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STATUS AND TRENDS OF LOON POPULATIONS SUMMERING IN ALASKA, 1971–1993[1]

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Abstract. Loons (*Gavia* spp.) were counted during the Alaska-Yukon Waterfowl Breeding Population Survey from 1971 to 1993 and the Arctic Coastal Plain Waterbird Breeding Population Survey from 1986 to 1993. Population indices for Alaska (not corrected for visibility bias) are presented by species for boreal forest, tundra, and both habitats combined. Minimum mean population estimates (1977–1993) with 95% confidence intervals were 15,360 (±2,235) Red-throated Loons (*G. stellata*), 69,498 (±5,596) Pacific Loons (*G. pacifica*), 8,886 (±843) Common Loons (*G. immer*) and 2,636 (±614) Yellow-billed Loons (*G. adamsii*). Populations of Pacific, Common and Yellow-billed Loons did not change significantly between 1977 and 1993, whereas Red-throated Loons declined by 53% to a 1993 level of 9,843 (±2,447) ($r^2 = 0.65$, $P < 0.001$). Factors affecting results from aerial surveys are discussed.

Key words: aerial surveys; Alaska; breeding; distribution; Gavia; Gaviidae; *loons; population trends; populations.*

INTRODUCTION

Five species of loons (*Gavia* spp.) are present during the summer in Alaska, and all but the Arctic Loon (*Gavia arctica*) breed in substantial numbers within the state. Their widespread distribution across vast areas of remote habitat has precluded development of a comprehensive, affordable survey to estimate statewide populations. Smaller-scale surveys have been done on the Yukon Flats in central Alaska (Lanctot and Quang 1992), the Colville River Delta in the arctic (North 1986), and the Kenai Peninsula National Wildlife Refuge in southcentral Alaska (Smith 1981).

Although no survey has been conducted specifically to obtain statewide loon population estimates in Alaska, the U.S. Fish and Wildlife Service (USFWS) has counted loons during two annual aerial waterfowl surveys: the Alaska-Yukon Waterfowl Breeding Population Survey and the Arctic Coastal Plain Waterbird Breeding Population Survey. The Alaska-Yukon Waterfowl Breeding Population Survey (AYS) is part of a continental survey program that annually monitors the population status of North American waterfowl on their major breeding grounds (Smith 1995). The survey has been conducted in Alaska since 1957. Although it was designed primarily for ducks, other highly visible waterbirds, such as loons, have been counted. Loons have been recorded consistently in Alaska since 1971. The AYS covers the major waterfowl habitats in Alaska except the Pacific coastal habitats (from the Aleutians to the southeast panhandle) and the Arctic Coastal Plain. In 1986, the Arctic Coastal Plain Waterbird Breeding Population Survey (ACPS) was begun to complement the AYS and provide a more complete estimate of waterbird population status and trends in Alaska.

In this paper we summarize data collected on Red-throated Loons (*G. stellata*), Pacific Loons (*G. pacifica*), Common Loons (*G. immer*), and Yellow-billed Loons (*G. adamsii*) during the AYS (1971–1993) and ACPS (1986–1993). We provide minimum mean population estimates and densities by species and present relative abundance and population trends.

SURVEY AREAS AND METHODS

ALASKA-YUKON WATERFOWL BREEDING POPULATION SURVEY

The AYS area encompassed 206,682 km² of waterfowl habitat in Alaska, subdivided into seven boreal forest (43% of total) and four tundra (57% of total) production areas (Fig. 1). Boreal forest

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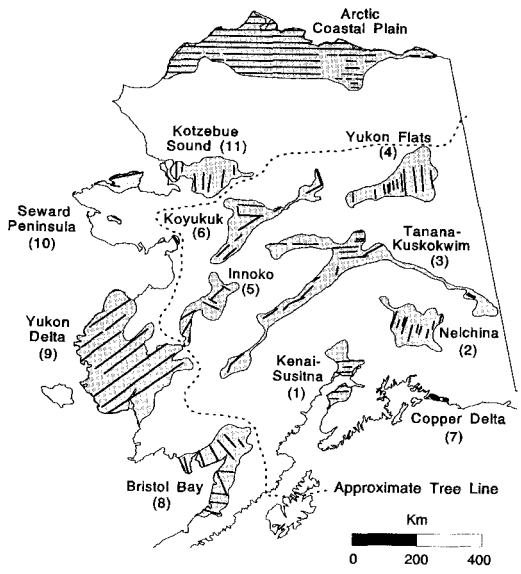

FIGURE 1. Survey areas and line transects of the Alaska-Yukon (1971–1993) and Arctic Coastal Plain (1986–1993) Waterfowl Breeding Population Surveys. Arctic Coastal Plain transects shown are from the 1992 survey. Boreal forest habitat = areas 1–7; tundra habitat = areas 8–11 and the Arctic Coastal Plain. See text for definition of habitat types.

was defined broadly as the area east and south of the tree line (Fig. 1), where coniferous or mixed coniferous-hardwood forests dominate the landscape. Tundra was defined as the area west and north of the tree line, where the climate is too harsh to accommodate tree growth. Because transition zones occur between the two habitat types, some production areas defined as tundra have scattered areas where trees are present, and vice versa.

Of the total survey area, 2,269 km^2 (1%) were sampled. Linear transects consisting of 214 segments, each 26 km (16 mi) in length, were flown annually from 1971 to 1993 (Fig. 1). Beginning in 1984, an additional ten segments, each 13 km (8 mi) in length, were flown annually on the Copper River Delta. The survey area included most of the major waterfowl nesting habitats in Alaska. However, additional areas of low density waterfowl habitat existed outside the survey area and were not sampled.

Survey methods followed USFWS protocol for aerial waterfowl breeding population surveys (USFWS and Canadian Wildlife Service 1987). Surveys were flown each year from mid-May to mid-June using fixed-wing aircraft on amphibious floats. Transects were flown 30–40 m above ground level and at an air speed of 155 km per hour. Loons, ducks, geese, swans, and cranes were counted out to a distance of 200 m on each side of the transect line. Loons were identified to species except Arctic Loons, which could not be distinguished from the air and were thus included as Pacific Loons.

Observations were recorded on cassette tape and later entered into a computer for data storage, summary, and analyses. Yellow-billed Loons were not included in the AYS analyses because their sightings were extremely rare. Population indices for individual loon species were calculated for each production area by converting the number of birds observed in the sample to birds per unit area and then expanding to total area. No visibility correction factors were applied because none have been adequately developed for aerial surveys for loons. Loons were not counted on the Copper River Delta until 1984. Consequently, the 1984–1993 averages for each species were used to estimate the contribution of the Copper River Delta to the total population estimates. The overall results were not greatly affected since the Copper River Delta accounted for less than 0.5% of the total loons observed.

ARCTIC COASTAL PLAIN WATERBIRD BREEDING POPULATION SURVEY

The ACPS area included all contiguous waterfowl habitats on the Arctic Coastal Plain, from the north side of the Brooks Range to the arctic coast and from Point Lay to the U.S.-Canadian Border (Fig. 1) (King and Cain 1987). In 1992 and 1993, the boundary was refined slightly to eliminate areas of non-habitat. The total survey area encompassed an average of 66,964 km^2 in 1986–1993 (Brackney and King 1993). Transects varied between years, averaging 1,462 km^2 (Fig. 1). Sampling effort was approximately 2% of the total survey area during all years of the survey.

Survey methods followed the same procedures as described above for the AYS. Surveys were conducted between mid- to late June and early July.

STATISTICAL METHODS

Population estimates were bounded with 95% confidence intervals (C.I.). Population trends were tested for significance using the correlation coefficient from simple linear regression. Regres-

TABLE 1. Mean population indices of loons, by species and area, in Alaska. n = 17 years except the Arctic Coastal Plain, where n = 8 years.

Stratum	Mean population (95% C.I.)			
	Red-throated	Pacific	Common	Yellow-billed
Kenai-Susitna (1)	49 (±48)	249 (±138)	1,375 (±216)	–
Nelchina (2)	106 (±49)	247 (±95)	353 (±150)	–
Tanana-Kuskokwim (3)	162 (±100)	821 (±160)	1,326 (±232)	–
Yukon Flats (4)	278 (±183)	5,797 (±787)	1,604 (±450)	–
Innoko (5)	250 (±113)	246 (±82)	182 (±52)	–
Koyukuk (6)	133 (±47)	389 (±137)	452 (±138)	–
Copper Delta (7)	211 (±38)	20 (±17)	19 (±12)	–
Boreal subtotal	1,189 (±290)	7,769 (±862)	5,311 (±582)	–
Bristol Bay (8)	1,998 (±520)	1,275 (±281)	920 (±289)	–
Yukon Delta (9)	5,934 (±1,285)	30,415 (±4,383)	2,401 (±447)	–
Seward Peninsula (10)	3,353 (±777)	2,371 (±707)	123 (±109)	–
Kotzebue Sound (11)	360 (±155)	1,836 (±392)	79 (±60)	–
Arctic Coastal Plain	2,526 (±655)	25,832 (±3,144)	52 (±49)	2,636 (±614)
Tundra subtotal	14,171 (±2,150)	61,729 (±5,346)	3,575 (±505)	–
Total	15,360 (±2,235)	69,498 (±5,596)	8,886 (±843)	–

sions were conducted by habitat and species and by species alone. Population estimates and trends were examined from 1977 onward, because analyses of other waterfowl data collected on the AYS indicated that survey results were likely affected by the type of aircraft used (Hodges et al. in press). The USFWS de Havilland turbine beaver (N754), which was used exclusively after 1976, was designed specifically for improved visibility during aerial surveys. Other waterfowl species showed a consistent and substantial increase in numbers when the turbine beaver came into service in 1977 (Hodges et al. in press).

RESULTS

The mean population indices and associated densities for each loon species are presented by area in Tables 1 and 2. These represent 17-year means for areas 1–11 and 8-year means for the Arctic Coastal Plain.

RED-THROATED LOONS

Red-throated Loons made up 16% of the total loon population index and were the second most abundant loon species summering in Alaska. They were recorded in all of the survey areas, but the majority (92%) occurred on the tundra (Table 1, Fig. 2). The Yukon Delta supported the highest number and accounted for 39% of the total.

The simple linear regression fitted line of the total Red-throated Loon population showed that Red-throated Loons declined 53% from 20,833 (±2,447) in 1977 to 9,843 (±2,447) in 1993 (r^2 = 0.65, $P < 0.001$) (Fig. 3). Analyses by area showed that the decline was most significant on the Yukon Delta (r^2 = 0.52, $P < 0.01$), the Seward Peninsula (r^2 = 0.34, $P < 0.02$), and Kotzebue Sound (r^2 = 0.33, $P < 0.02$). Because the Red-throated Loon population changed significantly during the survey period, the latest population

TABLE 2. Mean densities of loons (loons/km^2), by species and area, in Alaska. n = 17 years except the Arctic Coastal Plain, where n = 8 years.

Stratum	Mean density (loons/km^2)			
	Red-throated	Pacific	Common	Yellow-billed
Kenai-Susitna (1)	0.01	0.04	0.24	–
Nelchina (2)	0.01	0.02	0.03	–
Tanana-Kuskokwim (3)	0.01	0.03	0.06	–
Yukon Flats (4)	0.01	0.21	0.06	–
Innoko (5)	0.03	0.03	0.02	–
Koyukuk (6)	0.01	0.04	0.04	–
Copper Delta (7)	0.20	0.02	0.02	–
Boreal subtotal	0.01	0.09	0.06	–
Bristol Bay (8)	0.08	0.05	0.04	–
Yukon Delta (9)	0.09	0.44	0.03	–
Seward Peninsula (10)	0.34	0.24	0.01	–
Kotzebue Sound (11)	0.03	0.13	0.01	–
Arctic Coastal Plain	0.04	0.39	0.00	0.04
Tundra subtotal	0.08	0.33	0.02	–
Total	0.06	0.25	0.03	–

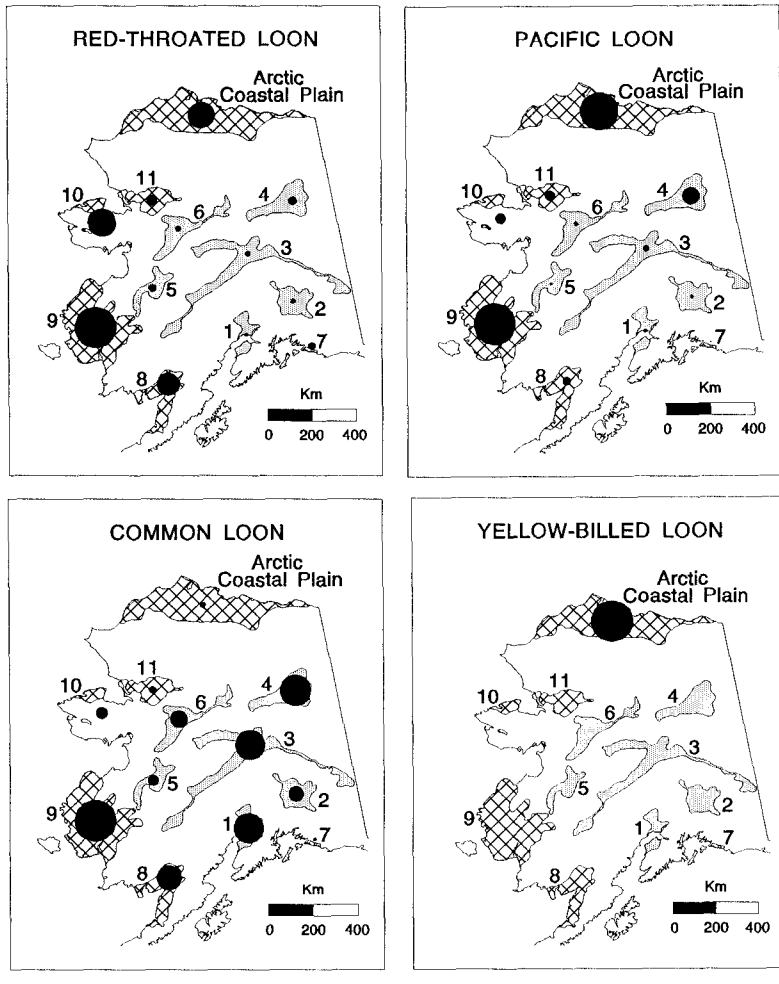

FIGURE 2. Relative abundance of loons among production areas in Alaska, based on the mean number of loons from 1977–1993. Circle sizes are relative to total population sizes. Tundra habitats are cross-hatched.

estimate of 9,843 (±2,447) from the fitted line in 1993 is more appropriate than the long-term mean estimate of 15,360 (±2,235) (Table 1).

PACIFIC LOONS

Pacific Loons were the most abundant loon species in Alaska, accounting for 72% of the total loon population index. They were most abundant on the tundra; the Yukon Delta and Arctic Coastal Plain supported 44% and 37%, respectively, of total Pacific Loons (Table 1, Fig. 2). A substantial number (8%) were also found on the Yukon Flats in boreal forest habitat.

The total Pacific Loon population showed no significant change from 1977 to 1993 ($P > 0.10$) (Fig. 3). This was also the case for populations examined separately by boreal forest ($P > 0.10$) and tundra ($P > 0.10$) habitat types.

COMMON LOONS

Common Loons comprised 9% of the total loon population index. Of the Common Loons observed, 60% were found in the boreal forest and were distributed fairly evenly among the areas (Table 1, Fig. 2). They were essentially absent from the Arctic Coastal Plain. The Yukon Delta also supported a large number of Common Loons, despite the fact that this area is classified as tundra habitat. However, most Common Loons in that area were recorded on segments that crossed

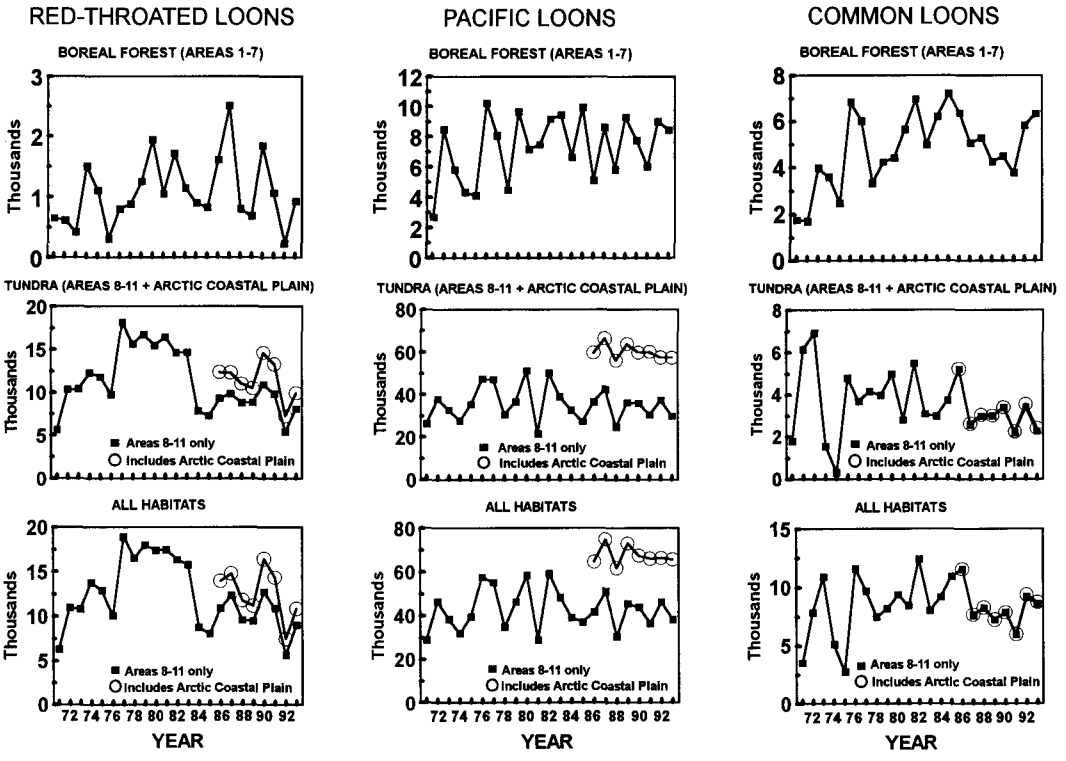

FIGURE 3. Breeding population estimates (uncorrected for visibility bias) of Red-throated, Pacific, and Common Loons in boreal forest and tundra habitats in Alaska, 1971–1993 (surveyed areas only).

the Yukon River, where riparian habitat supports the presence of trees beyond the general tree line.

The total Common Loon population showed no significant change from 1977 to 1993 ($P > 0.10$) (Fig. 3). Analyses by habitat type showed that the boreal forest population did not change significantly during the same time period ($P > 0.10$). The tundra population did show a slight decline from 1977–1993, but the change was only slightly significant ($r^2 = 0.26$, $P < 0.05$).

YELLOW-BILLED LOONS

Yellow-billed Loons comprised 3% of the total loon population index. They were observed almost exclusively on the Arctic Coastal Plain (Table 1, Fig. 2). However, they are known to occur in relatively small numbers on the Seward Peninsula and Kotzebue Sound drainages and on St. Lawrence Island (North 1993). Their distribution on the Arctic Coastal Plain was highly clumped, which resulted in highly variable local densities.

The Arctic Coastal Plain population of Yellow-billed Loons showed no significant change between 1986 and 1993 ($P > 0.10$) (Fig. 4).

DISCUSSION

The AYS was designed to monitor long-term trends of breeding populations of ducks across most of the major waterfowl habitats of North America. We think the ancillary loon data gathered during the AYS and ACPS can be used to determine long-term population trends of loons in Alaska. Both surveys were highly standardized to minimize variability between years due to survey techniques, so generally the same proportion of birds should have been observed each year. The surveys were conducted at the same time each year, and transects were flown in the same order and direction. The same plane was used for the AYS after 1976. Only three pilot/observers flew and recorded left-side observations during the entire history of the surveys. Hodges et al. (in press) separated left- and right-seat ob-

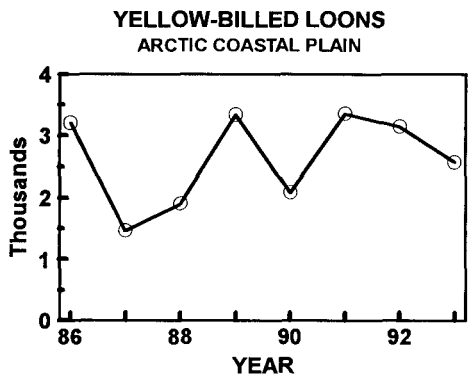

FIGURE 4. Breeding population estimates (uncorrected for visibility bias) of Yellow-billed Loons on the Arctic Coastal Plain, Alaska, 1986–1993.

server data from the AYS and determined that the use of different right-seat observers over time did not significantly affect overall waterfowl trend results.

On the other hand, the AYS was not designed specifically to estimate statewide populations of waterfowl or other waterbirds. Not all waterfowl or loon habitats were included in this survey (e.g., the Aleutian Islands, southeast Alaska, and the Arctic Coastal Plain). In addition, sampling was selective in some production areas rather than random or systematic, perhaps resulting in over- or underestimating loon numbers in those areas.

Other factors that relate to aerial survey techniques apply to both the AYS and ACPS and resulted in an unknown number of loons being missed by observers. Some of these factors included: 1) observation time was limited due to aircraft speed; 2) a small portion of the transect directly underneath the aircraft was invisible to observers, except when they viewed forward; 3) numerous species besides loons were surveyed simultaneously; 4) vegetation may have obscured birds, particularly in the interior; 5) incubating birds were inconspicuous and sometimes missed; 6) observers were subject to various sources of error and inconsistencies; 7) weather affected survey conditions; and 8) some loons avoided the approaching aircraft by diving. The degree to which these different factors affected counts probably differed by species. For example, Yellow-billed Loons were larger than the other species, had highly visible yellow bills and tended to dive less when the aircraft approached (R. King, pers. obs.; J. McIntyre, Utica College, pers. comm.). Red-throated Loons, on the other hand, were much smaller, blended in more with their environment, and often partially submerged their bodies as the aircraft flew over. Pacific Loons dived more frequently than others but sometimes could be identified underwater.

Visibility correction factors to account for birds missed by observers during aerial surveys have not yet been adequately developed for loons in Alaska. One attempt made by the USFWS using helicopter-fixed-wing comparison surveys (Conant et al. 1991) was unsuccessful, possibly due to problems with avoidance behaviors by loons to the helicopter.

On the Yukon Flats, Lanctot and Quang (1992) designed a loon aerial survey that attempted to correct for visibility bias. They used a modified version of the line transect method (Burnham et al. 1980), in which they corrected for the problem of loons becoming less visible as their distance from the aircraft increased. The survey method also accounted for the fact that the observers could not see loons present directly underneath the aircraft (Quang and Lanctot 1991). This method still did not account for all loons, however, because some loons were likely missed by observers, even in close proximity to the aircraft.

Due to the lack of complete statewide coverage and adequate visibility correction factors for loons, our survey data provided minimum statewide population estimates. Few other loon estimates exist for Alaska. Ruggles and Tankersley (1992) conducted a thorough literature review and interviewed land managers throughout Alaska. They reported statewide estimates of 16,000–20,000 Red-throated Loons, 100,000–125,000 Pacific Loons, 10,000–12,000 Common Loons, and 1,164–4,200 Yellow-billed Loons. Their numbers are roughly comparable to ours (Table 1), given that their scope of area was larger.

Estimates for smaller portions of the state also provide comparisons to the AYS. Lanctot and Quang (1992) reported population estimates for the Yukon Flats that were considerably larger than ours (Table 3). The difference may be partly explained by the fact that Lanctot and Quang restricted their survey to loons and corrected for visibility bias. Expanded breeding population surveys were also flown by USFWS on the Yukon Flats in 1989–1990, as well as on the Yukon Delta in 1989–1992 (Table 3) (Hodges 1990, Platte and Butler 1993). These expanded surveys were similar to the AYS but were designed to obtain a larger, more representative sample of

TABLE 3. Comparison of population estimates for loons from three independent surveys on the Yukon Flats (4) and Yukon Delta (9), Alaska.

Location	Alaska-Yukon survey	Expanded breeding pair survey	Lanctot and Quang (1992) year 1988
Yukon Flats (1989 & 1990)			
Red-throated	270[a]	83[b]	–
Pacific	7,088	6,446	12,740[c]
Common	1,080	303	3,120
Yukon Delta (1989–1992)			
Red-throated	4,604	4,931	
Pacific	28,442	33,550	
Common	2,097	1,682	

[a] Survey area = 27,972 km², estimated in the 1950s as the total waterfowl habitat on the Yukon Flats from 1:1,000,000 scale aviation maps. No visibility bias correction.
[b] Survey area = 53,613 km², estimated in the 1980s as the total waterfowl habitat on the Yukon Flats from detailed examination of 1:250,000 scale USGS topographic maps. No visibility bias correction.
[c] Survey area = 26,000 km². Survey method partially accounts for visibility bias.

the waterfowl habitats in these areas. The expanded breeding population survey sample on the Yukon Flats was extended to cover 53,613 km², the estimated total area of wetland habitat on the Yukon Flats. The AYS estimated populations for a smaller area (27,972 km²) but sampled disproportionately more high-quality waterfowl habitat. Estimates for Pacific Loons were similar from the two surveys, but the AYS estimated substantially higher numbers of Red-throated and Common Loons (Table 3). The AYS and the expanded survey on the Yukon Delta, on the other hand, sampled comparable areas, though at different intensities. The results there were quite similar (Table 3).

Population estimates from the AYS and ACPS have large variance between years. Therefore, long-term data sets such as ours are necessary to detect modest changes in loon populations. Counting loons during surveys of multiple waterbird species increases the affordability of collecting such long-term data.

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