Habitat Quality for Stopover Migrants at Rushton Woods Preserve, Chester County, Pennsylvania

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Declines of migratory landbird populations in North America are well documented and have typically been attributed to habitat loss on the breeding and wintering grounds (Askins et al. 1990, Donovan et al. 2002, Sauer et al. 2013). However, declines may also be due to factors encountered during the migratory period; birds must navigate through unfamiliar habitat where food availability is unreliable while simultaneously coping with an increased predation risk and inclement weather. The extent to which habitat fragmentation affects stopover habitat, or even what constitutes ideal stopover habitat, is likely to vary among regions and species, and regional data are necessary for designing effective conservation measures. Following Moore et al. (1995), we define stopover habitat as any area where migratory landbirds stop to rest and refuel between flights.

Past conservation efforts to reverse declines of migratory landbirds have focused on breeding and wintering ground habitat conservation. However, there is an increasing awareness that conservationists must consider all phases of a migrant's annual cycle – breeding, fledgling, migration and wintering – because success in each phase is linked to the next (Moore et al. 1995, Donovan et al. 2002, Sillett and Holmes 2002, Rappole 2013). On their breeding grounds, many species are relatively inflexible with respect to habitat preference – conditions necessary for successful reproduction. This inflexibility renders breeding populations more susceptible to habitat alteration. Likewise, many species exhibit strict habitat preferences on their wintering grounds (e.g., Cody 1985, Moore et al. 1995). Stricter habitat preferences make crafting targeted, species-specific conservation goals a more straightforward process. However, because habitat preferences are more plastic during migration, large numbers of species occur together during the migratory period (Moore 2000, Mehlman et al. 2005).

Presently, we have a limited understanding of what habitats and habitat attributes are preferred by each species while on stopover, as well as the extent to which resource limitation at stopover sites influences fitness (Blem 1990, Moore 2000, Mehlman et al. 2005). High quality stopover habitat provides the necessary resources (food and vegetative cover) that permit migrants to meet the energetic demands of migration in a timely manner (Mehlman et al. 2005). Recognizing the unpredictable nature of migrants' stopover site selection, Mehlman et al. (2005) encouraged researchers and conservationists to develop a network of many monitoring locations, so sites along a migratory route can be assessed by their capacity to meet migrants' needs. For instance, a small isolated site may not be used from year to year except when migrants experience poor weather because that site provides sufficient cover and resources for birds to rest while the storm passes. Another less-than-ideal site may provide a variable amount of suitable habitat, located within a matrix of unsuitable habitat, for example heavily urbanized or suburbanized landscapes. Migrants may use these sites in some years, but in others there may or may not be sufficient resources for some species. Finally, the highest quality habitat provides sufficient space, food, and protection for many species during stopover consistently over the years. Large unfragmented tracts of heterogeneous forested habitat have been found to meet these needs, because they contain many types of stopover habitat, and sites that do not provide sufficient food resources, yet provide cover, may contribute to a successful migration.

One measure of habitat quality is the evaluation of the rate of body mass change in migrants (Dunn 2000). Migratory birds spend up to 30% of the year on migration, traveling hundreds or thousands of miles to and from breeding and wintering grounds, while making many stops in between (Moore et al. 1995, Mehlman et al. 2005, Bonter et al. 2007). At each stopover, fat deposition is essential; each bird accumulates fat to fuel the next long flight by compulsive eating (hyperphagia). During the migratory period, hyperphagic birds exhibit increased appetite and can deposit as much as 50% of their normal body mass in fat stores (Blem 1990, Moore et al. 1995). The ability, or inability, to deposit fat during migration can cause carry-over effects, influencing survivorship and reproduction on the winter and breeding grounds (Sandberg and Moore 1996, Marra et al. 1998, Webster et al. 2002). For example, Smith and Moore (2003) found that female American Redstarts (*Setophaga ruticilla*) arriving at a northerly breeding location in better body condition exhibited higher reproductive performance, suggesting that the quality of habitat encountered during the migratory phase of the avian annual cycle influenced fitness during the breeding season.

Each year, many migratory species utilize stopover habitats at Rushton Woods Preserve (RWP), part of an Important Bird Area (IBA) in Chester County, Pennsylvania. RWP is a 34.7 ha preserve that includes 10.9 ha of mature deciduous forest embedded in a larger (94.7 ha) woodland fragment. The land now occupied by woodland, including the RWP parcel, was historically used for pasture and cropland, and now constitutes one of the largest forest fragments in Chester County, with a canopy of 40–60 years of age, dominated by American beech (*Fagus grandifolia*) and tulip tree (*Liriodendron tulipifera*). Over 8.1 ha of cool season grassy meadows and early successional shrub-scrub, and 2.8 ha of organic agriculture, occupy the remaining area of the study site (Hartman et al. 2014). RWP is now owned and managed by Willistown Conservation Trust (WCT), an organization that conducts year-round public education and outreach through organic farming, restoration, and community events. In addition to these activities, WCT operates a bird banding station at RWP during fall and spring migration, as well as during the breeding season following a MAPS protocol (Monitoring Avian Productivity and Survivorship). The banding station was created in 2009 with funds from a Conservation Grant from the Delaware Valley Ornithological Club.

Methods

We assessed stopover habitat quality at RWP during the fall migratory periods (August 26 to November 4) of 2014 and 2015. First, we assumed that if high quality habitat attracts more migrants, then density estimates or capture rates for each species and age class (e.g., birds captured per 100 net-hours) should be positively correlated with habitat quality (Johnson 2007). Second, we estimated rates of body mass change for a suite of migratory species in which at least 30 individuals were captured. Positive mass gain can be interpreted as evidence of abundant food resources combined with sufficiently low predation risk to permit efficient foraging (Dunn 2000, Bonter et al. 2007, Seewagen and Slayton 2008, Smith and Hatch 2016). Although we captured birds in the early successional shrub-scrub only, it is assumed that the birds used the entire study site to forage, not only the immediate area around our nets.

Assessing the species and density of the vegetation can aid in understanding food availability and the level of vegetative protection provided from the structure. In the early successional shrub area, we characterized vegetation within an 11.3 m radius circle at each net location following the methods of James and Shugart (1970) and estimated tree diameters with a calibrated yard stick divided into the following size classes: (A) 3–6 cm, (B) 6–9, (C) 9–15, (D) 15–21, (E) 21–27, (F) 27–33, (G) 33–40, and (H) greater than 40. To estimate shrub density, we counted all woody stems less than 3 cm in diameter at breast height, along the diameter transects leading in each cardinal direction from the center of the circle to its edge. We measured the percent of canopy and ground cover at 20 locations on the transects (10 on each). Next, we recorded the presence or absence of green vegetation on the crosshair of an ocular tube.

We erected twelve stationary mist nets (one 6 m and eleven 12 m in length) within the early successional shrub-scrub zones that separate the meadows and operated them three days per week for 4.5 hours per day on average. The nets were opened approximately 15 minutes before sunrise and closed at 11 am. To reduce the risk of harming the birds, we did not operate nets during periods of rain, high winds, or extreme heat (Ralph et al. 1993). We checked nets once every 30 minutes and fitted each captured bird with an aluminum band bearing a unique serial number (U.S. Geological Survey). We measured wing chord to the nearest millimeter (mm) and used a digital scale to determine mass to the nearest 0.1g. We scored subcutaneous fat on an increasing scale of 0–6 (Ralph et al. 1993), with 0 representing no visible fat. When possible, we used Pyle's (1997) criteria to determine the sex and age class of the bird (i.e., hatch-year, HY; after hatch-year, AHY).

To control for differential sampling effort, we estimated capture rates by dividing the number of individuals captured by the total number of hours the nets were open (one 12 m net operated for 1 hr equals 1 net-hour), then multiplied by 100 to estimate birds captured per 100 net hours (b/100nh; Seewagen et al. 2011). To evaluate mass change, we converted capture times to minutes since sunrise (Dunn 2000) and estimated average rate of body mass change in all species (n = 16) with at least 30 or more captures. We included only first captures to avoid over-sampling locally breeding and winter resident birds (Dunn 2002, Jones et al. 2002). If food resources at RWP were abundant, permitting migrants to gain mass, we expected a positive relationship between body mass at first capture and minutes since sunrise (i.e., the time available for foraging). Models were run in SPSS version 21 (IBM 2012), following methods used by Smith and Hatch (2016), with capture year, date, and minutes since sunrise included as fixed effects, and wing chord treated as a random effect.

Results

Vegetative Characteristics

Average canopy height was 12.9 m, and the most common trees in rank order were black cherry (*Prunus serotine*), box elder (*Acer negundo*), and black walnut (*Juglans nigra*) (Table 1). Average shrub height was 3.4 m, and shrub stem density was comprised mainly of amur honeysuckle (*Lonicera maackii*), spicebush (*Lindera benzoin*), and multiflora rose (*Rosa multiflora*) (Table 1). Snags constituted a large amount of stem density in the understory, and the most abundant stem was multiflora rose. Rose rosette disease is present on the study site and may be responsible for the multiflora rose snags (AVF pers. obs.).

Capture Rates and Mass Change

We captured 2,176 new individuals of 67 species with a total capture rate of 73.5 birds per 100 net hours during the fall migratory periods of 2014 and 2015 (Table 2). Gray Catbirds (*Dumetella carolinensis*) had the highest capture rate (25 b/100nh), followed by White-throated Sparrows (*Zonotrichia albicollis*) (9 b/100nh). Most of the captures were HY birds (82%). Only 3 of 16 (19%) species gained mass while stopping over at RWP during the fall migratory period (Table 3): Hermit Thrush (*Catharus guttatus*) (2.6% of mean mass gained per hour), White-throated Sparrow (0.5%), and Gray Catbird (0.5%). We found no evidence of mass loss in any of the species examined (Table 3).

Gray Catbird (*Dumetella carolinensis*)
Drawn by Katrina Rakowski based on photo by Joel Sartore/National Geographic Photo Ark.

Discussion

Our results indicate that RWP was used by many species during the fall migratory periods of 2014 and 2015. However, only 19% of the species examined showed evidence of mass gain, suggesting that the site was not a high quality refueling area for all migrants during the two years of this study. Importantly, we found no evidence that any species lost mass, so RWP seems to provide suitable stopover habitat for at least some migratory species (Dunn 2000; Seewagen et al. 2011).

The most abundant species in both years were Gray Catbirds and White-throated Sparrows. Interestingly, capture rates at RWP were substantially higher than at four other migratory landbird monitoring sites in the northeastern United States and Canada during the same time period (Table 4). Unlike our study site at RWP, Braddock Bay Bird Observatory, McGill Bird Observatory, and Powdermill Avian Research Center (PARC) conduct constant effort mist-netting

Table 1. Trees and Shrubs of Rushton Preserve and Relative Density

Species of trees and shrubs at Rushton Woods Preserve, and their relative densities: the average number of trees or shrubs in 0.04 ha (400 m^2) circular plots conducted at each net lane (n = 12).

COMMON NAME	SCIENTIFIC NAME	% TREE DENSITY	% SHRUB DENSITY
Spicebush	*Lindera benzoin*	13.0	
Tulip Poplar	*Liriodendron tulipifera*	4.7	0.5
Virginia Creeper	*Parthenocissus quinquefolia*	0.5	
Grape sp.	*Vitis sp.*	6.6	
Oriental Bittersweet	*Celastrus orbiculatus*	3.2	2.5
Black Locust	*Robinia pseudoacacia*	4.9	
Red Oak	*Quercus rubra*	4.7	
Black Walnut	*Juglans nigra*	12.1	1.2
Gray Birch	*Betula populifolia*	3.2	
Rubus sp.	*Rubus sp.*	4.1	
Multiflora Rose	*Rosa multiflora*	9.6	
Black Cherry	*Prunus serotine*	17.9	
Crab Apple	*Malus sp.*	1.4	
Autumn Olive	*Elaeagnus umbellate*	1.5	
Sumac sp.	*Sumac sp.*	3.2	0.5
Box Elder	*Acer negundo*	12.3	2.0
Red Maple	*Acer rubrum*	3.2	
Maple sp.	*Acer sp.*	3.2	
Flowering Dogwood	*Cornus florida*	3.2	
Black gum	*Nyssa sylvatica*	4.7	
Privet	*Ligustrum sp.*	4.1	
White Ash	*Fraxinus americana*	9.5	0.8
Jap. Honeysuckle	*Lonicera japonica*	4.0	
Amur Honeysuckle	*Lonicera maackii*	8.7	43.0
Snag		6.1	38.9

(i.e., nets are typically open every day throughout the migratory season, PARC unpubl. Data; Patterson 2015, 2016). Although these stations accumulate many more net hours, RWP capture rate was twice as high. Also, included in Table 4 is Alfred Station, which was operated similarly to RWP – in fall 2014, where both stations operated 28 days.

Although capture rates are indicators of site use, they offer little insight into the fitness consequences of using a stopover site (Johnson 2007). However, combined with mass change estimates, evidence of the importance of a stopover site becomes clearer. Unfortunately, for mass change rates, we could only use data from two migratory seasons, yielding sample sizes of fewer than 100 individuals for 11 of the 16 species. Although a minimum of 30 individuals is recommended, Dunn (2002) suggests a larger sample size is needed to see overall trends in mass change due to variation in food throughout and between seasons. Therefore, some of my species may have gained or lost mass at undetectable rates.

Table 2. Capture Rates by Species

Capture rates (birds/100 net-hours) by species during the fall migratory periods of 2014 and 2015 at Rushton Woods Preserve; *n* is the total number of first captures.

COMMON NAME	SCIENTIFIC NAME	*n*	CAPTURE RATE
Sharp-shinned Hawk	*Accipiter striatus*	1	0.04
Red-bellied Woodpecker	*Melanerpes carolinus*	6	0.21
Downy Woodpecker	*Picoides pubescens*	7	0.25
Northern Flicker	*Colaptes auratus*	4	0.14
Yellow-bellied Flycatcher	*Empidonax flaviventris*	2	0.07
Acadian Flycatcher	*Empidonax virescens*	1	0.04
Willow Flycatcher	*Empidonax traillii*	1	0.04
Eastern Phoebe	*Sayornis phoebe*	2	0.07
White-eyed Vireo	*Vireo griseus*	1	0.04
Yellow-throated Vireo	*Vireo flavifrons*	1	0.04
Blue-headed Vireo	*Vireo solitarius*	1	0.04
Red-eyed Vireo	*Vireo olivaceus*	12	0.42
Blue Jay	*Cyanocitta cristata*	5	0.18
Carolina Chickadee	*Poecile carolinensis*	16	0.56
Tufted Titmouse	*Baeolophus bicolor*	24	0.85
White-breasted Nuthatch	*Sitta carolinensis*	3	0.11
Brown Creeper	*Certhia americana*	3	0.11
House Wren	*Troglodytes aedon*	43	1.51
Winter Wren	*Troglodytes hiemalis*	2	0.07
Carolina Wren	*Thryothorus ludovicianus*	13	0.46
Golden-crowned Kinglet	*Regulus satrapa*	1	0.04
Ruby-crowned Kinglet	*Regulus calendula*	108	3.80
Veery	*Catharus fuscescens*	39	1.37
Gray-cheeked Thrush	*Catharus minimus*	15	0.53
Swainson's Thrush	*Catharus ustulatus*	34	1.20
Hermit Thrush	*Catharus guttatus*	42	1.48
Wood Thrush	*Hylocichla mustelina*	28	0.99
American Robin	*Turdus migratorius*	42	1.48
Gray Catbird	*Dumetella carolinensis*	735	25.89
Brown Thrasher	*Toxostoma rufum*	4	0.14
Cedar Waxwing	*Bombycilla cedrorum*	1	0.04
Ovenbird	*Seiurus aurocapilla*	28	0.99
Worm-eating Warbler	*Helmitheros vermivorum*	4	0.14
Northern Waterthrush	*Parkesia noveboracensis*	2	0.07
Black-and-white Warbler	*Mniotilta varia*	18	0.63

(continued)

Table 2. Capture Rates by Species *(continued)*

COMMON NAME	SCIENTIFIC NAME	*n*	CAPTURE RATE
Nashville Warbler	*Leiothlypis ruficapilla*	3	0.11
Connecticut Warbler	*Oporornis agilis*	9	0.32
Common Yellowthroat	*Geothlypis trichas*	91	3.21
American Redstart	*Setophaga ruticilla*	27	0.95
Magnolia Warbler	*Setophaga magnolia*	28	0.99
Bay-breasted Warbler	*Setophaga castanea*	1	0.04
Chestnut-sided Warbler	*Setophaga pensylvanica*	6	0.21
Blackpoll Warbler	*Setophaga striata*	2	0.07
Black-throated Blue Warbler	*Setophaga caerulescens*	39	1.37
Palm Warbler (Western)	*Setophaga p. palmarum*	1	0.04
Palm Warbler (Yellow)	*Setophaga p. hypochrysea*	17	0.60
Yellow-rumped Warbler	*Setophaga coronata*	6	0.21
Black-throated Green Warbler	*Setophaga virens*	2	0.07
Canada Warbler	*Cardellina canadensis*	6	0.21
Wilson's Warbler	*Cardellina pusilla*	1	0.04
Chipping Sparrow	*Spizella passerina*	19	0.67
Field Sparrow	*Spizella pusilla*	48	1.69
Fox Sparrow	*Passerella iliaca*	3	0.11
Dark-eyed Junco	*Junco hyemalis*	23	0.81
White-crowned Sparrow	*Zonotrichia leucophrys*	1	0.04
White-throated Sparrow	*Zonotrichia albicollis*	256	9.02
Savannah Sparrow	*Passerculus sandwichensis*	1	0.04
Song Sparrow	*Melospiza melodia*	156	5.50
Lincoln's Sparrow	*Melospiza lincolnii*	10	0.35
Swamp Sparrow	*Melospiza georgiana*	26	0.92
Eastern Towhee	*Pipilo erythrophthalmus*	37	1.30
Northern Cardinal	*Cardinalis cardinalis*	51	1.80
Rose-breasted Grosbeak	*Pheucticus ludovicianus*	3	0.11
Indigo Bunting	*Passerina cyanea*	10	0.35
House Finch	*Haemorhous mexicanus*	6	0.21
Purple Finch	*Haemorhous purpureus*	2	0.07
American Goldfinch	*Spinus tristis*	36	1.27
Totals:	**67 species**	**2,176**	**76.66**

Interestingly, Hermit Thrush showed the highest rate of mass change at RWP (2.6%), showing higher rates of mass gain than a site in metropolitan Detroit (0.81%; Craves 2009), three areas on Long Point, Ontario (-0.23%, 0.12%, 0.3%; Dunn 2002), and along the southern shoreline of Lake Ontario (Braddock Bay) in New York State (0.35%; Bonter et al. 2007). White-throated Sparrows captured at RWP gained mass at lower rates (0.5%) than at Braddock Bay (0.63%) (Bonter et al. 2007) and in a New York

Table 3. Estimates of Mass Change Rates for 16 Species

Results of mixed models estimating mass change rates for 16 species of migratory landbirds during fall migration at Rushton Woods Preserve, 2014–2015. For each species, the number of individuals sampled (*n*) is shown with model coefficients (β), standard errors (SE), and probability values (P) for the effect of time since daylight. Year, date, and wing chord length are not shown, but were included as independent variables in the models (see Methods). Percent mass change estimates were calculated from unstandardized coefficients (ß weights). For the 3 species exhibiting significant gain in mass, the % of mean mass change per hour (Δ) is shown.

Species	*n*	β	SE	P	mass (g)	Δ (%)
House Wren	43	0.002	0.002	0.330	11.5	
Ruby-crowned Kinglet	108	0.001	0.001	0.126	6.5	
Veery	39	0.001	0.009	0.884	35.4	
Swainson's Thrush	34	0.004	0.005	0.408	32.2	
Hermit Thrush	42	0.013	0.006	0.048	30.7	2.6
Wood Thrush	27	0.004	0.011	0.753	51.3	
American Robin	41	0.002	0.006	0.728	77.9	
Gray Catbird	733	0.003	0.001	0.001	38.4	0.5
Common Yellowthroat	91	-0.001	0.002	0.773	10.0	
Magnolia Warbler	28	0.002	0.001	0.141	8.4	
Black-throated Blue Warbler	39	0.003	0.002	0.232	9.8	
Field Sparrow	48	0.000	0.002	0.822	12.9	
White-throated Sparrow	256	0.002	0.001	0.026	25.3	0.5
Song Sparrow	156	0.003	0.002	0.080	20.7	
Eastern Towhee	36	-0.004	0.015	0.816	41.4	
American Goldfinch	36	-0.004	0.002	0.836	12.5	

Table 4. Capture Rates and Percent Hatch Year Birds

Capture rates (birds per/100 net-hours) and percent hatch-year (HY) birds reported in 2014 and 2015 at five fall migratory landbird monitoring stations (Patterson 2015, 2016, PARC unpubl. data): Alfred Station (AS) and Braddock Bay Bird Observatory (BBBO) in New York, McGill Bird Observatory (MGBO) in Québec, Canada, and Powdermill Avian Research Center (PARC) and Rushton Woods Preserve (RWP) in Pennsylvania.

	Year	AS	BBBO	MGBO	PARC	RWP
Capture Rate	2014	40	28.8	59.7	31.7	74.2
	2015	19.4	26.9	44.4	27.8	78.9
% Hatch Year	2014	66	86.1	78.4	—	82
	2015	60	86.5	82	—	83.1

City park (1.6%) (Seewagen et al. 2011). Gray Catbirds captured at RWP (0.5%) gained mass at higher rates (0.5%) than on Long Point, Ontario (-0.18, 0.27, 0.52), but showed rates lower than at Braddock Bay (0.79%) (Bonter et al. 2007). Detroit, Long Point, Braddock Bay, and the New York City Park sites were all determined to be good quality stopover habitats due to the rates of mass gain.

In comparison to other sites, the proportion of HY birds captured at RWP appears to be similar (Table 4). Young birds are expected to be especially vulnerable to predators and may forage less efficiently (Woodrey 2000, Jones et al. 2002) possibly influencing estimated mass gain rates (Heise and Moore 2003). Morris et al. (1996) found that over a ten-year period, HY birds showed lower fat stores and lower average mass at first capture than AHY birds. Likewise, Woodrey and Moore (1997) found in three of six migratory species, that young birds carried significantly less subcutaneous fat, and Jones et al. (2002) found that AHY birds had a 10% higher rate of mass gain than HY birds. My data set provided insufficient numbers to compare rates of mass change in HY and AHY between species. Future data collection and analysis could investigate if HY birds at RWP are gaining mass at a slower rate. In conclusion, our results (high capture rates, evidence of mass gain in some species, no evidence of mass loss) suggest that RWP provides important habitat for many species, especially HY birds.

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