Waterfowl on Weather Radar: A New View of Dabbling Duck Migration

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Extended Abstract: Research from the last two decades has elucidated the importance of migration and stopover ecology in the annual cycle of waterfowl. However, conservation goals and objectives for migrant waterfowl in the mid-continent have often been based on antiquated data or conjecture, and many aspects of waterfowl ecology during migration remain poorly understood. Studying migration ecology of ducks has been difficult because movement events may happen over large spatial extents and are often nocturnal. Key uncertainties that remain include length of time spent at stopover sites, factors that affect departure probability, and spatial patterns of migration.

Weather surveillance radar (WSR) has the potential to reveal new insights into duck migration. Although the technique has been useful in studying bird movements at broad spatial and taxonomic levels, it has not yet been applied to quantitative questions related to waterfowl migration. We used data from WSR to better understand the ecology of dabbling duck migration and provide information to aid conservation planning efforts. Our objectives were to: 1) evaluate the use of WSR as a technique for the quantitative study of duck movements; 2) estimate average annual stopover duration for fall-migrating ducks at an important wetland complex in the Illinois River valley (IRV); 3) develop predictive models of duck departures based on local weather conditions, and; 4) examine spatial patterns of duck migration relative to riparian corridors.

Using WSR to study dabbling duck migration requires information on target classification and on the relationship between numbers of ducks and amount of radar echo. In the fall of 2008, we used a thermal infrared camera (TIR) to ground-truth duck movements on weather radar. Our field estimate of the mean radar cross section of all dabbling ducks (112.5 cm²) aligned well with the only published estimate for mallards (120.0 cm²). We also found a strong relationship between TIR estimates of duck density and corresponding measures of echo on radar ($R^2 = 0.90$, $n = 8$).

Thus, the results of our ground-truthing efforts have provided critical data for future use of WSR as a tool for investigating key questions of duck migration that occur over long periods of time.

Joint Ventures (JVs) responsible for waterfowl conservation in mid-migration regions of North America typically estimate habitat needs based on the energetic requirements of ducks passing through the region during migration. However, ducks arrive and depart these wetlands throughout fall, resulting in considerable turnover in fall populations. Site surveys can provide indices of duck use, but the actual number of birds using a site and length of time they spend at these stopovers is largely unknown. This information is required to estimate the total forage required to sustain migratory waterfowl throughout a season.

We examined 8 years of data (1996-1998, 2003, and 2005-2008) from the National Weather Service radar in Lincoln, Illinois to identify and count ducks emigrating during fall (mid-October-mid-December) from a known stopover site in the IRV. To estimate average annual stopover duration (days/duck), we divided aerial-inventory estimates of total use-days at the site by the total number of departing ducks on radar. The overall mean (10.1 ± 2.8 days [SD]) was considerably less than the value most JVs use in energetic carrying capacity models (28 days). Our estimates of stopover duration varied among years (6-14 days).
and we wondered if habitat quality explained this variation. Regression indicated a strong ($R^2 = 0.58$) positive and linear relationship between an index of foraging habitat quality (1-5 scale) and estimated stopover duration (Fig. 1).

![Fig. 1. Mean annual stopover duration (days) during fall versus a habitat quality index for an important stopover site in the Illinois River valley, Illinois, USA.](image)

We also developed a comprehensive database of duck departures during each fall and used it to investigate the relationship between departure timing and weather conditions. This approach had advantages over those of many previous studies because we were able to identify explicit cases of departure and non-departure. We developed a set of candidate models intended to explain variation in daily emigration using biologically justifiable covariates related to wind direction and speed, visibility, cloud height, temperature, and pressure. We used logistic regression to model departure, ranking competing models based on Akaike’s Information Criteria. The best model accounted for favorable wind direction, visibility, cloud height, pressure trend, and temperature with $\text{pseudo-}R^2 = 0.51$.

After ducks depart stopovers, they must assess conditions aloft and find suitable habitat further along the flyway. Investigating the way in which ducks move during migration provides insight on how they interact with the landscape, the atmosphere, and each other. Indeed, correct understanding of patterns of movement and subsequent distributions of ducks across a region is critical to appropriately allocate resources for wetland conservation and management. Recent decades have brought considerable changes in land-use, hunting pressure, climate, and duck populations in North America. It is likely migratory pathways of at least some duck species have changed during this time period as well.

Historically, corridors defined by rivers have dominated thinking about waterfowl migration. Although rivers do serve as migration corridors in some regions, the prevalence of this pattern in Illinois and throughout the mid-continent is in doubt. Substantial evidence indicates many avian taxa exhibit spatial flexibility in migration systems, and measurable spatial shifts have been documented over just a few decades. We measured the track of every group of ducks departing our study site in the IRV over 8 years (1996-1998, 2003, and 2005-2008). We used the radar data to follow each group of birds from the time it left its source wetland until it left the domain of the radar. The direction of departure was remarkably consistent within and among years, ($\bar{X} = 152 \pm 1^\circ \text{[SE]}$), and differed greatly from the course of the Illinois River (220°). Thus, birds departing our study location did not use the Illinois River as a migration corridor from 1996-2008.

In summary, our research provides groundwork that will allow researchers to investigate dabbling duck migration using WSR. Using this technique, we developed a simple and robust estimate of average stopover duration and explained considerable variation in exact departure events during fall using local weather data. Finally, the radar gave substantial evidence that, contrary to long-standing notion, ducks emigrating from our study area did not follow a river corridor. Many questions regarding waterfowl movements and migration ecology remain, but it is clear that WSR can be a powerful tool in addressing them.