tailed Grouse
Band-tailed Pigeon
Western Screech-Owl
Great Horned Owl
Snowy Owl
Northern Hawk Owl
Northern Pygmy-Owl
Barred Owl
Great Gray Owl
Short-eared Owl
Boreal Owl
Northern Saw-whet Owl
Black Swift
Vaux's Swift
Rufous Hummingbird
Belted Kingfisher
Yellow-bellied Sapsucker
Red-breasted Sapsucker
Downy Woodpecker
Hairy Woodpecker
Three-toed Woodpecker
Black-backed Woodpecker
Northern Flicker
Olive-sided Flycatcher
Western Wood-Pewee
Alder Flycatcher
Hammond's Flycatcher
Pacific-slope Flycatcher
Say's Phoebe
Eurasian Skylark
Horned Lark
Tree Swallow
Violet-green Swallow
N. Rough-winged Swallow
Bank Swallow
Cliff Swallow
Barn Swallow
Gray Jay
Steller's Jay
Black-billed Magpie
American Crow
Northwestern Crow
Common Raven
Black-capped Chickadee
Siberian Tit
Boreal Chickadee
Chestnut-backed Chickadee
Red-breasted Nuthatch
Brown Creeper
Winter Wren
American Dipper
Arctic Warbler
Golden-crowned Kinglet
Ruby-crowned Kinglet
Bluethroat
Northern Wheatear
Mountain Bluebird
Townsend's Solitaire
Gray-cheeked Thrush
Swainson's Thrush
Hermit Thrush
American Robin
Varied Thrush
Yellow Wagtail
White Wagtail
Black-backed Wagtail
Red-throated Pipit
American Pipit
Bohemian Waxwing
Cedar Waxwing
Northern Shrike
European Starling
Warbling Vireo
Red-eyed Vireo
Tennessee Warbler
Orange-crowned Warbler
Yellow Warbler
Magnolia Warbler
Yellow-rumped Warbler
Townsend's Warbler
Blackpoll Warbler
American Redstart
Northern Waterthrush
MacGillivray's Warbler
Common Yellowthroat
Wilson's Warbler
Western Tanager
American Tree Sparrow
Chipping Sparrow
Savannah Sparrow
Fox Sparrow
Song Sparrow
Lincoln's Sparrow
Golden-crowned Sparrow
White-crowned Sparrow
Dark-eyed Junco
Lapland Longspur
Smith's Longspur
Snow Bunting
McKay's Bunting
Red-winged Blackbird
Rusty Blackbird
Brown-headed Cowbird
Rosy Finch
Pine Grosbeak
Red Crossbill
White-winged Crossbill
Common Redpoll
Hoary Redpoll
Pine Siskin

APPENDIX B: Bird and Habitat Data Booklets

See KEFJ_datasheets.pdf for electronic version of datasheets.

Appendix (continued).

APPENDIX C: Map of Survey Areas



APPENDIX D: National Wetlands Inventory Reference Sheet

NATIONAL WETLANDS INVENTORY (NWI) KEY AND CLASSIFICATION CODES

1. Water is dominant factor determining the nature of soil development and the types of plant and animal communities living in the soil and on its surface. This area is at least periodically saturated with or covered by water. This includes shorelines where no vegetation occurs due to erosion or wave action. If soil is not covered or saturated at this time, presence of obligate wetland plant species indicates presence of a wetland (See below for list of obligate and facultative wetland indicator plants). **Yes**: This is a wetland. Go to 2. **No**: This is NOT A WETLAND. NWI=NA.

2. a) Saltwater or tidal influence is present. Go to 3.
b) Saltwater or tidal influence is not present. Go to 4.

3. a) Saltwater is not substantially diluted by freshwater at this location. SYSTEM=MARINE (NWI=M).
b) Saltwater is substantially diluted by freshwater runoff from the land, especially at the mouth of larger streams and rivers. SYSTEM=ESTUARINE (NWI=E).

4. a) Water flows and is contained within a channel. SYSTEM=RIVERINE (NWI=R).
b) Water is not contained in a channel, and appears to flow very slowly or not at all. This includes dammed rivers or streams. Go to 5.

5. a) Persistent emergent vegetation cover ≥30%. SYSTEM=PALUSTRINE (See PALUSTRINE CLASSES for NWI code).
b) Persistent emergent vegetation cover <30%. Go to 6.

National Wetland Inventory Codes*	
SYSTEM	**CODE**
MARINE	**M**
ESTUARINE	**E**
RIVERINE	**R**
LACUSTRINE	**L**
PALUSTRINE	**See Below**

* Modified from NWI Codes (USFWS 2004)

6. a) Area ≥8 ha or water depth >2 m or wave-formed or bedrock shoreline present. SYSTEM=LACUSTRINE (NWI=L).
b) Area <8 ha and water depth <2 m and no wave-formed or bedrock shoreline present. SYSTEM=PALUSTRINE (See PALUSTRINE CLASSES below).

PALUSTRINE CLASSES

	Name	**Description**	**Code**
Persistent emergent vegetation cover ≥30%:	Forested Wetland	Trees (≥6 m tall) cover ≥30% of area.	**PFO**
	Scrub-shrub Wetland	Trees (≥6 m tall) alone cover <30%of area, but with shrubs cover ≥30% of area.	**PSS**
	Emergent Wetland	Emergent vegetation dominated by graminoids or forbs.	**PEM**
	Moss-Lichen Wetland	Emergent vegetation dominated by mosses or lichens.	**PML**
	Aquatic Bed	Vegetation submerged or floating on surface of water.	**PAB**
Persistent emergent vegetation cover <30%:	Unvegetated Shore/Bottom	Substrate of shore or bottom predominantly covered by rock, stones, organic material, or other unconsolidated matter.	**PUB**

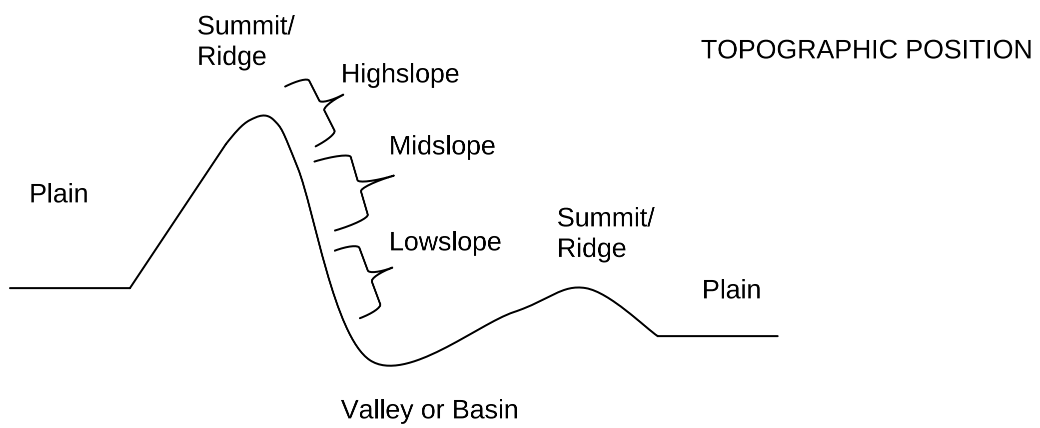
Obligate Wetland Indicators (WETLAND LIKELY PRESENT)		
Family	Scientific Name (synonym)	Common Name
Brassicaceae -- Mustard family	*Cardamine pratensis*	BITTER-CRESS, MEADOW
Cyperaceae -- Sedge family	*Carex aquatilis*	SEDGE, WATER
	Carex pauciflora	SEDGE, FEWFLOWERED
	Carex pluriflora	SEDGE, SEVERAL FLOWERED
	Carex rostrata	SEDGE, BEAKED
	Carex sitchensis	SEDGE, SITKA
	Eriophorum angustifolium	COTTON-GRASS, NARROW-LEAF
	Trichophorum caespitosum	BULRUSH, TUFTED
	Scirpus microcarpus	BULRUSH, SMALL-FRUIT
Droseraceae -- Sundew family	*Drosera spp.*	SUNDEWS
Ericaceae -- Heath family	*Andromeda polifolia*	ROSEMARY, BOG
	Kalmia microphylla	LAUREL, ALPINE BOG
	Vaccinium oxycoccos	CRANBERRY, SMALL
	(Oxycoccos microcarpus)	CRANBERRY, BOG
Hippuridaceae -- Mare's-tail family	*Hippuris vulgaris*	MARE'S-TAIL, COMMON
Lentibulariaceae -- Bladderwort family	*Pinguicula villosa*	BUTTERWORT, HAIRY
Menyanthaceae -- Buckbean family	*Menyanthes trifoliata*	BUCKBEAN
Myricaceae -- Bayberry family	*Myrica gale*	SWEETGALE
Ranunculaceae -- Buttercup family	*Caltha palustris*	MARSH-MARIGOLD, COMMON
	Ranunculus lapponicus	BUTTER-CUP, LAPLAND
	Ranunculus pallasii	BUTTER-CUP, PALLAS'
Rosaceae – Rose family	*Comarum palustre* *(Potentilla palustris)*	MARSHLOCKS, PURPLE (CINQUEFOIL, MARSH)

Facultative Wetland Indicators (WETLAND MAY BE PRESENT,ESPECIALLLY IF MORE THAN ONE SPECIES OCCURS)		
Family	Scientific Name (synonym)	Common Name
Asteraceae -- Aster family	*Petasites frigidus*	COLTSFOOT, ARCTIC SWEET
	Senecio congestus	GROUNDSEL, MARSH
Cyperaceae -- Sedge family	*Eriophorum vaginatum*	COTTON-GRASS, TUSSOCK
Ericaceae -- Heath family	*Chamaedaphne calyculata*	LEATHERLEAF
	Kalmia polifolia	LAUREL, PALE
	Ledum decumbens	LABRADOR-TEA, NARROW-LEAF
	Ledum groenlandicum	LABRADOR-TEA, GREENLAND
Juncaceae -- Rush family	*Juncus spp*	RUSHES
Menyanthaceae – Buckbean family	*Nephrophyllidium crista-galli (Fauria crista-galli)*	DEER-CABBAGE
Onagraceae -- Evening Primrose family	*Circaea alpina*	NIGHTSHADE, SMALL ENCHANTER'S
Pinaceae -- Pine family	*Larix laricina*	LARCH, AMERICAN
	Picea mariana	SPRUCE, BLACK
Ranunculaceae -- Buttercup family	*Ranunculus occidentalis*	BUTTER-CUP, WESTERN
Rosaceae -- Rose family	*Rubus chamaemorus*	CLOUDBERRY
	Sanguisorba canadensis	BURNET, CANADA

Appendix (continued).

APPENDIX E: Topography Reference Sheet

Topographic Position	Description of Topographic Positions
In hills or mountains	
Summit	Top of hill or mountain.
Ridge	A long, narrow elevation of the land surface forming an extended upland between drainages.
High slope	Geomorphic component that forms the uppermost inclined surface at the top of a slope. Surface profile is generally convex.
Midslope	Intermediate slope position.
Lowslope	Gently inclined surface at the base of a slope. Surface profile is generally concave.
Basin	A depressed area with no or limited surface outlet. Nearly level to gently sloping bottom surface between mountains or hills.
Valley	An elongate, relatively large, externally-drained depression of the earth's surface that is primarily developed by stream erosion and is positioned between hills or mountains.
No hills or mountains present	
Plain	An extensive lowland area that ranges from level to gently sloping or undulating. A plain has no prominent hills or valleys, and occurs at low elevation with reference to surrounding areas. Local relief generally less than 100 m.



Local Feature	Description
Step in slope	Nearly level shelf interrupting a steep slope on a mountain or hill.
Cutbank	A steeply sloping embankment of exposed soil as formed through erosion or road construction.
Dunes	Mounds, ridges, or hills of loose, windblown granular material, usually sand, either bare or covered with vegetation.
Flood plain	The nearly level, sometimes terraced alluvial deposit that borders a stream and is subject to inundation under flood-stage conditions, built of sediment deposited during overflow and lateral migration of the stream.
Cliff/Rock Face	Very steep to perpendicular or overhanging face made of rock.
Alluvia/Moraine	Unvegetated glacial deposits, and alluvial deposits of gravel, sand, and silt.
Other	Define other local topographic features as necessary.

APPENDIX F: Kessel Habitat Classification Sheet

This classification system[1] has been developed specifically in relation to habitats used by birds in Alaska. Generally, a habitat with woody vegetation should be classified based on the tallest canopy of woody plants present in sufficient amounts to attract birds from the local breeding community, even if the canopy cover is sparse.

I. Fresh or brackish waters
- a. LACUSTRINE WATERS AND SHORELINES (lakes, ponds, shorelines)
- b. FLUVIATILE WATERS AND SHORELINES (streams, rivers, shorelines)

II. Marine waters
- a. NEARSHORE WATERS (protected coastal waters)
- b. INSHORE WATERS (exposed coastal waters)

III. Unvegetated substrates
- a. ROCKY SHORES AND REEFS (boulders, rocks, rubble)
- b. BEACHES AND TIDAL FLATS (gravel, sand, silt, mud)
- c. BARRIER ISLANDS (usually with sparse or no vegetation)
- d. ALLLUVIA AND MORAINES (unvegetated alluvial and glacial deposits)
- e. CLIFFS AND BLOCK-FIELDS (sea stacks, tors, screes, lava flows, etc.)
- f. SUBTERRANEAN SOIL (soil substrate, cut-banks)

IV. Meadows (dominated by herbaceous plants, mostly graminoids)
- a. WET MEADOW (wet; includes small ponds and vegetated pond margins)
- b. DWARF SHRUB MEADOW (mesic; shrubs < 0.4 m present)
- c. GRASS MEADOW (relatively dry; mostly graminoids)
- d. SALT GRASS MEADOW (periodically tidal; graminoids)
- e. TALL FORB MEADOW (forbs > 0.4 m)

V. Shrubbery (< 5 m; multiple-stemmed shrubs or young trees)
- a. DWARF SHRUB MAT (dry; shrubs < 0.4 m dominant)
- b. LOW SHRUB THICKET (0.4-1.1 m)
- c. MEDIUM SHRUB THICKET (1.2-2.4 m)
- d. TALL SHRUB THICKET (2.5-4.9 m)

VI. Forests and woodlands (woody plants > 5 m)
- a. DECIDUOUS FOREST (> 90% deciduous)
- b. CONIFEROUS FOREST (> 90% coniferous)
- c. MIXED DECIDUOUS-CONIFEROUS FOREST
- d. SCATTERED WOODLAND AND DWARF FOREST (canopy < 20%)

VII. ARTIFICIAL HABITATS

[1] Source: Kessel, B. 1979. Avian habitat classification for Alaska. Murrelet 60:86-94.