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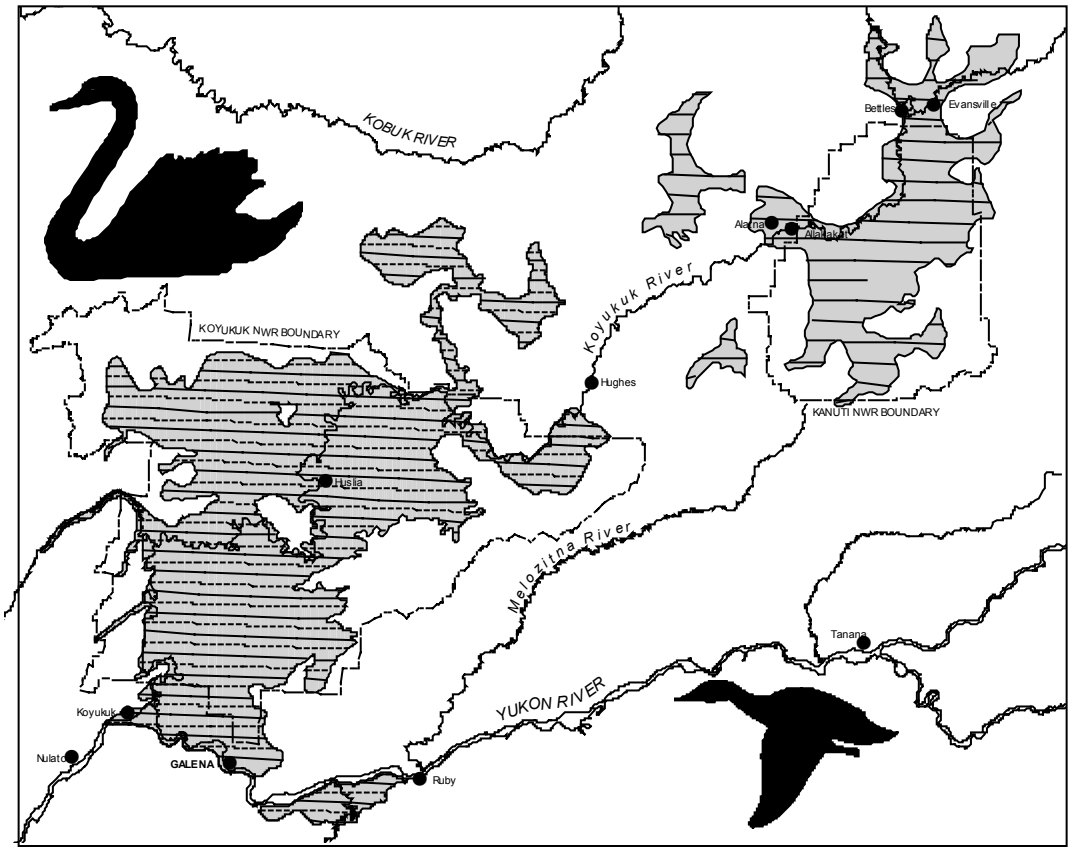

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WATER BIRD ABUNDANCE AND DISTRIBUTION ON KOYUKUK AND KANUTI NATIONAL WILDLIFE REFUGES AND ADJACENT WETLANDS, ALASKA, 1996-1997

by

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EXECUTIVE SUMMARY

Surveys were flown to estimate abundance and map distribution of water birds in June 1996 and 1997 on Koyukuk National Wildlife Refuge and in June 1997 on Kanuti National Wildlife Refuge and nearby wetlands. An estimated 228,000 ducks, 4,000 geese, and 1,200 loons were present on the Koyukuk survey area in June 1996. American wigeon were the most numerous ducks comprising 23% of the duck population. Other abundant species included scaup, green-winged teal, mallards, and shovelers. Coefficients of variation for population indices of abundant species ranged from 11-17%. Estimates for the 1997 survey which included both refuges, were 212,000 ducks, 12,000 geese, and 1,300 loons. American wigeon were most abundant with 25% of the duck population followed by scaup, teal, and pintails in decreasing order of abundance. Population sizes of white-fronted geese were considerably different between years, being about 4 times larger in 1997 due to a large number of flocked birds.

A computerized geographic information system (GIS) was used to map bird locations and densities for most species. The highest concentrations of waterfowl occurred in the wetlands north and east of Huslia as well as along the Koyukuk and Dulbi Rivers in the south-central portion of Koyukuk Refuge. Wetlands within the Kanuti refuge contained lower densities of most species of waterfowl except scaup. Relatively few waterfowl were observed on the Pah River Flats, the upper Alatna River and the elevated plateau south of the Koyukuk Wilderness. Density maps were created only for species with sufficient observations. Point location maps only are presented for species observed infrequently.

The aerial survey systematic design and GIS analyses provide detailed water bird abundance and distribution information. Results can be compared to those from the North American Waterfowl Breeding Population Survey's Koyukuk Stratum to evaluate both designs and improve subsequent surveys to meet specific objectives. Region 7, Division of Realty has used the water bird density maps in their Acquisition Priority System model to assess value of inholdings for waterfowl. Maps can be used as data layers for further analyses such as creating stratified survey designs and examining relationships between remotely sensed habitat data and water bird distribution.

INTRODUCTION

An aerial waterfowl breeding population survey was initiated in 1957 and has been conducted annually on the Koyukuk/Kanuti area (collectively called the Koyukuk stratum) as part of the North American Waterfowl Breeding Population Survey (NAWBPS) (Conant and Groves 1998). The purpose of the NAWBPS is to provide population indices for use in developing waterfowl harvest regulations. Intensity of coverage on the Koyukuk stratum by this survey is limited since it is only one of 12 strata surveyed annually by one crew in Alaska and the Yukon Territory. On the Koyukuk stratum, the survey consists of ten transects totaling 515 km. Transect placement was based on landmarks as aids in navigation to ease annual repeatability of the survey. Consequently, important habitats may not have been adequately sampled or conversely, could have been oversampled. Thus, non-random placement of transects may result in biased estimates of bird abundance. Also, because NAWBPS data are recorded by 16-mile segments along each transect, these data provide limited information on water bird distribution.

Within the last 10 years, several improvements and advancements in technology have been incorporated into designing and conducting aerial surveys and analyzing data in Alaska by Migratory Bird Management. We began by using a statistically valid standard survey design with systematically-spaced transects following suggestions of Caughley (1977). We developed a geographic information system consisting of custom True BASIC programs and PC ARC/INFO software which allowed us to generate a set of transects for any geographic area and plot them on topographic maps for use in the aircraft. Use of a Global Positioning System (GPS), enabled us to accurately navigate systematic transects. We also developed a technique to obtain geographic coordinates of every bird observation using continuously running cassette recorders and a computerized data entry program (Butler et al. 1995a). Recently, however, Jack Hodges (Migratory Bird Management, Juneau) has developed a new data collection program that eliminates the need for continuously running tapes. Bird location data have been entered into the GIS allowing mapping of species density (Butler et al. 1995b) as well as further analyses such as developing stratifications for population estimates or overlays with habitat information.

This system has been used on the Selawik area (Platte 1998), Innoko area (Platte 1996), Bristol Bay region (Platte and Butler 1995), Yukon Flats National Wildlife Refuge (Platte and Butler 1992), Yukon Delta National Wildlife Refuge (Balogh and Butler 1994, Platte and Butler 1993), Copper River Delta (Butler and Eldridge 1991), the west coast of Alaska, and the arctic coastal plain of Alaska (Brackney and King 1993, Larned and Balogh 1993). Improvements include increased precision in population indices, greater resolution in density distribution maps, and calculation of population indices on desired land parcels such as federal versus non-federal land.

The objectives for the expanded aerial breeding population survey on Koyukuk and Kanuti refuges were as follows:

1. Estimate the abundance of water birds.

2. Map the distribution of water birds.

3. Compare the new survey design with the traditional design.

Comparison of the expanded breeding population survey results with those of the NAWBPS and development of an improved survey design will be addressed in a future report.

STUDY AREA

Koyukuk and Kanuti national wildlife refuges occupy about 4.5 million and 1.6 million acres respectively in central Alaska (Fig. 1). Both refuges have extensive lowlands termed the Koyukuk and Kanuti Flats. The expanded breeding pair survey area covered the wetlands within both refuges as well as some areas outside the refuge boundaries. The total area surveyed was about 14,000 km^2 in 1996 and 20,000 km^2 in 1997. The Koyukuk area was surveyed in both years whereas the Kanuti area was surveyed only in 1997.

The Koyukuk refuge contains an abundance of wetlands including lakes, sloughs and streams. The rivers and streams are extremely meandering with a low gradient, and have extensive spring flooding (U.S. Fish and Wildlife Service 1987a). Lake types on the refuge include upland basin lakes, ice-formed lakes on the flats, river-flooded lowland lakes, and oxbow lakes. The shorelines and depths of most lakes fluctuate annually due to river flooding, summer thunderstorms, and spring runoff. Shallow lakes can be highly productive of aquatic plants and invertebrates due to high summer temperatures. Breakup of ice in the rivers occurs in May, freeze-up occurs in late September-early October.

Water resources on the Kanuti refuge are similar. Rivers and streams are slow and meandering. Small ponds and marshes dominate the Kanuti lowlands. The ponds most favorable for waterfowl are shallow with gradual banks and a margin of graminoid vegetation (U.S. Fish and Wildlife Service 1987b).

The climate of the area is characterized by seasonal extremes in both temperatures and hours of daylight. The average July temperature is about 65° F. Temperatures can reach the 90's when the sun provides almost continuous radiation during the summer where the lowlands are protected from coastal winds and clouds by the surrounding hills. The frost-free period lasts about 100 days.

METHODS

Aerial Survey Techniques

The traditional NAWBPS transects are shown in Figure 1. For the expanded breeding population survey, we used a True Basic program and PC ARC/INFO to generate systematically-spaced transects from a random coordinate within the predetermined survey area. Transects were oriented east-west along great circle routes and totaled about 1,800 kms in 1996 and 2,500 kms in 1997 (Fig. 2). One set of flightlines was flown in 1996 and the alternate set was flown in 1997. Systematic sampling was appropriate for the dual objectives of mapping distributions and estimating total numbers when accuracy of the estimate's standard error was not critical (Caughley 1977). We divided transects into 18.5 km segments to facilitate data recording and plotted transects and segments on 1:250,000 scale topographic maps for use in the aircraft. Distance between transects was 7.4 km resulting in a sample of 734 km^2 (5%) of the 14,000 km^2 Koyukuk survey area in 1996. In 1997, transects were also spaced at 7.4 km intervals and the Kanuti area was also sampled. The sampled area in 1997 totaled 1,000 km^2 , about 5% of the 20,000 km^2 survey area.

Survey methods followed the conventions established for breeding ground surveys in North America (USFWS and CWS 1987). The survey was flown on June 8, 9, 10, 12, and 13, 1996 and May 28, 29, 30, 31 and June 1, 2, 3, 4, and 8, 1997 to coincide with egg-laying or early incubation stages of breeding waterfowl. The aircraft was flown at 137 - 153 km hr^{-1}, 30 - 46 m of altitude, with wind speed < 24 km hr^{-1}, ceilings > 152 m and visibility > 16 km. The pilot used a global positioning system and the survey maps to maintain a precise course while flying transects.

A new data collection program called Global Positioning System Voice Survey written by Jack Hodges (Migratory Bird Management, USFWS, Juneau) was used for

the expanded surveys. This system uses a notebook computer connected with a global positioning system (GPS) receiver and a remote microphone and mouse. The pilot and observer recorded transect numbers, segment numbers, segment start and stop points, cardinal direction of the start end of the segment, and bird observations directly into the computer to a .WAV format sound file using the remote microphone and mouse. Birds observed were identified to species and counted as a single, pair, or number in flock.
Simultaneously latitude/longitude coordinates for each observation were automatically downloaded from the GPS to a text file. A data transcription program was used to replay the sound files, enter header information, species codes, group sizes and combine these with the coordinate information to produce a final data file. Jack Hodges and Alan Brackney collected the data both years.

Population estimates

We calculated densities, population estimates and variability for each species using a ratio estimate described by Cochran (1977). Estimates were based on indicated total birds: 2*(S+P)+F where S = number of single birds observed, P = number of bird pairs observed, and F = number of birds in flocks. For ducks, a single male was assumed to represent a breeding pair with the nesting hen not easily observable. Single male ducks were doubled for all observed species except scaup and ring-necked duck. Single observations of other water bird species (geese, swans, cranes, grebes, loons, terns, and gulls) were not doubled. Numbers of ducks were corrected for visibility bias using correction factors from Conant and Groves (1992). Visibility correction factors for other water bird species are currently unknown. Population estimates were calculated for each year for the entire survey area as a whole and for the survey area divided into several large geographic strata (Fig. 3). This stratified analysis was done to try to reduce the variance of the estimates.

Population estimate variance was based on the variation among sampling units (entire transects). The sample size (number of transects) was 104 in 1996 and 153 in 1997. The additional variance associated with visibility correction factors was not included in our calculations.

Water bird distribution

We produced water bird density distribution maps using a GIS technique that differed from the technique developed by Butler et al. (1995b) that was used for previous surveys. However, the GIS technique produced similar results. Similarly to both techniques, geographic coordinates of observed birds were calculated in True BASIC by combining transect position and length files with bird observation files. Data for both years were combined to produce species distribution maps.

A moving average technique (Eberhardt and Thomas 1991) was used to convert the bird groups to bird density. Instead of using a True BASIC program as in the past, we used GIS to calculate bird density in sequential 4000 meter blocks along each transect. Densities in blocks at the ends of transects were based on blocks less than 4000 meters in length because transects were not equally divisible by 4000. The resulting location and density data were converted to a triangulated irregular network (TIN), then to a grid

and finally to a choropleth (patterned polygon) map of water bird density for abundant species using ARC/INFO. Low, medium and high density levels correspond to the lower, middle and upper 33% quantiles of the cumulative density for each species.

RESULTS AND DISCUSSION

Population estimates

The number of ducks of each species observed were initially summarized into 4 groups: single drakes, pairs, birds in small flocks (groups of 3 or 4 birds), and birds in large flocks (groups of 5 or more birds) (Table 1). The proportion of singles and paired birds to flocked birds can be indicative of the breeding segment of the population. We present population estimates based on a simple expansion of the density by the amount of surveyed area in Tables 1 and 2. Tables 3 and 4 contain population estimates based on expansion of the densities within 8 and 10 geographic strata, respectively.

The population estimate for ducks in 1996 was 228,000. American wigeon were the most abundant ducks with about 53,000 birds and a density close to 1/km^2 . Scaup were next in abundance with 38,000. The 1996 duck population consisted of 23% wigeon, 17% scaup, 16% green-winged teal, 12% mallard, 12% northern shoveler, 10% pintails, 3% goldeneye, 2% black scoter, 2% bufflehead, 1% oldsquaw, and 1% ring-necked duck. Coefficients of variation were lowest for scaup and the dabbling duck species, ranging from 11 – 17%. Variability was relatively high for other duck species. The estimated goose population of about 4,000 was comprised of 31% Canada geese and 69% white-fronted geese in 1996.

The duck population was slightly lower in 1997 with 212,000, even though the 1997 survey included the Kanuti wetlands. American wigeon were the most numerous ducks in 1997, followed by scaup and green-winged teal. Numbers of wigeon were very similar between years whereas there were about 10,000 more scaup in 1997 than 1996 due to substantial scaup densities on Kanuti. Densities of other duck species were substantially lower on Kanuti and adjacent wetlands resulting in the overall lower duck population for the entire survey area in 1997.

Species composition in 1997 was 25% wigeon, 22% scaup, 14% green-winged teal, 11% mallard, 10% pintail, 9% shoveler, 3% bufflehead, 2% goldeneye, and 1% or less for other species. Coefficients of variation were between 9 and 13% for the dabbling ducks and scaup. Canada geese were 11% of the total goose population of 12,000, compared to 89% white-fronts. The white-fronted goose population estimate for 1997 was 4 times that of 1996 due mostly to more observations of flocked birds and larger flock sizes. The 1996 survey was conducted later and perhaps the lower number of white-fronts resulted from more birds on nests being less visible to surveyors.

Average duck density on the survey area 1996-1997 was about 3.3/km^2 (Table 5). Duck densities were the lowest of any of the expanded survey areas. Lensink and Rothe (1986) observed that the Koyukuk Basin was the least productive major wetland region of interior Alaska probably because of the relative stability and low productivity of closed basin lakes.

Water bird distribution

More than 4,800 geographic locations of birds were obtained from the 1996-1997 surveys. Water bird locations and density polygons were mapped for the major species occurring on the survey area (Figs. 4-47). While most species were widely distributed throughout the survey area, the highest concentrations of waterfowl occurred on the wetlands between the Koyukuk River and the Huslia River northwest of Huslia. Large numbers of birds were also using the broad swath of wetlands extending northwestward from Galena to the Koyukuk River. The patch of habitat near Sam
White Lake just south of the Koyukuk Wilderness Area contained pintails mallards, teal, wigeon, shovelers and scaup.

Scaup were the most widely distributed species occurring over most of the survey area. Mallards were widely distributed but most prevalent in the wetlands between the Koyukuk River and the Huslia River northwest of Huslia and the southern portion of the Koyukuk refuge north of Galena and Koyukuk. White-fronted geese were widely scattered in the northern half of Koyukuk refuge however higher densities tended to be associated with the Koyukuk and Dulbi Rivers. Kanuti refuge contained small numbers of waterfowl except for scaup and wigeon which were most abundant in the central and southern parts of the refuge.

Several areas had lower densities for most species including much of the broad 200-300 foot elevation plateau with few lakes extending south of the Koyukuk Wilderness area. This generally poor habitat could be eliminated from future surveys. The Pah River Flats area had some scaup but little else. The upper Alatna River corridor had very low densities as well. Generally, densities decreased farther up the river corridors, up the smaller drainages, and as elevation increased toward the survey area periphery.

RECOMMENDATIONS

Accurate water bird abundance and distribution information over large geographic areas provides baseline information for management decision-making. The information can be used for land acquisition planning, mitigation planning, permit reviews, harvest regulation, and identification of unique ecological areas. Waterfowl density maps for the Yukon Delta and Yukon Flats National Wildlife refuges have been incorporated into the Division of Realty Acquisition Priority System model for ranking private lands within refuges for acquisition. Maps for Koyukuk and Kanuti refuges will also be included in this model.

Analyses should be conducted to compare the results from this survey and the NAWBPS. This information is important for designing future surveys to meet specific objectives.

Migratory Bird Management has mapped water bird distribution and abundance on many of the important wetlands in Alaska using the survey techniques and geographic information system developed. However, important areas remain that have not been intensively surveyed. These areas could potentially be sampled in one year (given adequate time, money, personnel, and aircraft availability) at sufficient intensity for detailed distribution mapping. We recommend that expanded surveys be conducted in these areas to contribute to a standardized water bird database for the State of Alaska.

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Table 1. Population indices based on unstratified area surveyed by aerial survey in June 1996 on Koyukuk National Wildlife Refuge and adjacent wetlands.

Species	Drakes	No. of Pairs	Birds in small flocks[1]	Birds in large flocks[2]	Indicated total birds[3]	Visibility correction factor[4]	Population index[5]	Birds per sq. km.
Mallard	118	38	0	69	381	4.01	28961	2.08
Northern pintail	152	28	3	36	399	3.05	23068	1.66
Green-winged teal	81	23	0	25	233	8.36	36923	2.65
American wigeon	212	87	0	142	740	3.84	53864	3.87
Northern shoveler	121	41	0	51	375	3.79	26941	1.94
Scaup*	292	230	0	282	1034	1.93	37828	2.72
Canvasback	1	0	0	0	2	2.43	92	0.01
Ring-necked duck*	23	5	0	0	33	4.02	2515	0.18
Goldeneye	32	5	0	15	89	3.61	6090	0.44
Bufflehead	62	15	0	0	154	1.86	5430	0.39
Oldsquaw	11	5	0	20	52	1.87	1843	0.13
Black scoter	37	40	4	15	173	1.17	3837	0.28
Surf scoter	10	7	0	0	34	1.17	754	0.05
White-winged scoter	10	3	0	0	26	1.17	577	0.04
Common merganser	3	0	0	0	6	1.27	144	0.01
Red-breasted merganser	9	0	0	0	18	1.27	433	0.03
Canada goose*	5	12	3	31	63	1	1194	0.09
White-fronted goose*	10	14	41	66	145	1	2749	0.20
Tundra/trumpeter swan*	23	16	11	5	71	1	1346	0.10
Sandhill crane*	7	2	17	5	33	1	626	0.04
Red-necked grebe*	59	10	0	0	79	1	1497	0.11
Common loon*	22	7	0	0	36	1	682	0.05
Pacific loon*	9	6	4	0	25	1	474	0.03
Red-throated loon*	1	0	0	0	1	1	19	< 0.01
Jaeger*	7	0	0	0	7	1	133	0.01
Glaucous gull*	40	16	6	18	96	1	1820	0.13
Mew gull*	24	15	16	37	107	1	2028	0.15
Arctic tern*	58	9	16	303	395	1	7487	0.54

1 Small flocks are defined as groups of 3 or 4 birds
2 Large flocks are defined as groups of 5 or more birds
3 T is indicated total birds = 2 * (singles + pairs) + flocks
4 V is the visibility correction factor
5 Population index = A * T/S * V
A = Square kilometers in survey area = 13,917
S = Square kilometers in sample = 734

* Single birds not doubled to calculate indicated total birds

Table 2. Population indices based on unstratified area surveyed by aerial survey in June 1997 on Koyukuk and Kanuti National Wildlife Refuges and adjacent wetlands.

Species	Drakes	No. of Pairs	Birds in small flocks[1]	Birds in large flocks[2]	Indicated total birds[3]	Visibility correction factor[4]	Population index[5]	Birds per sq. km.
Mallard	101	39	0	13	293	4.01	22715	1.17
Northern pintail	123	42	0	45	375	3.05	22113	1.14
Green-winged teal	58	28	0	8	180	8.36	29093	1.49
American wigeon	229	90	0	79	717	3.84	53230	2.73
Northern shoveler	100	26	0	0	252	3.79	18465	0.95
Scaup*	257	349	3	332	1290	1.93	48134	2.47
Canvasback	6	5	0	29	51	2.43	2396	0.12
Ring-necked duck*	14	12	0	0	38	4.02	2953	0.15
Goldeneye	23	9	0	0	64	3.61	4467	0.23
Bufflehead	63	20	0	5	171	1.86	6149	0.32
Oldsquaw	17	5	4	0	48	1.87	1735	0.09
Black scoter	8	5	0	0	26	1.17	588	0.03
Surf scoter	19	25	0	9	97	1.17	2194	0.11
White-winged scoter	0	2	0	18	22	1.17	498	0.03
Common merganser	1	1	0	0	4	1.27	98	0.01
Red-breasted merganser	5	2	0	0	14	1.27	344	0.02
Canada goose*	10	10	10	30	70	1	1353	0.07
White-fronted goose*	16	31	92	387	557	1	10769	0.55
Tundra/trumpeter swan*	39	17	0	0	73	1	1411	0.07
Sandhill crane*	20	12	4	6	54	1	1044	0.05
Red-necked grebe*	56	13	0	0	82	1	1585	0.08
Common loon*	25	12	0	0	49	1	947	0.05
Pacific loon*	7	5	0	0	17	1	329	0.02
Red-throated loon*	2	0	0	0	2	1	39	< 0.01
Jaeger*	11	1	0	0	13	1	251	0.01
Glaucous gull*	39	7	7	0	60	1	1160	0.06
Mew gull*	59	22	33	60	196	1	3789	0.19
Arctic tern*	71	22	42	227	384	1	7424	0.38

4 Small flocks are defined as groups of 3 or 4 birds
5 Large flocks are defined as groups of 5 or more birds
6 T is indicated total birds = 2 * (singles + pairs) + flocks
4 V is the visibility correction factor
5 Population index = A * T/S * V
A = Square kilometers in survey area = 19,478
S = Square kilometers in sample = 1008

* Single birds not doubled to calculate indicated total birds

Table 3. Water bird population indices based on stratified design (Fig. 3) from June 1996 aerial survey of Koyukuk National Wildlife Refuge, Alaska.

Species	Birds per sq. km.	Standard error	Indicated total birds population index[1]	(Visibility corrected population index)	Standard error	% Coefficient of variation	Lower 95% confidence interval	Upper 95% confidence interval
Mallard	0.509	0.085	7090	(28431)	1183	17	4770	9409
Northern pintail	0.538	0.073	7491	(22848)	1019	14	5493	9489
Green-winged teal	0.322	0.042	4475	(37411)	583	13	3332	5617
American wigeon	0.992	0.106	13802	(53000)	1470	11	10921	16684
Northern shoveler	0.509	0.067	7089	(26867)	937	13	5252	8925
Scaup*	1.399	0.148	19474	(37585)	2058	11	15441	23507
Ring-necked duck	0.045	0.01	622	(2500)	141	23	346	898
Goldeneye	0.122	0.03	1693	(6112)	411	24	888	2499
Bufflehead	0.203	0.032	2829	(5262)	447	16	1953	3705
Oldsquaw	0.07	0.023	972	(1818)	319	33	346	1598
Black scoter	0.233	0.058	3246	(3798)	807	25	1665	4827
Surf Scoter	0.045	0.021	629	(736)	296	47	49	1209
White-winged scoter	0.035	0.017	488	(571)	240	49	19	958
Common merganser	0.008	0.008	110	(140)	114	104	-114	335
Red-breasted merganser	0.028	0.013	390	(495)	178	46	41	739
Canada goose*	0.085	0.029	1177	N/A	400	34	393	1961
White-fronted goose*	0.19	0.042	2641	N/A	589	22	1486	3795
Tundra/trumpeter swan*	0.096	0.019	1338	N/A	262	20	825	1852
Sandhill crane*	0.044	0.014	619	N/A	192	31	243	995
Red-necked grebe*	0.106	0.015	1481	N/A	208	14	1074	1888
Common loon*	0.049	0.011	680	N/A	147	33	391	968
Pacific loon*	0.034	0.011	471	N/A	153	22	171	771
Jaeger*	0.009	0.004	130	N/A	61	47	11	249
Glaucous gull*	0.128	0.025	1780	N/A	355	20	1085	2475
Mew gull*	0.145	0.036	2013	N/A	500	25	1032	2993
Arctic tern*	0.527	0.157	7340	N/A	2179	30	3069	11610

1 Population index = A * T/S within each stratum then summed over all strata
A = Square kilometers in survey stratum
T = indicated total birds: 2 * (singles + pairs) + flocks in stratum
S = Square kilometers sampled in stratum

* Single birds not doubled to calculate indicated total birds

Standard visibility correction factors: Factors for species other than those listed below have not been determined
Mallard = 4.01, Wigeon = 3.84, Teal = 8.36, Shoveler = 3.79, Pintail = 3.05, Canvasback = 2.43,
Scaup = 1.93, Ring-necked duck = 4.02, Goldeneye = 3.61, Bufflehead = 1.86, Oldsquaw = 1.87,
Scoter = 1.17, Merganser = 1.27

Table 4. Water bird population indices based on stratified design (Fig. 3) from June 1997 aerial survey of Koyukuk and Kanuti National Wildlife Refuges, Alaska.

Species	Birds per sq. km.	Standard error	Indicated total birds population index[1]	(Visibility corrected population index)	Standard error	% Coefficient of variation	Lower 95% confidence interval	Upper 95% confidence interval
Mallard	0.286	0.037	5578	(22368)	721	13	4164	6992
Northern pintail	0.362	0.042	7054	(21515)	809	12	5469	8639
Green-winged teal	0.176	0.024	3434	(28708)	462	13	2530	4339
American wigeon	0.708	0.06	13792	(52961)	1178	9	11482	16101
Northern shoveler	0.246	0.029	4798	(18184)	566	12	3688	5908
Scaup*	1.266	0.12	24669	(47611)	2332	10	20099	29239
Canvasback	0.049	0.024	961	(2335)	475	49	30	1892
Redhead	0.006	0.003	114	(355)	62	55	-9	236
Ring-necked duck	0.037	0.01	730	(2935)	191	26	355	1105
Goldeneye	0.059	0.013	1140	(4115)	248	22	654	1626
Bufflehead	0.169	0.021	3293	(6125)	412	13	2485	4101
Oldsquaw	0.048	0.013	935	(1748)	260	28	425	1446
Black scoter	0.025	0.01	490	(573)	202	41	94	886
Surf Scoter	0.094	0.024	1824	(2134)	474	26	896	2752
White-winged scoter	0.022	0.017	420	(491)	336	80	-238	1077
Red-breasted merganser	0.014	0.005	266	(338)	95	36	80	452
Canada goose*	0.07	0.018	1358	N/A	342	25	687	2029
White-fronted goose*	0.545	0.174	10618	N/A	3380	32	3993	17243
Tundra/trumpeter swan*	0.071	0.012	1386	N/A	242	18	912	1860
Sandhill crane*	0.052	0.01	1019	N/A	197	19	634	1405
Red-necked grebe*	0.078	0.011	1516	N/A	222	15	1080	1951
Common loon*	0.048	0.01	936	N/A	193	21	557	1315
Pacific loon*	0.017	0.005	340	N/A	103	30	138	543
Jaeger*	0.012	0.004	243	N/A	84	35	78	408
Glaucous gull*	0.059	0.009	1143	N/A	168	15	813	1472
Mew gull*	0.192	0.031	3745	N/A	597	16	2574	4915
Arctic tern*	0.366	0.078	7122	N/A	1521	21	4141	10103

1 Population index = A * T/S within each stratum then summed over all strata
A = Square kilometers in survey stratum T = indicated total birds: 2 * (singles + pairs) + flocks in stratum
S = Square kilometers sampled in stratum

* Single birds not doubled to calculate indicated total birds

Standard visibility correction factors: Factors for species other than those listed below have not been determined
Mallard = 4.01, Wigeon = 3.84, Teal = 8.36, Shoveler = 3.79, Pintail = 3.05, Canvasback = 2.43, Redhead = 3.11,
Scaup = 1.93, Ring-necked duck = 4.02, Goldeneye = 3.61, Bufflehead = 1.86, Oldsquaw = 1.87, Scoter = 1.17, Merganser = 1.27

Table 5. Comparison of densities[1] (per sq. km) for selected species and total ducks from spring aerial surveys on 8 survey areas in Alaska.

	Survey Area							
Species or group	Yukon Delta NWR[2]	Yukon Flats NWR[3]	Arctic coastal plain[4]	Bristol Bay region[5]	southern unit Innoko NWR[6]	northern unit Innoko NWR and Yukon River wetlands[7]	Selawik NWR/ Noatak Lowlands[8]	Koyukuk/ Kanuti NWRs[9]
Northern pintail	4.7	3.0	3.4	1.1	3.1	1.7	4.6	0.5
Mallard	1.0	3.4	0.5	0.9	0.5	1.7	1.3	0.4
Green-winged teal	1.9	1.8	0.1	1.0	2.3	3.7	1.9	0.3
American wigeon	1.1	3.1	0.1	0.4	1.8	3.2	5.7	0.9
Northern shoveler	1.3	2.5	--	0.3	1.1	1.5	1.3	0.4
Canvasback	0.1	1.5	--	--	--	0.1	--	--
Scaup	2.8	6.1	0.4	1.9	1.3	1.2	4.0	1.3
Oldsquaw	0.5	0.1	1.5	0.1	--	--	0.6	0.1
Scoter	1.2	1.9	0.2	1.0	0.5	0.1	0.9	0.2
Total ducks	16.0	24.0	6.0	7.0	11.0	13.2	20.5	3.3

[1] Densities are based on indicated total birds (except for scaup) corrected for visibility bias and calculated as average of mean annual densities.
[2] Surveys from 1989-1992
[3] Surveys from 1989-1991
[4] Surveys from 1986-1990
[5] Surveys from 1993-1994
[6] Survey in 1994
[7] Survey in 1995
[8] Surveys from 1996-1997
[9] Surveys from 1996-1997

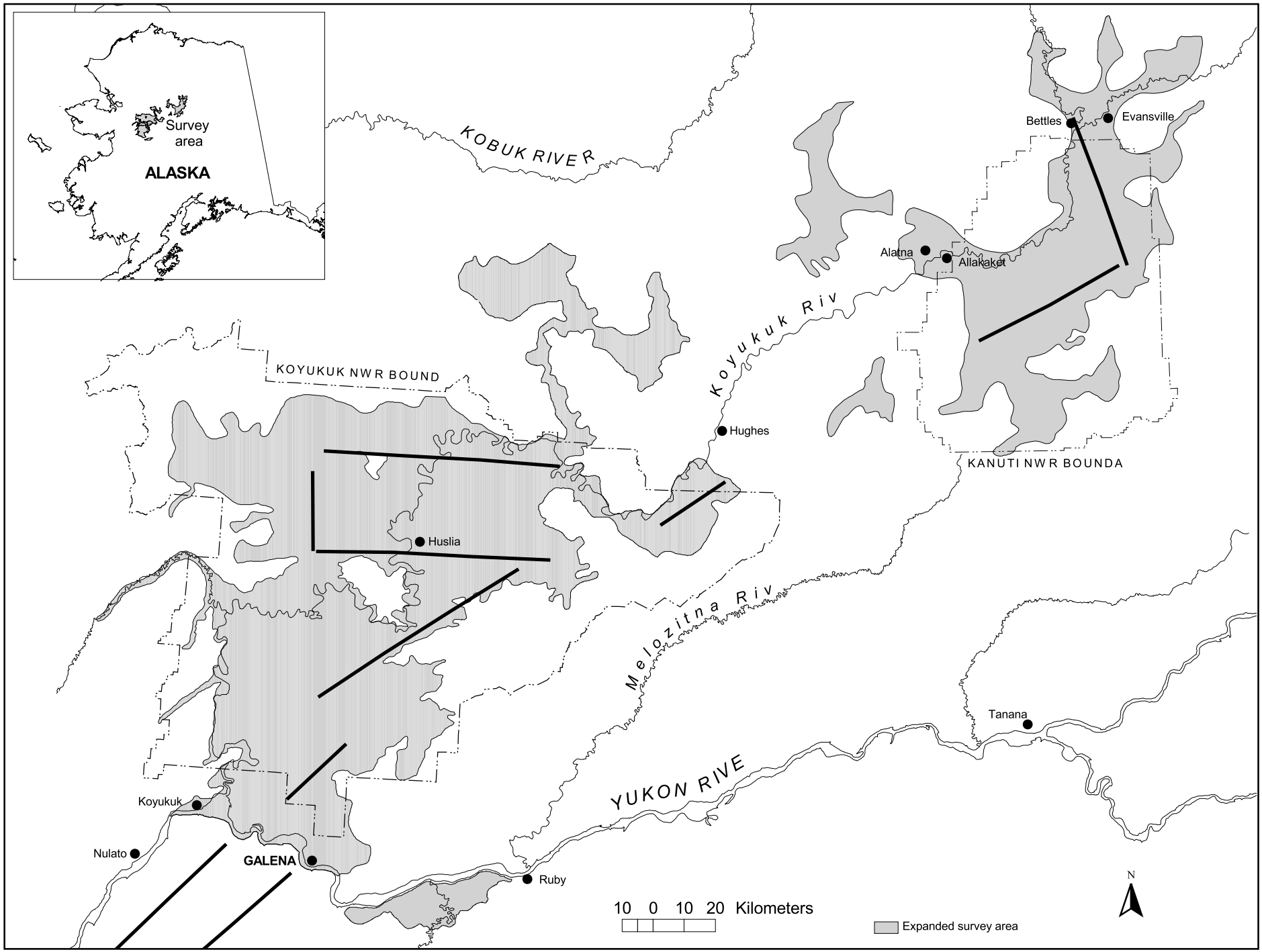

Fig. 1. Traditional survey flightlines relative to expanded survey area for Koyukuk and Kanuti National Wildlife Refuges, Alaska, June 1996 and 1997.

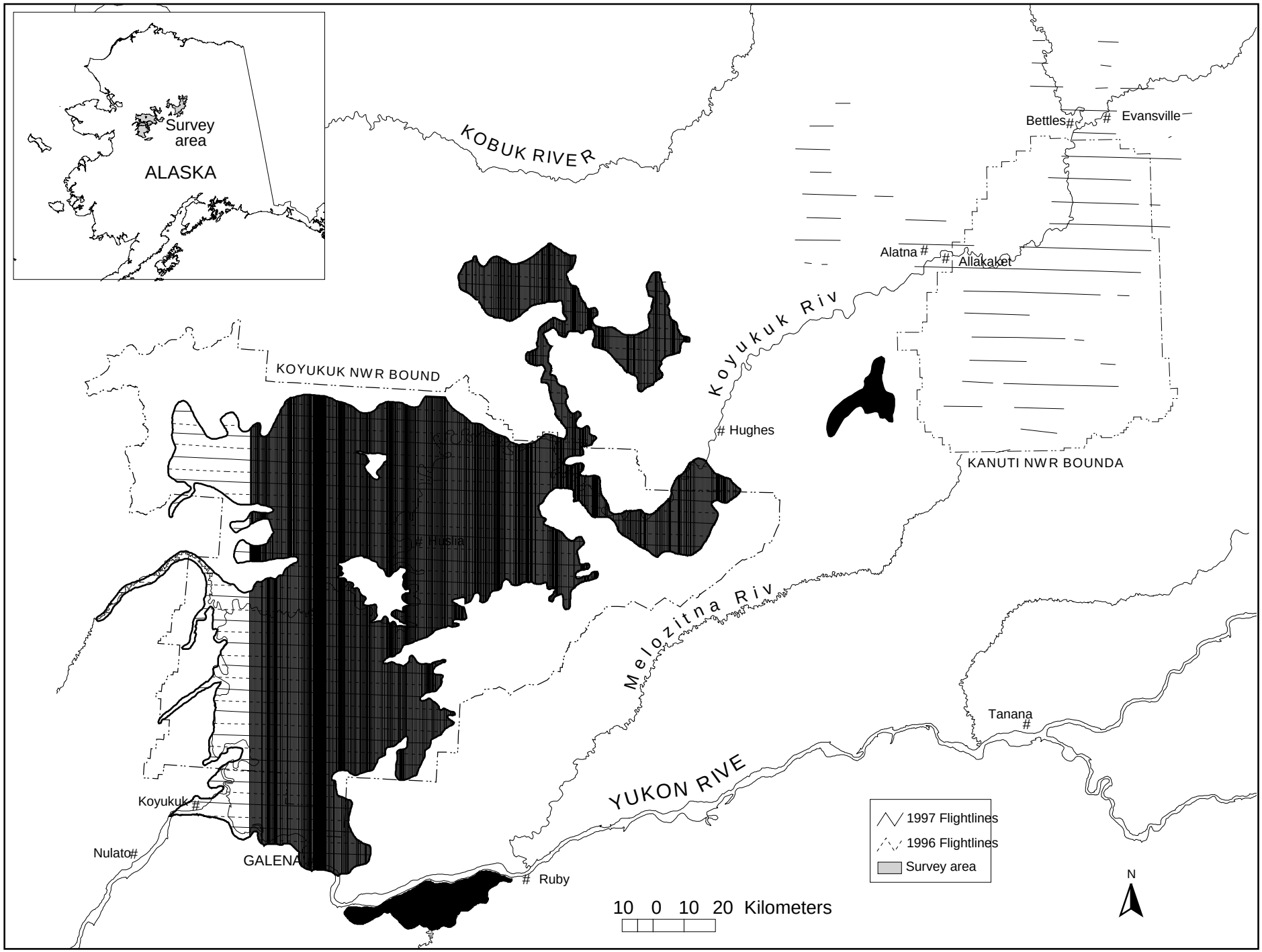

Fig. 2. Survey area and flightlines for aerial surveys of Koyukuk and Kanuti National Wildlife Refuges, Alaska, June 1996 and 1997.