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Natural Resource Program Center

Breeding Bird Monitoring at Isle Royale National Park, Michigan: 1996-2008

Natural Resource Technical Report NPS/GLKN/NRTR—2009/160

ON THE COVER
Swamp Sparrow (*Melospiza georgiana*) nest at Lake Benson shoreline, Isle Royale National Park.
Photograph by: Alexander Egan.

Breeding Bird Monitoring at Isle Royale National Park, Michigan: 1996-2008

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Abstract

Standardized, unlimited distance point counts were conducted on established trails at Isle Royale National Park from 1996 to 2008. Eight routes, with a total of 130 points, spanned the island. Species used in data analyses were those appropriately sampled by point count methods in forested terrain. An average of 1,424 individuals representing 57 species was detected annually. Eighty-five species from twenty-five families were identified during the 13-year period. In order to track changes in abundance over time, linear regression analyses were reported for most species that were detected. Significant increases were found for ten species: pileated woodpecker, golden-crowned kinglet, brown creeper, song sparrow, hairy woodpecker, hermit thrush, Wilson's snipe, yellow-bellied flycatcher, alder flycatcher, and red-breasted nuthatch. Significant declines were found for eight species: Cape May warbler, evening grosbeak, least flycatcher, rose-breasted grosbeak, chipping sparrow, Tennessee warbler, common raven, and Canada warbler. Isle Royale trends were compared to regional analyses by state, regional forest ecosystem, and regional national forests. Results were generally consistent with other studies. Findings from annual park reports, including diversity measurements for each route and comparison of species richness detected on point counts with a recent, five-year breeding bird atlas are discussed. These results demonstrate that the Isle Royale bird survey is a useful tool that park managers can utilize for identifying species of concern on the island, while both the public and regional land managers can benefit from the general information revealed on this widely valued group of vertebrates.

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Introduction

To successfully manage a landscape, it is necessary to have a basic knowledge of local species and how those species fare over time. Avian communities have been viewed as possibly the most straight-forward and useful group of organisms to both survey and use as a proxy of overall community health, including primary productivity (Lin et al. 2008). Songbirds are commonly studied by land managers because male advertisement (singing) provides a relatively simple way to identify species during the breeding season and because the varying habitat requirements of birds offer an opportunity to detect broader changes in the landscape (May 1982; Etterson et al. 2007). At Isle Royale National Park, Michigan, passerines and many other species have been monitored with point counts along established trails. Isle Royale offers the unique landscape of a large, isolated island, surrounded by a large lake, with minimal human intrusion and habitats that have been federally protected from direct human-caused changes for nearly 70 years.

There has been at least a century of work on avian populations at Isle Royale. Historical reports include annotated checklists describing resident, breeding, and migrant birds (M'Creary 1909; Peet 1909; Krefting et al. 1966; Johnsson et al. 1981) and a non-annotated checklist (Janke et al. 1994). Efforts to note unique birds or behaviors include Van Buskirk and Smith (1984), Martin (1989), and Gostomski (1996). Studies that attempted to locate all species breeding on the island include two atlas surveys (Brewer et al. 1991; Kalamazoo Nature Center in press). The most recent atlas, utilizing data collected from 2002-2008, documented 144 species during the breeding season, with 79 species confirmed breeding on the island. An additional 44 of the non-confirmed species were likely to be regular breeding species (Egan, unpublished data).

The National Park Service's Inventory and Monitoring program, of which this survey is a part, has been essential to identifying species and tracking populations within park units. Isle Royale National Park established a formal breeding bird survey in 1994 (Gostomski and Oelfke 1994). Since that time, the survey objectives have been: 1) to determine the size and composition of the Neotropical (long-distance) migrant, continental (short-distance) migrant, and resident passerine communities and other species detectable by point count protocols; 2) to annually monitor these communities and make general comparisons between years; and 3) to compare the status of these communities with other regional populations. In 1996, all points were permanently tagged, ensuring that observers sampled the same locations annually. Consequently, annual analyses are now confined to the data from 1996-present. The current 13-year dataset offers a baseline look at species occurring at Isle Royale and their general trends from 1996 to 2008. As surveys continue into the future, analyses should allow for identifying species of concern, detecting rare birds, detecting declining trends before they become critical, tracking changes due to habitat succession or management actions, and giving a general status of avian populations (Thomas and Martin 1996; Bart 2005). A list of common and scientific names for each species is included in the appendix.

Study Area

Isle Royale National Park (Keweenaw County, Michigan, USA) is an archipelago of one main island surrounded by several hundred smaller islands in northwestern Lake Superior, approximately 100 km (60 mi) north of Houghton, Michigan, and approximately 32 km (20 mi) east of Grand Portage, Minnesota (Figure 1). The park encompasses 544 km^2 (210 mi^2, >132,000

acres) of land, but the park boundary extends out four miles from shore, making the total park area 2200 km^2 (850 mi^2) including Lake Superior waters. Ninety-nine percent of the land base is federally designated wilderness. The Lake Superior shoreline is pocketed by many bays, harbors, peninsulas, and islands, particularly on the northeastern half of the island. Long, narrow inland lakes and wetlands are generally created by the ridge-and-valley topography of the island due to tilted bedrock (Huber 1973). The forest-dominated terrestrial ecosystems are principally composed of northern hardwoods (*Acer saccharum* and *Betula alleghaniensis*) in western portions of the park, and boreal forest (*Picea glauca*, *Abies balsamea*, *Populus tremuloides*, and *Betula papyrifera*) in eastern portions of the park (McInnes et al. 1992).

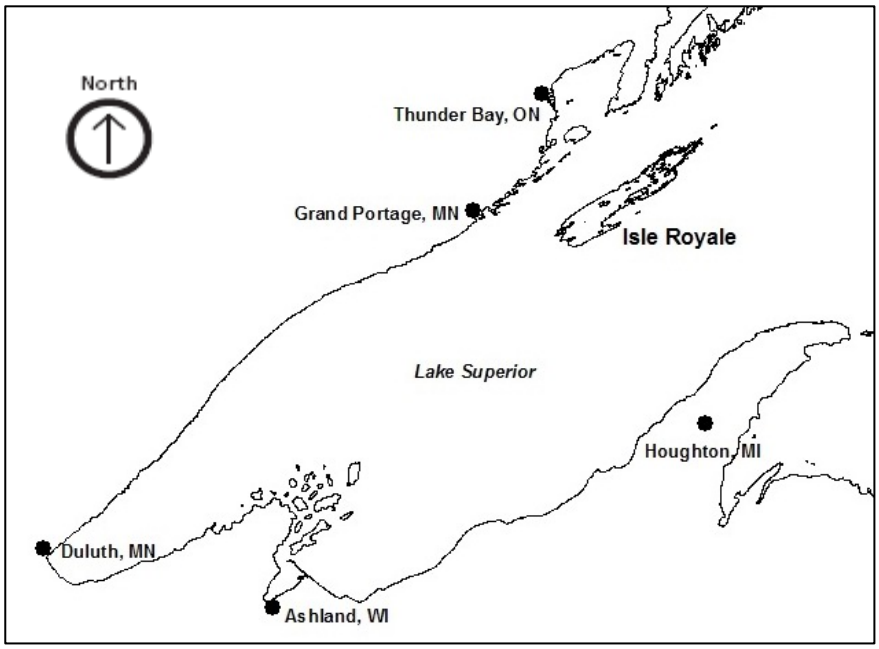


Figure 1. Map of western Lake Superior, including Isle Royale.

Methods

Survey Techniques

The point count methods and analyses incorporated here have been commonly used in North America (Ralph et al. 1993; Ralph et al. 1995; Nur et al. 1999), and have also appeared to work well for unlimited distance point counts in heavily forested habitats (Howe et al. 1997). Surveys were conducted at 130 points distributed along eight transects (hiking trails) on Isle Royale and Passage Island (Figure 2, Table 1). Six transects (FELK, ISTR, MTOJ, PASS, TMLC, WIND) were established in 1994 based on GIS analysis of island habitats. Stratification was used to place points in most of the island's general habitats, although upland habitats were favored due to trail construction practices (Gostomski and Oelfke 1994). In 1995, sampling shifted from intensive coverage (by habitat) to extensive coverage in which all parts of the island were represented. To this end, the LRGR route was added in 1995, which placed a second route in the central portion of the island (Gostomski and Oelfke 1995), and the CHLR route was added in 1996, which established a shoreline-to-ridgetop gradient (Beeman and Oelfke 1996). As a result of route placement, and due to the general topography of upland and lowland habitats being in close proximity, most habitats across Isle Royale were at least partially represented during breeding bird surveys. Because this has not been quantified, current analyses have not taken habitat associations into account, but future objectives include habitat and distance measurements.

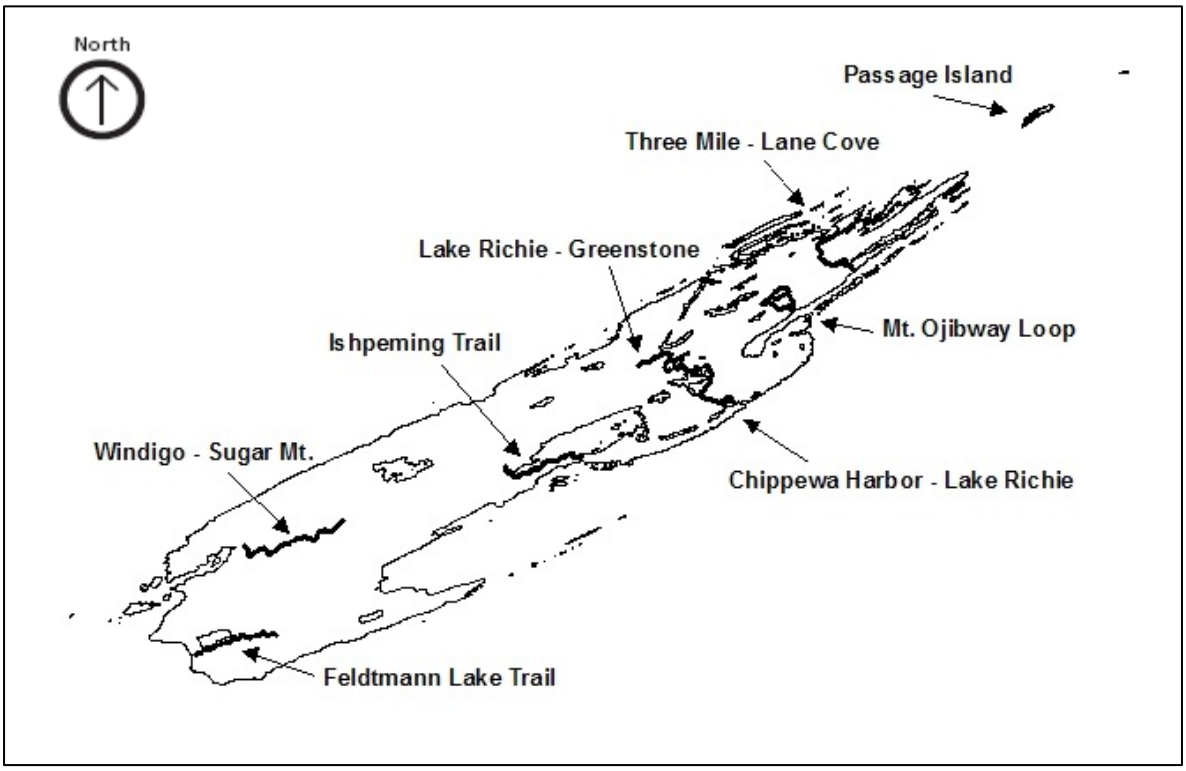


Figure 2. Map of Isle Royale, including the general locations of the eight bird survey routes.

Roadside point counts have been known to increase the likelihood of detecting species that prefer edge habitats, but narrow roads in otherwise intact forest habitats have not generally appeared to reduce detection of forest species, particularly if the canopy was intact over a single-lane road and there was essentially no change in adjacent vegetation (Keller and Fuller 1995; Hanowski and Niemi 1995; Hutto et al. 1995). Since all Isle Royale transects were in federally designated wilderness or land managed as de facto wilderness, and were located on narrow foot trails, it is probable that there were no edge effects influencing species detection or habitat use.

Table 1. Breeding bird survey transect locations, length of transects, and number of tagged survey points at Isle Royale National Park, 1996-2008.

Transect	Transect Length, km (mi)	Number of Points
Passage Island (PASS)	1.3 (0.8)	4
Three Mile-Lane Cove (TMLC)	6.9 (4.3)	16
Chippewa Harbor-Lake Richie (CHLR)	6.4 (3.9)	16
Mt. Ojibway Loop (MTOJ)	8.2 (5.1)	19
Lake Richie-Greenstone (LRGR)	7.8 (4.8)	20
Ishpeming Trail (ISTR)	7.0 (4.3)	18
Feldtmann Lake Trail (FELK)	7.0 (4.3)	16
Windigo-Sugar Mt. (WIND)	8.3 (5.1)	21
Totals	52.9 (32.6)	130

Points were approximately 0.4 km (¼ mi) apart, and had a tagged tree associated with each in order to relocate the same spot. Points were visited once annually between 0530 (approximately ½ hour before sunrise) and 1000 EDT by one skilled observer and usually one recorder. The window for accomplishing routes was approximately 10 June - 30 June. Surveys were never conducted before 10 June, but poor weather conditions pushed some surveys into the first few days of July. Temperature, cloud cover, and wind were recorded at each point. Unlimited radius point counts were five minutes in duration, during which all species were recorded and categorized as "seen", "heard", or "flyover." Data were recorded in one-minute intervals. Birds not heard or seen during the five-minute count but present at a census point before or after the count period, or while walking between points, were recorded as "miscellaneous." Miscellaneous species were not included in the data analysis.

Surveys were not conducted, or were discontinued, if weather requirements were not met. Rain and fog were not acceptable conditions, except for very light rain if singing did not appear to be influenced (this occasionally happened on the last few points of a route). Wind was the overwhelming problem for Isle Royale bird surveys. Wind speeds of >16 km/hr (10 mph) were avoided. It was not uncommon for a particular route to take several days to accomplish in order to satisfy wind speed requirements.

Prior to the standardization of point locations in 1996, observers estimated a distance of 250 m between points. Consequently, the number of points completed in 1996 and 1997 varied due to

the slower hiking abilities of some observers (resulting in fewer points accomplished on some transects), or to an inability to find tagged trees, which caused observers to revert to the pattern of estimating hiking distances (Beeman and Oelfke 1997). Since 1998 the only fluctuations in number of points surveyed were due to unacceptable weather conditions late in the morning and no opportunity to return and finish the route at a later date.

Bibby et al. (2000) described many sources of bias that typically occur in bird surveys. The Isle Royale survey methods addressed sources of bias by incorporating standard techniques to estimate bird populations on the island (Ralph et al. 1995). The same three observers have done the surveys since 2000; all had extensive experience identifying by sight and sound the species that were expected to occur on the island, knew island habitats, and were highly motivated to produce quality work. Pre-2000 observers were known or presumed to have had equal skills and motivation.

Data Analysis

All passerines detected during point counts were included in analyses. For many non-passerine species, such as gulls, raptors, waterbirds, and nocturnal species, point count protocols were not generally considered appropriate. Landbirds such as woodpeckers (Picidae), kingfishers (Alcedinidae), swifts (Apodidae), and cuckoos (Cuculidae) were included because it has been thought that these groups can be sufficiently surveyed by the point count method (Ralph et al. 1993; Ralph et al. 1995; Howe et al. 1997). With vocal displays for mate attraction and territoriality fulfilling the same role as in landbirds, three additional species were included in data analysis: American bittern, sora, and Wilson's snipe. The majority of unknown observations (birds detected but not identified to species) were woodpeckers. Without direct visual observation, and due to indistinguishable overlap in many non-vocal noises made by woodpeckers, species confirmation could not be made in some instances. Individuals not identified to species were not included in analyses.

Simple linear regression analyses were done in the program JMP® 7.0 (©SAS Institute Inc. 2007), using the total annual count for each species as the dependent variable and time (year) as the independent variable. As suggested by Nur et al. (1999), the annual total counts for each species were log-transformed prior to trend analysis. The logarithmic transformation enables the slope parameter estimates from the regressions to be interpreted as an instantaneous rate of change, or an average proportional change in the population over time. Moreover, using log-transformation helps the data better fit the assumptions inherent in linear analysis and reduces variability around the trend line. In order to include years where no individuals were detected for a given species, an ecologically important event, particularly for species in serious decline, annual totals for all species had a one (1) added before log transformation (thus, log[x+1]; Southwood and Henderson 2000).

Isle Royale regression data were compared to trends for Minnesota, Michigan, Ontario, and to much wider, habitat-based strata of Northern Spruce Hardwoods (including northern portions of Minnesota, Wisconsin, and the entire upper peninsula of Michigan) and Closed Boreal Forest (a belt across Canada including nearly the entire northern shore of Lake Superior) (Sauer et al. 2008). These regional data were calculated differently due to the unique challenges of interpreting the road-based, continent-wide data used for the North American Breeding Bird Survey (see Geissler

and Sauer 1990 for details), and the time frame in which the data were collected is different (1980-2007). Nonetheless, they are very useful as a broader index of species trends. In western Ontario and the states surrounding Lake Superior, the Northern Spruce Hardwoods and Closed Boreal Forest strata are comparable to the more widely known Bird Conservation Regions of Boreal Hardwood Transition and Boreal Softwood Shield, respectively (Rich et al. 2004).

Trends were calculated for all species that occurred in at least three years between 1996 and 2008. These trends can indicate an implied relationship of annual populations to time, so that a significant trend suggests a strong change during the 13-year period, either increasing or decreasing, but a weak trend generally appears to indicate that numbers are too variable for a trend to have been revealed. P-value and r^2 are included with species trends, allowing the reader to draw their own conclusions regarding a trends' ecological importance. Further statistical details (mean, standard deviation, variance, r^2, adjusted r^2, root mean square error, f-test and t-test with P-values, skewness, kurtosis, and the 95% confidence intervals) for the regression coefficient of each species can be found in Egan (2008b).

Results

In most years, all 130 points were surveyed (Table 2). An average 1,424 individuals representing 57 species were recorded during the 13-year period. Both the number of species (62) and individuals (1,739) in 2007 were the highest recorded, while the fewest species (53) were recorded in 2006 and the fewest individuals (1,028) were recorded in 1998 (Table 2). Six species failed to be detected during the 5-minute point counts, although they were detected at other times during the survey: brown-headed cowbird, Connecticut warbler, pine grosbeak, tree swallow, willow flycatcher, and yellow-headed blackbird.

A total of 85 species from 25 families were detected during point counts between 1996 and 2008. The number of species detected, by family, was dominated by wood-warblers (Parulidae), with 21 species. Tyrant flycatchers (Tyrannidae) comprised the second most common family, with eight species. Wood-warblers similarly dominated the number of individuals detected during point counts, while sparrows (Emberizidae) were the second most common group (Egan 2008a).

Unidentified individuals were generally woodpeckers (Picidae) making drumming or foraging sounds that could not be attributed to a particular species. Woodpeckers were probably the most biased population with regard to the ability to identify an individual, which was possibly why species such as black-backed and three-toed woodpeckers were not recorded during Isle Royale bird surveys. On occasion, individuals from other families fell into the unknown category if only a brief sound or sight was not enough to make identifications with certainty. Since 1999, an average of two individuals from non-Picadae families remained unknown during annual surveys (mean = 1.9/year, or an average of 1/10 of 1% of annual observations).

Isle Royale species that showed a statistically significant increase from 1996 to 2008 were pileated woodpecker (trend = +0.06, P = 0.003), golden-crowned kinglet (trend = +0.06, P = 0.02), brown creeper (trend = +0.06, P = 0.04), song sparrow (trend = +0.04, P = 0.0002), hairy woodpecker (trend = +0.04, P = 0.01), hermit thrush (trend = +0.03, P = 0.006), Wilson's snipe (trend = +0.03, P = 0.009), yellow-bellied flycatcher (trend = +0.03, P = 0.02), alder flycatcher (trend = +0.03, P = 0.04), and red-breasted nuthatch (trend = +0.02, P = 0.01) (Table 3, Figure 3). While P indicates statistical significance, the trend indicates the biological importance, in terms of a species' average proportional change during the time period, of changes for each species (e.g., pileated woodpeckers appeared to increase an average of 6% annually between 1996 and 2008). These species were detected in all thirteen years except for golden-crowned kinglet, which was detected in twelve of the thirteen years. In total, 47 species had increasing trends, ten of which were significant (Table 4).

Isle Royale species that showed a statistically significant decrease from 1996 to 2008 were Cape May warbler (trend = -0.10, P = 0.001), evening grosbeak (trend = -0.09, P = 0.002), least flycatcher (trend = -0.07, P = 0.006), rose-breasted grosbeak (trend = -0.05, P = 0.003), chipping sparrow (trend = -0.05, P = 0.003), Tennessee warbler (trend = -0.04, P = 0.05), common raven (trend = -0.03, P = 0.005), and Canada warbler (trend = -0.03, P = 0.03) (Table 3, Figure 4). Of these species, only common raven and chipping sparrow were detected in all thirteen years. A total of 24 species had decreasing trends, eight of which were significant (Table 4).

Table 2. Comparisons of species and individuals detected during bird surveys, by year, including number of points surveyed annually at Isle Royale National Park, 1996-2008.

	Year															
	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	Mean	Min	Max
No. of points surveyed	133	122	130	130	129	130	130	130	126	130	130	130	130	129	122	133
No. of species	57	58	61	60	60	55	54	55	56	54	53	62	59	57	53	62
No. of individuals	1,430	1,261	1,028	1,610	1,441	1,426	1,513	1,451	1,090	1,420	1,647	1,739	1,458	1,424	1,028	1,739

Table 3. Simple linear regression trends (average proportional change per year), r^2, and P-values for all species observed during 5-minute point counts at Isle Royale, 1996-2008.

	Study Area[1]							
Species[2]	Isle Royale[2]	Michigan	Minnesota	Ontario	NSH	CBF	r^2	P-value
Pileated woodpecker	**+ 0.06**	++	++	++	++	+	0.56	0.003
Golden-crowned kinglet	**+ 0.06**	++	+	+	+	–	0.41	0.02
Brown creeper	**+ 0.06**	+	▪	+	+	▪	0.34	0.04
Song sparrow	**+ 0.04**	▪	–	–	–	–	0.74	0.0002
Hairy woodpecker	**+ 0.04**	–	+	++	++	+	0.47	0.01
Hermit thrush	**+ 0.03**	++	+	+	++	+	0.52	0.006
Wilson's snipe	**+ 0.03**	–	–	– –	– –	–	0.48	0.009
Yellow-bellied flycatcher	**+ 0.03**	▪	▪	–	+	+	0.40	0.02
Alder flycatcher	**+ 0.03**	+	–	–	–	–	0.34	0.04
Red-breasted nuthatch	**+ 0.02**	++	+	+	++	+	0.43	0.01
Red crossbill	+ 0.07	▪	▪	▪	+	▪	0.28	0.07
Red-winged blackbird	+ 0.04	– –	– –	– –	– –	–	0.29	0.06
Black-capped chickadee	+ 0.03	+	+	++	++	++	0.29	0.06
Northern waterthrush	+ 0.03	–	– –	–	▪	+	0.21	0.11
American goldfinch	+ 0.03	++	+	+	++	+	0.16	0.17
Sora	+ 0.02	▪	–	▪	+	▪	0.29	0.06
Nashville warbler	+ 0.02	+	– –	–	– –	+	0.27	0.07
Common yellowthroat	+ 0.02	–	–	–	– –	–	0.24	0.09
Mourning warbler	+ 0.02	–	– –	– –	– –	– –	0.22	0.11
Blue jay	+ 0.02	+	–	+	++	++	0.18	0.15
Veery	+ 0.02	+	–	– –	– –	++	0.12	0.24
Chimney swift	+ 0.02	–	– –	– –	– –	▪	0.07	0.40
Cedar waxwing	+ 0.02	– –	–	– –	– –	+	0.04	0.50
Winter wren	+ 0.01	+	–	++	++	+	0.20	0.12
Swamp sparrow	+ 0.01	–	++	++	++	++	0.20	0.13
Magnolia warbler	+ 0.01	+	–	+	+	+	0.16	0.18
Blackburnian warbler	+ 0.01	+	–	+	+	+	0.08	0.34
American bittern	+ 0.01	+	–	–	– –	+	0.07	0.38
Olive-sided flycatcher	+ 0.01	▪	–	– –	– –	–	0.07	0.39
Yellow-bellied sapsucker	+ 0.01	++	+	+	++	▪	0.06	0.42
Scarlet tanager	+ 0.01	+	–	–	– –	▪	0.05	0.47
Northern flicker	+ 0.01	– –	– –	– –	– –	–	0.05	0.48
Belted kingfisher	+ 0.01	–	–	– –	– –	–	0.04	0.52

Table 3. Simple linear regression trends (average proportional change per year), r^2, and P-values for all species observed during 5-minute point counts at Isle Royale, 1996-2008 (continued).

	Study Area[1]							
Species[2]	Isle Royale[2]	Michigan	Minnesota	Ontario	NSH	CBF	r^2	P-value
Blue-headed vireo	+ 0.009	++	—	+	++	+	0.02	0.67
Pine siskin	+ 0.007	▪	—	—	——	—	0.00	0.85
American robin	+ 0.005	++	—	—	—	—	0.05	0.45
Yellow-rumped warbler	+ 0.004	++	+	—	+	—	0.03	0.57
Indigo bunting	+ 0.004	—	——	++	++	▪	0.00	0.85
Northern parula	+ 0.004	++	+	+	++	+	0.00	0.87
Eastern wood-pewee	+ 0.003	+	—	——	——	▪	0.00	0.85
Ruby-crowned kinglet	+ 0.003	—	—	——	——	—	0.00	0.89
White-throated sparrow	+ 0.002	+	+	—	——	—	0.01	0.74
Swainson's thrush	+ 0.002	+	+	—	——	——	0.01	0.81
Purple finch	+ 0.002	+	—	—	—	—	0.00	0.90
Slate-colored junco	+ 0.002	+	▪	——	——	——	0.00	0.91
Black-throated green warbler	+ 0.001	++	—	+	++	—	0.00	0.88
Black-throated blue warbler	+ 0.0008	+	▪	+	++	+	0.00	0.96
Yellow-billed cuckoo	▪	++	—	—	—	▪	--	--
Mourning dove	▪	++	—	++	▪	▪	--	--
Eastern phoebe	▪	++	+	+	++	▪	--	--
Eastern kingbird	▪	——	——	——	——	▪	--	--
Philadelphia vireo	▪	▪	▪	++	++	++	--	--
Barn swallow	▪	——	——	——	——	—	--	--
Marsh wren	▪	▪	——	▪	——	▪	--	--
Sedge wren	▪	+	+	+	+	▪	--	--
Eastern bluebird	▪	++	++	++	++	▪	--	--
Gray catbird	▪	++	+	—	——	▪	--	--
Brown thrasher	▪	——	—	—	—	▪	--	--
Yellow warbler	▪	+	+	—	——	—	--	--
Yellow-breasted chat	▪	▪	▪	▪	▪	▪	--	--
Northern cardinal	▪	++	++	++	++	▪	--	--
Ovenbird	- 0.002	+	+	——	——	—	0.02	0.67
Red-eyed vireo	- 0.003	++	++	++	++	+	0.04	0.54
Gray jay	- 0.004	▪	—	+	—	—	0.00	0.90
Palm warbler	-.0.007	▪	▪	▪	+	▪	0.04	0.52
Black-and-white warbler	- 0.007	—	—	—	——	—	0.06	0.40

Table 3. Simple linear regression trends (average proportional change per year), r^2, and P-values for all species observed during 5-minute point counts at Isle Royale, 1996-2008 (continued).

Species[2]	Study Area[1]						r^2	P-value
	Isle Royale[2]	Michigan	Minnesota	Ontario	NSH	CBF		
White-winged crossbill	- 0.009	▪	▪	▪	—	—	0.00	0.84
Pine warbler	- 0.009	++	+	+	++	▪	0.03	0.56
White-breasted nuthatch	- 0.01	+	+	—	+	▪	0.05	0.46
Great crested flycatcher	- 0.01	—	+	— —	— —	▪	0.07	0.37
Chestnut-sided warbler	- 0.01	—	— —	—	—	— —	0.09	0.32
Bay-breasted warbler	- 0.02	▪	▪	+	— —	—	0.21	0.12
American crow	- 0.02	+	++	++	++	+	0.26	0.07
American redstart	- 0.02	+	+	—	— —	—	0.27	0.07
Black-billed cuckoo	- 0.03	—	— —	+	—	▪	0.12	0.25
Common grackle	- 0.03	— —	—	+	+	+	0.27	0.07
Downy woodpecker	- 0.03	—	+	—	+	—	0.28	0.06
Canada warbler	**- 0.03**	—	—	— —	— —	—	0.35	0.03
Common raven	**- 0.03**	++	+	+	+	+	0.53	0.005
Tennessee warbler	**- 0.04**	▪	—	— —	— —	— —	0.30	0.05
Chipping sparrow	**- 0.05**	+	+	—	— —	—	0.56	0.003
Rose-breasted grosbeak	**- 0.05**	—	—	— —	— —	+	0.56	0.003
Least flycatcher	**- 0.07**	— —	—	— —	— —	—	0.51	0.006
Evening grosbeak	**- 0.09**	—	— —	— —	— —	— —	0.61	0.002
Cape May warbler	**- 0.10**	▪	▪	—	—	—	0.63	0.001

[1] Non-Isle Royale data are from Sauer et al. (2008), and are given as trend direction and significance: — —/++ = P ≤0.05, —/+ = P >0.05. Missing data (▪) are due to low numbers detected on routes. NSH = Northern Spruce Hardwoods, CBF = Closed Boreal Forest (see text for details).

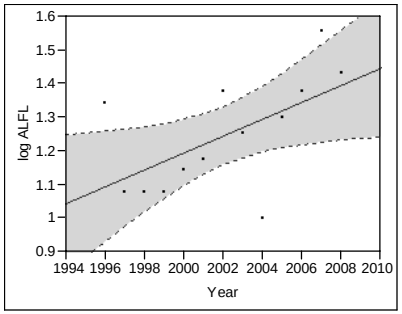
[2] Species and Isle Royale trends in bold indicate P ≤0.05.

Fourteen species were only detected in one or two years and were not included in trend analysis (Tables 3 and 4). Some species that were common and abundant had considerable annual fluctuations, with only a weak, uncertain trend detected (e.g., ovenbird and white-throated sparrow).

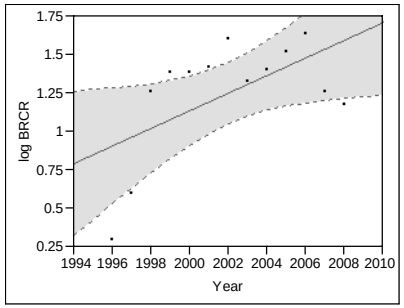
Table 4. Population trends for Isle Royale birds during point-count surveys, 1996-2008.

Trend	1996-2008
Increase	10 species (12%)
Decline	8 species (9%)
No statistical change	53 species (62%): 37 increasing (44%) and 16 decreasing (19%)
Insufficient data	14 species (16%)

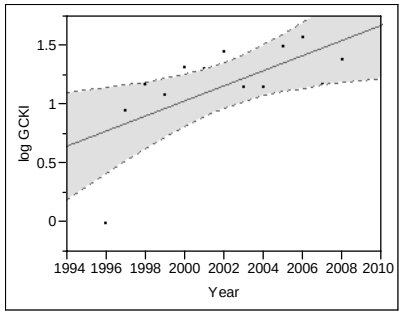
From 1996-2008, a high number of wood-warblers (Parulidae) were observed during point counts, both in terms of the diversity of species represented and in some of the most abundant numbers of individuals occurring annually (e.g., black-throated green warbler, Nashville warbler, and ovenbird). This result is similar to other studies in the Great Lakes region (Apostle Islands National Lakeshore 2005; Etterson et al. 2007). Finches (Fringillidae) and tyrant flycatchers (Tyrannidae), while having a high number of represented species, accounted for many fewer individuals. Some species, such as the winter wren (Troglodytidae) and red-eyed vireo (Vireonidae), were the dominant representative of their respective families (Egan 2008a).



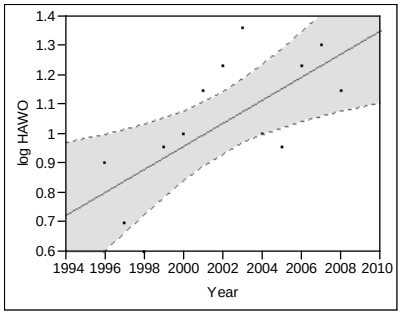
Alder flycatcher (ALFL)
r^2=0.34, P=0.04



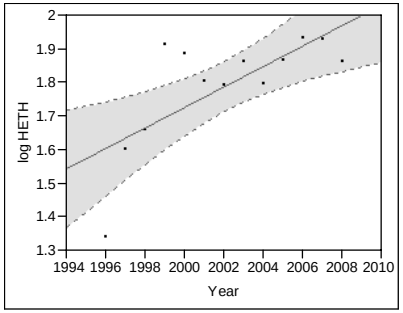
Brown creeper (BRCR)
r^2=0.34, P=0.04



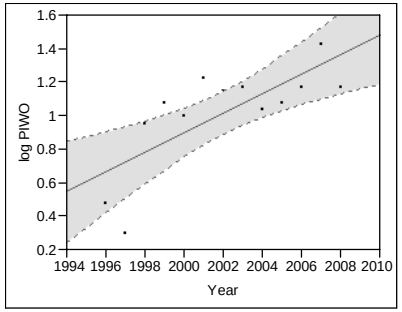
Golden-crowned kinglet (GCKI)
r^2=0.41, P=0.02



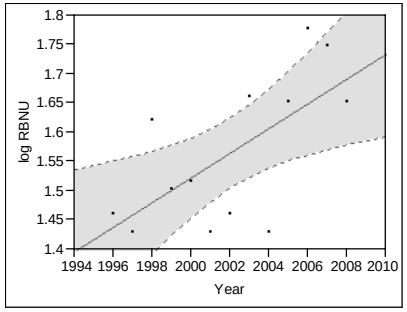
Hairy woodpecker (HAWO)
r^2=0.47, P=0.01



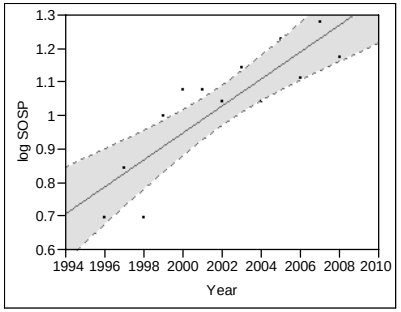
Hermit thrush (HETH)
r^2=0.52, P=0.006



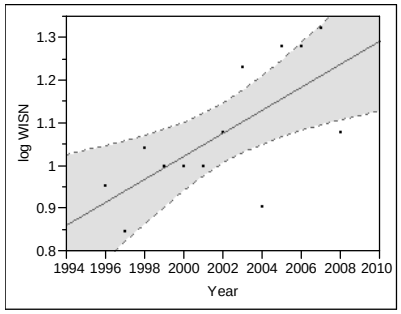
Pileated woodpecker (PIWO)
r^2=0.56, P=0.003



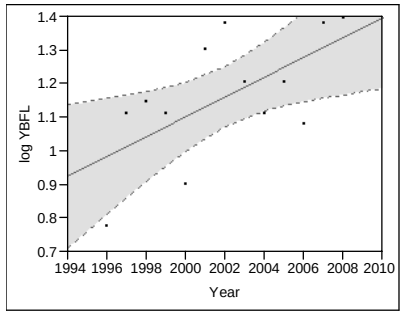
Red-breasted nuthatch (RBNU)
r^2=0.43, P=0.01



Song sparrow (SOSP)
r^2=0.74, P=0.0002

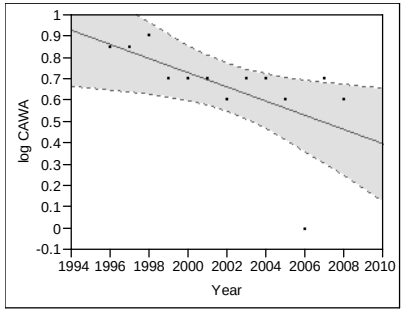


Wilson's snipe (WISN)
r^2=0.48, P=0.009

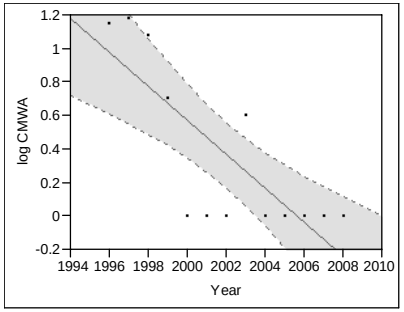


Yellow-bellied flycatcher (YBFL)
r^2=0.40, P=0.02

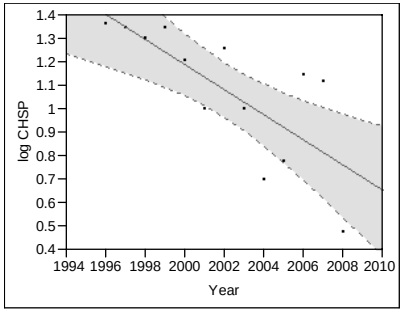
Figure 3. Bivariate fit (log by year) of species with statistically significant increases, Isle Royale National Park, 1996-2008. Trend line and 95% confidence intervals are shown.



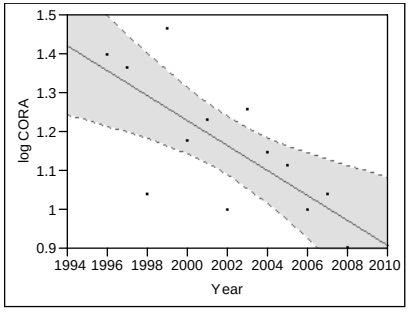
Canada warbler (CAWA)
r^2=0.35, P=0.03



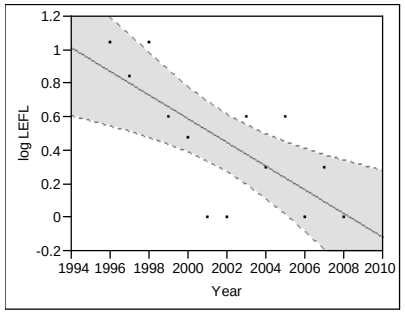
Cape May warbler (CMWA)
r^2=0.63, P=0.001



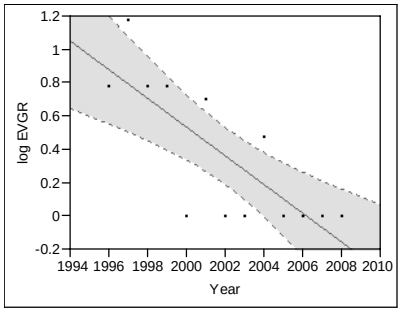
Chipping sparrow (CHSP)
r^2=0.56, P=0.003



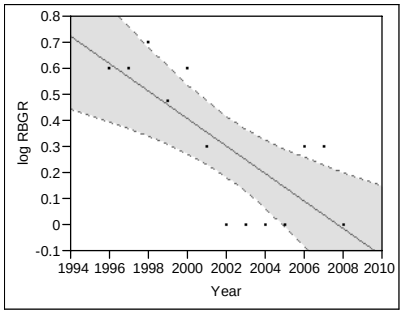
Common raven (CORA)
r^2=0.53, P=0.005



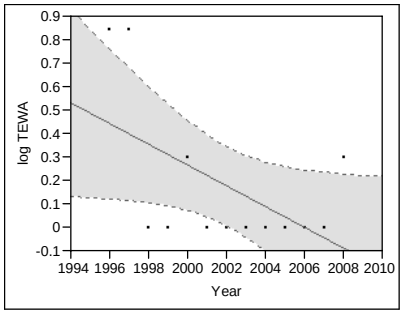
Evening grosbeak (EVGR)
r^2=0.61, P=0.002



Least flycatcher (LEFL)
r^2=0.51, P=0.006



Rose-breasted grosbeak (RBGR)
r^2=0.56, 0.003



Tennessee warbler (TEWA)
r^2=0.30, 0.05

Figure 4. Bivariate fit (log by year) of species with statistically significant declines, Isle Royale National Park, 1996-2008. Trend line and 95% confidence intervals are shown.

Discussion

The original goals of the Isle Royale breeding bird survey included assessing how avian species were faring over time and comparing results with other regional studies. Simple linear regression analysis has been the primary component addressed here, with diversity and species richness analyses noted for a slightly broader evaluation of avian community health. Detailed results beyond regression analyses can be found in annual park reports (e.g., Egan 2008a). Other factors, such as weather and habitat changes, have not yet been analyzed. The high numbers of both individuals and species detected in 2007 may have resulted from unusually calm and warm weather in mid-June, with no environmental noise to interfere with the location and identification of birds on most points. The low number of individuals in 2004 may be due to particularly cool and windy conditions, even though it appeared that migration was over in early June, as usual. Wind can reduce observer detection of individuals, while colder weather can inhibit singing (Bibby et al. 2000).

Regression Analysis and Trends

Even short-term studies can adequately detect trends, particularly if the sample size or magnitude of change is greater than 5% per year (Thogmartin et al. 2007). It is believed that Isle Royale data has the power to detect a 10% change in most species' abundance with the current 13-year dataset, and many species trends should have sufficient power to detect a 5% change (Lind et al. 2005). However, the detection abilities vary per species, with white-throated sparrow requiring only eight years of data to detect a 2% change, while veery would require up to 23 years to detect a 10% change (Lind et al. 2005). As a result, continued monitoring will bring a much more refined understanding of changes occurring among bird populations at Isle Royale, but the current dataset should provide an acceptable understanding of the general avian community.

Both the significantly increasing and decreasing trends (Table 3, Figures 3 and 4) were generally consistent with regional data except for song sparrow, Wilson's snipe, and alder flycatcher, which had declining trends regionally, and common raven, which had an increasing trend in all regional calculations (Sauer et al. 2008). It was an encouraging sign for Isle Royale populations that there were many more species with increasing trends (n = 47) versus species with declining trends (n = 24), although the non-significant trends must often be viewed with caution.

Many of the significantly declining species exhibited a limited but persistent presence during surveys in the late 1990s yet were nearly absent in surveys after 2000, leading to the notable results. These numbers may be informative in comparison to regional data and may help with inferences regarding larger population trends. The declines in already uncommon species could be a particular concern for those species, although significant declines in common species, such as chipping sparrow and common raven at Isle Royale, may be a more worrisome ecological sign (Gaston and Fuller 2007). Chipping sparrow and common raven have long been regular summer residents on the island (Krefting et al. 1966; Brewer et al. 1991).

Regional and Isle Royale data clearly show that Cape May warbler, evening grosbeak, least flycatcher, rose-breasted grosbeak, Tennessee warbler, and Canada warbler are all species that should be given special attention by land managers in the western Great Lakes region (Sauer et al. 2008) (Table 3). Canada warbler and Cape May warbler are federally listed as a species of

concern (USFWS 2002). Other species that have occurred on Isle Royale bird routes and are listed as species of concern are American bittern, black-throated blue warbler, and Connecticut warbler, all showing declines in both the Great Lakes and Boreal Hardwoods (Sauer et al. 2008). LeConte's sparrow, a species not detected on surveys but present in the park, has shown declines in these two regions and nationally, while black-billed cuckoo has shown declines in the Great Lakes and nationally. Finally, olive-sided flycatcher, sedge wren, and yellow-billed cuckoo have shown declines nationally (USFWS 2002).

Comparisons of Isle Royale data with regional data from three national forests in northern Minnesota and northern Wisconsin yielded mixed results (Etterson et al. 2006). Most species either generally fit the trend results from national forests or non-significant trends did not make for strong comparisons. Species showing significant increases in both studies were hairy woodpecker, red-breasted nuthatch, and golden-crowned kinglet. Species showing significant declines in both studies were Tennessee warbler, rose-breasted grosbeak and evening grosbeak. Species with contradictory results were song sparrow (significant declines in at least one national forest, but significant increases at Isle Royale) and Canada warbler and chipping sparrow (significant increases in at least one national forest, but significant declines at Isle Royale). These varied results reveal the importance of studying populations from many land units and diverse ecological landscapes within the same region, exposing a more complex pattern of change. Elias (1997) found that some species showing strong declines elsewhere in the region were common in her study area in northern Wisconsin, which was presumably due to mostly undisturbed habitat components there; this may be similar to the situation at Isle Royale.

Species Diversity and Richness

Diversity, as measured by the Simpson Index of Diversity (Southwood and Henderson 2000), has been generally accepted as an important component of resilience and health in ecological systems (Magurran 1988; Loreau et al. 2001; Secretariat of the Convention on Biological Diversity 2006). Isle Royale diversity values appeared to be relatively high (0.94-0.95) and annually stable (2-3% range of variation) on six of the eight routes (Egan 2008a). On the index scale of 0-1, these results indicated a highly diverse and relatively evenly distributed population and can serve as stand-alone indicators (Buckland et al. 2005; Payne et al. 2005). Lower diversity values were found for the Windigo (13 year mean = 0.89) and Passage Island (13 year mean = 0.86) routes. The Windigo route traverses a relatively uniform habitat of mature sugar maple/yellow birch forest and was expected to have a lower diversity value due to lower species richness, fewer individuals, and the more abundant species consequently driving the statistic with greater influence. Passage Island likely had a lower diversity because of the low number of points (4) and because surveys typically yield one or two species with very high abundance.

From 2002-2008 an island-wide breeding bird atlas was coordinated in conjunction with a state-wide effort led by the Kalamazoo Nature Center. During atlas efforts, 97 landbird species that fit the current point count protocol requirements were documented, with 84 (87%) of those species also detected during point counts (Egan, unpublished data). Species detected during the atlas surveys but not during point counts were presumably either (a) known breeding species that were not well represented by route habitats (e.g., sedge wren, barn swallow, and tree swallow), (b) species that were probably breeding but have proven rare and difficult to detect during point counts (e.g., black-backed and American three-toed woodpeckers, Connecticut warbler,

Baltimore oriole and pine grosbeak), or (c) cryptic species that may have been present but went undetected during point-counts (e.g., LeConte's sparrow and brown-headed cowbird). Yellow-billed cuckoo and yellow-breasted chat were the only species detected during point counts that were not detected in atlas observations, with the latter species outside of its normal breeding range.

The variation observed in species numbers from year to year was often due to uncommon species, such as eastern wood-pewee or scarlet tanager, being missed altogether in some years (Egan 2008a). It was generally noted that these species were present but were not detected during point counts (pers. obs.). Some variation was also due to rare species that were observed in only a handful of years, such as eastern bluebird and northern cardinal.

Conclusions

Careful investigations using widespread and tested techniques, such as point-counts, offer an "early-warning" system for managers (Barker and Sauer 1995). The inventory portion of this project is generally well established, especially when point count data are compared to breeding evidence during atlas surveys (although some species that are known or suspected to be breeding at Isle Royale have not yet been observed during survey point counts).

Isle Royale results generally match other findings for species occurring in the western Great Lakes region, particularly for species showing significant change. Confidence in some of the non-significant results remains low, generally due to either high variability in annual numbers, which makes a trend difficult to detect, or when annual counts of a species are low. Still, these numbers offer a best-estimate trend that helps shed light on the status of bird populations at Isle Royale. In addition, the trends at Isle Royale are useful in conjunction with trends on larger scales to augment a "big-picture" analysis (Sauer et al. 2007; Etterson et al. 2007).

Diversity appears reasonably high both annually and as a long-term average. One could speculate that high diversity and species richness is due to the protected, remote aspects of Isle Royale habitats, along with the representation of various habitats on most routes (Bohning-Gaese 1997; Twedt et al. 1999; Hamer and Hill 2000; Hobson and Bayne 2000; Buckland et al. 2005). In addition, the upper Great Lakes are included in a band of high avian diversity in North America (Robbins et al. 1986). Although it would be ideal to know the causes of population changes at Isle Royale, the current methods are probably inadequate to reveal more than correlations between avian communities and factors such as habitat or climate change. Weather and localized noise are the only factors known to influence results, although these estimations are currently anecdotal.

Long-term annual monitoring of avian communities is expected to continue. This consistency is important for expanding the current dataset, but it is vital also because monitoring projects are intended to give baseline data for potential future needs that are as-yet unidentified. If it is found that a species in the breeding bird survey dataset is in need of specific monitoring and is not being well represented by the current methods, additional survey efforts can be implemented to better track the species in question (Ralph et al. 1993). It is fortunate that Isle Royale National Park encompasses a complete ecological system (a large, remote island) and has a strong preservationist mandate within its political boundaries (Wilderness Act 1964; Saetersdal et al. 1993; Reyers et al. 2000). Because of this high level of protection from direct threats, and because the indirect threats (climate, atmospheric pollution, land-use changes on migration or wintering grounds) are outside the purview of park managers, general monitoring is probably a sufficient level of research for most avian species at Isle Royale.

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Appendix. Common and scientific names for bird species (AOU 1998).

Common Name	Scientific Name	Common Name	Scientific Name
Alder flycatcher	*Empidonax alnorum*	Marsh wren	*Cistothorus palustris*
American bittern	*Botaurus lentiginosus*	Mourning warbler	*Oporornis philadelphia*
American crow	*Corvus brachyrhynchos*	Nashville warbler	*Vermivora ruficapilla*
American goldfinch	*Carduelis tristis*	Northern cardinal	*Cardinalis cardinalis*
American redstart	*Setophaga ruticilla*	Northern flicker	*Colaptes auratus*
American robin	*Turdus migratorius*	Northern parula	*Parula americana*
Barn swallow	*Hirundo rustica*	Northern waterthrush	*Seiurus noveboracensis*
Bay-breasted warbler	*Dendroica castanea*	Olive-sided flycatcher	*Contupus cooperi*
Belted kingfisher	*Ceryle alcyon*	Ovenbird	*Seiurus aurocapilla*
Black-and-white warbler	*Mniotilta varia*	Palm warbler	*Dendroica palmarum*
Black-billed cuckoo	*Coccyzus erythropthalmus*	Philadelphia vireo	*Vireo philadelphicus*
Blackburnian warbler	*Dendroica fusca*	Pine grosbeak	*Pinicola enucleator*
Black-capped chickadee	*Poecile atricapillus*	Pine siskin	*Carduelis pinus*
Black-throated blue warbler	*Dendroica caerulescens*	Pine warbler	*Dendroica pinus*
Black-throated green warbler	*Dendroica virens*	Pileated woodpecker	*Dryocopus pileatus*
Blue-headed vireo	*Vireo solitarius*	Purple finch	*Carpodacus purpureus*
Blue jay	*Cyanocitta cristata*	Red-breasted nuthatch	*Sitta canadensis*
Brown creeper	*Certhia americana*	Red crossbill	*Loxia curvirostra*
Brown-headed cowbird	*Molothrus ater*	Red-eyed vireo	*Vireo olivaceus*
Brown thrasher	*Toxostoma rufum*	Red-winged blackbird	*Agelaius phoeniceus*
Canada warbler	*Wilsonia canadensis*	Rose-breasted grosbeak	*Pheucticus ludovicianus*
Cape May warbler	*Dendroica tigrina*	Ruby-crowned kinglet	*Regulus calendula*
Cedar waxwing	*Bombycilla cedrorum*	Scarlet tanager	*Piranga olivacea*
Chestnut-sided warbler	*Dendroica pensylvanica*	Sedge wren	*Cistothorus platenses*
Chimney swift	*Chaetura pelagica*	Song sparrow	*Melospiza melodia*
Chipping sparrow	*Spizella passerina*	Sora	*Porzana carolina*
Common grackle	*Quiscalus quiscula*	Swainson's thrush	*Catharus ustulatus*
Common raven	*Corvus corax*	Swamp sparrow	*Melospiza georgiana*
Common yellowthroat	*Geothlypis trichas*	Tennessee warbler	*Vermivora peregrine*
Connecticut warbler	*Oporornis agilis*	Tree swallow	*Tachycineta bicolor*
Dark-eyed junco	*Junco hyemalis*	Veery	*Catharus fuscescens*
Downy woodpecker	*Picoides pubescens*	Warbling vireo	*Vireo gilvus*
Eastern bluebird	*Sialia sialis*	White-breasted nuthatch	*Sitta carolinensis*
Eastern kingbird	*Tyrannus tyrannus*	White-throated sparrow	*Zonotrichia albicollis*
Eastern phoebe	*Sayornis phoebe*	White-winged crossbill	*Loxia leucoptera*
Eastern wood-pewee	*Contopus virens*	Willow flycatcher	*Empidonax traillii*
Evening grosbeak	*Coccothraustes vespertinus*	Wilson’s snipe	*Gallinago delicata*
Gray catbird	*Dumetella carolinensis*	Winter wren	*Troglodytes troglodytes*
Gray jay	*Perisoreus canadensis*	Yellow-bellied flycatcher	*Empidonax flaviventris*
Great crested flycatcher	*Myiarchus crinitus*	Yellow-bellied sapsucker	*Sphyrapicus varius*
Golden-crowned kinglet	*Regulus satrapa*	Yellow-billed cuckoo	*Coccyzus americanus*
Hairy woodpecker	*Picoides villosus*	Yellow-breasted chat	*Icteria virens*
Hermit thrush	*Catharus guttatus*	Yellow-headed blackbird	*Xanthocephalus xanthocephalus*
Indigo bunting	*Passerina cyanea*	Yellow-rumped warbler	*Dendroica coronata*
Least flycatcher	*Empidonax minimus*	Yellow warbler	*Dendroica petechia*
Magnolia warbler	*Dendroica magnolia*		

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