INNOKO NATIONAL WILDLIFE REFUGE MOLTING GOOSE SURVEY – AN ANALYSIS OF THE FIRST 10 YEARS

By

Steven D. Kovach[1], Robert M. Platte[2], Edward Mallek[3], and Karen S. Bollinger[3]

[1] Innoko National Wildlife Refuge, McGrath, Alaska
[2] Anchorage Migratory Bird Management Office, Anchorage, Alaska
[3] Fairbanks Migratory Bird Management Office, Fairbanks, Alaska

Progress Report INN-2010-01
August 2010

Table of Contents

List of Tables i
List of Figures ii
List of Appendices ii
Abstract 1
Introduction 2
Study Area 2
Methods 2
Results 3
Conclusions and Recommendations 5
Acknowledgments 6
Literature Cited 6

List of Tables

Table 1. Molting goose surveys dates and crews, Innoko National Wildlife Refuge, Alaska…... 8
Table 2. Comparison of geese counted on 2 July 2006 on specific lakes and those counted from transects on 3 July 2006, Innoko National Wildlife Refuge, Alaska. CAGO refers to Canada geese; GWFG refers to greater white-fronted geese…….…….. 8
Table 3. Proportions of Canada Goose kernel area, numbers of groups, and number of individuals found within corresponding Greater White-fronted Goose (GWFG) kernel area based on surveys of molting geese in early July on Innoko National Wildlife Refuge, Alaska, 2000-2009……. 8
Table 4. Results of 90% kernel analysis of molting goose locations from surveys conducted in early July on Innoko National Wildlife Refuge, Alaska, 2000-2009……... 9

List of Figures

Figure 1. Molting goose survey area and transect lines, Innoko National Wildlife Refuge, Alaska…… 10
Figure 2. Molting goose and swan locations from early July 2000-2009 relative to targeted survey lakes and sloughs on Innoko National Wildlife Refuge, Alaska…….. 11
Figure 3. Results of molting Canada Goose (CAGO) and Greater White-fronted Goose (GWFG) surveys in early July on Innoko National Wildlife Refuge, Alaska……... 12
Figure 4. Results of swans counted during molting goose surveys in early July on Innoko National Wildlife Refuge, Alaska. Survey crews did not record swan numbers or locations during the 2000, 2003, and 2005 surveys……..… 13
Figure 5. Locations of Canada Goose (CAGO) and Greater White-fronted Goose (GWFG) groups located on 3 July 2006 while flying transects compared to lakes surveyed the previous day, Innoko National Wildlife Refuge, Alaska…… 14
Figure 6. Greater White-fronted Geese (GWFG) and Canada Geese (CAGO) 50% and 75% density kernels based on surveys of molting geese on Innoko National Wildlife Refuge, Alaska in early July, 2000-2009……..… 15
Figure 7. Greater White-fronted Geese (GWFG) and Canada Geese (CAGO) 90% and 95% density kernels based on surveys of molting geese on Innoko National Wildlife Refuge, Alaska in early July, 2000-2009……. 16
Figure 8. Distribution of Greater White-fronted Geese recorded during the molting goose surveys in early July 2000-2009 on Innoko National Wildlife Refuge, Alaska……... 17
Figure 9. Distribution of Canada Geese recorded during the molting goose surveys in early July 2000-2009 on Innoko National Wildlife Refuge, Alaska……... 18
Figure 10. Results of a 90% kernel analysis of goose locations from molting goose surveys in early July 2000-2009 on Innoko National Wildlife Refuge, Alaska……..… 19
Figure 11. Recommended new survey area and transects for the Innoko National Wildlife Refuge, Alaska molting goose survey. For survey areas without transect lines, see Figure 12 for more detail…….. 20
Figure 12. Recommended targeted lakes/sloughs/river segment for the Innoko National Wildlife Refuge, Alaska molting goose survey. Numbers are reference numbers only…… 21

List of Appendices

Appendix 1. Results of molting goose surveys on Innoko National Wildlife Refuge, Alaska. SWANS refers to Tundra and Trumpeter Swans combined……. 22

Abstract

Molting geese (*Branta* spp., *Anser* spp.) have been counted annually in early July from 2000-2009 by aerial surveys on portions of the Innoko National Wildlife Refuge (INWR), Alaska. These surveys have been a cooperative effort by INWR and the Waterfowl Branch, Migratory Bird Management Division, U.S. Fish and Wildlife Service. The survey consisted of systematic flightlines flown to cover the entire survey area and thus an attempt to count all geese present. Annual counts of Greater White-fronted Geese (*A. albifrons*) have varied widely over the course of the surveys ranging from a high of 27,243 birds in 2003 to a low of 9,761 birds in 2005. Much of the variability in numbers may be due to variability of the nesting season because most of the molting birds are failed or non-breeding adults or non-breeding second year birds from other interior areas. However, detectability of birds appears to be an influencing factor as well. Both Greater White-fronted and Canada Geese were predominantly distributed in the southern portion of the survey area along the Iditarod and Innoko Rivers. Spatial analysis of the data resulted in identification of areas occupied by most of the geese over time. These use areas were much smaller than the original survey area. Based on these findings we propose redesigning the survey to increase the efficiency (reduction of time required to conduct the survey by half) while maintaining ability to census the majority of the birds using the refuge. Several small targeted lakes in the northern portion of the original survey area are also recommended to be retained for future surveys.

Introduction

Innoko National Wildlife Refuge (INWR) has been known to host large numbers of molting Cackling Geese (*Branta hutchinsii*), Canada Geese (*B. canadensis*) (hereinafter collectively referred to as Canada Geese), and Greater White-fronted Geese (*Anser albifrons*) (Fischer 2008). The first known goose banding efforts at INWR took place in the late 1940s (Innoko NWR unpublished data). Knowledgeable workers estimate the proportion of Greater White-fronted Geese molting at INWR at approximately 70% of the population that utilizes Interior Alaska; making monitoring of this population important from many perspectives. Efforts to quantify the number of molting geese using INWR began in the 1990s (Innoko NWR unpublished data). From 8-10 July 1999 INWR staff conducted a reconnaissance flight in the southcentral portion of the refuge examining 90 different lakes. This effort identified 2,065 Canada Geese and 6,830 Greater White-fronted Geese (MBM, unpublished data). This led the refuge and the Migratory Bird Management Division to design a survey specifically for quantifying the number of molting geese on INWR each summer. A systematic set of flightlines covering the survey area was developed. This survey has been flown every year since its inception in 2000 as a cooperative effort between INWR and the Waterfowl Branch, Migratory Bird Management Division.

This progress report simply summarizes the results of the first 10 years of this survey and contains only a limited analysis of the data collected to date. We also identify problems that have occurred with past surveys. We offer a suite of suggestions to improve the efficiency of future surveys as well as topics for further data analysis.

Study Area

INWR is located in the southwestern part of Interior Alaska (Fig. 1). The refuge is bordered by the Yukon River on the west. The Innoko River runs diagonally northeast to southwest through the refuge. The Innoko River and its major tributaries (Iditarod River, Hather Creek, Mud River, and Dishna River) dominate the landscape.

The molting goose survey area encompasses 1,905 km^2 (736 mi^2; Fig. 1) in the central portion of the refuge. The survey area consists of rivers, sloughs, lakes, a variety of wetland and low shrub habitats, and black spruce bog habitats (Talbot and Markon 1988; Bureau of Land Management et al. 2002). While the survey area is characterized by low physiographic relief, the area is bounded by a number of rolling hills.

Methods

The survey area contained 129 transects totaling 2,071 km (1,287 mi) spaced at 0.93 km (0.58 mi) intervals (Fig. 1). A Cessna-206 aircraft equipped with amphibious floats was used to conduct all surveys. In most cases, the survey team consisted of a pilot and a single observer; occasionally a second observer was also on board to learn the survey methods. Aircraft generally flew at 145-170 kmph (90-106 mph), 90 m (300 ft) above ground level while searching for birds. Survey aircraft left the transect line as necessary to circle groups of birds in order to identify and enumerate all birds observed.

Data were recorded by the pilot using the Voice/GPS Survey Recording program (the latest version used was 6.2; John Hodges, USFWS Juneau Alaska) on a laptop computer connected to the aircraft global positioning system. Data were transcribed by the pilot following completion of the survey using the Transcribe portion of the Voice/GPS Survey Recording program resulting in latitude-longitude coordinates for all bird sightings.

While observations of animals besides the three goose species were collected, only swans (*Cygnus* spp.) were collected more frequently than any other species over the 10 years.

We made a copy of the original data that contained only the goose and swan observations and segregated observations between adults and young of the year when possible.

All data were converted to geographic information system features to facilitate spatial analysis. Kernel theory (Seaman et al. 1999, Powell 2000) states that locations with duplicate records can bias the results by giving greater weight to locations with duplicate records versus those locations with only single records. We tested the influence of having duplicate records (due to separation of adults from young or separation between species) for locations against having a single record for each location (i.e., collapsing the data into a single record) using the 2001 data. We found that the 95% kernel boundary for the duplicate records as 1% smaller than the 95% kernel boundary for the single record locations. As no real difference was found, we used all goose observations as reported by the survey pilots.

We subjected the combined sighting locations of Greater White-fronted Geese and Canada Geese to a kernel analysis using the Hawth's Tools extension (version 3.27; Beyer 2007) for ArcMap (versions 9.2 and 9.3.1, Environmental Systems Research Institute, Redlands, CA). We used a bivariate normal kernel distribution, the default smoothing factor, and set the output cell size to 50 m (164 ft); all data points were given an equal weighting factor.

Due to cautions from Beyer (2009) on possible problems with the tool running under ArcMap 9.3.1, we evaluated the kernel results produced by ArcMap version 9.3.1 against that produced by ArcMap version 9.2 to ensure proper functioning. We found no differences either in the aerial extent or geographic positioning between the two. All further analysis was completed using ArcMap version 9.3.1.

Data point locations and kernel density (85%, 90%, and 95% densities) boundaries were examined against land cover data (Bureau of Land Management et al. 2002) and hydrography (USGS 1981*a*, 1981*b*) to help interpret the results. We chose the 90% kernel boundary as the basis for defining a new survey area after inspecting all 3 kernels and balancing the desire to incorporate as much of the historic data points as possible without including an excessive amount of non-habitat area. This boundary was smoothed by screen-digitizing and then used to clip the original transects to produce a new set of survey transects.

Basic comparison of the distribution of Greater White-fronted Geese and Canada Geese was accomplished by computing 50%, 75%, 90%, and 95% density kernels for each species separately. Overlap between the species was determined by the proportion of kernel area, goose groups, and goose numbers of Canada Geese compared to Greater White-fronted Geese.

Results

Surveys were flown in early July of each year and required between 2 and 4 days to complete (Table 1).

For undocumented reasons, the short transect lines in the middle part of the survey area were not flown in 2000 or 2001. Beginning in 2002, the northern-most 36 transects (consisting of 54 transect segments totaling 704 km [438 mi]) were dropped from the survey and replaced with 16 lakes. At some point, 6 additional lakes to the east of the survey area and various segments of Hather Creek were included for the targeted surveying (Fig. 2). In 2006, not only were the 22 specific lakes in the northern part of the survey area flown, but all the transects were flown as well. A review of all the survey data against the 22 specific lakes showed that the 6 added lakes, as well as the southwest most lake have recorded a single swan and a single goose group, respectively. Three other lakes only have a single swan observation (Fig. 2).

Numbers of Canada Geese recorded ranged from 680 to 8,348 (3,315 to 8,348 if the 2000 survey is excluded) while Greater White-fronted Geese ranged from 9,837 to 27,260 (Fig. 3, Appendix 1); reasons that so few Canada Geese were recorded in 2000 are unknown. Young of the year generally comprised a very small percentage of the total counted; the exception being in 2007 when 15.2% of the Canada Geese counted were young of the year and

1.5% of the Greater White-fronted Geese counted were young of the year (Appendix 1). Brood locations in 2007 were widely dispersed throughout the survey area with no real concentration areas.

Both Trumpeter (*Cygnus buccinator*) and Tundra Swans (*C. columbianus*) occur at INWR (USFWS 2008). While present each year, swan numbers were only recorded during 7 of the 10 surveys (Fig. 4). The 2006 survey detected over twice as many swans as any other survey; the reason for this one time spike in detections is unknown.

Molting Greater White-fronted Geese at INWR largely consist of non-breeding and failed breeding birds, and non-breeding second-year birds from other parts of Interior Alaska (Salomonsen 1968, Hohman et al. 1992, Fischer 2008). Year to year variation in the number of Greater White-fronted Geese counted is partly explained by this behavior. Weather during the survey may also contribute to annual variation, but insufficient data were recorded to allow us to investigate this further.

Sightability and detectability were unquantified influencing factors in this survey. Day to day variation in these factors was demonstrated in 2006 when the northern lakes were flown on one day and transects for the same area were flown the following day (Table 2). The lake only survey yielded 97% and 53% of the Canada Goose observations and groups, respectively, compared with the transect survey. The lake only survey recorded 53% and 50% of the Greater White-fronted Goose observations and groups, respectively, compared with the transect survey. An examination of where goose groups were located during the transect flight showed that every goose group except one was located on a lake visited during the lake only flight (Fig. 5); the exception was a single group of 12 adult and 13 young Greater White-fronted Geese located on a small lake just east of Dishkaket Slough. This small lake could easily have been overlooked during the lake only survey. Again, no data on weather conditions were available to provide insights to explain the differences from one day to the next. The time of day the two surveys were flown was different, however. Observations during the lake only survey were made between 2009 hrs and 2120 hrs whereas observations during the transect survey were made between 1135 hrs and 2023 hrs. Time and activity data collected in 2006 indicated that all evening observations of geese were on shores associated with taller vegetation whereas geese are as likely to use open water, shoreline, or shores with lower vegetation as shores with taller vegetation during the day (Ely, personal communication, 2010). This is one possible explanation for the reduced numbers observed during the lake only flight compared to the transect flight the next day.

A kernel analysis of Greater White-fronted Goose locations from all the surveys combined was compared to a kernel analysis of Canada Goose locations (Figs. 6 and 7). Depending on the kernel size, we found that 82 – 99% of all Canada Geese were found within the areas associated with Greater White-fronted Geese (Table 3).

A cursory examination of where geese had been detected during the surveys and the survey area boundary (Figs. 8 and 9) indicated that the survey area boundary may be excessively large. The 90% kernel boundaries (Fig. 10) encompassed 96.1% of all goose groups and 97.9% of all geese counted (Table 4). We then examined the size and location of the kernel areas from a survey logistics perspective we found: 8 areas were associated with survey lakes/sloughs in the northern portion of the survey area; 9 areas could be merged together; 1 larger separated area with 2 adjoining smaller areas could be effectively joined, 1 larger separated area could be efficiently surveyed; and 2 small isolated areas (containing 3 groups of geese summing to 13 adults) that could not be easily merged or surveyed.

Excluding the 8 northern kernel areas associated with the lakes/sloughs, kernel polygon boundaries were merged and smoothed into 3 survey areas. The smoothed survey areas, combined with the northern lakes, encompassed 98.7% of the Canada Geese and 99.1% of the Greater White-fronted Geese observed. The smoothed survey areas were then used as the

basis for a proposed new survey area. The proposed new survey area is 769 km^2 (297 mi^2) with 66 transects totaling 793 km (492 mi; Fig. 11).

Swans were not well represented by the kernel analysis. The kernel analysis area contained only 25.6% of the swan locations (25.1% of the total swan observations) whereas the smoothed survey area contains 48.3% of the swan locations (47.3% of the total swan observations). Similar to the 2006 results for the northern portion of the survey area, swans appear to be predominately located on waterbodies not used by geese.

Conclusions and Recommendations

This survey was conceived and designed to census molting geese on INWR. The survey appears to have accomplished that goal. Additionally, the survey has generated a large spatial dataset suitable for further spatial analysis.

The kernel analysis and the smoothed survey area boundaries indicate that the survey area can be reduced without compromising previously collected data. The recommended survey area (Fig. 11) is 769 km^2 (297 mi^2) with 66 transects totaling 793 km (493 mi). This represents a reduction of 60% from the original survey area and a reduction of 474 km (295 mi) from transects flown in most years (and a reduction of 1,278 km [794 mi] from the original design).

We recommend that the 22 targeted lakes in the northern part of the survey area be reduced to those 11 highlighted in Fig. 12 to improve survey efficiency. We believe that this reduced survey area and reduced number of targeted lakes will require only 2 days of effort. Other than the specific transects and lakes, we are not advocating any other changes to the basic survey methods, therefore, detection rates of geese in the proposed survey area should be the same as those from previous surveys.

We recommend that transects depicted in Fig. 11 and lakes depicted in Fig. 12 be flown every year while the original survey transects be flown at 5 year intervals. Repeating the entire survey design every 5 years will allow biologists and managers to asses if any shifts in distribution of geese are occurring and to revalidate that the reduced survey area is still appropriate. If adopted, we recommend that the new survey areas be flown in 2010 and the original survey area flown in 2011 as 2006 was the last time the original transects were flown.

We recommend that a standardized list of species to be recorded during future surveys, as well as a standardizing of the species codes that will be stored in the data files, be agreed upon between INWR and the Anchorage Migratory Bird Office. The Voice/GPS Survey Recording program allows for recording the aircraft path which we recommend be done each day to obtain the best information on the survey search effort. Transcription of the recorded data using the Transcribe part of the Voice/GPS Survey Recording program should be done using the 'Breeding Pop Survey' option so that the final data file will be consistently formatted for validation with existing data checking programs. Final data files and track files should be sent to both INWR and the Anchorage Migratory Bird Office for GIS data processing and addition to existing geodatabases containing all previous years' data.

To facilitate area use analysis in the future, we recommend that pilots make a greater effort to ensure that locations of goose groups are recorded over the waterbody itself and not over land.

We recommend that additional analysis of molting goose data be completed; especially an analysis of habitat types, waterbody types, coupled with other covariates to develop habitat selection models for both molting Greater White-fronted Geese and Canada Geese.

We recommend that the variables to be collected for every survey, at a minimum, include the following:

- survey basics of pilot name, observer name(s), aircraft N number, and date;

- environmental variables (wind speed and direction, ambient temperature, and cloud cover) be recorded at the start and end of each survey day;
- daily survey start and end points (including start and end points associated with breaks taken during the survey);
- transect start and end points;
- number of Canada Goose adults and young (e.g., 12 adults, 3 young);
- number of Greater White-fronted Goose adults and young; and
- notes about any deviations from the survey design, water levels in relation to "average" grazing lawn presence (e.g., high water, grazing lawns covered or minimally exposed; grazing lawns present; extensive amounts of exposed mud below grazing lawns), and major storms or weather fronts for the 3 day period both proceeding and following the survey.

We recommend that a study be developed to investigate factors influencing sightability and detectability of geese. This study would need to look at both smaller and larger lakes as well as rivers to ensure consistency between waterbody size and type. Results of this study should be used to refine the conditions under which the survey is conducted and thereby reduce some of the year to year variation in the observations.

More information needs to be collected regarding water depth, grazing lawn availability, and distribution of geese to better predict potential effects from changing water regimes due to changing climatic conditions.

Results indicate that swans are largely located in areas away from geese and generally not well represented in either the recommended survey area or in the targeted lakes. If INWR desires to collect data on swan numbers, then a swan specific survey needs to be developed and initiated.

Acknowledgments

We would like to acknowledge the assistance provided by all the observers over the course of this survey, as well as logistical support provided by INWR staff over the previous 10 years. We would like to acknowledge P. Anderson for flying the 2009 survey.

This report was improved by reviews from C. Ely, J. Martin, and D. Whitworth.

Literature Cited

Beyer, H. L. 2007. Hawth's analysis tools for ArcGIS. Version 3.27. Available at http://www.spatialecology.com/htools.

Beyer, H.L. 2009. Hawth's analysis tools for ArcGIS web page, http://www.spatialecology.com/htools. Accessed 8 December 2009

Bureau of Land Management, Innoko National Wildlife Refuge, and Ducks Unlimited. 2002. Innoko earth cover classification. Anchorage, AK; Technical Report 47. Bureau of Land Management.

Hohman, W. L., C. D. Ankney, and D. H. Gordon. 1992. Ecology and management of postbreeding waterfowl. Pp. 128-189, *in* B. D. J. Batt, A. D. Afton, M. G. Anderson, C. D. Ankney, D. H. Johnson, J. A. Kadlec, and G. L. Krapu, eds. Ecology and management of breeding waterfowl. Minneapolis, MN; University Minnesota Press.

Fischer, J.B. 2008. Midcontinent Greater White-fronted Geese in Alaska – 2008 Project Updates. Unpublished report. Anchorage, AK; U.S. Department of Interior, Fish and Wildlife Service, Migratory Bird Management, Waterfowl Management Branch.

Powell, R. A. 2000. Animal home ranges and territories and home range estimators. Pages 65–110 *in* L. Boitani and T. K. Fuller, editors. Research techniques in animal ecology: controversies and consequences. Columbia University Press, New York, New York, USA.

Seaman, D. E., J. J. Millspaugh, B. J. Kernohan, G. F. Brundige, K. J. Raedeke, and R. A. Gitzen. 1999. Effects of sample size on kernel home range estimates. Journal of Wildlife Management 63:739–747.

Salomonsen, F. 1968. The moult migration. Wildfowl 19: 5-24.

Talbot, S.S., and C.J. Markon 1988. Intermediate-scale vegetation mapping of Innoko National Wildlife Refuge, Alaska using Landsat MSS digital data. Photogrammetric Engineering and Remote Sensing, 54(3):377-383.

USFWS (U.S. Fish and Wildlife Service). 2008. Revised comprehensive conservation plan for the Innoko National Wildlife Refuge. Anchorage, AK; U.S. Department of Interior, Fish and Wildlife Service.

USGS (U.S. Geological Survey). 1981a. Hydrology digital line graphic geodataset, Ophir 1:63,360 scale quadrangles.

USGS (U.S. Geological Survey). 1981b. Hydrology digital line graphic geodataset, Iditarod 1:63,360 scale quadrangles.

Table 1. Molting goose surveys dates and crews, Innoko National Wildlife Refuge, Alaska.

Dates	Pilot	Observer
9-11 July 2000	J. Sarvis	B. Aston
5-7 July 2001	E. Mallek	B. Aston
6-7 July 2002	E. Mallek	L. Lysne
4-5 July 2003	E. Mallek	S. Charbonnet
5-6 July 2004	E. Mallek	S. Charbonnet
3-5 July 2005	E. Mallek	H. Wilson
3-6 July 2006	K. Bollinger	R. Corcoran
4-7 July 2007	K. Bollinger	R. Corcoran
5-9 July 2008	K. Bollinger	S. Kovach
6-7 July 2009	P. Anderson	S. Kovach

Table 2. Comparison of geese counted on 2 July 2006 on specific lakes and those counted from transects on 3 July 2006, Innoko National Wildlife Refuge, Alaska. CAGO refers to Canada geese; GWFG refers to greater white-fronted geese.

Species/Age	On Lakes		On Transects	
	Number of Birds	Number of Groups	Number of Birds	Number of Groups
CAGO Adults	213	16	212	30
CAGO Young	37	4	45	7
CAGO Total	250	16	257	30
GWFG Adults	82	4	137	8
GWFG Young	16	1	43	2
GWFG Total	98	4	180	8

Table 3. Proportions of Canada Goose kernel area, numbers of groups, and number of individuals found within corresponding Greater White-fronted Goose (GWFG) kernel area based on surveys of molting geese in early July on Innoko National Wildlife Refuge, Alaska, 2000-2009.

	GWFG Kernel Area			
	50%	75%	90%	95%
Kernel Area Overlap	83.9	84.5	88.4	89.4
Number of Groups	70.7	85.8	95.6	97.6
Number of Individuals	82.0	93.2	98.0	99.0

Table 4. Results of 90% kernel analysis of molting goose locations from surveys conducted in early July on Innoko National Wildlife Refuge, Alaska, 2000-2009.

Species	% of locations	% of total count
Canada Geese	97.1	98.7
Greater White-Fronted Geese	95.2	97.7

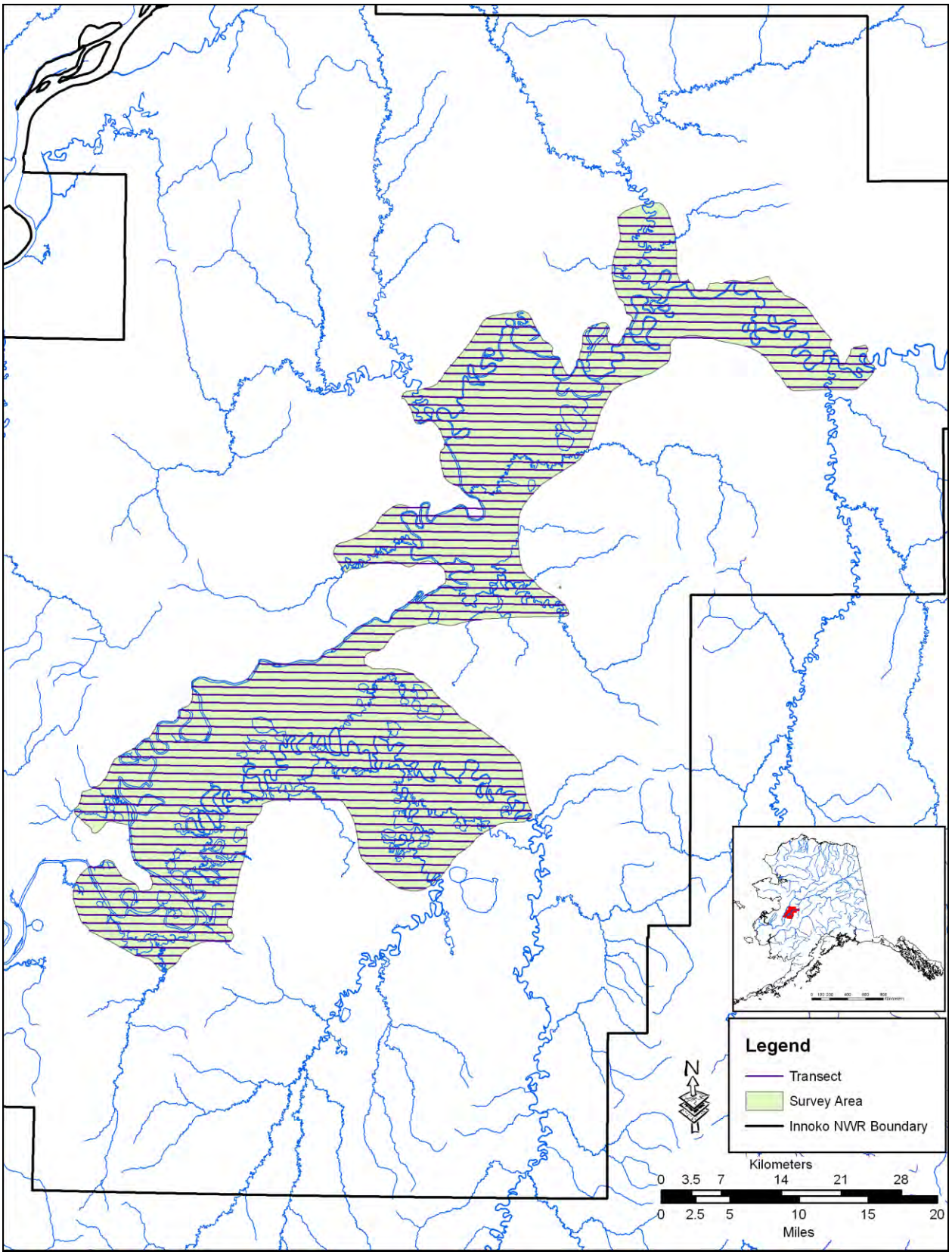

Figure 1. Molting goose survey area and transect lines, Innoko National Wildlife Refuge, Alaska.

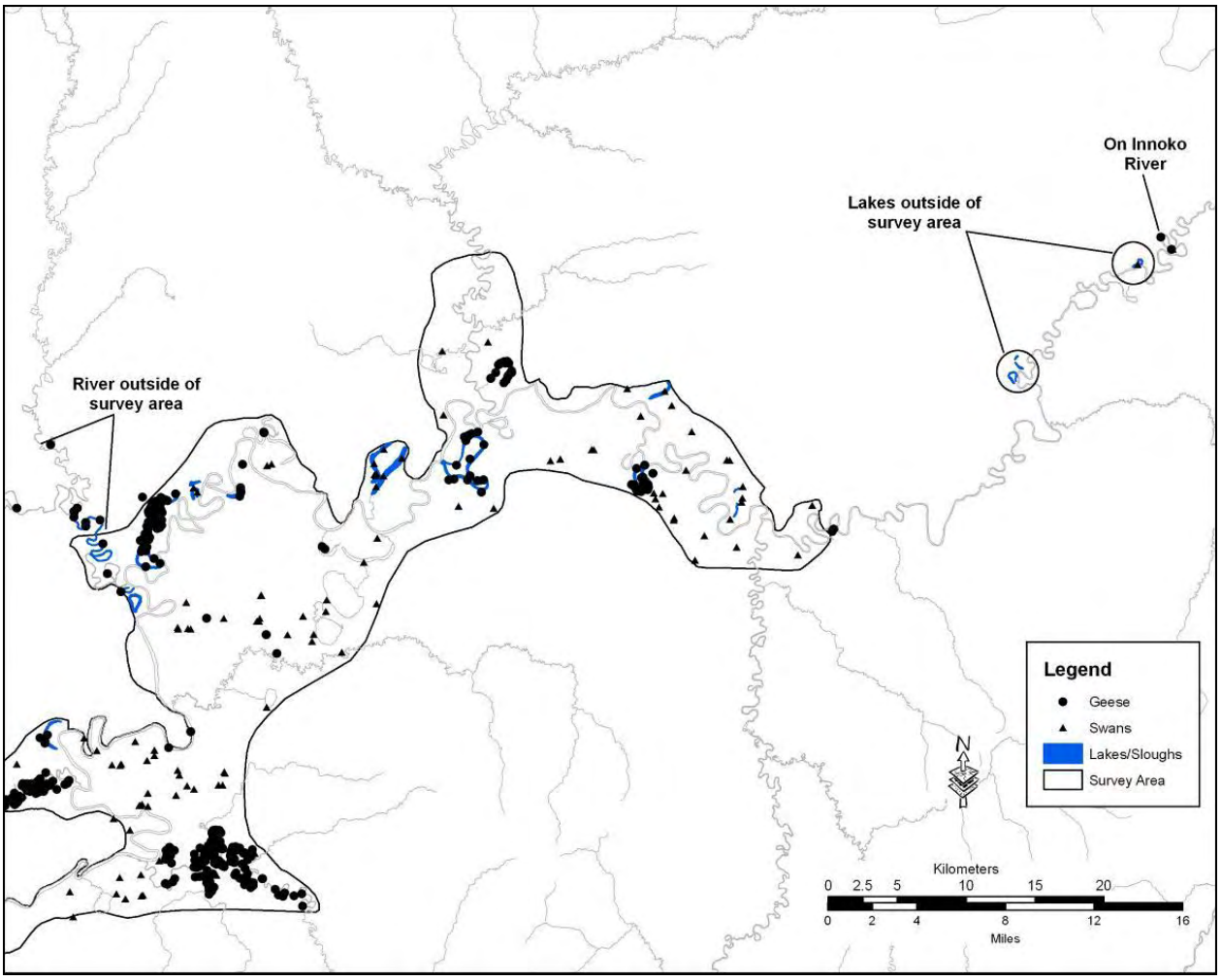

Figure 2. Molting goose and swan locations from early July 2000-2009 relative to targeted survey lakes and sloughs on Innoko National Wildlife Refuge, Alaska.

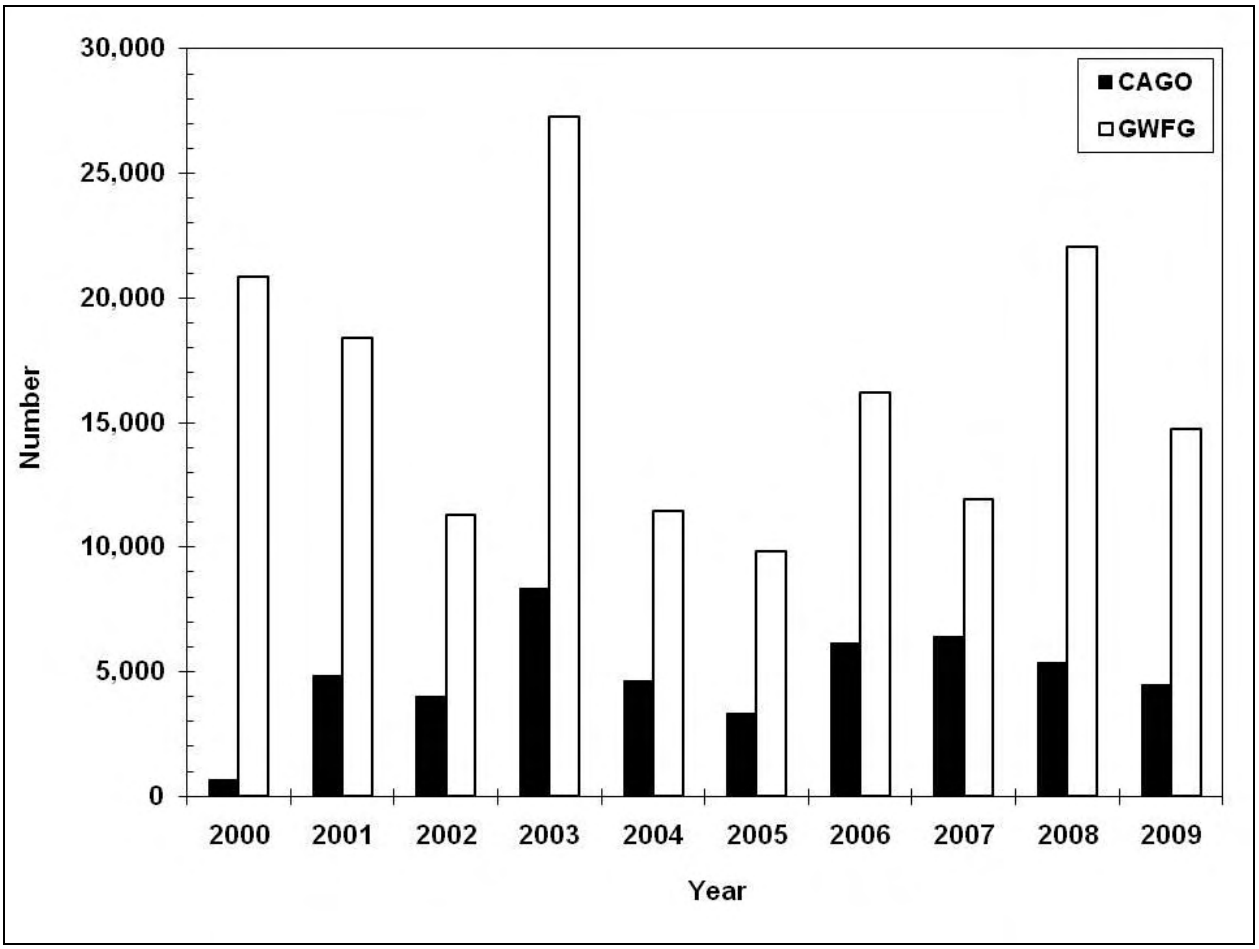

Figure 3. Results of molting Canada Goose (CAGO) and Greater White-fronted Goose (GWFG) surveys in early July on Innoko National Wildlife Refuge, Alaska.

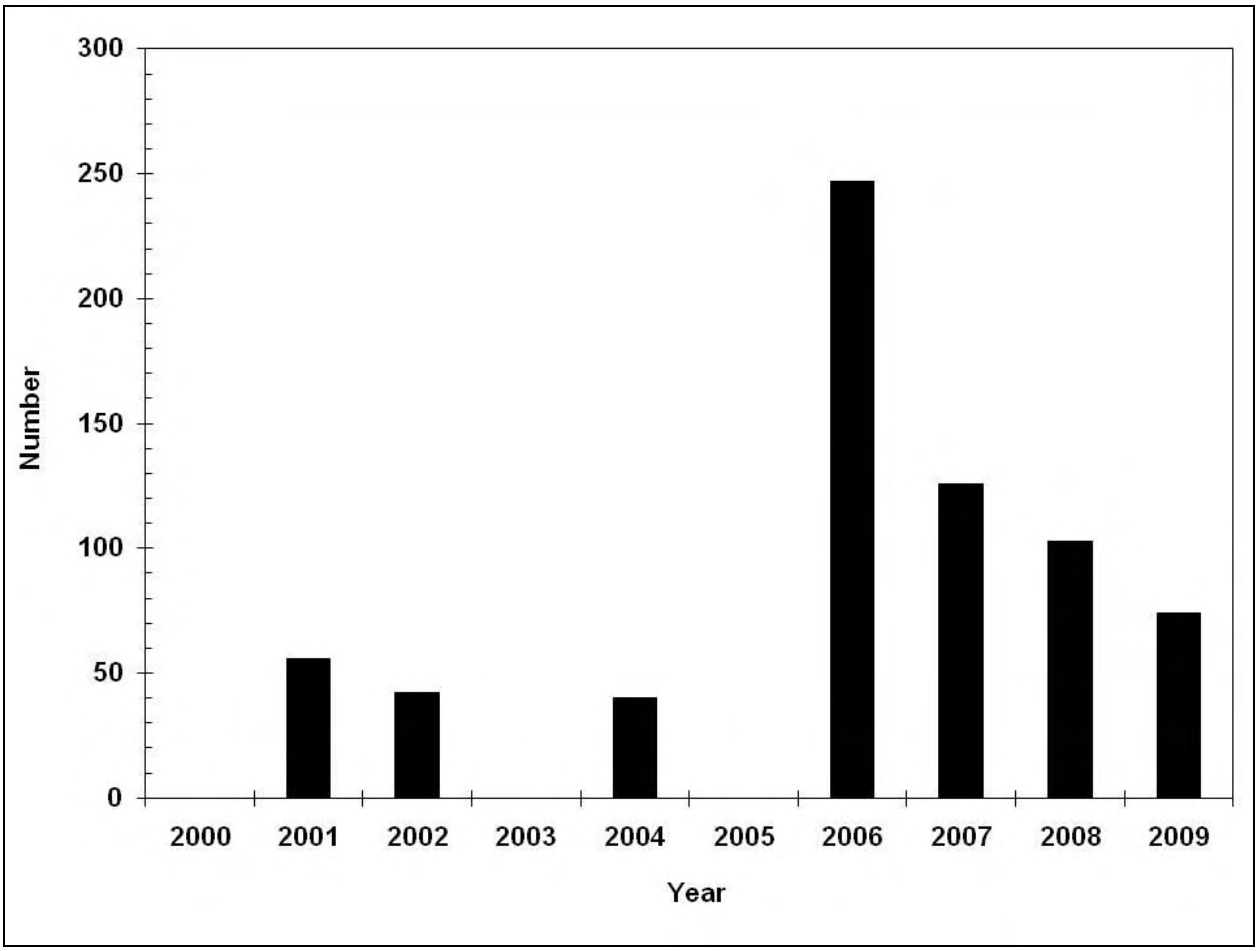

Figure 4. Results of swans counted during molting goose surveys in early July on Innoko National Wildlife Refuge, Alaska. Survey crews did not record swan numbers or locations during the 2000, 2003, and 2005 surveys.

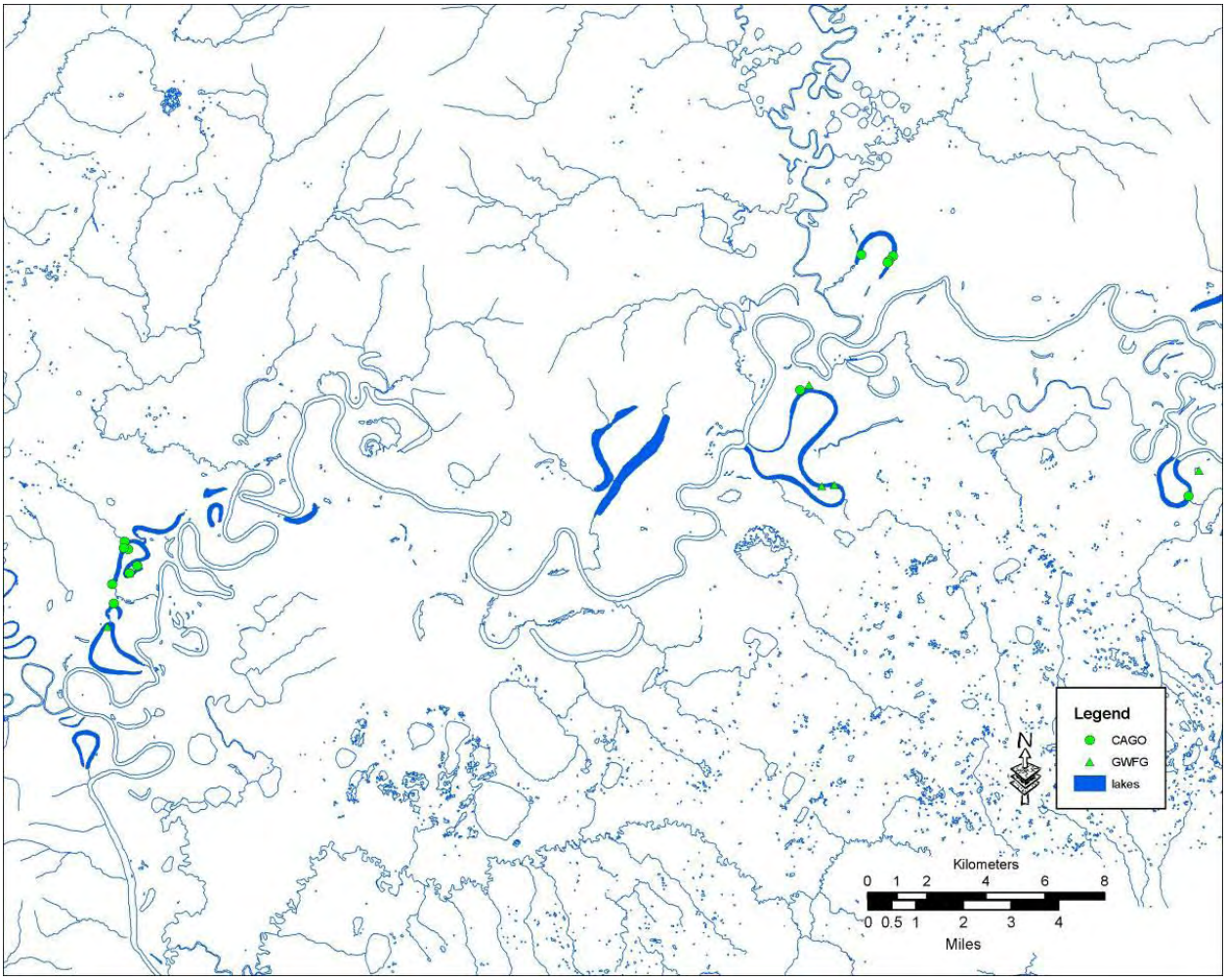

Figure 5. Locations of Canada Goose (CAGO) and Greater White-fronted Goose (GWFG) groups located on 3 July 2006 while flying transects compared to lakes surveyed the previous day, Innoko National Wildlife Refuge, Alaska.

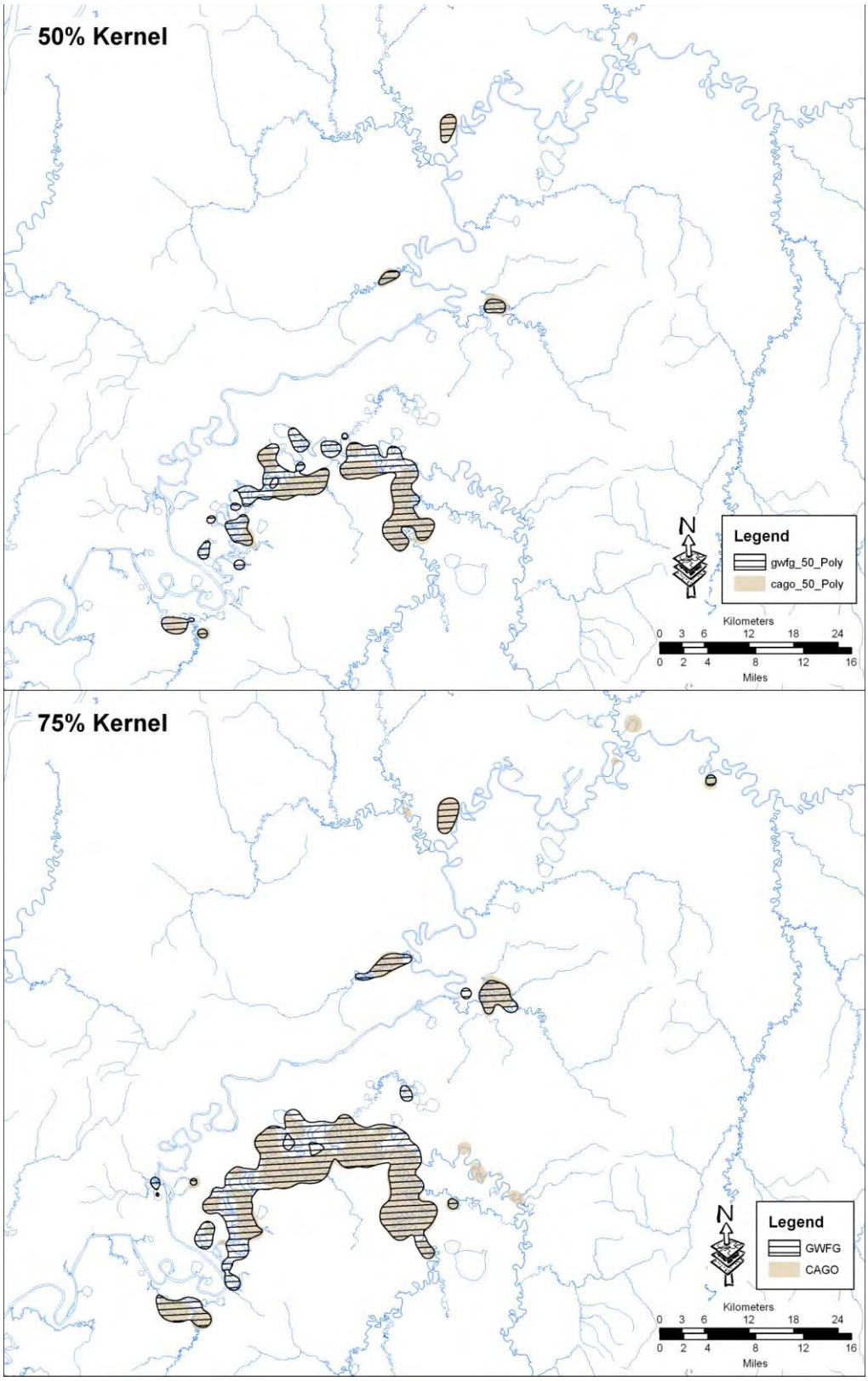

Figure 6. Greater White-fronted Geese (GWFG) and Canada Geese (CAGO) 50% and 75% density kernels based on surveys of molting geese on Innoko National Wildlife Refuge, Alaska in early July, 2000-2009.

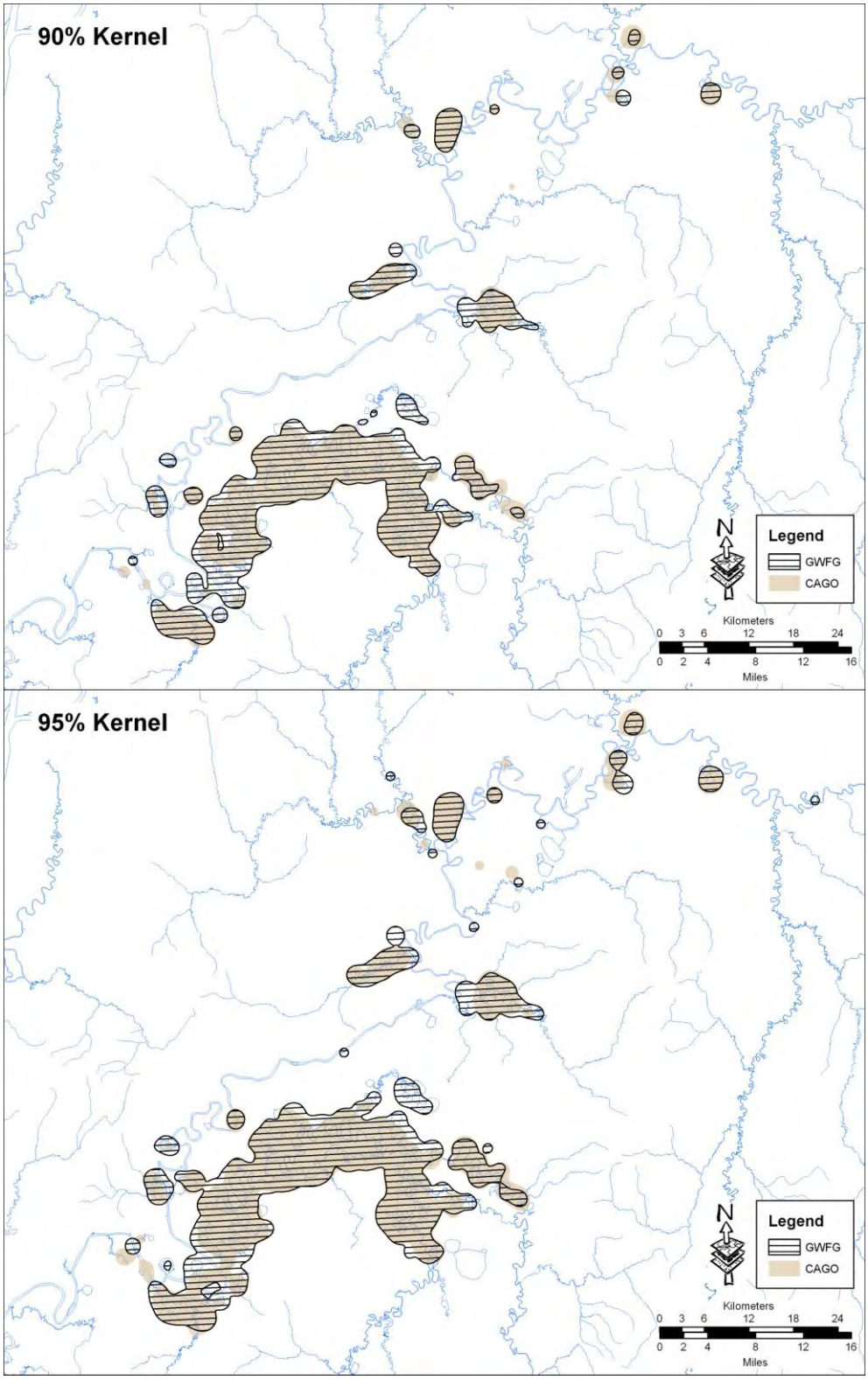

Figure 7. Greater White-fronted Geese (GWFG) and Canada Geese (CAGO) 90% and 95% density kernels based on surveys of molting geese on Innoko National Wildlife Refuge, Alaska in early July, 2000-2009.

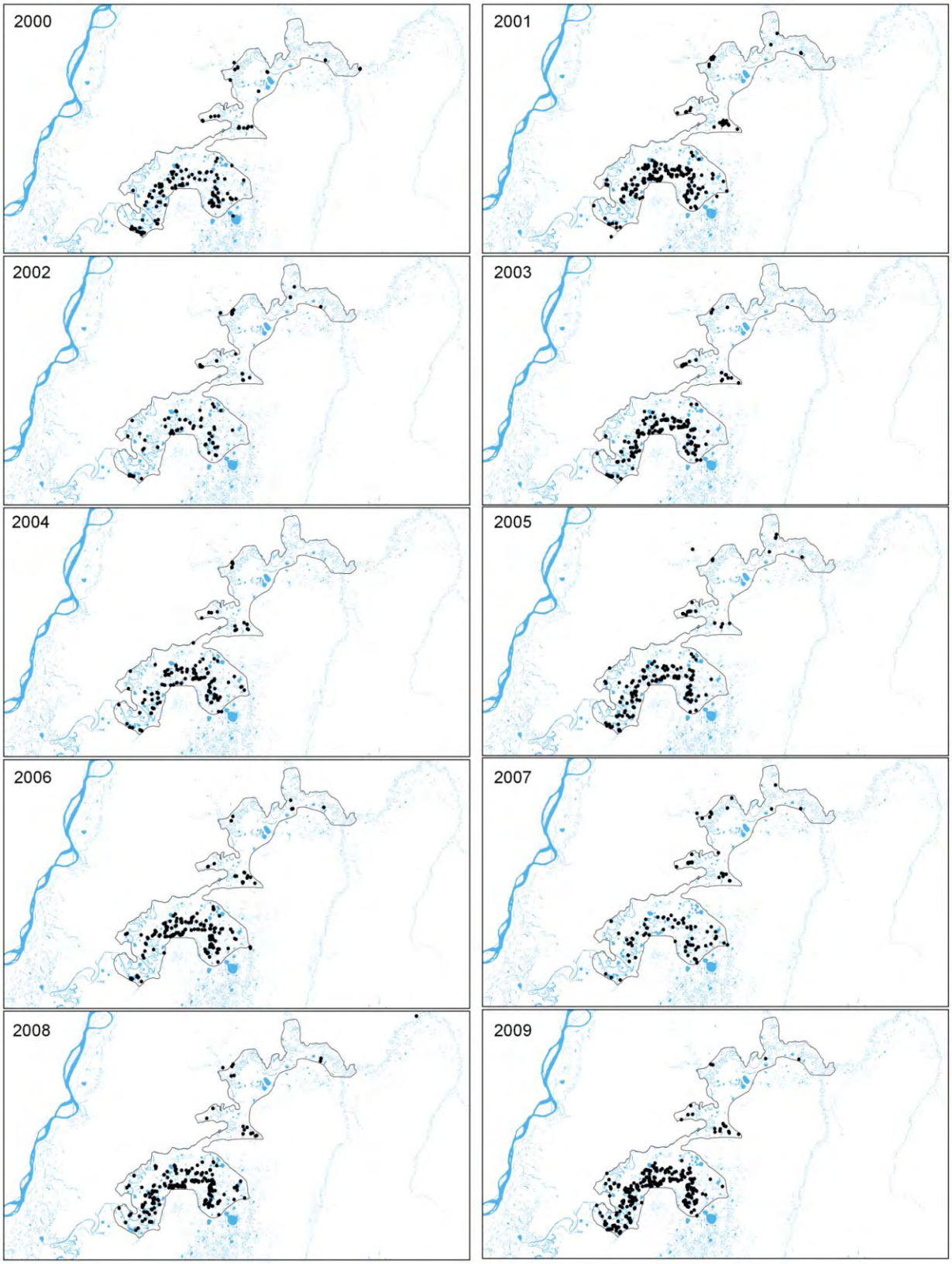

Figure 8. Distribution of Greater White-fronted Geese recorded during the molting goose surveys in early July 2000-2009 on Innoko National Wildlife Refuge, Alaska.

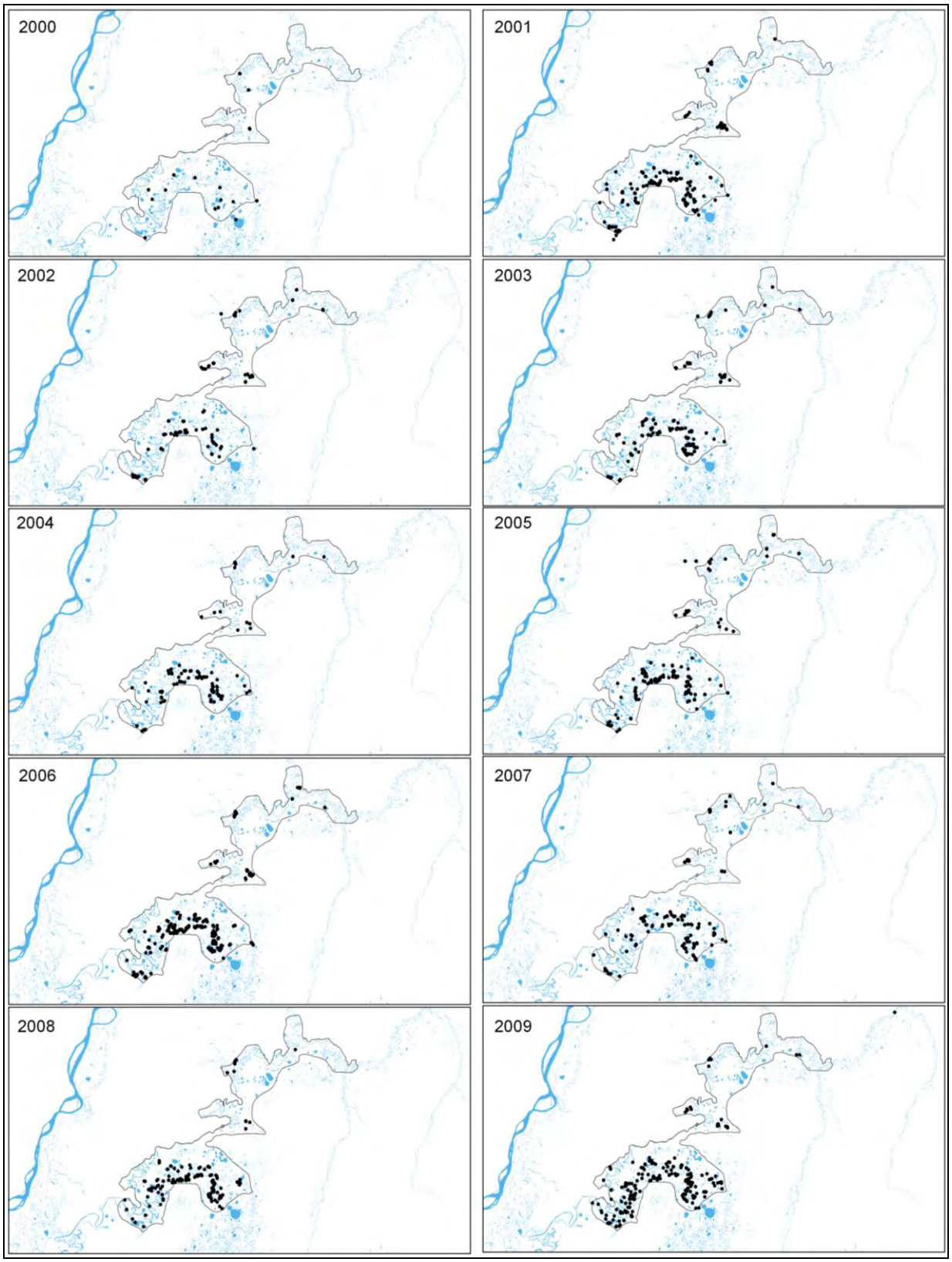

Figure 9. Distribution of Canada Geese recorded during the molting goose surveys in early July 2000-2009 on Innoko National Wildlife Refuge, Alaska.

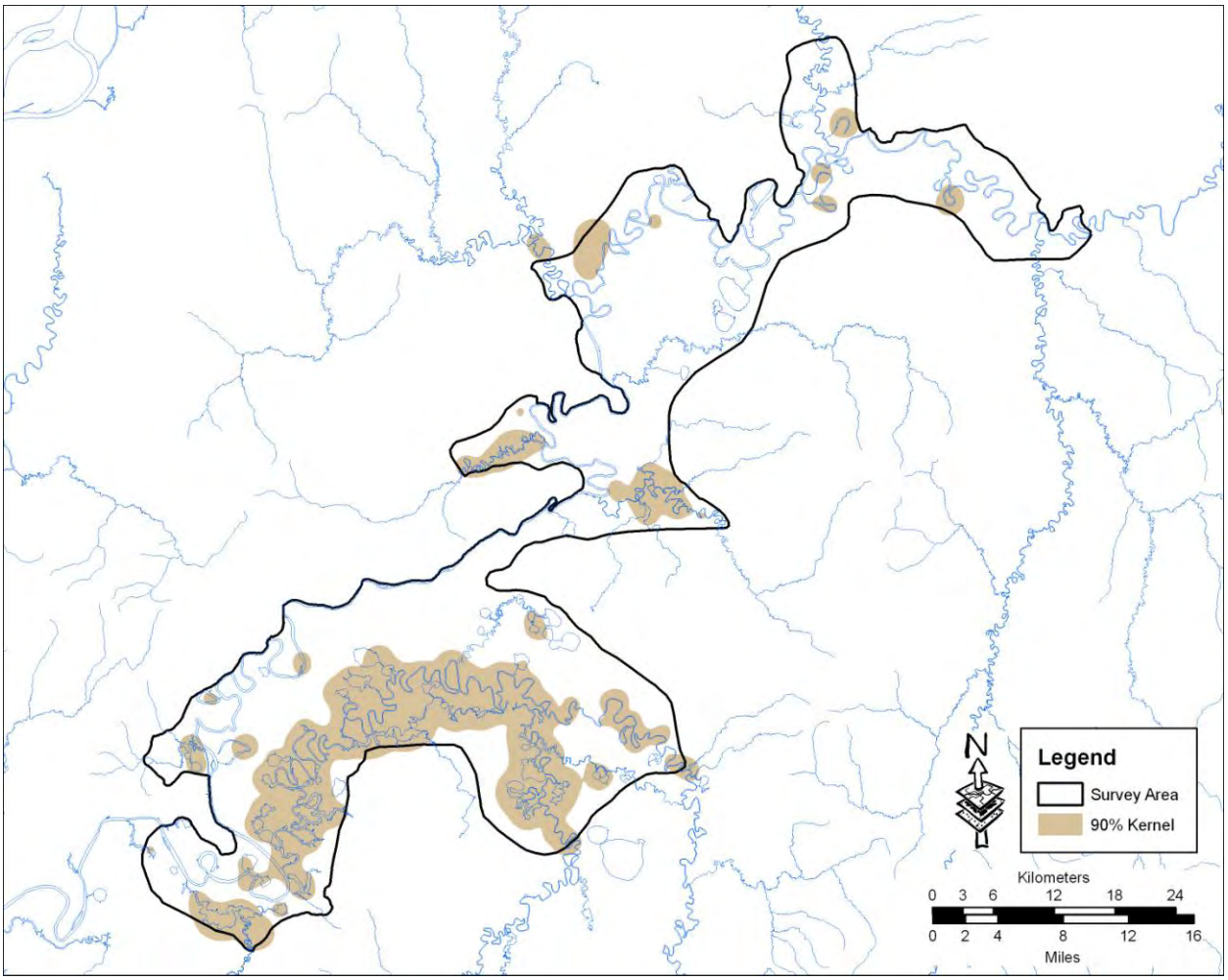

Figure 10. Results of a 90% kernel analysis of goose locations from molting goose surveys in early July 2000-2009 on Innoko National Wildlife Refuge, Alaska.

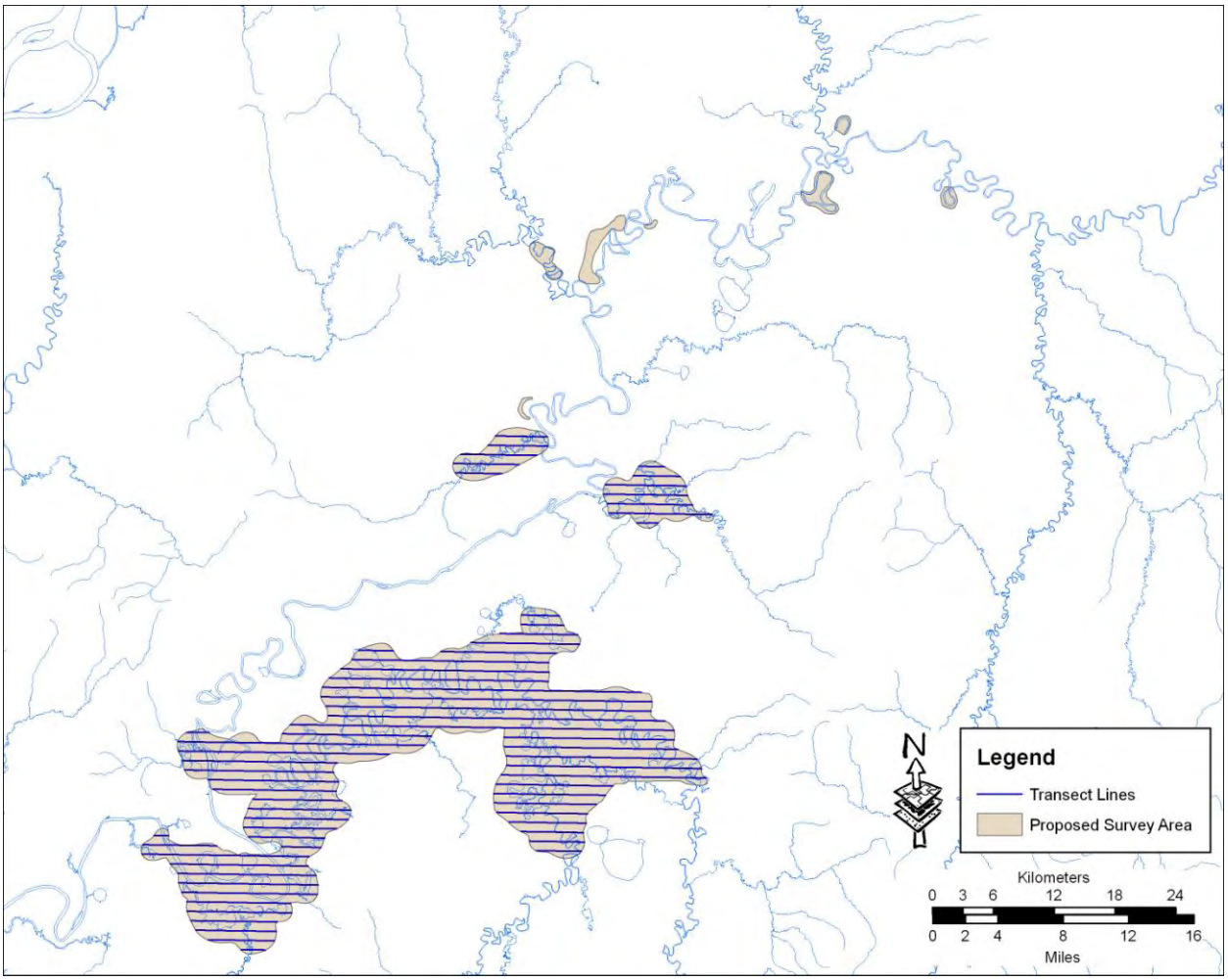

Figure 11. Recommended new survey area and transects for the Innoko National Wildlife Refuge, Alaska molting goose survey. For survey areas without transect lines, see Figure 12 for more detail.

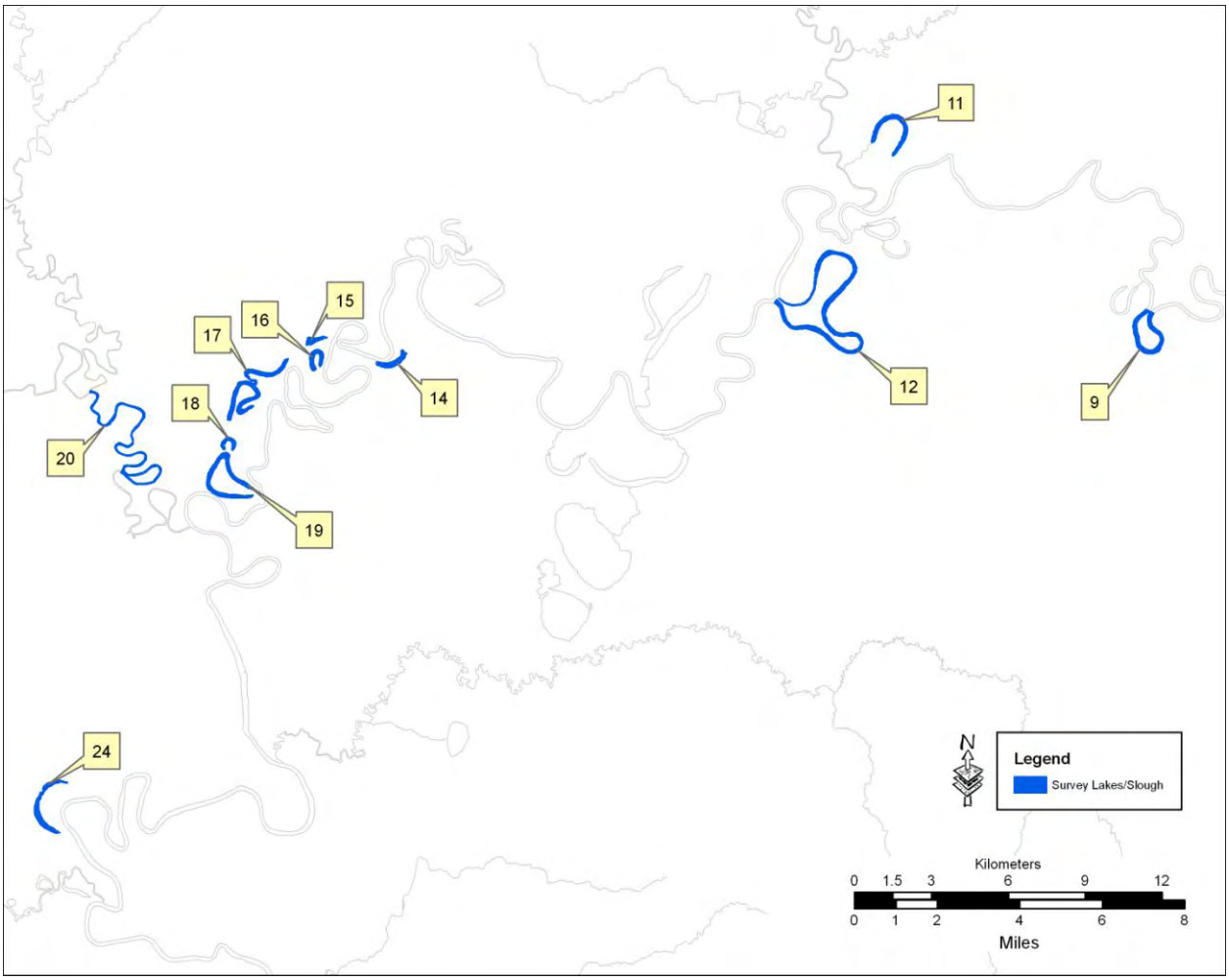

Figure 12. Recommended targeted lakes/sloughs/river segment for the Innoko National Wildlife Refuge, Alaska molting goose survey. Numbers are reference numbers only.

Appendix 1. Results of molting goose surveys on Innoko National Wildlife Refuge, Alaska. SWANS refers to Tundra and Trumpeter Swans combined.

Year	Canada Geese		Greater White-fronted Geese		SWANS	
	Adults	Young	Adults	Young	Adults	Young
2000	652	28	20,724	121	n/a	n/a
2001	4,814	25	18,246	137	57	9
2002	3,903	14	11,273	19	39	3
2003	8,216	132	27,243	17	n/a	n/a
2004	4,625	35	11,420	42	39	1
2005	3,153	162	9,761	76	n/a	n/a
2006	6,027	144	16,146	66	205	42
2007	5,414	974	11,754	177	109	17
2008	5,208	137	21,977	53	94	9
2009	4,470	n/a	14,717	n/a	73	1