

Report

Migratory and Interhabitat Connectivity of North American Wintering Songbirds on the South Coast of Puerto Rico: Program Development and the Resolution of Long-Distance Migratory Pathways II

Report to the Nuttall Ornithological Club for 2015-16

Fred C Schaffner PhD
and
Ivelisse Rodríguez-Colón MS

Department of Biology
School of Natural Sciences and Technology
Universidad del Turabo
PO Box 3030
Gurabo, Puerto Rico 00778
fschaffner@suagm.edu

Abstract. During this season the Blake-Nuttall fund has provided continuing support for (1) a recently established academic program in ornithology and avian conservation (the only such effort in Puerto Rico); (2) employ mist netting, color banding, and stable isotopic analysis for multiple species and light-level geolocator deployment for Northern Waterthrushes (*Parkesia noveboracensis*) to establish links between breeding and wintering populations of migratory songbirds that nest in North America and winter, or stop over in Puerto Rico; (3) document patterns of molt in Neotropical Migrants; and, (4) establish a long-term monitoring program for migratory and year-round resident species of terrestrial birds that utilize secondary coastal dry forest and mangroves in and around the area of the Jobos Bay National Estuarine Research Reserve (JBNERR). The funds have provided continuing support for undergraduate, and graduate student research focusing on long-distance migratory and interhabitat movement, habitat quality, and social structure of migrants and nesting residents, and promote and enhance the academic and professional development of ornithology and citizen science in Puerto Rico. This project provides the first implementation of archival light-level geolocator technology by a Puerto Rican institution to study the migratory connectivity of Neotropical migratory birds in Puerto Rico and will complement existing information derived from banding returns and stable isotope analyses. This project allows us to demonstrate new technology to students and the public and help establish the specific intercontinental migratory connectivity of specific populations of migratory birds, especially the Northern Waterthrush, that breed in North America and pass the winter in Puerto Rico and/or South America. We deployed 40 light-level geolocators on Northern Waterthrushes at Jobos Bay in Salinas, Puerto Rico.

Introduction

A recent comprehensive analysis by Nytche et al. 2015 indicate that according to the most recent analysis of conservation planning priorities conducted by a joint task force of internationally

recognized experts from the US Fish and Wildlife Service (Florida/Caribbean Migratory Bird Field Office), and the USDA Forest Service International Institute of Tropical Forestry (Nytch et al. 2015), Jobos Bay Estuary National Research Reserve is among those habitats and *designated stewardship areas* that stand out as top priority habitats in which to focus additional conservation efforts, yet insufficient substantive information is available (Nytch et al. 2015).

An important factor to consider is the rise in sea level that is projected to accompany increased global temperatures associated with climate change, and the effects this will have on coastal dry forest habitat. One anticipated outcome of rising seas and mutable coastal morphology is that mangroves will successfully accrete peat and migrate inland (where human infrastructure is not a barrier), thereby encroaching on dry forest habitat (McKee et al. 2007; Kerr 2009; Blunden et al. 2011; McKee 2011).

If dry forest does not expand into new areas at the same rate it is converted to estuarine habitats, native and migratory birds that rely on dry forest for breeding and overwintering could be at risk (PRCCC 2013b). Rodríguez-Colón (2012), for example, studied North American migrant songbirds that depend on interconnected mangrove and dry forest habitat in Puerto Rico's southern coastal region of Jobos Bay National Estuarine Research Reserve, concluding that these populations will be jeopardized by sea level rise if dry forest habitat is reduced, degraded, or eliminated. Avian populations in other coastal dry forest areas in Puerto Rico may face a similar threat, resulting in compromised reproduction and overwintering survival. Thus, an adequate assessment of habitat quality and avian populations in these and adjacent areas is essential (Rice et al. 2007; Jacobs et al. 2012a, 2012b; Rodríguez-Colón 2012; Nytch et al. 2015).

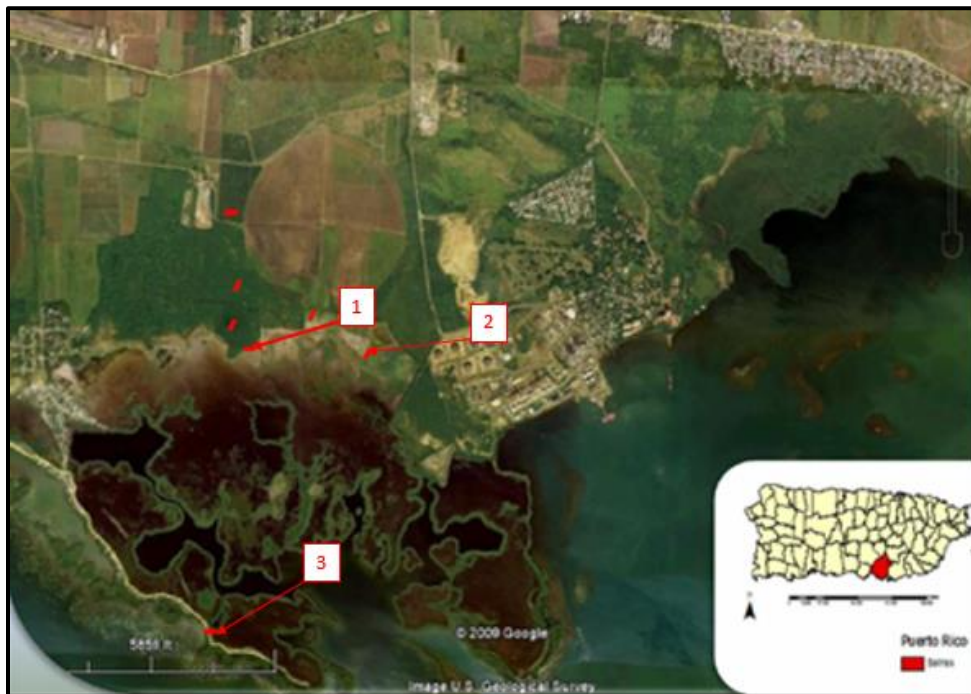


Figure 1. Jobos Bay National Estuarine Research Reserve (JBNERR) and adjacent agricultural lands. Short red lines indicate mist netting sites, including (1) a mangrove-dry forest interhabitat corridor (“El Corredor”), (2) a mesquite (*Prosopis juliflora*) dominated coastal area adjacent to mangroves

(“La Poza”) near a freshwater impoundment, and (3) a red mangrove (*Rizophora mangle*) dominate site at “Camino del Indio”.

Neotropical migrant species can be limited in size by factors such as reproductive success and parental survival rates during the breeding season, and by individual survival during the nonbreeding season (see also Marra et al. 1993), as well as during the long distance migration between sites (see Paxton et al. 2007; 2008; Faaborg et al. 2010a,b, Hobson et al. 2014). 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.

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 and “leap frog migration” (which may be characteristic of very long distance migrants) in which northern populations begin moving earlier, overflying southern populations. A similar pattern of leapfrog migration also has been recently revealed in Ovenbirds (*Seiurus aurocapilla*) by Hallworth and Marra (2015) using Miniaturized GPS tags.

As noted, 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.

Results and Discussion

Academic personnel participating in this project thus far have included undergraduates enrolled in BIOL 365 and BIOL 366 (Undergraduate Research I, II), BIOL 357 (Special Topics) and master’s degree and doctoral students at *Universidad del Turabo*, led by doctoral student Ivelisse Rodríguez-Colón. These efforts include many visitors and the general public, and to date over 100 people have had the opportunity to visit or participate in the project, including several recurrent volunteers.

Mist Netting and Banding. Mist netting and banding continued as in previous seasons. However, this season (Sep 2015-Jun 2016) we noted a considerable increase in Northern Waterthrushes from nearly 200 the previous season to about 300 in 2015-2016. This included our first “Foreign” recapture. This was a Northern Waterthrush captured at the mesquite site (La Poza) on 12 December 2015 that had been originally banded on 3 September 2013 by Michelle J Davis at Bill Baggs State Park in Miami, Florida. Additional and more detailed analyses of the season’s and long term and banding data are underway, including species richness, diversity and dominance.

Table 1. Total numbers of encounters, new bands, recaptures, as well as the number of Northern Waterthrush (NOWA) new captures (New Bands) and recaptures for 2014-15 and 2015-16. Recaptures include same day and subsequent recaptures. Thus total captures are slightly lower.

	Sep 2014- May 2015	Sep 2015- Jun 2016
Total Encounters	1,008	1150
Total Banded	643	712
Total Recaptures	298	394
Unprocessed	53	44
NOWA New Bands	83	174
NOWA Recaptures	117	138

Stable Isotopic Analysis. Preliminary results from feather deuterium analyses have been reported in last season’s report (see Appendices 1 and 2) and presented in various forums, including the Birds Caribbean meeting in Jamaica in 2015. Subsequently a total of over 640 feathers collected in 2013-2014 have undergone laboratory analysis and statistical analyses are now underway. Additional samples from 2015-2016 have still await laboratory analyses.

Geolocator Deployment. This project provides the first implementation of archival light-level geolocator technology in Puerto Rico to better understand the migratory connectivity of migrant songbirds, especially the Northern Waterthrush (*Parkesia noveboracensis*). This is one of the most significant species occurring in our coastal dry forest and may be an important indicator of habitat quality. Complete understanding of population trends in this habitat and for all migratory species requires understanding of phenomena that occur on the nesting, stop-over and wintering areas.

Migratory connectivity is an important concept for understanding the biology of migratory birds (most species are declining) and for better implementation of strategies for their conservation and protection of their habitat. While general information exists on the overall nesting, migratory and wintering areas of many species, specific details that can connect a specific population's wintering area with its breeding that population's specific nesting location and migratory stop-over areas is lacking for most species. Approaches to resolve these mysteries involve the use of (1) visual observations, mist netting and color banding returns, (2) stable isotopic analyses, and (3) remote sensing or electronic tracking data. This more precise characterization exists for only a few species and populations, none of which occur in Puerto Rico or the eastern Caribbean.

Archival light level geolocators are a relatively new technology, originally developed by the British Antarctic Survey to track long distance animal movements. This technology makes use of on-board miniature data loggers to determine latitude and longitude based on day length and date, and time of solar apogee (noon) relative noon at GMT (ZULU time). The sensors are activated and placed on the bird. The bird is then released and the data are downloaded from the data logger upon recapture. This technology was first made available to the public in 2007 and first used on large species, but recent advances in miniaturization have produced geolocators sufficiently small (about 0.5 g) for use on tiny songbirds.

We initially obtained 20 geolocators and placed our first geocator on a Northern Waterthrush on Monday, Sept. 21st, 2015 – one of the first geotagged birds in Puerto Rico and the first placed by a Puerto Rican institution (Figure 2). However, with recapture probabilities substantially less than 100%, we felt we needed additional units in order to achieve sufficient returns to determine the proportions of birds that use Puerto Rico as a transit (stop-over) location versus those that use our site as a complete wintering area. Although these first-deployed units (Migrate Technology Integeop50B1-7-dip, ca. 0.5 g) offered the advantage of an 11-month estimated battery life, their greater weight meant that we had to be very selective and only deploy on birds over 18 g body mass.



Figure 2. First geocator placed on a Northern Waterthrush (*Parkesia noveboracensis*) in Salinas, Puerto Rico, 21 Sep 2015.

Some 20 additional units were purchased with Blake-Nuttall Fund money in March 2016. These newer units were the Migrate Technology Integeop-P30Z-7- DIP Light-level Geolocator model, with an estimated battery life of 6-7 months (vs 11 months for the previous units). They have the advantage of being light enough (less than 0.40 g) to be placed on any sized Northern Waterthrush (Figure 3), but the disadvantage they present is that they cannot be activated or deactivated on board (on the bird) and data cannot be downloaded onboard. However, the estimated battery life of these newer units should be sufficient enough to capture the birds' return trips to their nesting grounds and most of their flights back from their nesting grounds.



Figure 3. Migrate Technology Integeop-P30Z-7-DIP Light-level Geolocator with leg-loop harness attached, ready to be activated and deployed.

Both the previous units and the new units were mounted on the birds using a modification of the leg-loop harness of Rappole and Tipton (1981) and Streby et al. (2015) (Figure 4). The previous units also could be activated in the field and all but two (2) were mounted with a custom-fitted braided nylon cord provided by the manufacturer (Figure 5). In contrast to the previous units, the new units must be activated and the contacts cut and sealed with adhesive prior to deployment on the bird (Figures 6 and 7).

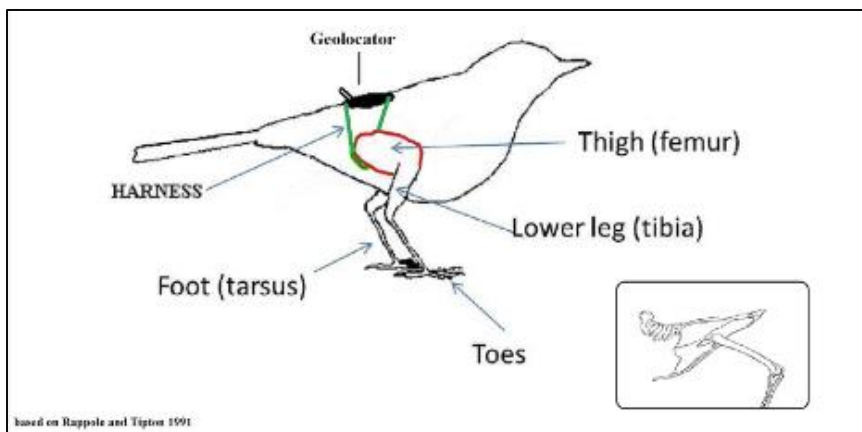


Figure 4. Leg-loop harness, adapted from Rappole and Tipton (1981) and Streby et al. (2015).

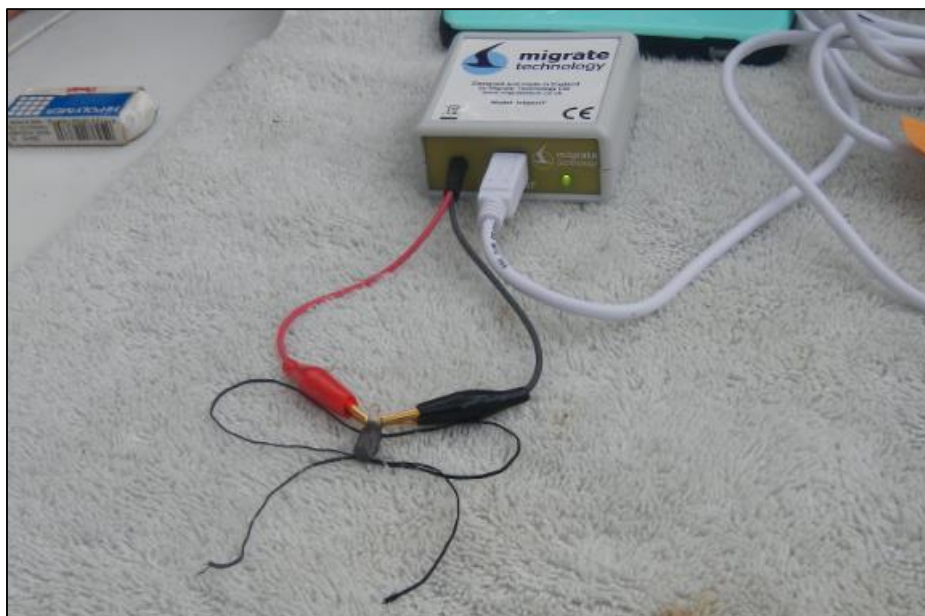


Figure 5. Field activation of the older model geolocator. Also shown is the braided nylon cord used to custom-fit the units to the bird.

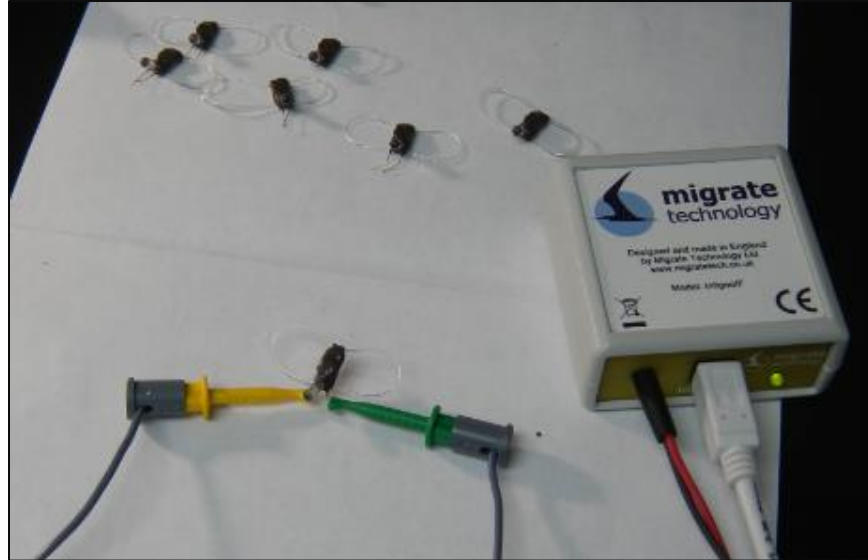


Figure 6. Activation of the Migrate Technology Integeo-P30Z-7-DIP geolocator.



Figure 7. Unactivated Integeo-P30Z-7-DIP geolocator with uncut contacts (left, # 339), and activated unit with contacts cut and sealed with adhesive (right, # 335).

In contrast to most (all but 2) of the previous units we used 0.8 mm or 0.7 mm “Stretch Magic” flexible clear plastic cord to construct the leg loop harness for the new units. The cord was joined by heating the cut ends with a common soldering iron and then joining the melted ends together. The “span”, or leg to leg distance of the harness was initially established based on regression equations of Naef-Daenzer (2007), which were developed for multiple species (Figures 8-10). After some experimentation many birds we conducted fitting and activation in the field by setting up a

“mini-lab” by connecting the soldering iron to a vehicle battery through an inverter and activation as usual with a laptop computer (Figures 11 and 12).

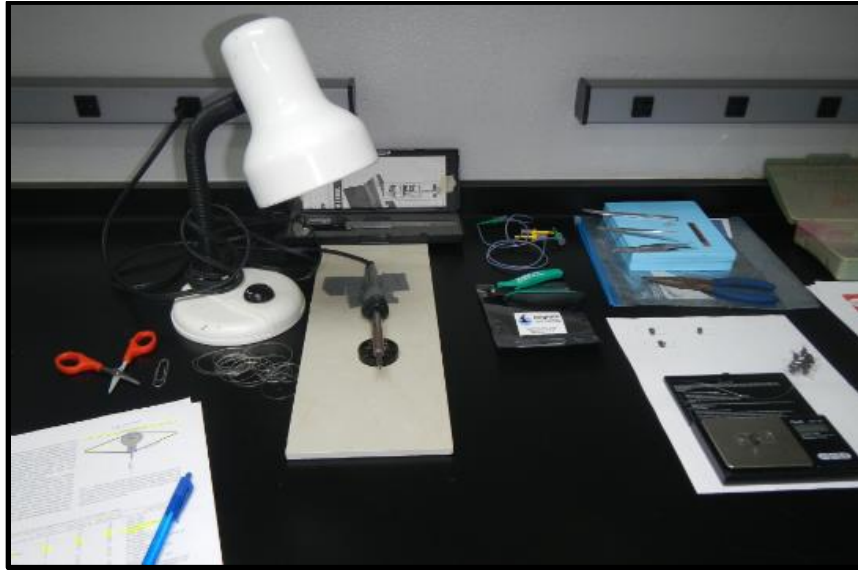


Figure 8. Laboratory set-up for fitting leg loop harnesses and activating geolocators.

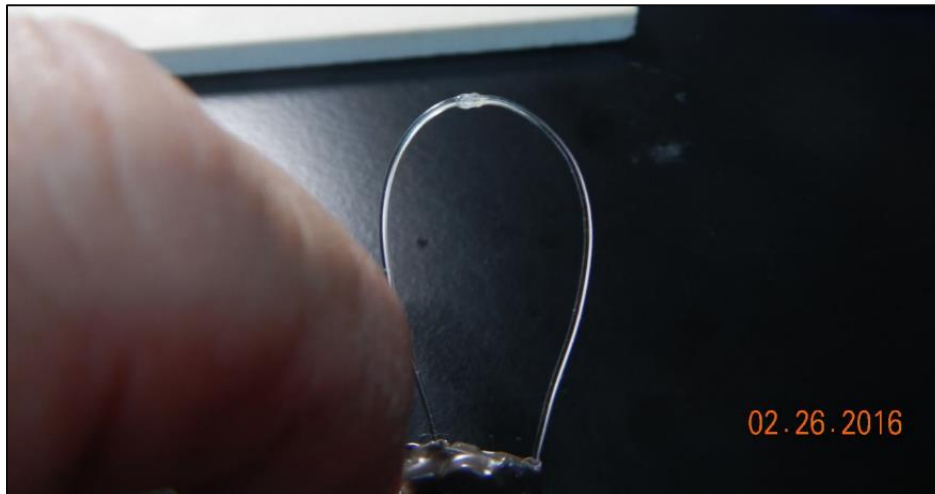


Figure 9. Joined leg loop harness joined after heating with a soldering iron.



Figure 10. Measuring the leg loop harness “span”.



Figure 11. Field “mini-lab” setup for custom fitting of geolocator harnesses for individual birds, including a conventional soldering iron connected via an AC inverter to a vehicle battery.



Figure 12. Joining a leg loop harness harnesses in the field.

A total of 21 Geolocator units were placed on birds from February 27th through April 3rd, 2015, in addition to the 19 units deployed Sep-Dec 2015 – a total of 40 units were deployed on birds in the environment. Three birds tagged during Sep-Dec 2015 were recaptured on Feb. 7, 27 and 28, 2016 (birds 29906, 5287 and 3307, respectively), and bird 29906 was recaptured again on April 10th, 2016. All were found to be in excellent physical condition and bird 52874 had increased its body mass by 10% at the time of recapture (18.0 g on Dec. 12th to 19.9 g on Feb. 27th, not including the tag). On Feb. 28th, 2016 the heavier tag that bird 39307 carried since October 4th, 2015 was replaced with the newer, lighter model unit (Figure 13). By the end of the season (May 1st, 2015) 19 birds had been fitted with the older units in (Sep-Dec 2015) and released – 17 with braided cord harnesses and two with plastic harnesses. Nine of these were birds that had been captured and banded in a previous year or previously during the same season (Recaptures), while 10 were birds captured for the first time (New Bands). All geolocator deployed birds were captured at either the mesquite site (“*La Poza*”) or at the interhabitat corridor site (“*El Corredor*”).



Figure 13. Comparison of the lighter model Integeop-P30Z-7-DIP (left) with the older model unit removed from bird 39307 on 28 Feb 2016.

Of a total of 1 older model and 20 new model Integeop-P30Z-7-DIP geolocators were deployed from Feb. 27th through April 3rd, 2015 (Figures 14-15), five were recaptured birds while 16 were new captures. Of this combined group (of 21 birds) six were subsequently captured on seven occasions and all had gained weight (not counting the geolocator). Bird 54269 showed a dramatic body mass increase from 15.65 g to 24.09 g, suggesting that it had adapted well to carrying the unit. These observations suggested that the 40 tagged birds were tolerating the geolocators well and we look forward to field work again on August 27th, 2016 in hopes of recapturing a substantial proportion of them, downloading their data and learning specific details of their travels.



Figure 14. Northern Waterthrush carrying an Integeop-P30Z-7-DIP geolocator.



Figure 15. Northern Waterthrush carrying an Integeo-P30Z-7-DIP geolocator.

References

- Alsop III FJ. 1995. A communal roost of gray catbirds at Eco Pond, Everglades National Park. *Florida Field Naturalist* 23:69-69.
- Ambrose III HW, Ambrose KP, Emlen DJ, Bright KL. 2002. *A handbook of biological investigation*. 6th Edition. ISBN: 0-88725-266-4.
- Arendt W J, Faaborg J, Wallace GE, Garrido OH. 2004. Biometrics of birds throughout the Greater Caribbean Basin. *Proceedings of the Western Foundation of Vertebrate Zoology* 8:1-33.
- [AVMA] American Veterinary Medical Association. 2013. *AVMA Guidelines on Euthanasia*. American Veterinary Medical Association.
- Balph MH. 1979. Some color-banding techniques for flocking birds. *North American Bird Bander* 4(4):158-160.
- Baltz ME. 2000. *The non-breeding season ecology of neotropical migratory birds in the dry zone of Puerto Rico*. [PhD dissertation]. [Columbia, MO]: University of Missouri.
- Baker JD, Johanos TC. 2006. Effects of research handling on the endangered Hawaiian monk seal. *Marine Mammal Science* 18: 500–512.
- Barron DG, Brawn JD, Weatherhead PJ. 2010. Meta-analysis of transmitter effects on avian behaviour and ecology. *Methods in Ecology and Evolution* 1:1–8.
- Bedrosian BE, St Pierre AM. 2007. Frequency of injuries in three raptor species wintering in northeastern Arkansas. *The Wilson Journal of Ornithology* 119: 296–298.
- Bass I. 2007. *Six Sigma Statistics with Excel and Minitab*. The McGraw Hill Companies. ISBN: 978-0-07-148969-0.
- Bibby CJ, Burgess ND, Hill DA, Mustoe SH. 2005. *Bird Census Techniques*. 2nd Edition. San Diego (CA): Academic Press. ISBN: 0-12-095831-7.

- Bird Banding Laboratory. 2010. How many birds are banded? Patuxent Wildlife Research center. Available at: <http://www.pwrc.usgs.gov/BBL/homepage/howmany.cfm> [accessed 1 November, 2010].
- Blunden J, Arndt DS, Baringer MO (eds). 2011. State of the Climate in 2010. Bulletin of the American Meteorological Society 92 (6): S1-S266.
- Bolker BM, Brooks ME, Clark CJ, Geange SW, Poulsen JR, Stevens MHH, White, JSS. 2008. Generalized linear mixed models: a practical guide for ecology and evolution. Trends in Ecology and Evolution, 24, 127–135.
- Bonham CD. 1989. Measurements for terrestrial vegetation. Wiley-Interscience, New York.
- Boutlet M, Gibbs HL, Hobson KA. 2006. Integrated Analysis of Genetic, Stable Isotope, and Banding Data Reveal Migratory Connectivity and Flyways in the Northern Yellow Warbler (*Dendroica petechia*; Aestiva group). Ornithological Monographs 61: 29-78.
- Bowen GJ, Wassenaar LI, Hobson KA, 2005. Global application of stable hydrogen and oxygen isotopes to wildlife forensics. Oecologia 143: 337–348. Brower E, Zar JH, von Ende CN. 1998. Field and Laboratory Methods for General Ecology. 4th ed. Wm. C. Brown Publishers, Dubuque IA (Times Mirror International/McGraw-Hill).
- Brown DR, Sherry TW. 2008. Solitary winter roosting of Ovenbirds in core foraging area. Wilson Journal of Ornithology 120:455-459.
- Buckland ST. 2006. Point transect surveys for songbirds: robust methodologies. Auk 123: 345-357.
- Burnham K, Anderson D. 2002. Model Selection and Multimodel Inference. A Practical Information-Theoretic Approach. 2nd edn. Springer, New York.
- Burson III SL, Reitsma LR, Hunt PD. 2005. Conservation implications of multiple habitat use by Northern Waterthrushes during the nonbreeding season. Caribbean Journal of Ornithology 18:72-76.
- Buskirk RE, Buskirk WH. 1976. Changes in Arthropod Abundance in a Highland Costa-Rican Forest. American Midland Naturalist 95:288-298.
- Case TJ, Faaborg J, Sidell R. 1983. The role of body size in the assembly of West Indian bird communities. Evolution 37:1062-1074.
- Colbeck GJ, Gibbs HL, Marra PP, Hobson K, Webster MS. 2008. Phylogeography of a widespread North American migratory song bird (*Setophaga ruticilla*). Journal of Heredity 99(5):453-463.
- Confer JL, Holmes RT. 1995. Neotropical migrants in undisturbed and human-altered forests of Jamaica. The Wilson Bulletin 107: 577-589.
- Cottam G, Curtis JT. 1956. The use of distance measures in phytosociological sampling. Ecology 37:451-460. <http://people.hws.edu/mitchell/PCQM.pdf>.
- Cox GW. 1996. A Laboratory Manual for General Ecology. 6th ed. Wm. C. Brown Publishers, Dubuque IA (Times Mirror International/McGrawHill).
- Crooks K, Sanjayan M. 2006. Connectivity Conservation. Cambridge University Press. ISBN :13 978-0-511-34882-2.
- Dahdouh-Guebas F, Koedam N. 2006. Empirical estimate of the reliability of the use of the Point-Centered Quarter Method (PCQM): Solutions to ambiguous field situations and description of the PCQM+ protocol. Forest Ecology and Management 228:1-18.
- Damschen EI, Haddad NM, Orrock JL, Tewksbury JJ, Levey DJ. 2006. Corridors increase plant species richness at large scales. Science. 313:1284-6.
- Dugger KM, Faaborg JF, Arendt WJ, Hobson KA. 2004. Understanding the survival and abundance of over-wintering warblers: Does rainfall matter? The Condor 106:744–760.
- Dunn J, Garrett K. 1997. Warblers. The Peterson Field Guides. ISBN: 0- 395-78321-6.
- Dunning JB. 2008. CRC Handbook of Avian Body Masses, 2nd Edn. CRC Press, London.
- Evans ML, Stutchbury BJM, Woolfenden BE. 2008. Off-territory forays and the genetic mating system of the wood thrush. Auk. 125:67-75.

- Ewel JJ, Whitmore JL. 1973. The ecological life zones of Puerto Rico and the U.S. Virgin Islands. USDA Forest Service Research Publication ITF-18.
- Faaborg J, Holmes RT, Anders AD, Bildstein KL, Dugger KM, Gauthreaux SA, Heglund P, Hobson KA, Jahn AE, Johnson DH. 2010a. Conserving migratory land birds in the new world: do we know enough? *Ecological Applications* 20:398-418.
- Faaborg J, Holmes RT, Anders AD, Bildstein KL, Dugger KM, Gauthreaux SA, Heglund P, Hobson KA, Jahn AE, Johnson DH, Latta SC, Levey DJ, Marra MP, Merkord CL, Nol E, Rothstien SI, Sherry TW, Sillett TS, Thompson II FR, Nils W. 2010b. Recent advances in understanding migration systems in New World land birds. *Ecological Monographs*: 80(1):3-48.
- Fair JM, Paul E, Jones J. 2010. Guidelines to the use of wild birds in research. The ornithological council; Special Publication, Available at: <http://www.nmnh.si.edu/BIRDNET/guide> [accessed 1 November, 2010].
- Fraser G, Stutchbury BJM. 2004. Area-sensitive birds move extensively among forest patches. *Biological Conservation* 118: 377-387.
- Fretwell S. 1980. Evolution of migration in relation to factors regulating bird numbers. In: Keast, A. and Morton, E S (eds). *Migratory birds in the neotropics: ecology, behavior, and conservation*. Smithsonian Institution Press, Washington D.C., pp. 517-527.
- Fuller MR, Obrecht III HH, Pennycuik CJ, Schaffner FC. 1989. Aerial tracking of radio-marked White-tailed Tropicbirds over the Caribbean Sea. In: Amlaner CJ, editor. 1989. *Proceedings of the Tenth International Symposium on Biotelemetry*, Fayetteville, AR: University of Arkansas Press. p 133-137.
- Gill FB. 2007. *Ornithology*. 3rd ed. W. H, Freeman and Company. New York, NY.
- González CM. 2001. Management Plan for the Jobos Bay National Estuarine Research Reserve. Guayama/Salinas, Puerto Rico.
- Grandin T, Doering M. 2003. Distress in Animals: Is it Fear, Pain, or Physical Distress? American Board of Veterinary Practitioners – Symposium of 2002, 7 pp). American Board of Veterinary Practitioners
<http://www.grandin.com/welfare/fear.pain.stress.htm>.
- Greenberg R, Marra PP. 2005. *Birds of two worlds*. Smithsonian Institution. ISBN: 0-8018-8107-2.
- Groom JM, Meffe GK, Carroll CR. 2006. *Principles of Conservation Biology*. Chapter 7. Sinauer Associates, Inc. Sunderland MA. ISBN: 0-87893-518-5.
- Hallworth MT, Parent K, Reitsma L. 2009. Modified version of the leg harness technique for mounting radio transmitters. *North American Bird Bander* 34(2):6-9.
- Hallworth MT, Reitsma L, Parent K. 2011. Habitat use of the Louisiana Waterthrush during the non-breeding season in Puerto Rico. *Wilson Journal of Ornithology* 12(3):567-574.
- Hallworth MT, Studds CE, Sillett T, Marra PP. 2013. Do archival light-level geolocators and stable hydrogen isotopes provide comparable estimates of breeding ground origin? *The Auk* 130 (2):271-282.
- Hayes MP, Schaffner FC. 1986. Life history notes: *Rana catesbeiana*, predation. *SSAR Herpetological Review* 17 (2): 44-45.
- Hill GE. 2004. Headstart for some redstarts. *Science* 306:2201-2202.
- Hobson KA, McFarland KP, Wassenaar LI, Rimmer CC, Goetz JE. 2001b. Linking breeding and wintering grounds of Bicknell's Thrush using stable isotope analysis of feathers. *Auk* 118:16-23.
- Hobson KA, Van Wilgenburg SL, Faaborg J, Toms JD, Rengifo C, Llanes Sosa A, Aubry Y, Brito Aguilar. 2014. Connecting breeding and wintering grounds of Neotropical Migrant songbirds using stable Isotopes: a call for and isotopic atlas of migratory connectivity. *Journal of Field Ornithology* 85(3):237–257.

- Hobson KA, Van Wilgenburg SL, Wassenaar LI, Larson K. 2012. Hydrogen ($\delta^2\text{H}$) isotopes in feathers and precipitation: Sources of Variance and Consequences for Assignment to Isocapes. *PlosOne* 7(4): e35137.
- Hobson KA, Wassenaar LI. 2001. A stable isotope approach to delineating population
- Hobson KA. 2005. Stable Isotopes and the Determination of Avian Migratory Connectivity and Seasonal Interactions. *The Auk* 122(4):1037-1048.
- Hobson KA, Van Wilgenburg SL, Faaborg J, Toms JD, Rengifo C, Llanes Sosa A, Aubry Y, Brito Aguilar. 2014. Connecting breeding and wintering grounds of Neotropical Migrant songbirds using stable Isotopes: a call for and isotopic atlas of migratory connectivity. *Journal of Field Ornithology* 85(3):237–257.
- Holmes RT, Sherry TW, Reitsma L. 1989. Population structure, territoriality and overwinter survival of two migrant warbler species in Jamaica. *Condor* 91: 545-561.
- Hunt PD, Reitsma L, Burson III SL. 2005. Spatial and Temporal Distribution of Northern Waterthrushes among Nonbreeding Habitats in Southwestern Puerto Rico. *Biotropica* 37(4): 697-701.
- IPCC Intergovernmental Panel on Climate Change. 2002. Climate Change and Biodiversity. IPCC Technical Report V. Intergovernmental Panel on Climate Change, OMM/WMO/PNU/UNEP. ISBN: 92:9169-104-7.
- Jacobs, KR, Carrubba L, and Diaz E (Eds.). 2012a. Puerto Rico Coastal Zone Management Program, Department of Natural and Environmental Resources, NOAA Office of Ocean and Coastal Resource Management. San Juan, PR. 63 pp.
- Jacobs, K.R., L. Carrubba, and E. Diaz (Eds.). 2012b. Puerto Rico Coastal Zone Management Program, Department of Natural and Environmental Resources, NOAA Office of Ocean and Coastal Resource Management. San Juan, PR. 153 pp.
- Janzen DH, TW Schoener. 1968. Differences in insect abundance and diversity between wetter and drier sites during a tropical dry season. *Ecology* 49:96-110.
- Jennings S, Gardali T, Seavy NE, Geupel GR. 2009. Effects of mist netting on reproductive performance of wrentits and song sparrows in central coastal California. *The Condor* 111: 488–496.
- Jirinec V, Campos BR, Johnson, MD. 2011. Roosting behaviour of a migratory songbird on Jamaican coffee farms: landscape composition may affect delivery of an ecosystem service. *Bird Conservation International* 21(3):353-361.
- Johnson MD. 2000a. Evaluation of an arthropod sampling technique for measuring food availability for forest insectivorous birds. *Journal of Field Ornithology* 71:88-109.
- Johnson MD. 2000b. Effects of shade tree species and crop structure on the arthropod and bird communities in a Jamaican coffee plantation. *Biotropica* 32:133-145.
- Johnson JB, Omland KS. 2004. Model selection in ecology and evolution. *Trends in Ecology and Evolution* 19: 101–108.
- Johnson MD, Sherry TW. 2001. Effects of food availability on the distribution of migratory warblers among habitats in Jamaica. *Journal of Animal Ecology* 70:546-560.
- Johnson MD, Strong AM. 2000. Length-weight relationships of Jamaican arthropods. *Entomological News*. 111:270-281.
- Kelly JF, Johnson MJ, Langridge S, Whitfield M. 2008. Efficacy of stable isotope ratios in assigning endangered migrants to breeding and wintering sites. *Ecological Applications: a publication of the Ecological Society of America* 18:568-76.
- Kelly JF, Rugg KC, Smith TB. 2005. Combining isotopic and genetic markers to identify the breeding origins of migrant birds. *Ecological Applications* 15(5):1487-1494.
- Kelly JF. 2002. Insights into Wilson's Warbler migration from analyses of hydrogen stable-
- Kelly JF. 2006. Stable Isotope Evidence Links Breeding Geography and Migration Timing in Wood Warblers (Parulidae). *The Auk* 123(2):431-43.

- Kerr RA. 2009. What Happened to Global Warming? Scientists Say Just Wait a Bit. *Science* 326:28-29.
- Ktitorov P, Bairlein F, Dubinin M. 2008. The importance of landscape context for songbirds on migration: body mass gain is related to habitat cover. *Landscape Ecology* 23:169-179.
- Laboy EN, Capella J, Robles PO, González CM. 2006. Jobos Bay Estuarine Profile, A national estuarine research reserve.
- Laboy EN. 2009. Environmental Management issues in an estuarine ecosystem: A case study from Jobos Bay, Puerto Rico. In: Laboy-Nieves EN, Schaffner FC, Abdelhadi A, Goosen MFA, editors. 2009. Environmental Management, Sustainable Development and Human Health. AK Leiden, NL: CRC Press/Balkema. p 361-398.
- LaManna JA, George TL, Saracco JF, Nott MP, DeSante DF. 2012. El Niño-Southern Oscillation influences annual survival of a migratory songbird at a regional scale. *The Auk* 129(4):734-743.
- Langin KM, Reudink MW, Marra PP, Norris DR, Kyser TK, Ratcliff LM. 2007. Hydrogen isotopic variation in migratory bird tissues of known origin: implications for geographic assignment. *Oecologia* 152: 449-457.
- Latta SC. 2012. Avian research in the Caribbean: past contributions and current priorities. *Journal of Field Ornithology*. 83(2):107–121, 2012.
- Latta SC, Faaborg J. 2001. Winter site fidelity of Prairie Warblers in the Dominican Republic. *Condor* 103:455-468.
- Latta SC, Faaborg J. 2002. Demographic and population responses of Cape May Warblers wintering in multiple habitats. *Ecology* 83:2502-2515.
- Lefebvre G, Poulin B, McNeil R. 1992. Abundance, feeding-behavior, and body condition of Nearctic warblers wintering in Venezuelan mangroves. *Wilson Bulletin* 104:400-412.
- Lefebvre G, Poulin B, McNeil R. 1994. Temporal dynamics of mangrove bird communities in Venezuela with special reference to migrant warblers. *Auk* 111:405-415.
- Lefebvre G, Poulin B. 1996. Seasonal abundance of migrant birds and food resources in Panamanian mangrove forests. *Wilson Bulletin* 108:748-759.
- Lindzey JK, Gower Jr WR, Mishinsky HR, Owens UE, Graham LN, Gografe SJ, Van Etten JH, Engleman, RW. 2002. A Unique Application of the IACUC for Studies of Wild Animals in or from Natural Settings. *Contemporary Topics, American Association of Laboratory Animal Science* 41(6): 33-36.
- Mackenzie GJ, Schaffner FC, Swart PK. Insights into Feeding Ecology and Geographic Range of Wading Birds in South Florida Using Stable C, O, and N Isotopes. In prep.
- Majer JD, Recher HF, Perriman WS, Achutan N. 1990. Spatial variation of invertebrate abundance within canopies of two Australian eucalypt forests. *Studies in Avian Biology* 13:65-72.
- Marra PP, Hobson KA, Holmes RT 1998. Linking winter and summer events in a migratory bird by using stable carbon isotopes. *Science* 282:1884-1886.
- Marra PP, Holmes RT 2001. Consequences of dominance-mediated habitat segregation in American Redstarts during the nonbreeding season. *Auk* 118:92-104.
- Marra PP, Sherry TW, Holms RT. 1993. Territorial exclusion by a long-distance migrant warbler in Jamaica: a removal experiment with American Redstarts (*Setophaga ruticilla*). *Auk* 110:565-572.
- Marra PP. 2000. The role of behavioral dominance in structuring patterns of habitat in structuring patterns of habitat occupancy in a migrant bird during the nonbreeding season. *Behavioral Ecology* 11:299-308.
- Marra PP, Norris DR, Haig SM, Webster M, Royle JA. 2006. Migratory connectivity. Pages 157-183 in KR Crooks and M Sanjayan, eds. *Connectivity conservation*. Cambridge University Press, Cambridge, UK.

- Martin TE, Geupel GR. 1993. Nest Monitoring Plots: Methods for locating nests and monitoring success. *Journal of Field Ornithology* 64(4): 507-519.
- Martinuzzi S, Gould WA, Ramos-Gonzales OM. 2007. Land development, land use, and urban sprawl in Puerto Rico integrating remote sensing and population census data. *Landscape and Urban Planning* 79 288-297.
- Matson KD, Tieleman BI, Klasing KC. 2006. Capture stress and the bactericidal competence of blood and plasma in five species of tropical birds. *Physiological and Biochemical Zoology* 79:556–564.
- McKinnon EA, Fraser KC, Stutchbury BJM. 2013. New discoveries in landbird migration using geolocator, and a flight plan for the future. *The Auk* 130(2):211-222.
- McKinnon Stanley CQ, Stutchbury BJM. 2015. Carry-over effects of nonbreeding habitat on start-to-finish performance of a songbird. *PLOS ONE* DOI:10.1371/journal.pone.0141580 November 3, 2015, 17 pp.
- McKee, K.L. 2011. Biophysical controls on accretion and elevation change in Caribbean mangrove ecosystems. *Estuarine, Coastal and Shelf Science* 91:475-483. Elsevier Ltd.
- McKee, K.L., Cahoon, D.R., and I.C. Feller. 2007. Caribbean mangroves adjust to rising sea level through biotic controls on change in soil elevation. *Global Ecology and Biogeography* 16:545-556.
- Mitchell K. 2007. Quantitative Analysis by the Point-Centered Quarter Method. Department of Mathematics and Computer Science. Hobart and William Smith Colleges Geneva, NY 14456.
- Morris GL. 2000. Hydrologic Hydraulic and Biological Analysis of Jobos Estuarine Mangrove Mortality Jobos, Puerto Rico: Puerto Rico Land Authority.
- Murphy PG, AE Lugo.1986. Ecology of tropical dry forest. *Annual Review of Ecology and Systematics* 17:67-88.
- Neelin JD, Münnich M, Su H, Meyerson JE, Holloway CE. 2006. Tropical drying trends in global warming models and observations. *Proceedings of the National Academy of Sciences*. 103(16):6110-6115.
- Nocera JJ, Ratcliffe LM. 2009. Migrant and resident birds adjust antipredator behavior in response to social information accuracy. *Behavioral Ecology* 21: 121.
- Norris DR, Marra PP, Montgomerie TK, Kyser TK, Ratcliffe LM. 2004. Reproductive effort, moulting latitude and feather color in a migratory songbird. *Science* 306:2249-2250.
- Norris DR, Marra PP, Bowen GJ, Ratcliff LM, Royle JA, Kyser TK. 2006. Migratory Connectivity of a widely distributed songbird, the American Redstart (*Setophaga ruticilla*). *Ornithological Monographs* 61:14-28.
- Norris DR, Stutchbury BJM. 2002. Sexual differences in gap crossing ability of a forest songbird revealed through radiotracking. *Auk* 119: 528-532.
- North American Banding Council. 2001. North American Bander's Study Guide, North American Banding Council Publication Committee. Available at: <http://www.nabanding.net/pubs.html> [accessed 1 November 2010].
- Noss R, Csuti B, Groom MJ. 2006. Habitat fragmentation. Pp 212-251 (Ch 7), in Groom MJ, Meffe GK, Carroll CR eds., *Principles of Conservation Biology*, 3rd ed. Sinauer Associates, Inc. Publishers. Sunderland MA.
- Nur N, Geupel GR, Ballard G. 2004. Estimates of adult survival, capture probability, and recapture probability: evaluating and validating constant effort mist netting. *Studies in Avian Biology* 29: 63–70.
- Nytch CJ, Hunter WC, Nuñez-García F, Fury C, Quiñones M. . 2015. Avian conservation planning and priorities for Puerto Rico and the US Virgin Islands (BCR 69). Report to the US Fish and Wildlife Service as specified in work contract no. F12PX02389.

- Nur N, Jones SL, Geupel GR. 1999. A statistical guide to data analysis of avian monitoring programs. US Department of the Interior, US Fish and Wildlife Service, BTP-R6001-1999, Washington, DC.
- Oberle MW. 2010. Puerto Rico's Birds in photographs. A complete guide and CD-ROM including the Virgin Islands. 3 ed. Editorial Humanitas, Seattle, Washington. ISBN-13: 978-0-9650104-5-0.
- Ohlendorf HM, Custer TW, Schaffner FC, Stafford CJ. 1985. Reproduction and organochlorine contaminants in terns at San Diego Bay. *Colonial Waterbirds* 8: 42-53
- Pardieck K, Waide RB. 1992. Mesh size as a factor in avian community studies using mist nets. *Journal of Field Ornithology* 63: 250–255.
- Paxton KL, Ripper III CV, O'Brien C. 2008. Movement patterns and stopover ecology of Wilson's Warblers during spring migration on the lower Colorado River in southwestern Arizona. *The Condor* 110(4):672-681.
- Paxton KL, Ripper III CV, Theimer TC, Paxton EH. 2007. Spatial and temporal migration patterns of Wilson's Warbler (*Wilsonia pusilla*) in the Southwest as revealed by stable isotopes. *The Auk* 124(1):162-175.
- Pennycuik CJ, Schaffner FC, Fuller MR, Obrecht III HH, Sternberg L. 1990. Foraging flights of the White-tailed Tropicbird *Phaethon lepturus*: radiotracking and doubly-labeled water. *Colonial Waterbirds* 13 (2): 96-102.
- Pérez MR, Fernández CG, Sayer JA. 2007. Los servicios ambientales de los bosques. 16(3):81-90.
- Peterson SM, Streby HM, Kramer GR, Lehman JA, Buehler DA, Andersen, DA. 2015a. Geolocators on Golden-winged Warblers do not affect migratory ecology. *Condor* 117:256-261.
- Peterson SM, Streby HM, Lehman JA, Kramer GR, Fish AC, Andersen DA. 2015b. High-tech or field techs: Radio-telemetry is a cost-effective method for reducing bias in songbird nest searching. *Condor* 117:386-395.
- Post W. 1978. Social and foraging behavior of warblers wintering in Puerto Rican coastal scrub. *Wilson Bulletin* 90:197-214.
- Post W. 1982. Why do Grey Kingbirds roost communally? *Bird Behav.* 4: 46-49.
- Powell GVN, Bjork R. 1995. Implications of intratropical migration on reserve design: A case study using *Pharomachrus mocinno*. *Conserv Biol.* 9: 354-362.
- Powell GVN, Schaffner FC. 1991. Water trapping by seagrasses occupying bank habitats in Florida Bay. *Estuarine, Coastal and Shelf Science* 32: 43-60.
- [PRCCC] Puerto Rico Climate Change Council (PRCCC) Working Group 1. 2013a (In Press). Geophysical and Chemical Scientific Knowledge. In Puerto Rico's State of the Climate 2010-2013: Assessing Puerto Rico's Social-Ecological Vulnerabilities in a Changing Climate. Jacobs, K.R., L. Carrubba, and E. Diaz (Eds.), Puerto Rico Coastal Zone Management Program, Department of Natural and Environmental Resources, NOAA Office of Ocean and Coastal Resource Management. San Juan, PR. 63 pp.
- [PRCCC] Puerto Rico Climate Change Council (PRCCC) Working Group 2. 2013b (In Press). Ecology and Biodiversity. In Puerto Rico's State of the Climate 2010-2013: Assessing Puerto Rico's Social-Ecological Vulnerabilities in a Changing Climate. Jacobs, K.R., L. Carrubba, and E. Diaz (Eds.), Puerto Rico Coastal Zone Management Program, Department of Natural and Environmental Resources, NOAA Office of Ocean and Coastal Resource Management. San Juan, PR. 153 pp.
- Price T. 1981. The ecology of the Greenish Warbler *Phylloscopus trochiloides* in its winter quarters. *Ibis* 123:131-144.
- Pyle P. 1997. Identification Guide to North American Birds, Part 1: Columbidae to Ploceidae. 2nd printing. Slate Creek Press, Bolinas, California.

- Pyle P. 2008. Identification Guide to North American Birds, Part II. Anatidae to Alcidae. Slate Creek Press, Bolinas, California.
- R Development Core Team. 2009. R: A Language and Environment for Statistical Computing. R Foundation for Statistical Computing, Vienna. Available at: <http://www.R-project.org> [accessed 1 November, 2010].
- Raffaele HA. 1989. A guide to the birds of Puerto Rico and the Virgin Island. Princeton University Press. ISBN: 0-691-02424-3.
- Ralph CJ, Geupel GR, Pyle P, Martin TE, DeSante DF. 1993. Handbook of Field Methods for Monitoring Landbirds. United States Department of Agriculture Forest Service, Albany, CA.
- Rappole JH, Mc Donald MV. 1994. Cause and effect of population declines of migratory birds. *The Auk* 111(3):652-660.
- Rappole JH, Tipton AR. 1991. New Harness Design for Attachment of Radio Transmitters to Small Passerines. *Journal of Field Ornithology* 62:335-337.
- Recher HF, Gowing G, Armstrong T. 1985. Causes and frequency of deaths among birds mist-netted for banding studies at two localities. *Australian Wildlife Research* 12: 321–326.
- Reitsma LR, Hunt PD, Burson III SL, Steele BB. 2002. Site fidelity and ephemeral habitat occupancy: Northern Waterthrush use of Puerto Rican Black Mangroves during the nonbreeding season. *Wilson Bulletin* 114: 99-105.
- Reitsma LR, Marra P, Smith J. 2004. Fourth and Final Year Report (2004): The Importance of Mangroves to Neotropical Migratory Birds at Naval Station Roosevelt Roads, Puerto Rico. Cooperative Agreement # DACA87-00-H-0007 with the Army Corps of Engineers.
- Reudink MW, Marra PP, Kyser TK, Boag PT, Langin KM, Ratcliff. 2009. Non-breeding season events influence sexual selection in a long-distance migratory bird. *Proceedings of the Royal Society Series B*:1619-1626.
- Remsen JV, Good DA. 1996. Misuse of data from mist-net captures to assess relative abundance in bird populations. *The Auk* 113: 381–398.
- Rice SM, Collazo JA, Alldredge MW, Harrington BS, Lewis AR. 2007. Local annual survival and seasonal residency rates of Semipalmated Sandpipers in Puerto Rico. *Auk* 124:1397-1406.
- Rivera-Milan FF, Schaffner FC. 2002. Demography of Zenaida Doves on Cayo del Agua, Culebra, Puerto Rico. *Condor* 104: 587-597.
- Rodríguez-Colón I. 2012. Inference of hábitat connectivity via hábitat use by resident and migratory birds between secondary dry forest and mangroves at Jobos Bay National Estuarine Research Reserve. [Thesis 99 pp] Universidad del Turabo, Gurabo, PR.
- Rodríguez-Colón I, Schaffner FC. 2012. Inference of habitat connectivity via habitat use by resident and migratory birds between mangroves and secondary dry forest in Jobos Bay National Estuarine Research Reserve, Puerto Rico. Abstract, 5th North American Ornithological Conference, Vancouver, BC, Canada, 14-18 August 2012.
- Rodríguez-Colón I, Schaffner FC. 2011. Multiple habitat use, corridor behavior and diurnal migrations by Neotropical migrant warblers at Jobos Bay, Puerto Rico. American Ornithologists Union, 129th Stated Meeting, 24-29 July, 2011, Jacksonville, Florida. Presentation and abstract.
- Rodríguez-Colón I, Schaffner FC. 2011. Inference of habitat connectivity by diurnal migrations by Neotropical migratory warblers at Jobos Bay, Puerto Rico. Abstract. 18th Regional Meeting, Society for the Conservation and Study of Caribbean Birds (SCSCB). 21-25 July, 2011. Freeport, Bahamas.
- Rohwer S, Hobson KA, Yang S. 2011. Stable isotopes (δD) reveal east-west differences in scheduling of molt and migration in northern rough-winged swallows (*Stelgidopteryx serripennis*). *The Auk* 128(3):522-530.
- Runge CA, Watson JEM, Butchart SHM, Hamson JO, Possington, Miller RA. 2015. Protected areas and global conservation of migratory birds. *Science* 350 (6265):1255-1258.

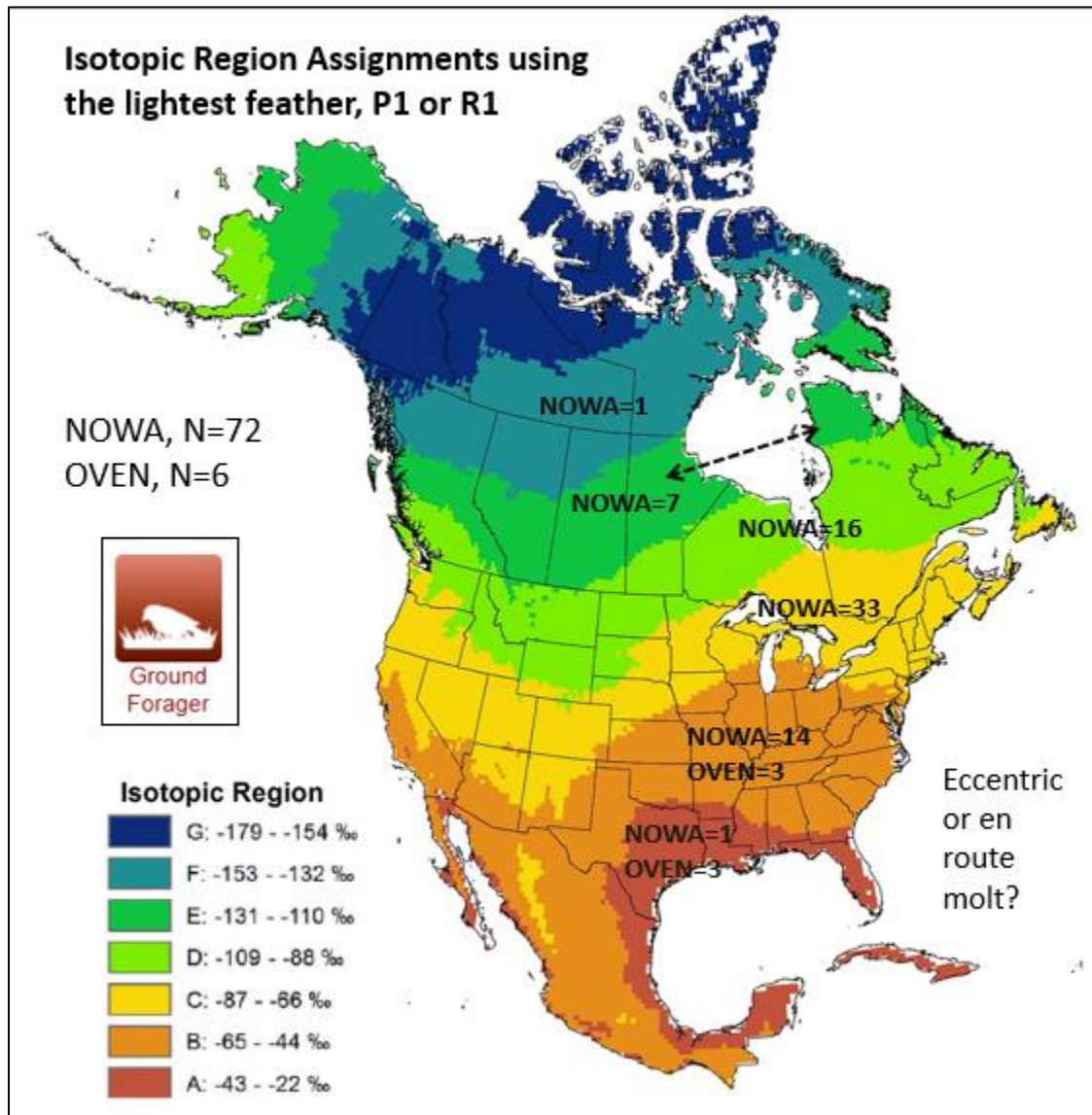
- Rush SA, Stutchbury BJM. 2008. Survival of fledgling Hooded Warblers in large and small forest fragments? *Auk* 125: 183-191.
- Rubenstein DR, Chamberlain CP, Holmes RT, Ayres MP, Waldbauer JR, Traves GR, Tuross NC. 2002. Linking breeding and wintering ranges of a migratory songbird using stable isotopes. *Science* 295:1062-1065.
- Schaffner FC. 2012. Book Review - Seabird Breeding Atlas of the Lesser Antilles. (Invited book review). *The Auk* 129(4): 792-793.
- Schaffner FC. 2010. An Inventory of Breeding Seabirds of the Caribbean. (Invited book review). *The Auk* 127(4): 720-721.
- Schaffner FC. 2006. Accelerated Terrestrialization of a Subtropical Lagoon: The Role of Agency Mismanagement. In: Proceedings of the 32nd Annual Conference on Ecosystems Restoration and Creation. Tampa, FL. p 92-110.
- Schaffner FC. 1998. Recent changes in aquatic bird populations and habitat characteristics at Laguna Cartagena National Wildlife Refuge, Puerto Rico: Implications for restoration. Abstract, In: 1998 North American Ornithological Conference, 6-12 April, 1998, St Louis, MO.
- Schaffner FC. 1991. Nest site selection and nesting success of White-tailed Tropicbirds (*Phaeton lepturus*) at Cayo Luís Peña, Puerto Rico. *Auk* 108: 911-922.
- Schaffner FC. 1990. Food provisioning by White-tailed Tropicbirds: effects on the developmental pattern of chicks. *Ecology* 71 (1): 375-390.
- Schaffner FC. 1990. Feed size and feeding periodicity in pelagic birds: notes on methodology. *Colonial Waterbirds* 13 (1): 7-15.
- Schaffner FC. 1990. Egg recognition by Elegant Terns (*Sterna elegans*). *Colonial Waterbirds* 13 (1): 25-30, 1990.
- Schaffner FC. 1989. When will the U.S. Navy bring itself into full compliance with the Sikes Act at Roosevelt Roads, Puerto Rico? *El Pitorre* 2 (2): 4-5.
- Schaffner FC. 1986. Trends in Elegant Tern and northern anchovy populations in California. *Condor* 88: 347-354.
- Schaffner FC. 1985. Royal Tern nesting attempts in California: isolated or significant incidents? *Western Birds* 16: 71-80.
- Schaffner FC. 1981. A Sandwich Tern in California. *Western Birds* 12: 181-182.
- Schaffner FC, Norton RL, Taylor JP. 1986. Range expansion of Cayenne Terns on the Puerto Rico Bank. *Wilson Bulletin* 98: 317-318.
- Schaffner FC, Sánchez-Colón YM. 2011. Population trends in West Indian Whistling Ducks and other *Dendrocygna* at Laguna Cartagena, Puerto Rico. Abstract. 18th Regional Meeting, Society for the Conservation and Study of Caribbean Birds (SCSCB). 21-25 July 2011. Freeport, Bahamas.
- Schaffner FC, Swart PK. 1991. Influence of diet and environmental water on the carbon and oxygen isotopic signatures of seabird eggshell carbonate. *Bulletin of Marine Science* 48 (1): 23-38.
- Schowalter TD. 1994. Canopy arthropod community structure and herbivory in a tropical rain forest at Luquillo Experimental Forest, Puerto Rico, following Hurricane Hugo. *Biotropica* 26:312-319.
- Schwartz P. 1964. The Northern Waterthrush in Venezuela. *Living bird* 3:169-184.
- Sherry TW, Holmes RT 1996. Winter habitat quality, population limitation, and conservation of neotropical nearctic migrant birds. *Ecology* 77:36-48.
- Sibley DA. 2003. *The Sibley Field Guide to Birds of Eastern North America*. Alfred A, Knopf, New York.
- Sillett TS, Holmes RT. 2002. Variation in survivorship of a migratory song bird throughout its annual cycle. *Journal of Animal Ecology* 71:296-308.

- Simons TR, Moore FR, Gauthreaux SA. 2009. Mist netting trans-Gulf migrants at coastal stopover sites: The influence of spatial and temporal variability on capture data. *Studies in Avian Biology* No 29: 135-143.
- Smith JAM, Reitsma LR, Marra PP. 2010. Moisture as a determinant of habitat quality for a nonbreeding Neotropical migratory songbird. *Ecology* 91(10): 2874-2882.
- Smith JAM, Reitsma LR, Marra PP. 2011a. Influence of Moisture and Food Supply on the Movement Dynamics of a Nonbreeding Migratory Bird (*Parkesia noveboracensis*) in a Seasonal Landscape. *The Auk* 128:43-52.
- Smith JAM, Reitsma LR, Marra PP. 2011b. Multiple space-use strategies and their divergent consequences in a nonbreeding migratory bird (*Parkesia noveboracensis*). *The Auk* 128:53-60.
- Smith JAM. 2008. The Non-Breeding Ecology of a Neotropical Migratory Songbird: The influence of Habitat Quality on Spatial and Social Behavior and Consequences for Individual Performance. [PhD dissertation]. [Fairfax, VA]: George Mason University.
- Smith, JAM, Reitsma LR, Rockwood LL, Marra PP. 2008. Roosting behavior of a Neotropical migrant songbird, the Northern Waterthrush *Seiurus noveboracensis*, during the nonbreeding season. *Journal of Avian Biology* 39:460-465.
- Spotswood EN, Goodman KR, Carlisle J, Cormier RL, Humple DL, Rousseau J, Guers SL, Barton GG. 2012. How safe is mist netting? Evaluating the risk of injury and mortality to birds. *Methods in Ecology and Evolution* 2012(3): 29–38.
- Stacier CA. 1992. Social behavior of the Northern Parula, Cape May Warbler, and Prairie Warbler wintering in second-growth forest in southwestern Puerto Rico. In: Hagan J. M. and Johnston DW (eds). *Ecology and conservation of Neotropical migrant land birds*. Smithsonian Institution Press, Washington DC, pp. 309-320.
- Stacier CA. 1992. Social behavior of the Northern Parula, Cape May Warbler, and Prairie Warbler wintering in second-growth forest in southwestern Puerto Rico. In: Hagan JM. and Johnston DW (eds). *Ecology and conservation of neotropical migrant landbirds*. Smithsonian Institution Press, Washington DC, pp. 309-320.
- Staicer CA. 1991. The Role of Male Song in the Socioecology of the Tropical Resident Adelaide's Warbler (*Dendroica adelaidae*). PhD Dissertation, University of Massachusetts.
- Stamm DD, Davis DE, Robbins CS. 1960. A method of studying wild bird populations by mist-netting and banding. *Bird-Banding* 31: 115–130.
- Stephens PA, Buskirk SW, Hayward GD, Martinez D. 2005. Information theory and hypothesis testing: a call for pluralism. *Journal of Applied Ecology* 42: 4–12.
- Streby HM, Kramer GR, Peterson SM, Lehman JA, Buehler DA, Andersen DE. 2015a. Tornadoic storm avoidance behavior in breeding songbirds. *Current Biology* 25, 1-5, January 5, 2015, <http://dx.doi.org/10.1016/j.cub.2014.10.079>.
- Streby HM, McAllister TL, Peterson SM, Kramer GR, Lehman, Andersen DE. 2015b. Minimizing marker mass and handling time when attaching radiotransmitters and geolocators to small songbirds. *Condor* 115: 249-255.
- Strong AM, Sherry TW. 2000. Habitat-specific effects of food abundant on the condition of Ovenbirds wintering in Jamaica. *Journal of Animal Ecology* 69: 883-895.
- Studds C, Marra PP. 2007. Linking fluctuations in rainfall to nonbreeding season performance in a long-distance migratory bird, *Setophaga ruticilla*. *Climate Research* 35:115-122.
- Stutchbury BJ. 1994. Competition for winter territories in a neotropical migrant-the role of age, sex and color. *Auk* 111: 63-69.
- Sydeman WJ, Hobson KA, Pyle P, McLaren EB. 1997. Trophic relationships among seabirds in Central California: Combined Stable isotope and dietary approach. *Condor* 99:327-336.
- Tanaka LK, Tanaka SK. 1982. Rainfall and Seasonal Changes in Arthropod Abundance on a Tropical Oceanic Island. *Biotropica* 14:114-123.

- Toms JD. 2011. Non-breeding competition between migrant American Redstarts (*Setophaga ruticilla*) and resident Adelaide's Warblers (*Dendroica adelidae*) in the Guanica Biosphere Reserve, southwest Puerto Rico [PhD dissertation]. [Columbia, MO]: University of Missouri.
- Townsend JM, Rimmer CC, Brocca J, McFarland KP, Townsend AK. 2009. Predation of a wintering migratory songbird by introduced rats: can nocturnal roosting behavior serve as predator avoidance? *Condor* 111(3):565-569.
- Townsend JM, Rimmer CC, McFarland KP. 2010. Winter territoriality and special behavior of Bicknell's Thrush (*Catharus bicknelli*) at two ecologically distinct sites in the Dominican Republic. *Auk* 127(3):514-522.
- Vázquez-Plass EO. 2008. Avian distribution along a gradient of urbanization in Puerto Rico. [PhD thesis]. [Rio Piedras, PR]: University of Puerto Rico.
- Vázquez-Plass EO, and J.M. Wunderle Jr. 2013. Avian distribution along a gradient of urbanization in northeastern Puerto Rico. *Ecological Bulletins* 54:141-156.
- Warde W, Petranks JW. 1981. A correction factor table for missing point-center quarter data. *Ecological Society of America* 62:491-494.
- Wiley, J.W. 1985. Shiny cowbird parasitism in two avian communities in Puerto Rico. *Condor* 87:165-176.
- Winker K, Rappole JH, Ramos, MA. 1990. Population dynamics of the Wood Thrush (*Hylocichla mustelina*) in southern Veracruz, Mexico. *Condor* 92:444-460.
- Wunder MB, Norris DR. 2008. Improved estimates of certainty in stable isotope based geographic assignments for tracking migratory animals. *Ecological Applications* 18: 549-559.
- Wunderle JM. 1982. The timing of the breeding season in the bananaquit (*Coereba flaveola*) on the island of Grenada, W.I. *Biotropica* 14(2): 124-131.
- Wunderle JM Jr. 1994. *Census Methods for Caribbean Land Birds*. United States Department of Agriculture. Forest Service, Southern Forest. Experiment Station New Orleans, Louisiana. General Technical Report SO-98.
- Wunderle JM. 1997. Responses of Bird Populations in a Puerto Rican Forest to Hurricane Hugo: The First 18 Months. *The Condor*. 97: 879-896.
- Wunderle Jr JM, Curie D, Helmer E, Ewert DN, White JD, Ruzycki TS, Parresol B, Kwit C. 2010. Kirtland's Warblers in anthropogenically disturbed early-successional habitats on Eleuthera, The Bahamas. *Condor* 112(1):123-137.
- Voss MA, Shutler D, Werner J. 2010. A hard look at blood-sampling of birds. *The Auk* 127: 704–708.
- Zuberogitia I, Arroyo B, O'Donoghue B, Zabala J, Martínez J, Martínez JE, Murphy SG. 2012. Standing out from the crowd: are patagial wing tags a potential predator attraction for harriers (*Circus* spp.)? *J Ornithol* 153:985–989.
- Zuur AF, Ieno EN, Walker NJ, Saveliev AA, Smith GM. 2009. *Mixed Effects Models and Extensions in Ecology with R* Springer, New York.

Appendix 1 (from last season's report).

Isotopic Region Assignments using the isotopically lightest feather, P1 or R1, for Ground Foragers, Northern Waterthrushes (NOWA) and Ovenbirds (OVEN).



Appendix 2 (from last season's report).

Isotopic Region Assignments using the isotopically lightest feather, P1 or R1, for leaf-gleaning canopy foragers. Codes: PRAW=Prairie Warbler; NOPA=Northern Parula; YEWA=Yellow Warbler; BANA=Bananaquit (local reference).

