AUDUBON SOCIETY OF RHODE ISLAND

THE STATE OF OUR BIRDS

Part II: Migration

The current status and suggested conservation actions for birds migrating through Audubon Society of Rhode Island wildlife refuges

Written and Edited by

Charles Clarkson, PhD

The State of Our Birds: The Work Continues

How do birds use Audubon properties during periods of migration? What can we do to provide high-quality stopover habitat to birds?

This report offers a first glimpse into the world of avian migration across Audubon land.


Red-breasted Nuthatch *(Sitta canadensis)*


Tree Swallow *(Tachycineta bicolor)*


American Goldfinch *(Spinus tristis)*

Birds have been undergoing migratory movements for hundreds of thousands of years, and today a spectrum of movement behavior exists, including long-distance and short-distance migration as well species that undergo no movement (residents) or nomadic movements.

Understanding bird migration is essential to our ability to reverse population declines and mitigate the effects of climate change. When birds move across the landscape, they make decisions that dictate their success during subsequent overwintering and breeding periods such as how far to travel, where to stop and how long to stop.

As climate change increases the unpredictability of weather events, birds that have timed their migratory movements over thousands of generations to coincide with gradual spring warming or fall senescence are finding themselves out-of-phase with the plant and insect communities they rely on to meet their own physiological demands and those of their offspring.

When we help birds survive, we help each other –
Support the Audubon Avian Research Initiative.

asri.org/AvianResearchInitiative

The State of Our Birds: The Work Continues

Let's work together and give birds a chance.

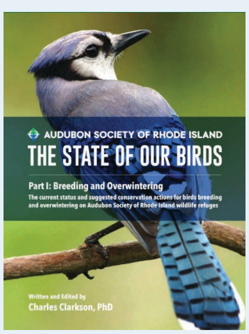
Ruby-throated Hummingbird
(*Archilochus colubris*)

Blackburnian Warbler
(*Setophaga fusca*)

This "phenological mismatch" is leading to declines in many bird species, with those that undergo long-distance migration experiencing the greatest loss (Both et al. 2009).

This report begins to pull together the information we need to better understand when birds move across our properties and what they need to fuel their journeys. We've learned a lot about the birds that migrate across our properties, however, the data used to generate the information in this report come from a single spring and fall migration.

It is well known that the movement patterns of birds during migration can and do change. Therefore much more data are necessary to capture this between-year variability. The information presented throughout the remainder of this report will be used as a guide for management purposes, with the understanding that continued study of our migratory birds is absolutely necessary.



The State of Our Birds Report: Part I

In January 2023, Audubon introduced "The State of Our Birds Report: Part I" which summarized which avian species are present on our public wildlife refuges throughout the year. It discusses the long-term trend in these bird populations within our region and highlighted nine species as "Responsibility Birds" that require additional attention to help bolster their populations.

To learn more about the Audubon Avian Research Initiative and download "The State of Our Birds Report: Part I" please visit asri.org/AvianResearchInitiative.

When we help birds survive, we help each other –
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Audubon Touisset Marsh Wildlife Refuge
Warren, RI

White-throated Sparrow *(Zonotrichia albicollis)*

Acknowledgements

The information contained in this report would never have been possible without the tremendous support from our volunteers. To better understand the current status of our birds and the trends their populations exhibit, a large amount of data collection is necessary. The dedication these volunteers have shown to the Avian Research Initiative has been tremendous, and the Audubon Society of Rhode Island is deeply appreciative of their commitment to bringing our birds back.

Informing Our Conservation

Hermit Thrush (*Catharus guttatus*) at Audubon Touisset Marsh Wildlife Refuge, Warren, RI.

Bird migration has fascinated humans since we first noticed that our avian communities changed over the course of a year. The noisy, vibrant birds of the summer disappear in the winter and are replaced by less colorful species that spend little time vocalizing. The quest to determine how and why these changes take place has led the scientific community on a fact-finding mission that is still far from complete.

Many great thinkers of our past have weighed-in on the subject of migration. Over a thousand years ago, the Greek philosopher Aristotle posited that birds simply transform from one species into another during certain times of the year. A ludicrous notion by today's standards, yet at the time it was a convenient explanation for why Garden Warblers (*Sylvia borin*) were nowhere to be found in the winter while the numbers of Blackcaps (*Sylvia atricapilla*) grew. Equally far-fetched ideas dominated the scientific community for centuries: it was believed that birds flew to the moon during the winter, that they hibernated over the winter in the mud at the bottom of lakes and ponds and that hummingbirds rode on the backs of geese in order to cover greater distances.

Today, our understanding of bird migration is not nearly so outlandish. We know that almost half of all avian species undergo some form of migration. We know that many species migrate at night, when atmospheric stability and fewer predators makes the journey safer. These nocturnal migrants complete their journeys by relying on a number of navigational tools, such as a celestial compass, geographic landmarks on the surface of the earth and even the earth's magnetic field (which they can sense using light-sensitive proteins).

Modern advances in technology have allowed us to understand just how much site fidelity exists in migratory birds (a great deal for many species), how far birds fly (over 7,000 miles nonstop for species such as the Bar-tailed Godwit (*Limosa lapponica*)) and the routes that they take. Our understanding of bird migration is continuously increasing as we learn more about the amazing journeys birds have been taking for thousands of years. We also learn more about the extreme costs of migration, including mortality driven by predators along their routes, deteriorating habitats and climate change.

The more bird migration comes into focus, the more we realize that, to conserve our declining birds, we must focus our attention on these strenuous and perilous periods in their lives. A well-rounded management plan should consider not only the overwintering and breeding periods, but the ability of land to provide for birds that are undergoing long and arduous journeys. Because, while we now understand a great deal more about the migrations of birds, the truth behind these movements is no less unbelievable than the ideas theorized by our predecessors. For example, although it is obvious that birds do not fly to the moon, the Arctic Tern (*Sterna paradisaea*) will travel up to 1.5 million miles over the course of its lifetime undergoing migratory movements…a distance equivalent to three round-trip voyages to the moon.

These amazing creatures that predate humans by millions of years and have filled us with curiosity and awe now rely on us to safeguard their future. At the Audubon Society of Rhode Island, our focus remains on doing what we can to rise to this challenge, including describing migration across our refuges and providing for birds that transit through our state.

– **Charles Clarkson, PhD**
Director of Avian Research
Audubon Society of Rhode Island

Report Overview: Principal Findings

- Western Rhode Island is considered one of the most important areas in New England for stopover during bird migration. Research suggests it is considerably more important than eastern Massachusetts or southeastern New Hampshire and Maine.
- Most bird species that undergo migration (both Short- and Long-Distance migration) utilize our state more as migratory stopover habitat than as breeding habitat. Providing high-quality habitat for these birds is therefore critical to ensure that they are able to make their journey successfully.
- In the spring, migrant diversity increases steadily until breeding season on Audubon properties, with the median date of peak detection falling between May 5 and May 11.
- During the fall, the total number of Neotropical (Long-Distance) migrants declines throughout the season as the number of Nearctic (Short-Distance) migrants increases. The median date of peak detection falls between October 7 and October 11.
- While the conservation of large, undisturbed and well-connected tracts of habitat are essential at providing breeding and overwintering habitat, the Audubon Society of Rhode Island should also focus on protecting small and isolated habitat patches throughout the state to provide for the needs of migrating birds.

American Goldfinch *(Spinus tristis)*

The Audubon Avian Research Initiative

A three-step management plan to mitigate local decline and contribute to regional population growth.

Step 1

Baseline Data Collection and Identification of "Responsibility Birds"

- Collection of baseline data on distribution, abundance, habitat associations and long-term population trends for all species breeding, overwintering and migrating through Audubon Society of Rhode Island properties.
- Identification of "Responsibility Birds" that are in need of additional monitoring and management recommendations.

Step 2

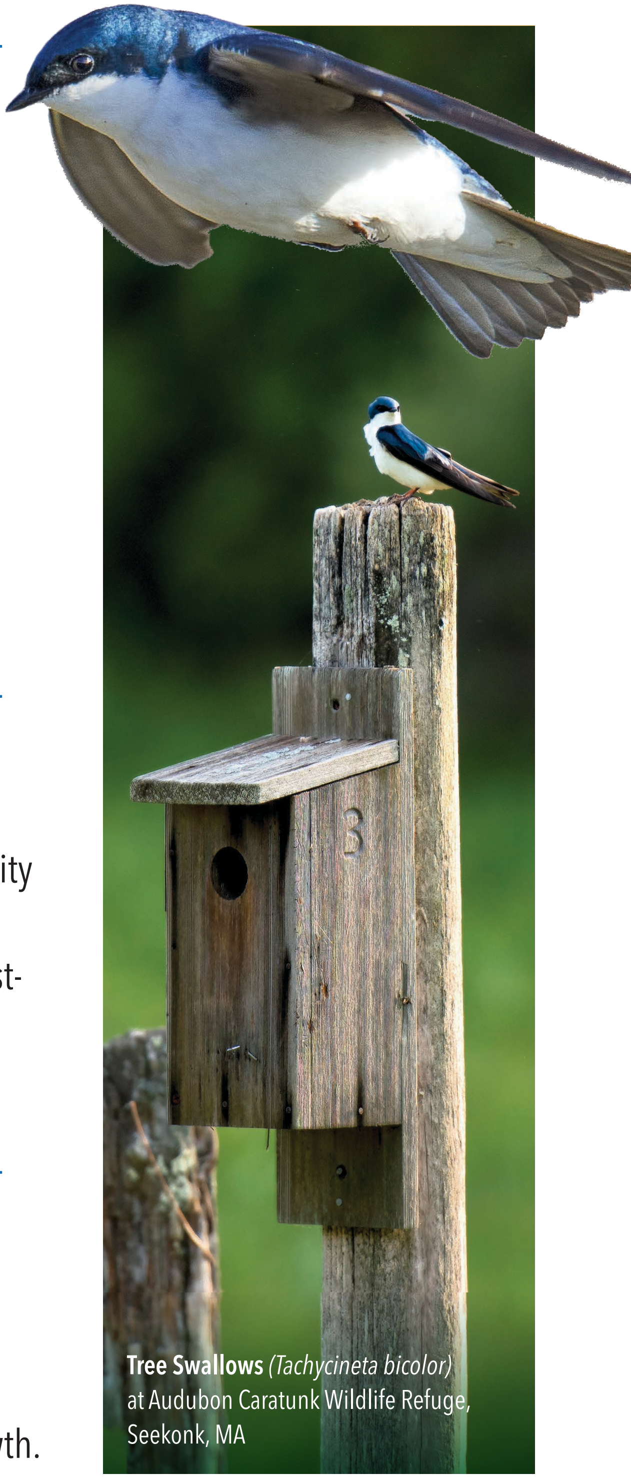
Detailed Monitoring of "Responsibility Birds"

- Monitoring schemes will be implemented for all "Responsibility Birds" to collect detailed data on habitat-use, productivity and phenology (timing of important biological events, such as nest-building, egg-laying, chick-fledging, molting and migration).

Step 3

Implementation of Management Plans

- Management plans informed by baseline data collection and targeted monitoring will be implemented to mitigate local declines and contribute to state and regional population growth.



Tree Swallows *(Tachycineta bicolor)* at Audubon Caratunk Wildlife Refuge, Seekonk, MA

Management Recommendations

Every acre of conservation land counts.

To truly understand any natural system, continuous data collection is a necessity. Intra- and interannual variability in weather, prey availability, bird movements and habitat use makes it near impossible to detect patterns and create effective management plans using a single season of data. This report provides the starting point for better understanding how birds utilize our properties during periods of migration. Without question, our land is important to birds. Protected habitats provide refuge to birds seeking to replenish lost energy reserves and stock up for pending migratory movements. The degree to which Audubon properties provide these resources likely changes annually.

At its core, this research initiative seeks to understand when, on average, birds move through our state and how much turnover exists in the avian community during these periods (which enables us to determine the capacity of our properties to provide the requisite resources that fuel their migrations). The chronology of migration can help predict which species will most likely experience a "phenological mismatch" with the resources they require and may ultimately aid in determining how best to mitigate population loss. Moving forward, the Audubon Society of Rhode Island will plan to:

Continue monitoring migratory movements

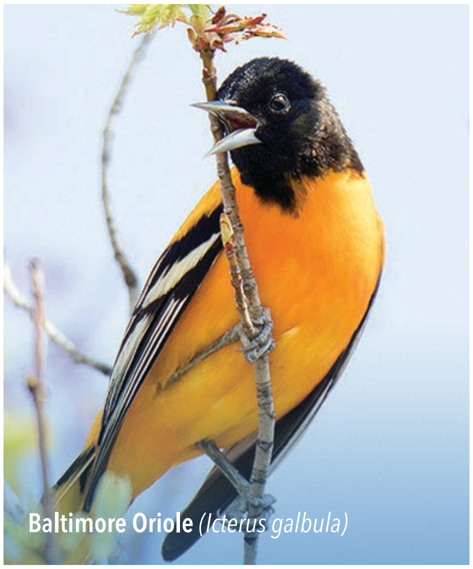
Data collection on migratory birds will continue across Audubon properties, allowing us to refine our migration chronology data, better capture the "true" breadth of the avian community that passes through our refuges, and build on the trends we have established with this preliminary report.

Ensure that our landholdings include all potential habitats that are useful to migrating birds

It is well-established that birds not only rely on large, contiguous tracts of intact habitat for nesting, overwintering and migration, but that small, isolated habitat "islands" hold their own importance for providing for birds in need, particularly during times of movement. Birds utilizing the Atlantic Flyway during migration may require emergency provisions along their journey. Having small patches of habitat, particularly in the most urban environments, is essential to providing birds the lifeline they may need during periods of increased stress. The Audubon Society of Rhode Island currently protects many small (< 20 acre) parcels in the state. Documenting use of these small habitat patches by migrating birds will commence in the fall of 2023.

Common Yellowthroat *(Geothlypis trichas)* at Audubon Maxwell Mays Wildlife Refuge, Coventry, RI

Belted Kingfisher *(Megaceryle alcyon)*



Baltimore Oriole *(Icterus galbula)*

Background and Methodology

Background

Approximately half of all bird species on earth undergo some form of migration during their annual cycle. For these species, migration represents the most energetically expensive and dangerous periods in their lives (Sillett and Holmes 2002, Rushing et al. 2017, Bayly et al. 2019). Migration accounts for half of the mortality avian populations experience during the course of a year and birds in migration face a risk of death that is six-times higher than during the period of the year in which they are stationary (Klaassen et al. 2014). While some species of bird undergo staggering nonstop migrations of thousands of kilometers (Watts et al. 2021), most species do not possess the requisite energetic stores to complete a nonstop journey and require refueling along their migratory route (Moore 2018, Bayly et al. 2019).

Some species may incorporate multiple stopover sites, highlighting the crucial role these refueling locations play in the annual success of migratory birds. Individual birds may spend as much as 30% of their total annual cycle refueling at stopover locations either en route to northerly breeding grounds or southerly overwintering areas (Mehlman et al. 2005), and up to 95% of the period of migration may be spent at stopover sites (Alerstam 2003). Birds seek to replenish metabolized energy stores during periods of stopover, and individuals in poorer nutritional condition typically remain at these sites for lengthier periods of time, increasing their exposure to numerous threats, including degraded habitats and predation (Dierschke 2003).

Black-throated Blue Warbler
(Setophaga caerulescens)

The Black-throated Blue Warbler *(Setophaga caerulescens)* is a long-distance migrant and flies approximately 3,000 km (1,864 mi) between its breeding and overwintering grounds.

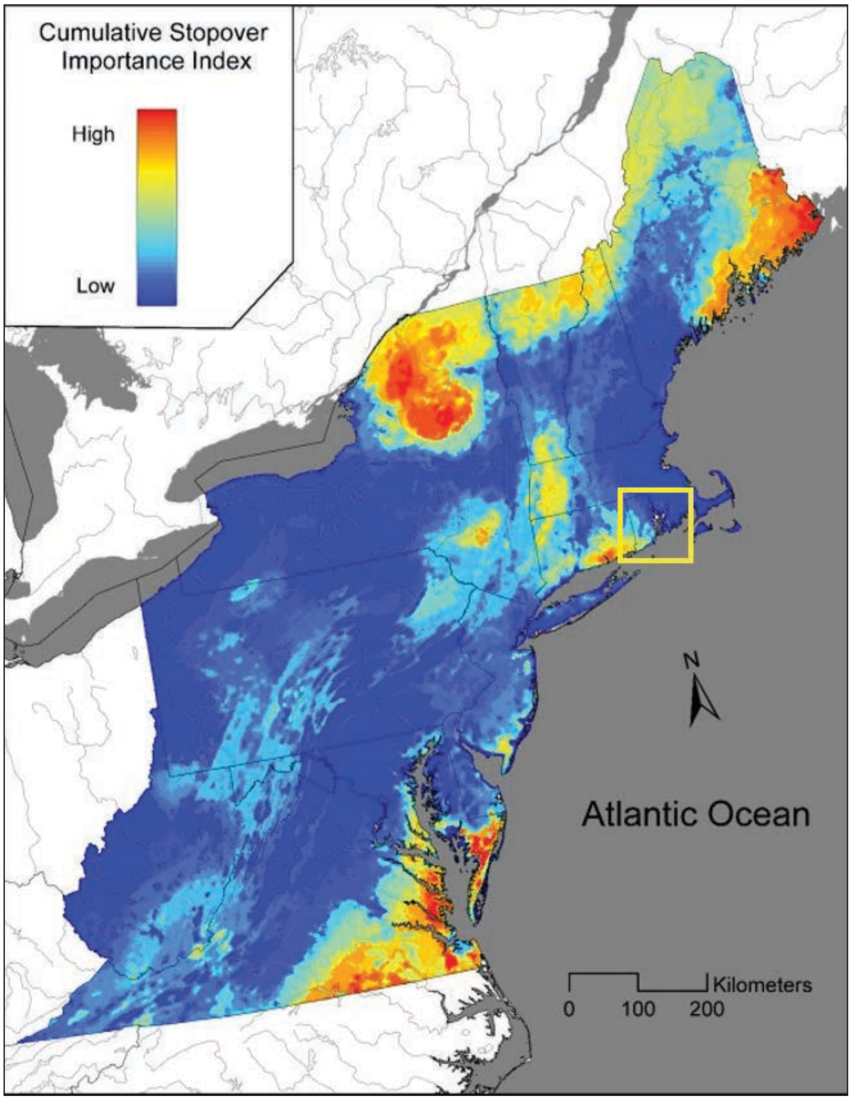
Staging shorebirds

An estimated 4,000 species of birds migrate, or roughly 40% of the total number of bird species on earth. Some shorebird species can fly over 14,484 km (9,000 mi) to reach their destination.

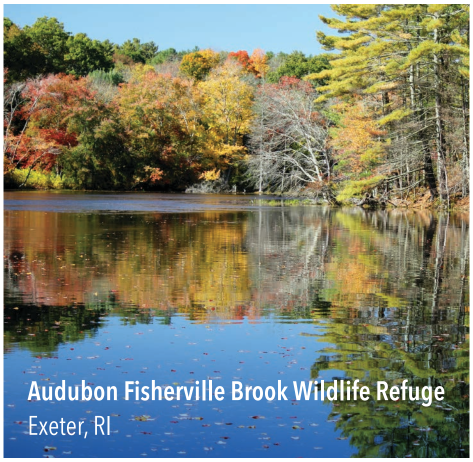
Background and Methodology

Stopover Importance

The amount of time a bird spends at a stopover site is influenced by the interactions of four main factors: 1) weather conditions, 2) the current physiological condition of the individual bird, 3) the risk of predation at a given stopover location and, 4) the availability of resources at previous and potential future stopover sites (Mehlman et al. 2005). Appropriate conservation of migratory stopover locations therefore requires the creation of a network of sites along established migratory routes, as these four factors lead to a great deal of variation in patch use by migrants. While high-quality habitat may be critical in some years, weather-driven migratory "fall outs" can lead to small, fragmented, non-conserved or low-quality habitat patches being used disproportionately at times (Mehlman et al. 2005). This spatial and temporal variation in habitat use during migration makes conservation planning difficult.



Stopover importance during fall migration along the mid-Atlantic and New England Regions. Importance was determined by ranking stopover use during the 2008 -2014 fall migration seasons (Buler et al. 2017). Note the high relative-importance of western Rhode Island (yellow box).



Audubon Fisherville Brook Wildlife Refuge
Exeter, RI

Audubon Touisset Marsh Wildlife Refuge
Warren, RI

Audubon Powder Mill Ledges Wildlife Refuge
Smithfield RI

Background and Methodology

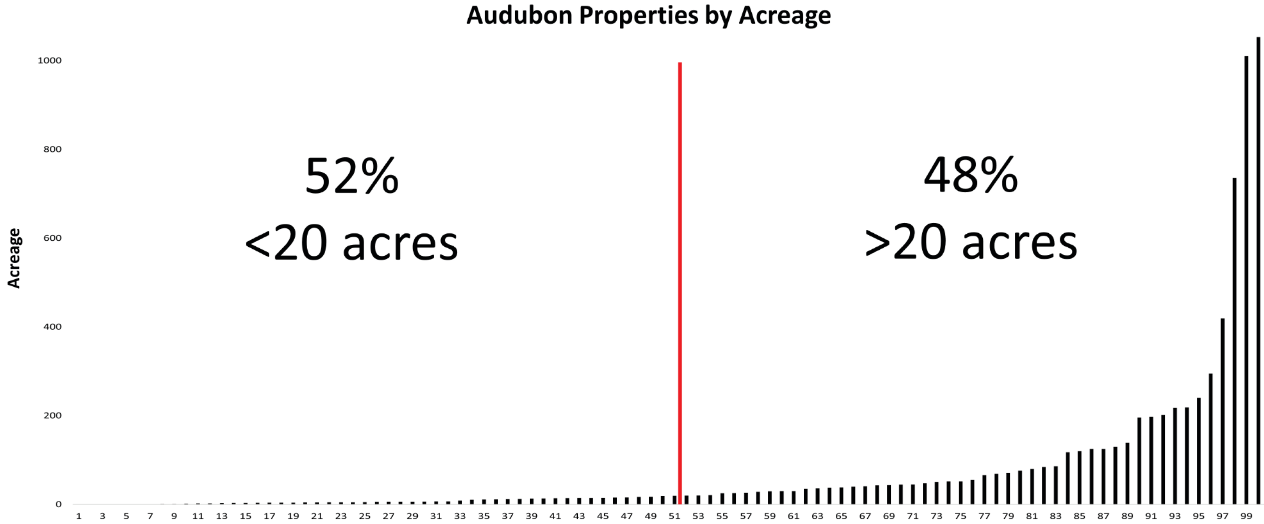
Audubon Properties

At the Audubon Society of Rhode Island, effective management of our protected land includes the conservation of large, contiguous patches of high-quality stopover habitat as well as small habitat patches that can serve as potential emergency stopover locations. These so called "fire escape" sites, (Mehlman et al. 2005) are absolutely crucial and, without them, migrating birds may not be able to find suitable stopover habitat during periods of high-stress, which may lead to increased mortality events.

The paradigm of identifying and conserving large tracts of "high-quality" habitat to provide for migrating birds represents a "conceptual barrier" to wildlife management practices. Although these kinds of habitats are critical to breeding and overwintering birds and more generally to the conservation of biodiversity, studies of avian movement and habitat use during periods of migration are elucidating the importance of small, isolated and "low-quality" habitats that often would not be considered to provide for the needs of migrants.

Small, fragmented parcels of habitat often possess elevated levels of biodiversity relative to the surrounding landscape (Szangolies et al. 2022) and may provide critical resources to birds undergoing migration. Recent research at the University of Florida documented that over 100 species of long-distance migrants will utilize habitat patches between 1–50 acres as stopover habitat (unpublished data). This is in addition to the species that would potentially utilize these sites during periods of emergency "fall out".

Small, isolated patches of habitat can provide critical resources to birds experiencing stress during periods of migration. Shown above: Neutaconkanut Park, Providence, RI.



Although the average size of all properties the Audubon Society of Rhode Island manages is 73 acres, 52% of the parcels are less than 20 acres in size. While most conservation projects focus on protecting large, well-connected habitats, the management of small parcels across the landscape offers important stopover locations for migratory bird species. Small conserved sites, even those completely surrounded by unusable habitat, can serve as critical "fire escapes" for migrating birds (Mehlman et al. 2005).

Background and Methodology

Bird-Habitat Associations

Climate change is expected to disproportionately affect our birds, with those species undergoing long-distance migrations suffering the greatest population losses through time. This report subdivides species by their migratory habit to allow for a better understanding of the phenology of these different types of migrants.

Nearctic (Short-Distance) Migrants

Nearctic species are those that spend the entirety of their annual cycle north of the Tropic of Cancer. These species typically nest and overwinter in temperate North America. For some species of Nearctic birds, small numbers of individuals may stay and overwinter in our state, such as the Pine Warbler and Eastern Towhee. For most species, after breeding across Canada and northern portions of the United States, individuals typically migrate to the southern U.S. and northern Mexico.

Neotropical (Long-Distance) Migrants

Neotropical migrants breed throughout the temperate regions of North America and spend the overwintering period south of the Tropic of Cancer. Many species of Neotropical migrant will fly to Central and South America during the non-breeding season. Individuals of some species, such as Cedar Waxwings (*Bombycilla cedrorum*) may actually overwinter in Rhode Island, while other individuals fly as far south as Honduras during the non-breeding period.

Resident Species

As the name suggests, these species tend to spend their entire annual cycle in one location. Of course, few birds maintain a year-round territory, so many resident species undergo nomadic or short-distance movements during the overwintering period. Still, relatively few birds travel long distances between the non-breeding and breeding seasons.

Birds that migrate through the state of Rhode Island consist of Nearctic and Neotropical Migrants. The designation refers to the geographic distribution of the species over the course of its annual cycle.

Commonly Encountered Nearctic Migrants:

Eastern Towhee *(Pipilo erythrophthalmus)*

Pine Warbler *(Setophaga pinus)*

Ruby-crowned Kinglet *(Regulus calendula)*

Commonly Encountered Neotropical Migrants:

Baltimore Oriole *(Icterus galbula)*

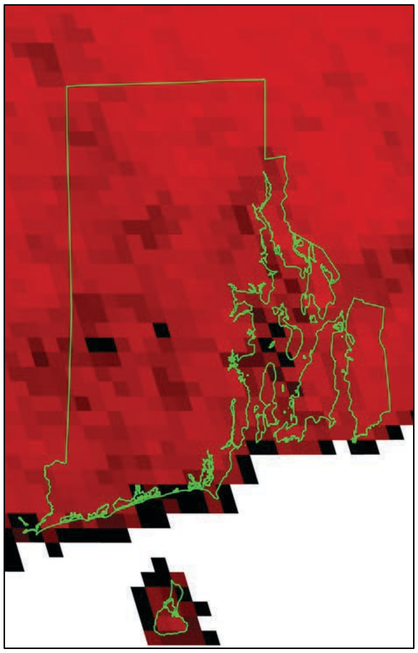
American Redstart *(Setophaga ruticilla)*

Gray Catbird *(Dumetella carolinensis)*

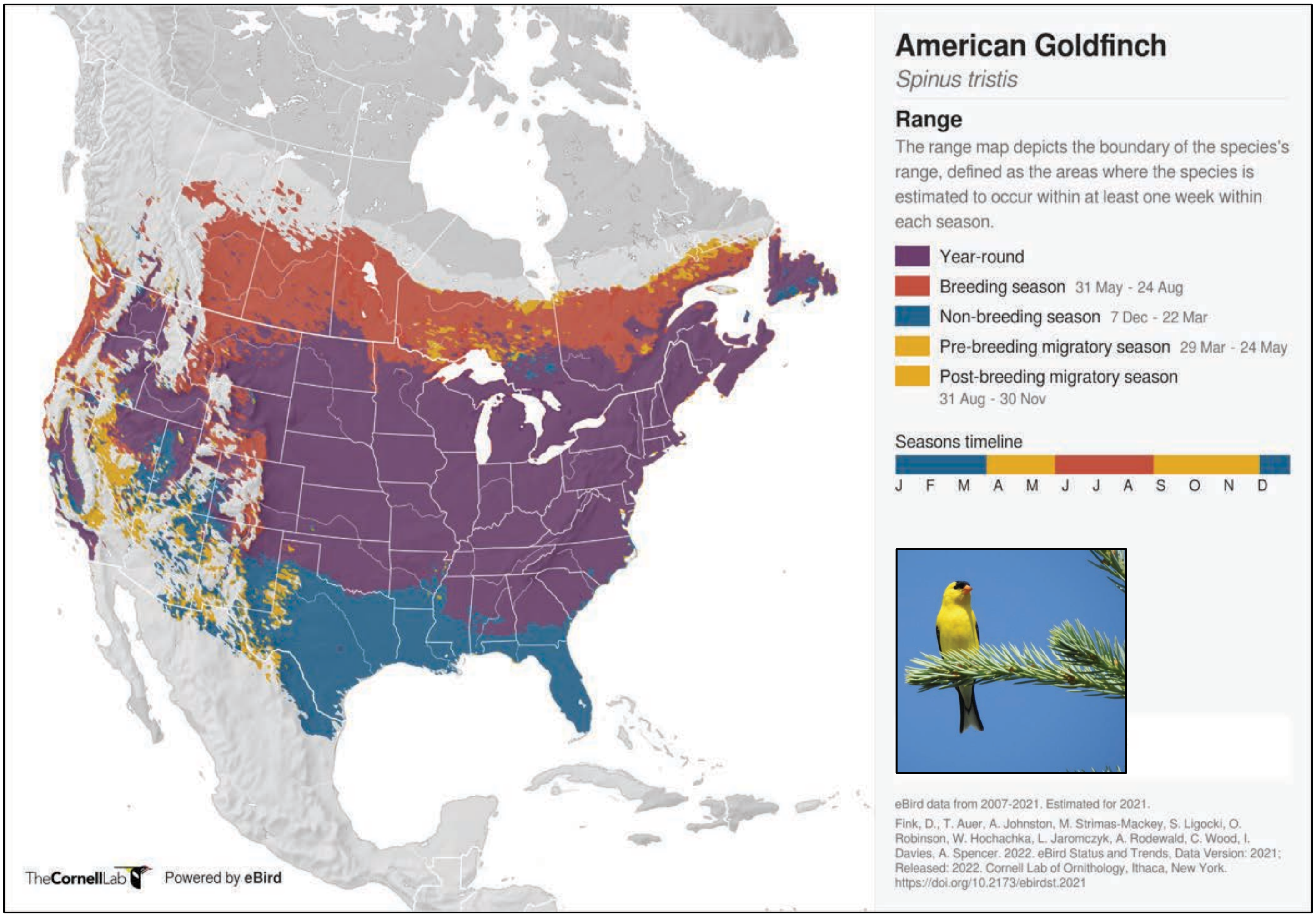
Background and Methodology

How Are Species Designated?

The American Goldfinch *(Spinus tristis)* is a species that can be found in Rhode Island year-round. However, some individuals do migrate south to the Gulf Coast and northern Mexico during the non-breeding season (see range map below). In Rhode Island, the abundance of American Goldfinches fluctuates throughout the year, with statewide abundances lower in the non-breeding season (1.1 birds per party hour) than in the breeding season (1.7 birds per party hour) (fewer individuals in the state during the non-breeding season). As the goal of this study was to understand the movement patterns of birds that undergo both long- and short-distance migrations, American Goldfinches, along with some other species that may be encountered in the state year-round, are considered Nearctic (Short-Distance) migrants as opposed to year-round residents. Our populations fluctuate as birds enter and leave the state. We do not know how far individuals that leave Rhode Island travel.



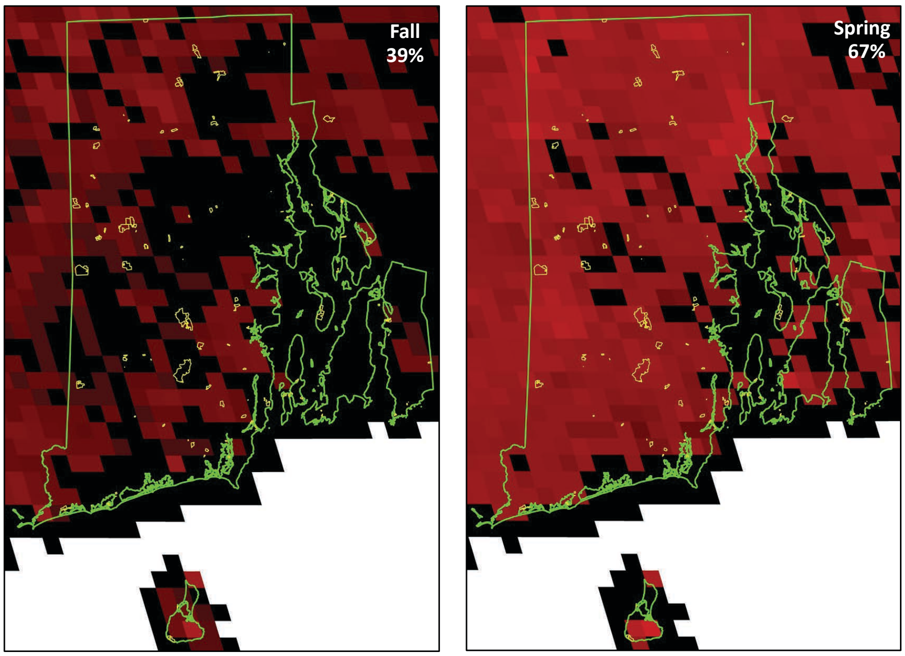
(Right) Data represent change in abundance between breeding and non-breeding season. Darker pixels indicate larger change in abundance between seasons (Data derived from Fink et al. (2022))



Background and Methodology

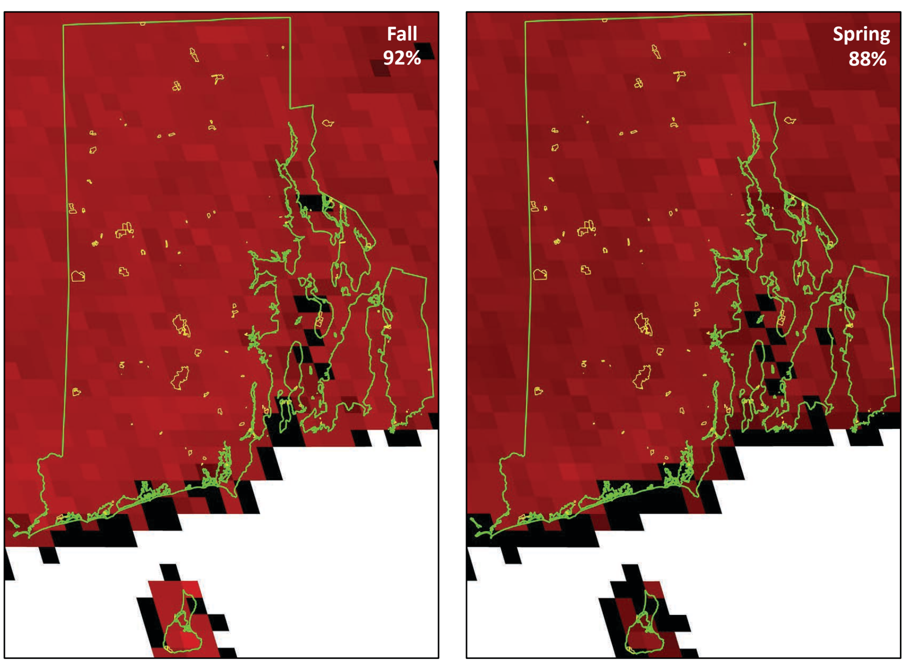
The percentage of Rhode Island used by birds during periods of migration changes.

Maps were created using data from eBird Status and Trends (Fink et al 2022) and were generated using QGIS (Ver 3.28.1). Yellow polygons represent Audubon properties. The red pixels indicate frequency of detection, with brighter red indicating higher frequencies.



Blackburnian Warblers are detected across much more of the state during spring migration than in fall. Only 7% of the state is used during the breeding season.

Blackburnian Warbler
(Setophaga fusca)



The Northern Parula, a Neotropical Migrant, is found throughout the state during both periods of migration, with slightly more of the state used during Fall. Only 21% of the state is used during the breeding season.

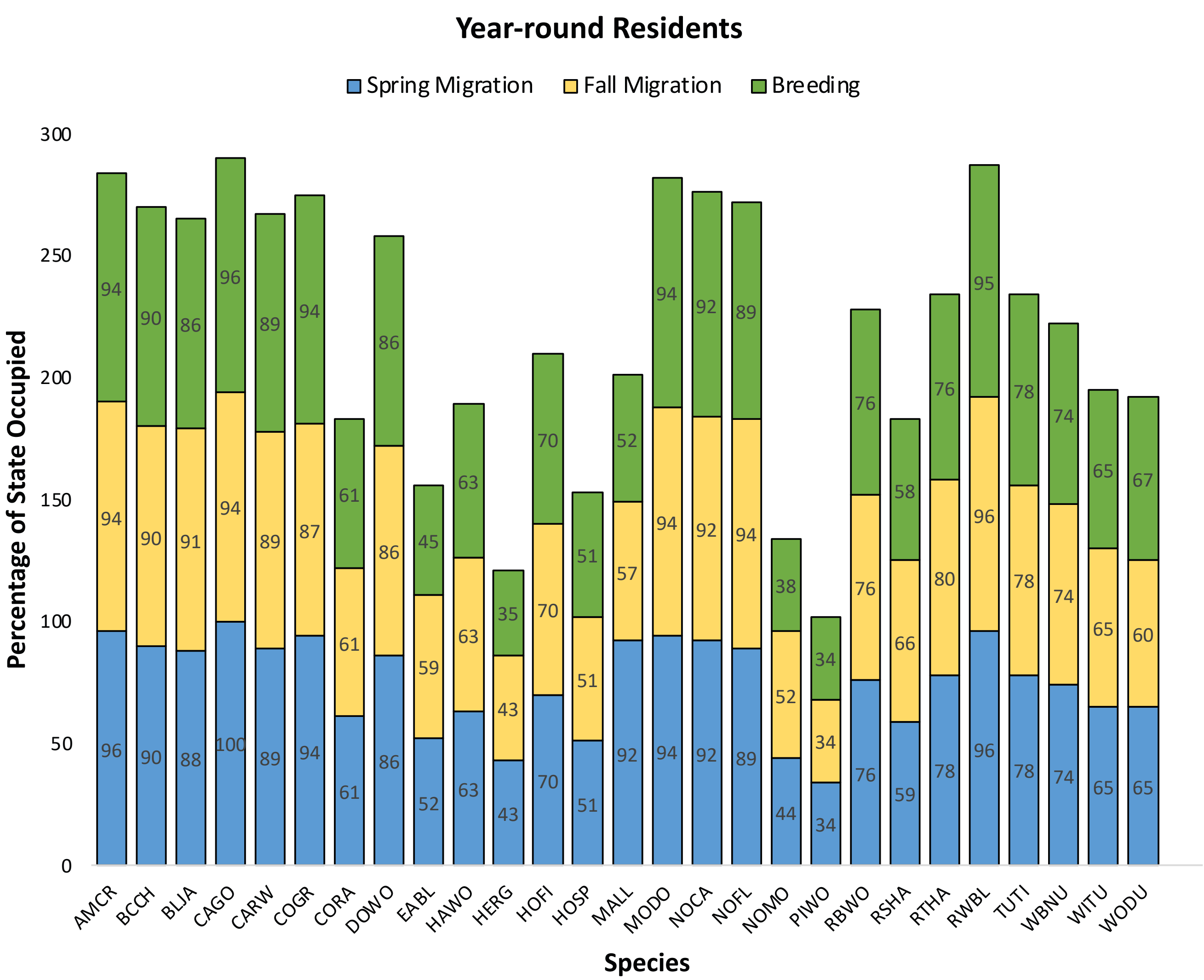
Northern Parula
(Setophaga americana)

Background and Methodology

How Birds Use Our State: Year-round Residents

The graph below illustrates the variability in use of Rhode Island by the most commonly detected Year-round Residents during surveys. Data represent the percentage of the state in which each species is detected during each time period of the year (spring and fall migration and breeding). Although a number of individuals for all of these species stay and breed in Rhode Island, 40% of Year-round Residents utilize the state more frequently during periods of migration than during the breeding season. For definitions of four-letter bird codes, refer to page 18.


Red-shouldered Hawk (*Buteo lineatus*)



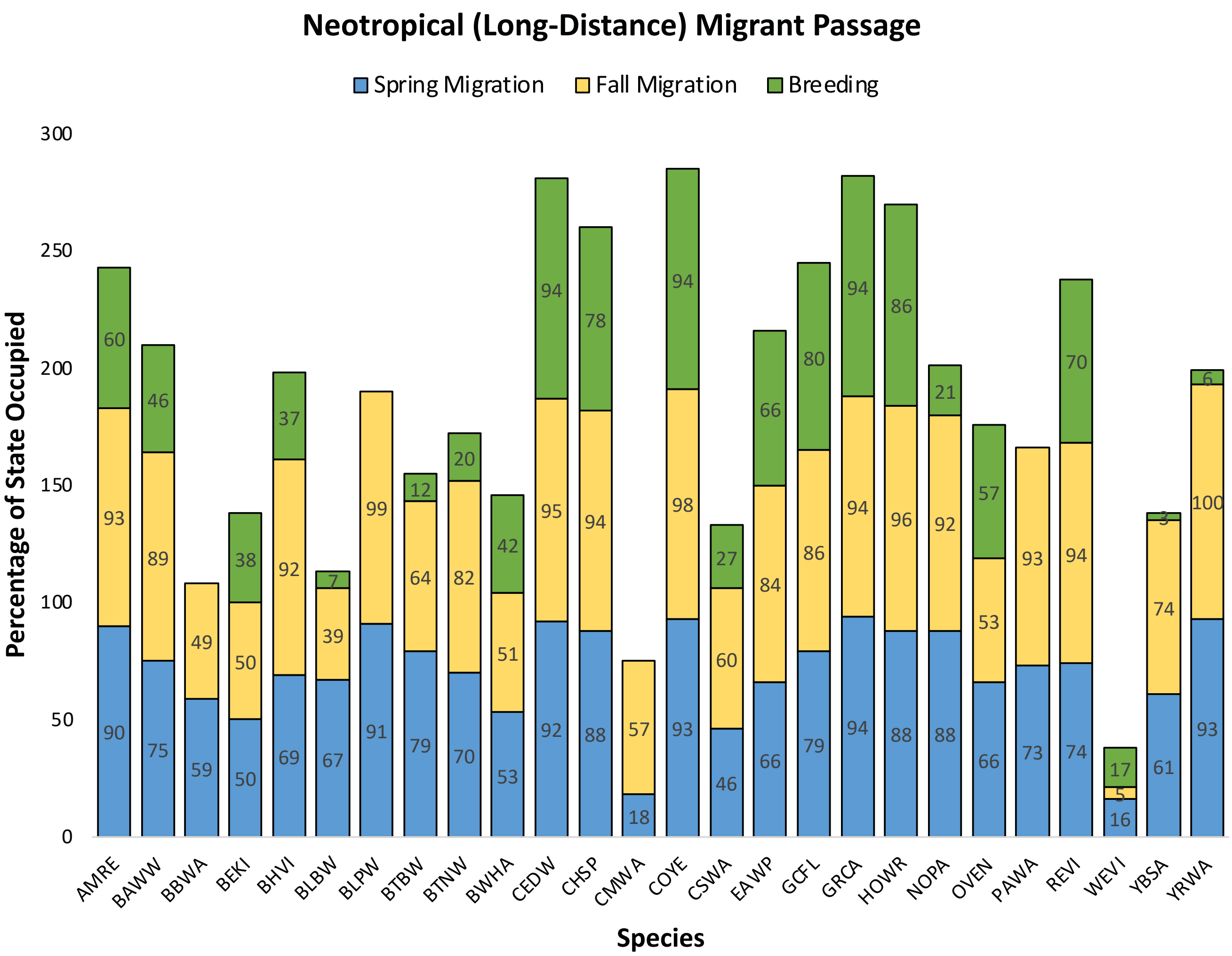
Data represent the percentage of the state within the range boundaries for a species for a given season and are averaged from 2007 – 2021. Data obtained from eBird Status and Trends (Fink et al 2022).

Background and Methodology

How Birds Use Our State: Neotropical Migrant Passage

The graph below illustrates the variability in use of Rhode Island by the most commonly detected Neotropical (Long-Distance) migrants during surveys. Data represent the percentage of the state in which each species is detected during each time period of the year (spring and fall migration and breeding). Most Neotropical migrants (96%) utilize the state more frequently during periods of migration than during the breeding season. For definitions of four-letter bird codes, refer to page 18.

Ovenbird (*Seiurus aurocapilla*)



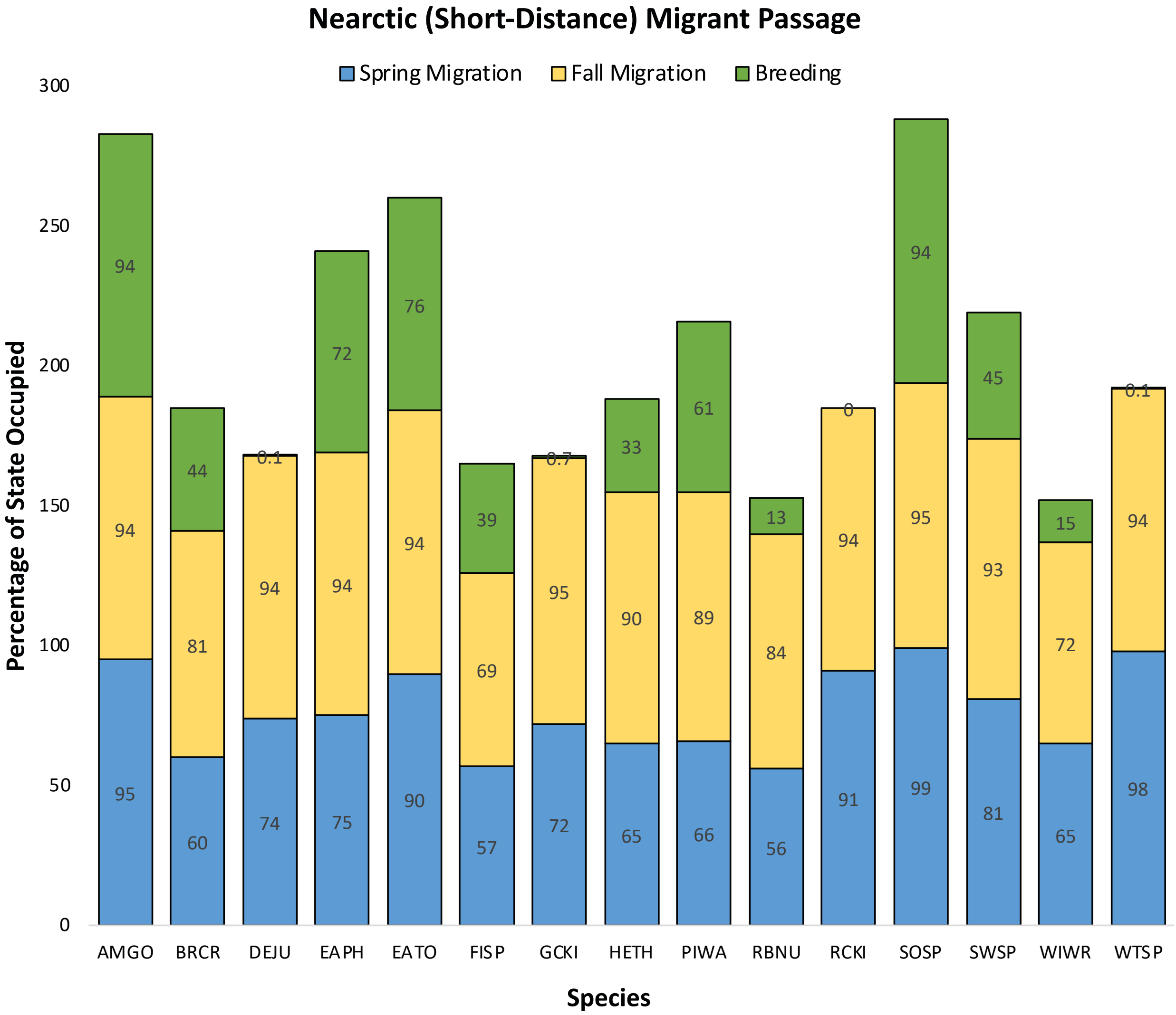
Data represent the percentage of the state within the range boundaries for a species for a given season and are averaged from 2007 – 2021. Data obtained from eBird Status and Trends (Fink et al 2022).

Background and Methodology

How Birds Use Our State: Nearctic Migrant Passage

The graph below illustrates the variability in use of Rhode Island by the most commonly detected Nearctic (Short-Distance) migrants during surveys. Data represent the percentage of the state in which each species is detected during each time period of the year (spring and fall migration and breeding). All Nearctic Migrants (100%) utilize the state more frequently during periods of migration than during the breeding season. For definitions of four-letter bird codes, refer to page 18.

Red-breasted Nuthatch *(Sitta canadensis)*



Data represent the percentage of the state within the range boundaries for a species for a given season and are averaged from 2007 – 2021. Data obtained from eBird Status and Trends (Fink et al 2022).

Bird Codes

CODE	SPECIES	MIGRATION TYPE
AMCR	American Crow	Resident
AMGO	American Goldfinch	Nearctic (Short-Distance) Migrant
AMRE	American Redstart	Neotropical (Long-Distance) Migrant
BAWW	Black-and-white Warbler	Neotropical (Long-Distance) Migrant
BBWA	Bay-breasted Warbler	Neotropical (Long-Distance) Migrant
BCCH	Black-capped Chickadee	Resident
BEKI	Belted Kingfisher	Neotropical (Long-Distance) Migrant
BGGN	Blue-gray Gnatcatcher	Neotropical (Long-Distance) Migrant
BHVI	Blue-headed Vireo	Neotropical (Long-Distance) Migrant
BLBW	Blackburnian Warbler	Neotropical (Long-Distance) Migrant
BLPW	Blackpoll Warbler	Neotropical (Long-Distance) Migrant
BLJA	Blue Jay	Resident
BRCR	Brown Creeper	Nearctic (Short-Distance) Migrant
BTBW	Black-throated Blue Warbler	Neotropical (Long-Distance) Migrant
BTNW	Black-throated Green Warbler	Neotropical (Long-Distance) Migrant
BWHA	Broad-winged Hawk	Neotropical (Long-Distance) Migrant
CAGO	Canada Goose	Resident
CARW	Carolina Wren	Resident
CEDW	Cedar Waxwing	Neotropical (Long-Distance) Migrant
CHSP	Chipping Sparrow	Neotropical (Long-Distance) Migrant
CMWA	Cape May Warbler	Neotropical (Long-Distance) Migrant
COGR	Common Grackle	Resident
CORA	Common Raven	Resident
COYE	Common Yellowthroat	Neotropical (Long-Distance) Migrant
CSWA	Chestnut-sided Warbler	Neotropical (Long-Distance) Migrant
DEJU	Dark-eyed Junco	Nearctic (Short-Distance) Migrant
DOWO	Downy Woodpecker	Resident
EABL	Eastern Bluebird	Resident
EAPH	Eastern Phoebe	Nearctic (Short-Distance) Migrant
EATO	Eastern Towhee	Nearctic (Short-Distance) Migrant

Bird Codes

CODE	SPECIES	MIGRATION TYPE
EAWP	Eastern Wood-Pewee	Neotropical (Long-Distance) Migrant
FISP	Field Sparrow	Nearctic (Short-Distance) Migrant
GCFL	Great Crested Flycatcher	Neotropical (Long-Distance) Migrant
GCKI	Golden-crowned Kinglet	Nearctic (Short-Distance) Migrant
GRCA	Gray Catbird	Neotropical (Long-Distance) Migrant
HAWO	Hairy Woodpecker	Resident
HERG	Herring Gull	Resident
HETH	Hermit Thrush	Nearctic (Short-Distance) Migrant
HOFI	House Finch	Resident
HOSP	House Sparrow	Resident
HOWR	House Wren	Neotropical (Long-Distance) Migrant
MALL	Mallard	Resident
MODO	Mourning Dove	Resident
NOCA	Northern Cardinal	Resident
NOFL	Northern Flicker	Resident
NOMO	Northern Mockingbird	Resident
NOPA	Northern Parula	Neotropical (Long-Distance) Migrant
NOWA	Northern Waterthrush	Neotropical (Long-Distance) Migrant
OVEN	Ovenbird	Neotropical (Long-Distance) Migrant
PAWA	Palm Warbler	Neotropical (Long-Distance) Migrant
PIWA	Pine Warbler	Nearctic (Short-Distance) Migrant
PIWO	Pileated Woodpecker	Resident
RBNU	Red-breasted Nuthatch	Nearctic (Short-Distance) Migrant
RBWO	Red-bellied Woodpecker	Resident
RCKI	Ruby-crowned Kinglet	Nearctic (Short-Distance) Migrant
REVI	Red-eyed Vireo	Neotropical (Long-Distance) Migrant
RSHA	Red-shouldered Hawk	Resident
RTHA	Red-tailed Hawk	Resident
RWBL	Red-winged Blackbird	Resident

Bird Codes

CODE	SPECIES	MIGRATION TYPE
SCTA	Scarlet Tanager	Neotropical (Long-Distance) Migrant
SOSP	Song Sparrow	Nearctic (Short-Distance) Migrant
SWSP	Swamp Sparrow	Nearctic (Short-Distance) Migrant
TUTI	Tufted Titmouse	Resident
VEER	Veery	Neotropical (Long-Distance) Migrant
WBNU	White-breasted Nuthatch	Resident
WEVI	White-eyed Vireo	Neotropical (Long-Distance) Migrant
WITU	Wild Turkey	Resident
WIWR	Winter Wren	Nearctic (Short-Distance) Migrant
WODU	Wood Duck	Resident
WOTH	Wood Thrush	Neotropical (Long-Distance) Migrant
WTSP	White-throated Sparrow	Nearctic (Short-Distance) Migrant
YBSA	Yellow-bellied Sapsucker	Neotropical (Long-Distance) Migrant
YRWA	Yellow-rumped Warbler	Neotropical (Long-Distance) Migrant

Rethinking Migration

The Brown Creeper *(Certhia americana)* is found in Rhode Island throughout the year, leading many to consider the species a resident. However, although individual creepers may be detected in the state year-round, it is rather unlikely that these are the same individuals. Some birds may fly as far south as Northern Mexico in the non-breeding season and Brown Creepers are listed as one of the seven most susceptible species to building collisions during migration (American Bird Conservancy).

For the purposes of this report, the species is considered a Nearctic (Short-Distance) migrant to better enable the Audubon Society of Rhode Island to accommodate its needs during periods of migration.

Brown Creeper *(Certhia americana)*

Methodology

Spring Migration

A total of 6 Acoustic Recording Units (ARUs; SM4 recorders, Wildlife Acoustics) were deployed at Audubon properties during the first week of April 2022 (Figures 1 & 2). Recorders were equipped with two omni-directional microphones (sensitivity: -35 ± 4 db (0 dB=1V/pa@1KHZ)) to capture the soundscape and were programmed to record from 0400 until 2100 each day with a 30-minute duty cycle (30-minutes of recording followed by 30-minutes of no recording) throughout the recording window. A 500GB SD card in each ARU allowed for data capture without periodic downloading. ARUs were checked monthly to ensure they were working properly and batteries were replaced during each visit.

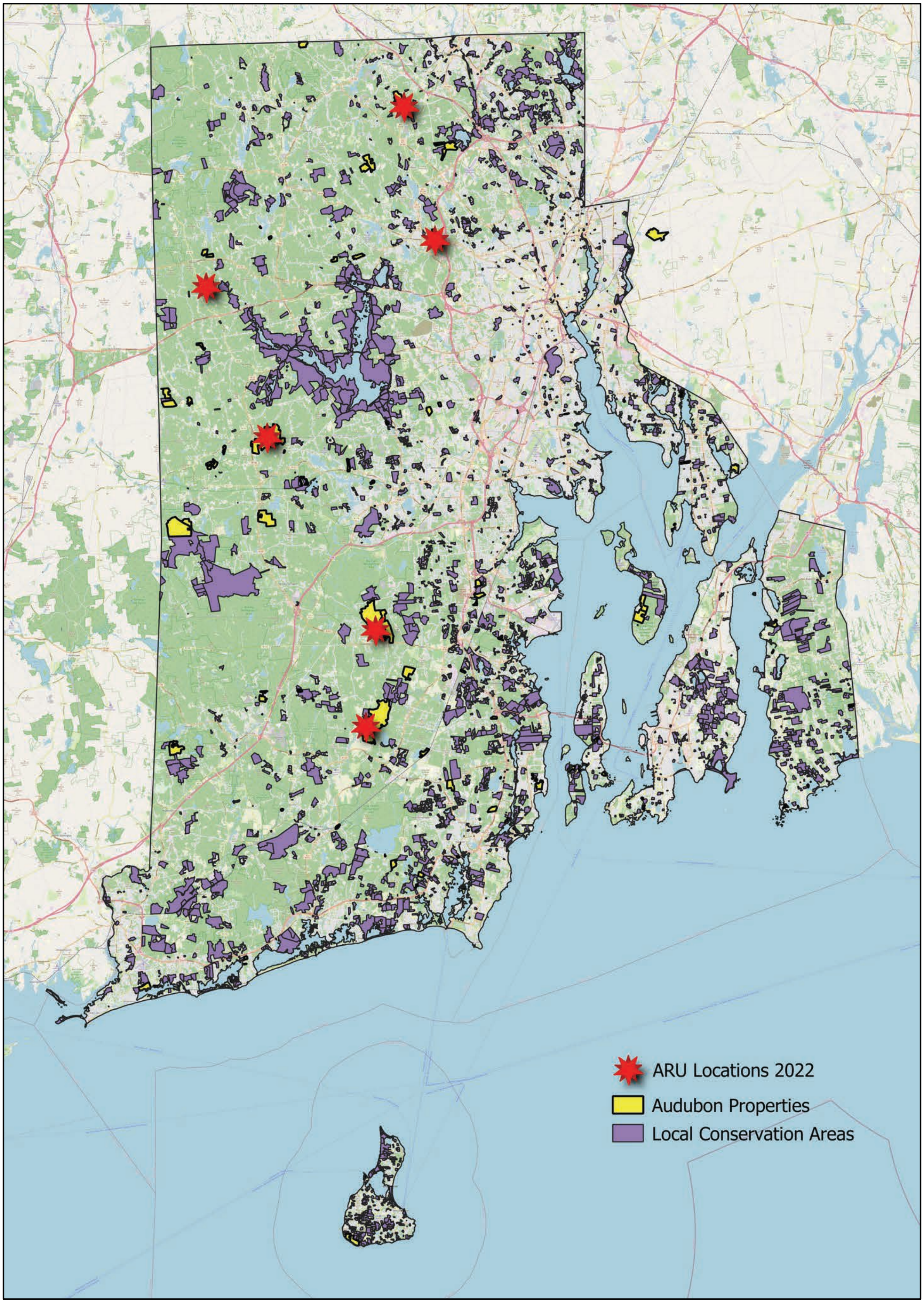
ARUs were placed in the three most prolific habitats found on Audubon Refuges: Deciduous Forest, Mixed Coniferous/Deciduous Forest and Forested Swamp. For each of these three habitat types, an ARU was placed in the largest contiguous tract of the habitat type we manage and a second was placed within a tract of habitat that was of the average size we manage (averaged across all Audubon properties, Table 1).

Figure 1. Acoustic Recording Units (ARUs), such as the one pictured here, were deployed at six Audubon Wildlife Refuges and recorded the soundscape in three distinct habitat types during the period of spring migration.

Table 1. The Audubon properties where Acoustic Recording Units (ARUs) were deployed.

Audubon Refuge	Habitat Type	Habitat Patch Size (acres)
George Parker Woodland Wildlife Refuge (PAWO)	Deciduous Forest (Large)	589.4
Powder Mill Ledges Wildlife Refuge (PML)	Deciduous Forest (Average)	54.5
Marion Eppley Wildlife Refuge (MAEP)	Forested Swamp (Large)	505.8
Fort Wildlife Refuge (FORT)	Forested Swamp (Average)	22.9
Fisherville Brook Wildlife Refuge (FIBR)	Mixed Coniferous/Deciduous (Large)	292.9
Cardi Swamp Wildlife Refuge (CARDI)	Mixed Coniferous/Deciduous (Average)	52.8

Figure 2. The location of the six Acoustic Recording Units (ARUs) placed on Audubon properties (red stars).



Methodology

Fall Migration

Fall migration data were collected from 1 September to 1 November 2022 across 11 Audubon properties (Table 2).

In order to capture the phenology of passage migrants, volunteers repeated surveys along designated transects every 3-4 days during the survey window. During each visit, all birds detected were recorded and birds encountered as part of a flock were designated as such. Volunteers recorded environmental variables (wind speed, sky conditions, temperature) during their survey and transects were not walked when inclement weather (wind, rain) was likely to reduce detection rates. Volunteers also recorded method of detection (bird was heard, seen or both), and when possible individual age and sex were noted.

When possible, birds encountered during fall transect surveys were identified by sex. For some species, such as this (male) Downy Woodpecker (*Picoides pubescens*), the distinction is relatively easy.

Table 2. The Audubon properties where sampling occurred during both spring and fall migration periods.

Audubon Property	Acreage	Sampling Effort
Fisherville Brook Wildlife Refuge	1,010	Spring, Fall
Caratunk Wildlife Refuge	200	Fall
Davis Memorial Wildlife Refuge	40	Fall
Fort Wildlife Refuge	235	Spring, Fall
Maxwell Mays Wildlife Refuge	295	Fall
Claire D. McIntosh Wildlife Refuge	28	Fall
George Parker Woodland Wildlife Refuge	860	Spring, Fall
Powder Mill Ledges Wildlife Refuge	100	Spring, Fall
Emilie Ruecker Wildlife Refuge	50	Fall
Touisset Marsh Wildlife Refuge	66	Fall
Waterman Pond Wildlife Refuge	28	Fall
Marion Eppley Wildlife Refuge	~1200	Spring
Cardi Swamp Wildlife Refuge	141	Spring

Data Analysis and Results

A total of 3.5 hours of recordings were analyzed for each ARU during the period of dawn chorus when vocal behavior of migrant birds was maximal (Figure 3). Recordings were analyzed from 0700 – 0730 every five days beginning on 20 April and ending on 20 May. This represents the time of day when vocal activity is high and the period when most migrants move through the state of Rhode Island (Figure 4).

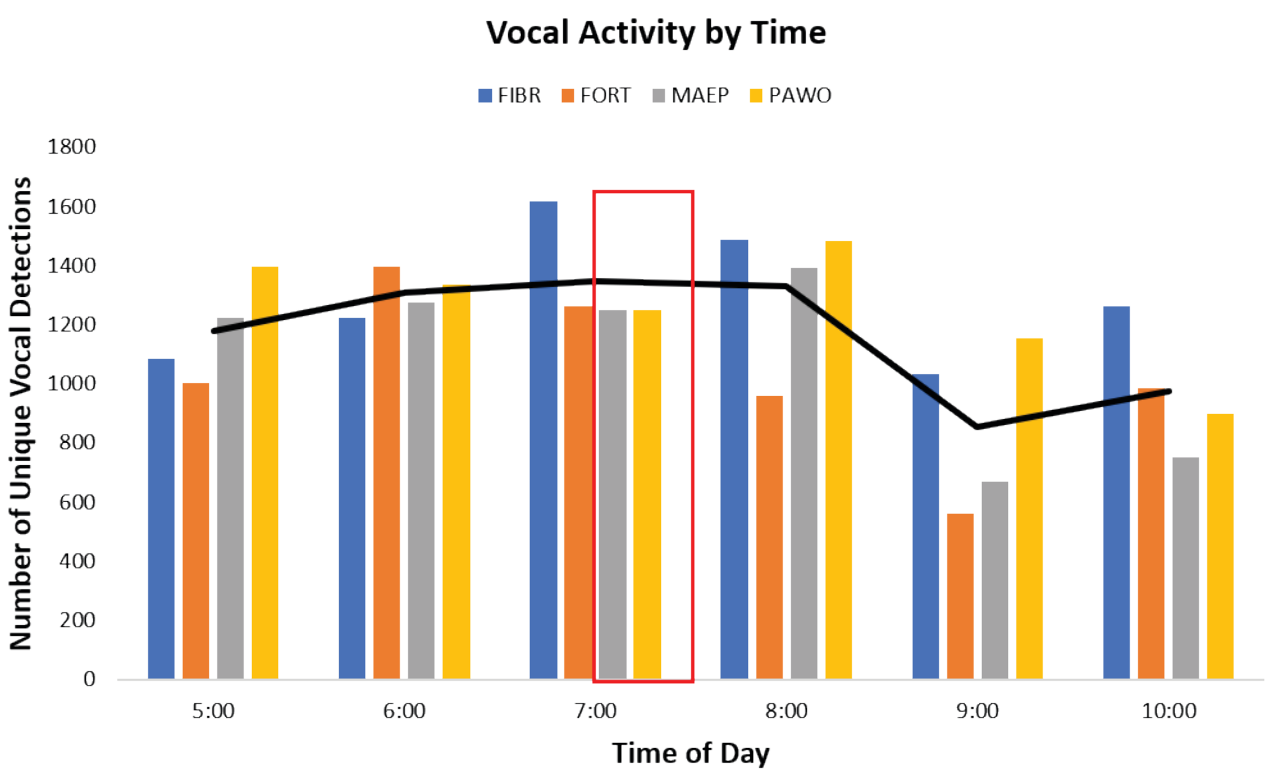
This sampling rate resulted in the identification of 49,743 unique vocal detections, or an average of 1,184 vocal detections per 30-min period (Kaleidoscope Pro Ver 5.4.8). A cluster analysis was performed on all audio samples and, where appropriate, a band-pass filter was applied to remove low-frequency ambient noise (Figure 5).

Bar and whisker plots were created for all species detected during spring and fall surveys to determine chronology of arrival and departure dates from the survey areas.

Alpha diversity (total number of species per survey) as well as proportion of migrant type was determined and hierarchical cluster dendrograms were created to determine degree of similarity between the avian communities detected at each of the 6 ARU locations (spring) and for each transect visit (fall). The clustering compared total species detection at each location and shared species between sites and paired locations based on degree of similarity (Jaccard Index). Analyses were conducted using the "ade" package in R (Thioulouse et al. 2018; Ver 4.2.2).

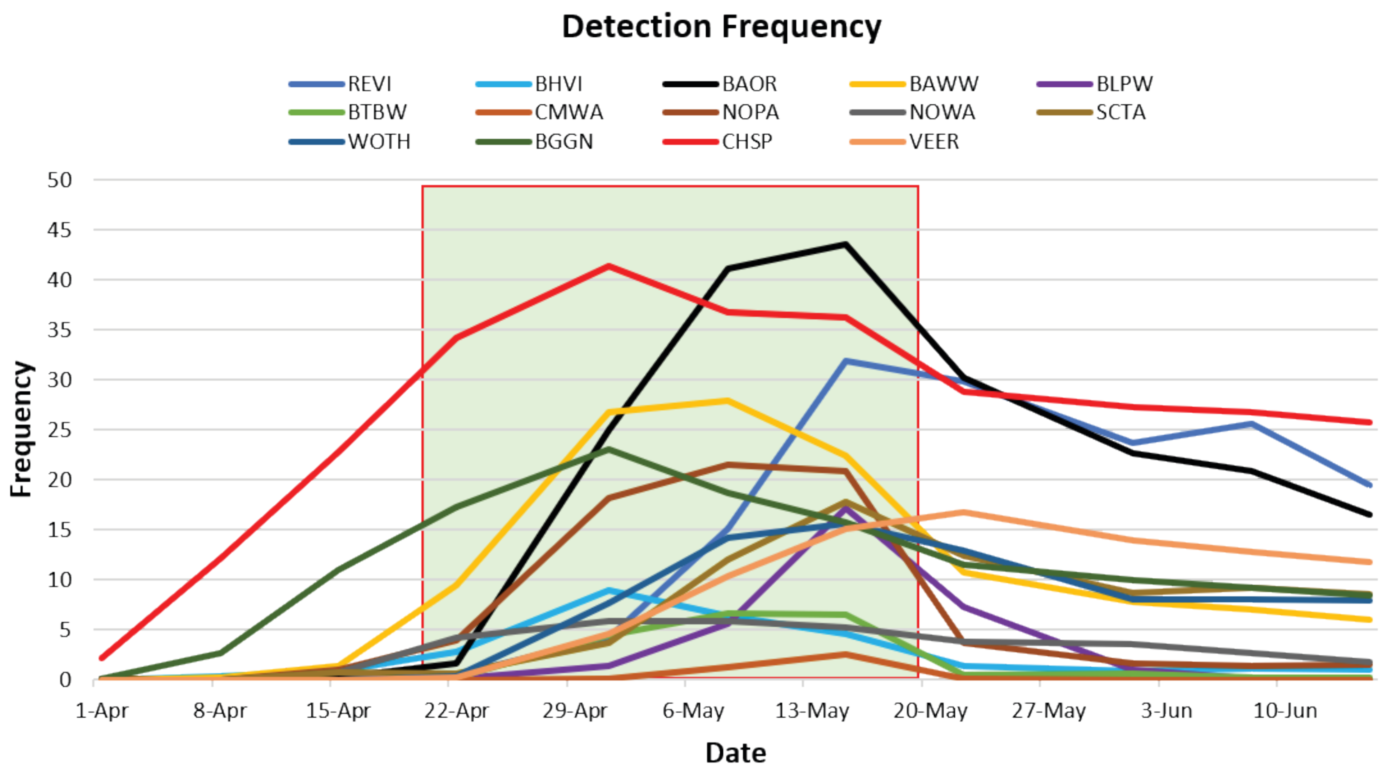
Because ARUs do not enable the enumeration of individuals, no abundance metrics were computed for the period of spring migration, while analysis of fall migration included cumulative encounter rates for all three migrant types as well as turnover (number of new arrivals and departures between each successive survey date).

Figure 3. Vocal activity across four Audubon properties during spring migration. The peak period of vocal activity coincided with the period of data analysis (0700 – 0730; red box). The black line represents average vocal activity. For definitions of Audubon Refuges, see Table 1 (page 21).



Data Analysis and Results

Figure 4. Detection frequency for 14 Long-Distance migrant species. The survey window (green box) coincides with the peak period of detection (data obtained from: Fink et al. 2022). For interpretation of Bird Codes, see page 18.



Baltimore Oriole *(Icterus galbula)*

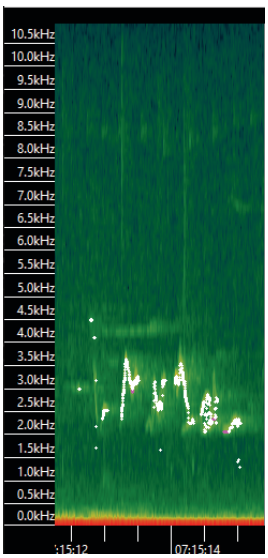
Blackpoll Warbler *(Setophaga striata)*

Northern Parula *(Setophaga americana)*

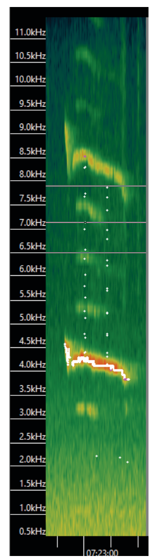
Data Analysis and Results

Software was used to cluster vocalizations by similarity in frequency (y-axis) and duration (x-axis). After cluster analysis was performed, sonograms were listened to in order to identify species. Frequency is measured in "Kilohertz; kHz", which is a metric of the "cycles per second" or the number of times a sound changes per second to produce the sound we hear. For reference, the highest note on a standard piano has a frequency of approximately 4 kHz. The intensity of the sound is represented as a color, with red, yellow and white vocalizations being more intense. Intensity can vary based on the orientation of the bird relative to the recording microphone or how loudly a bird chooses to vocalize. A cluster analysis was performed on all audio samples and, where appropriate, a band-pass filter was applied to remove low-frequency ambient noise (Figure 5).

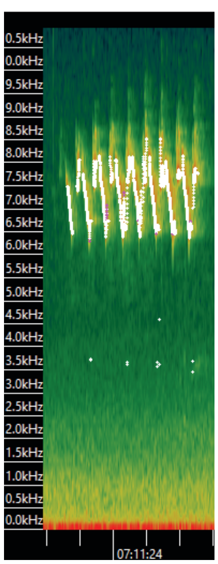
Figure 5. Example sonograms (visual representations of the energy produced when a bird vocalizes) of different species detected by Acoustic Recording Units (ARUs) placed at six Audubon properties.



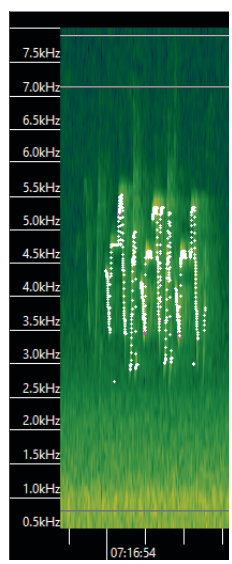
Scarlet Tanager
(Piranga olivacea)



Broad-winged Hawk
(Buteo platypterus)



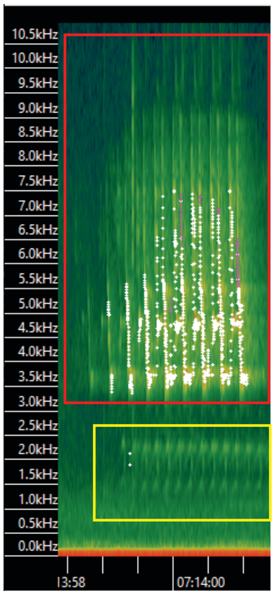
Black-and-white Warbler
(Mniotilta varia)



Common Yellowthroat
(Geothlypis trichas)

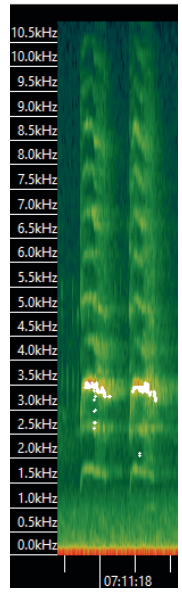
Data Analysis and Results

Figure 5. Continued

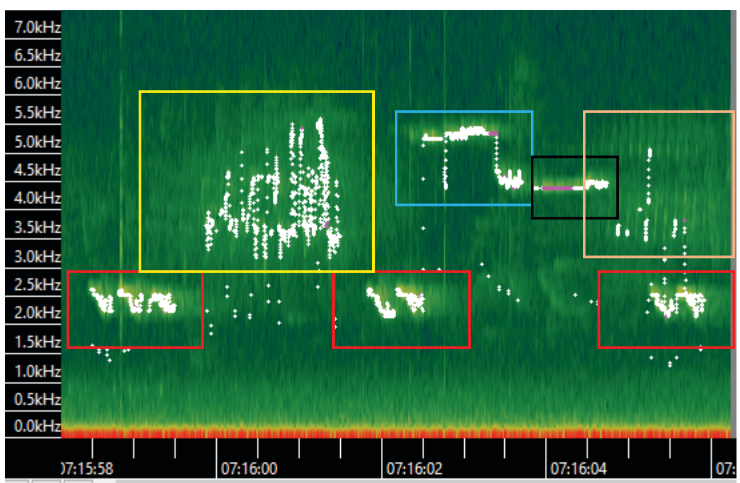


Ovenbird
(Seiurus aurocapilla)

White-breasted Nuthatch
(Sitta carolinensis)



Blue Jay
(Cyanocitta cristata)



Ovenbird
(Seiurus aurocapilla)

Tufted Titmouse
(Baeolophus bicolor)

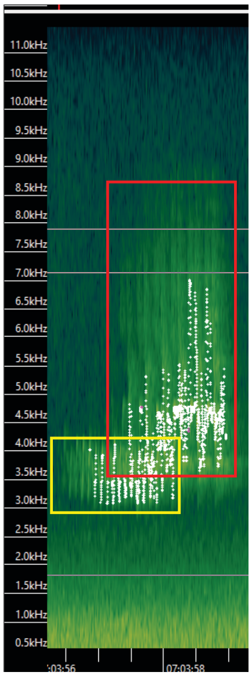
Black-throated Green Warbler
(Setophaga virens)

Broad-winged Hawk
(Buteo platypterus)

Pine Warbler
(Setophaga pinus)

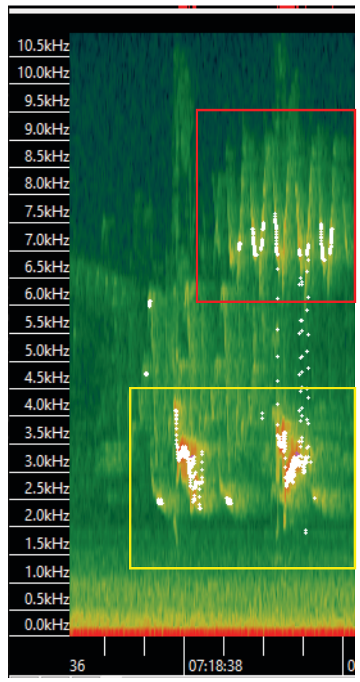
Data Analysis and Results

Figure 5. Continued



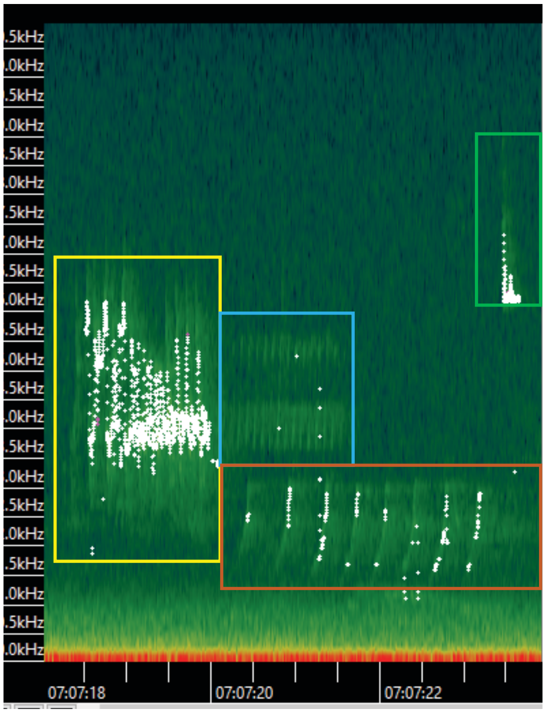
Ovenbird
(Seiurus aurocapilla)

Pine Warbler
(Setophaga pinus)



Black-and-white Warbler
(Mniotilta varia)

Yellow-throated Vireo
(Vireo flavifrons)



Northern Waterthrush
(Parkesia noveboracensis)

Pine Warbler
(Setophaga pinus)

Northern Cardinal
(Cardinalis cardinalis)
Song

Northern Cardinal
(Cardinalis cardinalis)
Call Note

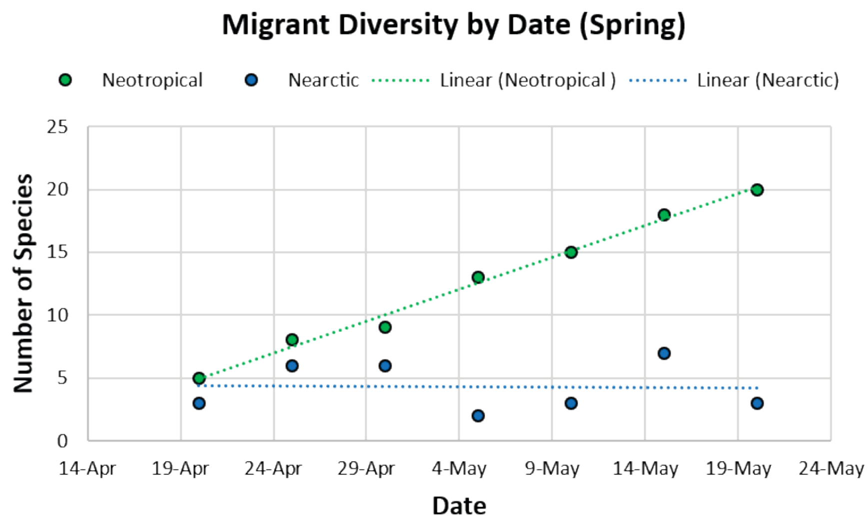
THE STATE OF OUR BIRDS

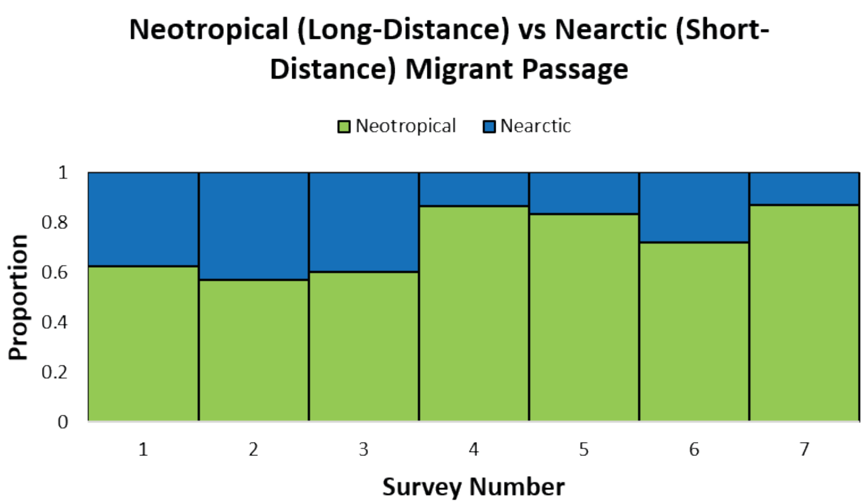
Spring Migration

Migrant Diversity

During spring migration, the number of Neotropical (Long-Distance) migrant species increased over the course of the sampling period when summed across all Audubon properties. Concurrently, the number of Nearctic (Short-Distance) migrant species remained relatively consistent. This is to be expected as a larger number of individuals for each Nearctic migrant species overwinter in Rhode Island and are therefore "available" for detection throughout the survey window. Therefore, even though the total number of individuals within the Nearctic migrant group may increase over the course of the sampling period (as individuals that overwintered south of Rhode Island move north), they do not influence the overall species assemblage.

Relatively few Neotropical migrants overwinter in the state and most travel to the Central and South American tropics during the non-breeding season. Birds traveling from these areas tend to arrive later in the season as a result of their lengthier migrations and the total number of Neotropical migrant species swells towards the end of the survey window. This also accounts for why the overall proportion of Neotropical migrants increases through time (bottom graph).

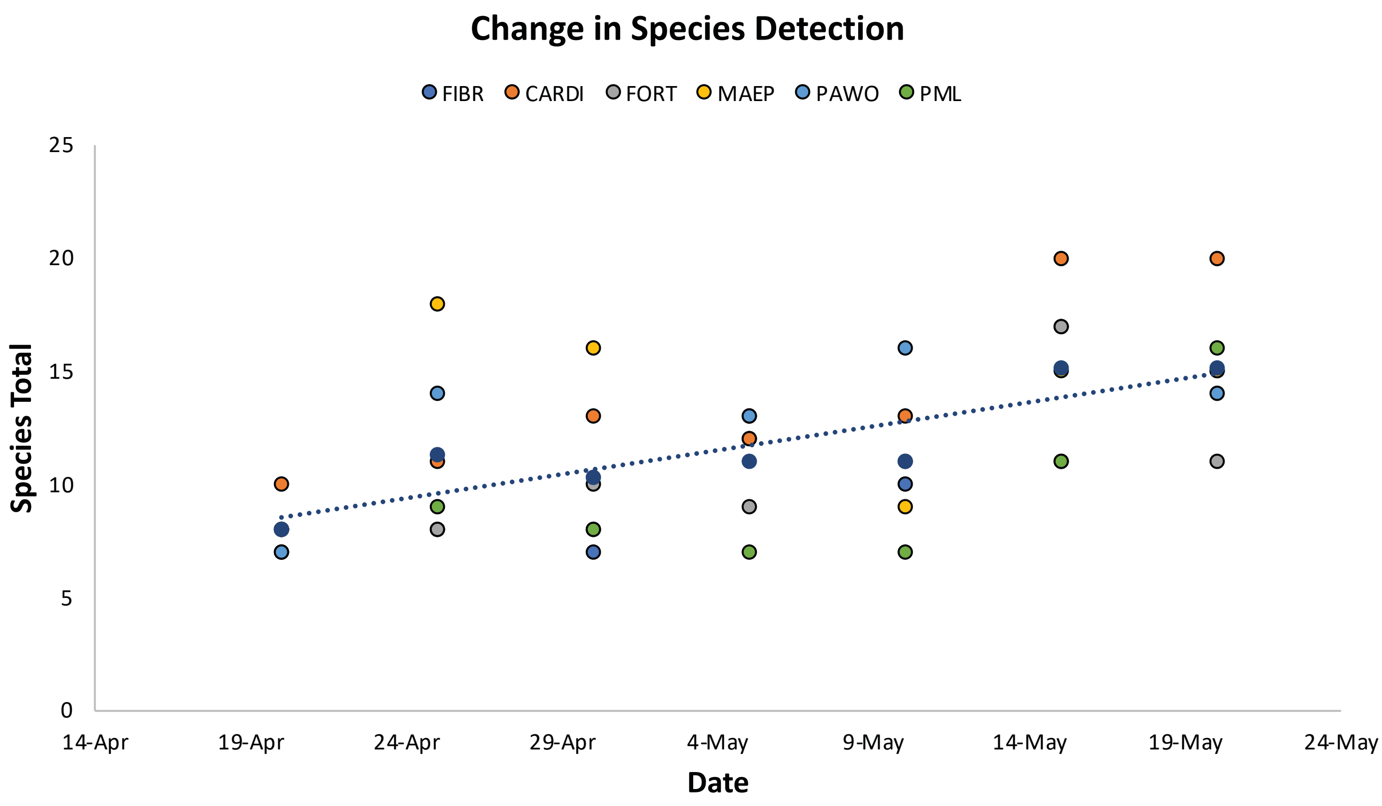




Spring Migration

Change in Species Detection

As expected, the avian community diversity (total number of species) increased during the spring migration survey period (blue dotted line displays average). Across all 6 sites surveyed, an average of 8 species were detected on 20 April and an average of 15 species were detected during the last survey on 20 May. The majority of new species added as the season progressed were Neotropical (Long-Distance) migrants. Cardi Swamp Wildlife Refuge (CARDI) and Marion Eppley Wildlife Refuge (MAEP) hosted the largest number of species throughout the season while Fort Wildlife Refuge (FORT) and Powder Mill Ledges Wildlife Refuge (PML) hosted the fewest species.




White-eyed Vireo *(Vireo griseus)*

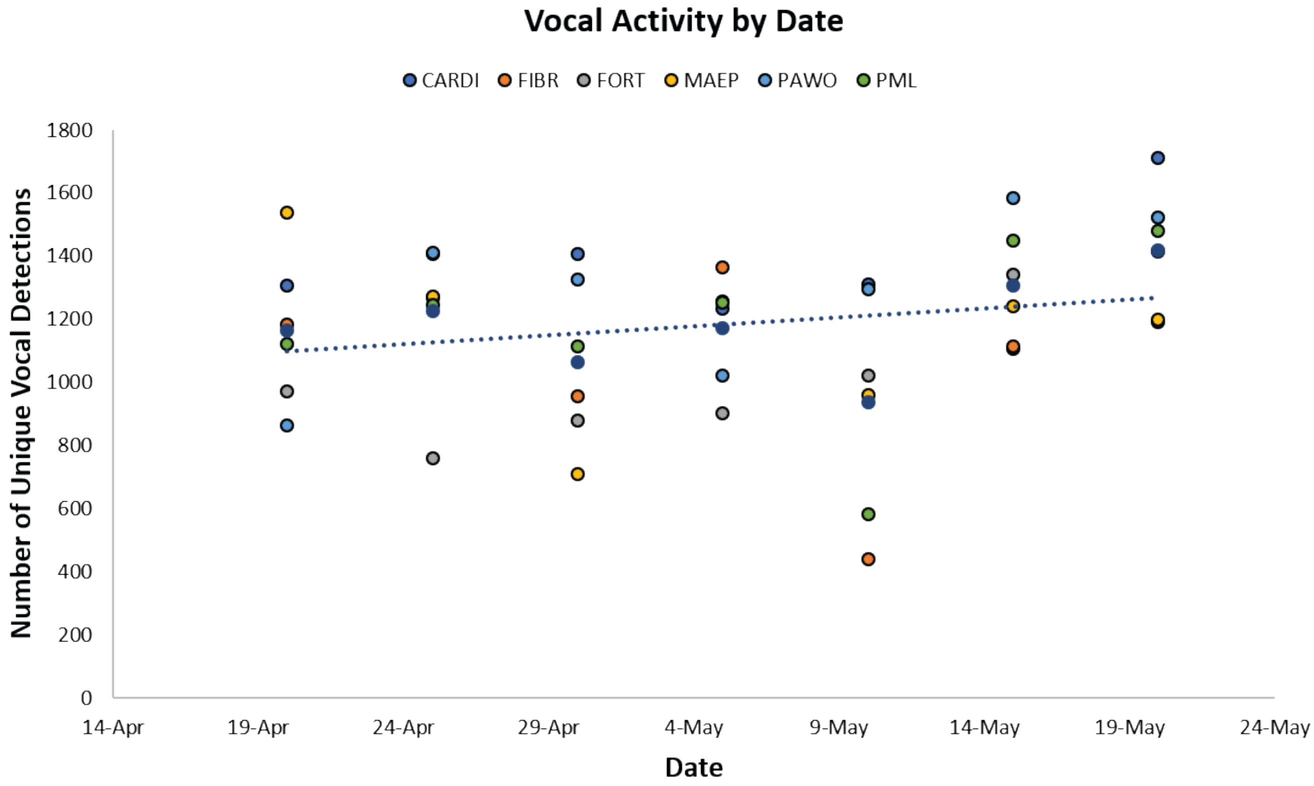

Cedar Waxwing *(Bombycilla cedrorum)*

Spring Migration

Vocal Activity

Vocal activity (defined as the number of unique vocal detections made during each 30-min survey period) varied by location, but generally increased over the course of spring surveys (blue dotted line displays average). An increase in vocal activity could be caused by increasing vocal behavior in birds present throughout the season or the arrival of new vocalizing individuals to the survey site.

Song Sparrow *(Melospiza melodia)*



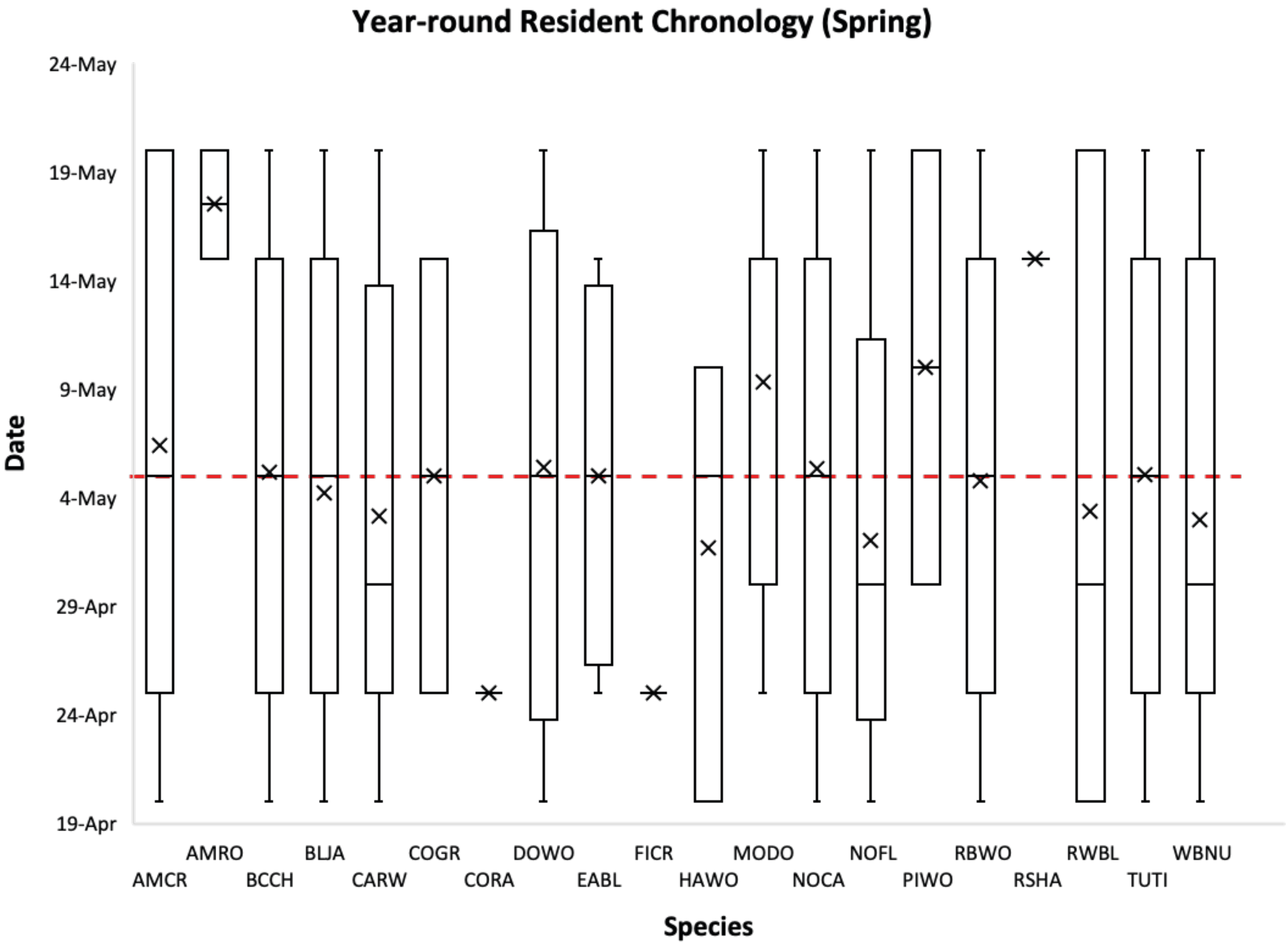
SITE	AVERAGE NUMBER OF UNIQUE VOCALIZATIONS PER 30-MIN PERIOD
Cardi Swamp W.R. (CARDI)	1334.6
Parker Woodland W.R. (PAWO)	1290
Powder Mill Ledges W.R. (PML)	1177.3
Marion Eppley W.R. (MAEP)	1167.9
Fisherville Brook W.R. (FIBR)	1125.7
Fort W.R. (FORT)	1010.7

Spring Migration

Year-round Resident Chronology (Spring)

Understanding the specific chronology of migrants on Audubon properties enables us to understand the degree to which phenological mismatch (out-of-phase timing between birds and the resources they require for nesting) may be occurring. For year-round residents, the median date of detection during surveys was 5 May (indicated by red-dashed line). The latest year-round resident to be detected during surveys was the American Robin (*Turdus migratorius*, AMRO) perhaps highlighting the fact that this species is nomadic during the non-breeding season and therefore unevenly distributed across the landscape.

Northern Flicker *(Colaptes auratus)*



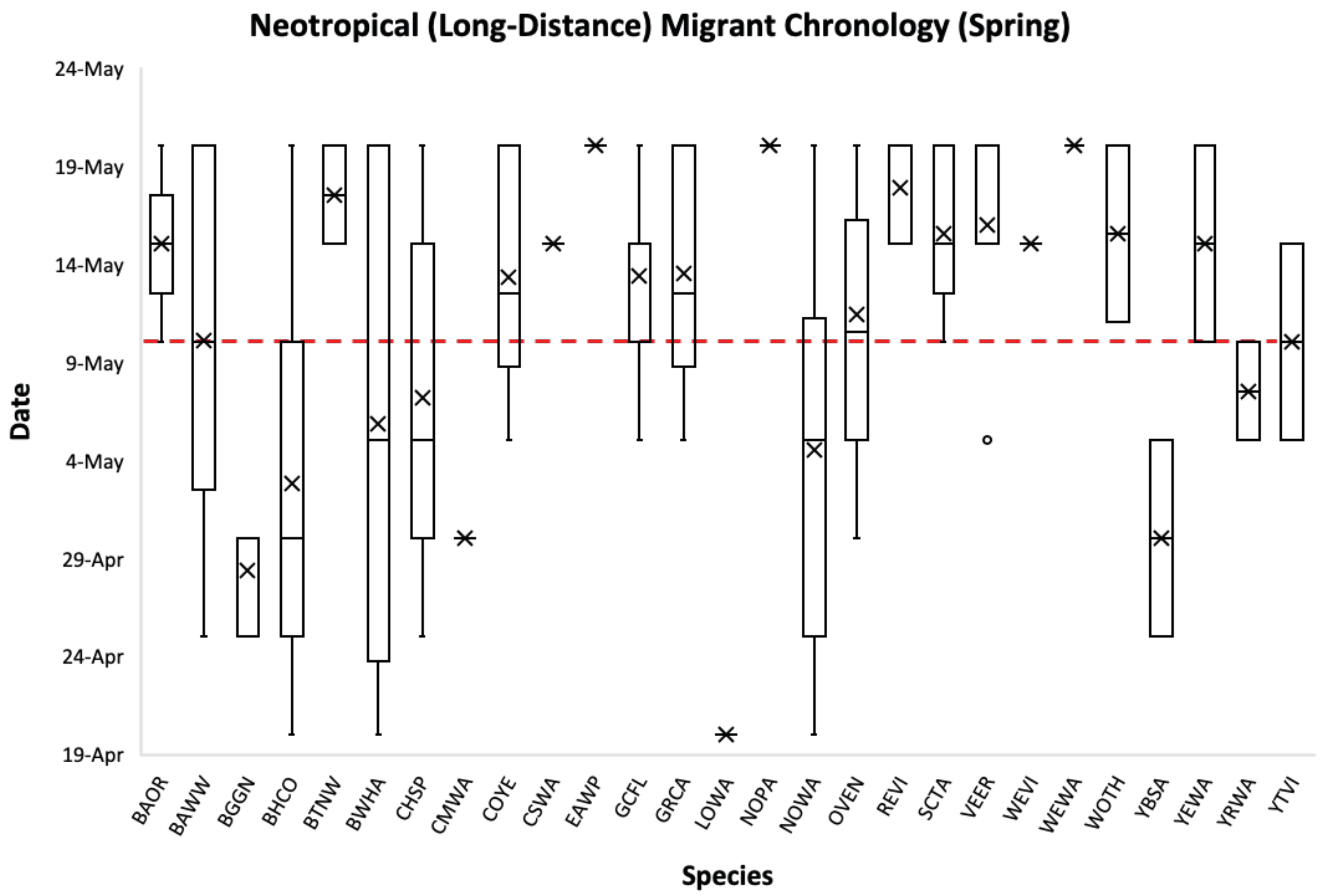
For assistance in interpreting this graphic, please refer to page 45.

Spring Migration

Neotropical (Long-Distance) Migrant Chronology (Spring)

Understanding the specific chronology of migrants on Audubon properties enables us to understand the degree to which phenological mismatch (out-of-phase timing between birds and the resources they require for nesting) may be occurring. For Neotropical (Long-Distance) migrants, the median date of detection during surveys was 11 May (indicated by red-dashed line). The earliest migrants to be detected were Brown-headed Cowbird (*Molothrus ater*, BHCO), Broad-winged Hawk (*Buteo platypterus*, BWHA), Northern Waterthrush (*Parkesia noveboracensis*, NOWA), and Louisiana Waterthrush (*Parkesia motacilla*; LOWA).


Yellow Warbler (*Setophaga petechia*)

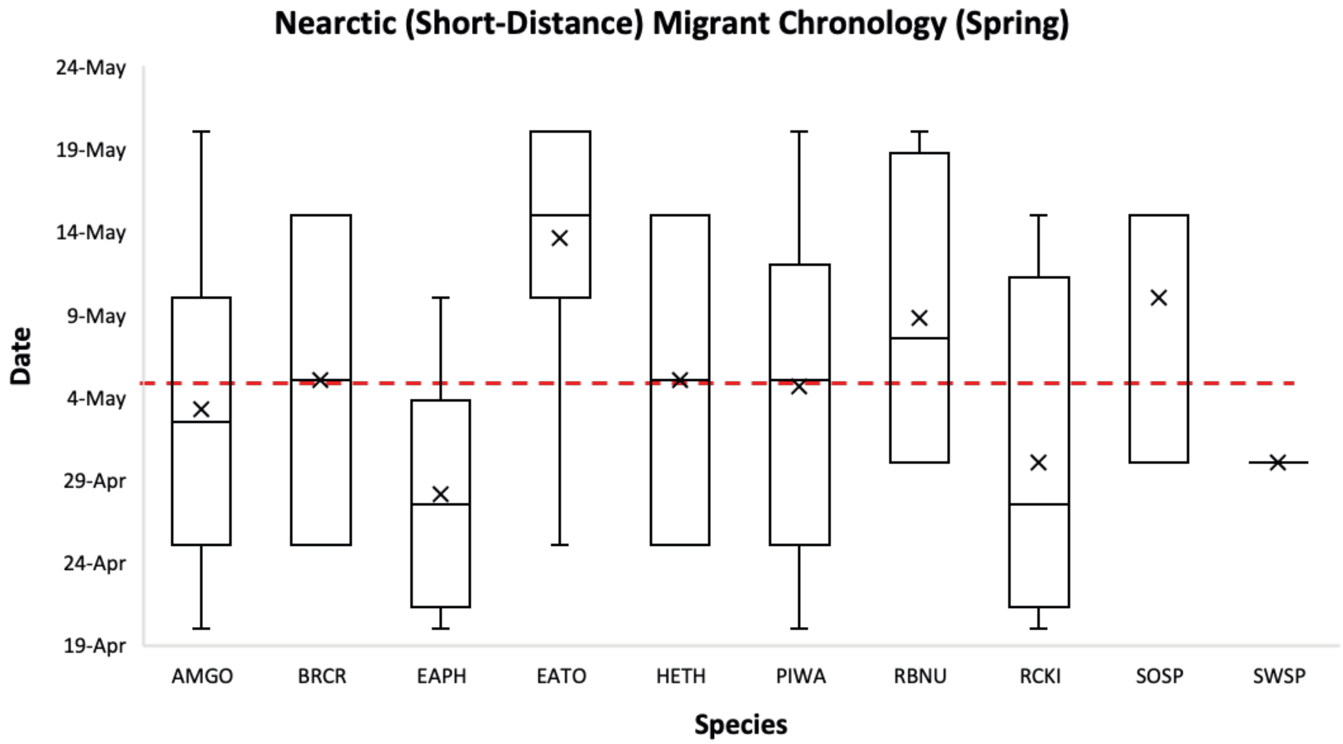


For assistance in interpreting this graphic, please refer to page 45.

Nearctic (Short-Distance) Migrant Chronology (Spring)

Understanding the specific chronology of migrants on Audubon properties enables us to understand the degree to which phenological mismatch (out-of-phase timing between birds and the resources they require for nesting) may be occurring. For Nearctic (Short-Distance) migrants, the median date of detection during surveys was 5 May (indicated by red-dashed line). The earliest migrants to be detected were American Goldfinch (*Spinus tristis*, AMGO), Eastern Phoebe (*Sayornis phoebe*, EAPH) Pine Warbler (*Setophaga pinus*, PIWA) and Ruby-crowned Kinglet (*Regulus calendula*, RCKI).

Hermit Thrush (*Catharus guttatus*)

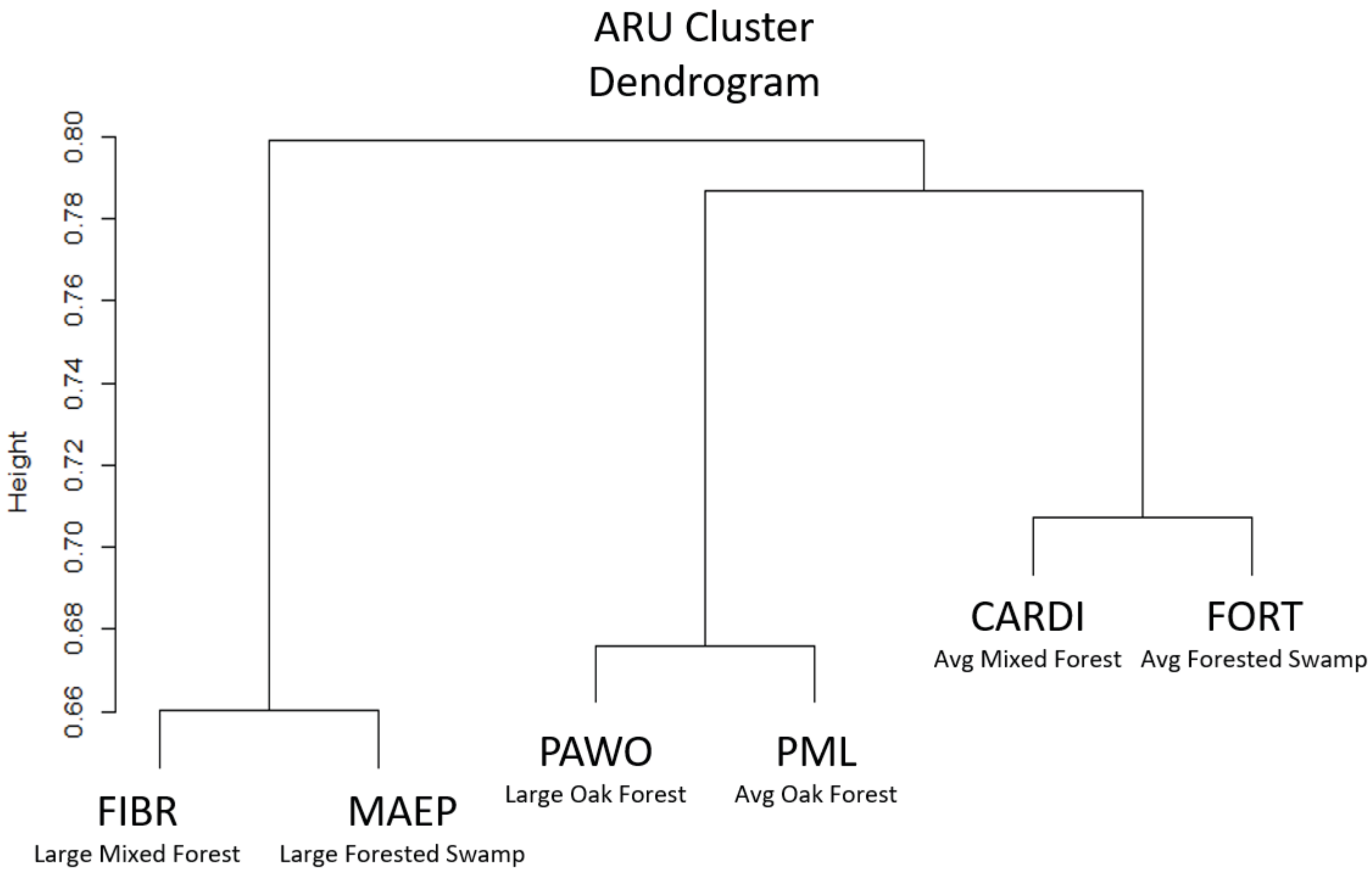


For assistance in interpreting this graphic, please refer to page 45.

Spring Migration

Acoustic Recording Units (ARUs)

The six Acoustic Recording Units (ARUs) were placed strategically in three distinct habitat types on Audubon properties (Mixed Forest, Oak Forest and Forested Swamp). The cluster dendrogram below illustrates the degree of relatedness between the avian communities (by analyzing both the total number of species at each site and the number of shared species between sites) at each of these locations. As can be seen, the bird communities at both Oak Forest sites (Parker Woodland Wildlife Refuge (PAWO) and Powder Mill Ledges Wildlife Refuge (PML)) were similar while little similarity existed between the two other habitat types. Because these data were collected over the course of a single migratory season, there is not sufficient evidence to suggest that this trend is significant and additional data will need to be collected in subsequent years.

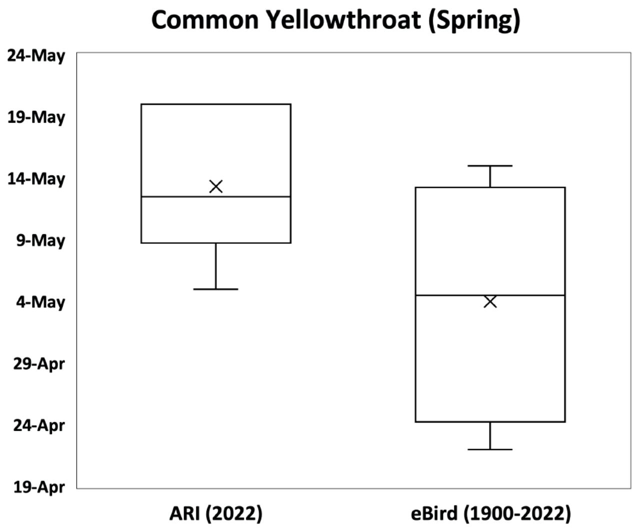


Responsibility Bird Spotlight

In the State of Our Birds Report: Part I, we identified nine species as "Responsibility Birds". The Common Yellowthroat is one of those species. These birds will receive additional monitoring across our refuges during the next 2-3 years in order to craft the most effective management plans possible in hopes of reversing long-term declines across the Mid-Atlantic and New England regions.

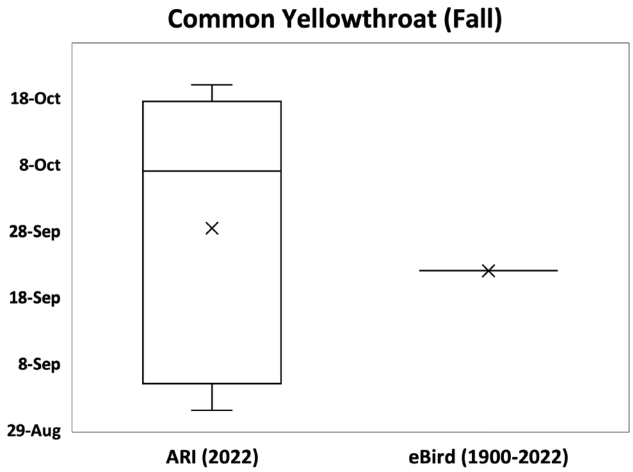
Records from the single year of data collection with the Avian Research Initiative (ARI) were compared to records submitted to eBird between the years of 1900–2022. The advantage of collecting detailed data specifically from our refuges was evident. Below is an example from the Fisherville Brook Wildlife Refuge.


Common Yellowthroat
(*Geothlypis trichas*)



During the spring migration, Common Yellowthroats were detected from 5 May until the end of the survey period (20 May) during Audubon surveys. eBird records for over 100 years show detections as early as 22 April, with detections ending on 15 May. Two items need to be highlighted with these data:

1. eBird data are submitted from anywhere on the wildlife refuge, while Audubon data come from a single mounted Acoustic Recording Unit (ARU). This highlights the need to supplement ARU data with survey data throughout the refuge.
2. eBird data are summarized in weekly intervals, which allows for less detailed information on exact dates of detection to be determined.



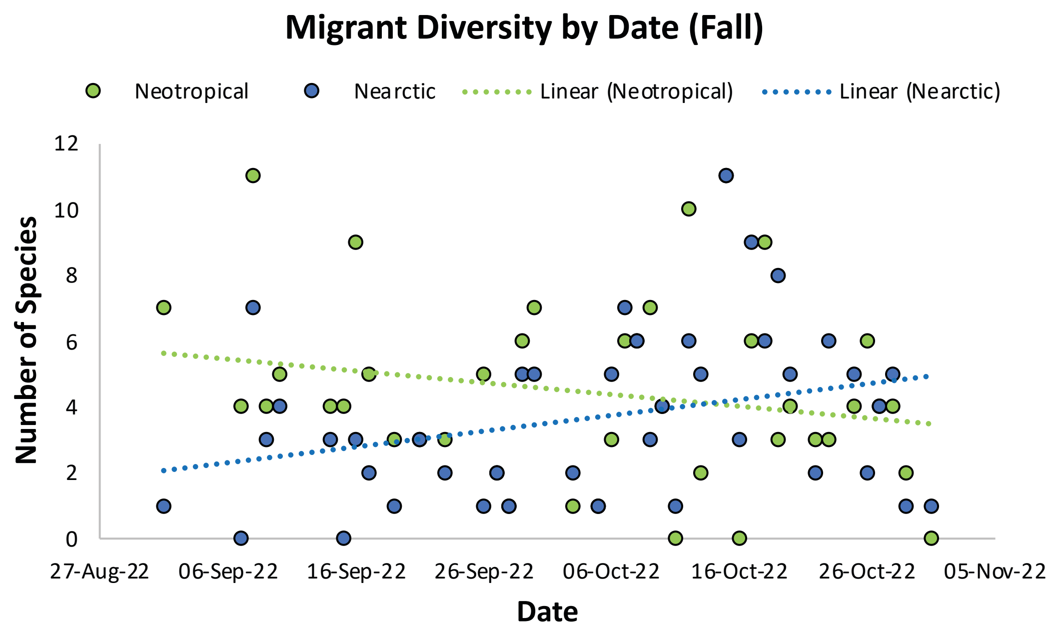
During the fall migration, Audubon surveys detected Common Yellowthroats from the start of the survey window (1 September) until 20 October, providing an overview of when the species departs the refuge in the fall. Over 100 years of eBird data has only a single detection of yellowthroats (on 22 September).

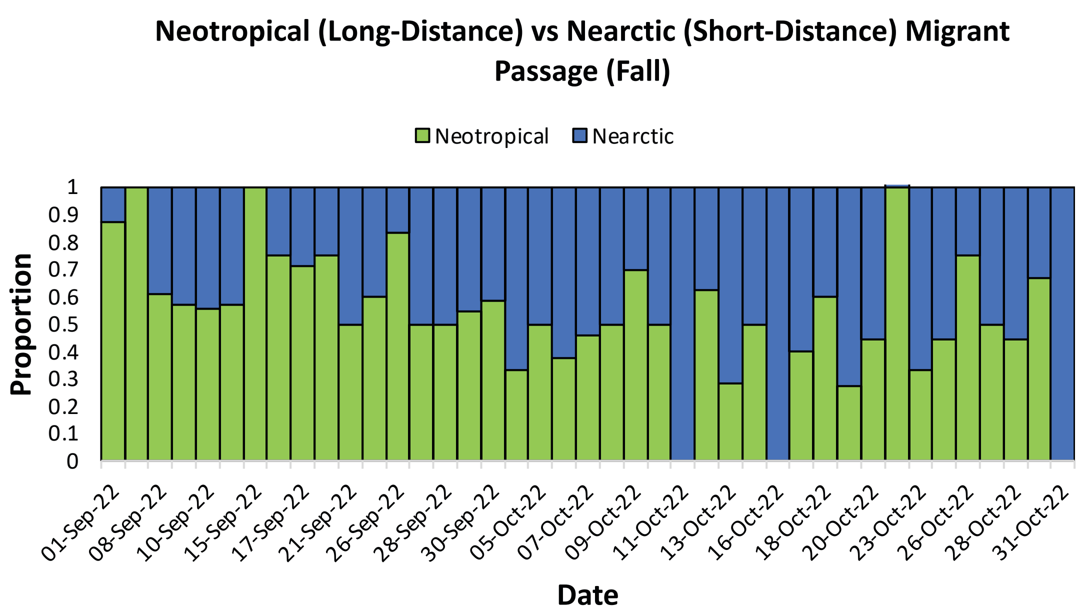
This highlights that fact that eBird data are only as useful as the frequency with which they are submitted. Clearly far more submissions are made during the spring than in the fall, limiting the utility of the data at providing information on fall migratory movements.

For assistance in interpreting these graphics, please refer to page 45.

Fall Migration

Over the course of the fall survey period (1 September – 1 November) the number of Neotropical (Long-Distance) migrants declined across all Audubon properties surveyed. This is to be expected as a large number of Neotropical migrants breed in Rhode Island and are therefore "available" for detection early in the survey period. The decline coincides with a period in which birds breeding in Rhode Island and in areas to the north begin their southward migrations. Concurrently, the number of Nearctic (Short-Distance) migrants increase across surveyed properties. This is to be expected as Nearctic species breeding north of Rhode Island arrive in the state either as transients or with the intention of overwintering in our state later in the season. This also accounts for why the overall proportion of Nearctic migrants increases through time (bottom graph).

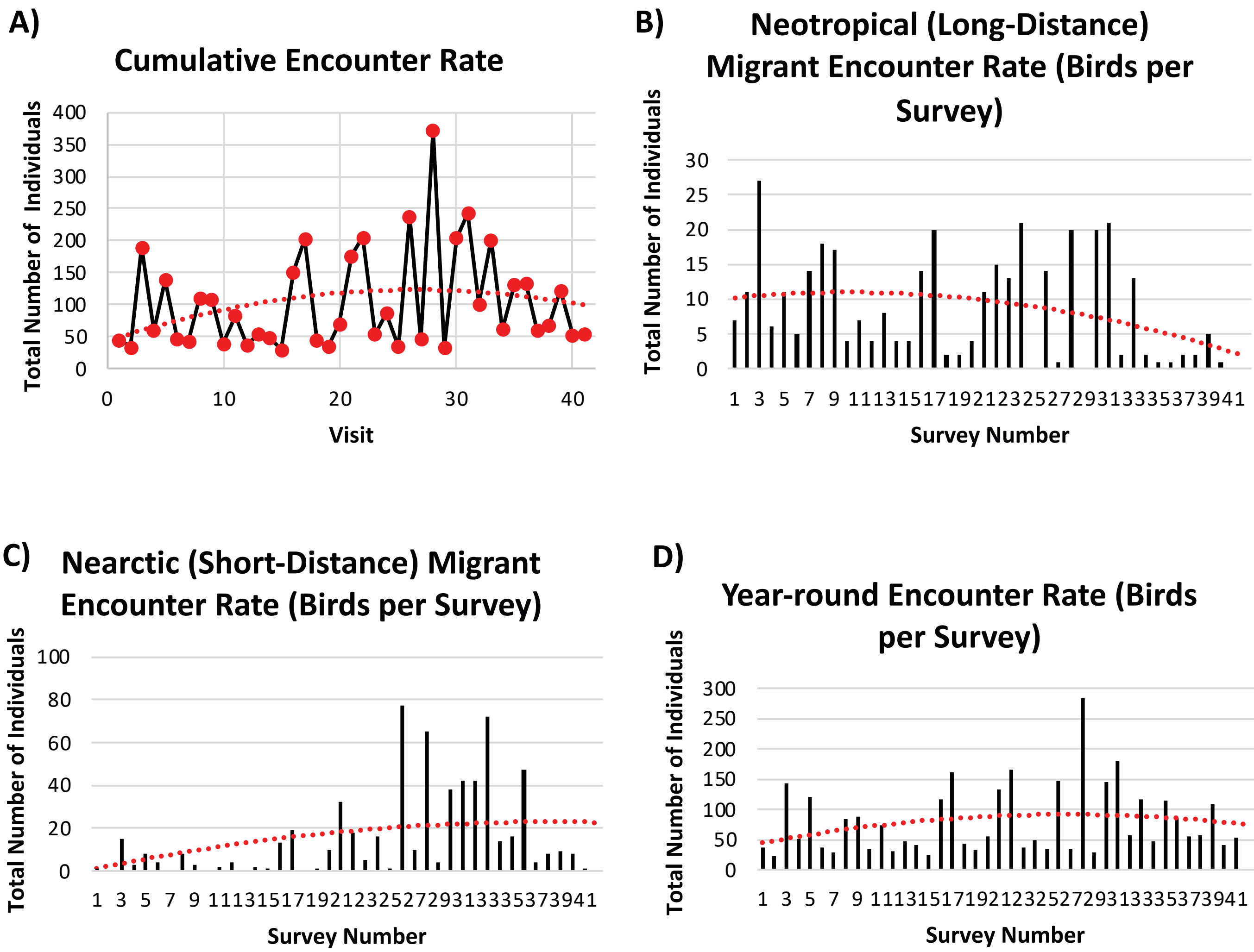




Fall Migration

Encounter Rates

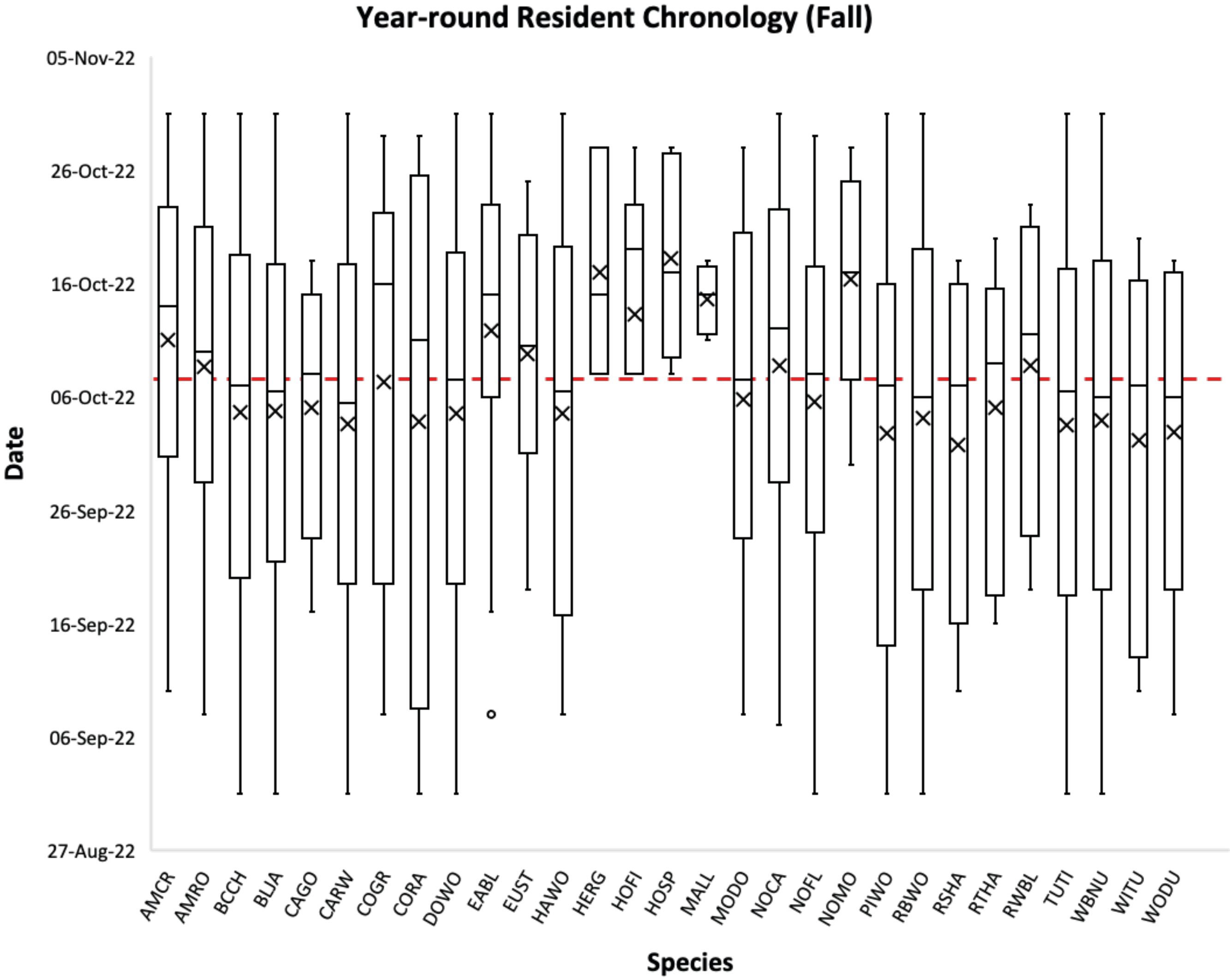
The total number of individual birds was recorded during fall transect surveys, which is a metric we were unable to collect using ARUs. As a result, the cumulative encounter rate of all birds and the encounter rate for each migrant type were plotted. A) Across all species, a general increasing trend in the total number of individuals was detected throughout the season, with abundance declining towards the end of the survey period. Coincident with the general decline in the total number of Neotropical (Long-Distance) migrant species, a decline in total number of individual birds was also detected (B), while the total number of Nearctic (Short-Distance) migrants increased during the same period (C). The number of year-round residents (D) exhibited a less obvious trend through time.



Fall Migration

Year-round Resident Chronology (Fall)

Understanding the specific chronology of migrants on Audubon properties enables us to understand the degree to which phenological mismatch (out-of-phase timing between birds and the resources they require for nesting) may be occurring. For Year-round residents, the median date of detection during surveys was 7 October (indicated by red-dashed line).



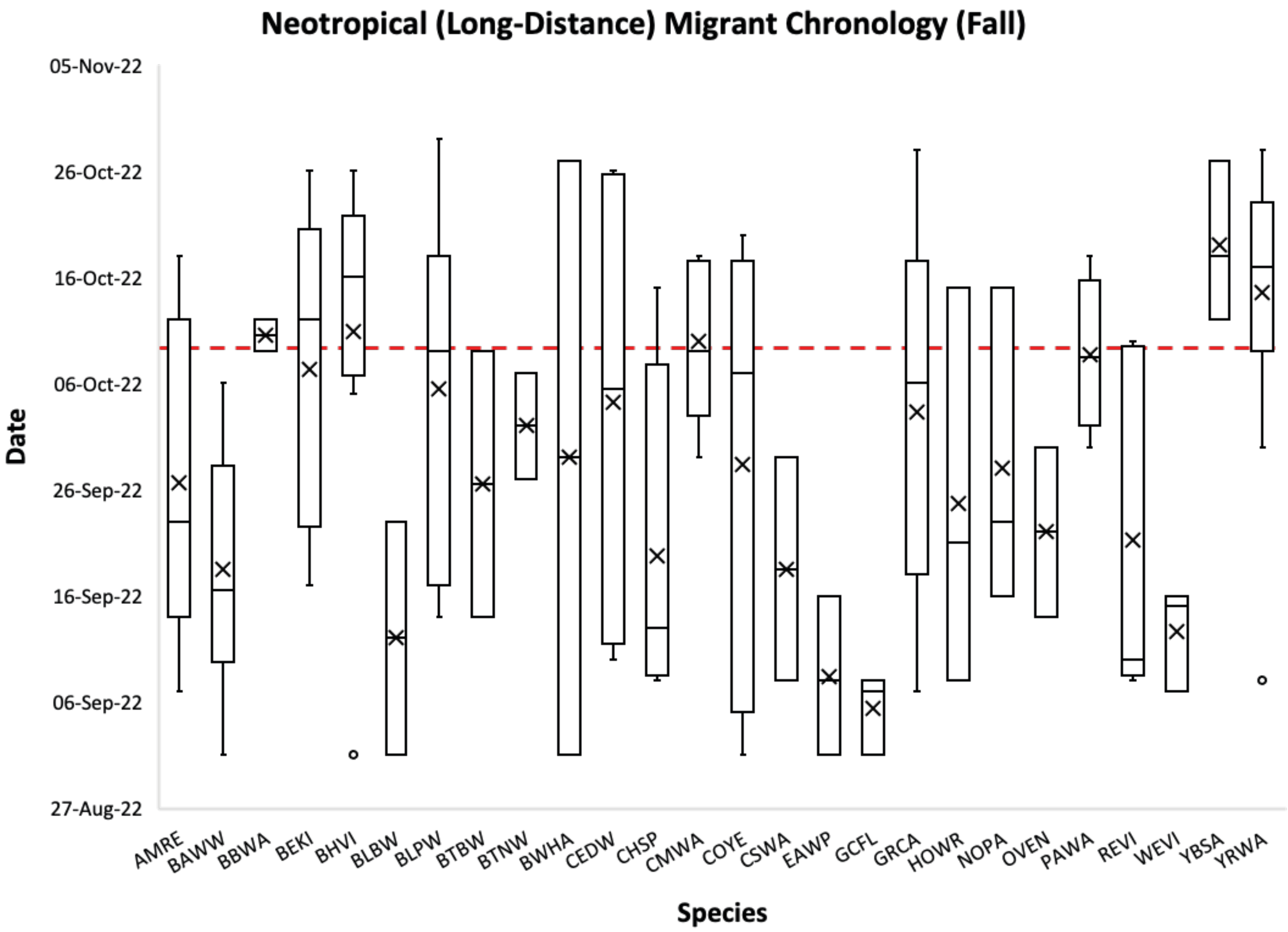
For assistance in interpreting this graphic, please refer to page 45.

Fall Migration

Neotropical (Long-Distance) Migrant Chronology (Fall)

Understanding the specific chronology of migrants on Audubon properties enables us to understand the degree to which phenological mismatch (out-of-phase timing between birds and the resources they require for nesting) may be occurring. For Neotropical (Long-Distance) migrants, the median date of detection during surveys was 7 October (indicated by red-dashed line). The latest migrants to be detected were Blackpoll Warbler (*Setophaga striata*, BLPW) and Gray Catbird (*Dumetella carolinensis*, GRCA).

Gray Catbird *(Dumetella carolinensis)*



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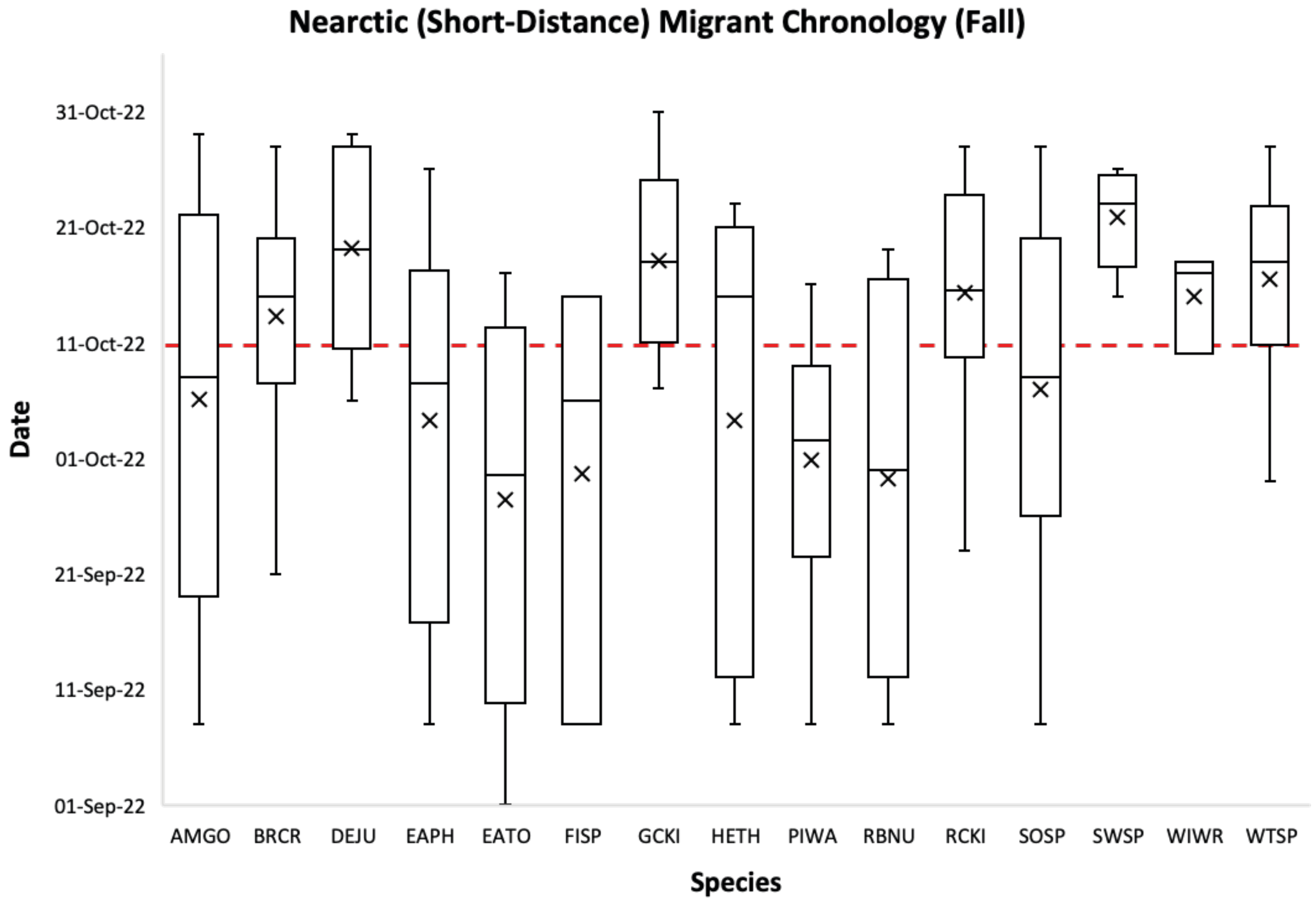
Nearctic (Short-Distance) Migrant Chronology (Fall)

Understanding the specific chronology of migrants on Audubon properties enables us to understand the degree to which phenological mismatch (out-of-phase timing between birds and the resources they require for nesting) may be occurring. For Nearctic (Short-Distance) migrants, the median date of detection during surveys was 11 October (indicated by red-dashed line). The latest migrants to be detected were American Goldfinch (*Spinus tristis*, AMGO), Dark-eyed Junco (*Junco hyemalis*, DEJU), Golden-crowned Kinglet (*Regulus satrapa*, GCKI), Ruby-crowned Kinglet (*Regulus calendula*, RCKI), Song Sparrow (*Melospiza melodia*, SOSP) and White-throated Sparrow (*Zonotrichia albicollis*, WTSP)

Ruby-crowned Kinglet
(Regulus calendula)

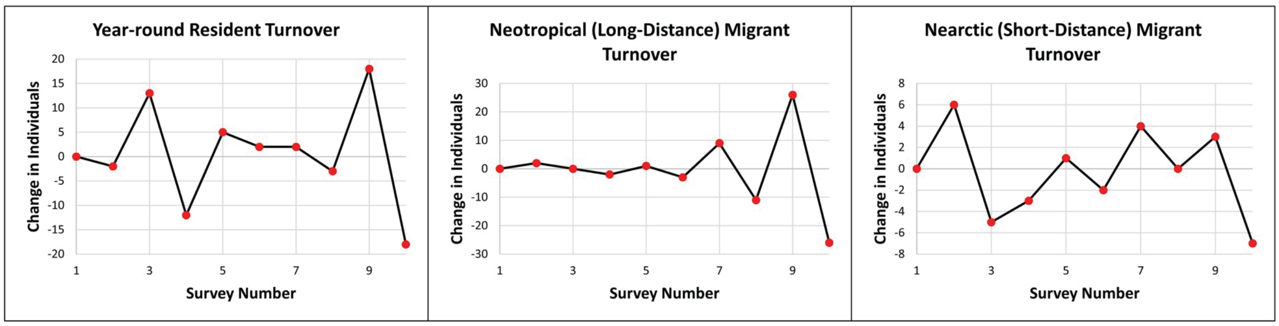


For assistance in interpreting this graphic, please refer to page 45.

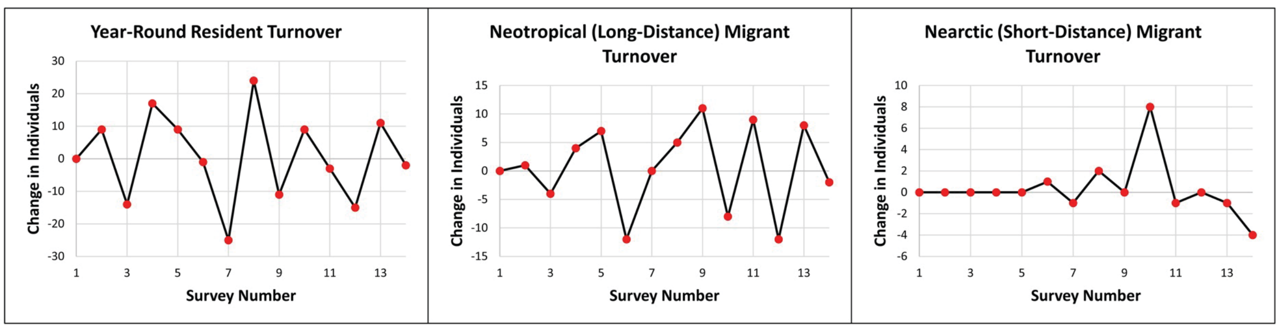
Fall Migration

Turnover in the total number of individuals detected at each transect provides an estimate of the new arrivals and departures to a site between surveys. Collected over multiple seasons, these data can provide an idea of the average stopover duration, which is a function of the resource availability at each site and/or the average nutritional condition of the migrants. Movement of individuals laterally across the landscape may affect turnover, which is one of the primary reasons surveys are conducted every 3-4 mornings. During fall migration, average turnover was: Fisherville Brook Wildlife Refuge (year-round residents: 0.5 (range: -18 – 18), Neotropical (Long-Distance) Migrants: -0.4 (range: -26 – 26), Nearctic (Short-Distance) Migrants: -0.3 (range: -7 – 6); Emilie Ruecker Wildlife Refuge (year-round residents: 0.6 (range: -25 – 24), Neotropical Migrants: 0.5 (range: -12 – 11), Nearctic Migrants: 0.3 (range: -4 – 8); Maxwell Mays Wildlife Refuge (year-round residents: 0.3 (range: -33 – 35), Neotropical Migrants: -0.2 (range: -4 – 6), Nearctic Migrants: -0.3 (range: -8 – 8).

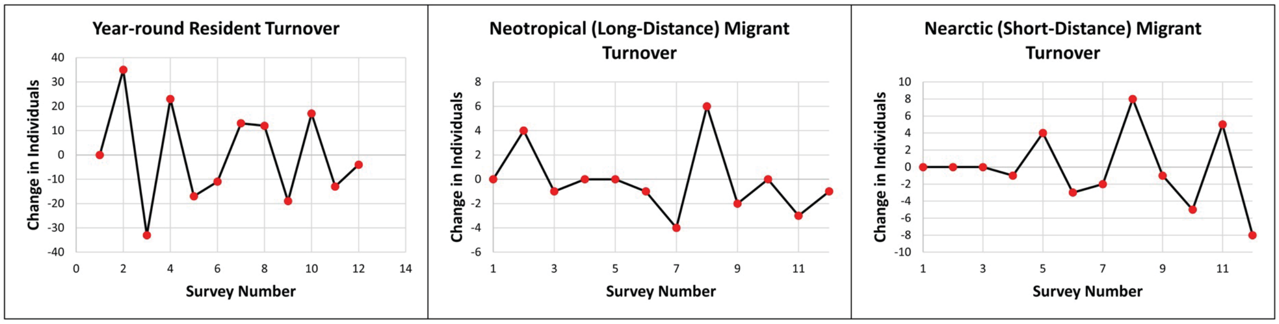
Fisherville Brook Wildlife Refuge Turnover



Emilie Ruecker Wildlife Refuge Turnover



Maxwell Mays Wildlife Refuge Turnover



For assistance in interpreting these graphics, please refer to page 46.

Appendix

Glossary of Terms, Interpreting the Graphics, Cluster Dendrograms

Audubon Caratunk Wildlife Refuge, Seekonk, MA

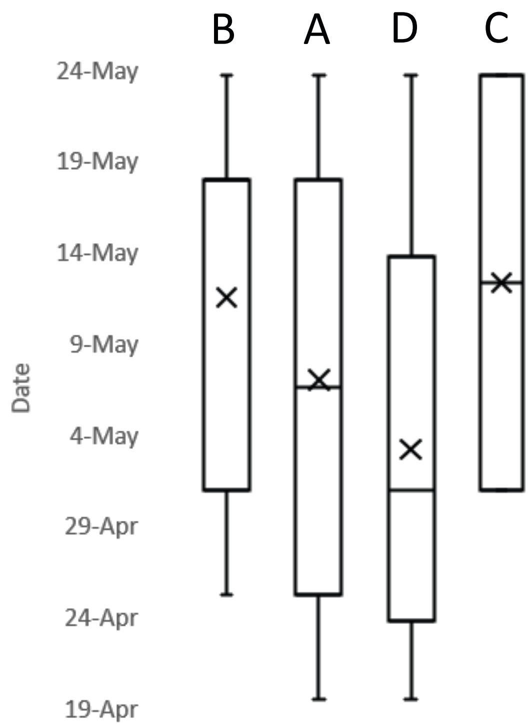
Glossary of Terms

TERM	DEFINITION
ARU	Acoustic Recording Unit. An autonomous recording device deployed to record the soundscape
Band-Pass Filter	A filter designed to pass frequencies within a predetermined range and omit (attenuate) frequencies outside of range
Cluster Dendrogram/Analysis	A diagram depicting hierarchical relationship between certain objects
Jaccard Similarity (Index)	A test of the similarity between two sets of data. Similarity is determined by comparing elements that are shared versus those that are distinct
Nearctic Migrant	A migratory species of bird that spends its entire annual cycle north of the Tropic of Cancer
Neotropical Migrant	A migratory species of bird that breeds north of the Tropic of Cancer and spends the overwintering period south of the Tropic of Cancer
Party Hour	The collective time a group spends performing a survey
Phenological Mismatch	Deviation between actual response of a species to certain environmental conditions and the expected response based on historical information
Transect Survey	A survey performed along an established route
Turnover	A measure of change that occurs through time through the loss and gain of individuals
Unique Vocal Detection	A unique element of sound produced by a bird that can be used to cluster vocalizations by similarity

Interpreting the Graphics

Chronology Graphs

The chronology graphs presented in this report depict the timing of passage by individual bird species. Each box and whisker plot displays values that describe the data.



A. The line in the middle of the box represents the median (middle) value of a dataset. Exactly half of all data values fall above and half fall below this value. The "X" represents the mean (average) value of the dataset. The top of the "box" represents the upper (3rd) quartile, or median value of the top half of data points, while the bottom of the "box" represents the lower (1st) quartile, or median value of the bottom half of data points. Finally, the "whiskers" reach to the minimum and maximum values of the data set. In this example, species "A" was detected on the median date of May 7, which was also the approximate mean date of detection. The lower quartile date of detection was April 25 while the upper quartile date of detection was May 18. The minimum or earliest date of detection for the species was April 20 while the maximum or latest date of detection was May 24.

B. If a plot has no center line depicting the median, the value is equal to either the upper or lower quartile.

C. A plot with only one or no "whiskers" represents a data set in which the minimum or maximum value (or both) are equal to the upper or lower quartile.

D. You can determine the amount of skew in the data set by looking at the location of the median value relative to the upper and lower quartiles. In species "D" the median is below the mean and closer to the lower quartile, indicating a positive skew (towards detections occurring later in the season as opposed to earlier in the season).

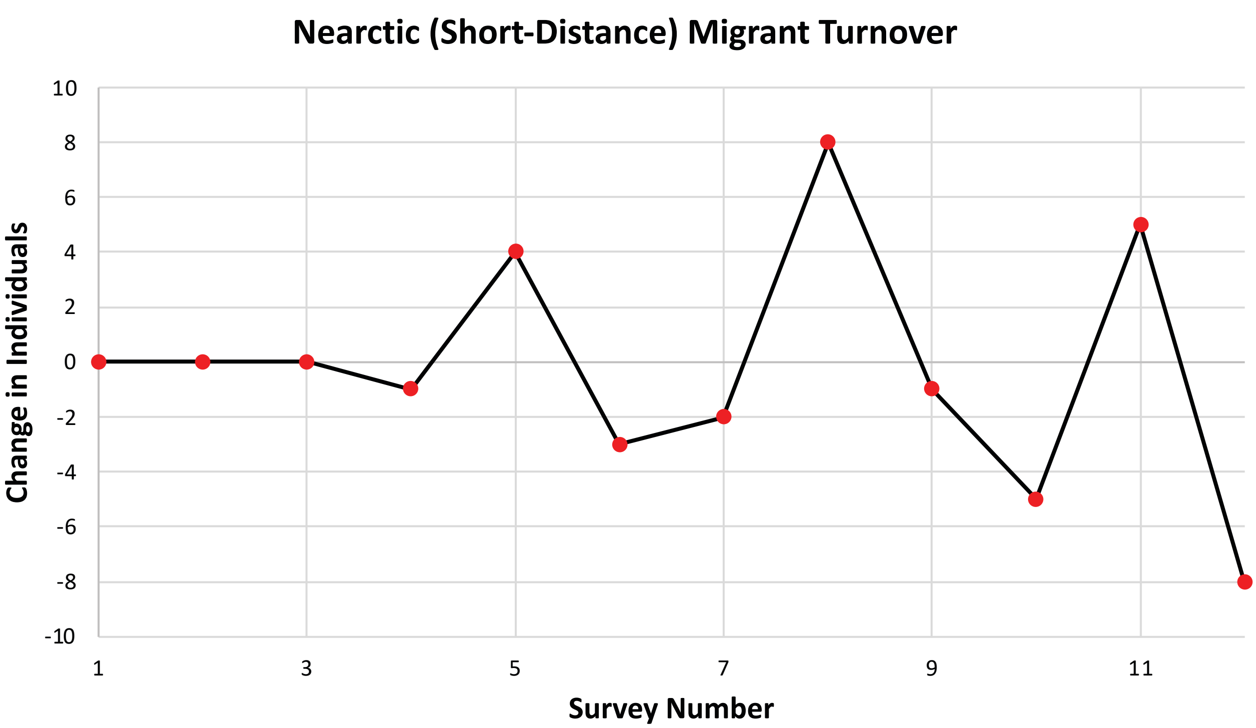
Interpreting the Graphics

Turnover

The amount of time a bird stops to refuel along its migration is likely a factor of habitat quality (and therefore resource availability), predation pressure and individual nutritional condition. Understanding how often assemblages of birds turnover at a given site can provide insight into these factors and guide more effective management.

At three Audubon Wildlife Refuges (Fisherville Brook W.R., Emilie Ruecker W.R and Maxwell Mays W.R.) surveys were conducted a minimum of 10 times over the course of Fall migration in order to determine turnover. Regular visits increase the likelihood that changes in the total number of individual birds encountered during each survey can be attributed to gain and loss due to migratory movements as opposed to lateral movement across the landscape.

Data are presented as the gain or loss in the number of encountered individuals during each visit. In the example below, the total number of Nearctic (Short-Distance) migrants remained unchanged during the first three surveys. By the fourth survey, turnover was detected as fewer individuals were recorded. Throughout the remainder of the survey period, turnover increased as a greater number of individuals were lost and gained during each successive survey. This suggests that turnover is low early in the season and becomes more pronounced by the end of the survey period.



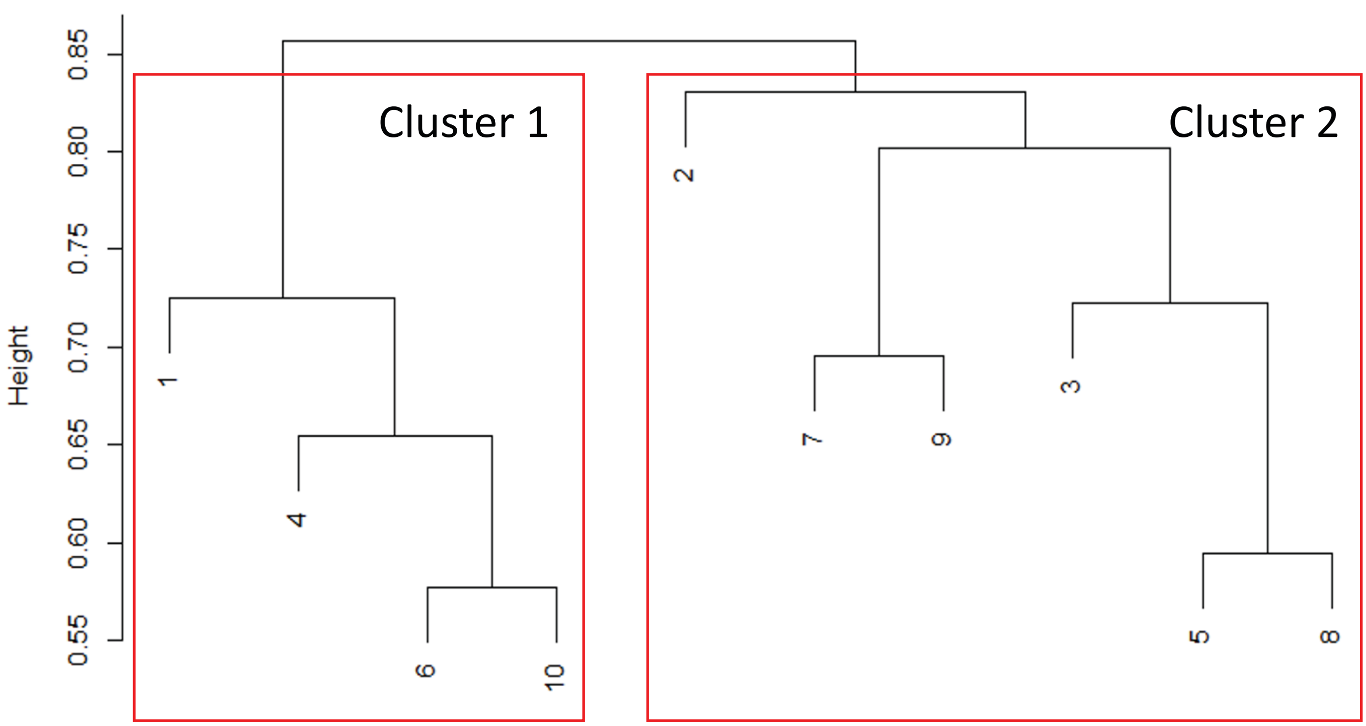
Interpreting the Graphics

Cluster Dendrograms

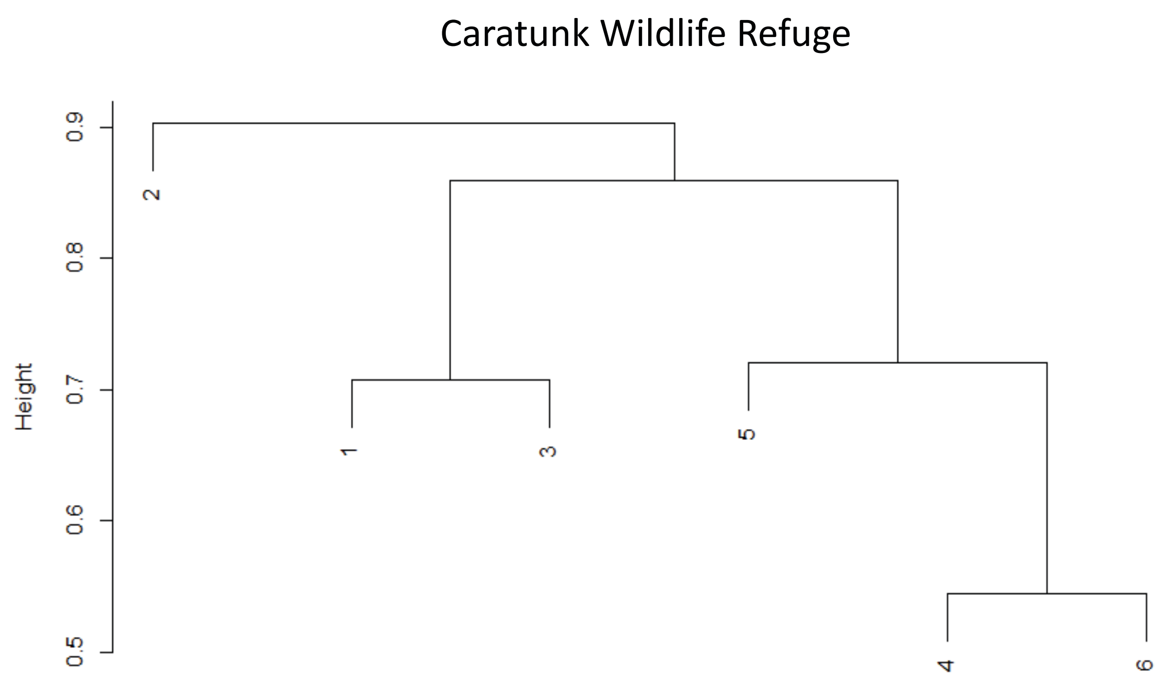
Cluster dendrograms were used to determine the relatedness of the avian communities present along a survey route during each visit to a particular site. As opposed to turnover, which measures the change in the total number of individuals detected during each survey, the dendrogram compares both the total number of species and the number of shared species between each visit and provides an idea of how similar the avian community is between each survey.

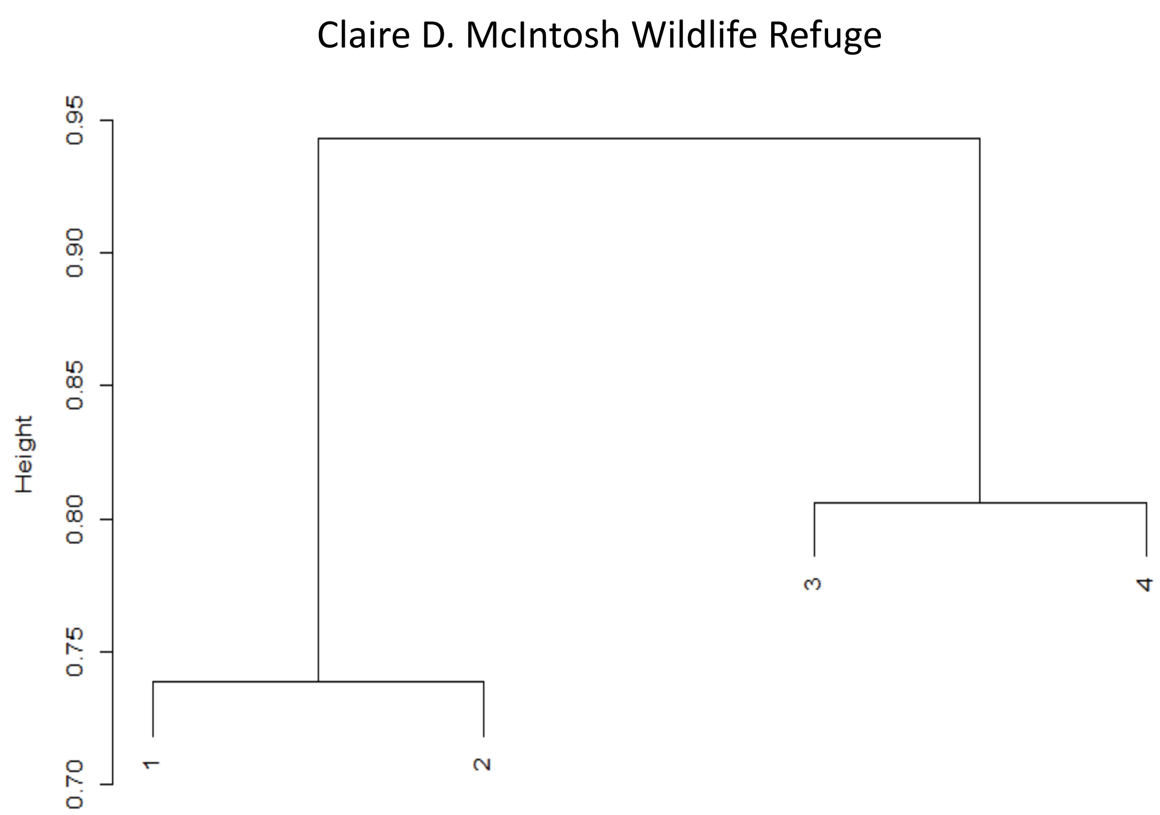
Dendrograms are interpreted by subdividing the data into groups (clusters) based on similarity. The selection of clusters is generally performed by determining the height along the y-axis that will be used to differentiate the data. In the below example, at a height of 0.84, two large clusters can be identified. The avian community recorded during visit 1 was most similar to the community recorded during visits 4, 6 and 10. And, the avian community recorded during the final visit (10) is more similar to the community recorded during the 6th visit than to the immediately previous survey (9). Within clusters, the difference in height between data sets is an additional measure of similarity. Thus, for cluster 1, the avian communities recorded during visits 6 and 10 are most similar to one another and most dissimilar to the avian community recorded during visit 1.

While at first not of obvious importance, these dendrograms allow for the visualization of turnover of the entire avian community over the course of the survey period. A great deal of variability suggests that no clear trend exists in the avian community at any given site over the course of the migratory period.



Cluster Dendrograms

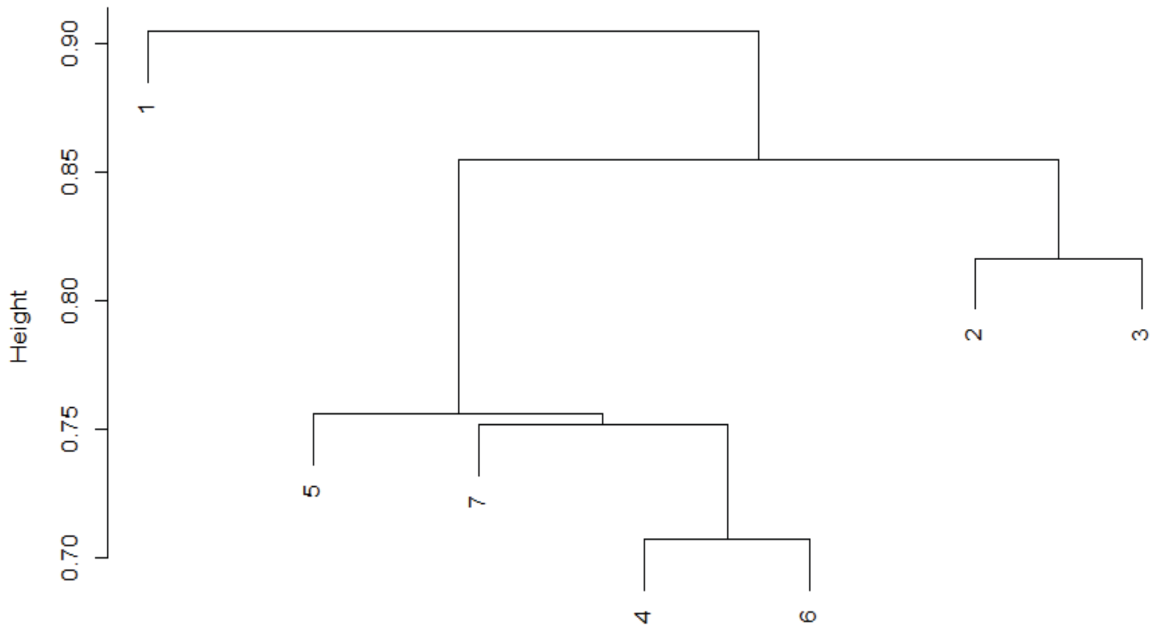




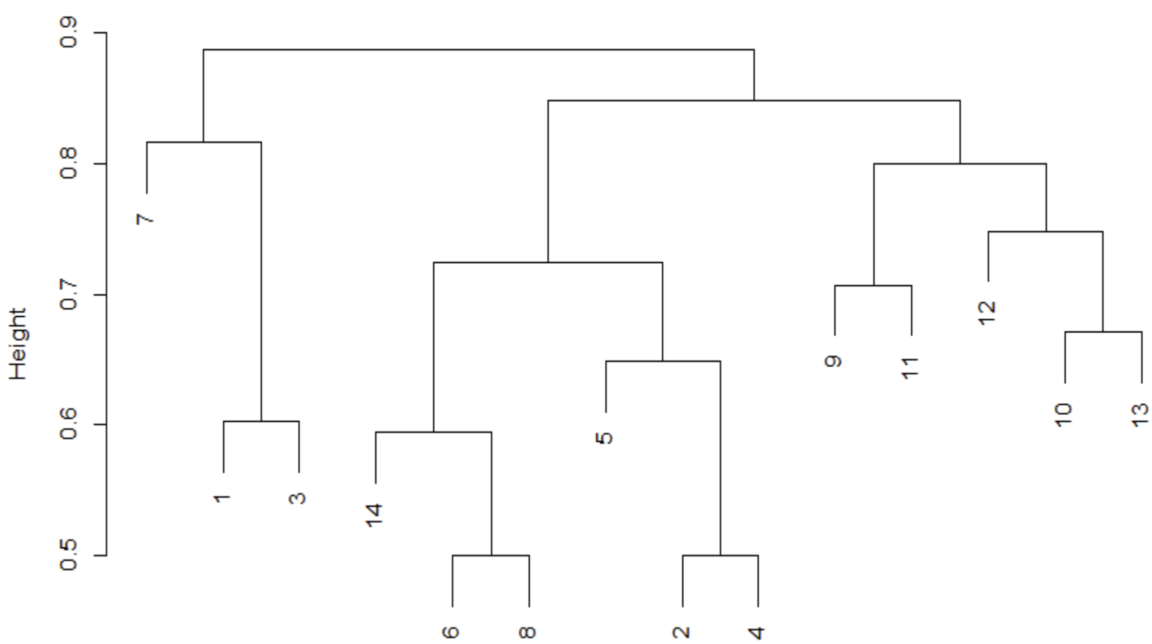
For assistance in interpreting these graphics, please refer to page 47.

Cluster Dendrograms

Davis Memorial Wildlife Refuge



Emilie Ruecker Wildlife Refuge



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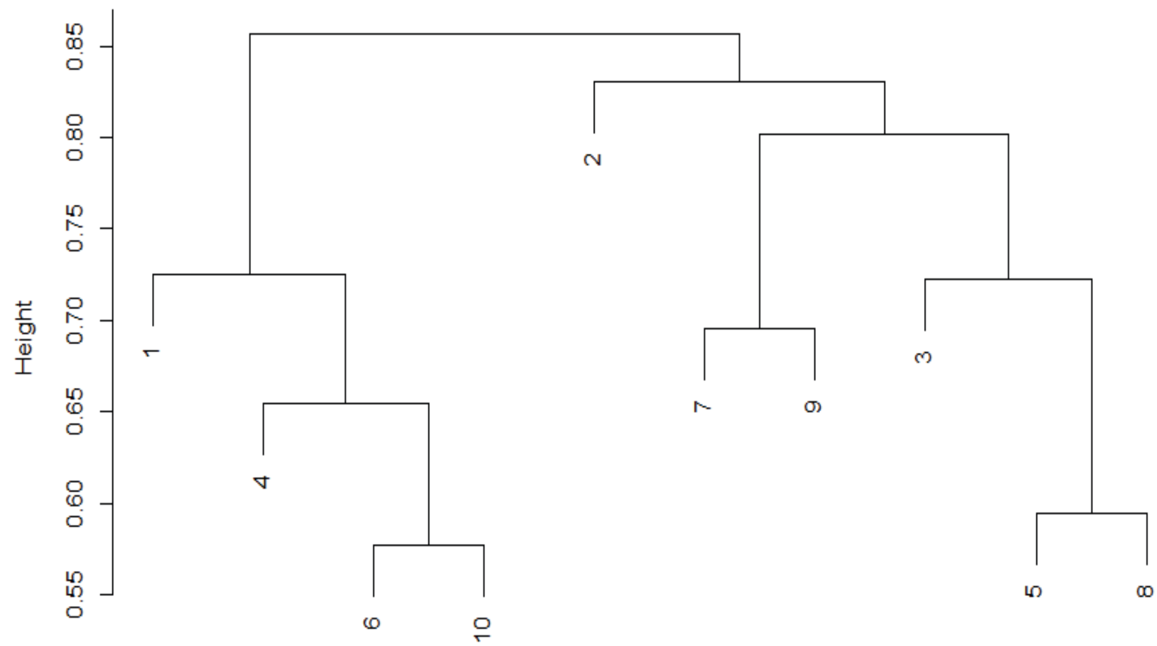
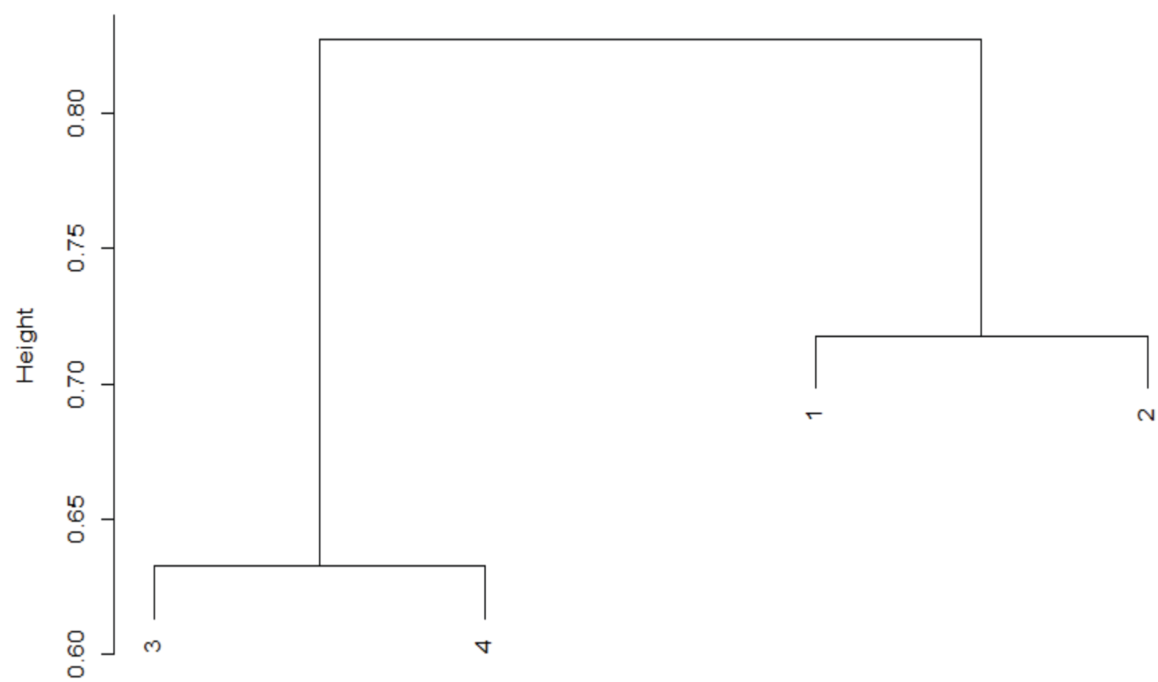
Cluster Dendrograms

Fisherville Brook Wildlife Refuge



Fort Wildlife Refuge



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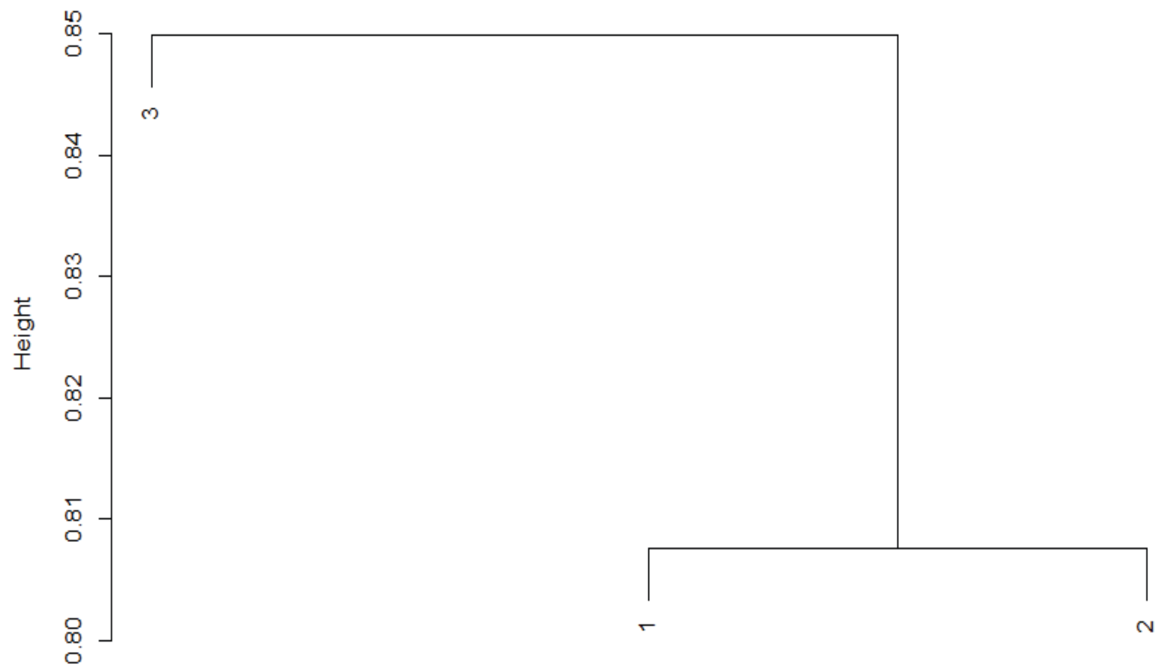
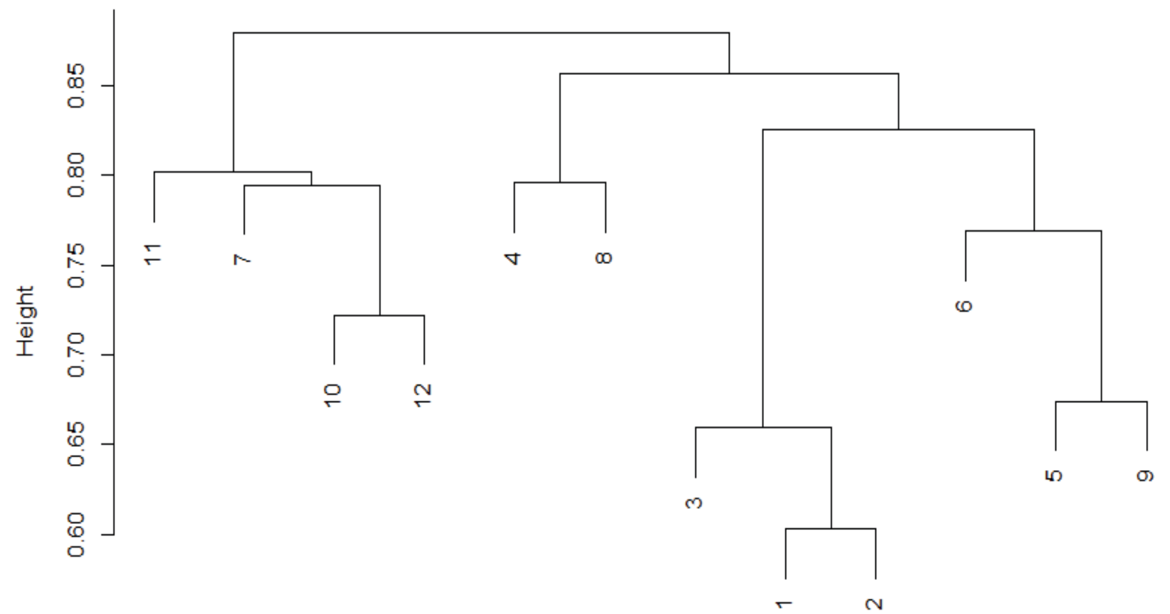
Cluster Dendrograms

George Parker Woodland Wildlife Refuge



Maxwell Mays Wildlife Refuge



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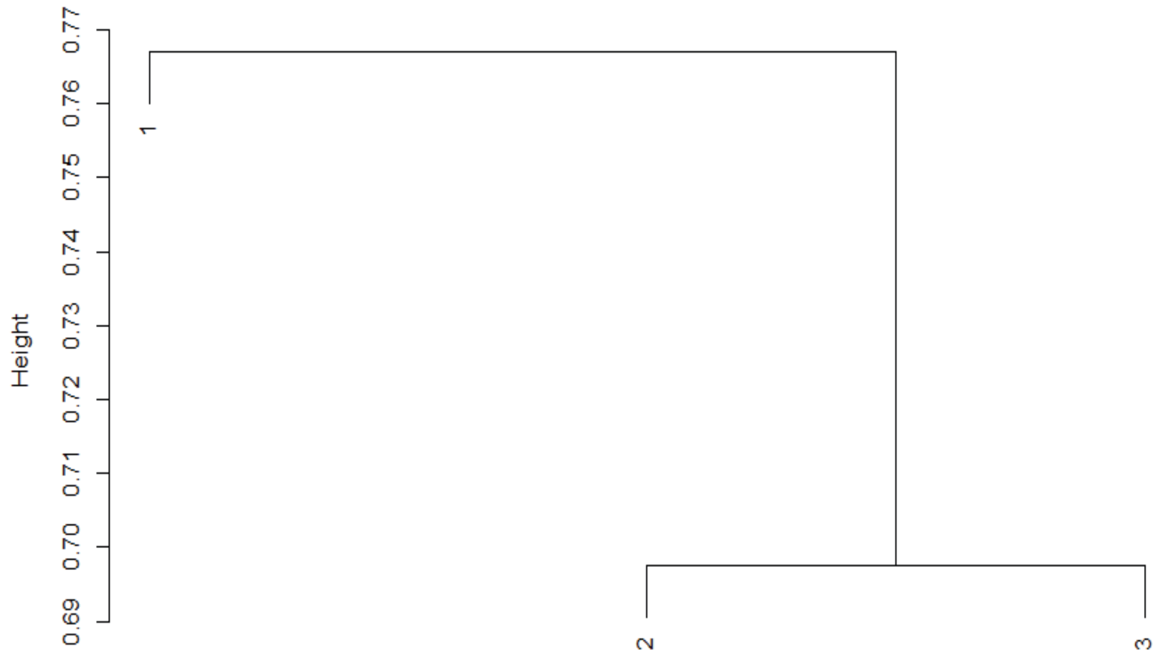
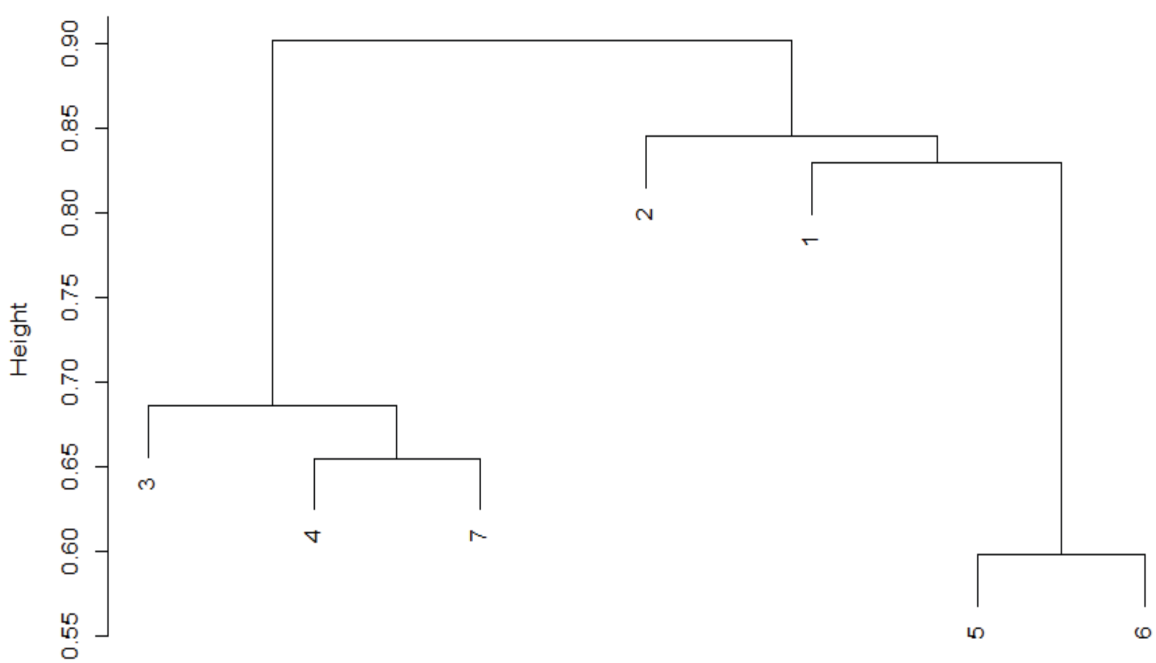
Cluster Dendrograms

Powder Mill Ledges Wildlife Refuge



Touisset Marsh Wildlife Refuge



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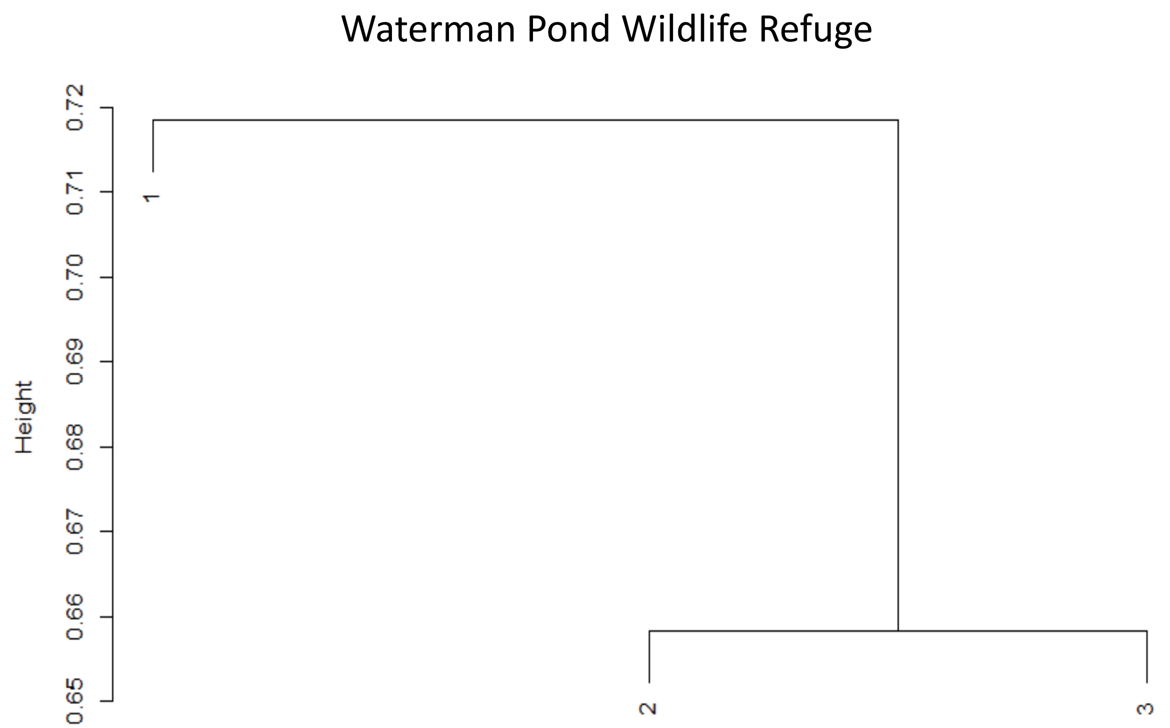
Cluster Dendrograms



For assistance in interpreting this graphic, please refer to page 47.


Ruby-throated Hummingbird (*Archilochus colubris*)

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For locations of Audubon Society of Rhode Island Wildlife Refuges that are open to the public, please visit **asri.org/hike**.

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