Interhabitat Connectivity of North American Wintering Songbirds on the South Coast of Puerto Rico

Report to the Nuttall Ornithological Club for 2013-14

Fred C Schaffner PhD
Department of Biology
School of Natural Resources and Technology
Universidad del Turabo
PO Box 3030
Gurabo, Puerto Rico 00778
fschaffner@suagm.edu

Abstract. Among the effects of global warming will be sea level rise (SLR) that will bring about coastline transformation and impacts on low-lying coastal dry forest. This study has been conducted in the Jobos Bay National Estuarine Research Reserve (JBNERR) on the eastern south coast of Puerto Rico. We conducted extensive mist netting at seven sites in the reserve and documented the occurrence and movements of several species of migratory Warblers in the Reserve. We also obtained information on the possible origins of long distance migrants that visit the Reserve in winter. Stable isotope methods involving the use of the measurement of stable hydrogen isotope abundance in feathers ($\delta 2H_f$) of Neotropical migrant songbirds that breed in North America and molt prior to fall migration can be used to connect the breeding and wintering grounds of individual birds (migratory connectivity). The feather deuterium isoscape ($\delta 2H_f$) for North America is much better known and structured than those for the Neotropics. Therefore, it makes more sense to sample birds at known wintering locations rather than at known breeding locations. Herein we demonstrate how feathers sampled on the wintering grounds at Jobos Bay, Puerto Rico can be used to infer breeding origins in North America. Using Bananaquits *(Coereba flaveola)* as our local baseline, our preliminary results indicate that some over-wintering Jobos Bay Northern Waterthrushes *(Parkesia noveboracensis)* and Yellow Warblers (*Setophaga petechia)*, originate from breeding grounds at latitudes as far north as mid- to upper Hudson's Bay, Canada (Zones D, E, and F) and that some first-year Yellow Warblers, Prairie Warblers *(Setophaga discolor*) and Ovenbirds (*Seiurus aurocapilla*) may experience eccentric molts *en route* to Puerto Rico. Our results also suggest the occurrence of two races of Prairie Warblers at Jobos Bay. Continuing and future studies involving additional feather sampling and the deployment of light-level geolocators will help pinpoint more specific breeding assignments and refine conservation efforts for these species. In addition, this Blake-Nuttall funded project has provided the basis for the development of a new academic ornithology program at *Universidad del Turabo*, the only such university program in Puerto Rico.

Introduction

This study has been conducted in the Jobos Bay National Estuarine Research Reserve (JBNERR) on the eastern south coast of Puerto Rico, focussing on the year-round resident and migratory land birds that utilize the low-lying coastal secondary dry forest and adjacent mangroves. The extent of this dry forest habitat is limited on the north (inland) by agricultural

and urbanized spaces, and on the south it is limited by recovering mangroves (Figure 1). The Reserve's mangroves provide important habitat for many species, including the passerines that are the focus of this project, but at the same time they are moving inland, limiting the extent of this dry forest habitat and highlighting the need to acquire additional adjacent land for the Reserve.

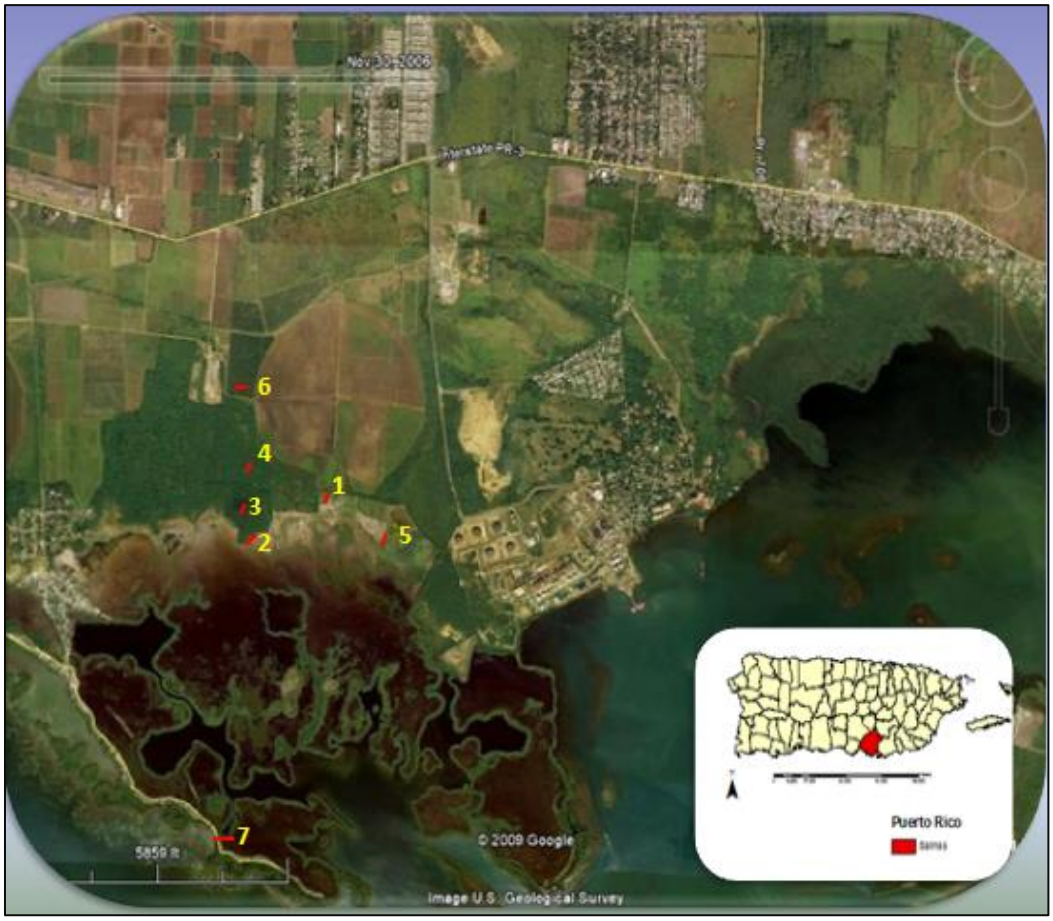

Figure 1. Jobos Bay National Estuarine Research Reserve (JBNERR) and adjacent agricultural lands. Short red lines indicate mist netting sites. Site 2 crosses an interhabitat corridor that intercepts movements of birds between mangrove night roosts and dry forest daytime feeding areas (Rodríguez-Colón 2012).

Neotropical migrant species can be limited in size by factors such as reproductive success and by parental and offspring survival rates during the breeding season, as well as by individual survival during the nonbreeding season (see Marra et al. 1993), and during the long distance migration between sites (see Paxton et al. 2007; 2008; Faaborg et al. 2010a,b). Moreover, a species may occur in distinct populations that winter in different locations or whose departure and return dates may be quite different, and these differences may be key to understanding population trends. For example, Rubenstein et al. (2002), using stable isotopic methods demonstrated that northern populations of the Black-throated Blue Warbler *(Setophaga caerulescens*) with stable population trends wintered in Cuba and the Western

Greater Antilles while declining populations nesting in the southern portion of their range tended to winter in eastern Hispaniola. This highlights the fact that optimal conservation and management of populations of migratory species require knowledge of conditions and events in both the specific nesting and wintering areas, and en route sites as well.

Kelly et al. (2002) and Kelly (2006) used isotopic methods to examine migratory patterns and dispersal distances in multiple species and contrasted distinct patterns of migration timing of birds passing through their stop-over site in New Mexico: (1) "chain migration" (which may be typical of medium distance migrants) in which all nesting populations begin moving at about the same time such that southern nesters arrive before more northern nesters versus "leap frog migration" (which may be characteristic of very long distance migrants) in which northern populations begin moving earlier, overflying southern populations (See Figure 1).

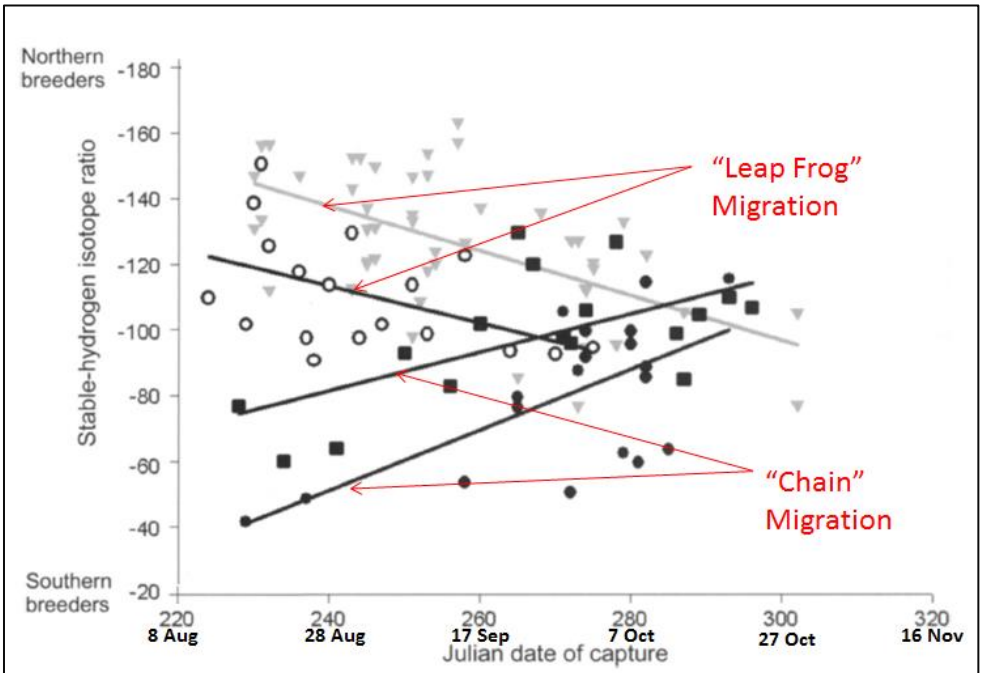

FIG. 1. Hydrogen stable-isotope ratio (δD) of feathers from individual wood warblers plotted against date of capture during autumn migration. Data are from Bosque del Apache National Wildlife Refuge in central New Mexico. Orange-crowned Warblers = filled squares, Yellow Warblers = open circles, and Common Yellowthroats = closed circles. Regression lines (black) fit to these data have slopes that deviate from zero (Yellow Warbler: $r^2 = 0.23$, $P < 0.05$, $n = 18$, $\delta D = 0.56 \times \text{date} - 248$; Orange-crowned Warbler: $r^2 = 0.38$, $P < 0.05$, $n = 17$, $\delta D = -0.59 \times \text{date} + 60$; Common Yellowthroat: $r^2 = 0.41$, $P < 0.05$, $n = 19$, $\delta D = -0.92 \times \text{date} + 170$). The gray least-squares regression line and triangles are for Wilson's Warbler from Kelly et al. 2002 ($r^2 = 0.34$, $P < 0.05$, $n = 65$, $\delta D = 0.68 \times \text{date} - 301$).

Figure 2. Chain migration and Leapfrog Migration deduced from stable isotope results (Adapted from Kelly 2006.

As noted previously, management and conservation require knowledge on the timing and pattern of migration, details on demography and habitat use patterns on the wintering sites, and the awareness of, and will to conserve migratory species at their nesting, stop-over and wintering sites.

Participants in this project have worked hard to raise awareness amongst our students' at all academic levels and among the community by including visitors and volunteers (the general public) to the Jobos Bay National Estuarine Research Reserve and members of the Puerto Rico Ornithological Society. To our knowledge, this is the only year-round monitoring and mist netting project in Puerto Rico and recognition of these efforts lead to an invitation to the PI to give a presentation on the project at the Congress on Protected Natural Areas, sponsored by the Nature Conservancy (TNC) held August 28-29, 2014. The success and recognition of this project has been made possible by support from the Blake-Nuttall Fund and we hope that the Fund will choose to continue this support.

In January of 2013 a Workshop on mist netting, aging, sexing and molt in migrant and year-round resident species. The Workshop was organized promoted by doctoral student Ivelisse Rodríguez Colón. Instructors included Dr Wayne Arendt of the US Forest Service's International Institute for Tropical Forestry and Dr Judith Toms, then a recent doctoral graduate from the University of Missouri studying under Dr John Faaborg. Participants included graduate students of the *Universidad del* Turabo, Personnel from the Puerto Rico Department of Natural and Environmental Resources, as well as members of the Puerto Rico Ornithological Society, and the PI. This was a very productive experience for all participants and also included the capture of the rare (to Puerto Rico) Blue winged Warbler (*Vermivora pinus*).

Figure 3. Participants in the January 2003 Workshop on mist netting, aging, sexing and molt in migrant and year-round resident species, held at Jobos Bay National Estuarine Research Reserve. Pictured are instructors Dr Wayne Arendt (back row third from the left, Dr Judith Toms (back row second from the right), organizer Ivelisse Rodriguez-Colón (middle row, first in the right), and participants.

During the period from September 2013 to August 2014 the project encountered (captured or recaptured) nearly 1,300 birds, an increase of over 500 encounters from the previous year. The project initially operated only during the months of January through April, but has now expanded to nearly year-round operation. This increase is due in large part to the acquisition of sufficient equipment, especially the replacement of worn or damaged nets, and supplies (funding support), enhanced outreach and program development, and the acquisition of a new (to the project) 4-wheel drive vehicle that finally allows us access to field sites during the wet season (May, and Aug-Nov), rain and mechanical failures permitting (vehicle repair and maintenance is funded directly by PI personal funds). Blake-Nuttall Funding has allowed us to fuel the vehicle and pay overnight expenses for participants using the Reserve's dormitory facilities (when required).

Figure 4. The project research vehicle, a 1991 Ford F-250. (a) The vehicle in its current configuration, (b) in its former configuration as a hay hauler, (c) interior, (d) road conditions to the study site during the rainy season. A six inch plastic sewer pipe (on the passenger side of the roof in (a) is used to transport the 10-ft. galvanized EMT pipes used as net poles.

Methodology

Mist netting has been conducted in both mangroves and dry forest, as well as in the inter-habitat corridor (Site 2). All birds captured were banded with USGS aluminum bands and focal species (Northern Waterthrushes, Yellow Warblers and Bananaquits) were color banded with unique 4-color band combinations to permit individual identification, and the time and specific capture location were recorded. Standard morphometric data including wing length and body mass, breast muscle size and fat scores, and body condition index parameters also were collected. Our usual protocol, especially at Site 2, which crosses the interhabitat corridor is to place a line of eight nets (12-m length, 30 mm mesh) in interconnected pairs (3 poles per pair)

during the afternoon of day 1 until dusk; then close the nets overnight, and resume netting the following morning beginning about 30 min before sunrise. Mist netting in the mangroves, such as at *Camino del Indio* (Site 7) requires a slightly different technique (Figure 5), and here, as at Site 1 early arrival in the morning is essential to avoid vandalism and conflicts with land crab trappers, who have damaged or destroyed several of our nets.

Figure 5. Mist netting in the mangroves at Camino del Indio, Site 7 (photo by Ivelisse Rodríguez-Colón).

For migrant species and our local Bananaquit reference, upon an individual's first capture, feathers (P1 and R1) were collected for δD stable isotopic analysis to determine latitude and geographic origin. As the project continues we also will collect material for genetic analysis. Genetic analyses of widespread North American species have indicated significant east-west differentiation (Boulet et al. 2006; Colbeck et al. 2008), and can be accomplished using soft tissue associated with base of the removed feather. Hydrogen isotope ratios can be integrated with genetic markers to increase the resolution of connectivity (Kelly 2002, 2006; Kelly et al. 2005, 2008, also see Hobson et al. 2001; Hobson 2005; Paxton et al. 2007, 2008; Kelly et al. 2005, 2008, 2009; Langin et al. 2007; Robinson et al. 2010; Rohwer et al. 2011).

As the project continues we also plan the attachment of geolocators to up to 20 of Northern Waterthrushes and possibly migrant Yellow Warblers. This offers the potential to provide more detailed information on the nesting origin and possible continued winter movement of these migrants. To distinguish whether our site is a stop-over site or the primary wintering ground, geolocators deployed from September through November will be removed and replaced with new geolocators on birds, if recaptured in March and April.

Results and Discussion

Mist netting results overall suggest a slight increase in Northern Waterthrushes, but varying populations of Prairie Warblers and others. The first year recapture rate for unbanded Northern Waterthrushes (banded for the first time at our site) is nearly 50%, declining to 24% for second year recaptures. This year we also began collecting feathers for Deuterium analysis and mtDNA analysis and we now are able to collect complete morphological data, and sex and age most birds using Pyle (1997).

These results compare favorably with those of Hallworth et al.'s (2013) geolocator study wherein they recaptured 20 of 50 (40%) Ovenbirds on the nesting grounds; and, they also recaptured 12 of 46 (26%) Ovenbirds en route or on the wintering grounds in Florida and Jamaica. Though not encumbered with a geolocator, our ability to predictably recapture Northern Waterthrushes at our site makes our birds excellent candidates for a geolocator study of the nesting origins of our winter visitors, as well as possible winter movements further south. Our chances of obtaining precise results are further enhanced because this species molts medially to distally and that we collect both P1 and R1.

Our data also suggest that (1) Northern Waterthrushes return to our sites for 1, 2, or 3 years, but that Prairie Warblers seldom return to our sites in a subsequent year and that, like the Northern Waterthrushes that feed in dry forest, nearly all Prairies commute daily between habitats. Efforts to locate or mist net Prairies in mangroves during mid-day have all failed. (2) Within Northern Waterthrushes the specific characteristics and origins of commuters versus mangrove foragers has remained elusive, but preliminary results from isotopic and observational data are beginning to tell us the possible origins of migrants (see below). (3) Questions related to the effect of habitat quality, particularly insect abundance on body condition and performance of residents and migrants are being addressed in the master thesis currently being written by Waleska Vázquez-Carrero and Giselle Caraballo-Cruz. Given the non-traditional status of nearly all of our students (they all have to balance their studies with their employment schedules) we found a radiotelemetry study of Northern Waterthrushes and Yellow Warblers would be impractical.

After many years of the rumored, but unconfirmed presence of the endangered Puerto Rican Nightjar *(Caprimulgus noctitherus)* at our site, a juvenile of the species walked into the bottom trammel of one of our nets in June of 2014. In addition, doctoral student Emilio Font was the first to discover that many of our difficult to identify "female" and "juvenile" Prairie Warblers were in fact the Florida *paludicola* subspecies.

Largely due to the efforts of doctoral student Ivelisse Rodríguez-Colón, who is our Northern Waterthrush specialist and who also has served as the Coastal Training Program Coordinator at the Reserve, the project has been able to host and benefit from more than 60 members of the general public, as well as members of the Puerto Rico Ornithological Society, who, without this project, would have no other opportunity to learn mist netting or see wild birds in the hand (Figure 6). This may help us achieve a long-term goal of establishing an MAPS-style constant effort monitoring program at Jobos Bay.

Figure 6. Members of the Puerto Rico Ornithological Society assisting with mist netting in the Bosque de Jagúey (Site 3) and banding on Sunday, September 14, 2014 (photo by Ivelisse Rodríguez-Colón).

An especially satisfying aspect of our Blake-Nuttall Fund support is its catalyzation of academics and undergraduate research at the *University del Turabo.* Awareness of the project resulted in, for the first time, and after many previous attempts, the successful offering of a complete lecture and laboratory/field course in Ornithology (Aug-Dec 2013), as well as an undergraduate course in Conservation Biology (Jan-May 2014), and attracted over 17 undergraduates to participate in the project (see Figure 7).

Among these undergraduates were Miriam Espino and Stephanie Santos, who recently left Puerto Rico to pursue studies in Veterinary Medicine at the University of Washington and Cornell University, and several others have expressed interest in continuing to graduate studies in ecology and environmental science. Others indicate that regardless of their eventual careers, participation in this project has heightened their appreciation and awareness of ecology and environmental issues.

Figure 7. Avian Ecology Research group, including undergraduates and graduate students.

Stable Isotopic Analysis.

A set of first primary (P1) and central tail (retrix, R1) feathers from 105 birds captured from Jan 2013 to Oct 2013 was sent to Dr Keith Hobson's lab (Environment Canada, Saskatoon, SK) for δD stable isotopic analysis to determine latitude and geographic origin for δD stable isotopic analysis to determine latitude and geographic origin. Initial results for the primary (P1) feathers show highly negative values for some Northern Waterthrushes (NOWA) (see Figures 8 and 9). An initial analysis applying Hobson et al.'s (2014) newly developed Isotopic Region model suggests that most of the sampled Yellow Warblers (18) are local nesters (similar isotopic signatures to Bananaquits) while others (13) are migrants and some Northern Waterthrushes come quite far away (highly negative signatures) (see Figures 10 and 11).

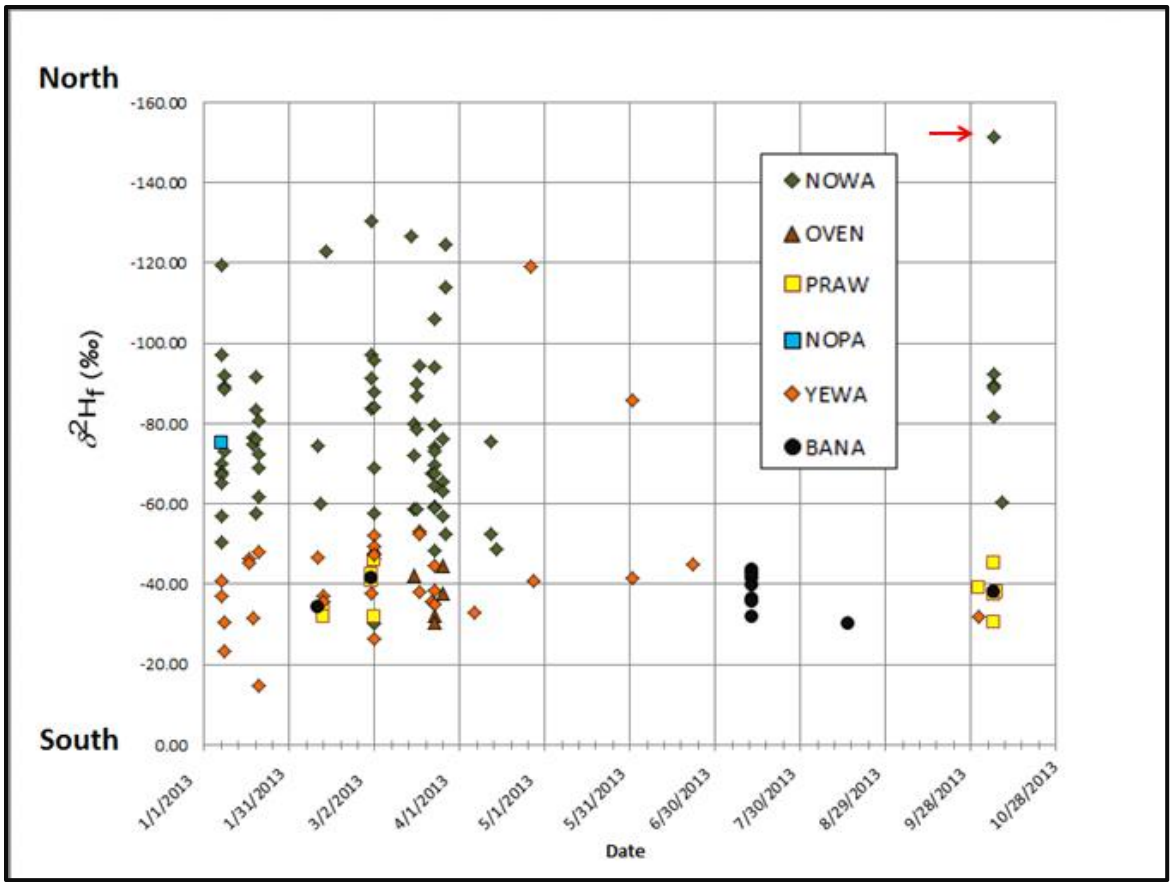

Figure 8. Initial results for δD stable isotopic analysis of primary (P1) feathers. Codes: NOWA=Northern Waterthrush; OVEN=Ovenbird; PRAW=Prairie Warbler; NOPA=Northern Parula; YEWA=Yellow Warbler; BANA=Bananaquit (local reference).

Fitting of these data into Hobson et al.'s (2014) Isotopic Regions (Figures 8 and 9) indicate that many Northern Waterthrushes (NOWA) and Ovenbirds (OVEN) had P1's grown in Isotopic Regions where the birds do not nest (Figures 8, Regions A and B for NOWA; Region A for OVEN), suggesting eccentric molt (Pyle 1997) and that many birds are actually molting *en route* and these data do not yet allow for resolution of chain versus leapfrog migration, though it is interesting that the least highest latitude results were obtained early (early October) in the migratory season (see Figure 10).

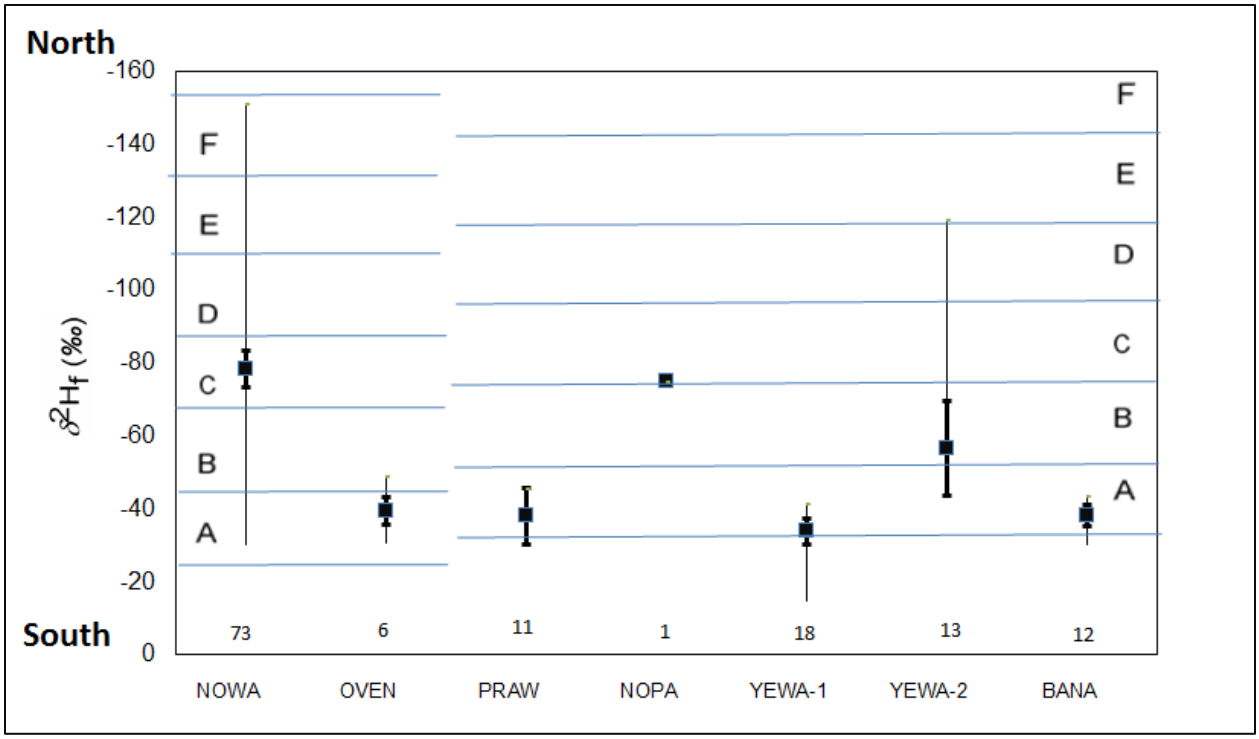

Figure 9. Initial results for δD stable isotopic analysis of primary (P1) feathers. Shown are the means (squares) standard deviations (heavy lines) and ranges (light lines) for each species or group. Codes: NOWA=Northern Waterthrush; OVEN=Ovenbird; PRAW=Prairie Warbler; NOPA=Northern Parula; YEWA=Yellow Warbler; BANA=Bananaquit (local reference).

Leaf-gleaning canopy foragers including Northern Parulas (NOPA) and Prairie Warblers (PRAW) and some Yellow Warblers (YEWA) also showed feather origins in Regions A and B and consistent with both the interpretation of nesting origin or *en route* and/or eccentric molt. However, two (2) YEWA grew their P1's at far northern Regions C and D and six grew their P1's in marine environments (less negative than Region A), consistent with living in or adjacent to mangrove areas (see Figure 11).

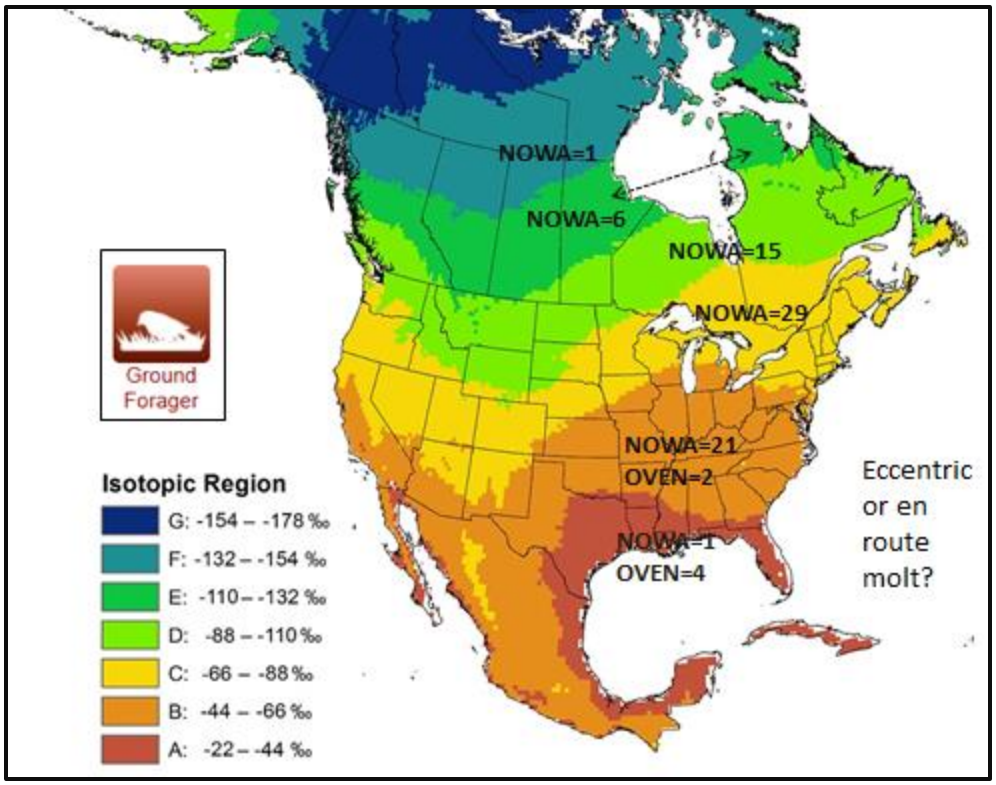

Figure 10. Isotopic Regions of P1 (first primary) feathers of Northern Waterthrushes (NOWA) and Ovenbirds (OVEN).

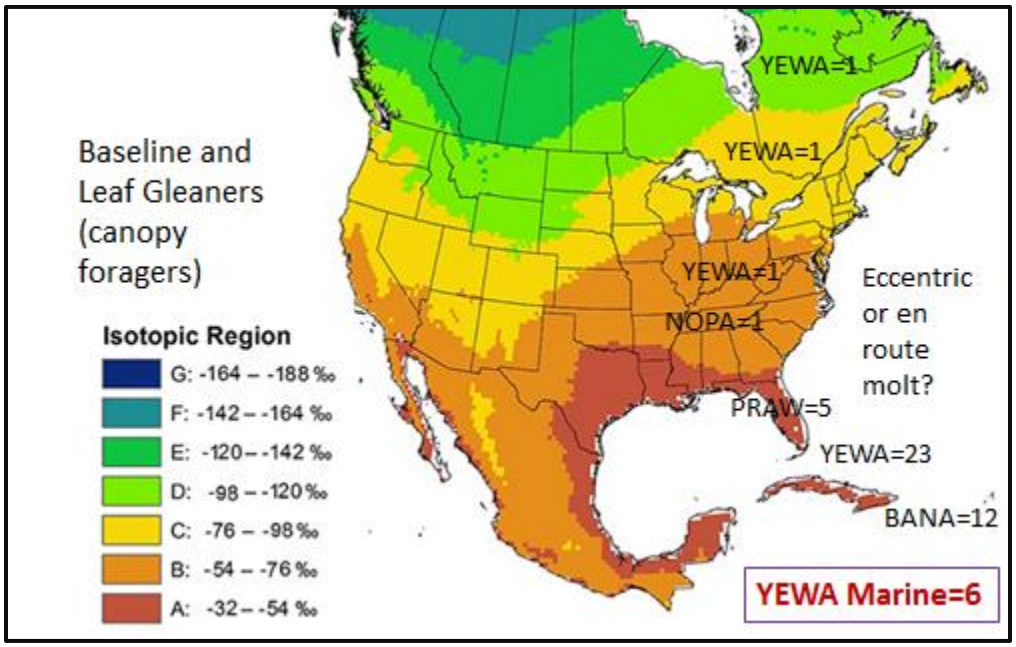

Figure 11. Isotopic Regions of P1 (first primary) feathers of leaf-gleaning canopy foragers. Codes: NOWA=Northern Waterthrush; OVEN=Ovenbird; PRAW=Prairie Warbler; NOPA=Northern Parula; YEWA=Yellow Warbler; BANA=Bananaquit (local reference).

Tail feather (R1) results are generally similar to P1 results in terms of a wide distribution amongst Regions suggesting route and/or eccentric molt, and some specimens actually suggest higher latitudes than did the P1 results. Resolution of apparent ambiguities may be obtained via additional sampling and isotopic analysis, and especially through the deployment of light-level geolocators such as those used by Hallworth et al. (2013) with Ovenbirds. In addition, genetic analyses (mitochondrial DNA (mtDNA) of widespread North American species have indicated that significant east-west differentiation can be accomplished using soft tissue associated with base of the removed feather (Boulet et al. 2006; Colbeck et al. 2008).

On May 10th, 2013 a Northern Waterthrush that had been color-banded on January 8th, 2013 was photographed in Ohio at the Magee Marsh Wildlife Area, on the south shore of western Lake Erie. Presumably this bird was on a stop-over headed towards the Canadian boreal forest (this species does not nest in Ohio). This recovery is consistent with our captures of Western Palm Warblers, rather than Yellow Palm Warblers. We have speculated the northward route of this bird along the west coast of Florida and the Gulf coast, then turning north towards the Great Lakes area. This suggestion may provide insight into the routes of other species such as the Kirtland's Warbler *(Setophaga kirtlandii)* returning from the Bahamas to Michigan. Also plotted is a straight line for a Northern Waterthrush originally banded in Manitoba on August 15, 2014 and recaptured by Manuel Grosselet in Vera Cruz, Mexico on September 8, 2014. Similarly, we captured the first migrants of the season on August 30, 2014 (see Figure 12). Though not one of our birds, this example illustrates the impressive travelling ability of the species.

Figure 12. Possible migratory routes of 2 Northern Waterthrushes.

Most recently, with the arrival of Hurricane Gonzalo, on the morning of Monday, 13 October 2014 we captured 4 female After Hatch Year (AHY) Blackpoll Warblers *(Setophaga striata)*. These were the first individuals we have captured in this project and their arrival is consistent with the "fallouts" observed elsewhere in the Caribbean when the birds, mostly females encounter a storm that presents an obstacle to further southwards travel (Baltz 2000; McNair et al. 2002; Boal 2014

Figure 13. After Hatch Year (AHY) female Blackpoll Warbler captured during the visit of Hurricane Gonzalo on 13 October 2014.

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