Abstract

The Alaska Bird Observatory monitored landbirds for the seventh consecutive breeding season (1992-1998) in Denali National Park and Preserve. We used on-road and off-road point counts to monitor avian populations. Nine off-road routes and two on-road routes surveyed from 1993-1997 were repeated in 1998, and two off-road routes were added in alpine tundra and riparian habitats. Two previously surveyed on-road routes were not surveyed in 1998 because they overlap with Denali National Park's Breeding-Bird-Survey routes. As in previous years, species richness was greatest near the west portion of the park, and frequency of occurrence of most species remained relatively constant among years. To determine the status of avian species nesting in the park, we recommend long-term monitoring in stratified habitat types, and developing cause-and-effect relationships for landbird population by analyzing annual productivity relative to population indices.

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1. Introduction

Few national parks in the United States have extensive inventory and monitoring programs (Evison et al. 1987). Yet, at least two federal legislative acts dictate that the National Park Service (NPS) initiate inventory and monitoring programs in all parks. It is NPS policy "to provide accurate scientific data upon which all aspects of planning, development, and management of the units of the system may be based" (Management Policies of the NPS IV-2, 1978). The Forest and Rangeland Renewable Resources Planning Acts of 1974 and 1976 mandate the inventory and monitoring of natural resources on public lands, while the National Environmental Policy Act of 1969 requires gathering baseline information to assess management options.

The NPS does not have a system-wide inventory and monitoring program, therefore, Denali National Park and Preserve (DENA) was selected as one of four parks nationwide to develop protocols to monitor long-term environmental fluctuations in the flora and fauna of the region (Van Horn et al. 1992). The NPS is responsible for managing 21.5 million ha (53 million acres) in 23 national parks in Alaska, or about 66% of the nation's NPS land base. Denali is a large park (2.4 million ha) and encompasses a broad array of habitat types (Viereck et al. 1992). In 1992, DENA implemented an interdisciplinary research project including monitoring of glaciers, soils, weather, hydrology, water quality, toxicants, aquatic productivity, vegetation, terrestrial invertebrates, small mammals, and birds (NPS 1992).

The objectives of the avian inventory and monitoring program on NPS lands are to develop protocols to quantify annual variation in relative abundance and to continue monitoring based on the protocol. Butcher et al. (1992) proposed national guidelines for all avian monitoring

programs for all federal agencies. They suggested monitoring programs be designed to have a 90% probability of detecting a cumulative 50%, or 2.7345% annual, decline in a species over a 25-year period. The Denali prototype program has field tested a variety of survey techniques for landbirds in the park from 1992-1996; this research was conducted by the Alaska Bird Observatory (ABO; Pogson and Rexstad 1994; Paton et. al. 1995; Paton and Pogson 1996; Paton 1997; Paton and Springer 1998). Additionally, the Institute for Bird Populations is managing a constant-effort mist-netting program under the administration of the Monitoring Avian Productivity and Survivorship (MAPS) program (DeSante et al. 1993). This latter program is designed to monitor changes to the ratio of adults to juveniles based on capture rates in mist nets.

2. Objectives

Fieldwork in 1998 had two primary objectives:

(1) Quantify interannual variation in the abundance of landbirds along the Denali National Park and Preserve road corridor.

(2) Establish new off-road routes in alpine tundra and riparian habitats.

3. Study Area

Denali National Park and Preserve is located in the central Alaska Range, approximately 210 km southwest of Fairbanks, Alaska. The study area encompassed 2 km on either side of the park road, which is 150 km long and extends westward from the park entrance at the Parks Highway (63°44'; 148°55') to the airfield near Kantishna (63°32';151°00; Figure 1). The growing season is relatively brief, with most areas in the road corridor snow free by mid to late June in most years. Permanent snow fields remain on north-facing slopes at higher elevations. The park road is often closed by snow in September. Mean temperatures at the Park Headquarters for

June, July, and August are 11.1°C (52°F), 12.5°C (54.5°F), and 11.1°C (52°F), respectively (National Park Service, unpubl. data).

A diversity of habitats are found in the road corridor including forested habitats (i.e., open and closed needleleaf forests, open and closed mixed deciduous-coniferous forests), shrub habitats (i.e., open and closed shrubs ranging in height from dwarf to tall), and alpine tundra (Viereck et al. 1992). Forest habitats are generally restricted to areas below 600-900 m (2,000'-3,000') elevation, and alpine tundra generally occurs above 915 m (3,000') elevation. The intervening elevations are dominated by shrub habitats. Forests are dominated by white spruce (*Picea glauca*), black spruce *(P. mariana*), quaking aspen (*Populus tremuloides*), balsam poplar (*P. balsamifera*) and paper birch (*Betula papyrifera*). Shrub habitats are dominated by a diversity of willows (e.g., *Salix planifolia, S. barcleyi, S. glauca*), dwarf birch (*B. glandulosa*), mountain alder (*Alnus crispa*), blueberry (*Vaccinium uliginosum*), and low bush cranberry (*V. vitis-idaea*). Upland tundra is dominated by sedges, grasses and forbs at higher elevations.
Elevations in the road corridor vary from 490 m near the park entrance to 1,220 m at Stony Pass.

We defined spruce forests as habitats where trees (i.e., single-stemmed woody plants >3 m height) comprised >10% of the crown cover (Viereck et al. 1992). Forest stands were <0.8 km from the park road for easy access and were large enough to contain the route (2.75 km long by 0.5 km wide).

4. Methods

Objective 1: Quantify interannual variation in the abundance of landbirds along the Denali National Park and Preserve (DENA) road corridor using on-road and off-road point counts.

4.1 On-road Routes

On-road point counts followed protocol developed for the national Breeding Bird Survey (BBS) (Droege 1990). We previously divided the park road corridor into four sampling units for a total of four BBS routes. We repeated Routes One and Four along the park corridor, and eliminated Routes Two and Three, because they overlap with NPS's official BBS route. Route One was 39.4 km (24.5 miles) in length and consisted of fifty point-count stations. Route Four was 29.8 km (18.5 miles) in length and consisted of 39 stations in 1993, 37 stations in 1994 and 1995, and 36 stations from 1996 to 1998. Counting stations were spaced 0.8 km (0.5 miles) apart and observers drove between stations, surveying one route per morning. Detections included birds heard (recorded as either singing or calling) or seen from counting stations during a three-minute census period. We recorded birds at an unlimited distance from counting stations. Routes started 30 minutes before official sunrise, or no earlier than 03:30 AM, and took 4-5 hours to complete.

Frequency-of-occurrence (FO) estimates (the proportions of stations with detections) were calculated for each route. We assumed independence among sampling points, as care was taken to not sample the same individual twice. Rational for this method of analysis and power calculations are presented in Paton (1994).

We recalculated FO estimates from previous years. From 1994 to 1996, routes were repeated several times within a year to determine peak singing rates of birds. When these data were later used to calculate annual FO, Paton et. al (1994, 1995, 1996, 1997) incorrectly included repeated measures at the same point as independent observations. The previous analyses therefore inflated the sample size from 50 to 900 points in some years. These estimates were also biased because they included data from a range of dates between 25 April and 17 July. Paton (1996) determined surveys should be conducted between 10-25 June in DENA. Therefore, we

recalculated FO estimates from previous years using survey data from 10 to 25 June. If a route was repeated during this time, we calculated mean frequency of occurrence for each route and standard error of the mean.

We pooled survey data for Common Redpoll (*Carduelis flammea*)and Hoary Redpoll (*Carduelis hornemanni*) into the taxon Redpoll because we were unable to identify individuals to species (Troy 1985). Similarly, we were unable to identify all woodpeckers to species because we could not distinguish drumming and vocalizations of Hairy Woodpecker (*Picoides villosus*) and Three-toed Woodpecker (*Picoides tridactylus*). These detections were denoted as Woodpecker spp.

4.2 Off-road Routes

Off-road surveys followed methodology developed by the Boreal Partners in Flight (BPIF) working group (Handel 1993a). In 1998 we resurveyed all off-road routes censused from 1993-1997, for a total of 108 point-count stations surveyed annually (Table 1). All off-road routes (n=9) were in spruce forest dominated habitats. Four routes were along the east end of the road, three were along the midway portion of the road, and four were near the west end of the road (Appendix 1,2,3).

Each off-road route consisted of 12 point-count stations spaced approximately 250 m apart. An observer surveyed one route per morning on foot. Surveys started at official sunrise (Dawson 1981, Verner and Ritter 1986) and took >3 hours to complete. At each point-count station, birds were recorded within an unlimited distance from the observer (Blondel et al. 1981, Ralph 1993) for afive-minute period. Data were subdivided into the number of detections before and after three minutes had elapsed. Detections were subdivided into the number of cues before and after three minutes, and into those ≤50 m and those >50 m from counting stations.

Table 1. Summary of avian surveys conducted in 1998 in Denali National Park and Preserve.

DATE	SURVEY TYPE	LOCATION	AREA
06-04-98	On-road route # 1	Mile 0 - 24.5	Parks Highway to Sanctuary River
06-11-98	On-road route # 1	Mile 0 - 24.5	Mile 0.0 to 24.5
06-17-98	On-road route # 4	Mile 75 - 90	Tundra ponds to Kantishna airpstrip
06-24-98	On-road route # 4	Mile 75 - 90	Mile 75.0 to 92.5
06-13-98	Off-road route	E. Hines Creek	Mile 4.9
06-12-98	Off-road route	Rock Cr. Rt. 2	Mile 3.3
06-16-98	Off-road route	Sanctuary S.	Mile 23.5
06-19-98	Off-road route	N. Camp Denali	Mile 89.9
06-25-98	Off-road route	Spruce Triangle	Mile 84.6
06-22-98	Off-road route	Teklanika	Mile 27.5
06-23-98	Off-road route	Rock Cr.West	Mile 3.6
06-14-98	Off-road route	Sanctuary N.	Mile 23.1
06-26-98	Off-road route	Permafrost	Mile 3.9
06-18-98	Off-road route	Camp Ridge	Mile 89.0
06-08-98	Off-road route	Moose Creek	Mile 89.0

Objective 2: Establish new off-road routes in alpine tundra and riparian habitats.

We initiated new off-road surveys in alpine tundra and a riparian area to determine whether additional species could be monitored in DENA. We used methods outlined in section 4.2 to conduct surveys along the new routes. The riparian route was located along Moose Creek, the only significant clear-running anadramous stream within the park road corridor. The vegetation along Moose Creek consists of open broadleaf forest dominated by paper birch, balsam poplar, and quaking aspen, and tall closed scrub dominated by willow and alder.

Tundra habitat surveyed while conducting the on-road BBS routes is low-lying tundra. We selected one route in alpine-tundra habitat (upland tundra) located in the Kantishna Hills of DENA. Paton (1996) and Handel (1994) suggested that point-count stations in tundra habitats be at least 500 m apart to ensure independence among points. Although data were collected at 250 m

intervals in alpine tundra, we excluded six of 12 points to ensure independence between points. Therefore, data collected at 500 m intervals were included in the analysis (n=6).

5. Results

5.1 On-road Point Counts

On-road Route One

Both species richness and frequency-of-occurrence estimates (FO) differed from previous data presented by Paton (1994, 1995, 1996, 1997) because fewer data points were included in our analyses. For example, Paton previously calculated FO estimates for Wilson's Warblers as 0.519, 0.379, 0.224, 0.53 in 1994, 1995, 1996, and 1997 respectively; we recalculated these estimates to be 0.618, 0.647,0.627,0.50 in 1994, 1995, 1996, and 1997 respectively.

Our estimates of species richness differed from Paton's earlier reports because we included data that were collected between 10-25 June. In contrast, Paton included data from 25 April to 17 July. We detected 47 species from 1993-1998 on this section of the park road with a mean of 30.0 species detected annually (Table 2), while Paton reported 69 species from 1993-1997 with a mean of 40 species detected annually. Species richness ranged from 21 species in 1993 to 38 species in 1994 (Table 2). Sixteen species (53.3%) were detected every year, and eight species were detected in only one year. Species detected in only one year were found at <1% of all counting stations. We detected 26 species in 1998.

During 1998, 13 species were detected at >16% of point-count stations, including Mew Gull, Swainson's Thrush, American Robin, Varied Thrush, Orange-crowned Warbler, Yellow-rumped Warbler, Wilson's Warbler, Savannah Sparrow, Fox Sparrow, White-crowned Sparrow,

Dark-eyed Junco, and Redpoll spp. FO estimates for most species remained relatively constant among years.

Whimbrels were detected on this route for the first time in 1998. While this is not a rare species in DENA, it is uncommon in the habitats along the park road.

Table 2. Interannual variation in frequency of occurrence along on-road Route One on the DENA road. The survey consisted of 50 stations sampled between 10-25 June. In years when the route was completed more than once during this time, mean and standard error (SE) are presented.

	1993	1994		1995		1996		1997	1998
Species		Mean (n=4)	SE	Mean (n=4)	SE	Mean (n=3)	SE		
Green-winged Teal				0.004					
Northern Pintail				0.007	*0.004*				
Harlequin Duck		0.007	*0.003*			0.013	*0.004*		
Northern Harrier						0.007	*0.004*	0.040	0.040
Northern Goshawk		0.005	*0.003*						
American Kestrel		0.005	*0.003*					0.040	0.020
Merlin		0.030	*0.006*	0.007	*0.004*	0.007	*0.004*	0.040	0.020
Willow Ptarmigan		0.035	*0.009*	0.040	*0.007*	0.113	*0.015*		0.100
Whimbrel									0.020
Upland Sandpiper		0.005	*0.003*			0.013	*0.008*	0.020	
Common Snipe	0.080	0.050	*0.013*	0.013	*0.008*	0.007	*0.004*		
Mew Gull	0.080	0.078	*0.005*	0.100	*0.012*	0.080	*0.013*	0.100	0.160
Northern Hawk Owl						0.020	*0.000*	0.020	
Three-toed Woodpecker		0.010	*0.003*	0.020	*0.007*	0.007	*0.004*		0.020
Northern Flicker		0.005	*0.003*	0.007	*0.004*				
Olive-sided Flycatcher	0.060	0.027	*0.006*	0.033	*0.004*	0.033	*0.008*	0.020	
Western Wood-Peewee						0.007	*0.004*		
Alder Flycatcher		0.005	*0.003*	0.007	*0.004*				
Violet-green Swallow		0.010	*0.005*	0.007	*0.004*				
Gray Jay		0.149	*0.012*	0.113	*0.008*	0.233	*0.017*	0.100	0.060
Black-billed Magpie	0.020	0.020	*0.004*	0.020	*0.007*	0.027	*0.004*	0.020	0.040
Common Raven		0.015	*0.005*			0.013	*0.004*		0.020
Boreal Chickadee	0.020	0.047	*0.009*	0.013	*0.008*	0.047	*0.010*	0.020	0.020
Brown Creeper		0.005	*0.003*						
Arctic Warbler		0.060	*0.010*	0.007	*0.004*	0.060	*0.018*	0.060	
Gray-cheeked Thrush	0.040	0.035	*0.006*	0.040	*0.007*	0.027	*0.008*	0.020	
Swainson's Thrush	0.200	0.223	*0.009*	0.233	*0.014*	0.240	*0.012*	0.120	0.240
Hermit Thrush	0.020					0.013	*0.004*	0.020	
American Robin	0.340	0.312	*0.009*	0.327	*0.023*	0.287	*0.010*	0.220	0.220
Varied Thrush	0.220	0.193	*0.009*	0.167	*0.010*	0.167	*0.010*	0.140	0.160
Bohemian Waxwing				0.013	*0.008*				
Northern Shrike		0.005	*0.003*						
Orange-crowned Warbler	0.120	0.353	*0.026*	0.540	*0.018*	0.413	*0.037*	0.420	0.480
Yellow-rumped Warbler	0.240	0.249	*0.017*	0.280	*0.018*	0.287	*0.014*	0.200	0.260
Blackpoll Warbler		0.005	*0.003*	0.020	*0.007*	0.007	*0.004*		0.020
American Tree Sparrow	0.640	0.673	*0.009*	0.687	*0.010*	0.640	*0.007*	0.680	0.660
Wilson's Warbler	0.460	0.618	*0.038*	0.647	*0.025*	0.627	*0.040*	0.500	0.460
Savannah Sparrow	0.420	0.440	*0.017*	0.413	*0.014*	0.427	*0.010*	0.380	0.280
Fox Sparrow	0.060	0.304	*0.018*	0.260	*0.007*	0.267	*0.027*	0.340	0.360
Lincoln's Sparrow		0.010	*0.003*			0.067	*0.010*	0.020	
Golden-crowned Sparrow						0.007	*0.004*		
White-crowned Sparrow	0.840	0.896	*0.009*	0.913	*0.004*	0.900	*0.007*	0.940	0.820
Dark-eyed Junco	0.340	0.359	*0.010*	0.293	*0.014*	0.287	*0.019*	0.320	0.320
Ruby-crowned Kinglet	0.020	0.070	*0.012*	0.040	*0.007*	0.113	*0.004*	0.060	0.060
Pine Siskin		0.005	*0.003*						
White-winged Crossbill	0.040	0.075	*0.019*	0.007	*0.004*			0.040	0.020
Redpoll Species	0.420	0.296	*0.022*	0.493	*0.014*	0.293	*0.044*	0.440	0.220

On-road Route Four

No data were collected on this route between 10-25 June in 1993. From 1994-1998 more species were detected on this route than other routes in DENA. (Table 3). Species richness is relatively high along this route because of the diversity of habitat types along its length, including a variety of ponds and lakes that attract waterbirds. Cumulative species richness was 65 species, with an average of 37 species per year. Twenty species were detected all six years, and fifteen species were detected in only one year.

During 1998, 12 species were detected at >20% of counting stations, including Alder Flycatcher, Gray-cheeked Thrush, American Robin, Orange-crowned Warbler, Wilson's Warbler, American Tree Sparrow, Savannah Sparrow, Fox Sparrow, White-crowned Sparrow, and Redpoll. As in past years, Gray-cheeked Thrush and Alder Flycatcher were found only on the west side of the park.

Table 3. Interannual variation in FO along on-road Route Four on the DENA road. The survey consisted of 50 point counts between 10 and 25 June. In years when the route was completed more than once during this time, mean and standard error (SE) are presented.

	1994		1995	1996	1997	1998	
Species	Mean(n=2)	SE				Mean (n=2)	SE
Common Loon	0.016	0.011				0.042	0.010
Greater White-fronted Goose			0.027				
Green-winged Teal	0.028	0.020	0.027	0.061	0.028	0.042	0.010
Mallard				0.030		0.014	0.010
Northern Pintail					0.056	0.042	0.010
Northern Shoveler					0.028	0.014	0.010
American Wigeon	0.014	0.010			0.139	0.028	0.000
Ring-necked Duck	0.030	0.002					
Greater Scaup	0.042	0.029				0.014	0.010
Lesser Scaup	0.155	0.050		0.030	0.028		
Unidentified Scaup	0.032	0.023	0.081		0.139	0.056	0.000
Oldsquaw	0.014	0.010					
Black Scoter	0.028	0.020					
Surf Scoter						0.028	0.000
White-winged Scoter						0.014	0.010
Common Goldeneye						0.014	0.010
Barrow's Goldeneye	0.030	0.002					
Bufflehead	0.014	0.010					
Northern Harrier						0.014	0.010
Merlin	0.014	0.010					
Willow Ptarmigan				0.061	0.167	0.139	0.020
Greater Yellowlegs					0.028	0.014	0.010
Lesser Yellowlegs	0.088	0.016	0.081	0.091	0.111	0.042	0.010
Spotted Sandpiper	0.014	0.010	0.027			0.028	0.000
Upland Sandpiper				0.030			
Whimbrel	0.072	0.028				0.014	0.010
Common Snipe	0.028	0.020	0.081	0.212	0.194	0.097	0.069
Red-necked Phalarope						0.014	0.010
Bonaparte's Gull	0.060	0.003		0.030	0.028		
Mew Gull	0.106	0.016	0.081	0.152	0.139	0.153	0.029
Herring Gull	0.032	0.023					
Arctic Tern	0.016	0.011		0.061	0.056	0.014	0.010
Short-eared Owl	0.028	0.020				0.014	0.010
Belted Kingfisher						0.014	0.010
Olive-sided Flycatcher				0.030		0.014	0.010
Western Wood-Peewee					0.056	0.014	0.010
Alder Flycatcher	0.564	0.034	0.595	0.576	0.472	0.625	0.029
Hammond's Flycatcher	0.016	0.011	0.027				
Violet-green Swallow				0.061			
Cliff Swallow	0.016	0.011	0.027	0.061		0.028	0.020
Barn Swallow					0.056		
Gray Jay				0.030	0.028	0.042	0.029
Black-billed Magpie						0.014	0.010
Common Raven						0.014	0.010

Table 3. Continued

	1994		1995	1996	1997	1998	
Species	Mean(n=2)	SE				Mean (n=2)	SE
Black-capped Chickadee			0.027				
Arctic Warbler	0.028	0.020	0.027			0.014	0.010
Ruby-crowned Kinglet					0.056	0.028	0.020
Gray-cheeked Thrush	0.381	0.064	0.405	0.364	0.361	0.292	0.029
Swainson's Thrush	0.044	0.008	0.027	0.121	0.056	0.042	0.010
Hermit Thrush	0.065	0.046	0.027	0.030	0.028	0.028	0.000
American Robin	0.328	0.004	0.189	0.212	0.139	0.208	0.069
Varied Thrush	0.088	0.016	0.108		0.083	0.069	0.029
Orange-crowned Warbler	0.561	0.055	0.784	0.606	0.639	0.583	0.059
Yellow Warbler			0.027	0.030	0.056		
Yellow-rumped Warbler	0.062	0.024	0.081	0.121	0.083	0.139	0.059
Blackpoll Warbler					0.028	0.014	0.010
Northern Waterthrush			0.027		0.083		
Wilson's Warbler	0.707	0.089	0.757	0.909	0.889	0.667	0.137
American Tree Sparrow	0.681	0.048	0.676	0.636	0.611	0.486	0.010
Savannah Sparrow	0.462	0.144	0.405	0.606	0.667	0.486	0.010
Fox Sparrow	0.700	0.016	0.784	0.545	0.750	0.681	0.069
Lincoln's Sparrow				0.121	0.139	0.028	0.020
White-crowned Sparrow	0.938	0.024	0.919	0.939	0.722	0.917	0.020
Dark-eyed Junco	0.180	0.010	0.081	0.091	0.083	0.111	0.039
White-winged Crossbill	0.016	0.011					
Redpoll Species	0.506	0.016	0.432	0.333	0.389	0.292	0.128

5.2 Off-road Routes

Spruce Forests

Forty-four species were detected during off-road surveys from 1993-1998 (Table 4). Annual species richness ranged from 26 to 32 species. Nineteen species were detected in all years, and nine species were detected in only one year. Thirteen species were detected at >16% of all point-count stations in 1998, including Gray Jay, Ruby-crowned Kinglet, Swainson’s Thrush, American Robin, Varied Thrush, Orange-crowned Warbler, Yellow-rumped Warbler, Wilson’s Warbler, American Tree Sparrow, Fox Sparrow, White-crowned Sparrow, Dark-eyed Junco and Redpoll sp.

The relative abundance of most taxa remained relatively constant from 1993 to 1998 (Table 4).

Coefficients of variation were relatively low and ranged from 0.04 (Dark-eyed Junco) to 0.44 (Redpoll spp.) in nine of the 10 most frequently observed species in 1998. In 1998, Fox Sparrows were observed at 25% of point-count stations. The coefficient of variation of this species was 0.96.

Most populations of landbirds breeding in the park appear to be relatively stable, rather than exhibiting dramatic year-to-year fluctuations. As expected, rare species exhibit the most annual variation because they are not detectable most years. Detections of irruptive species, such as White-winged Crossbill, Bohemian Waxwing, Pine Siskin, and Redpoll spp., were relatively low in 1998. The first detection of Northern Goshawk, a species that occurs in spruce-dominated habitats, was recorded during off-road surveys in 1998.

Table 4. Interannual variation in frequency of occurrence and total counts on off-road spruce-dominate survey routes. We conducted nine off-road surveys consisting of 12 points, for a total of 108 point-count stations.

	Frequency of Occurrence						Total No. of Individuals					
Species	1993	1994	1995	1996	1997	1998	1993	1994	1995	1996	1997	1998
Duck species		0.009			0.019			1			4	
Greater Yellowlegs	0.009						1					
Lesser Yellowlegs		0.028	0.056	0.037	0.028			6	9	4	5	
Spotted Sandpiper	0.037			0.028		0.046	5			4		5
Upland Sandpiper			0.009						1			
Common Snipe			0.009	0.019					1	2		
Mew Gull	0.083	0.065	0.046	0.056	0.102	0.037	14	12	6	7	18	5
Northern Goshawk						0.009						1
Merlin					0.009	0.009					1	1
Spruce Grouse			0.019	0.009						2	1	
Willow Ptarmigan				0.018	0.009	0.09			2			2
Northern Hawk-Owl				0.009	0.009					1	1	
Unidentified woodpecker	0.009						1					
Three-toed Woodpecker	0.009		0.037	0.046			2		4	5		
Northern Flicker	0.009					0.009	1					1
Olive-sided Flycatcher	0.102	0.046	0.139	0.083	0.037	0.028	13	5	16	9	4	4
Western Wood-Pewee	0.009						1					
Alder Flycatcher		0.009						1				
Hammond's Flycatcher			0.009						1			
Gray Jay	0.352	0.241	0.167	0.352	0.306	0.241	56	45	22	59	44	38
Black-billed Magpie		0.009			0.009	0.009		1			1	3
Common Raven	0.028			0.009	0.009	0.009	5			1	2	1
Boreal Chickadee	0.093	0.157	0.074	0.093	0.139	0.102	18	26	12	15	18	18
Arctic Warbler					0.009						1	
Ruby-crowned Kinglet	0.102	0.139	0.111	0.287	0.296	0.185	16	20	12	44	41	22
Gray-cheeked Thrush	0.065	0.028	0.102	0.083	0.065	0.009	8	4	15	10	9	1
Swainson's Thrush	0.546	0.713	0.472	0.463	0.491	0.491	96	163	92	92	92	103
Hermit Thrush	0.009	0.056	0.019	0.065	0.167	0.083	1	9	4	8	22	11
American Robin	0.509	0.435	0.435	0.546	0.481	0.426	72	67	62	99	72	63
Varied Thrush	0.407	0.574	0.463	0.528	0.407	0.417	63	114	81	115	76	62
Bohemian Waxwing	0.046	0.028		0.028	0.019		7	14		7	3	
Orange-crowned Warbler	0.287	0.167	0.296	0.148	0.231	0.213	41	22	46	28	29	32
Yellow-rumped Warbler	0.37	0.657	0.565	0.62	0.537	0.407	63	117	89	118	96	79
Blackpoll Warbler	0.009					0.009	1					1
Northern Waterthrush	0.009				0.009		2				1	
Yellow Warbler					0.009	0.056					1	11
Wilson's Warbler	0.296	0.361	0.389	0.361	0.314	0.407	45	54	56	65	46	63
American Tree Sparrow	0.296	0.296	0.315	0.176	0.296	0.287	57	80	60	33	54	60
Savannah Sparrow	0.056	0.13	0.093	0.139	0.12	0.074	20	25	13	27	19	14
Fox Sparrow	0.046	0.093	0.028	0.056	0.046	0.25	3	14	3	7	5	30
Lincoln's Sparrow	0.028	0.046		0.074	0.019	0.019	3	8		13	2	2
White-crowned Sparrow	0.611	0.722	0.769	0.593	0.759	0.787	153	219	210	181	245	258
Dark-eyed Junco	0.731	0.806	0.731	0.731	0.741	0.778	170	201	157	200	161	174
White-winged Crossbill	0.111	0.398	0.019	0.074	0.129	0.074	64	522	8	90	42	5
Redpoll species	0.657	0.259	0.361	0.389	0.278	0.222	172	49	49	94	45	36
Pine Siskin			0.009						1			
Total number of species	31	26	27	30	32	30						

Riparian Habitat

Sixteen species were detected on the riparian census route in the Moose Creek Drainage (Table 5). Ten species were detected at >16% of the total number of sampling points, including Spotted Sandpiper, Gray-cheeked Thrush, Swainson's Thrush, Ruby-crowned Kinglet, Blackpoll Warbler, Wilson's Warbler, Fox Sparrow, White-crowned Sparrow, Dark-eyed Junco, and Redpoll spp. Blackpoll Warbler were not detected consistently on other routes in DENA. This species has been designated a species of management concern, by the Boreal Partners in Flight working group.

Table 5. Total count and frequency of occurrence of birds detected in a riparian in the Moose Creek Drainage, at 12 points during 1998.

Species	Total Count	FO
Spotted Sandpiper	3	0.167
Hammond's Flycatcher	1	0.083
Ruby-crowned Kinglet	1	0.083
Gray-cheeked Thrush	5	0.333
Swainson's Thrush	19	0.750
Varied Thrush	1	0.083
Orange-crowned Warbler	20	0.833
Blackpoll Warbler	9	0.667
Northern Waterthrush	2	0.167
Wilson's Warbler	36	0.917
American Tree Sparrow	2	0.083
Savannah Sparrow	1	0.083
Fox Sparrow	19	1.000
White-crowned Sparrow	30	0.917
Dark-eyed Junco	5	0.167
Redpoll	7	0.417
Total	161	

Alpine Habitat

We surveyed six independent point-count stations in alpine habitat. The species richness for this route included seven species detected at >50% of all routes, including Horned Lark,

American Robin, American Pipit, and White-crowned Sparrow. Horned Lark and American Pipit were not detected in other habitat types in DENA. Upland Sandpipers are commonly found in alpine habitats and were also detected on this route.

Total count and frequency of occurrence of birds detected in an Alpine Tundra Route (Camp Ridge) at six sampling points during 1998.

Species	Total Count	FO
Upland Sandpiper	1	0.167
American Pipit	6	0.667
American Robin	6	0.833
Hermit Thrush	1	0.167
Fox Sparrow	1	0.167
White-crowned Sparrow	3	0.500
Horned Lark	3	0.500

6. Discussion

We recalculated frequency-of-occurrence estimates from previous years because an error of pseudoreplication was found in previous analyses. When points are pseudoreplicated, the sample size is artificially inflated, thus incorrectly decreasing the variance estimate. These estimates will become more important when analyses are used to determine long-term trends in landbird populations. Herein, we review the species that DENA has the power to monitor, based on new FO estimates.

Paton et. al. (1994) stated that if ≥100 on-road and 108 off-road point counts in spruce forest are surveyed, species that occur at >14% of point-count stations can be monitored with a 90% probability of detecting a 50% decline over a 25-year period. We conducted 86 on-road point counts this year. In addition, NPS conducts one on-road BBS route consisting of 50 points. If these routes are combined, NPS can reach their monitoring goals with substantial power. Data

from previous years should be analyzed to determine consistency between ABO and NPS data collection prior to combining these routes. If NPS retains 100 on-road point counts and 108 off-road point counts, twelve species can be monitored with the current protocol; Gray Jay, Swainson's Thrush, American Robin, Varied Thrush, Orange-crowned Warbler, Yellow-rumped Warbler, Wilson's Warbler, American Tree Sparrow, Savannah Sparrow, Fox Sparrow, White-crowned Sparrow, Dark-eyed Junco, and Redpoll spp.

In addition to these 12 species, several species could be monitored if we expanded the number of point counts in low-, medium-, and tall-shrub habitats; e.g., Alder Flycatcher, Gray-cheeked Thrush, and Arctic Warbler. Surveys in 1998 indicate more off-road points in riparian-mixed forest and alpine tundra, could allow us to monitor Upland Sandpiper, Spotted Sandpiper, Horned Lark, American Pipit, Blackpoll Warbler, and Northern Waterthrush, although our sample sizes were not great enough to conduct power calculations.

Off-road surveys in riparian habitats included high detections of Blackpoll Warblers. This species was not commonly detected elsewhere on our surveys in DENA. This species is designated a "priority bird species" by the BPIF working group and should be considered in land use plans, project planning, impact assessments, research, monitoring, outreach, and other activities.

Surveys conducted in alpine habitats can be conducted quickly, as footing is stable. Therefore, we suggest 12 points be conducted at 500-m intervals rather than 250-m intervals. We completed the alpine survey in three hours and suggest that 12 points could be conducted in the allotted time (3:30-9:00 AM).

7. Recommendations

1. Off-road point counts should stratify habitat types throughout the park.

Prior to 1998, off-road surveys were conducted exclusively in spruce-dominated forest stands. The previous protocol adequately monitors birds that use this habitat type; however, other species that are abundant in DENA may not be detected in spruce habitats. Paton and Pogson (1996) analyzed habitat use of passerines along the park-road corridor. Species richness was greatest in shrub habitats and lowest in mixed forest and tundra habitats (Paton and Pogson 1996). Although DENA does not have a habitat map, off-road surveys should represent common habitat types in the park. We suggest a more concerted effort be made to obtain point-count data that stratifies DENA in shrub, tundra, and mixed forest habitats, in addition to the current surveys in spruce forest.

2. Determine causes/effect relationships for changes in population trends.

Studies that examine demographic parameters of migratory bird populations are critical to identifying the proximate causes of population fluctuations (Temple and Wiens 1989; Verner 1992). Currently, the park monitoring protocol relies on ratios of adults to juveniles as an estimate of avian productivity, based on the MAPS protocol. Studies testing the assumption that mist-netting protocols can monitor productivity have found interspecific variation in the relationship between mist-net captures and actual productivity (determined by nest searching) (e.g. Chase et. al. 1996). The assumption that the MAPS protocol can monitor productivity has not been tested in DENA. Intensive nest searches would test the MAPS protocol and provide insight into causes for bird population declines if they occur. For example, nest searches may yield insights into increased predation rates caused by an influx of predators. Additionally, climatic and vegetative data could be incorporated into models that predict success of the

breeding season. These data are critical to understanding population dynamics of migrant and resident landbird species.

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Appendix 3. Map of on-road and off-road bird surveys in DENA