FALL MOVEMENTS OF MALLARDS MARKED IN MINNESOTA

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SUMMARY OF FINDINGS

During August through September of 2016, I marked 119 mallards (*Anas platyrhynchos*) with tracking units. I obtained GPS locations from dataloggers recovered by hunters or uploaded through the Argos satellite system to yield 3,506 tracking locations. Locations within the state of Minnesota (*n*=2,848) were used to examine habitat use. Marked birds stayed in Minnesota longer than expected and freeze up dates were later than average in 2016. When marked birds did leave the state, movements upon departure tended to be long with a mean distance of 434 km between a bird's last known location in Minnesota and its first known location outside of Minnesota. Marked birds used open water and emergent herbaceous wetland habitats combined for 55-80% of the time. Crop habitats were used most frequently at night (30% of proportional use) and more frequently for birds marked in the southern hunting zone than for birds marked in the northern hunting zone. Sample sizes were sufficient to detect differences in use of habitats among capture zones and time of day, but I did not detect differences in emigration rates between zones; given the late onset of winter, rates of emigration may have been similar between zones. For birds marked in 2016, biologically relevant differences were detectable when present.

During August through September of 2017, I marked 90 mallards with GPS tracking units; 79 of these units used the Argos system and 11 units were GPS dataloggers. During August through September of 2018, I marked 45 mallards with GPS tracking units that transmitted through the Argos system. We were planning to end fieldwork for the project after the 2018 field season, but after the season, we had 20 tracking units on hand that had not yet been deployed. During August through September of 2019, I marked the final 18 mallards with GPS tracking units that transmitted through the Argos system; 2 tracking units failed to start and could not be deployed.

Herein, I present summaries of preliminary analyses for birds marked in 2016, but I have not yet completed analyses for birds marked in 2017, 2018 or 2019. Beyond summary statistics, I provide here some example data as well as some comparisons with band recovery data for mallards marked in Minnesota. I expect to complete analyses by late 2020 to early 2021.

INTRODUCTION

Distribution of waterfowl during fall migration and concurrent hunting seasons is affected by numerous factors. Wildlife managers are tasked with setting season dates, bag limits, shooting hours, and further restrictions on harvest. Availability of waterfowl throughout the hunting season (retention) is important to Minnesota waterfowl hunters. Understanding the chronology of immigration and emigration events and the factors affecting those events is imperative.

Many factors may impact emigration rates and use of habitats. Weather plays an important role in the timing of migration by waterfowl during fall; as winter weather severity increases, the probability of southward waterfowl migration also increases (Schummer et al. 2010). Repeated exposures to disturbance associated with hunting have been found to alter distribution and habitat use and cause increased movements of wintering waterfowl (Dooley et al. 2010, Pease et al. 2005), but the effects of disturbance have not been investigated for waterfowl nearer their breeding habitats. Importantly, the effects of weather and anthropological disturbance are likely confounded; hunting seasons often coincide with changing weather patterns. In the presence of elevated human disturbance to waterfowl habitats that occurs during hunting seasons, it may be difficult to detect causes of temporal or spatial changes to a bird's natural migration pattern. Numerous studies have been conducted to understand the ecology of breeding waterfowl and some information is available on wintering waterfowl, but little work has been completed on waterfowl during migration periods. Due to their transient nature, waterfowl are inherently difficult to study during the migration periods. Thus, few studies have been undertaken to investigate patterns of fall migration.

In an effort to provide habitat to local and migrating waterfowl, retain waterfowl on the landscape throughout the duration of the season, provide hunting opportunities for its constituents, and to control waterfowl harvest, the Minnesota Department of Natural Resources has implemented numerous restrictions on duck harvest and disturbance to wetlands. Restrictions include establishment of waterfowl refuges, a 4 PM closure to duck hunting for the earliest portion of the duck season, designation of feeding and resting areas which restrict the use of motorized boats, a statewide ban on motorized decoys for the earliest portion of the season, and a ban on motorized decoys on state owned Wildlife Management Areas (WMA) for the entire season.

The importance of the hunting regulations implemented in Minnesota to provide secure areas for ducks is unclear because fall emigration and factors affecting the chronology of fall migration are poorly understood. Restrictions on afternoon shooting hours unilaterally in Minnesota did result in 3-4% lower recovery rates (a proxy for harvest rates) than when sunset closures occurred, but the researchers were unable to detect a difference in annual survival rates (Kirby et al. 1983). Restrictions on shooting hours that are more restrictive than what is allowed in the federal framework have been in place since 1973 but their importance is unknown. Assessment of the effects of shooting hour restrictions and other hunting regulations on movement patterns warrants investigation. Better understanding of movement patterns gained from this work will allow managers to better set season dates and alter restrictions on harvest.

OBJECTIVES

Overall study objectives were to:

1. Better understand emigration chronology for mallards (*Anas platyrhynchos*) in Minnesota.
2. Estimate distances and directions moved by mallards in Minnesota.
3. Identify migration stopovers used by mallards in Minnesota.
4. Estimate use of habitats for birds while in Minnesota.

More specifically, during the pilot-year of this study, we sought to inform subsequent years of data collection by addressing these specific objectives:

5. Estimate variability in emigration, movement, and habitat use data within and among hunting zones.
6. Estimate rate of sample size reduction throughout the tracking period.
7. Evaluate alternative tracking units in terms of data quantity and quality.

STUDY AREA

Currently, Minnesota utilizes 3 zones to manage duck hunting seasons (Figure 1). Timing of seasons and restrictions on shooting hours differ among the zones. I attempted to mark equal numbers of birds in each hunting zone, but was unable to mark birds in the central zone in 2016. In 2017, I marked 59, 20, and 11 birds in the north, central, and south zones, respectively.

METHODS

Marking

In 2016, I attached 39 GPS-Argos backpack units (Lotek Wireless Inc., Newmarket, Ontario, Canada) to adult female mallards; these units logged GPS data and then transmitted that data back to the Argos system upon completion of their duty cycle. These units were 15 g and able to record about 100 GPS fixes and transmit those fixes to Argos satellites before exhausting their battery life. In 2016, I also marked 80 hatch year male mallards with GPS-archival backpack units (Lotek Wireless Inc.). These units record GPS location data at a user specified interval, but must be recovered to acquire data. These units weighed 11 g and were configured as backpack type transmitters. I attached these units to hatch-year males because they have the highest recovery rate of any mallard age-sex cohort. Apparent direct (within first hunting year after marking) recovery of hatch year male mallards banded in Minnesota based on band returns was predicted to be 18% and an additional 6% were expected to be recovered in the 2^{nd} hunting season after deployment (USGS, Gamebirds data set).

GPS-logger or GPS-Argos backpack transmitter units receive satellite signals to estimate highly accurate locations; precision of locations is accurate to within a few meters. Of all available options, these units were deemed best suited for estimating detailed parameters associated with habitat use, use of refuge areas, local movements, and migration events. Birds were marked in conjunction with our current banding effort. We paid a $50 incentive for hunters returning tracking units.

After preliminary analyses for birds marked in 2016, we determined that slightly more data per unit cost were attained for birds marked with GPS-Argos units than GPS-logger units. Further, the manufacturer was able to change the firmware and programming of these tracking units for 2017 so that they would consume less battery and collect more data than the 2016 units. Thus, we elected to purchase only GPS-Argos units for use in 2017 and 2018. In 2017, I was also able to reuse 11 GPS-logger units and 8 GPS-Argos units that had been deployed in 2016, recovered by hunters, and refurbished with new harness material.

Tracking

In 2016, GPS-logger units were configured to attain location data every 11.5 hours; GPS-Argos units were configured to attain fixes every 22.5 hours and the units were set to begin this cycle at differing times. This allowed locations throughout the day and locations on each individual bird to shift over days and attain day and night fixes accordingly. In 2017, advances in firmware and programming of the tracking units allowed more frequent tracking; GPS-Argos units were set to attain location data every 11.5 hours in 2017 and 2018.

Movement Data

For birds marked in 2016, estimated point locations were determined to be inside or outside the state of Minnesota. A bird was determined to have emigrated upon its permanent exit from the state. Movement direction was measured as the azimuth between the birds marking location and its first location outside the state upon permanent emigration.

Use of Habitats

For birds marked in 2016, estimated point locations were overlaid on the 2011 National Land Cover Data layer and habitats were determined based on estimated point locations. Similarly, it was determined whether locations were on refuge or non-refuge locations and WMA or non-WMA locations based on appropriate GIS data layers.

Data Analyses - Movement Data

For birds marked in 2016, I determined date of permanent departure from the state (emigration) for each bird based on its location data. I used proportional hazards regression (Allison 1995) to examine variation in emigration rates due to the effects of the bird's age and sex or its location of marking. I estimate product-limit emigration rate (Kaplan and Meier 1958) for the marked sample and examine directionality of emigration trajectories.

Data Analyses - Use of Habitats

For birds marked in 2016, I divided the tracking period into 3 time periods based on hunting seasons: PREHUNT (the period before regular duck season was opened in Minnesota), HUNT (the period when regular hunting season was open anywhere in Minnesota), and POST (the period after regular duck season had closed anywhere in Minnesota). I divided location data into portions of the day as diurnal (sunrise to sunset) or nocturnal. I collapsed habitats to 5 basic categories for analysis including open water, forested or developed habitats, pasture habitats, crop habitats, or emergent marsh habitats. I determined use of habitats within the state of Minnesota based on 2,848 location estimates from 44 birds using compositional analyses (Aebischer et al.1993). I determined diurnal and nocturnal proportional bird use of habitat during each time period and replaced zero values with 0.002 (an order of magnitude lower than the lowest nonzero proportion of a habitat used by any bird in a combination of any time period and portion of day). To remove the unit sum constraint, I constructed log ratios by dividing proportional use of each habitat by proportional use of emergent marsh habitat and used Napierian logarithms of these ratios as response variables. I used split-plot, repeated measures multivariate analysis of variance to test for overall effects of season (PREHUNT, HUNT, POST), portion of day (day or night), cohort of marked bird, or zone of capture. I fit a full model containing all 4 of these explanatory factors as well as a term for repeated measures among birds.

Models were fit using backwards-stepwise procedures. I present estimates of proportional use of each habitat, averaged across birds, from the untransformed data within levels of significant ($P \leq 0.050$) explanatory variables from the final fitted model.

Similarly, I examined use of refuge areas (areas closed to waterfowl hunting by statute or regulation) and use of WMAs using analysis of variance after constructing proportions as outlined above. I present proportional use of these habitats below.

RESULTS

Movement Data

For birds marked in 2016, I did not detect differences in rates of emigration among cohorts or zones of capture ($P > 0.018$). Retention rates of marked birds in Minnesota remained > 80% until early November then declined to about 45% by mid-November, with remaining birds leaving the state in early-December (Figure 2). Latitudes of marked birds declined throughout the season (Figure 3) and vectors of emigration flights were mostly long and southeasterly (Figure 4). One noteworthy exception to the southeasterly emigration pattern was that in 2016, 6 birds marked in northwestern Minnesota moved north into southern Manitoba (Figure 5). This movement pattern took place in only a small percentage of birds, but represents movement that is not usually seen when examining band recovery data due to low hunting pressure and dilution of the banded sample by large numbers of other mallards.

Use of Habitats

We attained location data for birds marked with GPS-Argos units and assigned location data habitat attributes (Figure 6). For birds marked in 2016, I did not detect differences among proportional use of habitats by seasons or cohorts ($P > 0.090$), but proportional use of habitats differed among zones of capture ($P = 0.018$) and portion of day ($P < 0.0001$). Use of crop habitats were higher for birds marked in the south capture zone than for birds marked in the north capture zone (Figure 7). Use of open water habitats were highest during the day; use of crop habitats were highest during the night (Figure 8).

Use of areas closed to hunting varied by zone of marking and season ($P < 0.0029$). Proportional use of areas closed to hunting was 45% in the north hunting zone, whereas use of refuge areas was only 8% in the south hunt zone. Use of refuge areas was highest (44.9%) during the preseason period, but decreased to 22.6% and 27.3% during the hunting season and post-hunting periods, respectively.

Use of WMAs was 56%, 37%, and 27% during the preseason, hunting season, and post-hunting seasons, respectively. Use of WMAs during night was 39%, but 53% during the day.

DISCUSSION

Emigration rates were similar between zones of capture and cohorts; given the late onset of winter that occurred in 2016, this was not surprising. Temperatures were above normal through early December in northern Minnesota. When freeze up did occur in the north hunting zone it also occurred in much of the southern portion of the state shortly thereafter. I speculate that the extended retention time of the marked sample within Minnesota was likely due to the late onset of winter.

Use of open water and emergent wetland habitats was high; these estimates were based on the National Land Cover Database data currently available. More refined analyses of habitat use could be conducted if more informative and accurate GIS data layers are available. Further analyses including data from birds marked in 2017 and 2018 will be conducted in 2019. An additional sample of 25 Mallards are scheduled to be marked in August-September 2019 using GPS-Argos type tracking units.

ACKNOWLEDGMENTS

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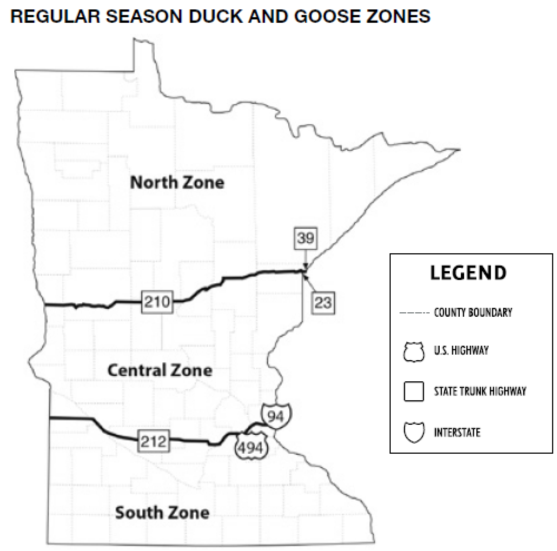


Figure 1. Minnesota waterfowl hunt zones boundaries, 2016.

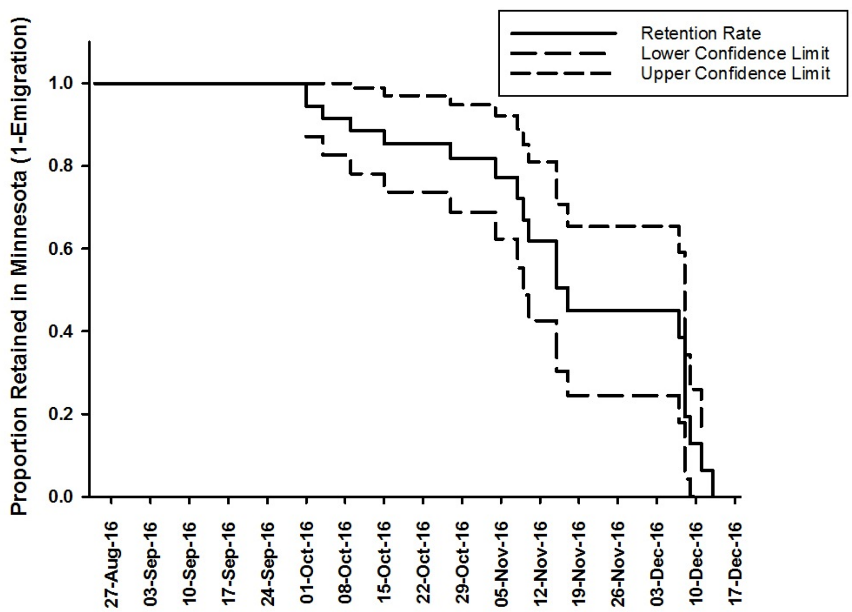


Figure 2. Retention curve for mallards marked with tracking units in Minnesota, 2016.

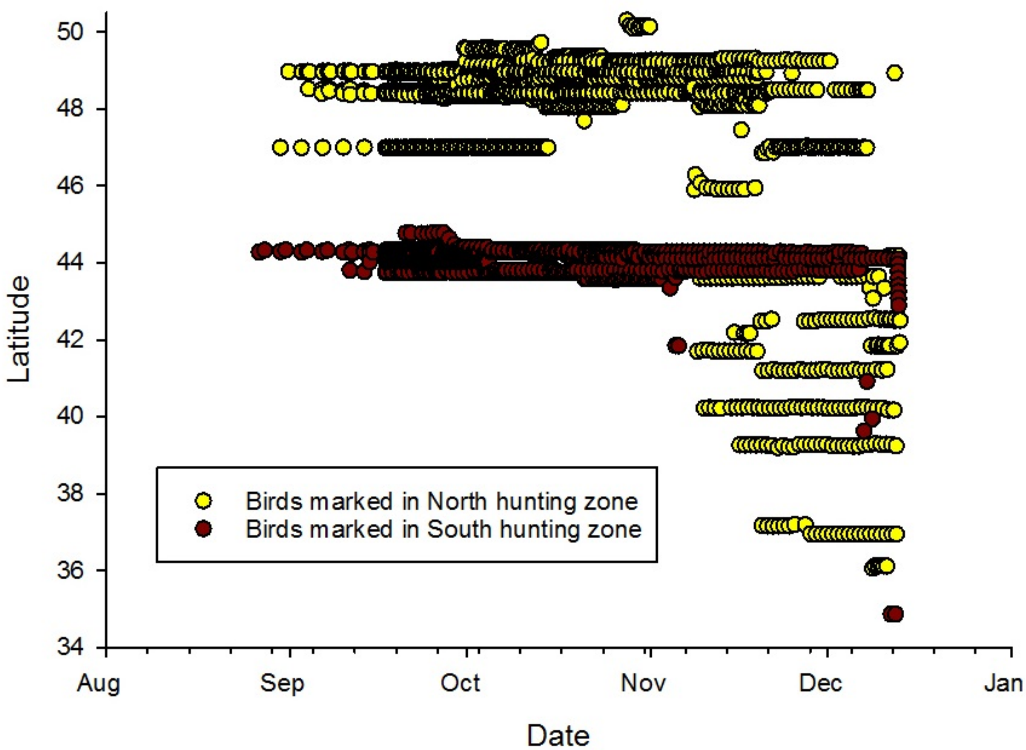


Figure 3. Scatter plot of location latitudes by date for mallards marked with tracking units in Minnesota, 2016.

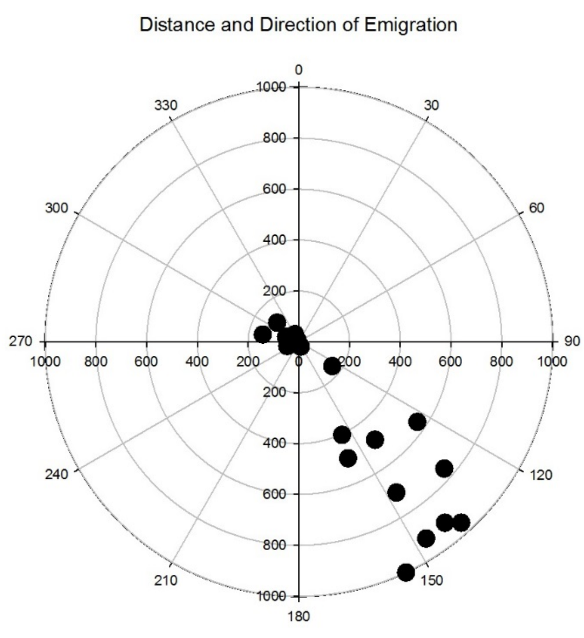


Figure 4. Polar plot of distance and direction of movement on permanent emigration (black dots) for mallards marked with tracking units in Minnesota, 2016. Concentric rings represent distances (km); azimuth (degrees) of movements are indicated on the outermost ring of the plot.

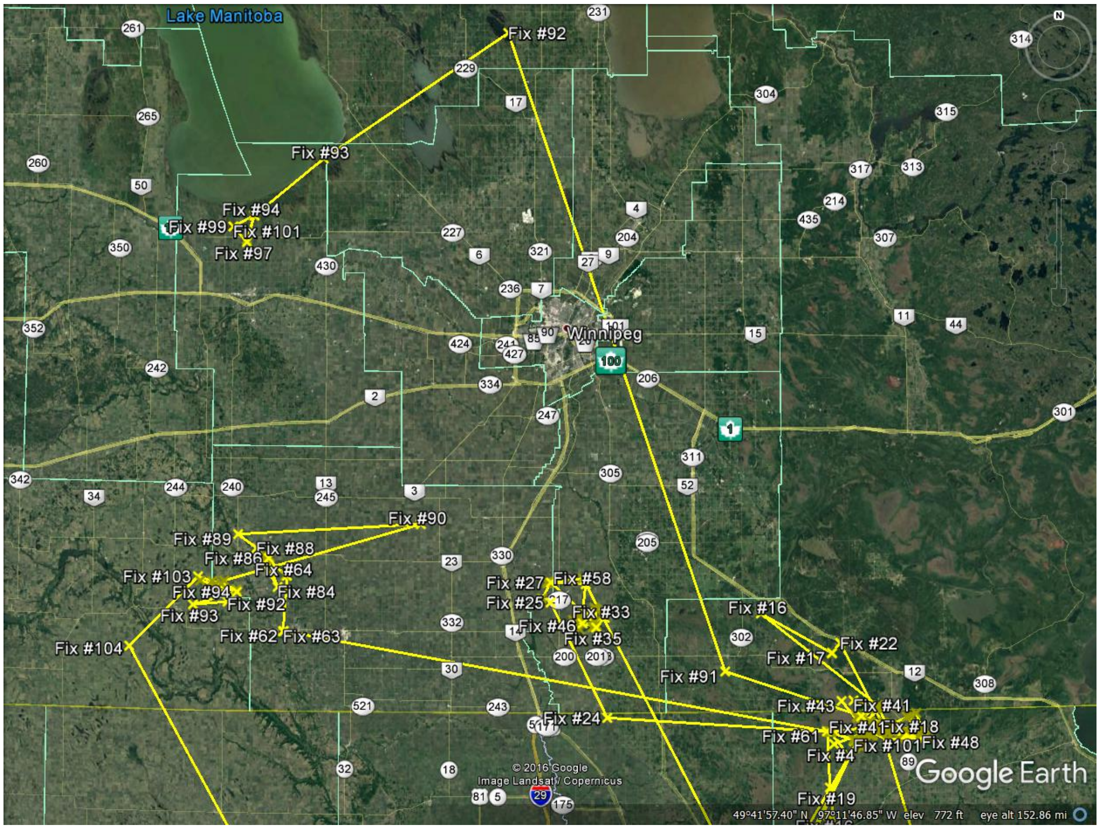


Figure 5. Movements of marked individuals into southern Manitoba from northwest Minnesota in 2016. Yellow Xs on the map represent telemetry fixes and consecutive fixes are connected by yellow lines.

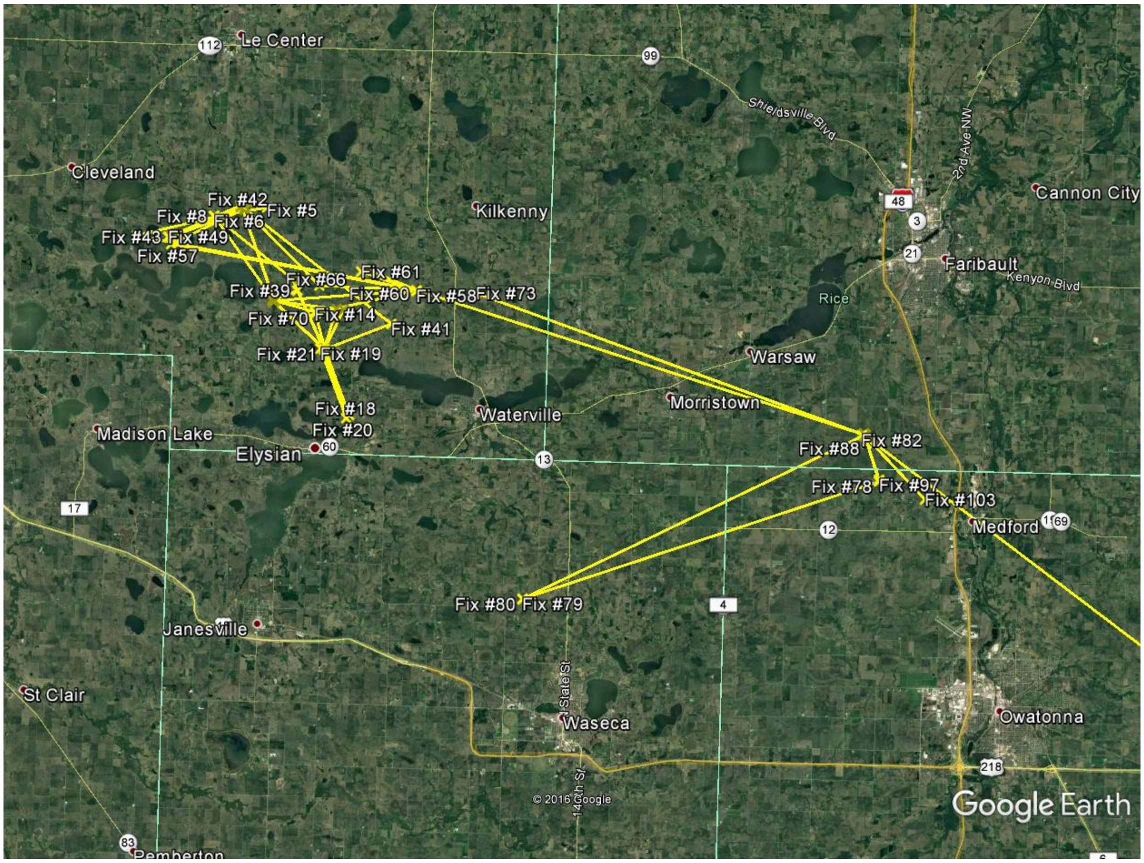
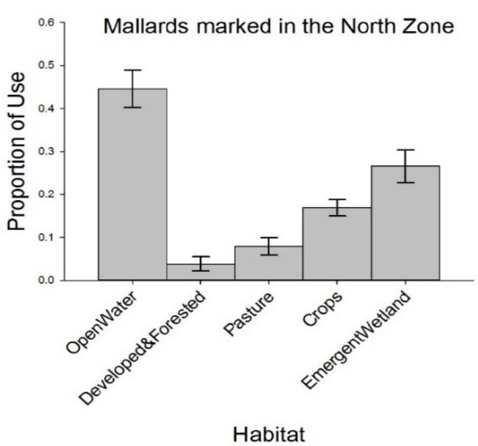


Figure 6. An example of tracking data for a single marked female used for habitat use analyses from Minnesota in 2016-2018. Yellow Xs on the map represent telemetry fixes and consecutive fixes are connected by yellow lines.



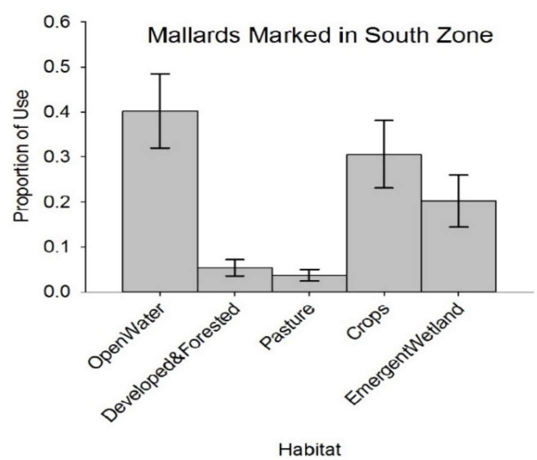


Figure 7. Proportional use of habitats by mallards marked in the Minnesota's north and south hunting zones, 2016. Proportions are expressed as an average across birds.

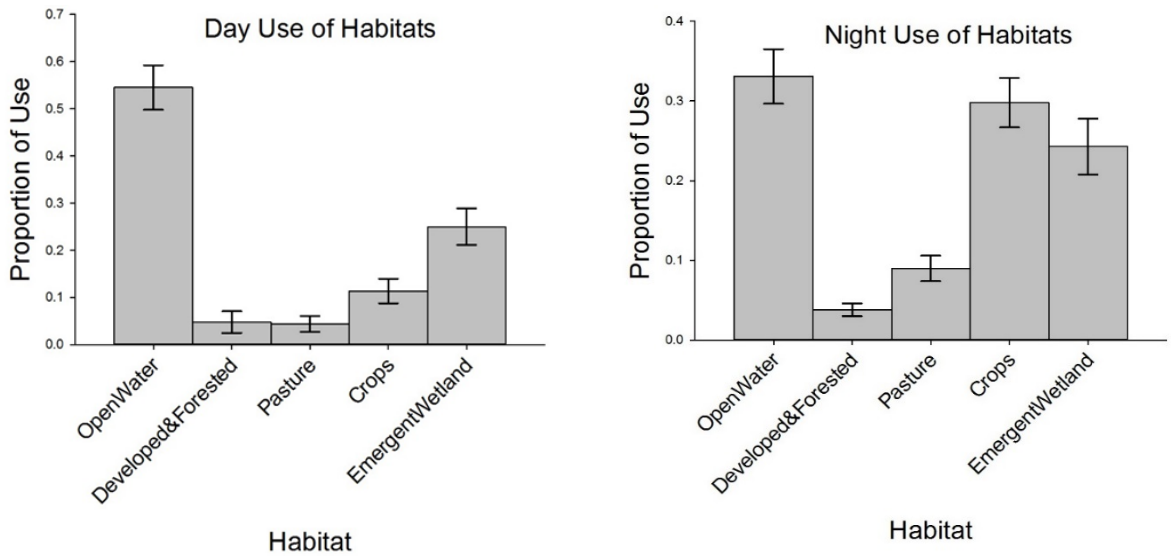


Figure 8. Proportional day or night use of habitats by mallards marked in the Minnesota's north and south hunting zones, 2016. Proportions are expressed as an average across birds.