WHAT DETERMINES SUCCESS? BREEDING HABITAT CHARACTERISTICS OF THE LOUISIANA WATERTHRUSH (*Seiurus motacilla*)

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ABSTRACT

Riparian habitats perform many important ecological functions, but are frequently affected by anthropogenic development. Recently, using bioindicator species, such as the Louisiana Waterthrush, to evaluate riparian health has become increasingly important. Louisiana Waterthrushes nest along stream banks and feed primarily on benthic macroinvertebrates, making them vulnerable to both changes in riparian production and diversity. It is important to determine aspects of the riparian environment that affect productivity. We measured various habitat characteristics of nesting Louisiana Waterthrushes to determine what territorial factors influence breeding success. Based on independent t-tests, we found that increased canopy cover and oak density were positively correlated with nest success. In contrast, increased poplar density and length of streams that are intermittent rather than perennial within territories were negatively correlated nest success. These four factors were placed in a binary logistic regression model. Canopy cover and poplar density were statistically significant, while oak density and intermittent streams were marginally significant. This model correctly predicted 86.1 percent of nest outcomes. Increased canopy cover may offer greater protection from visual predators. Poplar, a tree species characteristic of relatively open forests, is often replaced by oaks as the forest matures—which typically also increases canopy cover. Increased intermittent flow limits the productivity of streams, and therefore, decreases the reproductive success of the Louisiana Waterthrush. More research must be done to increase sample sizes, and consequently, the understanding of how these habitat factors affect the Louisiana Waterthrush.

INTRODUCTION

Riparian habitats are home to hundreds of organisms that perform many important ecological processes (Karr and Schlosser 1978, Sweeney 1992, Lowrance et al. 1997). Unfortunately, riparian habitats are affected by anthropogenic development and often suffer from erosion, sedimentation, and acidification. The variety and number of organisms that occur in riparian zones emphasize the importance of conserving these areas (Peak and Thompson 2006).

Riparian health is assessed in a variety of ways including chemical, periphyton, benthic macroinvertebrate, and fish surveys (Barbour et al. 1999). However, these methods frequently require extensive knowledge of the organism sampled or special equipment. The development of bioindicators as cost-effective and public-friendly methods may improve the monitoring of riparian ecosystems.

The Louisiana Waterthrush (*Seiurus motacilla*) provides a unique opportunity for monitoring forested riparian habitats. It is the only stream-obligate avian species in the Eastern United States; it feeds primarily on aquatic macroinvertebrates, including Ephemeroptera, Plecoptera, and Trichoptera (commonly referred to as EPT; Robinson 1995). The EPT taxa are sensitive to changes in their aquatic environment, and therefore, are often used to assess stream health (Morse et al. 2003, Muenz et al. 2006, Rose et al. 2008). The presence of the Louisiana Waterthrush along a stream is correlated with high proportions of the EPT, making it a good bioindicator of riparian quality in the areas it inhabits (Mattsson and Cooper 2006). Research and conservation of the Louisiana Waterthrush are important because of its dependence on riparian habitats often threatened by anthropogenic activities (Rich et al. 2004).

Measuring the quality of riparian habitats is complex; many factors may contribute to the Louisiana Waterthrush success, and short-term observations may not reflect all impacts. Earlier studies of the breeding ecology of the Louisiana Waterthrush in relation to variation in stream quality found no difference between the proportion of nests with fledglings of the Louisiana Waterthrush nesting on acidic and circumneutral streams (Mulvihill et al. 2008). However, on acidic streams, territory size was greater, clutch sizes were smaller, and nestlings had shorter wing lengths than those on circumneutral streams. Further, females nesting on circumneutral streams fledged more young than those on acidic streams. The birds appear to compensate for the reduced quality territories on acidic streams by establishing territories almost twice the size of those on the circumneutral streams; nonetheless, their fledgling success remained low.

To understand what aspects of territory quality influence the reproductive success of the Louisiana Waterthrush, we examined various ecological characteristics of breeding territories in relation to reproductive success. We predicted that territories with greater reproductive success would contain habitat characteristics that reduced predation, and also would include in-stream characteristics that allowed for easy foraging and abundant aquatic prey availability.

MATERIALS AND METHODS

Study Area

This study was conducted by the National Aviary of Pittsburgh, Pennsylvania and the Powdermill Avian Research Center in Rector, Westmoreland County, Pennsylvania. Research sites were located throughout the Ligonier Valley among the Laurel Highlands of southwestern Pennsylvania (40.1636°N, 79.2674°W; Figure 1). Riparian and in-stream habitat varied among the seven research streams. The selected streams ranged in pH from acidic to circumneutral, and the degree of land use and anthropogenic development also differed among each stream.

Data Collection

We walked along the banks of each stream searching for nests. Once located, we marked the coordinates of the nests with a handheld GPS unit. Data collected for each nest included: bank type (main stream, tributary, road, hillside, or other); bank height measured in meters; orientation of bank; visibility of the nest cup from the top, right, left, and front view at a distance of one meter recorded in a percentage; and distance in meters from the stream. Within a five meter radius of each nest, we also measured the total percent landcover of the following: soil, rocks without moss, leaf litter, fallen trees greater than 10 cm diameter, fallen trees less than 10 cm diameter, water or wetted areas, moss, ferns, forbs and broadleaf trees, and skunk cabbage. We estimated the height of the canopy and measured the percent canopy cover above each nest. Within an 11.3 meter radius around all nests, the number of shrubs (dbh<10 cm) and trees (dbh>10 cm) were tallied by species. Aquatic invertebrate samples and pH were also taken at all nests, but were not processed in time to use in this thesis.

We observed the singing and foraging behaviors of each breeding pair to determine territory area in reference to flags placed 50 meters apart along streams. Landscape level characteristics for breeding pair territories were mapped using ArcMap 9.2. Prior to field work, all research streams were digitized from orthophotographs, taken March 2003 and provided by the GIS Department of Westmoreland County. We made adjustments to the stream channels in the field, as necessary.

Using Trimble GeoXT GPS equipped with ArcPad, we classified the following stream habitat characteristics in the field: water regime (perennial, intermittent, ephemeral), in-stream habitat type (riffle, run, pool, or riffle-run), and substrate (bedrock, rubble, cobble/gravel, sand, mud, organic, or vegetated; Cowardin et al. 1979; Table 1 contains detailed descriptions of how each characteristic was determined). Debris dams within the stream channel were mapped, and any influence of human disturbance was noted at points along the streams. We also mapped the tributaries within 100 meters of the main stream and classified their water regime, in-stream habitat type, and substrate following the criteria described above. Within 50 meters of the main stream, we also mapped and classified the dominated vegetation type of evergreen and wetland patches. In the field, we mapped upturned trees and measured the length of the exposed root mass. All field data mapped with GPS units were geocorrected and edited using ArcMap 9.2.

During the field season, breeding adults and chicks were banded; each individual was given a unique color code for identification. We monitored nests and classified each one as successful (having at least one fledgling) or unsuccessful (having no eggs survive to the fledgling stage).

Statistical Analysis

Using SPSS 16.0, we performed independent-samples t-tests comparing various habitat measurements for successful versus unsuccessful nests. Variables that were determined to be statistically significant at an α of 0.05 were placed into a binary logistic regression model.

RESULTS

We found a total 39 nests during the 2007 field season. Two of the observed territories could not be mapped, and were therefore not used in analysis. We also were unable to use all measured variables in analysis because of missing data from some nests. On average, territories, regardless of outcome, had an area of 51533 square meters (m^2), evergreens covered 4854 m^2 of that area, and wetlands 1072 m^2. The average stream length within the observed territories was 7202 meters (m) with 1947 m of the in-stream habitat classified as runs, 953 m as riffle-runs, 2775 m as riffles, and 1121 m as pools. The average water regime distances within streams were as followed: 6550 m as perennial, 369 m as intermittent, and 283 m as ephemeral.

Of the 39 nests, 20 (51%) were successful and 19 (49%) were unsuccessful. Territories of successful nests had a significantly greater percentage of both canopy cover (n=39, d.f.=19.267, F=64.314, t=2.711, p=0.014) and oak trees (n=39, d.f.=37, F=7.736, t=2.196, p=0.036) than those of unsuccessful nests. Unsuccessful nests were in territories with a significantly greater percentage of poplar trees (n=39, d.f.=25.399, F=7.863, t=-2.417, p=0.023) than successful nests. We also found that territories with unsuccessful nests contained a significantly greater proportion of intermittent streams (n=37, d.f.-30.578, F=0.142, t=-2.513, p=0.17) than successful nests. No other variables used in analysis were found to be statistically significant in exploratory analyses (Table 2).

We used binary logistic regression to determine to what degree canopy cover, oak density, poplar density, and intermittent streams influenced reproductive success. Canopy cover and poplar tree density were statistically significant predictors of reproductive success, while oak density and intermittent streams were marginally significant (Table 3). The majority (86.1%) of all nest outcomes were correctly predicted by this logistic regression model.

DISCUSSION

Nests that fledged at least one chick were typically in territories that had significantly greater forest cover than unsuccessful nests. The significance of poplar trees, oak trees, and canopy cover found around Louisiana Waterthrush nests may indicate a set of underlying ecological relationship among these three factors. Poplar, an early successional species, is often found in open, less mature forests while oak, a late successional species, is considered a tree species of older-forest ecosystems. Although later-successional forest stages typically have more cover than early-successional habitats, there may be independent influences, over and above simple cover, of particular late-successional species. For example, increased oak density, especially during a season with great mast production, may decrease predation rates of Louisiana Waterthrush eggs and chicks. The oaks may produce a sufficient supply of acorns, a favorite food of Sciurid predators (Smith and Follmer 1972), that squirrel species prey less on Louisiana Waterthrush nests surrounded by a greater proportion of oak than poplar trees. However, data must be gathered on mast production of oaks among Louisiana Waterthrush breeding habitats to test this hypothesis.

Successful Louisiana Waterthrush territories were also characterized by steadier, less intermittent streams than unsuccessful territories. Our results suggest that Louisiana Waterthrush are less successful in less productive territories, as changes in stream flows affect productivity of aquatic systems (Riseng et al. 2004). Unpredictable stream flows also disrupt aquatic macroinvertebrates populations, which the Louisiana Waterthrush relies heavily on as a source of food for both adults and chicks. If the stream flow is inconsistent while parents are brooding eggs or raising chicks, the birds may not be able to gather enough food to continue raising young. Although researchers have observed Louisiana Waterthrushes foraging for prey typically not part of their diet when aquatic macroinvertebrate food sources are reduced (Mulvihill et al. 2008), this may not be enough to sustain themselves and their young. There may also be a relationship between food availability and depredation. As the food supply decreases, birds may have to spend more time foraging than guarding their nests (Zanette et al. 2003, Mattsson and Niemi, 2006, Mattsson and Cooper 2007).

Nonetheless, our results are only from one location and field season; our sample size was also low. Data collected during this single field season should be complied with data from future years to achieve a better understanding of how the habitat of the Louisiana Waterthrush affects its breeding success. Our small sample size did not allow for us to distinguish between unsuccessful nests that were lost to predators and nests that were unsuccessful for other environmental reasons. A larger sample size may have allowed us to break down further the classification of unsuccessful nests to determine how the breeding habitat may influence the ways in which a nest might succeed or fail. We may also be able to distinguish “more successful” and “less successful” nests in terms of number of chicks that reach the fledging stage.

Greater overhead cover and consistent streams appear, in this location, to contribute significantly to breeding success in Louisiana Waterthrushes. However, environmental factors at non-breeding sites also may affect the breeding success of the Louisiana Waterthrush. Research will continue on the Louisiana Waterthrush on its wintering grounds as part of this multi-year study. These studies at both the breeding and wintering grounds of the Louisiana Waterthrush provide a unique opportunity to help understand how avian populations, specifically Louisiana Waterthrush populations, change throughout its annual migratory cycle. Our research will inform avian conservation projects by helping to determine which habitat characteristics are important in the conservation of the Louisiana Waterthrush.

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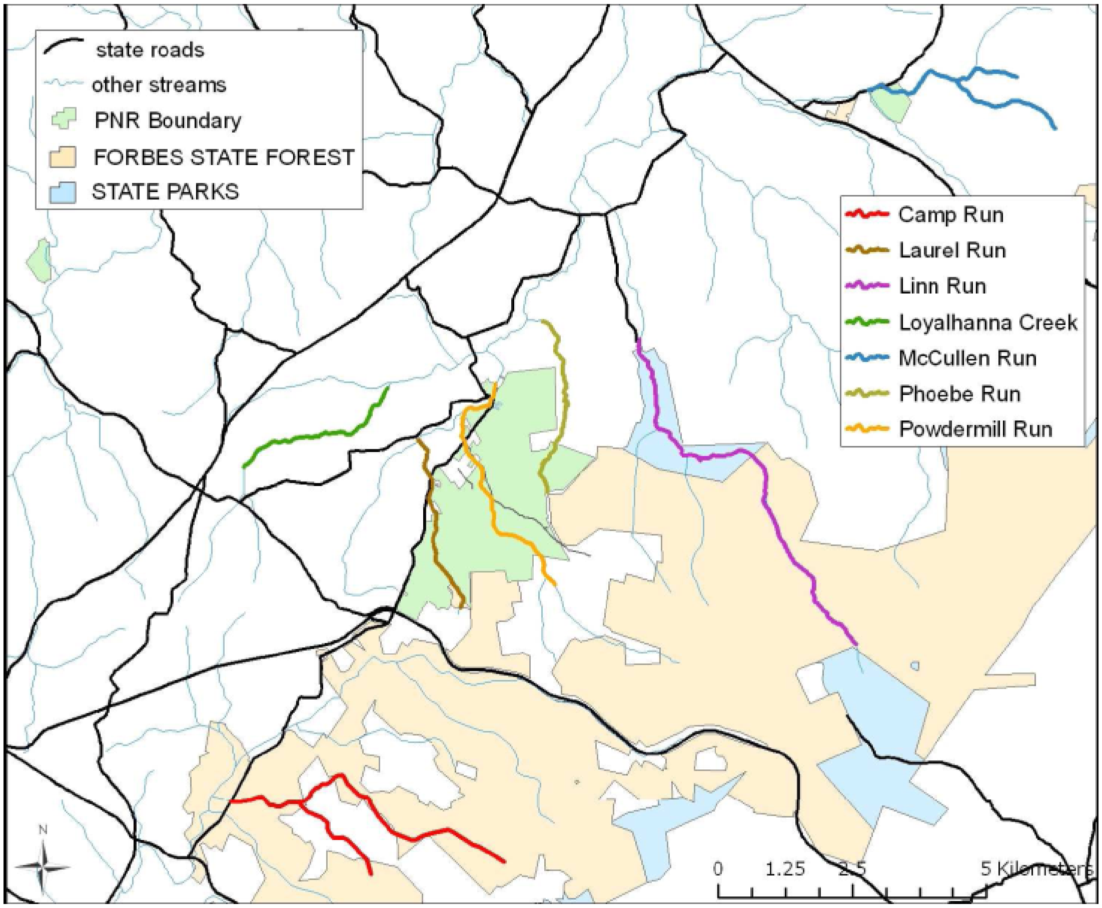

Figure 1: Map of seven research streams used in study. Streams are located in southwestern Pennsylvania among the Laurel Highlands of Ligonier Valley.

Table 1: Describes attributes used to classify water regime, in-stream habitat, and substrate of all mapped streams for study. From LOWA Stream Habitat Mapping Protocol (2007) and Cowardin et al. 1979.

Water Regime	**Description**
Perennial	Gradient is high and velocity of water is fast. Some water flows throughout the year.
Intermittent	The channel contains flowing water for only part of the year. When the water is not flowing, it may remain in isolated pools or surface water may be absent.
Ephemeral	Water flows only during high precipitation or melting events.
In-Stream Habitat	**Description**
Riffle	Fast current and shallow water with obvious surface turbulence. The bottom is made up of gravel, rubble, or boulders.
Run	Deeper than riffles with moderate current and little or no surface turbulence. Runs are found between riffles and pools. The bottom is made up of small gravel or rubble.
Riffle-Run	Segments of riffle and run alternate and each is less than five meters long.
Pool	Deeper with a slow current and no obvious surface turbulence or broken water. The deep, slow-moving water generally has a bottom of silt, sand, or small gravel.
Culvert	Water flows through human-made structure.
Not Available	No water present or not applicable
Substrate	**Description**
Bedrock	Bedrock covers more than 75% of stream channel.
Rubble	Characterized by stones, boulders, and bedrock that in combination covers more than 75% of the channel.
Cobble/Gravel	At least 25% of the substrate is covered by unconsolidated particles smaller than stones; cobbles or gravel dominate
Sand	Sand-sized particles dominate among the particles smaller than stones; often contains bars and beaches interspersed with mud or cobble/gravel
Mud	The particles smaller than stones are chiefly silt or clay
Organic	Channels formed in peat or muck
Vegetated	Streambed exposed long enough to be colonized by herbaceous annuals or seedlings, but is usually killed by rising water levels or sudden flooding

Table 2: Statistics from independent t-tests comparing successful and unsuccessful nests. All tests were performed with an alpha of 0.05. Significant results are marked with an asterisk (*) and those where equal variances were not assumed are marked with a caret (^). The variable, Snag Tree Percent, represents standing dead trees within the territories.

Variable	F	t	d.f.	p-value
Nest Visibility Above (%)	5.097	1.217	21.548^	0.257
Nest Visibility Front (%)	0.179	0.452	37	0.654
Nest Visibility Right (%)	0.015	-0.017	37	0.986
Nest Visibility Left (%)	0.474	0.955	37	0.346
Stream Bank Height (m)	0.018	0.693	37	0.493
Nest Height (m)	4.176	1.019	19.001^	0.321
Stream Width (m)	1.339	-0.894	36	0.377
Stream Bank Slope (°)	3.702	-1.306	37	0.199
Stream Bank Orientation (°)	0.149	-1.062	37	0.295
Nest Orientation (°)	0.366	-0.126	37	0.901
Soil Percent	5.861	1.239	25.660^	0.227
Rock Percent	0.010	-0.346	37	0.731
Litter Percent	2.484	0.526	37	0.602
Large Log Percent	1.289	-1.106	37	0.276
Small Log Percent	1.761	-0.638	37	0.527
Water Percent	0.000	-0.336	37	0.739
Moss Percent	5.925	1.542	31.276^	0.133
Fern Percent	8.355	-1.659	28.198^	0.108
Tree Percent	0.067	0.213	37	0.832
Skunk Cabbage Percent	5.332	-1.147	37	0.259
Canopy Height	0.358	0.152	34	0.880
Canopy Cover	64.314	2.711	19.267^	0.014*
Beech Tree Percent	3.430	1.430	37	0.161
Cherry Tree Percent	2.298	0.706	37	0.485
Hickory Tree Percent	2.166	-0.578	37	0.566
Maple Tree Percent	2.517	-0.413	37	0.682
Oak Tree Percent	7.736	2.196	29.653^	0.036*
Poplar Tree Percent	7.863	-2.417	25.399^	0.023*
Hemlock Tree Percent	3.221	0.645	37	0.523
Rhododendron Percent	5.147	-1.123	27.405^	0.271
Snag Tree Percent	1.775	0.318	37	0.752
Tulip Tree Percent	0.161	0.699	37	0.489
Other Tree Percent	0.000	-0.798	37	0.430
Total Evergreen Area (m^2)	2.861	0.779	35	0.441
Total Wetland Area (m^2)	0.091	0.295	35	0.770

Territory Perimeter (m)	0.157	-1.776	35	0.084
Territory Area (m^2)	0.021	-1.703	35	0.097
Total Stream Length in Territory (m)	0.083	-0.278	35	0.783
In-stream Habitat Culvert (m)	2.528	-0.800	35	0.429
In-stream Habitat Not Available (m)	4.816	0.884	30.968^	0.383
In-stream Habitat Pool (m)	0.816	-0.357	35	0.723
In-stream Habitat Riffle (m)	0.230	0.015	35	0.988
In-stream Habitat Riffle-Run (m)	0.068	-1.245	35	0.221
In-stream Habitat Run (m)	0.348	-0.092	35	0.927
Ephemeral Streams (m)	8.429	1.230	25.744^	0.230
Intermittent Streams (m)	4.818	-2.513	30.578^	0.017*
Perennial Streams (m)	0.142	-0.168	35	0.868

Table 3: Statistics from binary logistic regression model. Poplar density and canopy cover significantly affected nest success while intermittent streams and oak density were marginally significant. Odds ratio demonstrates the change in nest success seen with one unit increase or decrease of a given variable. The large and small coefficient and odds ratio for oak and poplar density, respectively, may be a result of an interaction between the two variables.

Variable	Coefficient	Standard Error	p-value	Odds Ratio
Intermittent Streams	-0.003	0.001	0.089	0.997
Oak Tree Percent	25.075	13.430	0.062	7.761E+10
Poplar Tree Percent	-28.291	12.076	0.019	0.000
Canopy Cover	0.455	0.196	0.020	1.577