WATERFOWL BANDING PROJECTS SUMMARY

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SUMMARY OF FINDINGS

During July-September 2019 we completed successful field seasons for 3 ongoing waterfowl banding projects. During these projects, we marked birds with aluminum metal leg bands provided by the United States Geological Survey. These marked birds will contribute to the long-term data set used to estimate waterfowl survival, harvest rates, and demographic distribution of harvest in Minnesota and at a continental scale. During the traditional summer banding project (Federal Aid Project 2W475), we were able to mark 1,189 ducks of 14 species with aluminum leg bands during this effort. During our preseason banding project (Federal Aid Project 2W472), we were able to mark an additional 467 ducks of 4 species. Additionally, during our south and central Minnesota expanded banding project (Federal Aid Project 2W466), we were able to mark 2,063 ducks of 6 species.

During 2019, in our summer banding project, 37% of the birds we banded were mallards (*Anas platyrhynchos*) and 23% of birds marked were ring-necked ducks (*Aythya collaris*). For the pre-season banding project, 83% of banded birds were mallards and 15% were wood ducks (*Aix sponsa*). For our south and central Minnesota expanded banding project, 76% of banded birds were wood ducks and 16% were blue-winged teal (*Spatula discors*).

The data produced via Minnesota Department of Natural Resources (MNDNR) banding efforts and subsequent hunter reports of harvested bands contribute to a long-term data set that allows for calculation of demographic parameters important to wildlife managers. Due to reliance on reported harvest of banded birds and structure of survival models, harvest information is available the summer after birds are marked when harvest is complete and records have been entered; survival estimates require 2 or more years of reporting post-banding. Band returns are also used to estimate several other important parameters for ducks, including but not limited to estimates of harvest distribution and identification of patterns in movements.

Currently, analyses are being conducted using band and recovery data for wood ducks marked in Minnesota from 1997-2017 through these ongoing banding project efforts. Information from two chapters of an in-progress Master's Thesis are included in this report; this thesis is unfinished, but substantial progress in analyses have been made and are shared here. These analyses should be regarded as preliminary until the thesis is finalized. This research is being conducted through the Wetland Wildlife Research Populations Group of MNDNR and Bemidji State University. Band and recovery data are being used to understand factors affecting harvest distribution for wood ducks banded in Minnesota and to estimate population size and understand trends over time for wood duck populations in the Mississippi Flyway.

Using linear mixed effects models, we analyzed the effects of age, sex, banding zone, and time to explain changes in distance moved from banding location to recovery location in order to better understand harvest distribution of wood ducks banded in Minnesota. We found that age of bird, time, and the zone of marking were all factors affecting the harvest distribution of wood ducks marked in Minnesota. Preliminary Lincoln estimates for the Mississippi Flyway ranged

from 4,796,061 to 7,581,376; further analyses will be needed to better understand potential trends in this data.

INTRODUCTION

Wood ducks are a cavity nesting waterfowl species indigenous to North America with an estimated breeding population of three million birds within the Atlantic, Mississippi, and Pacific flyways (Baldassarre 2014). Following a recovery from a large scale population decline in the early 1900s wood ducks are now the second most harvested duck in Minnesota and most of the Mississippi and Atlantic flyways (Bellrose and Holm 1994; Baldasarre 2014; Fronczak 2017). Wood duck breeding distribution differs from, most other waterfowl species because wood ducks breed throughout most of their habitat range (Baldassarre 2014). Wood ducks provide recreational hunting opportunities and waterfowl hunters provide funding for conservation through the purchase of hunting licenses, state and federal habitat stamps, and taxes on hunting related items. Little is known about movement dynamics of wood ducks in Minnesota which motivates this study.

Harvest distribution describes where birds from a specific production area are harvested (De Sobrino et al. 2017). Harvest distribution has helped define boundaries for populations used in the development of adaptive harvest management (AHM) protocols (U. S. Fish and Wildlife Service 1999) (Munro and Kimball 1982). Szymanski and Dubovsky (2013) described harvest distribution patterns for blue-winged teal that helped identify effectiveness of the Conservation Reserve Program and subsequent improvements to production throughout North Dakota and South Dakota (De Sobrino et al. 2017). Harvest distribution analyses have been used in the Pacific Flyway to describe production areas necessary for maintenance of sustainable waterfowl harvest (De Sobrino et al. 2017).

Dependable knowledge of patterns between production and harvest areas is beneficial for management of migratory waterfowl (Osnas et al. 2014). Descriptions of harvest distribution illuminate where birds move, and the factors affecting those movements. Better understanding areas utilized by wood ducks from a defined population enhances the efficiency of habitat conservation efforts and hunting regulations, by providing insight to where funding may best benefit conservation efforts. Some wood ducks inhabit the majority of the species range year round (Baldassarre 2014); this makes distinguishing harvest distributions difficult for local populations.

Habitat and hunting regulations are typically managed on a state scale (within a federal framework) (De Sobrino et al. 2017), but wood ducks have potential to move up and down the flyway throughout the year. Effective management regulations require that managers understand how harvest outside of the state might affect local populations and how local populations are affected by other state’s harvest and regulations.

There is limited population data for wood ducks (Shirkey and Gates 2020). Quantitative estimates of population sizes are important for managing wood ducks effectively. Knowledge and understanding of trajectories in population trends will help us better understand wood duck populations. Starting in 1955, annual abundance of North American ducks have been estimated using the Waterfowl Breeding Population and Habitat Survey (Alisauskas et al. 2014). These surveys are conducted using airplanes, helicopters, and ground crews. Traditional population estimates for waterfowl rely on detection from observers, typically from an airplane, but this method is ineffective for wood ducks due to lack of observability in their preferred habitat (Alisauskas et al. 2014). Within the area sampled, birds can be undetected due to observer fatigue or experience, weather conditions, or use of habitats that obstruct view from the air, generally referred to as “visibility bias” (Pollock and Kendall 1987). A common problem resulting from visibility bias is an underestimation of population size (Pollock and Kendall 1987).

Minnesota lies near the northern edge of the habitat range for wood ducks, within the North American Mississippi flyway (Baldassarre 2014). The Mississippi flyway includes Minnesota, Wisconsin, Michigan, Iowa, Illinois, Indiana, Ohio, Missouri, Kentucky, Tennessee, Arkansas, Alabama, Mississippi, and Louisiana. The provinces of Manitoba, Ontario, and Nunavut are also included in the flyway. Wood ducks typical breeding range within the Mississippi flyway is from central Manitoba and southern Ontario all the way down to the Gulf of Mexico (Baldassarre 2014). In fall and winter, at middle and southern latitudes, substantial mixture of breeding populations and populations of more northerly breeding populations that must migrate south to escape harsh winter conditions occurs; Wood ducks are present year round from southern Minnesota along the Mississippi River down to the Gulf of Mexico (Baldassarre 2014).

OBJECTIVES

1. Identify factors affecting harvest distribution for wood ducks banded in Minnesota using waterfowl band and recovery data.
2. Estimate population sizes for wood ducks within the Mississippi Flyway and describe any trends in population estimates for the Mississippi Flyway wood duck populations from 1999-2017.

METHODS

Band and Recovery Data Query – Distribution of Harvest

We obtained wood duck banding and recovery records from the United States Geological Survey (USGS) Bird Banding Laboratory, in Laurel, Maryland (USGS, Gamebirds data set). Recovery records for bands placed on normal wild-caught birds; including birds caught by night lighting or control band birds in a reward study were included. We excluded birds marked with auxiliary markers (i.e., nasal tags, patagial tags) because auxiliary-marked birds often have higher reporting rates (Arnold et al. 2016). Birds marked in Minnesota during the preseason banding period (1 July- 31 September) (Anderson and Henny 1972; Green and Krementz 2008) were selected to target birds being produced or producing offspring in the state. We selected direct band recoveries, (birds that were harvested in the hunting season immediately following their banding). Ducks banded as locals (i.e., flightless young of the year) and hatch year (flight-capable young of the year) were combined into a juvenile category (De Sobrino et al. 2017). We used only records with all known variables including age, sex, and recovery date. Single federal bands with a toll free or web address band were the only bands used to keep reporting methods and rates consistent.

Minnesota started marking wood ducks with toll free bands in 1997, and data were available through the 2017 hunting season when these analyses were initiated, so we restricted analysis to these years. Banding sites are distributed across the state (Figure 1). Our query produced a total of 2,411 harvest records (Figure 2). A large number of birds harvested at or near their banding location caused a bimodal zero rich data set (Figure 3). This distribution presents challenges for examining harvest distribution data.

Band and Recovery Data Query – Population Estimation

We obtained wood duck banding and recovery records from the United States Geological Survey (USGS) Bird Banding Laboratory (BBL), in Laurel, Maryland (USGS, Gamebirds data set) as outlined above and additionally included banding and recovery records for birds marked and/or harvested in the Mississippi Flyway. Birds marked anywhere during the preseason banding period (1 July - 31 September) (Anderson and Henny 1972; Green and Krementz 2008) and harvested within the Mississippi Flyway were included. We included only direct band recoveries (birds that were harvested in the hunting season immediately following their banding) in this data set.

Harvest data - Population Estimation

Starting in 1999 with a new survey, the United States Fish and Wildlife Service reports number of waterfowl harvested (Fronzak 2019). Data collected from hunter surveys (Harvest Information Program) and parts collection surveys are used to estimate the number of birds harvested. Based on the data structure the harvest estimated can be split into geographic areas and species each year. These are the estimates we used for our Lincoln estimator calculations for the Mississippi Flyway.

Preliminary Examination of Data – Distribution of Harvest

Examination of the data set reveals a few strong patterns that may help us understand the distribution of data. There is an apparent positive relationship between number of days from the start of the hunting season and distance traveled from banding location (Figure 4). There is a break in the data around 1000 km, where there are relatively few data points; middle latitude states, such as Iowa, Missouri, Illinois, Indiana, and Kentucky, have very few recovery points. Early season movements appear to be in random directions, but movements later in the season appear to be approximately straight south (Figure 5). We classified movements from banding sites to these early recovery points “local movements” because they are short distances from banding location to recovery location and in random directions. We classified movements from banding sites to the more distant recovery points “major movements” because they represent greater distances of recovery and appear to be movements towards wintering grounds. Nearly 41% of reported birds were harvested within 50 km from banding location. To better understand potential broad scale movements past mid-latitude, we present a strip chart (Figure 6). For this chart, recoveries were divided into three zones based on the recovery point latitude. Northern recoveries occurred early, and south zone recoveries occurred late; recoveries at the middle latitudes occurred throughout the season. For subsequent analyses, data were divided into harvest locations within the state of Minnesota and harvest locations that are outside of Minnesota (Figures 7 and 8). This produced an out of state data set with 1,312 recovery points. ArcGIS (10.6.1) and Program R (64 3.6.0) were used to calculate values for analyses and examine models.

Modeling- Distribution of Harvest

Distance traveled from banding location to recovery location (in kilometers), the change in latitude, and the change in longitude from banding location to recovery location were used as dependent variables in our analyses of harvest distribution.

For our independent variables, we classified banding zones within Minnesota based on the state’s current hunting zones (North, Central, or South; Figure 9), we calculated the number of days from hunting season start (hereafter, time), we used age determined at time of banding (adult or juvenile), and sex determined at banding (male or female) as fixed effect variables in the models (Bates et al. 2015). We also included year as a random effect variable in our models to further explain variation in the data (Bates et al. 2015).

Analyses – Distribution of Harvest

Three separate analyses using mixed effects regression models were constructed using distance, change in latitude from banding location to recovery location, and change in longitude from banding location to recovery location as a dependent variables. Together these three metrics of spatial movement will help describe what factors are the most important to harvest distribution. By using the same independent variables in each analysis, we tested what factors affect harvest distribution. As discussed above, wood ducks seemingly travel south when making major movements.

The global models contain an age and sex interaction term and time and zone interaction term. We tested for the interaction of age and sex because adult males molt earlier and have the ability to migrate earliest, juveniles have to fully develop in order to make large scale movements, and females wait to molt until their young fledge (Bellrose and Holm 1994). Figure 4 shows a strong relationship between time and distance traveled. Wood ducks are early migrants (Bellrose and Holm 1994) so we hypothesized an interaction between time and distance. We added banding zones into the model to test for differences in migration for birds marked at different latitudes.

Tested models – Distribution of Harvest

We constructed a global model based on what we know about wood duck biology and movements, and we suspect that age and sex will be important when comparing movements as well as the zone of marking and time. A year effect was included to account for annual variability, but it does not work towards answering our question of what affects harvest distribution, so it was included as a random effect variable.

Global models were tested against null models, models containing only wood duck based factors, and models without interaction terms as well. Model selection was based on Akaike's Information Criterion (AIC) scores. Models within 2 AIC units of the top model were considered to be competitive (Arnold 2010). Models that were more parsimonious (containing the fewest parameters) were considered more competitive if AIC scores were within 2 AIC units (Burnham and Anderson 2002). For the 3 analyses of movements we tested several models (Tables 2, 3, and 4).

Analysis – Population Estimation

Band reporting probability (reporting rate) is the probability that someone who comes in contact with a banded bird will report that bird to the BBL (Garrettson et al. 2014). If all recovered bands were reported, the reporting rate would be one. Garrettson et al. (2014) found that birds banded with a toll free number on their band had a 0.73 probability of being reported to the BBL, conditional on being found. We treated this reporting rate (0.73) as a constant throughout our data set.

We calculated fall flight estimates for the Mississippi Flyway using Lincoln (1930) estimator equations. Fall flight estimates (N) were calculated by taking the reported harvest estimate (E) for the flyway for a given year (Fronzak 2019) and multiplying it by the reporting rate of 0.73 (R) (Garrettson et al. 2014) and by the number of wood ducks marked and released (M) in the Flyway or that state for the given year. That term is divided by the number of bands harvested and reported (H) to the Bird Banding Laboratory. The estimator equation is:

$$N = \frac{E * R * M}{H}$$

Modeling – Population Estimation

Once we calculated fall flight estimates, we graphed them and added a linear trend line through them. The linear trend line is a model of population against year. This model will show if there is a trend over time, but because year is the only variable in the model it does not account for a high amount of variation in the data (low R squared values).

RESULTS

Distribution of Harvest - In State Recoveries

Of the 2,411 records the recoveries were in 25 different states spread over 3 different flyways (Table 6). About 46% of birds marked and recovered were harvested in Minnesota and 90% of recoveries occurred in the Mississippi flyway (Table 6). The high proportion of recoveries within state lines is important to note because it gives an idea of the effect Minnesota hunters have on the local population of wood ducks in the state due to harvest mortality.

Distribution of Harvest - Distance for out of State Recoveries

The best fit model describing factors that affect distance from banding location to recovery location was the global model (Table 2). On average, adult wood ducks travel 151 km further than juvenile birds. Male wood ducks travel 143 km more than female wood ducks, on average. Birds marked further north travel further than birds marked south of them but end up in the same wintering locations (Figure 10 and Figure 11). As the season progresses, birds are harvested at greater distances from their banding location.

Distribution of Harvest - Change in Latitude for out of State Recoveries

The best fit model describing factors that affect the change in latitude from banding location to recovery location was the model containing an additive relationship of zone and days (Table 3). No models were within 2 AIC values of the top model so no other factors are considered for describing factors affecting change in latitude. There is a direct relationship amongst days and change in latitude (Figure 12). As the season progresses the recoveries are reported further from the banding location. Birds marked further north have a larger change in latitude compared to birds marked further south (Figure 13).

Distribution of Harvest - Change in Longitude for out of State Recoveries

The best fit model describing factors that affect the change in longitude from banding location to recovery location was the model containing an additive relationship of age and zone (Table 4). No other models were within 2 AIC values of the top model. Adult wood ducks on average are being harvested 1.8972 degrees further east than juvenile birds (Figure 14). On average, birds marked in the southern zone (-2.6321 degrees) are harvested at two degrees further west than birds marked in the central (-4.475 degrees) or northern (-4.954 degrees) banding zones (Figure 15).

Population Estimation

Lincoln estimates for the Mississippi Flyway ranged from 4,796,061 in 2017 to 7,581,376 in 2011 (Figure 16). We failed to detect a significant trend through the data ($P= 0.462$) using a basic linear model testing population size over time in Program R (64 3.6.0) base stats package (R core team, 2017). Since the R-squared value for the population versus time trend was 0.03217, we conclude that there is no linear trend present in this data for the effect of year.

DISCUSSION

Distribution of Harvest

Nearly half of the harvest distribution for Minnesota marked wood ducks occurs in Minnesota (Table 6). Wood ducks harvested out of the state are reported at long distances almost straight south at their wintering grounds centered on Louisiana. This is interesting because it is known that there are overwintering wood ducks in the mid latitude states that they are “jumping” (Baldasarre 2014).

Age, sex, zone, and time are all indicated as important factors that affect the distance at which wood ducks are harvested from banding location. Adult birds are being harvested at greater distances from banding location to recovery location than juvenile birds, potentially due to a lower susceptibility to harvest (Bellrose and Holm 1994). Males molt earlier in the season than females, due to the incubating and brooding activities of females (Bellrose and Holm 1994). This may be why sex is indicated as an important factor in the model for distance. Zone of marking can be explained (Figure 11) because the birds from each of the zones all seem to be ending up in or near Louisiana (presumably their wintering grounds). There is no apparent separation of harvest among different marking zones, the primary difference among marking zones is that the birds marked further north are traveling further to get to the wintering grounds.

Zone and days are indicated as the two primary factors affecting change in latitude between marking and recovery locations for wood ducks marked in Minnesota. Similar to the reasons explaining distance can explain these trends for the change in latitude, because as discussed about when the birds initiate major movements they are doing so at a bearing of nearly 180 degrees (straight south). Age and zone are the two indicated factors of importance for change in longitude. The explanation for age and zone affecting the change in longitude may be effects of sampling distribution. The difference in longitude of the north and central banding locations compared to the southernmost banding zone locations is roughly two degrees, the average difference that the model indicates (Figure 14 and Table 5).

Population Estimation

Wood ducks breed, and spend considerable time in forested wetlands, making them difficult to detect during traditional survey techniques. There are not reported population estimates for each state, because of this. Population estimates for fall flight were calculated using Lincoln's (1930) method for estimation of population size. These estimates tend to be higher than more traditional survey estimates (Alisauskas et al. 2014) but depict population sizes at the beginning of the hunting season in a way that eliminates the visibility bias problem for wood ducks. Factors other than time, i.e. weather trends (i.e. wet/dry cycles), harvest regulations, etc. may explain the variation in population better than the model including only time and should be considered in future analyses.

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Table 1. Total ducks banded under Summer Waterfowl Banding project (2W475), Pre-Season Waterfowl Banding Project (2W472), and the Central/Southern Minnesota Duck Banding Project in Minnesota by the Division of Wildlife, 2019.

Species	Summer banding project	Preseason banding project	S/C MN banding project	Total
American Green-winged Teal	18		1	19
American Wigeon	14			14
American Black Duck		1		1
Blue-winged Teal	106		326	432
Canvasback	11			11
Common Goldeneye	161			161
Common Merganser	53			53
Gadwall	4			4
Hooded Merganser	23		1	24
Mallard	438	389	164	991
Northern Pintail	1	7		8
Northern Shoveler	6			6
Redhead	4		7	11
Ring-necked Duck	279			279
Wood Duck	71	70	1564	1705
Total	1189	467	2063	3791

Table 2. – AICc scores, covariates, model weight, change in AICc score, Degrees of Freedom, and model name for each tested modelused to examine factors affecting distance from banding location to recovery location for wood ducks banded in Minnesota and harvested out of state from 1997 - 2017. Factors present in each model are indicated with an "x".

AICc	Age	Sex	Age*Sex	Zone	Days	Zone*Days	Weight	∆AICc	Degrees freedom	Model name
18702.8	x	x	x	x	x	x	0.992	0.00	11	Mod7
18712.6	x	x		x	x	x	0.007	9.88	10	Mod9
18717.0	x	x	x	x	x		0.001	14.23	9	Mod113
18721.8	x			x	x	x	0.00	19.07	9	Mod11
18728.8		x		x	x	x	0.00	26.06	9	Mod10
18742.8				x	x	x	0.00	40.02	8	Mod8
18995.4	x	x	x		x		0.00	292.67	7	Mod12
19537.2	x	x	x	x			0.00	834.42	8	Mod112
19744.1							0.00	1041.33	3	ModNull

Table 3. AICc scores, covariates, model weight, change in AICc score, Degrees of Freedom, and model name for each tested modelused to examine factors affecting change in latitude from banding location to recovery location for wood ducks banded in Minnesota and harvested out of state from 1997 - 2017. Factors present in each model are indicated with an “x”.

AICc	Age	Sex	Age*Sex	Zone	Days	Zone*Days	Weight	∆AICc	Degrees freedom	Model name
6583.3				x	x		0.807	0.00	6	Mod133
6586.3	x	x	x	x	x		0.182	2.97	9	Mod199
6594.0				x	x	x	0.004	10.72	8	Mod14
6594.8	x			x	x	x	0.003	11.49	9	Mod17
6595.1		x		x	x	x	0.002	11.78	9	Mod16
6596.9	x	x		x	x	x	0.001	13.61	10	Mod15
6597.2	x	x	x	x	x	x	0.001	13.94	11	Mod13
6806.0	x	x	x		x		0.00	222.71	7	Mod18
7404.1	x	x	x	x			0.00	820.84	8	Mod188
7522.4							0.00	939.08	3	ModNull

Table 4. AICc scores, covariates, model weight, change in AICc score, Degrees of Freedom, and model name for each tested modelused to examine factors affecting the change in longitude from banding location to recovery location for wood ducks banded in Minnesota and harvested out of state from 1997 - 2017. Factors present in each model are indicated with an “x”.

AICc	Age	Sex	Age*Sex	Zone	Days	Zone*Days	Weight	∆AICc	Degrees freedom	Model name
6699.4	x			x			0.987	0.00	6	Mod26
6708.1	x			x	x		0.013	8.71	7	Mod25
6721.3	x	x		x	x	x	0.00	21.94	10	Mod21
6723.0	x	x	x	x	x	x	0.00	23.60	11	Mod19
6725.2	x			x	x	x	0.00	25.77	9	Mod23
6739.1		x		x	x		0.00	39.68	7	Mod27
6756.3		x		x	x	x	0.00	56.94	9	Mod22
6774.1				x	x	x	0.00	74.67	8	Mod20
6806.0	x	x	x		x		0.00	106.59	7	Mod24
6843.7							0.00	144.33	3	ModNull

Table 5. Number of recoveries per age classification from each banding zone for wood ducks marked in Minnesota from 1997 - 2017.

Zone	Adults	Juveniles
North	348	124
Central	280	148
South	179	197

Table 6. Number and percentage of reported direct recoveries for wood ducks banded in Minnesota 1997-2017 by state.

State of recovery	Harvest records	Percent of recoveries
Minnesota	1099	45.58%
Louisiana	400	16.59%
Arkansas	206	8.54%
Texas	146	6.06%
Mississippi	103	4.27%
Wisconsin	74	3.07%
Illinois	59	2.45%
Iowa	58	2.41%
Alabama	48	1.99%
Missouri	46	1.91%
Tennessee	42	1.74%
Georgia	26	1.08%
Florida	23	0.95%
Oklahoma	20	0.83%
South Carolina	15	0.62%
Indiana	11	0.46%
Michigan	9	0.37%
Kansas	6	0.25%
North Carolina	6	0.25%
Kentucky	6	0.25%
Ohio	3	0.12%
Virginia	2	0.08%
Nebraska	1	0.04%
North Dakota	1	0.04%
Delaware	1	0.04%
Grand Total	2,411	

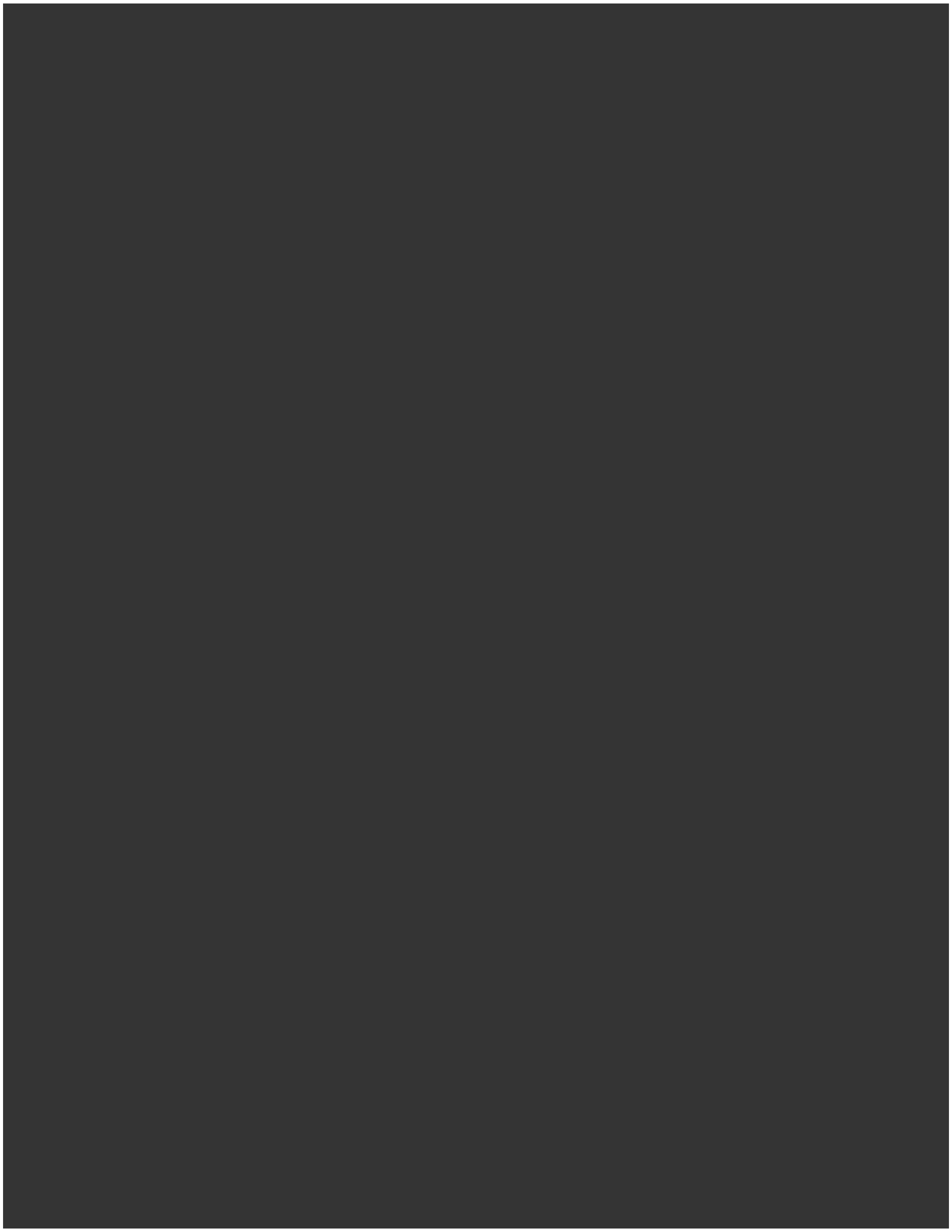

Figure 1. Map showing banding locations (open triangles) for wood ducks in Minnesota from 1997-2017.

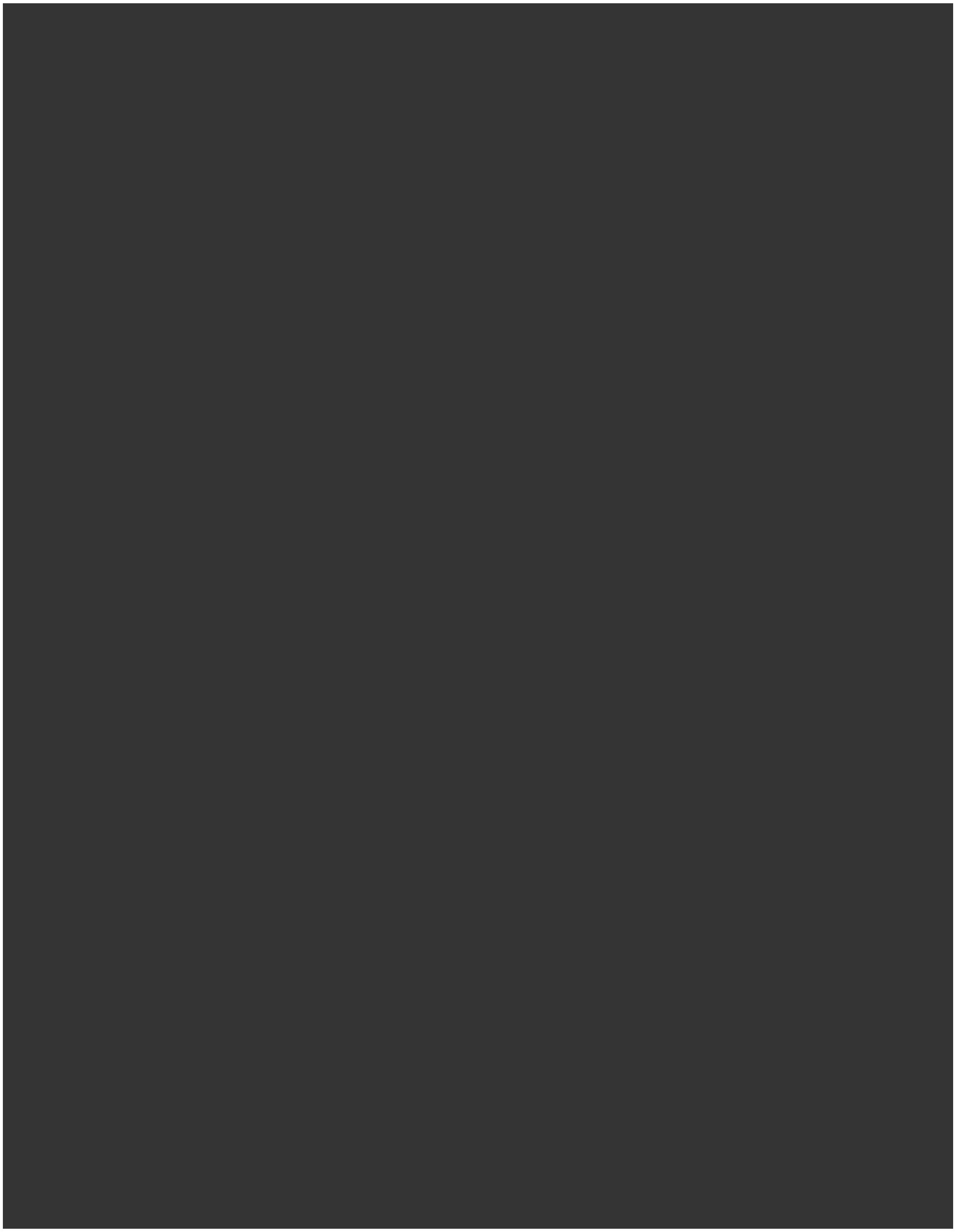

Figure 1. Recovery locations for 2,411 wood ducks banded in Minnesota 1997- 2017.

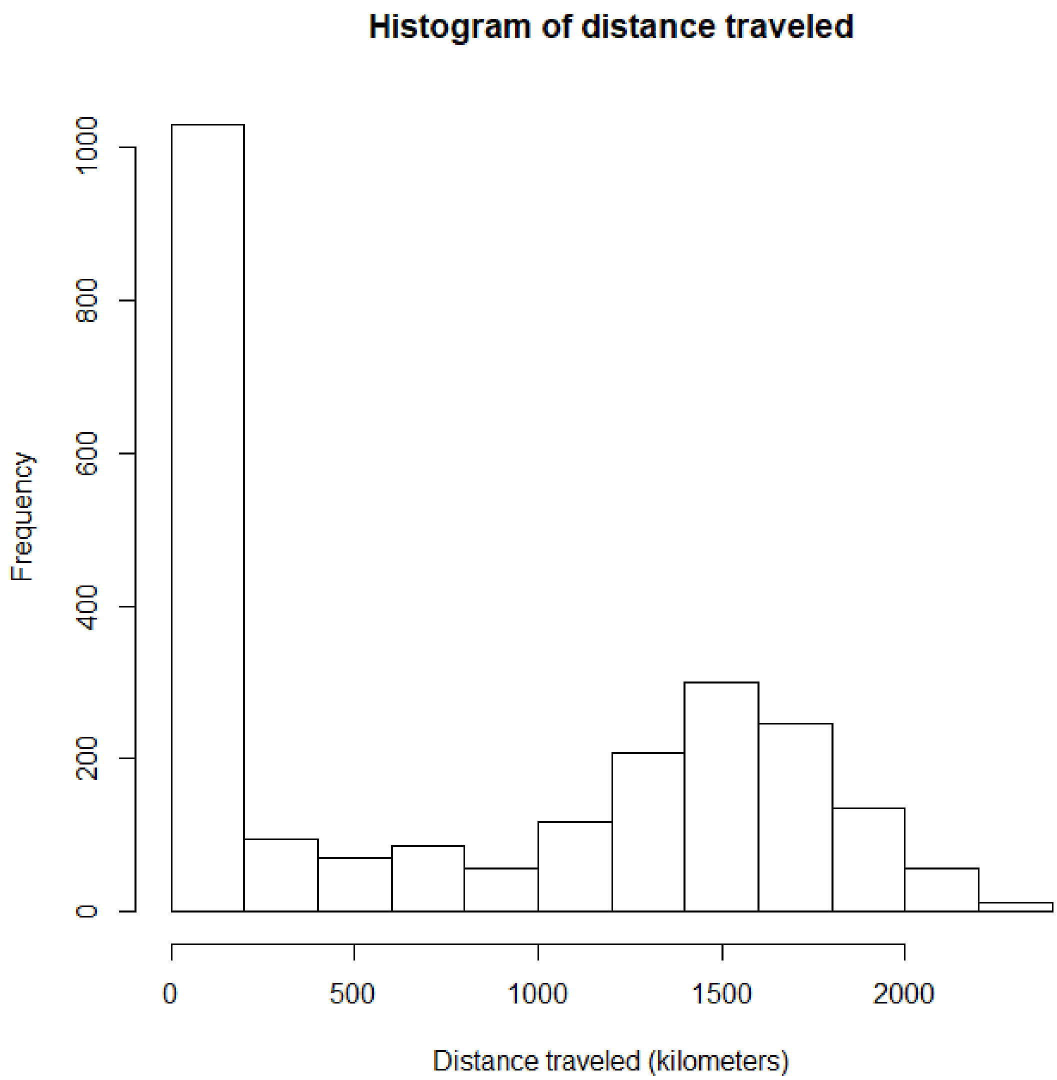

Figure 3. Histogram of distance from banding location to recovery location for wood ducks banded in Minnesota, 1997-2017 and recovered in the immediate hunting season after banding.

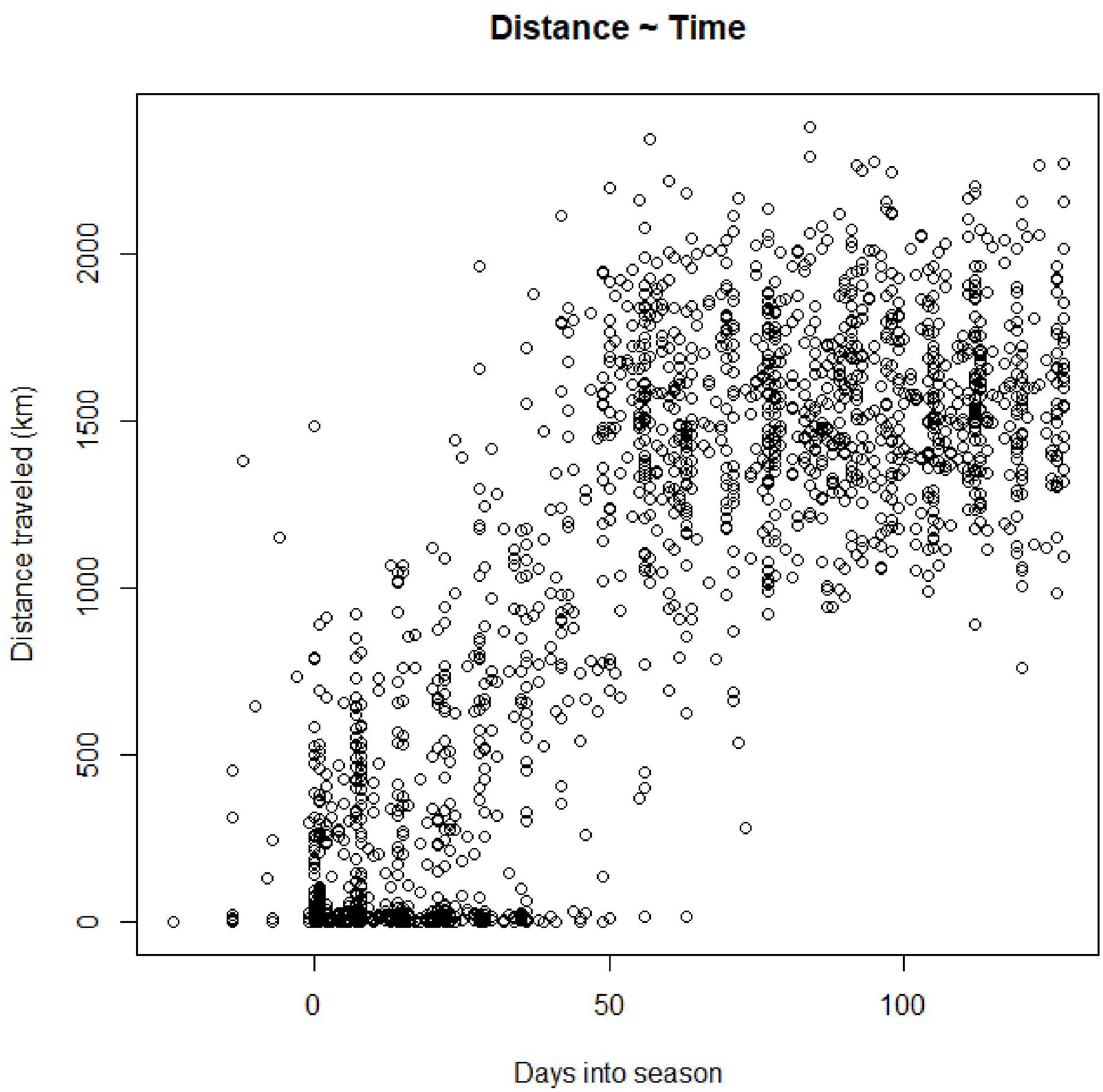

Figure 4. Relationship between time and distance traveled from banding location to recovery location for wood ducks banded in Minnesota, 1997 - 2017.

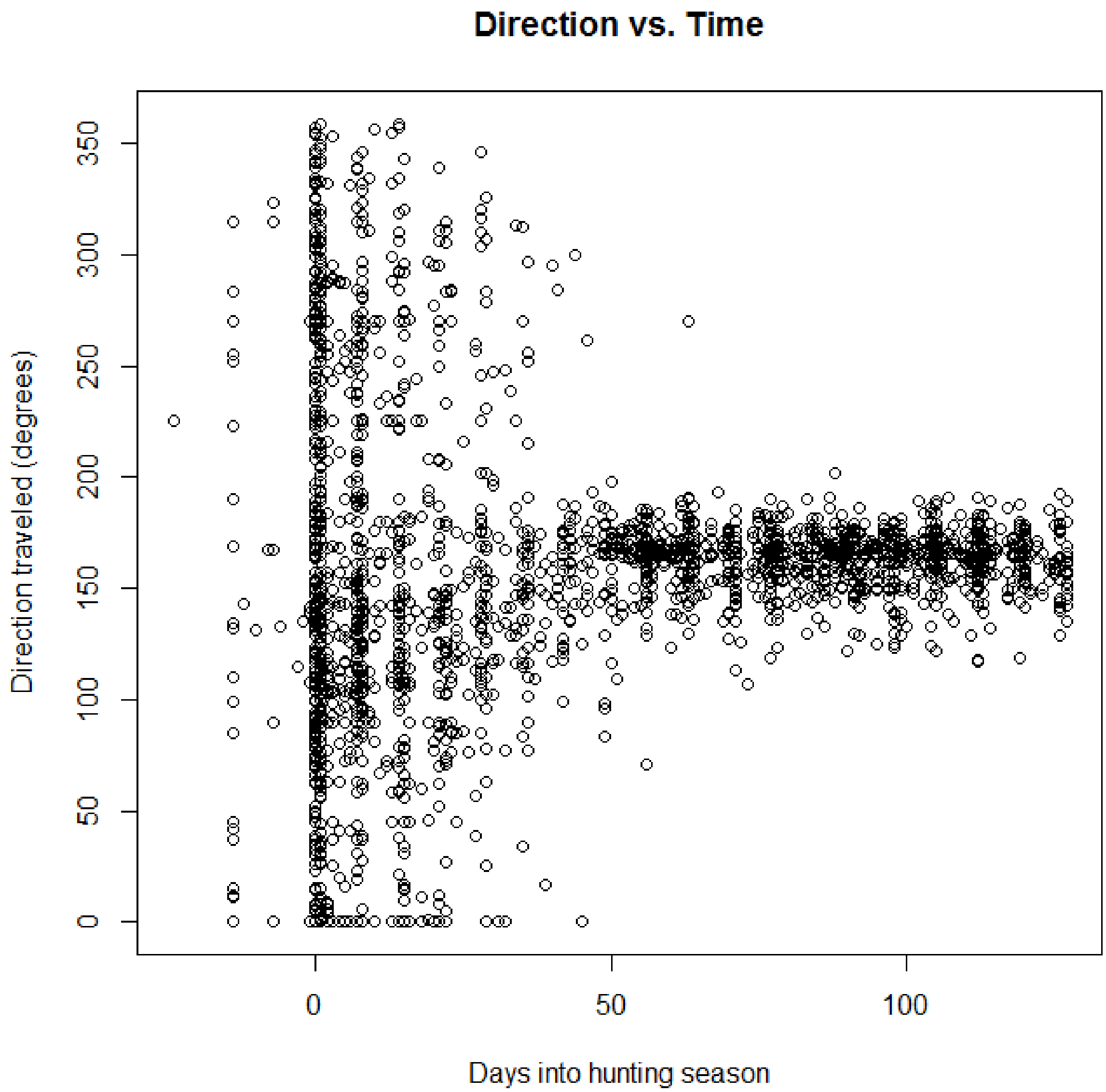

Figure 5. Relationship between time and direction of travel from banding location to recovery location for wood ducks banded in Minnesota, 1997 - 2017.

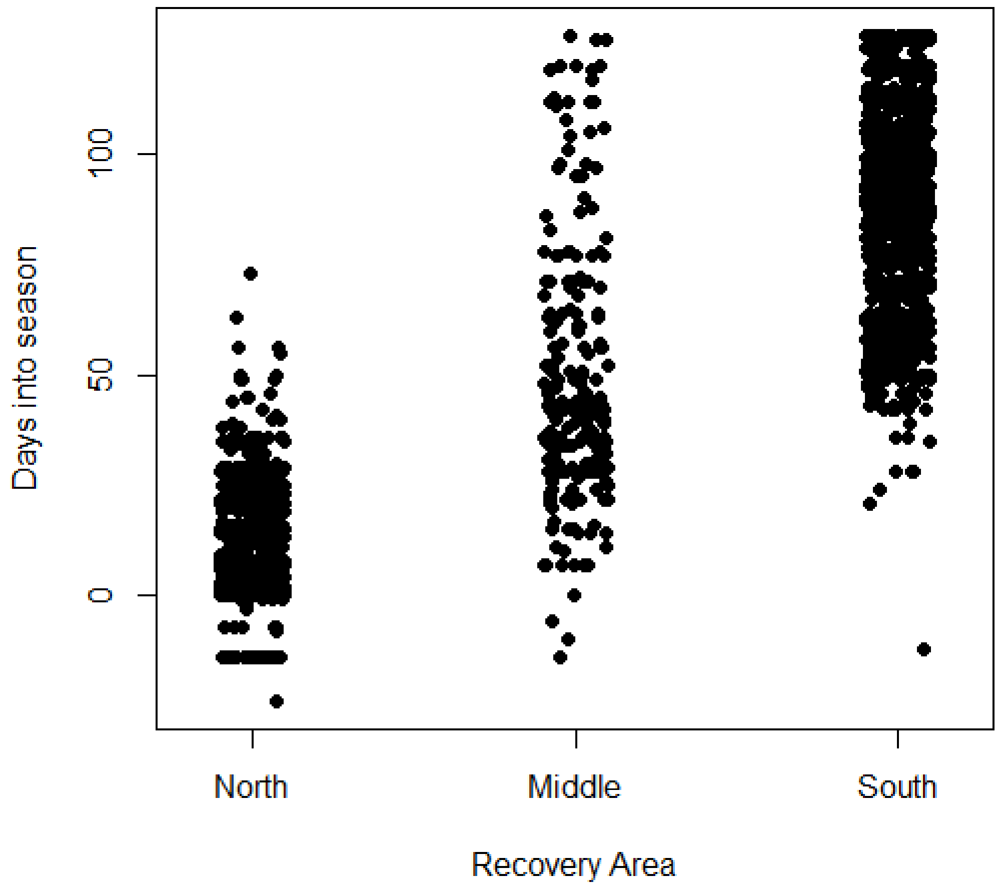

Figure 6. Strip chart of the relationship between harvest in each region and time for wood ducks banded in Minnesota, 1997 - 2017.

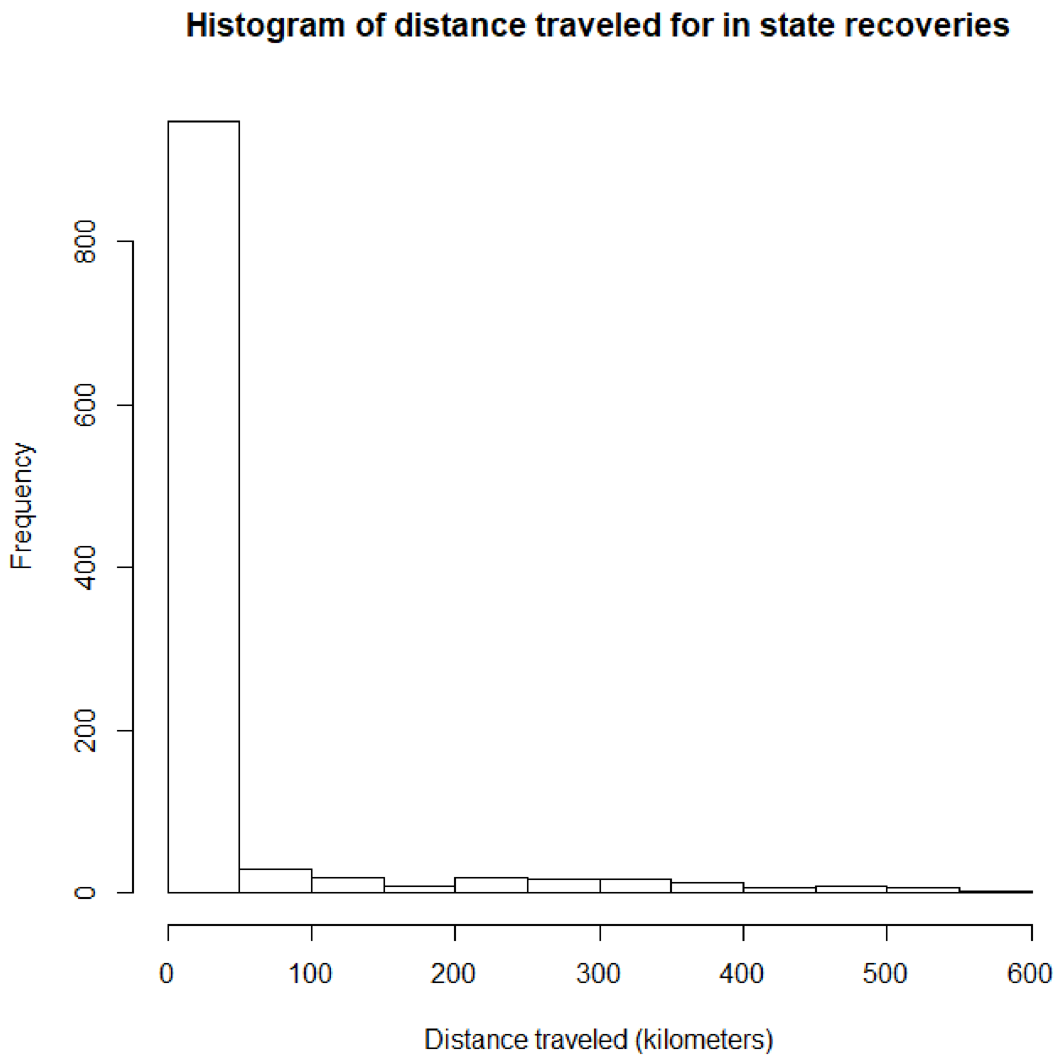

Figure 7. Histogram of distances from banding locations to recovery locations for wood ducks both banded and recovered in Minnesota from 1997 - 2017.

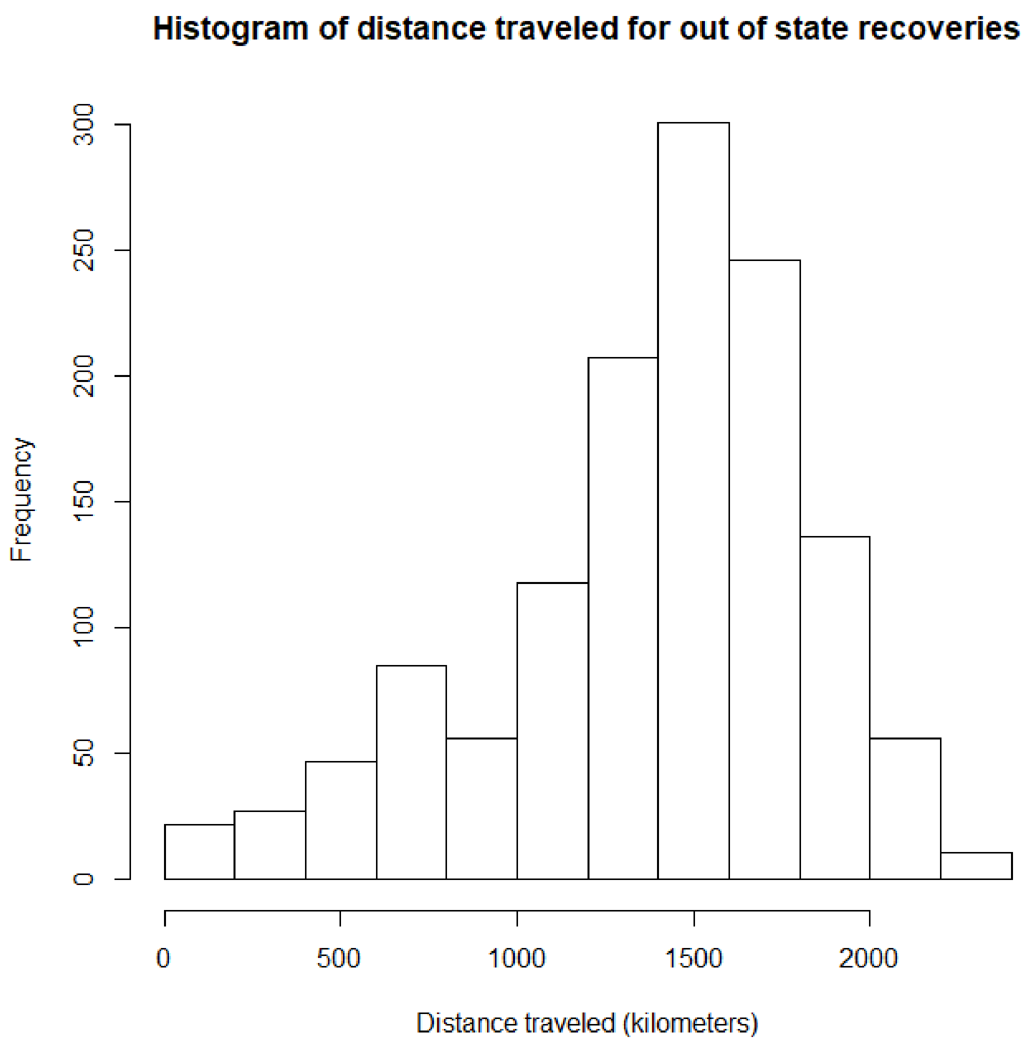

Figure 8. Histogram of distance between banding and recovery locations for wood ducks banded in Minnesota, but recovered out of state from 1997-2017.

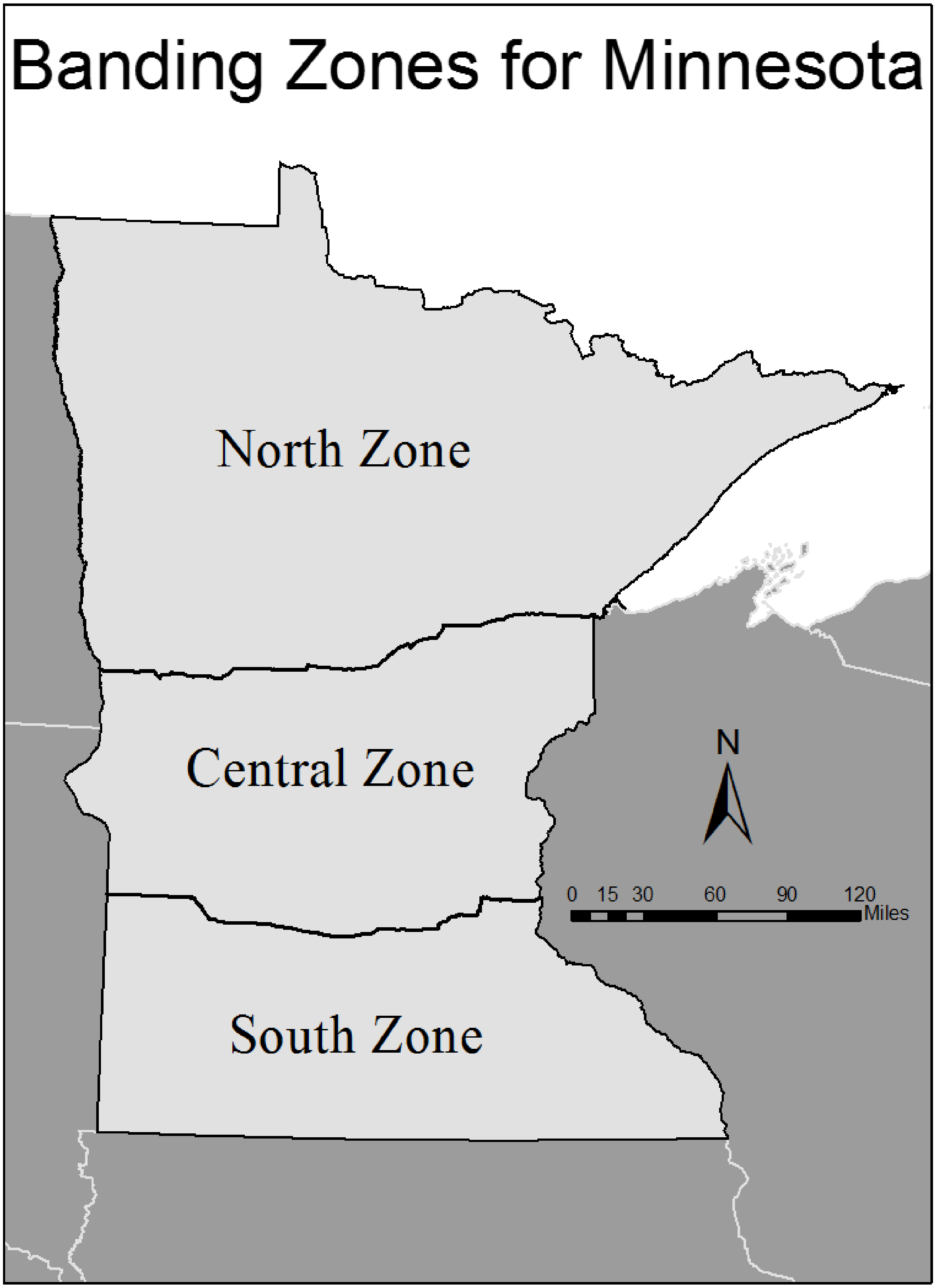

Figure 9. Map indicating the three hunting zones for Minnesota waterfowl; these were used as banding zones for analyses.

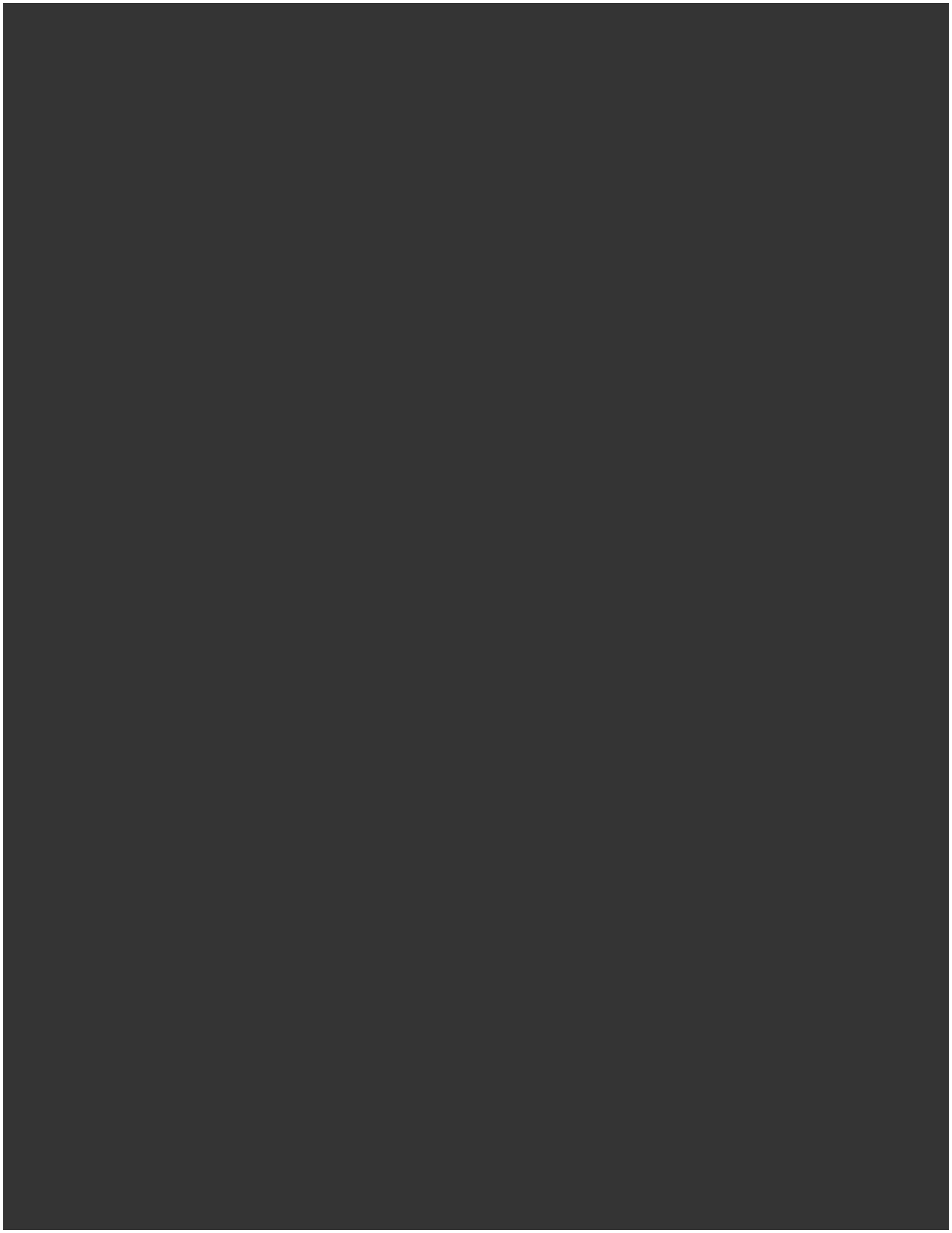

Figure 10. Map showing the recovery locations of banded wood ducks marked in each of the three banding zones in Minnesota from 1997-2017, North (N), Central (C), and South (S).

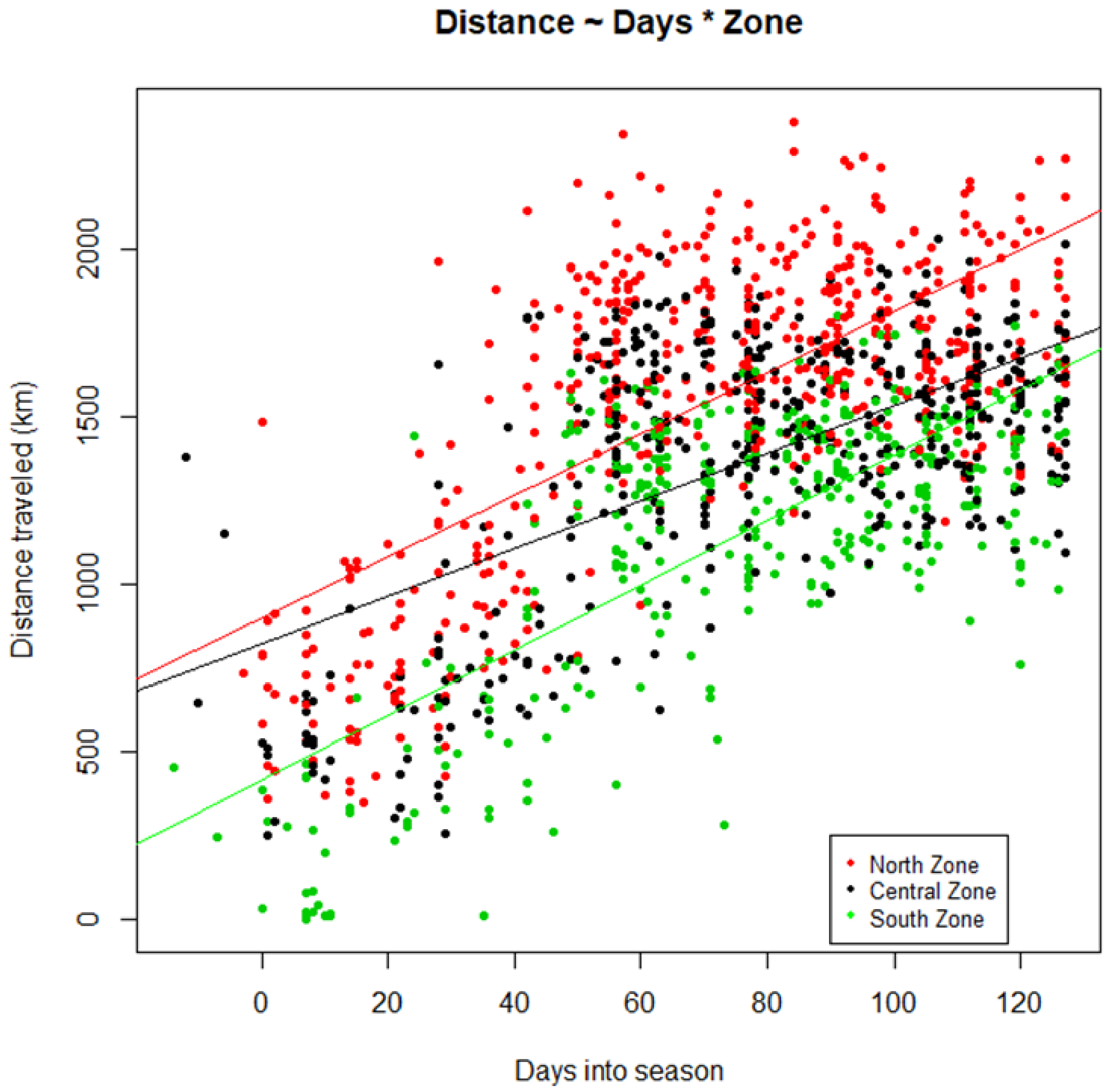

Figure 11. Distance traveled between marking and recovery locations by days into season for wood ducks banded in Minnesota, 1997 - 2017. Birds marked in the North, Central, and South Zones are indicated in red, black, and green respectively. Regression lines are fit for each zone, separately.

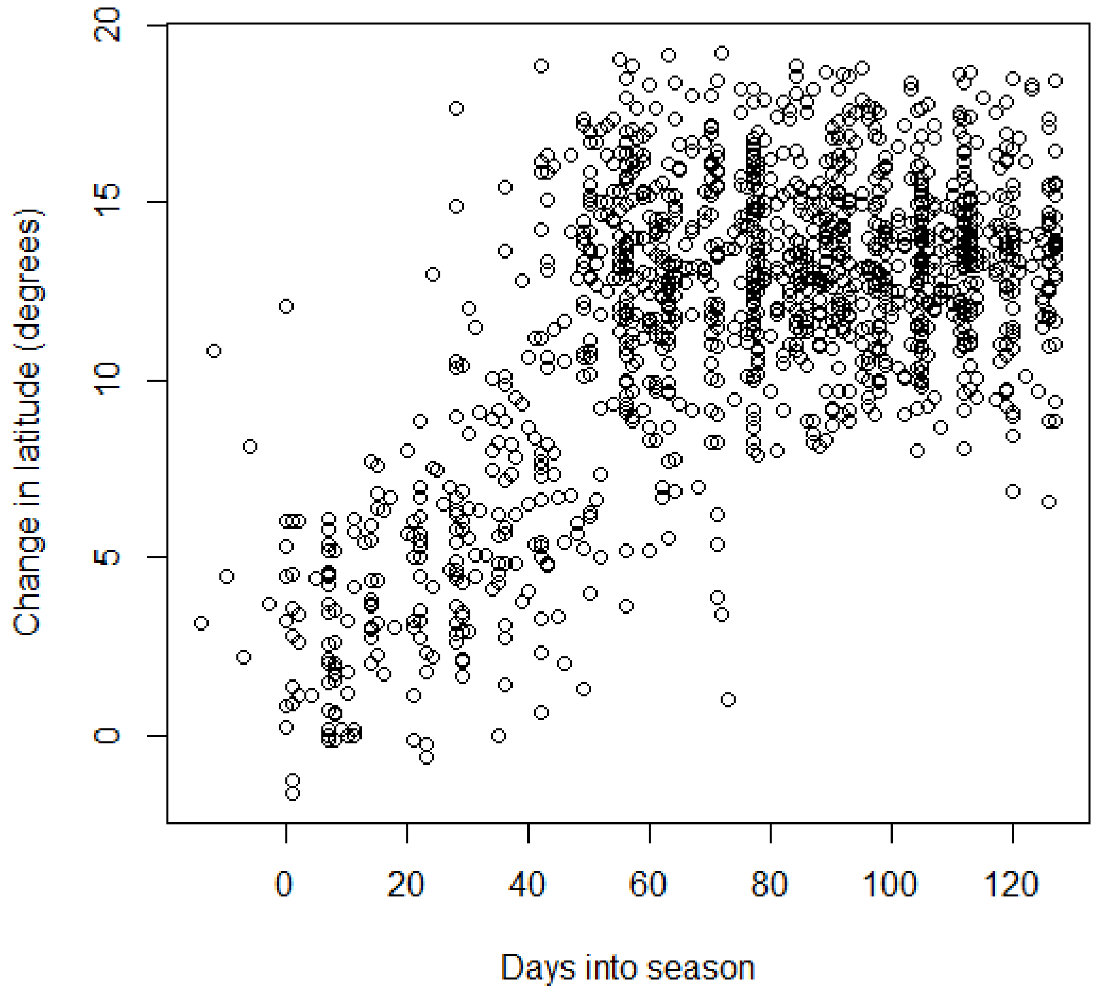

Figure 12. Days into the season (time) and the change in latitude from banding location to recovery location for wood ducks banded in Minnesota, 1997 - 2017.

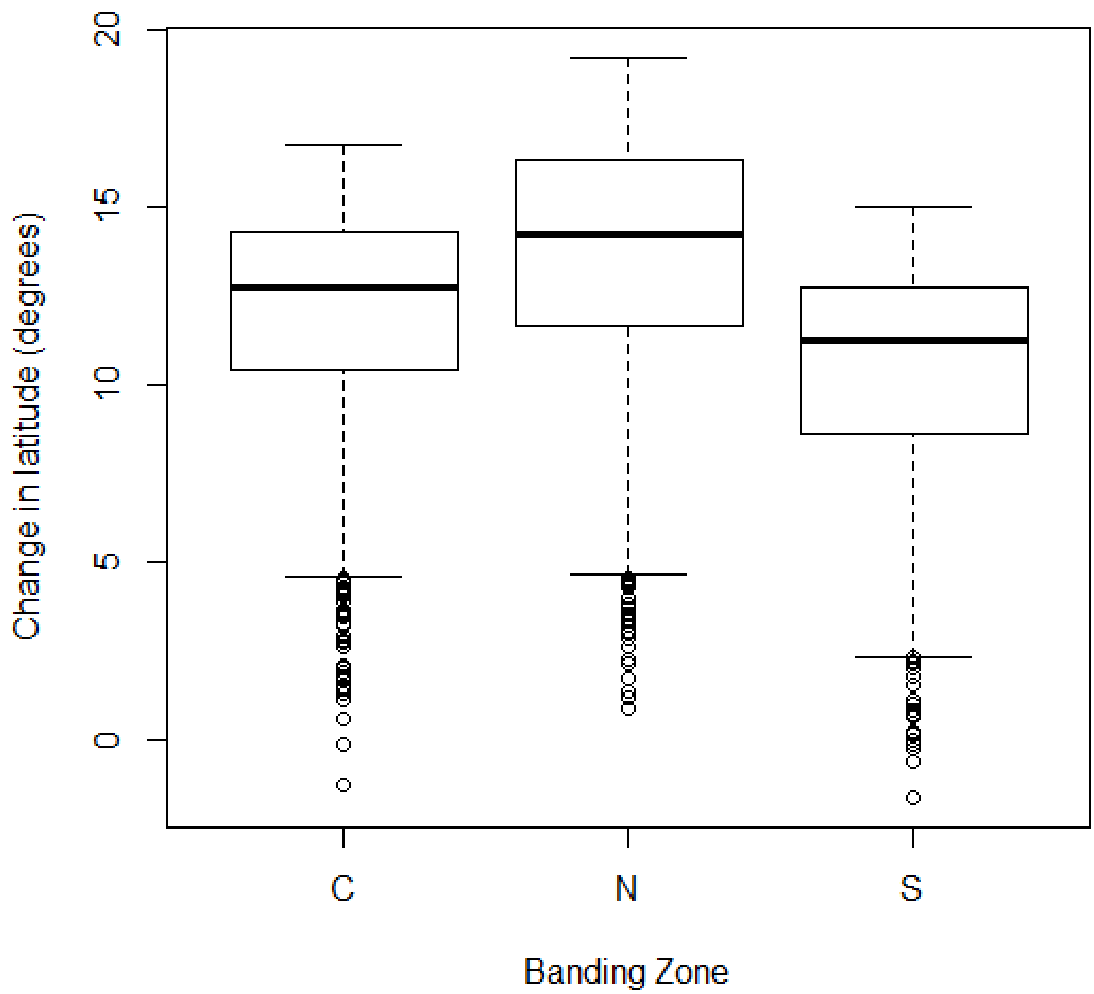

Figure 2. Change in latitude by banding zone for wood ducks marked in Minnesota from 1997 - 2017.

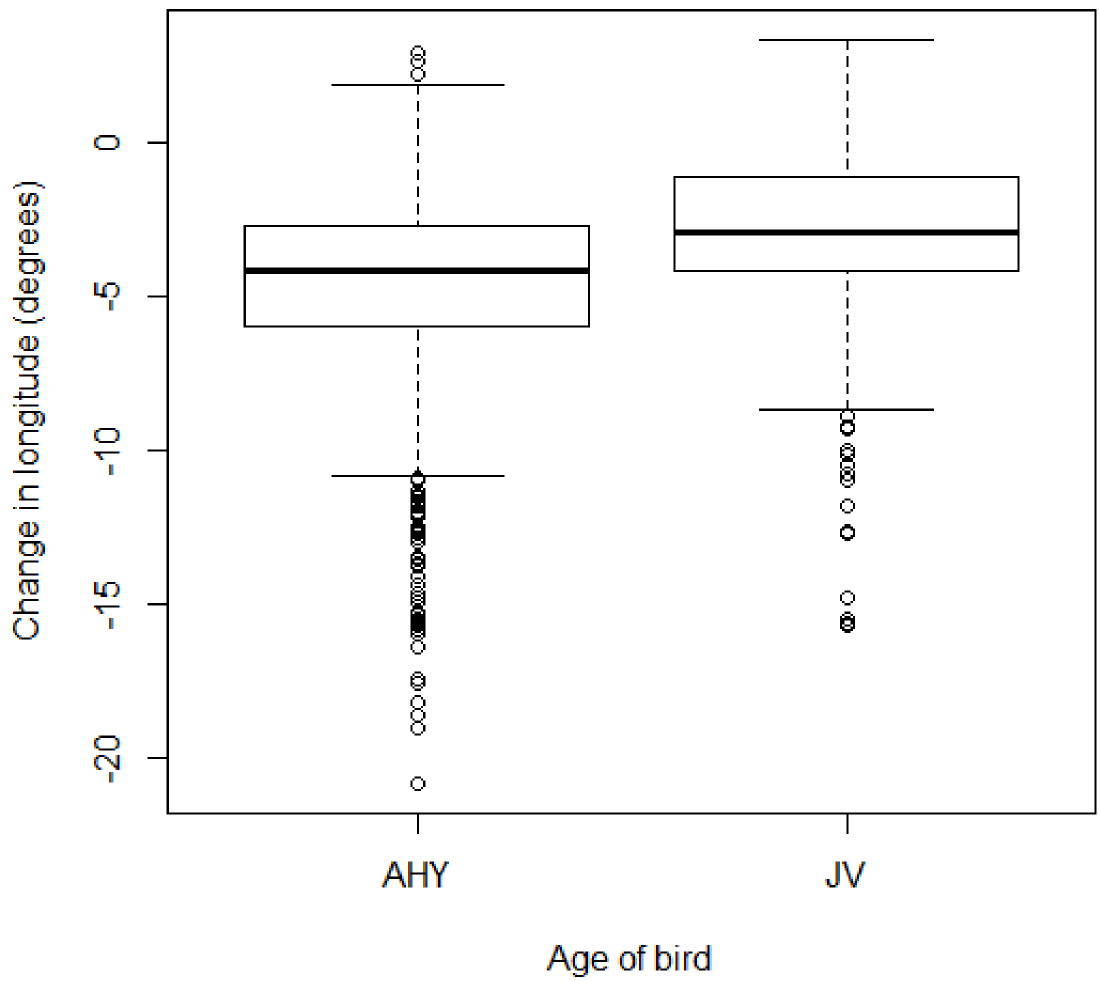

Figure 14. Change in longitude by age for wood ducks marked in Minnesota from 1997- 2017.

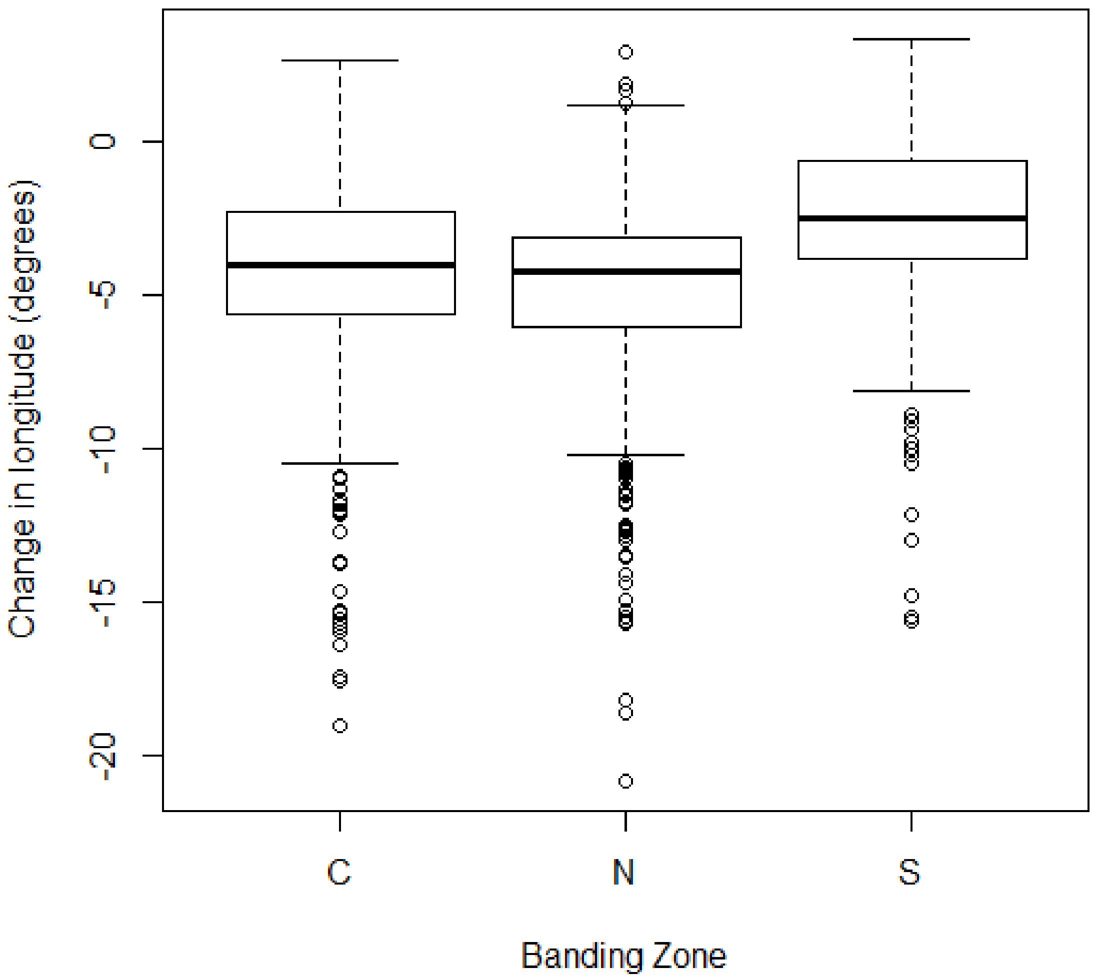

Figure 15. Change in longitude by banding zones for wood ducks marked in Minnesota from 1997 - 2017.

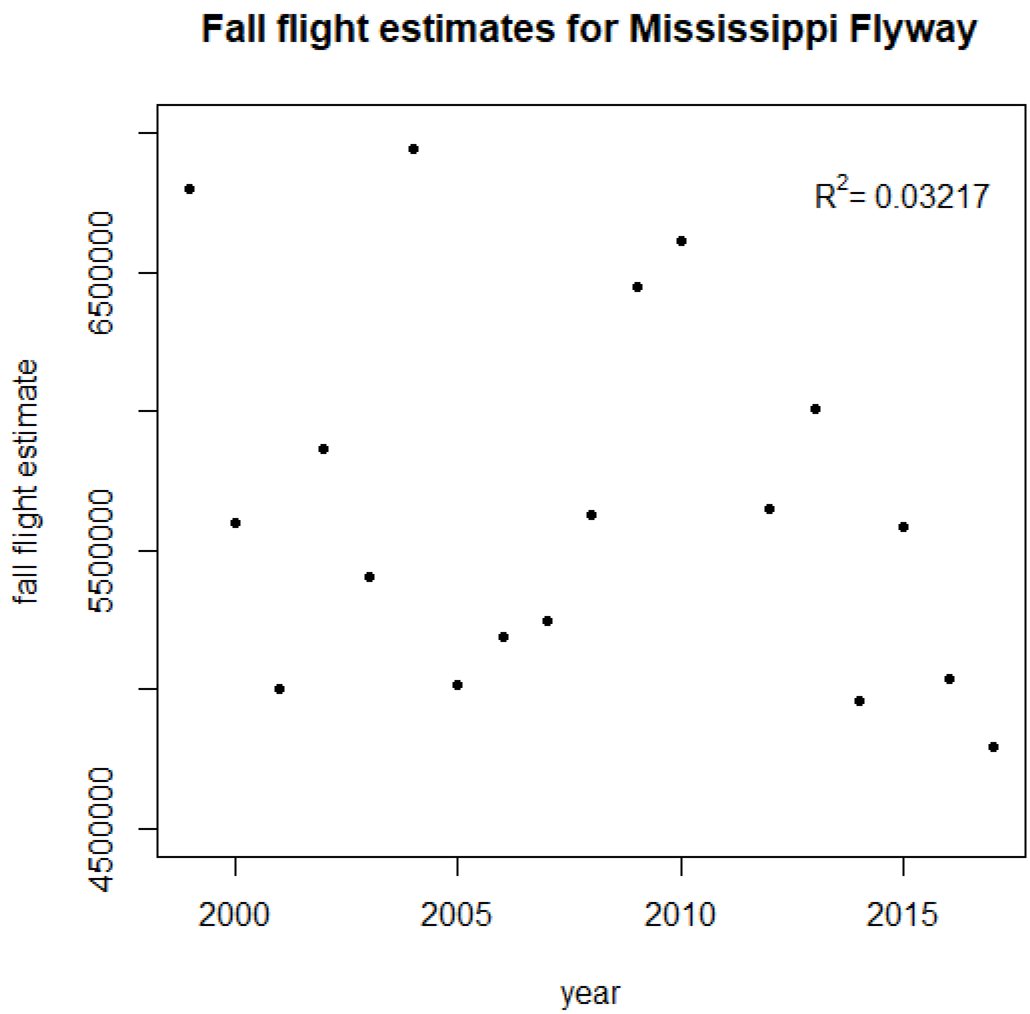

Figure 16. Fall flight estimates of wood ducks for the Mississippi Flyway 1999 - 2017.