PROGRESS REPORT – 21 September 2007

Title: Chronology and Rates of Migratory Movements, Migration Corridors and Habitats Used, and Breeding and Wintering Area Affiliations of Female Lesser Scaup Captured during Spring Stop-over on Pool 19 of the Mississippi River – A Pilot Study

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Introduction

The continental scaup population (lesser [*Aythya affinis*] and greater scaup [*A. marila*] combined) has declined markedly since 1978 (Austin et al. 1998, Afton and Anderson 2001). Annual population estimates of scaup have been below the population goal of the North American Waterfowl Management Plan since 1985 and reached an all-time low in 2006 (Wilkins et al. 2007). Afton and Anderson (2001) reported that the decline in the continental scaup population likely is driven by a decline in the lesser scaup population.

The segment of the scaup population wintering in states bordering the Gulf of Mexico and migrating north along the Mississippi River valley, subsequently through Iowa, Minnesota, and North Dakota (hereafter upper-Midwest), comprises a major component of the continental population and likely is experiencing the largest decline (Afton and Anderson 2001). Located partially within the upper-Midwest, Region 3 of the U.S. Fish and Wildlife Service (2002) declared lesser scaup a conservation priority citing a need to (1) provide key information that increases our understanding of limitations to conservation of this species, (2) acquire biological information to support conservation actions relating to habitat availability and quality, and (3) provide technical assistance to initiate, augment, or redirect conservation actions so that best management practices can be applied. Lesser scaup have high recreational and economic values; high historical abundance established this species as a staple to both hunters and bird-watchers (Chabreck 1964, Jessen 1981, U.S. Fish and Wildlife Service 2002).

Several major factors have been hypothesized as causing the scaup population decline including (Austin et al. 2000, Afton and Anderson 2001): (1) decreased quality and quantity of food resources on winter and spring migration stopover areas, (2) accumulation of contaminants, and (3) climate and habitat changes on boreal forest breeding areas, all of which may be directly or indirectly affecting female survival or recruitment. The first factor listed above has been formalized as the Spring Condition Hypothesis (Afton and Anderson 2001) and has been most extensively tested to date (Anteau 2002, 2006; Anteau and Afton 2004, 2006).

The Spring Condition Hypothesis states that reproductive success of lesser scaup has declined because females are arriving on breeding areas in poorer body condition than in the past, or not arriving at all, due to a decline in availability and/or quality of forage resources preventing females from acquiring sufficient nutrient reserves (lipid, protein, and mineral) during spring migration (Afton and Anderson 2001). Anteau and Afton (2004) documented a decrease, from historical levels, in body mass and lipid reserves of female lesser scaup currently migrating through northwestern Minnesota and arriving to breed in southwestern Manitoba. Concomitant with the decline in female body condition, Anteau and Afton (2006) also documented a decline, from historical levels, in forage quality of lesser scaup diets. Anteau (2006) further tested the scope and mechanisms of the Spring Condition Hypothesis and reported several key findings: (1) lipid reserves of females migrating through the upper-Midwest currently are much lower than are those of females at Pool 19, a major spring stopover to the south, (2) females migrating through the upper-Midwest are not storing lipids as expected, but rather are catabolizing lipids, and (3) densities of amphipods, a preferred lesser scaup food, currently are very low throughout the upper-Midwest and apparently are causing the observed decline in lipid reserves. In summary, all findings to date have been consistent with the Spring Condition Hypothesis, and, thus, this hypothesis presently can not be rejected.

Several important questions remain regarding Anteau's (2006) results, one of which is, what is the relative importance of stopover areas in the upper-Midwest for accumulation of nutrient reserves by migrating female lesser scaup? Rates and distances moved during a single migratory flight may be dependent on female body condition; females in superior condition may take longer, more rapid and frequent flights. If so, females in superior condition might have a lower probability of being sampled within the upper-Midwest region. Anteau (2006) attempted to evaluate this question by color-marking lesser scaup at Pool 19, with respect to body mass, and then observing them within the upper-Midwest; however, too few observations of color-marked birds were obtained to draw conclusions (see Appendix E in Anteau 2006:212). Clearly, Anteau's (2006) results indicate that many females migrating through the upper-Midwest in spring are in very poor body condition, but forage conditions may be better in the southern prairies of Canada, allowing females to regain body condition there before moving on to more northerly breeding areas. Thus, quantitative information on the proportion of time females spend in each of these regions of North America during spring migration would be a useful first step in evaluating Anteau's (2006) results and, ultimately, in prioritizing migration stopover areas for habitat conservation and management.

Accordingly, we initiated a pilot study with the major objective of documenting spring migration corridors and migratory flight parameters of radio-marked females, in order to estimate the proportion of time individuals of varying body mass spend on identified wetlands within the upper-Midwest and prairie Canada during spring. If after departing the upper-Midwest, females spend large amounts of time in prairie Canada before moving on to more northerly breeding areas, then future research of forage conditions and whether or not females are able to regain body condition in prairie Canada would be needed. Given the theoretical battery life of the satellite radios, we also will collect information on several secondary objectives, such as fall migration corridors and affiliations of breeding and wintering areas of females. Finally, we trapped and banded as many lesser scaup at Pool 19 as possible, which allowed us to randomly select females of various body mass for radio-marking, but also will provide opportunity for direct estimates of harvest rate and survival, using new band analysis techniques (Nicolai et al. 2006).

Specific Objectives:

1) Document migration corridors and affiliations to breeding and wintering areas of female lesser scaup captured during spring stop-over on Pool 19.

2) Document chronology and estimate rates of movement (km/day) and flight distances (km) of individual females and test for relationships among these flight parameters and female body mass at capture.

3) Identify specific lakes and wetlands used by migrating females and estimate the proportion of time spent in various regions (upper-Midwest, prairie Canada) of North America during migration.

4) Band a large sample (>2000) of lesser scaup to support and encourage subsequent annual operational bandings on Pool 19 that would provide opportunity for direct estimates of harvest rate and survival using new band analysis techniques.

Study Area

We captured lesser scaup on Pool 19 of the Mississippi River, between Hamilton and Dallas City, IL and between Keokuk and Fort Madison, IA. Pool 19 is an important middle latitude migration area for lesser scaup, where large numbers stopover prior to migrating through the upper-Midwest in spring (Thompson 1973, Havera 1999, Anteau 2006). Pool 19 has been described in detail by Thompson (1973) and Havera (1999).

Methods

We trapped, weighed, banded, and released male and female lesser scaup throughout the spring stop-over period, using standard techniques (Haramis et al. 1982, 1987; Pace and Afton 1999). We randomly selected a sub-sample of 17 females, with minimum body mass of 630 g and maximum body mass of 930 g, to be implanted with 38 g, intracoelomic satellite transmitters (PTTs; see below).

We tested PTTs for successful satellite transmission and confirmed them to be working prior to implantation. We used PTTs that were identical to those used successfully in an ongoing study of lesser scaup migrating from the Great Lakes region (Badzinski and Petrie 2006a, 2006b). Furthermore, we implanted PTTS in females within the range of body mass of those successfully radio-marked in the Great Lakes region (Scott Petrie, personal communication). Finally, we used a PTT duty cycle that theoretically provides locations every 1.4, 7.2, and 3.3 days during spring migration, on breeding and wintering areas, and during fall migration, respectively. The theoretical battery life allows potential coverage during 2 spring migration periods for each surviving radio-marked female.

Surgical Implant Procedures

Dr. Mark Mitchell, who is experienced in implanting PTTs in ducks, conducted all implant surgeries at the field site. Ducks were anesthetized using isoflurane. Initially, the anesthesia was delivered by facemask (5% isoflurane, 1 liter oxygen flow rate). Once females lost consciousness, they were intubated using a 3-0 to 4-0 endotracheal tube. Ducks were maintained at 2-3% isoflurane at a flow rate 1 liter of oxygen. Birds were positive-pressure ventilated during the procedure every 10 seconds. A stethoscope was used to monitor heart rate.

Ducks were surgically prepped at two sites: the dorsal synsacrum at the junction of the spine and pubis and the ventral abdominal muscles. The dorsal site was done first. The sterile surgical preparation was done using a 1% betadine solution and sterile saline. Once prepped, the surgical site was covered with a sterile 2 x 2 gauze pad. The duck then was placed in dorsal recumbency to prep the abdomen; the same sterile technique was then used. A clear surgical drape was placed after the surgical prep was completed. The ventral abdominal incision was made through the skin and rectus abdominis using a #15 scalpel blade. Once the coelomic cavity was opened, the right abdominal airsac was manually deflated.

The PTT antenna was placed into a blunt trochar and digitally guided through the incision (around the viscera) to the point of the pubic/spinal juncture. Using gentle pressure, the trochar was advanced through the skin and out the dorsum of the bird. The entire trochar and antennae was extracted sterilely out of the body cavity, by manipulating it through the clear drape.

The PTT then was digitally manipulated into place along the right body wall. The incision in the body wall was closed with 4-0 PDS using a simple continuous pattern. The skin also was closed with 4-0 PDS using a simple continuous pattern. A single 4-0 PDS suture was used to anchor the antennae to the skin on the dorsum of the bird. Birds were recovered on room air using an ambubag. Once females regained their righting reflex and were extubated, they were held in a warm, quiet area for 2 hours prior to release at the original capture site.

Analysis of satellite location data

We estimated the minimum number of migration stopover sites between Pool 19 and the inferred breeding site of each female, based on single or clustered locations (≥1 day) that varied ≤ 0.5 degrees of latitude or longitude. Potential breeding sites were inferred based on terminal clustered locations within the known breeding range of the species and date. We estimated straight-line distances between Pool 19 and the inferred breeding site for each female using the great circle distance equation. We inferred mortalities based on temperature and activity sensor data provided by ARGOS. We classified a PTT as failed when transmissions stopped, but temperature and activity sensor data for the last transmissions indicated that the bird was alive.

Preliminary Results

Satellite Radios

We captured and implanted PTTs in 17 female lesser scaup on Pool 19 of the Mississippi River during the period of 26 to 28 March 2007. Body mass at capture for the implanted females ranged from 630 to 930 g and averaged 763.5 ± 22.4 g (± SE).

Fourteen of the 17 implanted females subsequently migrated from Pool 19; 2 females died (3 and 27 days after release) on Pool 19 and the PTT of another female failed there. After release, the 14 females spent, on average, a minimum of 25.6 ± 1.8 days (± SE) on Pool 19 before migrating, with a range of 13 to 40 days. The mean departure date was 22 April 2007; the earliest and latest departure dates were 9 April and 5 May 2007, respectively.

Twelve females (86%) took a northwesterly overland tract and 2 females (14%) initially took a northerly tract when migrating from Pool 19 (Figures 1-14). Three females died while in migration; 2 in western Minnesota (40 and 52 days after release) and 1 in south central Manitoba (45 days after release).

Eleven females made, on average, a minimum of 6.3 ±1.1 (± SE) stops (Range = 1 to 11 stops) between Pool 19 and their inferred breeding sites. Straight-line distances, between Pool 19 and inferred breeding sites, ranged from 1860 to 4342 km and averaged 3020.1 ± 243.1 km (± SE). The mean time between departure from Pool 19 and arrival on the inferred breeding sites averaged 34.2 ± 2.8 days (± SE), with a minimum and maximum of 24 and 51 days, respectively. Mean overall rate of movement from Pool 19 to inferred breeding sites was 89.2 ± 4.4 km/day (± SE), with a range of 68.6 to 112.0 km/day.

Arrival dates on inferred breeding sites for 11 females ranged from 13 May to 9 June 2007, with a mean arrival of 25 May 2007. Arrival dates were positively correlated with straight-line distances from Pool 19 ($r = 0.7476$, $P = 0.0082$) and minimum number of stops between Pool 19 and inferred breeding sites ($r = 0.6526$, $P = 0.0295$), but were not correlated with overall movement rates (km/day) of individual females ($r = 0.0039$, $P = 0.99$). Moreover, overall movement rates (km/day) were not correlated with minimum number of stops between Pool 19 and inferred breeding sites ($r = 0.0555$, $P = 0.87$). Finally, body mass at capture was not correlated with any of the migratory flight parameters reported above (all Ps > 0.66).

Three females died on their breeding sites; 1 in northwestern Alberta (78 days after release) and 2 in south central NWT (82 and 163 days after release). PTTs of 3 other females also failed after arrival on their breeding sites. As of 21 September 2007, 5 females remain alive with functioning PTTs.

As of 6 September 2007, we have obtained 3281 locations on 17 females, and a relatively high proportion (61%) were locations classes 3, 2, and 1, i.e., the most accurate locations (Table 1). We examined a small sample of these locations in detail and were able to identify specific lakes and larger wetlands used by females; thus, the location data are promising for subsequent habitat use analysis.

Banding

We captured, banded and released a total of 2482 lesser scaup on Pool 19 during the period of 18 to 30 March 2007. This total included 309 AHY females and 2173 AHY males. Seventeen of the females were implanted with PTTs (see above), and 6 of the males had been banded and nasal-marked during March 2005 on Pool 19 in our previous research project there (see Anteau 2006). We recorded body mass and estimated the % of the esophagus containing corn for all captured birds. We recaptured 196 birds that had been banded and released by us during the 2007 pilot study; no foreign recaptures were obtained during this period.

Discussion

Potential effects of capture and implantation of PTTs (hereafter radio-effects) on survival and migration behavior of the 17 females are unknown and of concern with respect to results obtained in the pilot study. As of 21 September 2007, 8 of the 17 implanted females (47%) apparently have died, which appears to be a relatively high proportion based on annual survival estimates from banding data (Nicolai et al. 2007) and mark-recapture analysis (Rotella et al. 2003). Two mortalities occurred on Pool 19; one occurred soon after release, whereas the other occurred 27 days post release. Bald eagles and mammalian road kills (e.g., raccoons, mink) were frequently observed by banding crews, suggesting that potential predators of lesser scaup are abundant at Pool 19 (A. Afton, pers. obs.).

Waterfowl researchers typically exclude a short period following marking and release from their analyses of survival and habitat use, to minimize potential radio-effects on their results (e.g., Cox and Afton 1998). Researchers working on a variety of sea ducks (Mergini) have recommended censoring the first 14 days following radio implantation when estimating survival in such studies (Mulcahy and Esler 1999; Esler et al. 2000a, 2000b; Iverson et al. 2006). Based on these recommendations and the assumption that the magnitude of potential radio-effects decreases with time since implantation, the 3 observed mortalities during migration (40-52 days after release) and particularly the 3 mortalities that occurred after arrival on breeding sites (82-163 days after release) may be biologically relevant and informative, perhaps indicating that female lesser scaup are susceptible to some natural mortality during these periods of their life cycle.

The relative long period that some implanted females spent on Pool 19 after release also could be indicative of radio-effects and/or a response to plentiful food at this location (cf. Anteau and Afton 2004, Anteau 2006) and the late spring chronology in areas north and northwest of the Pool that occurred in April 2007. Interestingly, implanted females spent, on average, about the same amount of time on Pool 19 after release (P19 mean = 25.6 days) as did those on the Great Lakes (GL mean = 26 days; Badzinski and Petrie 2006b). Moreover, the distance (P19 mean = 3020.1 km, GL mean = 2570 km) and number of stops (P19 mean = 6.3, GL mean = 6 stops) between capture sites and breeding sites also were similar for females implanted at Pool 19 and on the Great Lakes.

The observed timing of arrival on inferred breeding sites by Pool 19 females and locations of their inferred breeding sites were reasonable based on the published literature (see Afton 1984, Austin et al. 1998), suggesting that the magnitude of radio-effects on migration behavior and chronology was relatively small for females that migrated from Pool 19. We hope to obtain comparable information in spring 2008, for those females that survive and have functioning PTTs then, to help assess potential radio-effects in their initial spring migration.

Conclusion

We believe that the pilot study was successful and the results obtained were useful and informative with respect to our specific objectives (see above). We are concerned about potential radio-effects on female survival; however, estimating survival of radio-marked females was not a specific pilot study objective. A large sample of radio-marked females, along with a continued intensive banding effort at Pool 19 would allow direct estimates of potential radio-effects on survival (cf. Esler 2000a).

We also are concerned that radio-effects may have contributed to the lengthy period that some radio-marked females spent on Pool 19 prior to migration. However, other ecological factors (plentiful food resources there) and spring weather (snow and prolonged cold temps north and northwest of Pool 19) also may have influenced stay times of radio-marked females. We believe that a larger sample of radio-marked females, marked over several springs, plus associated repeated observations of surviving females between years (allowed by theoretical battery life), are needed to assess potential radio-effects on stay times at Pool 19. Furthermore, weekly aerial surveys are needed on Pool 19, from March to early May, for comparing departure chronologies of radio-marked birds to trends in the scaup population throughout spring.

We found that, once radio-marked females left Pool 19, the general direction and chronology of movements, subsequent arrival times on inferred breeding sites, and locations of the inferred breeding sites areas all were reasonable based on previously published information. Thus, we believe that the magnitude of radio-effects on these migratory parameters probably is relatively small. Finally, we obtained adequate numbers of accurate locations (ARGOS location classes 1, 2 and 3) to conduct detailed analyses of habitat use during migration and identify important migration corridors for targeting potential habitat management activities.

In conclusion, we believe that further capture, radio-marking and banding of scaup at Pool 19 is warranted. Continued research on Pool 19 would provide useful information for more effective management of lesser scaup and their preferred habitats. The next step is to secure funding to implant PTTs in females in spring 2008 and beyond. Finally, we observed a relatively high PTT failure rate in the pilot study and will discuss replacement and performance issues in future research with the PTT manufacturer

Literature Cited

Afton, A. D. 1984. Influence of age and time on reproductive performance of female lesser scaup. Auk 101:255-265.

Afton, A. D., and M. G. Anderson. 2001. Declining scaup populations: a retrospective analysis of long-term population and harvest survey data. Journal of Wildlife Management 65:781-796.

Anteau, M. J. 2002. Nutrient reserves of lesser scaup during spring migration in the Mississippi Flyway: a test of the Spring Condition Hypothesis. Thesis, Louisiana State University, Baton Rouge, Louisiana, USA.

Anteau, M. J. 2006. Ecology of lesser scaup and amphipods in the upper-Midwest: scope and mechanisms of the Spring Condition Hypothesis and implications for migration habitat conservation. Ph.D. Dissertation. Louisiana State University, Baton Rouge, Louisiana, USA.

Anteau, M. J., and A. D. Afton. 2004. Nutrient reserves of lesser scaup during spring migration in the Mississippi Flyway: a test of the Spring Condition Hypothesis. Auk 121:917-929.

Anteau, M. J., and A. D. Afton. 2006. Diet shifts of lesser scaup during spring migration: support for the spring condition hypothesis. Canadian Journal of Zoology 86:779-786.

Austin, J. E., C. M. Custer, and A. D. Afton. 1998. Lesser Scaup (Aythya affinis). The birds of North America, number 338. The American Ornithologists' Union, Washington, D. C., USA, and the Academy of Natural Sciences, Philadelphia, Pennsylvania, USA.

Austin J. E., A. D. Afton, M.G. Anderson, R. G. Clark, C. M. Custer, J. S. Lawrence, J. B. Pollard, J. K. Ringelman. 2000. Declining scaup populations: issues, hypotheses, and research needs. Wildlife Society Bulletin 28:254-263

Badzinski, S. S. and S. A. Petrie. 2006a. Satellite tracking lesser scaup and greater scaup from the lower Great Lakes. Pages 5-7 *in* First Annual Newsletter of the Long Point Waterfowl and Wetland Research Fund, Port Rowan, Ontario, Canada.

Badzinski, S. S. and S. A. Petrie. 2006b. Satellite tracking lesser scaup and greater scaup from the lower Great Lakes. Pages 100-101 *in* Fourth North American Duck Symposium and Workshop, Bismarck, North Dakota, USA.

Chabreck, R. H. 1964. Scaup scoop. Louisiana Conservation 16(7/8):20-21 and 23.

Cox, R. R., Jr. and A. D. Afton. 1998. Effects of capture and handling on survival of female northern pintails. Journal of Field Ornithology 69:276-287.

Esler, D., D. M. Mulcahy, and R. L. Jarvis. 2000a. Testing assumptions for unbiased estimation of survival of radiomarked harlequin ducks. Journal of Wildlife Management 64:591-598.

Esler, D., J. A. Schmutz, R. L. Jarvis, and D. M. Mulcahy. 2000b. Winter survival of adult female harlequin ducks in relation to history of contamination by the Exxon Valdez oil spill. Journal of Wildlife Management 64:839-847.

Haramis, G. M., E. L. Derleth, and D. G. McAuley. 1982. Techniques for trapping, aging and banding wintering canvasbacks. Journal of Field Ornithology 53:342-351.

Haramis, G. M., E. L. Derleth, and D. G. McAuley. 1987. A quick-catch corral trap for wintering canvasbacks. Journal of Field Ornithology 58:198-200.

Havera, S. P. 1999. Waterfowl of Illinois: status and management. Illinois Natural History Survey, Special Publication 21.

Iverson, S. A., W. S. Boyd, D. Esler, D. M. Mulcahy, and T. D. Bowman. 2006. Comparison of the effects and performances of four types of radiotransmitters and use with scoters. Wildlife Society Bulletin 34:656-663.

Jessen, R. L. 1981. Special problems with diving ducks. International Waterfowl Symposium 4:139-149.

Mulcahy, D. M. and D. Esler. 1999. Surgical and immediate postrelease mortality of harlequin ducks (*Histrionicus histrionicus*) implanted with abdominal radiotransmitters with percutaneous antennas. Journal of Zoo and Wildlife Medicine 30:397-401.

Nicolai, C. A., J. S. Sedinger, A. D. Afton, and C. D. Ankney. 2006. Using banding date to control for assumption violations associated with direct recovery rate estimation: an example using five decades of lesser scaup banding data. Pages 80-81 *in* Fourth North American Duck Symposium and Workshop, Bismarck, North Dakota, USA.

Pace, R. M., III, and A. D. Afton. 1999. Direct recovery rates of lesser scaup banded in northwest Minnesota: sources of heterogeneity. Journal of Wildlife Management 63:389-395.

Rotella, J. J., R. G. Clark, and A. D. Afton. 2003. Survival of female lesser scaup: effects of body size, age, and reproductive effort. Condor 105:336-347.

Thompson, D. 1973. Feeding ecology of diving ducks on Keokuk Pool, Mississippi River. Journal of Wildlife Management 37:367-381.

U.S. Fish and Wildlife Service. 2002. Fish and wildlife resource conservation priorities, Region 3, January 2002. Version 2.0. Region 3, U.S. Fish and Wildlife Service, Fort Snelling, Minnesota, USA.

Wilkins, K. A., M. C. Otto, G. S. Zimmerman, E. D. Silverman, and M D. Koneff. 2007. Trends in duck breeding populations, 1955-2007. U.S. Department of the Interior, Fish and Wildlife Service, Administrative Report, Laurel, Maryland, USA.

Table 1. Number of locations received by location class for each female lesser scaup as of 6 September 2007.

Bird	Location Class[a]							Total
	0	1	2	3	A	B	Z	
72882	23	62	118	126	35	32	46	442
72883	12	53	93	177	21	19	43	418
72884	11	17	28	46	16	14	40	172
72885	32	40	84	214	26	39	69	504
72886	37	87	107	123	24	17	41	436
72887	12	45	63	116	40	24	47	347
72888	1	3	2	2	2	5	20	35
72889	7	18	17	23	12	18	36	131
72890	6	5	14	16	14	24	34	113
72891	5	8	13	24	6	2	29	87
72892	11	4	6	8	8	11	26	74
72893	18	9	8	25	10	14	45	129
72894	13	21	23	36	10	17	16	136
72895	0	7	11	15	6	11	30	80
72896	1	5	4	12	1	1	9	33
72897	2	3	9	12	12	11	21	70
72898	4	5	7	16	8	18	16	74
Total	195	392	607	991	251	277	568	3281

[a]3 = accuracy ≤ 150 m; 2 = 150 m ≤ accuracy < 350m; 1 = 350 m ≤ accuracy < 1000 m; 0 = accuracy ≥ 1000 m; A and B = no estimates of accuracy; and Z = invalid locations.

Figure 1. Migration tract of Lesser Scaup female 72882 from Pool 19 to her inferred breeding site in Alaska. Numbers associated with each migration stop and the terminal breeding site (solid circles) represent the first day (Julian date) the female was known to be at that location. This female was implanted and released on 28 March 2007 (Julian date = 87) and was alive as of 19 September 2007.

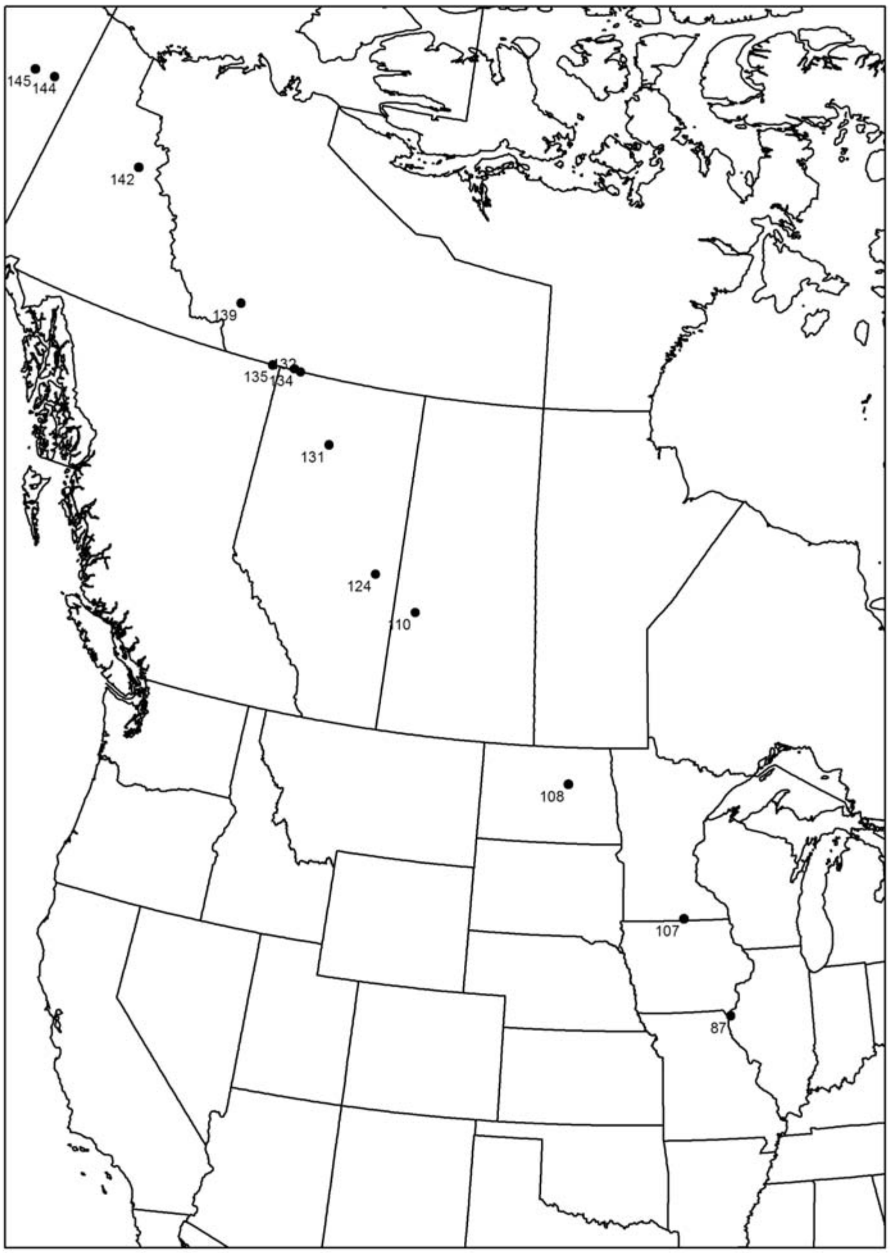

Figure 2. Migration tract of Lesser Scaup female 72883 from Pool 19 to her inferred breeding site in the Northwest Territories. Numbers associated with each migration stop and the terminal breeding site (solid circles) represent the first day (Julian date) the female was known to be at that location. This female was implanted and released on 28 March 2007 (Julian date = 87) and was noted dead on 7 September 2007.

Figure 3. Migration tract of Lesser Scaup female 72884 from Pool 19 until her death during migration in Minnesota. Numbers associated with each migration stop (solid circles) represent the first day (Julian date) the female was known to be at that location. This female was implanted and released on 27 March 2007 (Julian date = 86) and was noted dead on 6 May 2007.

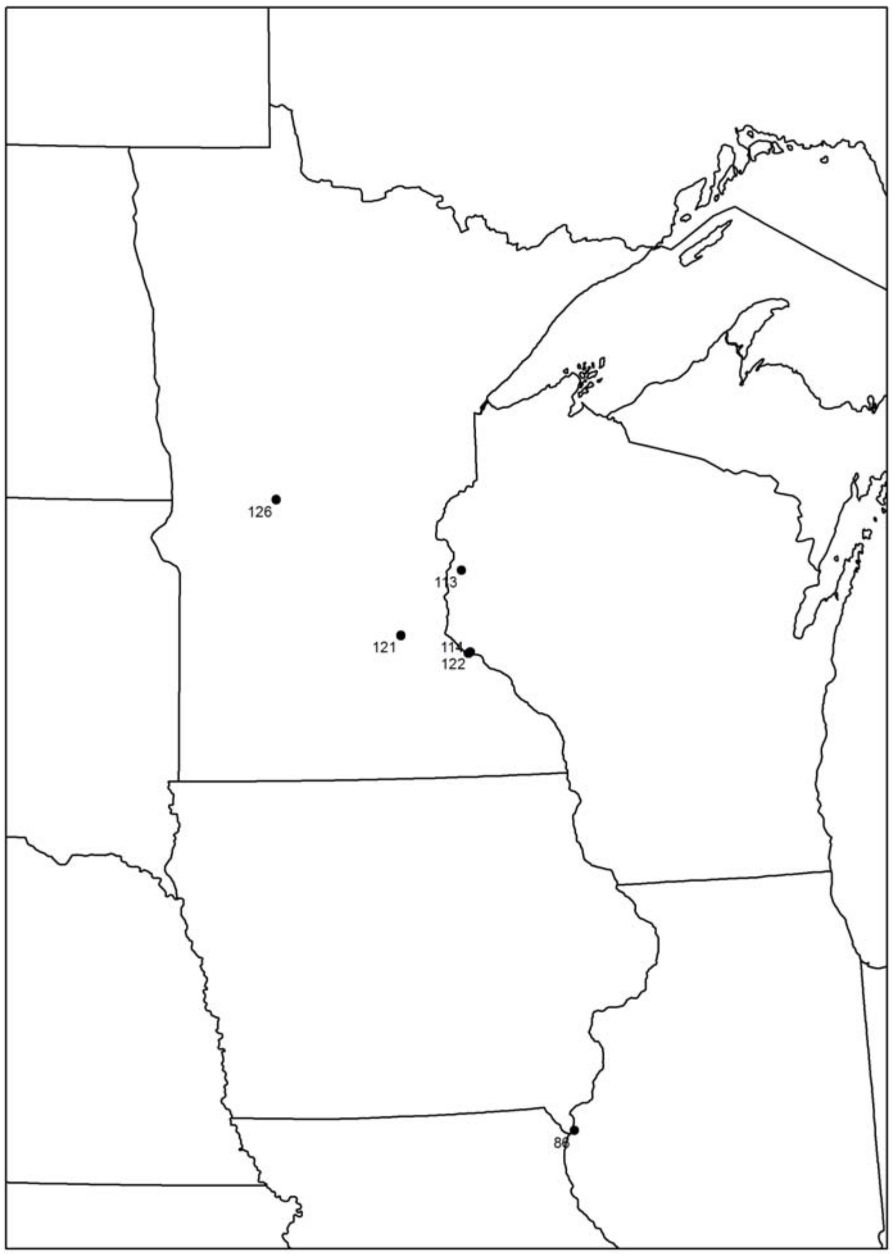

Figure 4. Migration tract of Lesser Scaup female 72885 from Pool 19 to her inferred breeding site in the Northwest Territories. Numbers associated with each migration stop and the terminal breeding site (solid circles) represent the first day (Julian date) the female was known to be at that location. This female was implanted and released on 28 March 2007 (Julian date = 87) and was alive as of 20 September 2007.

Figure 5. Migration tract of Lesser Scaup female 72886 from Pool 19 to her inferred breeding site in the Northwest Territories. Numbers associated with each migration stop and the terminal breeding site (solid circles) represent the first day (Julian date) the female was known to be at that location. This female was implanted and released on 28 March 2007 (Julian date = 87) and was alive as of 20 September 2007.

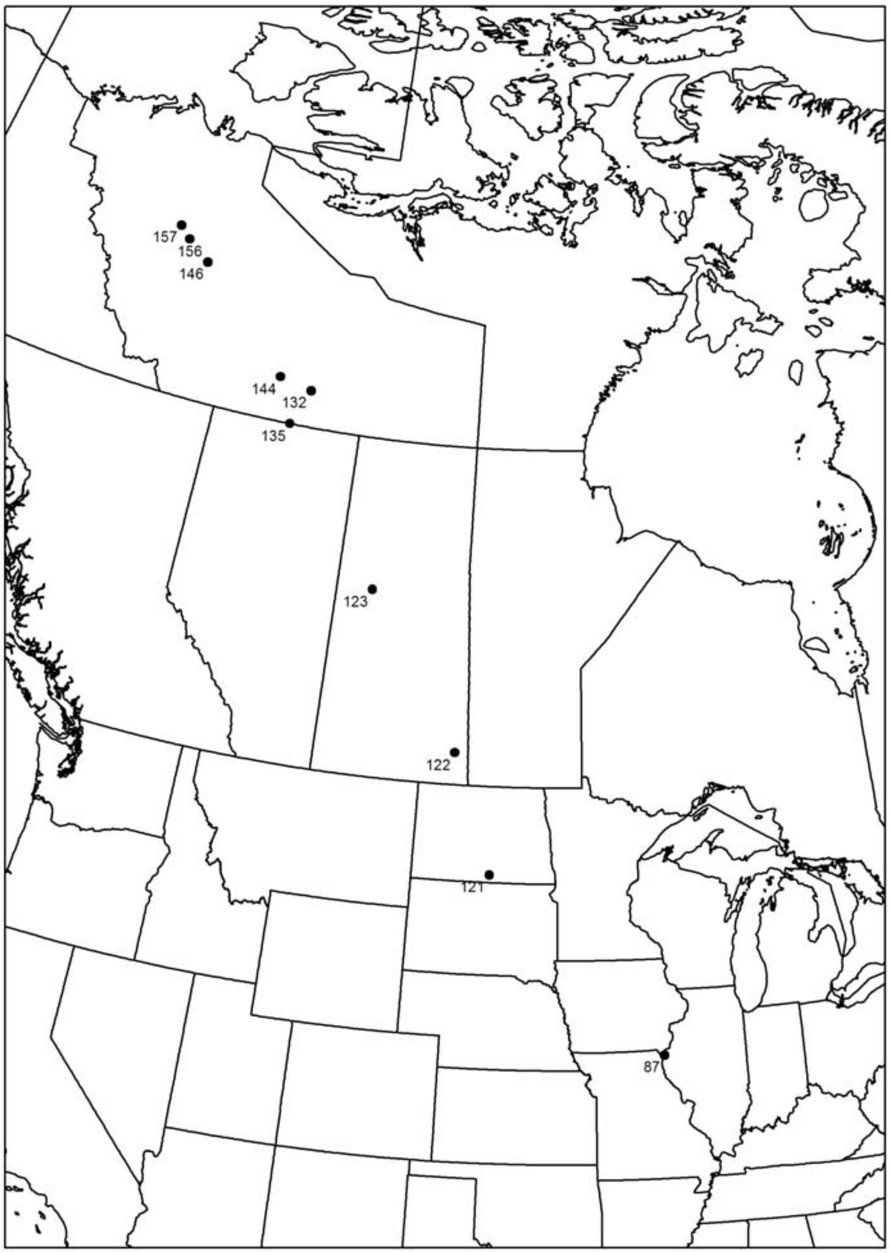

Figure 6. Migration tract of Lesser Scaup female 72887 from Pool 19 to her inferred breeding site in the Northwest Territories. Numbers associated with each migration stop and the terminal breeding site (solid circles) represent the first day (Julian date) the female was known to be at that location. This female was implanted and released on 28 March 2007 (Julian date = 87) and was noted dead on 18 June 2007.

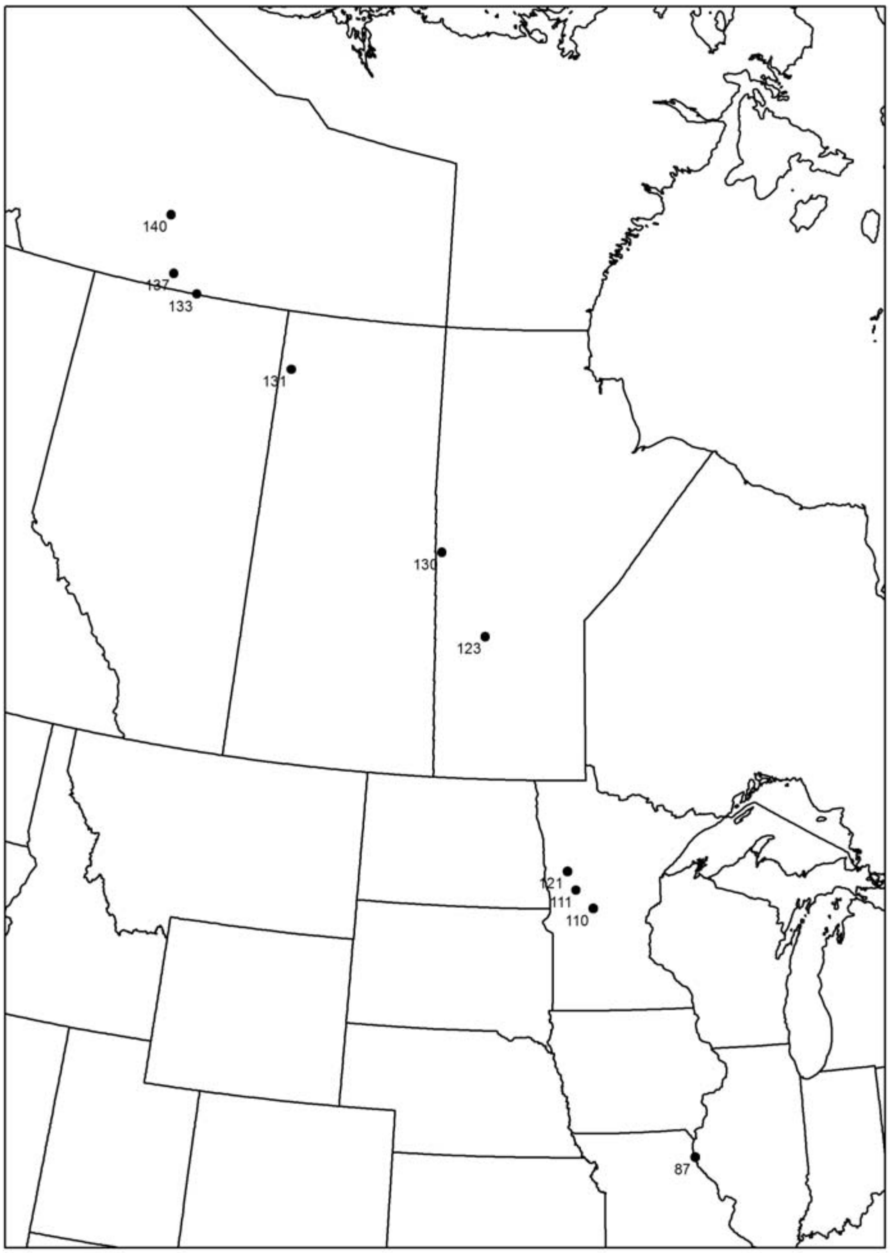

Figure 7. Migration tract of Lesser Scaup female 72890 from Pool 19 to her inferred breeding site in Alberta. Numbers associated with each migration stop and the terminal breeding site (solid circles) represent the first day (Julian date) the female was known to be at that location. Locations were received intermittently for this female and thus other migration stops probably were missed. This female was implanted and released on 26 March 2007 (Julian date = 85) and her PTT failed on 28 August 2007.

Figure 8. Migration tract of Lesser Scaup female 72891 from Pool 19 to her inferred breeding site in Manitoba. Numbers associated with each migration stop and the terminal breeding site (solid circles) represent the first day (Julian date) the female was known to be at that location. This female was implanted and released on 26 March 2007 (Julian date = 85) and her PTT failed on 25 May 2007.

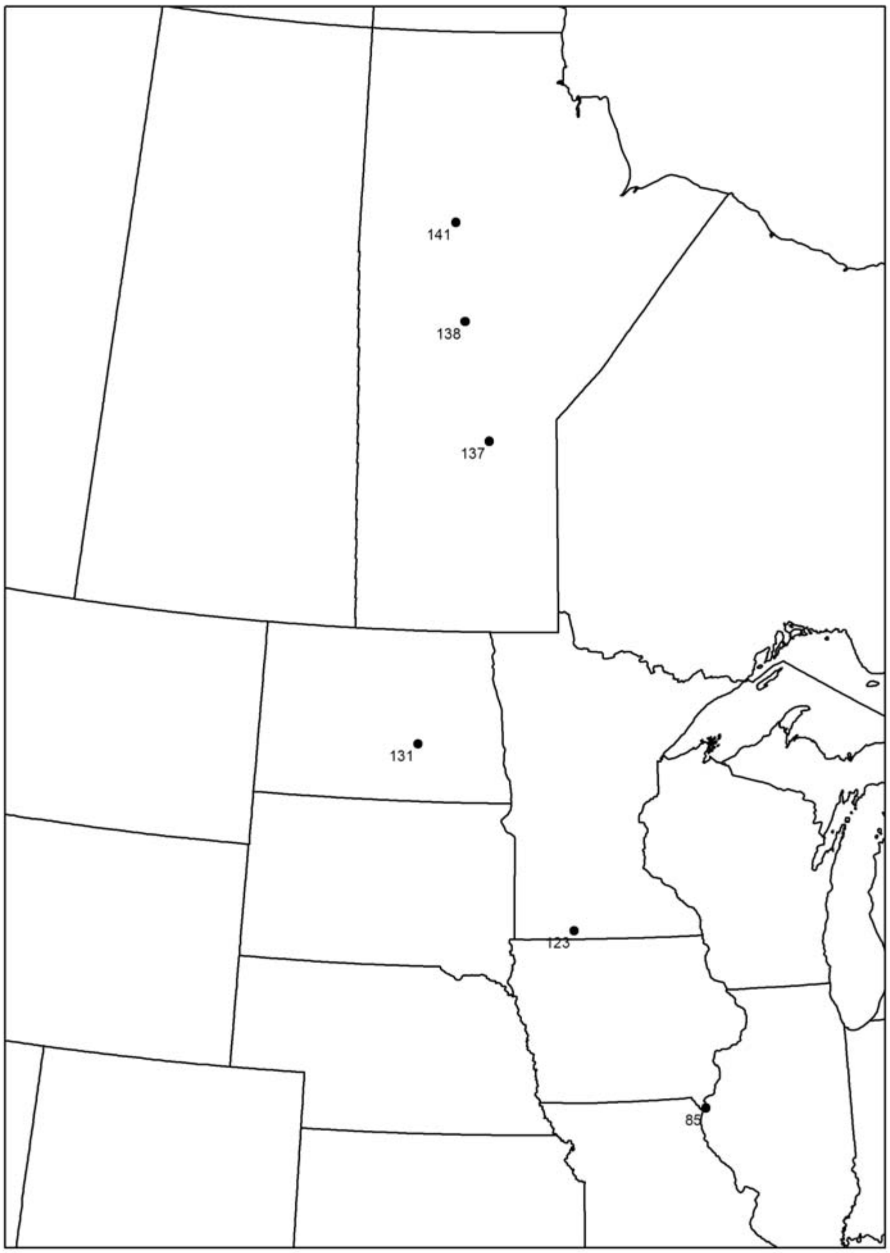

Figure 9. Migration tract of Lesser Scaup female 72892 from Pool 19 to her inferred breeding site in Alberta. Numbers associated with each migration stop and the terminal breeding site (solid circles) represent the first day (Julian date) the female was known to be at that location. This female was implanted and released on 27 March 2007 (Julian date = 86) and her PTT failed on 15 July 2007.

Figure 10. Migration tract of Lesser Scaup female 72893 from Pool 19 to her inferred breeding site in the Northwest Territories. Numbers associated with each migration stop and the terminal breeding site (solid circles) represent the first day (Julian date) the female was known to be at that location. This female was implanted and released on 26 March 2007 (Julian date = 85) and was alive as of 21 September 2007.

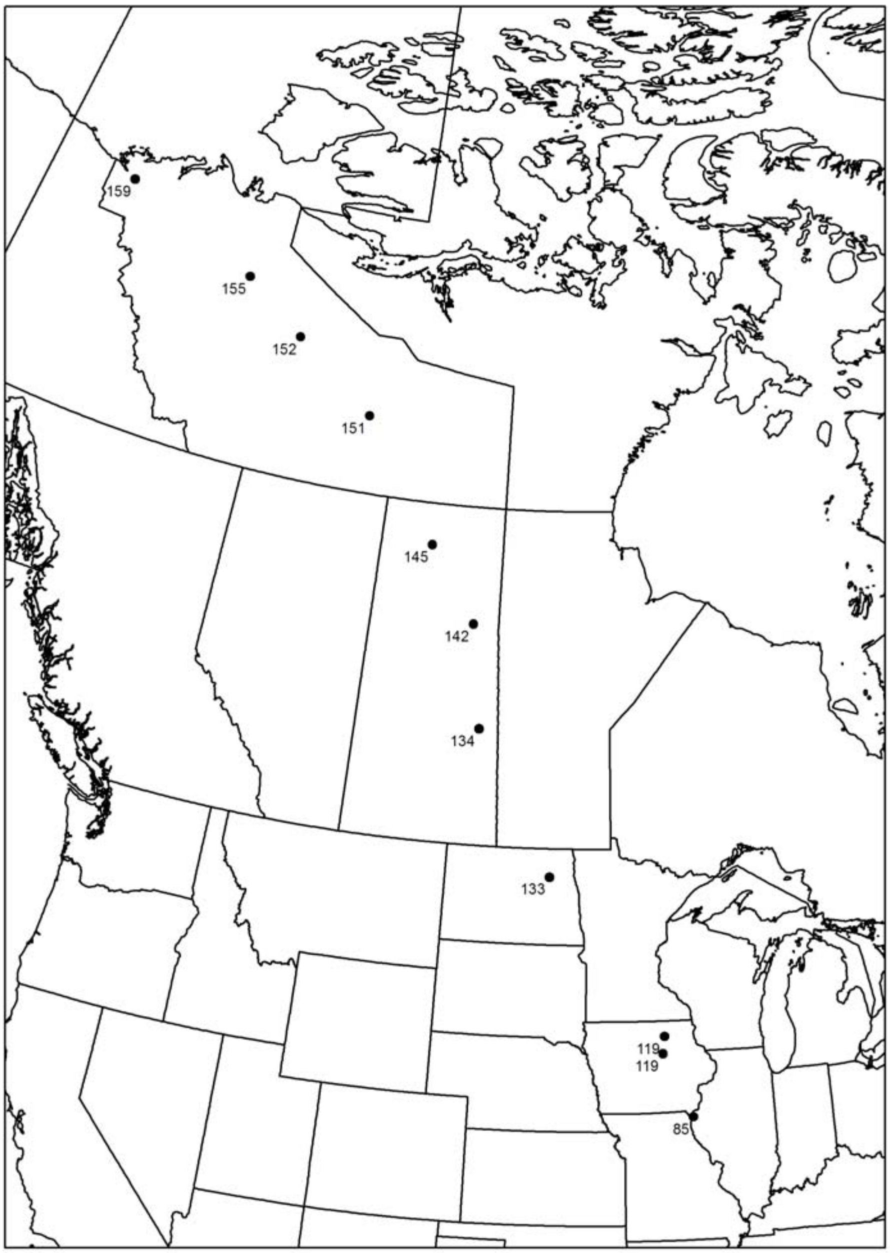

Figure 11. Migration tract of Lesser Scaup female 72894 from Pool 19 until her death during migration in Manitoba. Numbers associated with each migration stop (solid circles) represent the first day (Julian date) the female was known to be at that location. This female was implanted and released on 26 March 2007 (Julian date = 85) and was noted dead on 10 May 2007.

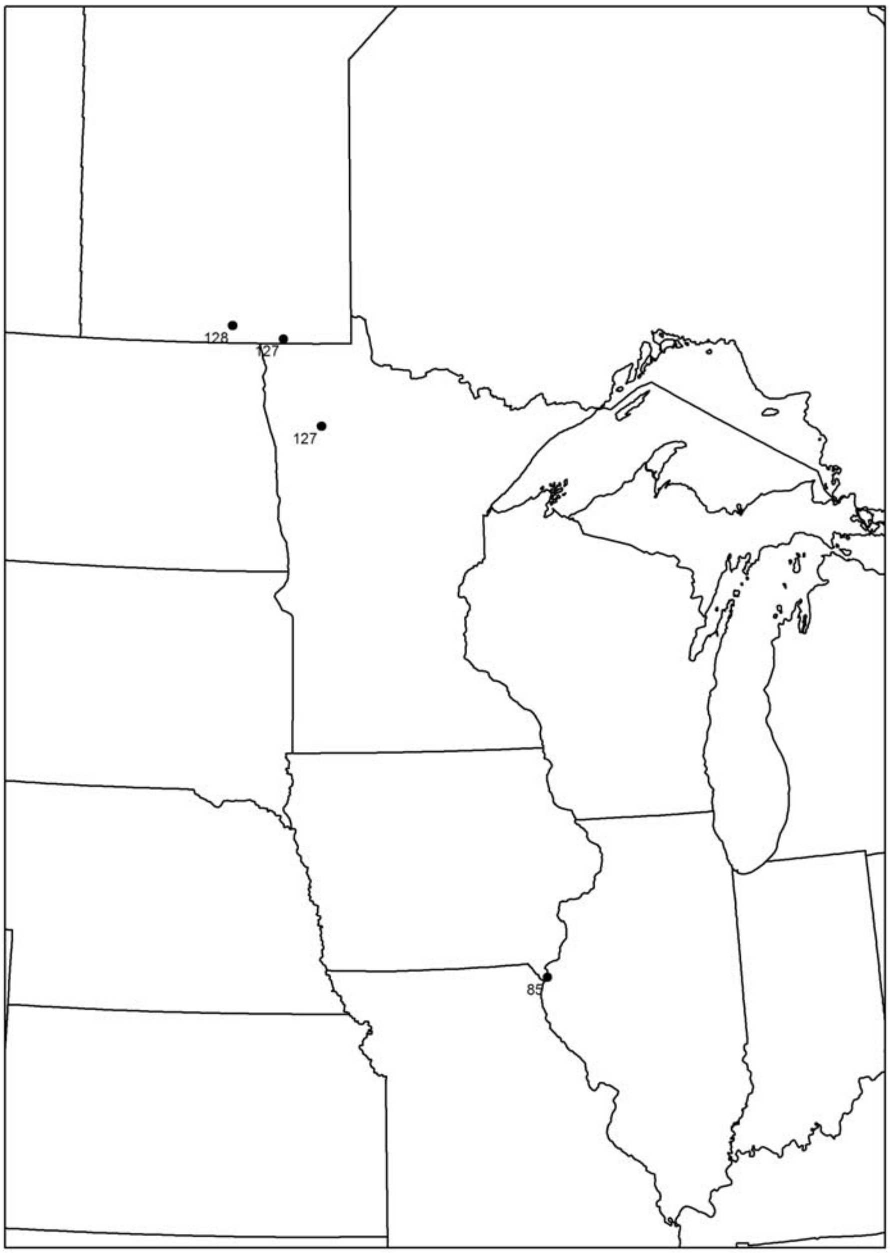

Figure 12. Migration tract of Lesser Scaup female 72895 from Pool 19 to her inferred breeding site in Alberta. Numbers associated with each migration stop and the terminal breeding site (solid circles) represent the first day (Julian date) the female was known to be at that location. Locations were received intermittently for this female and thus other migration stops probably were missed. This female was implanted and released on 26 March 2007 (Julian date = 85) and was noted dead on 12 June 2007.

Figure 13. Migration tract of Lesser Scaup female 72897 from Pool 19 to her inferred breeding site in Alberta. Numbers associated with each migration stop and the terminal breeding site (solid circles) represent the first day (Julian date) the female was known to be at that location. Locations were received intermittently for this female and thus other migration stops probably were missed. This female was implanted and released on 27 March 2007 (Julian date = 86) and was alive as of 17 September 2007.

Figure 14. Migration tract of Lesser Scaup female 72898 from Pool 19 until her death during migration in Minnesota. Numbers associated with each migration stop (solid circles) represent the first day (Julian date) the female was known to be at that location. This female was implanted and released on 27 March 2007 (Julian date = 86) and was noted dead on 18 May 2007.