Migratory Connectivity for Neotropical Migrant Songbirds In the Sudbury River Watershed

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Summary

Biodiversity Research Institute (BRI) deployed light-level geolocators on songbirds in the Sudbury River Watershed to determine the migratory pathways and connectivity of bird species potentially injured due to mercury contamination from the Nyanza Chemical Waste Dump Superfund Site in Ashland, Massachusetts. Data collected on geolocators (both time of day and ambient light level) can be used to infer spatial position of individuals throughout their annual cycle. We attached 45 geolocators (in total) to Veeries (*Catharus fuscenscens*), Gray Catbirds (*Dumetella carolinensis*), Wood Thrush (*Hylocichla mustelina*) and Rose-breasted Grosbeaks (*Pheucticus ludovicianus*) that we captured at the Great Meadows National Wildlife Refuge in the summer of 2013. In 2014, we retrieved 12 geolocators from birds that were recaptured at the same site. Gray Catbirds wintered in the southeastern United States and returned to the breeding grounds via the United States' eastern coast. Veeries wintered in Amazonian South America from Suriname to central Brazil. During fall migration most Veeries migrated in early August and some followed a trans-oceanic migration leaving from the northeast and arriving in Brazil in a few days. This appears to be the second geolocator-documented trans-oceanic migration in North America. In spring, Veeries returned to the breeding grounds via Central America and the Caribbean, consistently stopping over in the Nicaragua area. Overall, we documented some differences in migratory connectivity and behavior from the previous studies of these species. This study allowed us to specifically describe the migratory connections of individuals from a specific breeding area in a way that could not have been done via literature searches or another method. Given that migratory connectivity is crucial to understand for conserving migratory species, using geolocators is a necessary method to implement full life cycle conservation techniques for specific populations. It may be even more important for populations impacted by contaminants or other stressors.

Introduction

For species that are mobile, migration is a life history strategy that has evolved to increase reproduction by taking advantage of high food abundance during summer in non-tropical areas and avoiding resource limitations in those areas during the non-breeding season (Salewski and Bruderer 2007). Because most birds fly and are highly mobile, migration is a commonly employed strategy (Salweski and Bruderer 2007). Due to high mortality rates during migratory travel (Sillett et al. 2002), migration can be a primary determinant of population limitation in migratory birds (Newton 2004). Thus, to understand bird populations, we need to understand the process of migration and how it influences the conservation and management of these species (Martin et al. 2007).

Bird migration influences populations in a complex process where the spatial connections between the breeding and wintering grounds (migratory connectivity) and events from previous life stages (individual carry-over effects) can influence life history parameters throughout the life cycle (Webster and Marra 2002). Migratory connectivity influences populations via density-dependence effects. Strong spatial linkages between breeding and wintering grounds for individual populations mean that density-dependent effects at one wintering area are not equally distributed to all breeding areas. Combined with mortality over migration, this can mean that there are complicated relationships between the number of individuals on the breeding and wintering grounds. Unlike migratory connectivity, seasonal interactions occur at the individual scale where events in one stage of the life cycle can affect individual performance in subsequent stages. For example, a poor quality winter territory can translate into a late departure to the breeding grounds, and poor reproductive success once there (Norris et al. 2004). Both of these processes can influence conservation and management strategies. Strong migratory connectivity restricts the influence of conservation actions such that wintering ground restoration will only affect a few breeding populations. Individual carry-over effects can aggregate up to the population level and influence demography and population size (Both and Visser 2001).

Contaminants are a new area of study when it comes to migration. Mercury is a common environmental contaminant (Scheuhammer et al. 2007) that has negative effects on birds during the breeding season (Jackson et al. 2012; Frederick and Jayasena 2010) and also could influence survival in any season. There is also evidence to suggest that mercury can directly influence migration by altering molt and feather quality (Carlson et al. 2014) or influencing migratory energy stores (Adams 2014), which could then affect flight performance and potentially survival over the migratory period. In sum, we suspect that the effects of mercury are not limited to the life stage in which the animal is exposed to the contaminant. Similar to traditional seasonal interactions (described above), the negative effects of mercury exposure on the breeding grounds or non-breeding grounds could then influence individual fitness over migration and the subsequent stationary period. Thus, the effects of contaminants on migratory birds are potentially complex and difficult to measure. In order to have the best chance at quantifying these effects we need to understand the migratory patterns of the animals first.

To begin the process of understanding how mercury affects migratory birds, we first want to describe the migratory and non-breeding ecology of individuals that are potentially being exposed to the contaminant at the breeding grounds. The effects of contaminants are likely not just limited to the location of exposure and this study is the beginning of describing how mercury exposure affects populations throughout a migratory cycle. The purpose of this study was to identify the migratory routes and non-breeding grounds of birds breeding around the Sudbury River, MA to help ensure that appropriate full life cycle conservation measures were employed at the site. We hope that this study helps initiate and provide support for using full life cycle conservation techniques on contaminant-injured migratory songbird populations.

Methods

Songbirds were captured in the summers of 2013 and 2014 at Great Meadows National Wildlife Refuge (Strand Property and Refuge Headquarters; Fig. 1) and on the Sudbury Valley Trustees Round Hill property. We erected up to ten 30 mm mesh mist-nets at a time and pair them with playback of conspecific territorial calls was to attract target species. The Strand property was used exclusively for deploying geolocators on Gray Catbirds while birds captured around refuge headquarters and Round Hill were a mix of Veery, Rose-breasted Grosbeak, Wood Thrush and Gray Catbird. The same techniques were used during the recapture period in 2014, though all birds with geolocators had blood and feather samples taken for another project.

All captured birds were banded, aged, sexed, assessed for fat stores, measured (wing chords) and weighed, time permitting. In addition, we applied unique color band combinations and geolocators (MigrateTech, http://www.migratetech.co.uk/) to Veery, Gray Catbird, Wood Thrush and Rose-breasted Grosbeaks. This was done with a Rappole harness, the standard method for attaching geolocators to songbirds (Rappole and Tipton 1992). In this method, Kevlar string is wrapped around the pelvic girdle of the animal while securing a geolocator on the rump of the animal, just above the uropygial gland. Each harness is custom-fitted to each animal and knots are secured using super glue. We attached Intigeo P65C2 model to small Veeries and Intigeo-W50B model to Gray Catbirds, Wood Thrush, Rose-breasted Grosbeaks and large Veeries. All geolocators were less than 3% of the bird’s body weight.

Analysis of geolocator data was conducted using package “GeoLight” in the R Statistical Computing Environment. Wherein, the recorded light level and time stamp data were vetted by BRI staff then used in a provided algorithm to estimate the position of the individual for every day that we had sufficient data. Data were then exported to ArcGIS (ESRI, v. 10.2.2) for mapping and subsequent spatial analyses. For winter, we identified core use areas for the species using kernel density estimation processes that smooth and stack data so that areas used by multiple individuals are more obvious (Seaman and Powell 1996). During the migration periods we identified areas where birds stopped over for multiple days also using a kernel density estimator.

Results

Forty-five geolocators were deployed in Great Meadows National Wildlife Refuge in the summer of 2013 across the four species (Table 1). In 2014, seven Gray Catbird and five Veery geolocators were recovered. Two of the recaptured Veeries dropped their geolocator between deployment and recapture (Table 2). Data were downloaded from all geolocators; however, two devices had failures of various sorts. The first stopped collecting data in November (a Veery) and the second appeared to have a problem with its light sensor (a Gray Catbird). We did not include these data in any kernel density analysis due to the lack of data throughout the year.

Gray Catbird

We lacked information on Gray Catbird fall migration because of its timing with the autumn equinox (mid-September; a time when geolocators do not accurately estimate latitude). The primary wintering area for the study birds was Florida with one bird wintering further to the west in Louisiana and Mississippi (Fig. 2). During spring migration birds returned to Massachusetts primarily via a coastal route, stopping consistently in the Chesapeake Bay area (Fig. 3).

Veery

The Veeries in our study migrated to South America via the Atlantic flyway then returned to the breeding grounds via the Central American isthmus. Veeries began their fall migration early, two of the four arrived in South America before mid-August (Fig. 4). We also saw evidence of trans-oceanic migration in the fall. F331 and F374 showed accurate points over the water and a pathway with appropriate timing to suggest overwater travel. We lacked accurate positions during fall migration for the other birds. Once on the wintering grounds we found that there were few differences among individuals with most wintering in southern Brazil and one wintering closer to Suriname in northern Brazil (Fig. 5). In spring, birds returned via the Central American Isthmus and Greater Antilles with increased activity around Nicaragua then continuing up the United States' eastern seaboard to return to their Massachusetts breeding grounds (Fig. 6).

Discussion

We used geolocators to describe the migratory pathways of Veeries and Gray Catbirds at a mercury-contaminated breeding area in Sudbury, MA. These data showed some differences from what was reported in the literature for other populations of these species. While fall migration routes can be difficult to describe during the equinoxes, Veeries in our study migrated early enough to avoid this issue and we saw evidence that they migrated quickly, likely over-water, to their wintering areas in Brazil. During spring migration, we found that both species used a number of stopover areas for multiple days, particularly in Central America and the Mid-Atlantic United States. These data give conservation practitioners and managers tools for better protecting Veery and Gray Catbird populations that breed in the Sudbury River Valley.

Overall, we found that Gray Catbirds had strong migratory connections to the southeastern United States in the winter and the eastern United States coastal plain during spring migration. This pattern is similar to the pattern of migratory connectivity inferred from banding recaptures but different from connectivity estimated using geolocators from a population in Delaware (Ryder et al. 2011). In our study we showed connections to the northern Gulf of Mexico, which no other study has to date. Compared to the Delaware population, our birds appeared to winter in more northern Florida and further west, suggesting that catbirds are chain migrants and that birds that winter further north also breed further north. We should also note that while all birds wintered in the southeastern United States, many different states were represented suggesting that birds were distributed across a large area.

For Veeries, we found that their core winter areas were similar to past studies from a Delaware population. Primarily wintering in Amazonia we saw strong overlap with location, but we did not see the within-winter movements identified in the previous studies. Though, this could have been because of the low number of accurate winter points that we recovered from our geolocators or the low numbers of birds tracked in total. In the spring, we saw consistent stopover activity in Central America, indicating that areas in this region were important to a successful migration.

Unexpectedly, we saw evidence that Veeries in our study were embarking upon over-water migratory flights in the fall. Fall migration is a difficult time period to document with geolocators because many birds migrate around the equinox where latitude is difficult to estimate due to day length being similar across the globe. In our case, Veeries migrated early and moved quickly over the ocean. This pattern was not found in previous studies and it is unclear why. Perhaps trans-oceanic migrations are more successful when departing from further north. This is not the first instance of trans-oceanic migration in North America (DeLuca et al. 2015), but it may be the most surprising. Blackpoll warblers have been long thought to migrate over oceans (Nisbet et al. 1995), and while radar studies have suggested that other songbirds likely embark on similar journeys (though perhaps less frequently and less extreme routes; Williams et al. 1997). Veeries were not thought to be one of those species. Our data, while limited, support the idea that long trans-oceanic migrations are not species limited and perhaps are consistent among birds that winter in eastern South America and breed north of Cape Cod like Blackpolls and Veeries.

In our effort to understand the migratory patterns and connections of Neotropical migrants that breed in Sudbury, Massachusetts, we learned some important information that can help us better conserve these and other similar species. First, understanding migratory connectivity in the directly affected population is essential prior to undertaking full life-cycle conservation efforts. . We saw some similarities between our populations and others, but assuming similar connectivity to nearby breeding populations would have potentially led to a management action that would not directly help the population of interest. Second, it is difficult to predict migratory patterns in songbirds. We did not know that Veeries conducted trans-oceanic migratory flights, but this knowledge changes our perspective on their population biology and what management strategies would be useful for them during migration. We should note that our results in this study are dependent upon a relatively small sample size (Veery: n=5; Gray Catbird: n =7) and that continued work could lead to a different understanding emerging about migratory connectivity in this region.

Understanding the connections between migration and mercury exposure is a key next step for managing migratory bird populations generally. Mercury—while concentrated in areas as point sources because of past industrial development—is also distributed across the globe due to atmospheric deposition. Many birds are exposed to this contaminant and we are likely underestimating the effect of mercury on wild migratory birds because of the difficulties involved with unraveling these complexities. In sum, we are just at the beginnings of understanding how mercury exposure affects migrants and the many ecosystems they inhabit over the course of their annual cycle. The first step taken here—to document migratory behaviors—is a large one, but more research is needed to disentangle these effects and better understand how mercury limits migratory bird populations. Data from the current study will be useful for developing full life cycle conservation strategies for affected species in the Sudbury River area and directing funds to critical non-breeding habitat in Central America, northern South America and the Mid-Atlantic United States.

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Tables

Table 1. Number of geolocators deployed in 2013 by species and site.

Species	Great Meadows Headquarters	Strand Property	Total
Gray Catbird	9	15	24
Rose-breasted Grosbeak	2	0	2
Veery	17	0	17
Wood Thrush	2	0	2

Table 2. Number of geolocators recovered in 2014 by species and site.

Species	Great Meadows Headquarters	Strand Property	Total
Gray Catbird	4	3	7
Veery	5	0	5

Figures

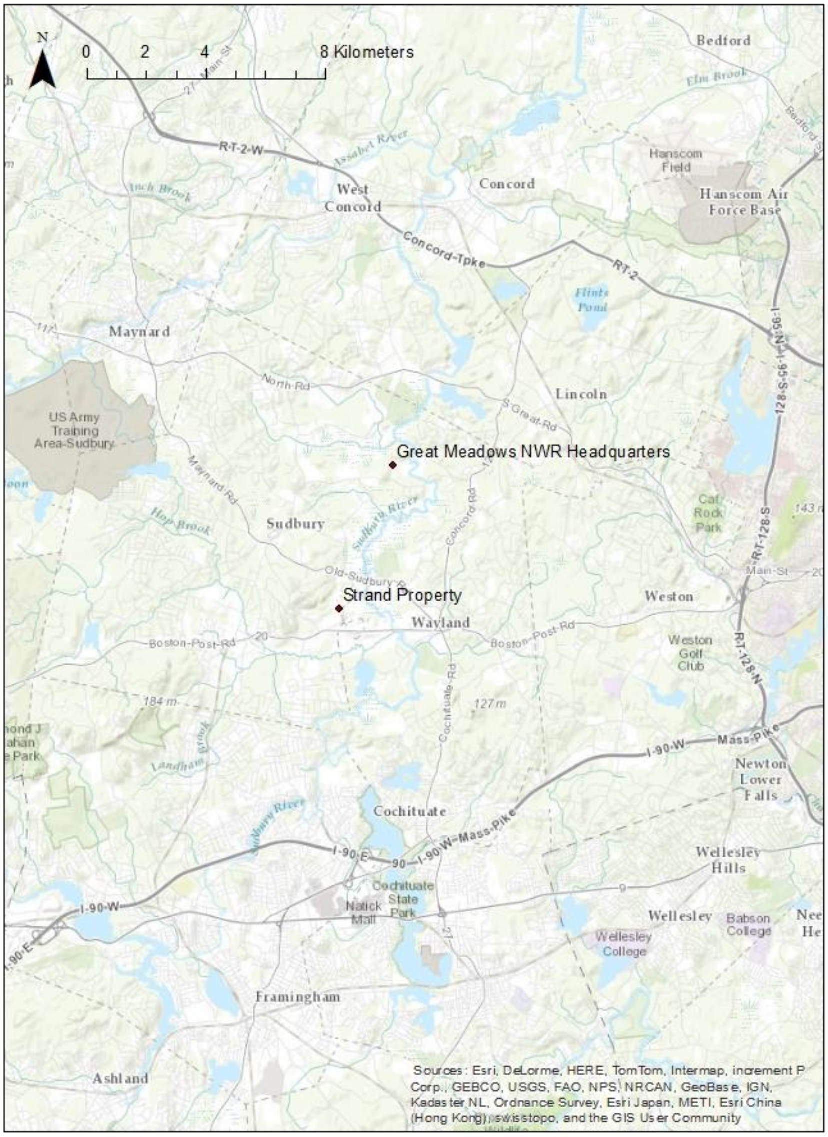

Figure 1. Field sites used for capturing and deploying geolocators on Gray Catbirds and Veeries. All capture at the Strand Property were on Refuge property while captures at Headquarters were on both Refuge and Sudbury Valley Trust lands.

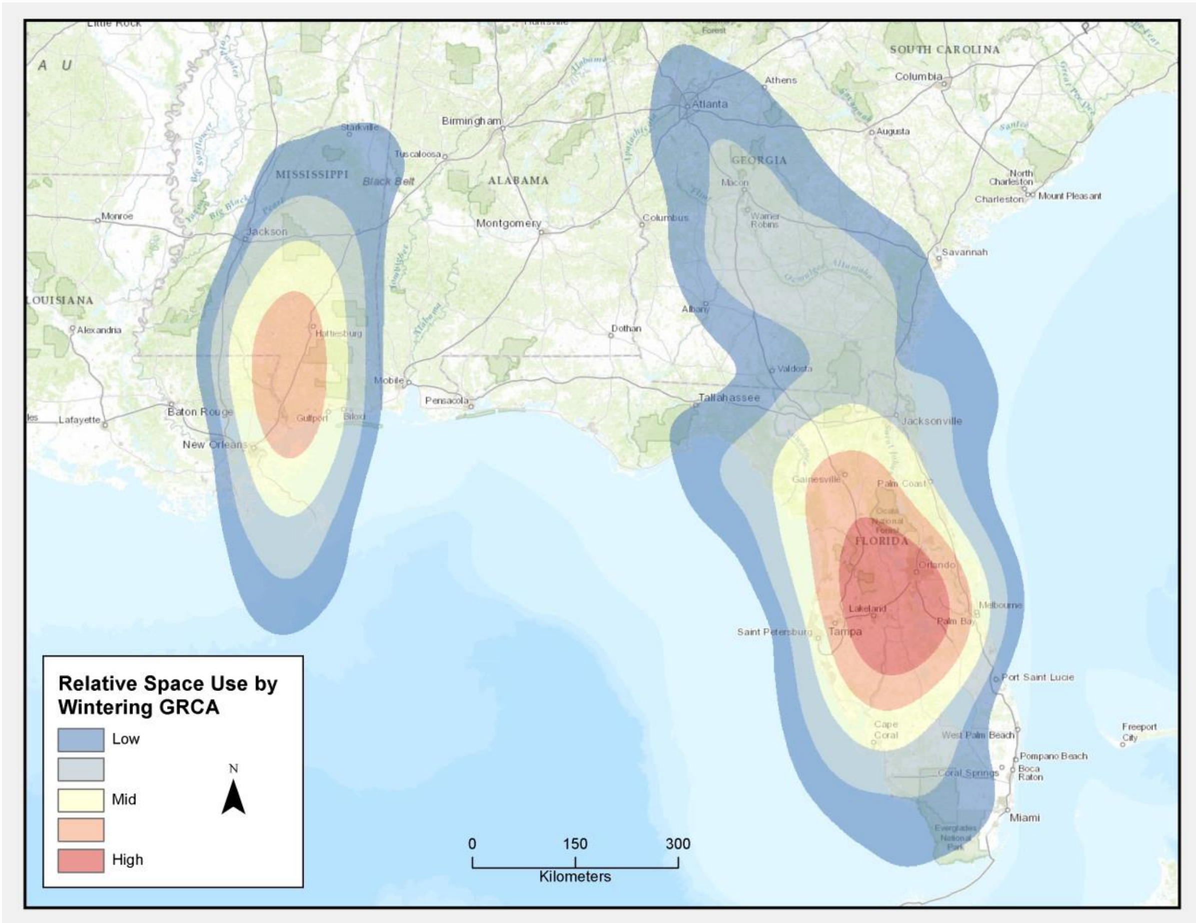

Figure 2. Gray Catbird wintering ground activity map calculated from a kernel density estimator and the location estimates for all seven individuals.

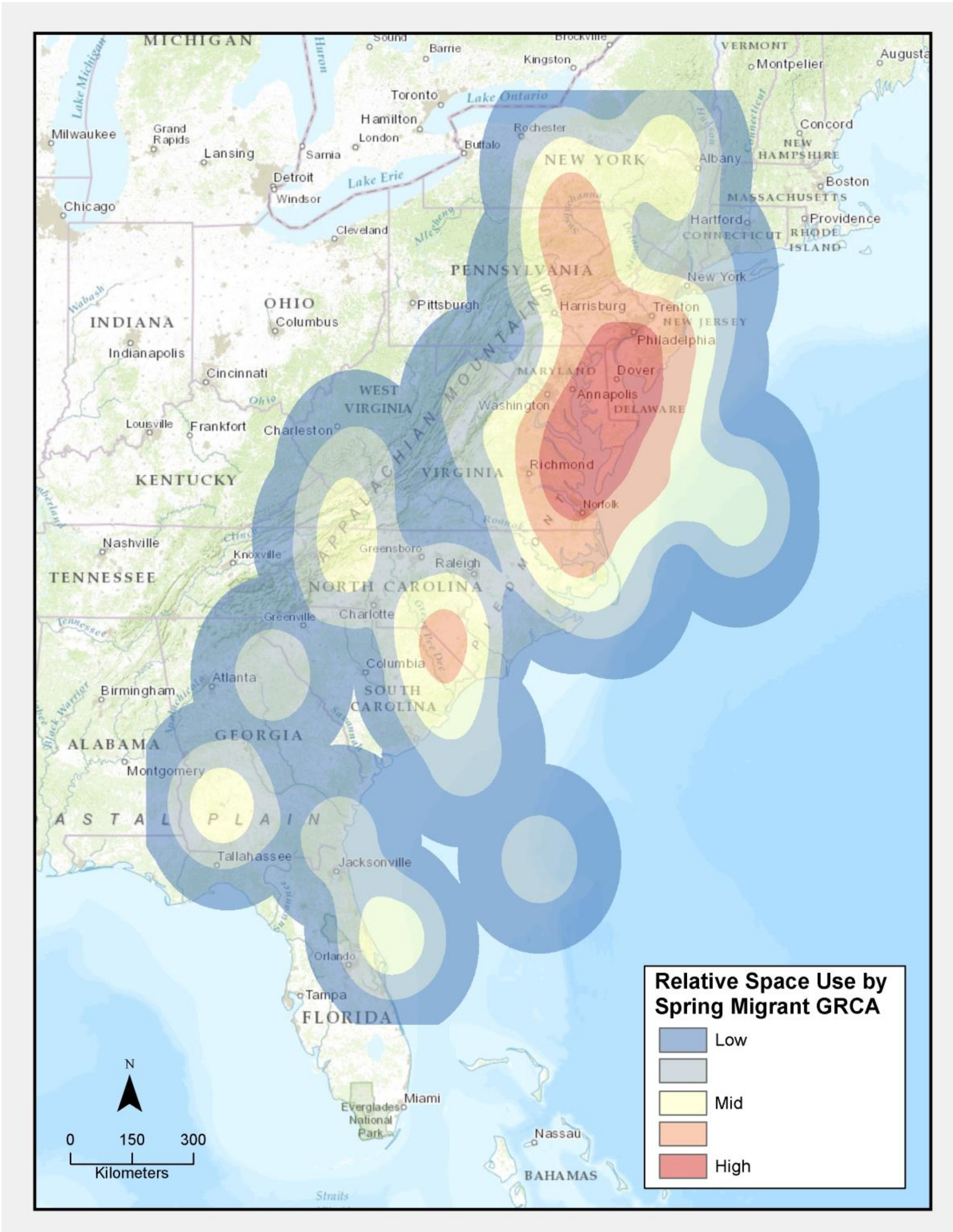

Figure 3. Spring migration stopover locations for Gray Catbirds calculated using a kernel density estimator and the location estimates for all seven individuals.

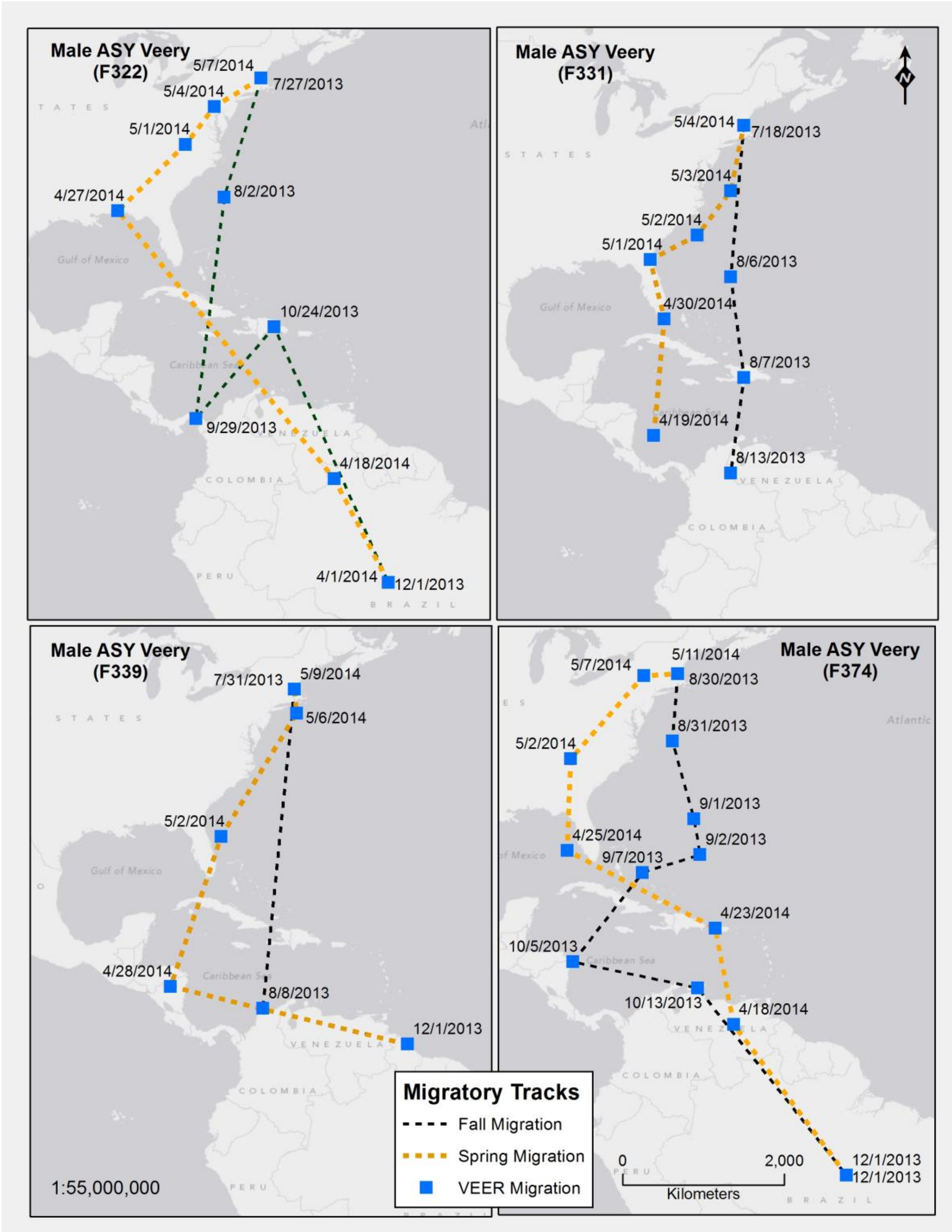

Figure 4. Fall migration tracks for Veeries with date and theoretical lines connecting each of the points. One Veery is not shown due to poor data quality during fall migration.

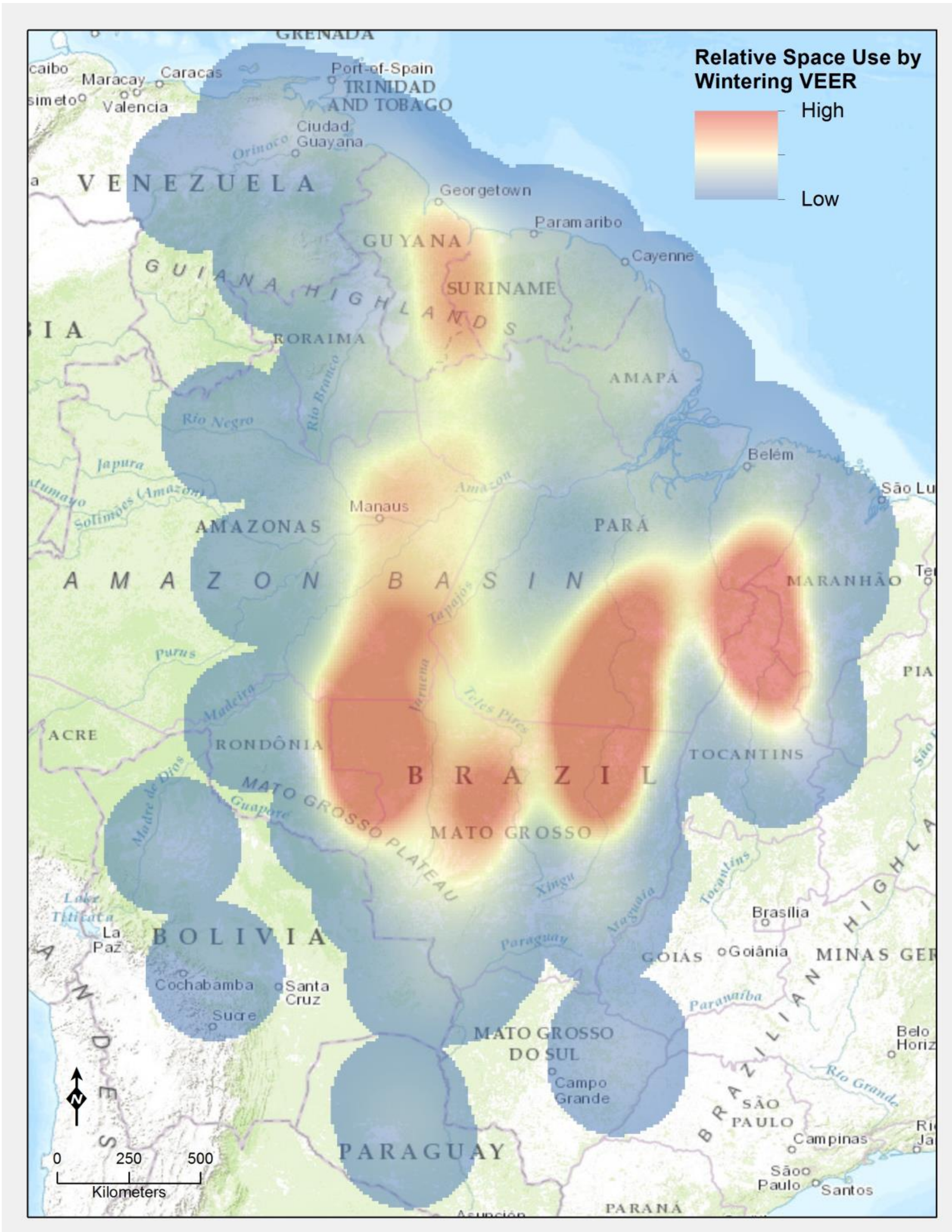

Figure 5. Veery wintering ground activity map calculated from a kernel density estimator and the location estimates for all five individuals.

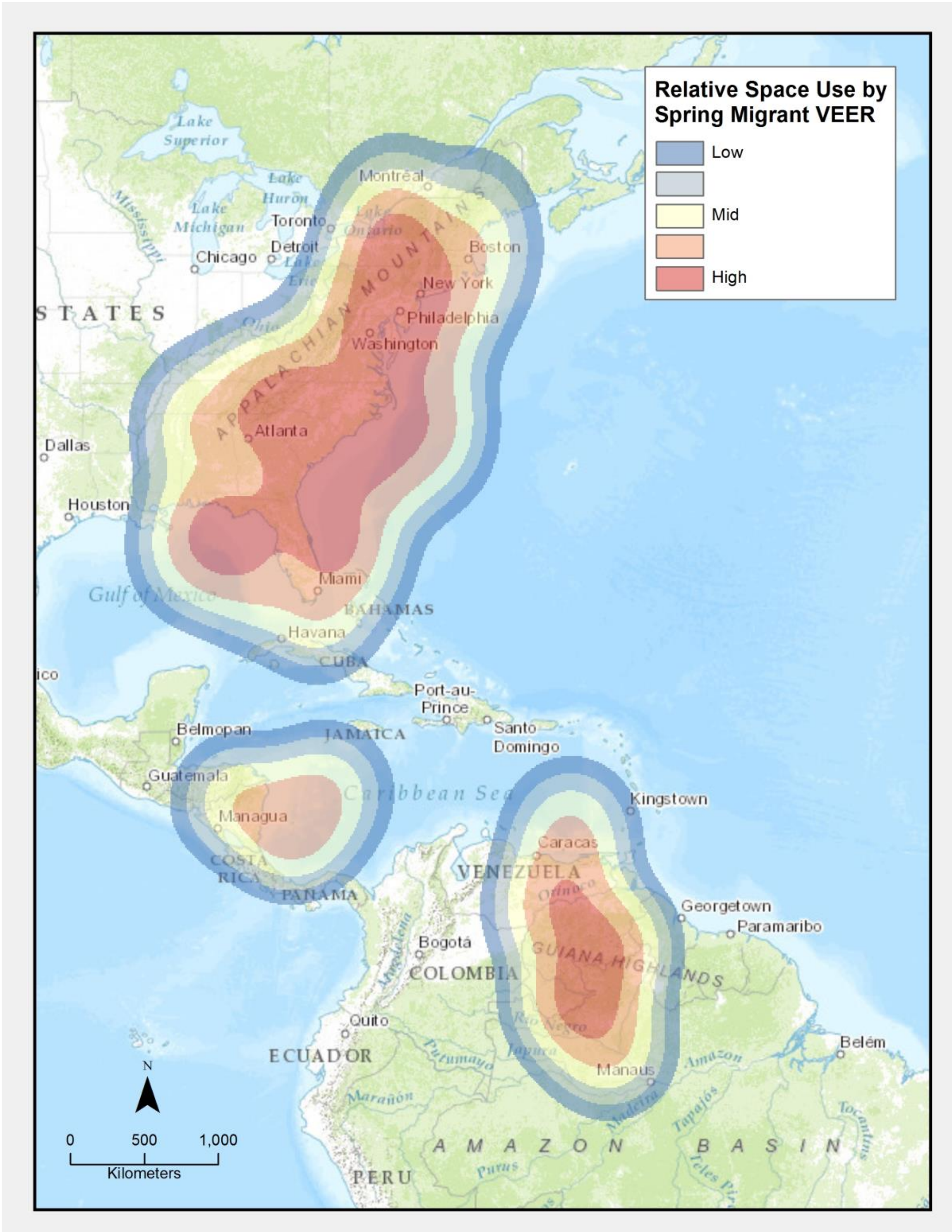

Figure 6. Spring migration stopover locations for Veeries calculated using a kernel density estimator and the location estimates for all five individuals.