

FORAGING HABITAT CHARACTERISTICS, PREY AVAILABILITY, AND
DETECTABILITY OF RUSTY BLACKBIRDS: IMPLICATIONS FOR LAND AND
WILDLIFE MANAGEMENT IN THE NORTHERN FOREST

by

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Abstract

A. L. Pachomski. Foraging Habitat Characteristics, Prey Availability, and Detectability of Rusty Blackbirds: Implications for Land and Wildlife Management in the Northern Forest, 98 pages, 18 tables, 7 figures, 5 appendices, 2017.

The Rusty Blackbird (*Euphagus carolinus*) is a migratory songbird that breeds in and near the boreal wetlands of northern New England and Canada. Although the Rusty Blackbird was once common, the species has declined by an estimated 90% since the 1960's (Greenberg et al. 2010). I used single-season occupancy analysis to model breeding Rusty Blackbirds' use of 60 beaver (*Castor canadensis*) influenced wetlands in Coos County, New Hampshire and Oxford County, Maine. I conducted three 30 minute detected/ not detected surveys, surveyed food availability and foraging habitat, and digitized each survey wetland. Rusty Blackbirds' use of wetlands was best predicted by the site covariates mud and invertebrate abundance and detectability was best predicted by survey period. Probability of wetland use decreased with increasing mud cover and increased with increasing aquatic invertebrate abundance. I recommend that future researchers survey for Rusty Blackbirds for 30 minute periods to maximize survey coverage.

Keywords: Rusty Blackbird, boreal wetlands, aquatic macroinvertebrates

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Introduction

The Rusty Blackbird: a species in decline

The Rusty Blackbird (*Euphagus carolinus*, RUBL) is a migratory songbird that breeds in and near wetlands of the boreal forests of Canada and the Acadian Forest of the northeastern United States. The Rusty Blackbird is considered a “poster child” for boreal avian species decline (Niven et al. 2004, IRBWG 2009). Although the Rusty Blackbird was once common, the species has declined by an estimated 90% since the 1960’s (Greenberg et al. 2010). The U.S. Fish and Wildlife Service has listed the Rusty Blackbird as a Focal Species of Birds of Management Concern; the IUCN Red List considers the species to be Vulnerable. The relatively recent, sharp decline suggests the Rusty Blackbird should be of even higher conservation concern.

The cause of the Rusty Blackbird’s decline is not fully understood; climate change (McClure et al. 2012), mercury contamination (Edmonds et al. 2010), hematozoa infections (Barnard et al. 2010), timber harvesting patterns (Powell et al. 2010), and habitat loss (Hamel et al. 2009) have been suggested as possible factors. Furthermore, the southeastern limits of the bird’s breeding range appear to have retreated northward coincident with the population decline (McClure et al. 2012). Thus, it is important to monitor Rusty Blackbirds to detect further population changes or range shifts and identify necessary conservation measures.

Breeding Rusty Blackbirds

Rusty Blackbirds breed in and near boreal wetlands from northern New England and the Maritime Provinces west to Alaska. Rusty Blackbirds in New England prefer regenerating

conifer forest habitat; they select nest sites with minimal canopy cover and high basal area of young conifers in New England (Luepold et al. 2015, Powell et al. 2010). . Their nests are typically found in small, live red spruce (*Picea rubens*), black spruce (*Picea mariana*), or balsam fir (*Abies balsamea*) trees surrounded by other small conifers. Occasionally, they nest in speckled alder (*Alnus incana*) swamps, in snags, or in isolated conifers in open areas. Nesting trees are typically small, with an average height of 2.5 m and an average diameter at breast height (DBH) of 4.1 cm in New Hampshire (Luepold et al. 2015).

At the landscape scale, the presence of wetlands far outweighs softwood cover in Rusty Blackbird habitat selection models, even though wetlands comprise a lower proportion of the landscape (Luepold et al. 2015). Powell et al. (2010) suggested that regenerating forest on previously harvested land may create an ecological trap where apparently suitable nesting habitat exposes birds to heavy predation pressure and results in lower nesting success. However, Powell et al. (2010) documented acceptable nesting success overall (61%); Luepold et al. (2015) also found nest success was robust in regenerating clear-cuts during both high and low predation years and concluded the ecological trap hypothesis may not be operating. Natural disturbance and forest management may actually contribute to patchy habitat preferred by Rusty Blackbirds. Luepold et al. (2015) found that 90% of nests in New England were located near a border between forest and open (i.e., wetland) habitats. This suggests the birds are dependent on disturbed areas for nesting grounds.

Perhaps the most important creator of the Rusty Blackbird's preferred disturbed habitat in New England is the American beaver (*Castor canadensis*). The beaver, an ecosystem engineer, creates impoundments of water by damming streams with mud, tree branches, and other vegetation (Rosell et al. 2005). These keystone mammals play an important role in New

England, creating wetland habitat for invertebrates, amphibians, birds, and other wildlife.

Because deciduous trees and shrubs are beavers' preferred food source (Müller-Schwarze and Sun 2003), they selectively harvest hardwoods in proximity to their impoundments, thereby increasing the percent cover of softwoods (Johnston and Naiman 1990). Beavers have a long lasting impact on the landscape; through digging channels and creating dams, beavers increase the depth of wetlands as well as increase wetland size (Hood and Larson 2015). Studies have found that beavers increase the diversity of and shift the macroinvertebrate assemblage (Margolis et al. 2001; McDowell and Naiman 1986) as well as increase macroinvertebrate abundance (McDowell and Naiman 1986) within beaver-impounded wetlands and streams. Thus, beavers may create ideal habitat for Rusty Blackbirds, with impounded, macroinvertebrate rich wetlands for foraging and clumps of nearby softwoods for nesting. Indeed, Powell et al. (2014) found that Rusty Blackbird occupancy in New England was best explained by the presence of puddles (a proxy for shallow pools of standing water), softwood cover greater than 70%, and evidence of beaver activity.

These open-water/young, dense conifer conditions may not persist on the landscape for long periods, necessitating repeated visits over time to document Rusty Blackbird population trends. Beaver ponds may be active for one to a few years at a time as the animals move to find new sources of food, resulting in a matrix of different-aged ponds, meadows and streams in a wetland complex (Cunningham et al. 2006).

Rusty Blackbird Foraging Ecology

Prior to Greenberg and Droege's (1999) paper on the decline of the Rusty Blackbird, published work on Rusty Blackbirds mostly consisted of location-specific, anecdotal accounts of Rusty Blackbird behavior and range; the Rusty Blackbird had not yet garnered the attention of the scientific community. In 2005, Greenberg founded the International Rusty Blackbird Working Group (IRBWG) to address the species' decline and increase efforts to research the species' biology and habitat needs. Since then, universities, land managers, and non-governmental conservation organizations have ramped up efforts to research the Rusty Blackbird, on both its breeding and wintering grounds, to better understand its ecology and to identify conservation needs.

Much research within the Rusty Blackbird's breeding range has focused on demography, possible causes of decline, habitat selection, and nesting ecology. No recent study has focused on breeding Rusty Blackbird foraging ecology; information about their diet and foraging site preferences are scant. We do know that Rusty Blackbirds are more insectivorous than other Icterids, based on their anatomy (Beecher 1951) and analysis of stomach contents (Beal 1900; Beecher 1951; Bent 1958; Martin et al. 1951). Breeding Rusty Blackbirds' diet consists mostly of aquatic macroinvertebrates, such as Odonate (dragonfly and damselfly) larvae (Avery 1995), but they also hunt aerial prey such as mosquitoes (Cade 1953). However, we know little about the details of their breeding diet or foraging site requirements. Understanding wetland prey availability during the breeding season in key habitats will enable managers to identify high-quality foraging sites and in the future potentially determine mechanisms behind the Rusty Blackbird decline and potential for recovery.

Survey approaches

Current Rusty Blackbird population estimates and previous research studies have used a variety of methods to survey populations. Historical population density data is based upon widespread survey routes, including the North American Breeding Bird Survey, which exist within numerous habitat types and include numerous species. Traditional avian point-counts are not sufficient for accurately detecting Rusty Blackbirds within their remote and inaccessible breeding grounds (Greenberg et al. 2010). Optimizing the efficiency and accuracy of occupancy surveys will help managers monitor Rusty Blackbird populations more effectively.

Recently, occupancy survey methods have been developed to account for missed detections of secretive and rare species (MacKenzie et al. 2002). Occupancy model analysis is a useful tool for studying rare, cryptic, or clustered species because it takes into account false negatives, or surveys during which the species is present but not detected. Since the Rusty Blackbird is both rare and often cryptic, it is important for researchers to quantify our limited ability to document presence and absence.

Research objectives

To bridge the gap in knowledge of breeding Rusty Blackbirds' foraging ecology, I focused my research on modeling Rusty Blackbird use of wetlands in northern New England as a function of foraging and nesting habitat covariates and survey covariates. I studied the characteristics of wetlands in northern New Hampshire and adjacent Maine, a remote, intensively managed forest landscape. This research is the first survey of Rusty Blackbird food availability on their New England breeding grounds. My study included three research objectives to better understand Rusty Blackbird foraging habitat needs and to advise monitoring protocol. Also, a

sub-goal of this research was to help Umbagog National Wildlife Refuge achieve its goal of assessing Rusty Blackbird habitat use as well as creating and implementing a Rusty Blackbird habitat management plan (U.S. Fish and Wildlife Service 2009).

My first objective was to model the probability of detecting Rusty Blackbirds as a function of various survey covariates using passive (without playback) surveys. I hypothesized that time of day would not affect probability of detection. I hypothesized that probability of detection would decrease with increasing wind speed, as Powell et al. (2014) found. I hypothesized that probability of detection would be higher during my second survey period because I anecdotally observed that Rusty Blackbird parents are most obvious while rearing chicks and less so during incubation and post-fledging periods. I hypothesized that probability of detection would decrease with increasing wetland size, assuming that the observer's ability to detect Rusty Blackbirds decreases over an increasing distance. I also modeled detectability as a function of date, as a finer-scale measure of the progression of a breeding season, as well as temperature and precipitation, which have been found to impact observers' ability to detect birds (Ralph et al. 1995).

My second objective was to use occupancy modeling to model single-season Rusty Blackbird use of wetlands as a function of habitat covariates, with a focus on foraging habitat and food availability, while accounting for imperfect detection. Powell et al. (2014) conducted the first study to model Rusty Blackbird occupancy of wetlands in New England. I aimed to build upon that study by adjusting survey methods, adding in prey availability and abundance, and conducting the surveys in a different area of northern New England.

I describe my methodology as studying “wetland use” rather than “site occupancy” because my study design does not fit in with traditional site occupancy survey methods and assumptions. To begin with, just because a Rusty Blackbird is observed at a wetland does not necessarily mean that that individual occupies that site. While some Rusty Blackbird nests are in trees directly on the edge of a wetland impoundment or within an alder swamp, other Rusty Blackbirds nest up to 95 meters away from wetlands (Powell et al. 2010b). Although evidence exists that some Rusty Blackbirds had actively nested near my survey points (Foss pers. comm.), I am not able to definitively say all of my survey sites were near Rusty Blackbird nests and within a pair’s territory. Although limited work has been done to assess Rusty Blackbird territory size, we don’t yet have a thorough understanding of their breeding territories and behaviors. Occupancy modeling requires that a site is closed, meaning that there is no immigration or emigration from the site within the study period. Because Rusty Blackbirds may forage among multiple wetlands within a large area, defining a site as a single wetland, as I did, may violate this closure assumption. Thus, I considered sites “used” by Rusty Blackbirds if I detected at least one Rusty Blackbird at least once during my study period. I labeled sites without any positive Rusty Blackbird detections as “undetected.” To model wetland use, I chose multiple a priori habitat covariates that were thought to be biologically important for Rusty Blackbirds, based on previous studies and my own experience in the field. In preceding decades, beavers highly modified wetland hydrology, open water and upland vegetation in the region; my survey sites were either active (impounded/modified by beavers in the past year and hosting a resident beaver colony) or inactive (previously impounded, but not currently occupied by beavers) impounded wetlands. I hypothesized that active beaver wetlands are more likely to be used by Rusty

Blackbirds because of beavers' positive impact on aquatic macroinvertebrate availability and breeding habitat (Hood and Larson 2014).

I expected Rusty Blackbird wetland use to increase with current beaver activity, presence of puddles, and greater softwood cover, as Powell et al. (2014) found. I hypothesized that higher percent softwood land cover within a 500 meter radius buffer, which is approximately the size of a breeding Rusty Blackbird's home range (Luepold et al. 2015), of wetlands and dense coverage of young softwoods surrounding a wetland would increase the probability of wetland use. I also wanted to explore the relationships between probability of wetland use and other biologically plausible habitat covariates, including wetland size, elevation, percent cover of open water, percent cover of mud, and depth of open water, within my study area.

My final objective was to evaluate the survey duration needed to effectively survey for Rusty Blackbirds in their foraging habitat. I expected to find that survey lengths of 30 minutes significantly increase detection rates compared to standard 10 minute point count surveys because Rusty Blackbirds are particularly secretive compared to other songbirds.

Hypotheses

- 1) Probability of detecting a present Rusty Blackbird: The likelihood that an observer will detect a present Rusty Blackbird:
 - a. Is not affected by time of day.
 - b. Decreases with increasing wind speed.
 - c. Is highest during the chick rearing period (survey period two).
 - d. Decreases with increasing wetland size.
- 2) Probability of Rusty Blackbird wetland use:

- a.* Increases with current beaver activity.
 - b.* Increases with presence of puddles.
 - c.* Increases with increasing softwood cover.
- 3) Rusty Blackbird monitoring protocol
 - a.* Survey lengths of 30 minutes significantly increase detection rates compared to standard 10 minute point count surveys.

Materials and Methods

Study area

I assessed breeding Rusty Blackbirds' use of both active and inactive beaver-influenced boreal wetlands in Coos County, New Hampshire and Oxford County, Maine. Sites were either on federal land owned by the U.S. Fish and Wildlife Service at Umbagog National Wildlife Refuge or were privately owned and managed by Wagner Forest Management, Ltd. This remote area of New England is heavily managed, with active logging operations occurring near most of my sites. The wetlands I surveyed were often surrounded by spruce and fir trees; other sites were in speckled alder swamps or were within a mixed forest.

Study site selection

I used remotely-sensed orthoimagery and expert knowledge of the study area to identify beaver-influenced wetlands of potentially suitable habitat. I used ArcMap 10.2.2 (ESRI, Redlands, CA) to randomly select 60 wetland sites (Appendix A) from a pool of 263 discrete (e.g. above a dam) wetlands within 500 meters of a road and within a 25 km radius of the town center of Errol, NH. Some sites were known to be used by Rusty Blackbirds in previous years as

I previously surveyed 16 of these 60 sites for a pilot study in 2013 (Appendix B; Pachomski and C. Foss, unpub. data). I surveyed sites in pairs based on their spatial proximity due to time and logistical constraints, thus sites were not randomly visited. In many cases, I surveyed more than one discrete wetland in a string of wetlands. Access issues (impassable roads) forced me to drop some previously selected sites and replace them with new randomly-selected wetlands. If a newly-chosen site didn't have another selected site nearby, I added another nearby wetland to create a pair. In total, I selected 21 of 60 sites in a systematic rather than random manner.

Field surveys

In 2014, I surveyed 60 wetlands within the Umbagog Lake region of northern New Hampshire and Maine. From 5 May to 10 May, I scouted sites to see if they were accessible and searched for territorial and nesting Rusty Blackbirds. I collaborated with researchers from Audubon Society of New Hampshire who also actively searched for nests by following females to potential nest locations. I began the first survey period after the first Rusty Blackbird nest of the season was found. I conducted surveys between 8:00 and 18:00 to maximize number of sites visited in the short breeding window.

With evidence of nesting Rusty Blackbirds, I began to record Rusty Blackbird wetland use on 14 May by conducting passive (without playback) presence/absence (detection/ non-detection) surveys. Although previous research found that the utilization of acoustic playback increased Rusty Blackbird detectability (Powell et al. 2014), I chose to conduct passive surveys because I wanted to document the behavior of Rusty Blackbirds and didn't want to further alter their behavior or potentially cause a pair to abandon its nest.

I also wanted to quantify how Rusty Blackbird probability of detection changes during different stages of the breeding cycle. Thus, I surveyed sites three times in two-week intervals that aligned with stages in the breeding season: incubation (14 May to 27 May), nestling (28 May to 10 June), and fledgling (11 June to 24 June). For two of 60 sites, due to site access issues I was only able to conduct two of the three surveys.

During each survey period, I collected data on Rusty Blackbird presence as well as detection and habitat covariates (Table 1). I conducted these surveys at a point near the southern edge of each wetland. During each 30 minute wetland use survey, I recorded whether a Rusty Blackbird was seen or heard, time to first detection (if detected), and whether or not the birds were banded. Additionally, I recorded survey specific variables, such as wind speed (recorded as mph and measured using an anemometer held at DBH and time of day, which may have impacted detection of Rusty Blackbirds. I also recorded observed breeding behavior, evidence of hatched chicks, and fledgling survival data to contribute to the long-term Rusty Blackbird population/nesting database of the Audubon Society of New Hampshire.

To determine if sites were currently occupied by American beaver, I looked for tooth/cut marks on branches and tree stumps, floating bark strips, branch piles, lodges, and new sticks/mud on dams and lodges. I collected field data on both foraging and nesting habitat variables, such as percent conifer cover around the wetland and presence or absence of puddles during each survey. I estimated percent exposed mud and percent open water within the wetland during each survey and then averaged the data across three surveys. I also measured water depth (cm) at a fixed location and calculated the average for the three survey periods. This sampling point was marked during the first survey at each site by a stake placed one meter from the water's edge towards the center of the pond, due North, at the southernmost end of the wetland's open water.

Following each Rusty Blackbird survey, I sampled aquatic invertebrates to quantify aquatic prey availability. I used ten sweeps of a D-frame dip net to probe along the water's edge and collect aquatic invertebrates. I collected these samples from the southern edge of each wetland's standing pool of water. Sometimes I was not able to access the southern end of the pond due to deep water or downed trees blocking my path in which case I sampled as close to the southern edge as possible. I sampled from the same spot (marked with a GPS and flagging tape) during repeat visits. Invertebrate samples were stored in 70 % ethanol in plastic bags for later identification.

Invertebrate sample processing and analysis

I worked with two aquatic invertebrate technicians to process prey samples. I sorted through invertebrate samples in the lab, first removing vegetation and debris and then rinsing the sample through a 250 μm sieve. I identified insects to Family, when possible, and classified other macroinvertebrates to Order or Subclass. I used the macroinvertebrate count as a proxy for abundance of Rusty Blackbird prey within a wetland. I averaged the count for each of the sites' three invertebrate samples and included this abundance as a site covariate in my wetland use models. I also included the total invertebrate Family richness for all of each site's samples. For taxa that I was only able to identify to Subclass or Order, such as leeches, I assumed that one Family was observed for each Subclass or Order. I used the two-sample Poisson rate test to test my hypothesis that sites with Rusty Blackbirds had more families per insect order than did sites without positive detections.

Geographic Information Systems (GIS) analyses

In addition to habitat data collected in the field, I also used a GIS to assess elevation, wetland size, and land cover as habitat characteristics that might drive Rusty Blackbird foraging

site selection. I imported my GPS survey points, which marked the southern edge of each wetland I surveyed, into Google Earth (Google 2014). Then, I used the 9/18/2013 orthoimagery (Map data: Google, Landsat/Copernicus) to screen-digitize each wetland as a polygon, using visual vegetative changes and on the ground survey experience as a guide. Delineations were reviewed and edited by C. Foss. We rated each site as high, medium, or low confidence (Table 2) based on degree of knowledge and difficulty of delineation. Then, I used the ArcMap conversion tool to convert the Google Earth .kml file to a shapefile and bring it into ArcMap. I edited this layer attribute table by adding a Rusty Blackbird field and populating sites as detected or not detected. Next, I calculated the area (m^2) of each wetland in ArcMap using the calculate geometry tool.

To analyze the percent softwood cover around each wetland, I used 2011 National Land Cover data (Homer et al. 2015). Within a 500 meter buffer from the perimeter around each wetland polygon, I calculated the percent coverage for each habitat type (see Figure 1 of cartographic model). As Rusty Blackbirds in northern New England have been found to have an average home range size of 37.5 hectares, equivalent to a circle with a radius of 347 meters, and a range of 3.8 hectares to 172.8 hectares (Powell et al. 2010a), a 500 meter radius is considered an appropriate estimation of Rusty Blackbird home range size (Luepold et al. 2015). I created a final map of land cover around wetlands with and without positive Rusty Blackbird detections (Figure 2).

Wetland use analysis

I used the Spearman Rho and Pearson Chi-Square tests to test for correlations among continuous and categorical covariates, respectively. I avoided including significantly correlated ($p < 0.05$) covariates within the same wetland use models. To make my data more suitable for

modeling, I standardized all continuous covariates to be z-scores (subtracted from the mean and divided by the standard deviation). Then, I used the protocol developed by MacKenzie et al. (2002) to model Rusty Blackbird wetland use using single species occupancy modeling. This method allowed me to estimate site use (a proxy for occupancy) and detection probabilities based on my detection histories for each site as well as field and geospatial data (Table 1). The occupancy modeling approach uses multinomial maximum likelihood to estimate the parameters p (probability of detection) and ψ (probability of occupancy). First, the log likelihood of each detection history, given the observed data, is calculated using the formula:

$$\ln (L(p_i|n_i, y_i)) \propto y_1 \ln(p_1) + y_2 \ln(p_2) + y_3 \ln(p_3) \dots + y_8 \ln(p_8)$$

where y_i is the frequency of each possible encounter history and p_i is the probability of observing each encounter history. Then, the model parameters are estimated by finding the corresponding combination of parameters which maximizes log likelihood.

I performed this analysis using Package UNMARKED (Fiske and Chandler 2011) in Program R (R Development Core Team 2016). My candidate set of models included biologically-plausible variables known or thought to affect Rusty Blackbird habitat suitability. I first modeled survey-specific covariates affecting detectability (date, precipitation, temperature, time, visit, wetland size, and wind). Then, I chose the model with the lowest AIC as the best-fit detectability model. Next, I included the top detectability covariates in my wetland use models, along with site covariates (beaver, invertebrate abundance, invertebrate richness, open water, mud, puddles, water depth, percent softwood, young softwood, elevation, wetland size). I used Package AICcmodavg (Mazerolle 2016) to estimate \hat{c} , the overdispersion parameter, adjust for overdispersion as needed and to assess model fit. I used the MacKenzie and Bailey Goodness-of-fit Test (MacKenzie et al. 2004) to test the fit of my global wetland use model,

which contained all of the covariates included in my candidate set of wetland use models, with 1,000 bootstraps.

Survey time, date, and length analysis

To test the effectiveness of surveying for Rusty Blackbirds for sampling lengths longer than the standard ten minute point count (Verner 1988), I created a new dataset for site detection histories given 10 minute survey periods. Because I noted time to first detection during my surveys, I was able to modify my survey data to reflect the detection histories that I would have observed had I surveyed for 10 minute rather than 30 minute periods. I used the McNemar test (McNemar 1947) for paired proportions to test the hypothesis that a survey length of 30 minutes had significantly higher detection rates than a survey length of 10 minutes. Also, to analyze how survey date and survey start time influenced time to first detection, I converted survey date to Julian day and survey start time to minute of day. I used the Spearman Rho test to test for correlations between these variables.

Results

Habitat characteristics

Though all 60 survey sites were beaver-influenced wetlands, only 7 sites (11.67%) had evidence of current beaver activity in 2014 (Table 3). Many sites were dominated by a large (>0.25 ha) pond of standing water, but sites covered a range of percent cover open water (mean = 54.2% \pm 3.0 SE; Table 3). Water depth at 1 meter from the edge had a mean average depth of 26.18 cm \pm 2.02 SE, averaged across all three survey visits (Table 3). In addition to large bodies

of standing water, sites also tended to have puddles, with 93% of sites having puddles in at least one of the three survey periods (Table 3). Most sites were surrounded by regenerating spruce (*Picea* sp.) and fir (*Abies balsamea*), with 47 sites (78%) having dense, young softwood cover (Table 16).

Wetlands were located at an average elevation of 473.3 meters (range = 110 to 780 meters; Table 3). Wetland size ranged from 200 m² to 78,344 m², with a median of 4,406 m² (Table 3; Figure 8). Within a 500 meter buffer of each wetland, land cover had an average of 20.3% softwood (range = 0 to 81.86%). Table 4 shows the land cover data for sites used by Rusty Blackbirds and Table 5 shows land cover data for sites at which Rusty Blackbirds were not detected.

Covariate correlations

I assessed correlations among continuous survey and site covariates using the Spearman Rho test. None of the significant correlations had strong relationships (Table 6) but many of the covariates significantly correlated with at least one other covariate. Temperature increased with survey date for the first survey period ($r_s = 0.435$, $p = 0.001$) and the second survey period ($r_s = 0.391$, $p = 0.002$). Wind speed decreased with survey date for the first survey period ($r_s = -0.329$, $p = 0.012$). Temperature increased with survey start time for the first survey period ($r_s = 0.281$, $p = 0.033$) and the third survey period ($r_s = 0.296$, $p = 0.022$). As elevation increased, wetland size ($r_s = -0.305$, $p = 0.018$) and percent softwood cover within a 500 meter buffer ($r_s = -0.277$, $p = 0.032$) decreased. Percent softwood cover was positively correlated with wetland size ($r_s = 0.303$, $p = 0.019$). As water depth near the edge of the pond increased, percent open water increased (r_s

= 0.321, $p = 0.012$) and percent mud decreased ($r_s = -0.344$, $p = 0.007$). Other covariates, such as survey start time and percent softwood cover, had significant but not biologically meaningful relationships (Table 6).

Detectability

I recorded survey covariates during all visits and detected Rusty Blackbirds during 66 out of 178 surveys (Figure 6). Precipitation (varying from a drizzle to moderate rain) occurred during 20 of 178 surveys. The average temperature was 20.8°C (± 0.39 SE) and the average wind speed was 1.46 mph (± 0.11 SE). The average survey start time was 11:51 AM (± 10 min SE).

My base detectability model, without survey covariates, yielded a detection probability of 0.589 ± 0.06 SE (95% CI: -0.09780755, 0.8187892). My top detectability model (number of parameters $k = 4$, $-2 \log\text{-likelihood} = 206.3808$, $\text{AIC} = 214.38$) included the survey covariate visit (survey period) and accounted for 51.33% of model weight (Table 7). Back-transformed parameter estimates on the probability scale for visit yielded $p = 0.765 \pm 0.08$ SE for visit 2, $p = 0.742 \pm 0.09$ SE for visit 3, and $p = 0.416 \pm 0.09$ SE for the intercept. I did not find support for any of the other covariate models ($\Delta\text{AIC} > 2$). The global detectability model fit the data well ($\chi^2 = 7.1284$, $p = 0.321$, $c\text{-hat} = 1.13$; Appendix C.1.) and thus I assumed that all other detectability models had suitable fit. Because $c\text{-hat}$ was close to 1, I did not need to adjust estimates of standard error for my candidate set of detectability models.

Wetland use analysis

I detected Rusty Blackbirds at over half of my sites (Naive wetland use estimate $\psi = 0.583$). Adjusting for imperfect detections, I found that Rusty Blackbirds were present in 62.9% of my sites (base wetland use estimate = 0.629 ± 0.07 SE (95% CI: -0.07128491, 1.128422)).

Because I had two sets of candidate models to separately assess the importance of survey and site covariates, I separately assessed model fit for each set using the set's global model, or a model containing all of the covariates included in that set. The global wetland use model did not fit as well ($\chi^2 = 11.9294$, $p = 0.081$, $c\text{-hat} = 1.78$; Appendix C.2.) as did the global detectability model, but with $\alpha = 0.05$ and a $c\text{-hat}$ value less than 3, I concluded that the model has acceptable fit (Lebreton et al. 1992). However, because a $c\text{-hat}$ value greater than 1 suggests overdispersion, I needed to adjust standard error estimates for each wetland use model by a factor of $c\text{-hat}$ (Lebreton et al. 1992).

I did not find strong support for any one of the original top ranked wetland use models based on AIC values (Table 8). Because mud and invertebrate abundance were among the top models, I added in a bivariate mud and invertebrate abundance model that had not previously been included in my analysis. Then, I adjusted models for overdispersion and ranked models based on QAIC values (Table 9). The top model (number of parameters $k = 7$, $-2 \log\text{-likelihood} = 188.231$, $\text{QAIC} = 123.4366$), included the survey covariate "visit" and the site covariates "mud" and "invertebrate abundance." This model accounted for over 60% of the adjusted model weight. Furthermore, three other models fell within two delta AIC units of the top model.. As model weight indicates the probability that a given model is the best model of the candidate set, and because the second and third top models were univariate models with "mud" and "invertebrate abundance," respectively, as covariates, there is a fair level of certainty that mud

and invertebrate abundance were the top predictors of Rusty Blackbird wetland use. Because the second model was not within 4 delta QAIC units of the top model, I did not model average parameter estimates across all of the models included in the candidate set of wetland use models (Burnham and Anderson 2002).

Invertebrate community assemblages

The results of my wetland use model ranking suggest that aquatic invertebrate abundance is an important predictor of Rusty Blackbird site selection in my study area (Table 9).

Invertebrate richness was less important than I expected, as it accounted for just 1.6% of QAIC model weight) Table 9). For simplicity, I modeled invertebrate richness and abundance across all taxa rather than include each group (Order) of invertebrates as a site covariate. However, it is worth noting the extent to which each group varied in richness and abundance across my study sites as well as the difference (or lack thereof) between groups at sites with and without positive Rusty Blackbird detections.

Most of my aquatic invertebrate samples consisted of insects but also included arachnids, clams, scuds, and leeches (Table 10). Wetlands had diverse and abundant aquatic invertebrate populations. Samples included specimens from 58 Families (Table 11). Insect taxa represented the Orders Coleoptera (beetles), Diptera (true flies), Ephemeroptera (mayflies), Hemiptera (true bugs), Lepidoptera (moths and butterflies), Megaloptera (dobsonflies, fishflies, and alderflies), Odonata (dragonflies and damselflies), Plecoptera (stoneflies), and Trichoptera (caddisflies). Other invertebrates included Amphipoda (scuds), Araneae (spiders), Collembola (springtails), Hirudinea (leeches), Oligochaeta (worms), and Veneroida (bivalve mollusks). Survey sites had a mean of 6.92 insect Families (± 0.37 SE; range = 1 to 14) and a mean invertebrate count of 49.98 specimens (± 6.70 SE; range = 6 to 205.5) (Table 10).

I tested for a significant difference between the numbers of insect Families per Order in sites used by Rusty Blackbirds (Table 12) versus sites without positive detections (Table 13). I found that used sites had a significantly higher rate of Coleoptera richness (mean = 1.06 ± 0.20 SE) than did undetected sites (mean = 0.52 ± 0.17 SE) ($p = 0.009$). I found no significant difference in richness rates for the Orders of Diptera ($p = 0.312$), Ephemeroptera ($p = 0.791$), or Odonata ($p = 0.115$). Sample sizes for the Orders Hemiptera, Lepidoptera, Megaloptera, and Plecoptera were too small to analyze (Table 14). I did not analyze richness results for non-insect invertebrate Orders because most non-insects were not identified to family.

I tested for a significant difference between the maximum abundance, listed as the highest count observed from three surveys, of invertebrate specimens per Order in sites used (Table 15) versus undetected (Table 16) by Rusty Blackbirds. I found that used sites had a higher level of maximum invertebrate abundance of Amphipoda ($p < 0.001$), Coleoptera ($p = 0.002$), Diptera ($p < 0.001$), Odonata ($p < 0.001$), and Trichoptera ($p = 0.033$) than did undetected sites (Table 17). The mean maximum count of Amphipoda in used sites was 3.20 ± 1.90 SE (range = 0 to 65) specimens and for undetected sites was 1.48 ± 0.48 SE (range = 0 to 10) specimens. The mean maximum count of Coleoptera in used sites was 1.4 ± 0.31 SE (range = 0 to 8) specimens and for undetected sites was 0.64 ± 0.24 SE (range = 0 to 4) specimens. The mean maximum count of Diptera in used sites was 22.54 ± 5.43 SE (range = 0 to 140) specimens and for undetected sites was 11.36 ± 2.95 SE (range = 1 to 76) specimens. The mean maximum count of Odonata in used sites was 3.14 ± 0.71 SE (range = 0 to 17) specimens and for undetected sites was 1.52 ± 0.40 SE (range = 0 to 8) specimens. The mean maximum count of Trichoptera in used sites was 2.11 ± 0.58 SE (range = 0 to 16) specimens and for undetected sites was 1.48 ± 0.48 SE (range = 0 to 10) specimens. I found that used sites did not have a significantly higher

rate of Ephemeroptera abundance than undetected sites ($p = 1.00$). Sample sizes for the Orders Aranae, Collembola, Hemiptera, Hirudinea, Lepidoptera, Megaloptera, Oligochaeta, Plecoptera, and Veneroida were too small to satisfy the test's assumption of normal approximation (Table 17).

Furthermore, I explored potential relationships between each invertebrate group and other wetland site covariates. I used the Spearman Rho test to test for correlation between maximum invertebrate specimen count per site per Order and the continuous site covariates that were included in my wetland use models (wetland size, percent softwood cover within a 500 meter buffer, elevation, water depth, percent open water, and percent mud). Though none of the observed correlations had strong relationships, some invertebrate Orders had significant correlations with other site covariates (Table 18). The abundance of Coleoptera ($r_s = 0.302$, $p = 0.019$) increased with increasing wetland size whereas larger wetland size was correlated with lower Ephemeroptera ($r_s = -0.271$, $p = 0.036$) and Megaloptera ($r_s = -0.316$, $p = 0.014$) abundance. Diptera abundance was negatively correlated with percent open water ($r_s = -0.279$, $p = 0.031$). Trichoptera abundance was negatively correlated with percent mud cover ($r_s = -0.258$, $p = 0.047$). Finally, Veneroida abundance increased with increasing elevation ($r_s = 0.322$, $p = 0.009$).

Survey length analysis

I conducted three 30 minute wetland use surveys at each of my 60 survey sites. On two occasions I first observed Rusty Blackbirds at a survey site after the 30 minute survey window ended. Because I collected habitat data after I finished surveying for Rusty Blackbird, I stayed at the survey site for an unspecified amount of time after completing each wetland use survey. For

these two occasions, I listed the results of the surveys as “not detected” because I did not observe any Rusty Blackbirds within my designated survey window. One of these occasions was the only observation of Rusty Blackbirds at that site, Dixville Notch. The other occasion occurred at Hilltop East, at which I detected Rusty Blackbirds during both other survey windows.

For surveys with positive detections of Rusty Blackbirds, average time to first detection was 5.3 minutes (± 0.82 SE). Time to first detection did not correlate with survey date ($r_s = -0.049$, $p = 0.697$; Figure 4). Time to first detection and survey start time had a significant but weak negative correlation ($r_s = -0.323$, $p = 0.008$; Figure 5). I detected Rusty Blackbirds during 66 out of 178 30-minute surveys. Of these 66 detections, 15 surveys had a time to first detection more than 10 minutes after the start of the survey. A ten minute long sampling period would have reduced the number of total positive detections by 22.7%. However, according to McNemar’s test (McNemar 1947), I did not find a significant difference in paired detection proportions for survey length for all survey periods. I failed to reject the null hypothesis ($\alpha = 0.05$) that proportion is the same for the first survey ($\chi^2 = 2.25$, $df = 1$, $p = 0.1336$) or the third survey period ($\chi^2 = 3.2$, $df = 1$, $p = 0.07364$). I did find a significant difference ($\alpha = 0.05$) in paired detection proportions for the second survey period the second survey ($\chi^2 = 6.125$, $df = 1$, $P = 0.01333$).

Discussion

Wetland use analysis

According to my model ranking, the best predictors of Rusty Blackbirds’ use of wetlands in northern New Hampshire and western Maine are aquatic invertebrate abundance and percent cover of mud. While mud was not identified as one of the top model covariates in a similar Rusty

Blackbird occupancy study in New England (Powell et al. 2014), our survey methods differed: Powell et al. used a binary measure of mud presence or absence within a site (visually observed in the field) as well as a visual field estimate of wetland size whereas I visually estimated percent cover of mud within a wetland and remotely calculated wetland size. Because it is relatively easy for an observer to estimate the percent cover of open water (versus mud or emergent vegetation) within a wetland, I recommend that future researchers target wetlands with at least 50% open water for breeding Rusty Blackbird surveys.

Current beaver activity in wetlands did not strongly influence wetland use by Rusty Blackbirds in my study area, as the model with wetland use as a function of beaver occupancy ranked lower than the null model (Table 9). Previous research found that the presence of current beaver activity increased the probability of Rusty Blackbird occupancy (Powell et al. 2014), which is expected given that beavers are associated with improved habitat for aquatic invertebrates (Hood and Larson 2014). Although I was unable to assess age of beaver-influenced wetlands or time since abandonment of sites without current beaver activity, I suspect that sites with recent beaver activity, perhaps within the last five years, may be just as favorable to Rusty Blackbirds as sites with current beaver activity because of the species' long-lasting impacts on wetland habitat. Furthermore, it's possible that aquatic invertebrate availability is related to water depth and vegetation cover along the wetland edge, factors which beavers influence, rather than the presence of beavers themselves (Hood and Larson 2014).

Invertebrate community assemblages and foraging ecology

Food availability appears to be an important predictor of Rusty Blackbird wetland use in my study area. My data suggest adult Rusty Blackbirds choose foraging sites based on aquatic invertebrate abundance, as probability of wetland use increased with increasing invertebrate

abundance. Rusty Blackbirds have been known to consume many different kinds of invertebrates (Ellison 1990) and they exhibit diet plasticity by switching to a more generalized diet of seeds, acorns, grains, and insects during the non-breeding season (Meanley 1971). Thus, it makes sense that invertebrate abundance was an important covariate whereas invertebrate richness did not predict wetland use.

Though the specifics of provisions seem to vary by species, some Icterid adults primarily feed aquatic insects to nestlings. Emergent aquatic insects are especially good food for blackbirds because they are easy to catch and are high-quality food items, whereas young birds cannot easily digest dry seeds (Orians 1985). Thus, chicks' dietary needs may mostly explain adult blackbirds' tendency to switch from a non-breeding omnivorous diet to a primarily insectivorous diet during the breeding season. Related species, including Yellow-headed Blackbirds (*Xanthocephalus xanthocephalus*), Red-winged Blackbirds (*Agelaius phoeniceus*), and Common Grackles (*Quiscalus quiscula*), provision to chicks a variety of invertebrates, including moths, damselflies, spiders, beetles, grasshoppers, and flies (Voigts 1973; Snelling 1968). Red-winged Blackbirds overlap in range with both Rusty Blackbirds and Common Grackles in the Northeast and have some dietary overlap (Orians 1985), but all three species' diets differ to some extent, suggesting that these species could coexist without too much competition for food.

Both male and female adult Rusty Blackbirds provision nestlings (Orians 1985), but males may provide the majority of food items to chicks (Loomis 2013). Previous accounts stated that Rusty Blackbird males do not feed incubating females (Orians 1985) but more recent research suggests that males may feed incubating females to minimize time spent off the nest especially in poor weather (Loomis 2013). Loomis (2013) studied provisioning rates of Rusty

Blackbird nestlings in Alaska and found that 97.2% of items fed to nestlings were Anisoptera nymphs. These findings suggest that Rusty Blackbird adults in that region of Alaska rely on aquatic and emerging dragonflies as food for their young, even when other large prey items, including Zygoptera nymphs, are more abundant (Loomis 2013). Given the species' diet plasticity, chick provisions could feasibly be more diverse. Researchers should look at nestling provisioning in other areas within the Rusty Blackbird's breeding range to see if other populations are equally dependent on Anisoptera nymphs.

Also, it would be interesting to see how a young Rusty Blackbird's diet changes as it ages. Since Anisoptera nymphs provide more calories than do Zygoptera nymphs (Swift 1970; Orians 1980), it would be logical for adult Rusty Blackbirds to selectively forage for and bring back Anisoptera nymphs to nestlings to maximize the ratio of energy gained via prey items to energy expended through traveling to forage sites and finding food. Since Red-winged Blackbirds reared in captivity readily ate novel invertebrate prey items (Alcock 1973), I would expect young Rusty Blackbirds to have a more diverse diet once they are capable of foraging on their own. However, compared to other Icterid species, breeding Rusty Blackbirds seem to have a more specialized diet and foraging tactic. Other Icterids feed young a variety of invertebrate taxa with multiple food items provisioned at a time (Orians 1985). Brewer's Blackbirds (*Euphagus cyanocephalus*) provision more food items at a time with increasing distance from the nest to the foraging site, presumably to maximize the amount of energy gained versus expended (Orians 1985). One study of Rusty Blackbirds in Alaska found that adults usually fed chicks one large (>2 cm) prey item at a time (Loomis 2013). Thus, it's possible that Rusty Blackbirds in Alaska may operate under a different foraging strategy based on finding high quality prey rather than minimizing energy spent foraging. Limited observation and trail camera footage of Rusty

Blackbirds in New England has shown adults provisioning multiple invertebrates at a time (Buckley 2013; C. Foss, pers. comm.), but more research is needed in this study area.

In Alaska, Rusty Blackbirds may time their nest cycle so that peak hatching overlaps with peak Anisoptera nymph abundance (Loomis 2013). I found Anisoptera nymphs during all three survey periods. Since Loomis surveyed invertebrates more frequently than I did, those results may have picked up on a more subtle pattern. Also, although I did not look at chick provisioning, I anecdotally found Rusty Blackbirds foraging throughout the day. Odonate emergence rates are highest during the mid to late morning (Orians 1985); therefore, Rusty Blackbirds may provision more frequently during that time. Also, Orians (1985) suggested that invertebrate prey availability may be lower in poor weather due to lower insect emergence rates. In 2014, the weather in my study area was generally warm (mean $20.8^{\circ}\text{C} \pm 0.39 \text{ SE}$) and relatively dry, as it only rained during 20 out of 178 surveys.

Future research should look at food (especially nymph and emerging adult Anisoptera) availability at all wetlands that fall within a breeding male's home range. Radio telemetry could enable researchers to elucidate how factors such as distance to nest and aquatic invertebrate availability influence breeding Rusty Blackbirds' use of foraging habitat. Anecdotal observations of Rusty Blackbirds in New England suggest that after chicks fledge, Rusty Blackbird broods move to areas that have multiple habitat types, have denser vegetation cover, and are closer to foraging habitat than nest locations (Ellison 1990). It would be interesting to compare invertebrate abundance in habitats used by nesting versus post-fledging Rusty Blackbirds.

There is another information gap relating breeding Rusty Blackbirds to weather impacts on both food availability and consumption. Stable isotope analyses of wintering Rusty

Blackbirds found that the species shifts its diet with changing weather patterns: birds consume more mast food items, such as acorns, prior to bouts of cold weather and consume more earthworms prior to precipitation events and warmer temperatures (Wohner et al. 2016). Similar research is needed for breeding Rusty Blackbirds.

Detectability

I found that the most important predictor of probability of detection for breeding Rusty Blackbirds was visit (survey period) (Table 7). Probability of detection given wetland use was highest during the second visit when parents were rearing nestlings (May 28th – June 10th, 2014). Because of prior knowledge of breeding Rusty Blackbird behavior, I expected survey period to affect detectability. Rusty Blackbirds tend to be highly secretive and hard to detect while they are building nests and laying and incubating eggs. Then, once eggs hatch, adult Rusty Blackbirds become more vocal and more obvious as they frequently forage for food and rear their young. After chicks fledge from the nest, some Rusty Blackbird families immediately leave the nesting area, perhaps in search of more dense cover, whereas other broods remain near the nest for a week or so (unpubl. data). Thus, I designed my study to capture differences in breeding season behavior by surveying for Rusty Blackbirds in three survey periods that coincide with their breeding stages.

Time of day, date, wind, temperature, precipitation, and wetland size were not important predictors of Rusty Blackbird detectability. These findings differ from the results of a similar study that found that increased wind speed reduced probability of detection (Powell et al. 2014). However, I measured wind speed in mph using an anemometer whereas Powell et al. (2014)

estimated wind speed using the Beaufort wind force scale, so our results may not be comparable. While experts generally recommend surveying for songbirds in the early morning (Drapeau et al. 1999) and not during poor weather, my results suggest that Rusty Blackbirds are still fairly detectable during light to medium bouts of rain; in addition, they vocalize throughout the day. Detectability of Rusty Blackbirds in Maine showed no peaks for time of day (Powell et al. 2014); my results from New Hampshire and western Maine concur. I did not find a relationship between Rusty Blackbird vocalization frequency and time of day (Appendix D). I recommend that future researchers survey throughout the day to maximize efficiency in accessing as many remote wetlands as possible.

Other factors that may affect detectability include vegetation cover within a wetland, noise created by running water, and anthropogenic noise. I attempted to qualify an observer's ability to detect Rusty Blackbirds with little to no background noise but was unable to accurately replicate field conditions (Appendix E). It would be interesting to compare site soundscapes to better understand how existing noise influences detectability (Pacifci et al. 2008). Also, there is a need to compare detectability among multiple habitat types. There exists no information on Rusty Blackbird occupancy of fens or wet meadows, yet the birds often forage in these habitats (C. Foss, pers. comm.). Such information would better prepare land managers to survey areas that have not been previously surveyed. Lastly, although I defined a site as a wetland, my actual unit of measurement is the distance over which I was able to detect Rusty Blackbirds at each site but I was unable to accurately quantify the distance at which I could hear Rusty Blackbird calls or songs (Appendix E).

Habitat characteristics

Sites used by Rusty Blackbirds and sites without any positive Rusty Blackbird detections were not different overall. Sites used by Rusty Blackbirds had an average land cover of 30.46% mixed forest, 24.49% deciduous forest, 18.12% evergreen (softwood) forest, 14.63% scrub shrub wetland, 9.09% woody wetland, and 0.29% herbaceous emergent wetland (Table 4). Sites without positive Rusty Blackbird detections had an average land cover of 30.53% mixed forest, 25.23% deciduous forest, 23.37% softwood forest, 5.43% scrub shrub, 9.17% woody wetland, and 0.51% herbaceous emergent wetland. I had expected used sites to have a higher softwood and herbaceous emergent wetland cover than undetected sites. However, all but one used site had at least some softwood forest and 31 out of 35 used sites had herbaceous emergent wetland habitat. These results suggest that the presence of softwood stands and wetlands is more important than the amount of these habitats within a Rusty Blackbird's territory. Indeed, Luepold et al. (2015) found that New Hampshire Rusty Blackbird nests occurred in sites with higher basal area of conifer, but the landscapes surrounding these nests (within a 500 meter radius) on average had greater deciduous forest cover than softwood cover.

Both Rusty Blackbird used versus undetected sites had similar elevation and dense young softwood cover (Table 3). A similar study found that the presence of dense young softwoods was not a strong predictor of Rusty Blackbird occupancy but that probability of occupancy increases with high softwood cover on the landscape scale (Powell et al. 2014). I did not find a difference between wetland size for used versus undetected sites, likely because sites represented a large range of wetland sizes. Used sites tended to have a lower percent mud cover (mean = 8.17% \pm 2.13 SE) and higher percent cover open water (mean = 57.6% \pm 3.85 SE) than did undetected sites (mean mud cover = 18.29% \pm 3.44 SE; mean cover of open water = 49.4% \pm 4.54 SE). In

comparison, Powell et al. (2014) concluded that mud cover and estimated size of wet area were not strong predictors of Rusty Blackbird occupancy.

Limitations

Because I often was not able to access the entire perimeter of each wetland, either due to flooding or impassible areas of downed trees, I had limited access to survey aquatic invertebrates. Because of this, I only was able to sample a small area (approximately 1 m²) at the edge of each wetland. With multiple invertebrate surveys in the same marked area of each site, I was able to compare temporal changes in invertebrate food availability within a site as well as get a generalized comparison of how well each wetland might provide food for Rusty Blackbirds. However, I recognize that my invertebrate surveys were limited in size and scope and therefore do not provide a complete picture of each site's invertebrate community structure. Furthermore, because I only surveyed aquatic invertebrates (which were mostly insects), I did not fully assess the availability of food at each site. Breeding Rusty Blackbirds have been known to forage for a variety of terrestrial and volant invertebrates, including snails (Ehrlich et al. 1988), grasshoppers (Beal 1900), caterpillars (Beal 1900), spiders (Beal 1900; Ehrlich et al. 1988; Matsuoka et al. 2010), mosquitoes (Cade 1953), adult dragonflies (Ellison 1990; Edmonds et al. 2012), adult mayflies (Edmonds et al. 2012), and beetles (Meanley 1971). Furthermore, though Rusty Blackbirds are mostly insectivorous during the breeding season (Orians et al. 1985), the species has been known to eat some vertebrates such as small fish (Ehrlich et al. 1988; Matsuoka et al. 2010) and salamanders (Ehrlich et al. 1988).

Rusty Blackbirds are known to forage at multiple wetlands within their home ranges (Powell et al. 2010a). Because I did not have accurate GIS data for each discrete wetland in my

study area, I was not able to assess the number of wetlands within each site's 500 m radius buffer.

General observations and suggestions for future research

It is surprising that adult Rusty Blackbirds exhibit plasticity in their diets but have such specific nesting habitat requirements. While Common Grackles and Red-winged Blackbirds breed in a variety of habitat types with varying degrees of proximity to and influence from people, Rusty Blackbirds seem to only breed among remote boreal wetlands. What is driving Rusty Blackbirds to breed in such limited habitat? Studies of other species suggest that Icterids prioritize nesting in optimal habitat over distance to foraging habitat (Orians 1985). But, are favored prey items more abundant in remote boreal wetlands than in wetlands just outside of the species' breeding range? Could competition with other birds limit the abundance and range of Rusty Blackbirds? Both Common Grackles (Lenington and Scola 1982) and Tri-colored Blackbirds (*Agelaius tricolor*) (Orians 1985) have been found to exclude Red-winged Blackbirds from optimal habitat. While the relationship between breeding Rusty Blackbirds and other Icterid species is unclear, researchers have suggested that the presence of Common Grackles and Red-winged Blackbirds could affect Rusty Blackbird occupancy (Powell 2008). Ellison (1990) found that Rusty Blackbirds in New England competed with Red-winged Blackbirds but not with Common Grackles. Anecdotal observations during my surveys suggest that Rusty Blackbirds can coexist with Common Grackles and Red-winged Blackbirds at a wetland.

As previously mentioned, other studies (e.g., Borchert 2015; DeLeon 2012) have suggested that wintering Rusty Blackbirds prefer sites with shallow water that is more amenable

to foraging. Because I anecdotally observed Rusty Blackbirds perching on floating sticks and emergent stumps in deep (>1 meter) water (Figure 7), those findings may not apply to breeding habitat in New England. Other studies in New England have also found that the relationship between shallow water cover and Rusty Blackbird occupancy is unclear (Scarl 2013). Future breeding-season wetland surveys should note the presence of perches in deep areas of standing water bodies, as such perches give Rusty Blackbirds access to otherwise inaccessible foraging areas. Additionally, future researchers should attempt to compare invertebrate food availability within multiple areas of foraging wetlands, including in the center of the wetland and within deep water. I was not able to sample invertebrates from the center of my survey wetlands because I did not have access to a boat and the water depth was too deep for me to be able to wade in.

Future research could also look at how temporal changes within a wetland during a season influence Rusty Blackbird habitat use. I attempted to get an anecdotal assessment of the changes in wetland hydrology over the course of the Rusty Blackbird breeding season by measuring changes in water depth and wetland size for each site. As described earlier, during the first survey of each site I erected a stake in the standing water, one meter from the water's edge. For the second and third survey periods, I recorded if the wetland had receded or expanded from its original open water boundary and measured the distance (meters) from the current edge location to the stake. Because I was unable to identify an appropriate analysis to compare temporal changes in wetland size and depth, I did not include this data in my wetland use analysis. Ideally, I would have been able to measure the deepest depth of each wetland, but I was not able to carry a kayak or other vessel to access the center of each pond.

As this was the first study to model wetland use (termed site occupancy in similar studies) for breeding Rusty Blackbirds with food availability covariates, these results are the first step to filling in a gap in research. Future researchers should further this work by conducting more comprehensive invertebrate surveys of potential Rusty Blackbird habitat. Because no recent study has investigated the breakdown of breeding Rusty Blackbirds' diet, we don't know how much of their summer diet is made up of aquatic invertebrates versus other food items. While my research has shed some light on what food is available at wetlands within the breeding range and how that food resource is affected by other habitat covariates, I was not able to assess what Rusty Blackbirds are actually foraging for and eating. Thus, I recommend that future researchers use stable isotope analysis to assess diet, as Wohner et al. (2016) have done for wintering Rusty Blackbirds. Furthermore, it would be interesting to compare the diets of nestlings, fledglings, and adults.

Future research could look at the connection between food resources and mercury bioaccumulation in boreal wetlands. Mercury contamination may contribute to the downward population trend of Rusty Blackbirds in the region due to the birds' reliance on aquatic insect prey and decades-long atmospheric deposition of mercury (Edmonds et al. 2010). Aquatic invertebrates in northeastern boreal wetlands have high methyl mercury concentrations, likely due to high levels of dissolved oxygen in the water and low pH (Edmonds et al. 2012). Since breeding Rusty Blackbirds eat predatory aquatic invertebrates, such as Odonates, they are even more likely to be exposed to harmful levels of methylmercury as it bioaccumulates up the food chain. Rusty Blackbirds in the Acadian forest (New England and the Canadian maritime provinces) were found to have high levels of mercury, with a geometric mean blood concentration of $0.94 \mu\text{g g}^{-1}$ and a geometric mean concentration of $8.26 \mu\text{g g}^{-1}$ in feathers.

(Edmonds et al. 2010). Such concentrations may be detrimental, as exposure of Common Grackle embryos to as low as $1 \mu\text{g/g}$ (wet-weight) of methylmercury caused a decline in embryo survival rates (Heinz et al. 2009). Rusty Blackbirds in the Acadian forest had higher mercury levels than did Rusty Blackbirds in Alaska. Furthermore, breeding Rusty Blackbirds overall had higher mercury levels than did wintering birds (Edmonds et al. 2010). Surprisingly, the concentration of mercury in the blood of breeding Rusty Blackbirds in the Acadian forest was not related to mercury concentrations of Anisoptera specimens collected at foraging sites but the mercury concentrations of other taxa (Ephemeroptera, Aranae, and Trichoptera) positively correlated (Edmonds et al. 2012). Further research on the diet of breeding Rusty Blackbirds is needed to understand how food items affect their exposure to mercury. Because of their highly insectivorous diet during the breeding season, Rusty Blackbirds are especially at risk of experiencing the effects of mercury bioaccumulation in aquatic organisms (Evers et al. 2012).

Lastly, in order to conserve Rusty Blackbirds we need a better understanding of their population dynamics. Because there are multiple factors that are thought to have contributed to the decline of this species, it is unclear as to whether or not the main factors that caused a decline are still operating. To better understand this, future researchers could study mortality rates of juveniles and adults. In recent years Rusty Blackbird researchers have been studying nest productivity as well as banding chicks and adults on their breeding grounds, including in my study area. However, much of the species' population has not been studied and many parameters of studied populations are unknown. Also, because the species is known to exhibit site fidelity, researchers should study the possibility that site fidelity could be causing Rusty Blackbirds to breed in suboptimal habitat. More information about the movement of individual Rusty Blackbirds within my study area would help assess how anthropogenic changes to this heavily

managed landscape may impact breeding Rusty Blackbirds' habitat use over time. Although limited technology is available for studying the survivorship and movement patterns of small birds, I am hopeful that the improving nanotag technology will soon enable researchers to learn more about this species.

Survey length and study design

For studies that investigate how habitat influences avian occurrence and abundance across the landscape, it is especially important to maximize survey effectiveness. Previous studies have found that longer surveys (20 or 25 minutes) are more effective than the standard 10 minute point count (Drapeau et al. 1999). Thus, I had expected to find that 30 minute long surveys for Rusty Blackbirds would be more effective than shorter surveys. While I observed numerous times to first detection of more than 20 minutes during my 2013 pilot study (Appendix A), I did not find a significant difference in paired detection proportions for survey 10 minute versus 30 minute survey lengths for sites with at least one Rusty Blackbird detection in 2014. However, given the time it takes to access these remote boreal wetlands, it makes sense for researchers to spend longer lengths of time surveying suitable habitat for Rusty Blackbirds. The optimal length of time likely varies with number of survey visits, time required to get to sites, and survey purpose.

While conducting longer surveys did not significantly improve my detection rates, it did allow me to record some interesting behaviors that I would probably not have seen had I done shorter surveys. For example, I observed a female Rusty Blackbird methodically circling up the

trunk of a spruce tree, likely in search of a nesting spot. I also saw adult Rusty Blackbirds chasing off much larger predators like the Broad-winged Hawk (*Buteo platypterus*).

Though anecdotal, such accounts of Rusty Blackbird behavior can help inform future studies. Also, behavior can have important implications for how to better conserve Rusty Blackbirds. For example, we don't know why some Rusty Blackbird families leave nesting areas once young are volant but others stay near their nest sites. Are they in search of better foraging resources, more protective cover from predators, or something else? In order to manage habitat for Rusty Blackbirds, we need to understand temporal changes in habitat requirements and diet. I encourage future researchers to spend extra time at wetlands to document Rusty Blackbird behavior.

Rusty Blackbird researchers have employed a variety of methods for surveying for Rusty Blackbirds within their breeding range. Powell et al. (2014) used 8-minute long surveys with 30-second playback to survey presence/absence within selected suitable roadside habitats during the breeding season. Similarly, Luscier et al. (2010) recorded presence/absence during 10-minute surveys at randomly selected locations within suitable wintering habitat, but these surveys were conducted without the use of vocal playbacks. On the other hand, Matsuoka et al. (2010) utilized passive (without playback) rapid area surveys along walking routes within extensive areas of suitable habitat. Using double-sampling methods, these rapid surveys were followed by a subsample of intensive nest searches. A comparison of rapid survey detection using pairs and lone females and actual nest presence revealed a rapid survey accuracy of 97% (Matsuoka et al. 2010). Rapid area searches were more effective than point counts in Alaska because they sampled a greater percentage of a pair's home range (Matsuoka et al. 2010). However, conducting similar surveys in heavily logged areas of New England would likely be very

difficult and unproductive. I found that wetland-based point counts were an effective way to survey for breeding Rusty Blackbirds.

Effective biodiversity protection and management requires cost- and time-effective detection methods. Rusty Blackbirds are notoriously difficult to detect due to early arrival on breeding territories, cryptic behavior, and tendency to travel a larger area post-fledging. To date, the Rusty Blackbird research community has not agreed upon a standard set of best monitoring techniques. My results suggest that future researchers should take into account the temporal variation in Rusty Blackbird detectability by conducting repeat visit occupancy surveys during the breeding period (typically late May to mid-June) for surveys at remotely identified wetlands with ponds of standing water and nearby nesting habitat. Furthermore, as the results of a recent study of boreal forest birds (Glennon et al. 2017) suggest, researchers should avoid using playback and instead passively survey Rusty Blackbirds.

Use of GIS to identify Rusty Blackbird foraging habitat

Originally, I wanted to model Rusty Blackbird wetland use and habitat characteristics in three foraging habitat types: beaver-influenced wetlands, acidic swamps, and acidic basin fens. I had wanted to use the TNC Northeast Habitat Classification maps to select from these three habitat types. However, I found that the map of my study area only identified a few swamps and fens. As this would not have given me a large enough sample size, I reduced my site selection to just beaver-influenced wetlands. Also, I found that some known wetlands weren't mapped as any kind of wetland habitat in the TNC classification, or were mapped as large as or smaller than they appear in recent orthoimagery and on the ground. I also found that this was true for National

Landcover Data (NLCD 2011; Homer et al. 2015) and National Wetlands Inventory (NWI; Cowardin et al. 1979; http://107.20.228.18/ArcGIS/services/FWS_Wetlands_WMS/mapserver/wmsserver?) maps. While these geospatial databases offer an immense amount of habitat information and are incredibly useful, I needed more detailed and field-matched data for my study purposes. Because boreal wetlands in my study area change from year to year, especially with the influence of beavers, I found that the best way to map my sites was to digitize wetland polygons using Google Earth. Because some regions may not have up to date imagery available, it's important to also visit sites to check for recent changes.

Management implications

While the relationship between current beaver activity and breeding Rusty Blackbird wetland use is still unclear, we know that Rusty Blackbirds utilize habitat altered by American beavers. Beavers create both breeding and foraging habitat by increasing softwood cover and by making ponds (Müller-Schwarze and Sun 2003). Furthermore, Anisoptera nymphs prefer dams of woody debris over other habitat types (Burcher and Smock 2002), so beavers may increase the abundance of preferred food for breeding Rusty Blackbirds. Although beavers have been reintroduced and have recovered after being over harvested for their fur and thus extirpated from many areas of their range, current population estimates suggest that beaver densities are still much lower than they were in pre-colonial times (Müller-Schwarze and Sun 2003). It's important for land managers within the Rusty Blackbird's breeding range to allow beaver populations to persist and continue to manage the boreal forest landscape.

Much of the Rusty Blackbird's breeding range is managed by humans with commercial forestry operations. At first glance, forestry may seem to benefit Rusty Blackbirds by allowing for stands of small regenerating conifers, which is the species' preferred nest habitat. However,

forestry practices such as pre-commercial thinning may be detrimental to Rusty Blackbirds because higher basal area is associated with higher nest success (Luepold et al. 2015). The construction of roads for access to managed stands may also impact Rusty Blackbirds, though the relationship between distance to road and nest predation is unclear (Luepold et al. 2015). One study suggested that harvested forest may pose an “ecological trap” to breeding Rusty Blackbirds (Powell et al. 2010b), but this hypothesis was not supported by more recent research (Luepold et al. 2015). Thus, more research is needed to fully assess how forest management can help or harm breeding Rusty Blackbird populations.

Humans also indirectly affect habitat for breeding Rusty Blackbirds. Anthropogenic sources of contaminants, such as mercury, that can be atmospherically deposited into North American boreal wetlands are problematic (Evers et al. 2012). Furthermore, climate change is affecting the water chemistry and invertebrate communities of North American boreal wetlands (Corcoran et al. 2009). A recent study in the Adirondack Park, NY by Glennon (2017) suggests that numerous boreal bird populations, including the Rusty Blackbird, have been and will continue to sharply decline. While there are other factors at play, the author suggests that climate change and habitat modification are the main contributors to the plight of boreal birds (Glennon 2017).

Conservation of the rapidly declining Rusty Blackbird species will require land managers and biologists to explore uncharted territory. Because habitat change, mercury pollution and climate change are regional to global issues that are difficult to address, and because other factors affecting Rusty Blackbird populations are unknown, I recommend that land managers in New England focus on protecting and improving foraging habitat near regenerating coniferous forest. My research suggests that Rusty Blackbirds prefer to forage in wetlands with low percent

cover of mud and higher percent cover of open water and emergent vegetation. Thus, land managers could experiment with managing wetland hydrology to increase the wet area of existing wetlands and create new wetlands, mimicking the engineering work of beavers. As my research suggests that Rusty Blackbirds select sites with higher aquatic invertebrate abundance, land managers should try to improve food availability within wetlands, perhaps by stocking ponds with native invertebrate prey species.

Also, as it may be easier to manipulate nesting habitat than foraging habitat, it is possible to create nest sites in forested wetlands with existing beaver-impounded ponds, other types of wetlands, and low-grade stream-associated wetlands. Foss and Lambert (2017) recommend managing forest within 243.84 meters of foraging habitat by creating young stands of spruce and fir trees while leaving a few tall live trees or snags as perches. Rusty Blackbirds prefer to nest in dense clumps of regenerating softwood stands with a basal area of at least 19.51 m²/ hectare, where nests can be supported by multiple branches. In New Hampshire, Rusty Blackbirds often nest in mixed stands, but the species appears to need a softwood cover of at least 35% (Foss and Lambert 2017).

Lastly, Rusty Blackbird conservation efforts would benefit from increased communication among the various stakeholders. Because much of the Canadian portion of the Rusty Blackbird breeding range has gone un-surveyed, U.S. and Canadian researchers should collaborate to fill in information gaps and identify key areas in need of protection. Land managers, both public and private, have an exciting opportunity to help preserve and improve breeding habitat for Rusty Blackbirds and other imperiled boreal species. Conservationists should expand upon education and engagement initiatives, such as the Rusty Blackbird Migration Blitz, to increase the general public's awareness of and concern for this species.

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Tables

Table 1: Site and field survey covariates used to model detectability and site occupancy of Rusty Blackbirds in northern New England in 2014.

Site Covariate	Description	Method
Size	Wetland size measured in meters squared	GIS
Elevation	Site elevation in meters	GIS
Pct.softwd	Percent softwood within a 500 meter buffer of wetland using NLCD 2011	GIS
Yng.softwd	Binary measure of presence of dense regenerating spruce and/or fir trees <5 feet	Field
Beaver	Binary measure of observed beaver activity	Field
OpenH2O	Visual estimate of percent open water within a wetland	Field
Mud	Visual estimate of percent exposed mud within a wetland	Field
Puddles	Binary measure of puddles observed 0, 1, 2, or 3 times out of three surveys	Field
Invert.richness	Total number of invertebrate families observed in three samples	Field
Invert.abundance	Average number of invertebrate individuals observed in three samples	Field
H2O depth	Average depth (cm) of open water near pond edge	Field

Survey Covariate	Description
Visit	Binary measure of surveying during periods 1, 2, or 3
Day	Survey date converted to Julian Day
Min	Survey start time converted to minute of day
Precip	Binary measure of presence of precipitation during survey
Wind	On the ground measure of wind (mph) at the start of the survey
Temp	Measure of temperature (Fahrenheit) at the start of the survey

Table 2: Location coordinates (decimal degrees) and confidence rankings of screen digitizations, based on the latest available orthoimagery and prior field experience, for wetlands surveyed for Rusty Blackbirds in northern New England in 2014.

Site Number	Site Name	Latitude	Longitude	Confidence ranking ^a
1	B Pond	44.73817	-70.9762	1
2	Bear's Crown	44.70647	-71.0970	1
3	Bear's Eye	44.70592	-71.0951	2
4	Between Greenoughs	44.83668	-71.1323	1
5	Big Greenough	44.83069	-71.1600	1
6	Bill's Cabin	44.85917	-71.2097	1
7	Black Bluff	44.94445	-71.2787	1
8	Blake Island	44.73001	-71.0399	1
9	Boat Ramp Lower	44.69185	-71.0617	1
10	Boat Ramp Upper	44.69717	-71.0587	2
11	Bungy	44.82647	-71.3469	1
12	Central Beaver Pond	44.81670	-71.1193	2
13	Closton Hill	44.58734	-71.2171	1
14	Closton Spur Lower	44.58453	-71.2213	1
15	Closton Spur Middle	44.58337	-71.2209	2
16	Closton Spur Upper	44.58178	-71.2211	1
17	Conner	44.72049	-71.0907	1
18	Corser Brook	44.86096	-71.2113	2
19	Danfino	44.89433	-71.2253	1
20	Deer Mountain	44.71943	-71.2385	2
21	Dixi	44.87860	-71.2154	1
22	Dixi Clear Cut	44.88761	-71.2223	1
23	Dixi North	44.88456	-71.2177	1
24	Dixville East	44.85303	-71.2802	3
25	Dixville Notch	44.84980	-71.2824	2
26	Dixville Spur Major	44.83980	-71.2628	1
27	Errol Hill Flats	44.74355	-71.1240	2
28	Four Mile Culvert	44.87429	-71.1992	1
29	Hayward Marsh	44.72322	-70.9707	3
30	Hilltop East	44.72694	-71.1046	1
31	Hilltop West	44.72696	-71.1021	1
32	Interior Beaver Pond	44.82281	-71.1210	1
33	Kelsey Lower	44.82199	-71.3364	1
34	Kelsey Upper	44.82264	-71.3370	1
35	Little Greenough	44.84268	-71.1349	1
36	Long Pond	44.81288	-71.1077	2
37	Magalloway Bend	44.81517	-71.0835	1

Site Number	Site Name	Latitude	Longitude	Confidence ranking ^a
38	Mile 10.8	44.89799	-71.2246	2
39	Mile 13	44.91712	-71.2514	2
40	Mud Hole Hill Lower	44.98170	-71.0730	1
41	Mud Hole Hill Upper	44.98070	-71.0745	1
42	Nathan Pond	44.90385	-71.2298	2
43	Newell Brook Fork	44.73297	-71.2598	1
44	Newell Junction	44.71102	-71.2512	2
45	North Millsfield	44.78930	-71.2664	1
46	Parmachenee Lower	44.98065	-71.0580	2
47	Parmachenee Middle	44.98155	-71.0587	1
48	Parmachenee Upper	44.98259	-71.0595	1
49	Round Pond Annex	44.80655	-71.1250	2
50	Sandflat Bridge Lower	44.70568	-71.1035	1
51	Sargent Cove	44.71244	-71.0672	1
52	Sturtevant East	44.81566	-71.0032	2
53	Sturtevant North New	44.82245	-71.0149	1
54	Sturtevant North Old	44.82017	-71.0174	2
55	Sweat Outlet 1	44.77505	-71.1997	1
56	Sweat Outlet 5	44.78004	-71.1983	3
57	Tidswell Bend	44.72564	-71.0465	1
58	Tidswell East	44.72917	-71.0268	1
59	Tyler Brook	44.73748	-71.0198	1
60	Windmill Crotch	44.74742	-71.2722	2

^a A ranking of 1 indicates high confidence, 2 indicates medium confidence, and 3 indicates low confidence.

Table 3: Summary of site covariates of wetlands surveyed for Rusty Blackbirds (RUBL) in northern New England, 2014.

Site	RUBL ^a	Elevation ^b	Size ^c	Young Softwood ^d	Beaver ^e	Open H ₂ O ^f	Mud ^f	Puddles Once ^g	Puddles Twice ^g	Puddles Thrice ^g	H ₂ O depth ^h
1	1	426	18597.26	1	0	20.00	75.00	0	0	1	15.33
2	1	398	8995.48	1	0	23.33	8.33	0	0	1	9.00
3	1	413	2992.13	1	0	26.67	16.67	0	0	1	6.33
4	0	473	4372.91	0	0	33.33	18.33	0	0	1	7.00
5	0	429	6063.23	1	0	50.00	9.00	0	0	1	6.33
6	0	642	1265.95	1	0	46.67	20.00	0	1	0	8.00
7	1	546	6768.46	1	0	43.33	1.67	0	1	0	27.33
8	1	389	15349.49	1	0	83.33	1.67	0	1	0	35.33
9	0	407	3574.59	0	0	40.00	25.00	0	0	1	8.67
10	1	405	16508.89	1	0	70.00	0.00	0	0	1	12.33
11	1	780	2684.54	1	0	85.00	10.00	1	0	0	37.33
12	1	441	8130.18	0	0	20.00	11.67	0	1	0	17.33
13	1	690	7262.39	1	0	58.33	11.67	0	0	1	31.33
14	1	445	1545.59	1	0	68.33	5.00	0	0	1	17.33
15	1	439	5718.74	1	0	56.67	8.33	0	0	1	21.00
16	1	440	7889.57	1	1	21.67	1.67	0	1	0	76.00
17	1	398	1286.97	1	0	70.00	1.67	0	0	0	19.83
18	1	654	3216.61	1	0	73.33	3.33	0	0	1	21.33
19	1	491	2767.53	1	0	53.33	6.67	0	0	1	31.33
20	0	550	4944.58	1	0	78.33	6.67	0	1	0	52.33
21	1	503	3608.34	1	1	48.33	3.33	1	0	0	42.33
22	0	498	1545.54	1	0	70.00	3.33	1	0	0	30.67
23	1	495	7391.75	1	0	10.00	0.00	0	0	1	19.67
24	1	451	2280.61	1	0	28.33	21.67	1	0	0	9.33
25	0	453	758.30	0	0	33.33	43.33	0	1	0	34.33
26	0	449	2444.31	1	0	80.00	6.67	0	1	0	12.67
27	1	159	12397.26	1	0	66.67	13.33	0	1	0	40.33

Site	RUBL ^a	Elevation ^b	Size ^c	Young Softwood ^d	Beaver ^e	Open H ₂ O ^f	Mud ^f	Puddles Once ^g	Puddles Twice ^g	Puddles Thrice ^g	H ₂ O depth ^h
28	1	488	8949.75	0	0	66.67	10.00	0	1	0	40.67
29	0	412	78344.39	1	0	40.00	21.67	1	0	0	16.33
30	1	414	9581.60	1	0	61.67	8.33	0	0	1	27.00
31	1	440	4008.10	0	0	55.00	6.67	0	0	1	8.00
32	0	438	12609.78	1	1	86.67	3.33	0	0	0	26.00
33	0	755	253.51	0	0	50.00	15.00	0	0	0	31.00
34	0	752	13253.20	1	0	35.00	23.33	0	0	1	31.67
35	0	448	2693.90	1	1	50.00	5.00	0	0	0	42.33
36	0	433	1611.97	1	0	10.00	55.00	0	0	1	15.67
37	0	380	1291.59	1	0	80.00	6.67	0	0	1	57.00
38	1	110	199.93	0	0	11.67	0.00	0	1	0	39.67
39	1	535	1204.32	1	0	56.67	5.00	0	0	1	13.67
40	1	543	4137.76	1	0	70.00	3.33	1	0	0	25.33
41	1	472	10807.00	0	0	86.67	3.33	0	0	1	26.67
42	0	521	373.00	0	0	48.33	20.00	0	0	1	7.33
43	1	352	1999.45	1	0	85.00	6.67	0	0	1	50.67
44	1	515	1463.56	1	0	70.00	6.67	1	0	0	43.00
45	1	586	9554.19	1	0	76.67	0.00	0	0	1	19.33
46	0	490	875.61	1	0	73.33	5.00	0	0	0	30.00
47	0	490	1176.53	1	0	78.33	1.67	0	0	0	60.00
48	1	479	1806.80	0	0	73.33	3.33	0	0	1	27.33
49	1	444	15210.72	1	1	83.33	5.00	0	1	0	25.00
50	1	383	12152.61	1	0	86.67	6.67	1	0	0	29.67
51	0	398	3970.58	1	0	15.00	11.67	0	1	0	13.00
52	0	421	8727.33	0	0	48.33	30.00	0	1	0	18.00
53	0	394	21639.06	1	0	10.00	18.33	0	0	1	10.00
54	0	399	29391.75	1	1	73.33	0.00	0	0	1	25.33
55	0	592	4439.09	1	0	40.00	0.00	0	1	0	62.00
56	1	591	665.02	0	1	62.50	7.50	1	0	0	31.00

Site	RUBL ^a	Elevation ^b	Size ^c	Young Softwood ^d	Beaver ^e	Open H ₂ O ^f	Mud ^f	Puddles Once ^g	Puddles Twice ^g	Puddles Thrice ^g	H ₂ O depth ^h
57	0	388	6992.66	1	0	31.67	58.33	0	0	1	9.67
58	1	404	61074.45	1	0	78.33	5.00	0	1	0	11.67
59	0	387	10028.12	1	0	33.33	50.00	0	0	1	31.33
60	1	683	11033.89	1	0	65.00	6.67	0	1	0	15.33

^a A binary measure of whether or not a Rusty Blackbird was detected at least once (0 = no, 1 = yes).

^b Elevation in meters.

^c Wetland size in meters squared, calculated in a GIS using screen delineated polygons.

^d A binary measure of presence of young softwoods (< 5 feet) surrounding the wetland at a density of at least 70%.

^e A binary measure of evidence of current beaver activity.

^f Visually estimated percent cover of the wetland.

^g A binary measure of the presence of puddles once, twice, or three times during surveys 1, 2, and 3.

^h A measure of water depth in centimeters.

Table 4: Percent land cover (NLCD 2011) within a 500 meter buffer of wetlands used^a by Rusty Blackbirds in northern New England, 2014. Land cover types include Open Water (OW); Development, Open Space (DOS); Development, Low Intensity (DLI); Development, Medium Intensity (DMI); Barren Land (BL); Deciduous Forest (DF); Evergreen Forest (EF); Mixed Forest (MF); Shrub Scrub (SS); Herbaceous (H); Woody Wetlands (WW); Emergent Herbaceous Wetlands (EHW).

Site	OW	DOS	DLI	DMI	BL	DF	EF	MF	SS	H	WW	EHW
1	0.00%	0.00%	0.00%	0.00%	0.00%	11.86%	16.89%	43.83%	4.08%	2.36%	19.72%	1.26%
2	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	40.00%	50.00%	0.00%	0.00%	10.00%	0.00%
3	0.00%	0.00%	0.00%	0.00%	0.00%	25.87%	9.62%	56.55%	7.96%	0.00%	0.00%	0.00%
7	0.00%	0.00%	0.00%	0.00%	0.00%	42.60%	12.02%	17.31%	3.77%	0.00%	24.30%	0.00%
8	2.52%	0.00%	0.00%	0.00%	0.00%	10.50%	15.38%	22.02%	15.13%	0.00%	34.45%	0.00%
10	0.00%	0.00%	0.00%	0.00%	0.00%	13.63%	26.27%	47.58%	4.21%	2.73%	1.98%	3.59%
11	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	81.86%	2.11%	11.68%	0.00%	4.35%	0.00%
12	1.03%	0.00%	0.00%	0.00%	0.00%	7.33%	40.10%	16.20%	24.42%	0.00%	10.54%	0.39%
13	0.00%	0.00%	0.00%	0.00%	0.00%	16.16%	21.24%	30.59%	10.94%	0.95%	20.13%	0.00%
14	0.00%	0.00%	0.00%	0.00%	0.00%	33.37%	9.90%	48.27%	1.33%	0.00%	7.14%	0.00%
15	0.00%	0.00%	0.00%	0.00%	0.00%	26.85%	20.83%	40.74%	3.24%	0.00%	8.33%	0.00%
16	0.00%	13.11%	0.00%	0.00%	0.00%	2.87%	13.52%	63.11%	0.00%	0.00%	7.38%	0.00%
17	0.00%	2.76%	1.02%	0.00%	0.00%	8.58%	31.56%	21.45%	21.35%	2.55%	10.73%	0.00%
18	0.00%	2.92%	0.00%	0.00%	0.00%	33.58%	8.39%	38.69%	16.42%	0.00%	0.00%	0.00%
19	0.00%	3.93%	0.00%	0.00%	0.00%	53.87%	2.31%	16.07%	3.12%	0.00%	20.69%	0.00%
21	0.00%	3.35%	0.00%	0.00%	0.00%	20.38%	5.97%	47.45%	15.72%	0.73%	6.40%	0.00%
23	0.00%	3.32%	0.00%	0.00%	0.00%	20.59%	12.56%	20.78%	29.46%	5.63%	7.66%	0.00%
24	0.00%	3.85%	1.54%	0.00%	0.00%	69.94%	6.55%	14.26%	2.31%	0.00%	1.54%	0.00%
27	0.00%	0.61%	0.70%	0.00%	0.00%	33.13%	25.33%	19.81%	9.29%	2.28%	8.85%	0.00%
28	0.00%	3.81%	0.00%	0.00%	0.00%	7.80%	31.01%	31.28%	12.69%	0.00%	13.42%	0.00%
30	0.00%	10.17%	1.36%	0.00%	0.00%	1.69%	22.71%	31.86%	31.19%	1.02%	0.00%	0.00%
31	0.00%	0.00%	0.00%	0.00%	0.00%	5.81%	35.72%	47.05%	10.26%	0.87%	0.29%	0.00%
38	0.00%	1.03%	0.00%	0.00%	0.00%	30.82%	18.84%	42.47%	0.00%	1.37%	5.48%	0.00%
39	0.00%	0.00%	0.00%	0.00%	0.00%	51.26%	4.83%	27.21%	4.62%	0.00%	12.08%	0.00%
40	0.00%	0.00%	0.00%	0.00%	0.00%	56.38%	6.04%	23.49%	14.09%	0.00%	0.00%	0.00%

Site	OW	DOS	DLI	DMI	BL	DF	EF	MF	SS	H	WW	EHW
41	0.00%	0.00%	0.00%	0.00%	0.00%	52.01%	2.42%	28.11%	11.91%	0.00%	3.22%	2.33%
43	0.00%	0.00%	0.00%	0.00%	0.00%	28.56%	4.81%	22.04%	35.47%	1.40%	7.72%	0.00%
44	0.00%	0.00%	0.00%	0.00%	0.00%	33.40%	6.45%	20.60%	33.40%	1.14%	4.99%	0.00%
45	0.00%	0.00%	0.00%	0.00%	0.00%	10.52%	16.46%	3.87%	56.47%	2.97%	9.17%	0.54%
48	0.00%	0.00%	0.00%	0.00%	0.00%	33.58%	19.34%	38.69%	6.20%	0.00%	2.19%	0.00%
49	8.53%	0.00%	0.00%	0.00%	0.00%	25.50%	11.49%	41.25%	8.79%	2.61%	1.83%	0.00%
50	0.00%	0.00%	0.00%	0.00%	0.00%	7.32%	32.40%	34.87%	11.18%	0.25%	13.98%	0.00%
56	0.00%	0.00%	0.00%	0.00%	0.00%	29.44%	0.00%	16.58%	46.36%	1.52%	5.25%	0.85%
58	6.03%	0.00%	0.00%	0.00%	0.00%	20.56%	7.20%	23.35%	8.63%	0.00%	33.59%	0.65%
60	0.00%	0.00%	0.00%	0.00%	0.00%	31.21%	14.08%	16.62%	36.22%	0.42%	0.76%	0.68%

^a Considered used if at least one Rusty Blackbird was detected at least once during three surveys.

Table 5: Percent land cover (NLCD 2011) within a 500 meter buffer of wetlands without detected^a Rusty Blackbirds in northern New England, 2014. Land cover types include Open Water (OW); Development, Open Space (DOS); Development, Low Intensity (DLI); Development, Medium Intensity (DMI); Barren Land (BL); Deciduous Forest (DF); Evergreen Forest (EF); Mixed Forest (MF); Shrub Scrub (SS); Herbaceous (H); Woody Wetlands (WW); Emergent Herbaceous Wetlands (EHW).

Site	OW	DOS	DLI	DMI	BL	DF	EF	MF	SS	H	WW	EEW
4	23.96%	0.00%	0.00%	0.00%	0.00%	7.83%	16.43%	47.83%	0.58%	0.00%	3.38%	0.00%
5	0.00%	0.00%	0.00%	0.00%	0.00%	37.05%	9.85%	21.01%	13.60%	1.69%	16.79%	0.00%
6	0.00%	3.58%	0.00%	0.00%	0.00%	28.87%	21.18%	18.34%	20.23%	3.37%	4.43%	0.00%
9	0.00%	0.00%	0.00%	0.00%	0.00%	22.51%	33.96%	22.80%	13.23%	0.20%	6.81%	0.49%
20	0.00%	0.00%	0.00%	0.00%	0.00%	35.29%	6.64%	23.06%	14.99%	7.50%	12.52%	0.00%
22	0.00%	2.81%	0.00%	0.00%	0.00%	37.27%	8.80%	40.07%	0.19%	0.00%	10.86%	0.00%
25	0.00%	6.60%	0.96%	0.00%	0.00%	36.74%	14.91%	12.89%	3.62%	3.41%	20.34%	0.53%
26	0.00%	7.23%	1.51%	0.90%	0.00%	51.61%	6.83%	14.06%	1.71%	5.12%	11.04%	0.00%
29	0.00%	0.00%	0.00%	0.00%	0.00%	43.41%	9.51%	22.93%	7.58%	1.05%	10.74%	4.78%
32	0.79%	0.00%	0.00%	0.00%	0.00%	12.80%	34.91%	30.25%	8.85%	2.45%	9.08%	0.87%
33	0.00%	0.00%	0.00%	0.00%	0.00%	7.04%	28.17%	57.75%	7.04%	0.00%	0.00%	0.00%
34	0.00%	0.00%	0.00%	0.00%	0.00%	3.84%	61.66%	20.58%	9.39%	0.00%	4.53%	0.00%
35	1.43%	0.00%	0.00%	0.00%	0.00%	25.03%	9.91%	51.11%	1.69%	0.00%	10.82%	0.00%
36	7.17%	7.68%	0.00%	0.00%	0.00%	4.88%	53.89%	15.58%	2.18%	2.18%	6.44%	0.00%
37	9.37%	2.50%	0.00%	0.00%	1.87%	13.22%	24.77%	25.18%	1.25%	0.00%	20.71%	1.14%
42	0.00%	4.03%	0.65%	0.76%	0.00%	41.55%	5.23%	35.11%	7.20%	0.44%	5.02%	0.00%
46	0.00%	0.00%	0.00%	0.00%	0.00%	28.44%	22.20%	39.75%	2.54%	0.63%	6.45%	0.00%
47	0.00%	0.00%	0.00%	0.00%	0.00%	60.00%	0.00%	40.00%	0.00%	0.00%	0.00%	0.00%
51	10.89%	7.88%	0.00%	0.00%	1.07%	10.99%	33.07%	32.39%	2.53%	0.00%	1.17%	0.00%
52	0.00%	0.00%	0.00%	0.00%	0.00%	25.57%	31.57%	39.40%	0.00%	1.64%	0.00%	1.82%
53	0.00%	0.00%	0.00%	0.00%	0.00%	17.60%	39.77%	34.07%	0.49%	0.00%	6.11%	1.96%
54	4.73%	0.00%	0.00%	0.00%	1.52%	24.43%	46.97%	16.86%	0.00%	0.00%	5.49%	0.00%
55	4.21%	0.00%	0.00%	0.00%	0.00%	25.07%	18.71%	34.97%	5.19%	0.29%	10.48%	1.08%
57	0.00%	0.00%	0.00%	0.00%	0.00%	28.51%	11.90%	29.70%	7.93%	0.00%	21.96%	0.00%
59	0.00%	0.00%	0.00%	0.00%	0.00%	1.09%	33.30%	37.65%	3.80%	0.00%	24.16%	0.00%

^a Considered undetected if no Rusty Blackbirds were detected during any of the three surveys.

Table 6: Spearman rank coefficients (r_s) for continuous site and survey covariates with significant ($p < 0.05$) correlations. Surveys were conducted in northern New England, 2014

variable 1	variable 2	r_s	p-value
pct.softwood	size	0.303	0.019
elevation	size	-0.305	0.018
elevation	pct.softwood	-0.277	0.032
invert.abundance	invert.richness	0.341	0.008
temp.1	pct.softwood	-0.349	0.007
wind.2	invert.richness	-0.379	0.003
wind.3	pct.softwood	0.268	0.038
time.1	pct.softwood	-0.307	0.019
time.2	size	-0.301	0.020
mud	openH2O	-0.459	0.000
H2Odepth	openH2O	0.321	0.012
H2Odepth	mud	-0.344	0.007
day.3	mud	-0.288	0.025
temp.2	invert.abundance	-0.275	0.033
temp.3	H2Odepth	-0.289	0.025
wind.2	invert.abundance	-0.3	0.020
temp.2	day.1	0.435	0.001
temp.2	day.2	0.391	0.002
temp.2	temp.1	-0.426	0.001
temp.3	day.2	-0.524	0.000
wind.1	day.1	-0.329	0.012
wind.1	day.2	-0.404	0.002
time.1	temp.1	0.281	0.033
time.3	temp.3	0.296	0.022
time.3	time.2	-0.319	0.013

Table 7: Model selection for detectability of Rusty Blackbirds in northern New England in 2014.

Model	k ^a	AIC ^b	Δ AIC ^c	w _i ^d	-2 Log-likelihood
p(visit) psi(.)	4	214.38	0.00	0.5133	206.3808
p(size) psi(.)	3	218.18	3.80	0.0768	212.1798
p(precip) psi(.)	3	219.19	4.81	0.0464	213.1861
p(temp) psi(.)	3	219.26	4.88	0.0447	213.2604
p(time) psi(.)	3	219.34	4.96	0.0430	213.3401
p(day) psi(.)	3	219.39	5.01	0.0419	213.3941
p(wind) psi(.)	3	219.50	5.12	0.0397	213.4986
p(day+precip) psi(.)	4	220.87	6.49	0.0200	212.8663
p(time+precip) psi(.)	4	220.96	6.58	0.0191	212.9581
p(day+time) psi(.)	4	220.99	6.61	0.0189	212.9889
p(temp+wind) psi(.)	4	221.05	6.67	0.0183	213.0526
p(time+temp) psi(.)	4	221.07	6.69	0.0181	213.0667
p(day+temp) psi(.)	4	221.08	6.70	0.0180	213.0775
p(time+wind) psi(.)	4	221.19	6.81	0.0170	213.1904
p(day+wind) psi(.)	4	221.25	6.87	0.0165	213.2528
p(time ²) psi(.)	4	221.32	6.94	0.0160	213.3170
p(day ²) psi(.)	4	221.36	6.98	0.0157	213.3578
p(temp*wind) psi(.)	5	222.43	8.05	0.0092	212.4333
p(time+precip+wind) psi(.)	5	222.90	8.52	0.0073	212.8988

^a Number of parameters;

^b Akaike's Information Criterion;

^c Difference in the model's AIC from that of the top model;

^d Akaike weight.

Table 8: Model selection for wetland use of Rusty Blackbirds in northern New England in 2014, using site occupancy analysis with the top detectability model (Table 6) as the base.

Model	k ^a	AIC ^b	Δ AIC ^c	w _i ^d	-2 Log-likelihood
p(visit) psi(mud)	5	209.63	0.00	0.2335	199.6278
p(visit) psi(invert.abundance)	5	210.05	0.43	0.1888	200.0531
p(visit) psi(invert.abundance+yng.softwood)	6	211.29	1.66	0.1017	199.2899
p(visit) psi(mud+yng.softwood)	6	211.60	1.97	0.0872	199.5985
p(visit) psi(beaver+invert.abundance)	6	211.73	2.11	0.0814	199.7348
p(visit) psi(invert.abundance+pct.softwood)	6	212.13	2.50	0.0670	200.1253
p(visit) psi(yng.softwood+beaver+invert.abundance)	7	212.79	3.16	0.4800	198.7905
p(visit) psi(invert.richness)	5	214.21	4.59	0.0236	204.2148
p(visit) psi(.)	4	214.38	4.75	0.0217	206.3808
p(visit) psi(openH20)	5	214.58	4.96	0.0196	204.5833
p(visit) psi(pct.softwood)	5	214.80	5.17	0.0176	204.7998
p(visit) psi(invert.richness+yng.softwood)	6	216.13	6.50	0.0091	204.1262
p(visit) psi(beaver+invert.richness)	6	216.21	6.58	0.0087	204.2123
p(visit) psi(yng.softwood)	5	216.24	6.61	0.0086	206.2380
p(visit) psi(puddles3x)	5	216.27	6.64	0.0084	206.2675
p(visit) psi(elevation)	5	216.34	6.71	0.0084	206.2762
p(visit) psi(size)	5	216.34	6.71	0.0081	206.3407
p(visit) psi(H20depth)	5	216.35	6.75	0.0081	206.3506
p(visit) psi(beaver)	5	216.38	6.75	0.0080	206.3754
p(visit) psi(openH20+pct.softwood)	6	216.53	6.90	0.0074	204.5286

Model	k ^a	AIC ^b	Δ AIC ^c	w _i ^d	-2 Log-likelihood
p(visit) psi(pct.softwood+puddles3x)	6	216.63	7.00	0.0070	204.6290
p(visit) psi(pct.softwood+beaver)	6	216.76	7.13	0.0066	204.7625
p(visit) psi(puddles3x+yng.softwood)	6	218.13	8.50	0.0033	206.1290
p(visit) psi(size+yng.softwood)	6	218.16	8.54	0.0033	206.1631
p(visit) psi(H20depth+yng.softwood)	6	218.22	8.59	0.0032	206.2175
p(visit) psi(yng.softwood+beaver)	6	218.23	8.60	0.0032	206.2298
p(visit) psi(H20depth+size)	6	218.32	8.69	0.0030	206.3211
p(visit) psi(beaver+size)	6	218.34	8.71	0.3000	206.3361
p(visit) psi(pct.softwood+beaver+puddles3x)	7	218.62	8.99	0.0026	204.6198

^a Number of parameters;

^b Akaike's Information Criterion;

^c Difference in the model's AIC from that of the top model;

^d Akaike weight.

Table 9: Model selection for wetland use of Rusty Blackbirds in northern New England in 2014, using site occupancy analysis with AIC scores adjusted for over-dispersion ($\hat{c} = 1.78$).

Model	k ^a	QAIC ^b	Δ QAIC ^c	Qw _i ^d	-2 Log-likelihood
p(visit) psi(invert.abundance+mud)	7	123.44	0.00	0.60	188.23
p(visit) psi(mud)	6	128.0627	4.626022	0.059774	199.6278
p(visit) psi(invert.abundance)	6	128.3099	4.873279	0.052823	200.0531
p(visit) psi(invert.abundance+yng.softwood)	7	129.8662	6.429594	0.024259	199.2899
p(visit) psi(.)	5	129.9888	6.552169	0.022817	206.3808
p(visit) psi(mud+yng.softwood)	7	130.0456	6.608989	0.022178	199.5985
p(visit) psi(beaver+invert.abundance)	7	130.1249	6.688238	0.021316	199.7348
p(.) psi(.)	3	130.2058	6.769164	0.020471	213.634
p(visit) psi(invert.abundance+pct.softwood)	7	130.3519	6.915265	0.019029	200.1253
p(visit) psi(invert.richness)	6	130.7295	7.292892	0.015755	204.2148
p(visit) psi(openH2O)	6	130.9438	7.507159	0.014154	204.5833
p(visit) psi(pct.softwood)	6	131.0697	7.633016	0.013291	204.7998
p(visit) psi(yng.sof+beaver+invert.abundance)	8	131.5758	8.139196	0.010319	198.7905
p(visit) psi(yng.softwood)	6	131.9058	8.469165	0.00875	206.238
p(visit) psi(puddles3x)	6	131.9229	8.486297	0.008675	206.2675
p(visit) psi(elevation)	6	131.928	8.491373	0.008653	206.2762
p(visit) psi(size)	6	131.9655	8.528884	0.008492	206.3407
p(visit) psi(H2Odepth)	6	131.9713	8.53466	0.008468	206.3506
p(visit) psi(beaver)	6	131.9857	8.549035	0.008407	206.3754
p(visit) psi(invert.richness+yng.softwood)	7	132.678	9.241379	0.005947	204.1262
p(visit) psi(beaver+invert.richness)	7	132.7281	9.291418	0.0058	204.2123

p(visit) psi(openH2O+pct.softwood)	7	132.912	9.47533	0.005291	204.5286
p(visit) psi(pct.softwood+puddles.3x)	7	132.9703	9.533694	0.005138	204.629
p(visit) psi(pct.softwood+beaver)	7	133.048	9.611328	0.004943	204.7625
p(visit) psi(yng.softwood)	7	133.8425	10.40581	0.003322	206.129
p(visit) psi(size+yng.softwood)	7	133.8622	10.4256	0.00329	206.1631
p(visit) psi(H2Odepth+yng.softwood)	7	133.8939	10.45727	0.003238	206.2175
p(visit) psi(yng.softwood+beaver)	7	133.901	10.46439	0.003226	206.2298
p(visit) psi(H2Odepth+size)	7	133.9541	10.51746	0.003142	206.3211
p(visit) psi(beaver+size)	7	133.9629	10.52622	0.003128	206.3361
p(visit) psi(pct.softwood+beaver+puddles.3x)	8	134.965	11.52833	0.001895	204.6198

^a Number of parameters;

^b Quasi Akaike's Information Criterion;

^c Difference in the model's QAIC from that of the top model;

^d Quasi Akaike weight.

Table 10: Summary of invertebrate taxa found at each wetland site (x-axis) surveyed in northern New England in 2014.

Order	Family	Coleoptera	Collembola	Diptera	Ephemeroptera	Hemiptera	Lepidoptera	Megaloptera	Odonata	Plecoptera	Trichoptera	Araneae	Amphipoda	Oligochaeta ^a	Hirudinea ^a	Veneroida
	Dytiscidae															
	Elmidae															
	Hydrophilidae															
	Scirtidae															
	Gyrinidae															
	Halipidae															
	Notonectidae															
	Curculionidae															
	Dryopidae															
	Linnichidae															
	Unknown															
	Unknown															
	Stratiomyidae															
	Tabanidae															
	Chaoboridae															
	Ceratopogonidae															
	Chironomidae															
	Culicidae															
	Pychopteridae															
	Tipulidae															
	Unknown															
	Baetidae															
	Leptophlebiidae															
	Siphonuridae															
	Caenidae															
	Ephemerellidae															
	Oligoneuridae															
	Ephemeridae															
	Heptageniidae															
	Potamanthidae															
	Corixidae															
	Notonectidae															
	Unknown															
	Corydalidae															
	Sialidae															
	Unknown															
	Aeshnidae															
	Cordulegastridae															
	Corduliidae															
	Gomphidae															
	Libellulidae															
	Coenagrionidae															
	Lestidae															
	Leuctridae															
	Perlodidae															
	Molannidae															
	Hydropsychidae															
	Polycentropodidae															
	Psychomyiidae															
	Lepidostomatidae															
	Limnephilidae															
	Phryganeidae															
	Hydroptilidae															
	Unknown															
	Unknown															
	Unknown															
	Unknown															
	Sphaeriidae															

[illegible]

^a Subclass

^b Results were pooled from two samples rather than three.

Table 11: Summary of invertebrate taxa found at Rusty Blackbird survey wetlands in northern New England in 2014. “Unknown” indicates that samples were not identified down to that taxonomic level and “NA” indicates that the level of classification is not applicable to the taxa.

Phylum	Class	Order	Suborder	Family
Annelida	Clitellata	Hirudinea ^a	Unknown	Unknown
Annelida	Clitellata	Oligochaeta ^a	Unknown	Unknown
Arthropoda	Arachnida	Araneae	Unknown	Unknown
Arthropoda	Insecta	Coleoptera	NA	Dytiscidae
Arthropoda	Insecta	Coleoptera	NA	Elmidae
Arthropoda	Insecta	Coleoptera	NA	Hydrophilidae
Arthropoda	Insecta	Coleoptera	NA	Scirtidae
Arthropoda	Insecta	Coleoptera	Adephaga	Gyrinidae
Arthropoda	Insecta	Coleoptera	Adephaga	Haliplidae
Arthropoda	Insecta	Coleoptera	Heteroptera	Notonectidae
Arthropoda	Insecta	Coleoptera	Polyphaga	Curculionidae
Arthropoda	Insecta	Coleoptera	Polyphaga	Dryopidae
Arthropoda	Insecta	Coleoptera	Polyphaga	Limnichidae
Arthropoda	Insecta	Collembola	Unknown	Unknown
Arthropoda	Insecta	Diptera	Unknown	Unknown
Arthropoda	Insecta	Diptera	Brachycera	Stratiomyidae
Arthropoda	Insecta	Diptera	Brachycera	Tabanidae
Arthropoda	Insecta	Diptera	Nematocera	Chaoboridae
Arthropoda	Insecta	Diptera	Nematocera	Ceratopogonidae
Arthropoda	Insecta	Diptera	Nematocera	Chironomidae
Arthropoda	Insecta	Diptera	Nematocera	Culicidae
Arthropoda	Insecta	Diptera	Nematocera	Ptychopteridae
Arthropoda	Insecta	Diptera	Nematocera	Tipulidae
Arthropoda	Insecta	Ephemeroptera	Unknown	Unknown
Arthropoda	Insecta	Ephemeroptera	Schistonota	Baetidae
Arthropoda	Insecta	Ephemeroptera	NA	Leptophlebiidae
Arthropoda	Insecta	Ephemeroptera	NA	Siphonuridae
Arthropoda	Insecta	Ephemeroptera	Pannota	Caenidae
Arthropoda	Insecta	Ephemeroptera	Pannota	Ephemerellidae
Arthropoda	Insecta	Ephemeroptera	Pisciforma	Oligoneuriidae
Arthropoda	Insecta	Ephemeroptera	Schistonota	Ephemeridae
Arthropoda	Insecta	Ephemeroptera	Schistonota	Heptageniidae
Arthropoda	Insecta	Ephemeroptera	Schistonota	Potamanthidae
Arthropoda	Insecta	Hemiptera	Heteroptera	Corixidae
Arthropoda	Insecta	Hemiptera	Heteroptera	Notonectidae

Phylum	Class	Order	Suborder	Family
Arthropoda	Insecta	Lepidoptera	Unknown	Unknown
Arthropoda	Insecta	Megaloptera	NA	Corydalidae
Arthropoda	Insecta	Megaloptera	NA	Sialidae
Arthropoda	Insecta	Odonata	Unknown	Unknown
Arthropoda	Insecta	Odonata	Anisoptera	Aeshnidae
Arthropoda	Insecta	Odonata	Anisoptera	Cordulegastridae
Arthropoda	Insecta	Odonata	Anisoptera	Corduliidae
Arthropoda	Insecta	Odonata	Anisoptera	Gomphidae
Arthropoda	Insecta	Odonata	Anisoptera	Libellulidae
Arthropoda	Insecta	Odonata	Zygoptera	Coenagrionidae
Arthropoda	Insecta	Odonata	Zygoptera	Lestidae
Arthropoda	Insecta	Plecoptera	NA	Leuctridae
Arthropoda	Insecta	Plecoptera	Systellognatha	Perlodidae
Arthropoda	Insecta	Trichoptera	Integripalpia	Molannidae
Arthropoda	Insecta	Trichoptera	Annulipalpia	Hydropsychidae
Arthropoda	Insecta	Trichoptera	Annulipalpia	Polycentropodidae
Arthropoda	Insecta	Trichoptera	Annulipalpia	Psychomyiidae
Arthropoda	Insecta	Trichoptera	Integripalpia	Lepidostomatidae
Arthropoda	Insecta	Trichoptera	Integripalpia	Limnephilidae
Arthropoda	Insecta	Trichoptera	Integripalpia	Phryganeidae
Arthropoda	Insecta	Trichoptera	Spicipalpia	Hydroptilidae
Arthropoda	Malacostraca	Amphipoda	Unknown	Unknown
Mollusca	Bivalvia	Veneroida	Sphaeriacea	Sphaeriidae

^a Subclass.

Table 12: Number of Families^a represented per insect Order from three aquatic macroinvertebrate surveys per wetland used^b by Rusty Blackbirds in northern New England, 2014.

Site	Coleoptera	Diptera	Ephemeroptera	Hemiptera	Lepidoptera	Megaloptera	Odonata	Plecoptera	Trichoptera
1	0	2	1	0	0	0	1	0	0
2	0	1	1	0	0	0	2	0	1
3	0	2	1	0	0	1	0	0	0
7	0	3	1	0	0	0	0	0	1
8	2	2	0	0	0	0	2	0	1
10	1	2	1	0	0	0	1	0	0
11	0	3	0	0	0	0	2	0	1
12	1	2	1	0	0	0	0	0	1
13	0	3	1	1	1	0	1	0	1
14	4	3	1	1	0	0	3	0	1
15	1	2	0	0	0	0	3	0	1
16	2	2	0	1	0	0	3	0	0
17	0	2	1	0	0	0	2	0	2
18	2	2	0	0	0	1	1	0	1
19	1	2	1	0	0	0	1	0	2
21	0	3	0	0	0	0	2	0	0
23	1	3	0	1	1	0	4	1	1
24	1	3	1	0	0	0	0	1	0
27	1	2	2	0	0	0	3	0	0
28 ^c	0	1	1	0	0	0	1	0	1
30	0	2	1	0	0	0	0	1	1
31	1	2	0	0	0	0	1	0	0
38	0	1	3	0	0	0	0	0	1
39	4	1	2	0	0	0	1	1	1
40	1	1	1	0	0	0	1	0	1
41	2	2	3	0	0	0	0	0	1
43	0	2	3	0	0	1	1	0	0

Site	Coleoptera	Diptera	Ephemeroptera	Hemiptera	Lepidoptera	Megaloptera	Odonata	Plecoptera	Trichoptera
44	0	0	1	0	0	0	0	0	1
45	3	4	0	2	0	0	4	0	1
48	1	2	3	0	0	0	2	0	1
49	0	3	0	0	0	0	2	0	1
50	1	4	2	0	0	0	1	0	0
56 ^c	1	1	4	0	0	0	2	0	1
58	4	3	0	0	0	0	2	0	1
60	2	2	1	0	0	0	1	1	1

^a If no specimens were identified to Family within an Order, the specimens were lumped and counted as one Family.

^b Considered used if at least one Rusty Blackbird was detected at least once during three surveys

^c Specimens were pooled from two, rather than three, samples.

Table 13: Number of Families^a represented per insect Order from three aquatic macroinvertebrate surveys per wetland without detected Rusty Blackbirds in northern New England, 2014.

Site	Coleoptera	Diptera	Ephemeroptera	Hemiptera	Lepidoptera	Megaloptera	Odonata	Plecoptera	Trichoptera
4	2	2	3	0	0	0	2	0	0
5	0	2	2	0	0	1	1	0	1
6	1	3	2	0	0	1	0	0	1
9 ^c	0	2	0	0	0	0	1	0	0
20	0	1	0	0	0	0	0	0	0
22 ^c	0	1	1	0	0	0	1	0	0
25	1	3	1	0	0	0	0	0	1
26 ^c	0	1	0	0	0	0	0	0	0
29	0	3	0	0	0	0	4	0	0
32	1	2	0	0	0	0	1	0	0
33	0	1	2	0	0	0	0	0	1
34	1	3	3	1	0	0	0	0	1
35	0	2	0	0	0	0	0	0	1
36	2	3	0	0	0	1	0	0	0
37	0	3	3	0	0	1	0	0	2
42	0	3	2	0	0	1	3	0	1
46	0	0	3	0	0	0	2	0	2
47	0	1	1	0	0	0	2	0	2
51	0	4	0	0	0	0	1	0	1
52	0	2	0	0	0	0	1	0	0
53	2	2	2	0	0	0	1	0	2
54	0	1	3	0	0	0	1	0	1
55 ^c	0	1	1	0	0	0	1	0	0
57	0	2	1	0	0	0	2	0	0
59	3	1	3	0	0	0	3	0	1

^a If no specimens were identified to Family within an Order, the specimens were lumped and counted as one Family.

^b Considered undetected if no Rusty Blackbirds were detected during any of the three surveys.

^cSpecimens were pooled from two, rather than three, samples.

Table 14: Summary statistics and results of a 2-sample Poisson rate test for difference between the numbers of insect Families^a represented per Order of sites used^b by Rusty Blackbirds (RUBL) versus sites without undetected^c sites in northern New England, 2014.

Order	RUBLused			RUBLundetected			Poisson Rate Test				
	Families	N	Rate	Families	N	Rate	Estimate for difference ^d	95% bound	Lower	Z	p-value ^e
Coleoptera	37	35	1.06	13	25	0.52	0.54	0.17		2.38	0.009
Diptera	75	35	2.14	49	25	1.96	0.18	-0.43		0.49	0.312
Ephemeroptera	38	35	1.09	33	25	1.32	-0.23	-0.71		-0.81	0.791
Hemiptera ^f	6	35	0.17	1	25	0.04	0.13	-0.01		1.63	0.052
Lepidoptera ^f	2	35	0.06	0	25	0.00	0.06	-0.01		1.41	0.079
Megaloptera ^f	3	35	0.09	5	25	0.20	-0.11	-0.28		-1.12	0.868
Odonata	50	35	1.43	27	25	1.08	0.35	-0.13		1.2	0.115
Plecoptera ^f	5	35	0.14	0	25	0.00	0.14	0.03		2.24	0.013
Trichoptera	27	35	0.77	18	25	0.72	0.05	-0.32		0.23	0.410

^a If no specimens were identified to Family within an Order, the specimens were lumped and counted as one Family.

^b Considered used if at least one Rusty Blackbird was detected at least once during three surveys

^c Considered unoccupied if no Rusty Blackbirds were detected during three surveys.

^d Rate for RUBL detected – RUBL undetected sites.

^e Significant p-values ($\alpha = 0.05$) are bolded.

^f The normal approximation may be inaccurate for small total number of occurrences.

Table 15: Maximum insect specimen abundance per survey per Order from three aquatic macroinvertebrate surveys per wetland used^a by Rusty Blackbirds in northern New England, 2014.

Site	Coleoptera	Diptera	Ephemeroptera	Hemiptera	Lepidoptera	Megaloptera	Odonata	Plecoptera	Trichoptera
1	0	140	1	0	0	0	2	0	0
2	0	11	1	0	0	0	1	0	1
3	0	17	1	0	0	1	0	0	0
7	0	16	1	0	0	0	0	0	2
8	3	7	0	0	0	0	3	0	1
10	1	48	1	0	0	0	1	0	0
11	0	13	0	0	0	0	2	0	1
12	1	115	1	0	0	0	0	0	5
13	1	6	2	0	1	0	10	0	3
14	5	4	1	3	0	0	17	0	2
15	1	14	0	0	0	0	8	0	0
16	1	20	0	1	0	0	13	0	0
17	0	21	3	0	0	0	11	0	12
18	2	13	0	0	0	1	1	0	5
19	1	8	1	0	0	0	1	0	3
21	0	12	0	0	0	0	1	0	0
23	1	95	0	1	1	0	5	1	1
24	0	14	2	0	0	0	0	2	0
27	1	7	2	0	0	0	9	0	0
28 ^b	0	7	1	0	0	0	1	0	1
30	0	24	2	0	0	0	0	1	2
31	1	12	0	0	0	0	1	0	0
38	0	59	5	0	0	0	0	0	16
39	4	1	3	0	0	0	3	1	1
40	1	6	2	0	0	0	2	0	1

Site	Coleoptera	Diptera	Ephemeroptera	Hemiptera	Lepidoptera	Megaloptera	Odonata	Plecoptera	Trichoptera
41	5	19	20	0	0	0	0	0	2
43	0	6	3	0	0	3	1	0	0
44	0	0	1	0	0	0	0	0	1
45	3	2	0	3	0	0	4	0	1
48	1	6	6	0	0	0	1	0	7
49	3	32	0	0	0	0	5	0	1
50	2	3	1	0	0	0	1	0	0
56 ^b	1	5	12	0	0	0	2	0	2
58	8	9	0	0	0	0	3	0	1
60	2	17	1	0	0	0	1	2	2

^a Considered used if at least one Rusty Blackbird was detected at least once during three surveys

^b Specimens were pooled from two, rather than three, samples.

Table 16: Maximum insect specimen abundance per survey per Order from three aquatic macroinvertebrate surveys per wetland without positive Rusty Blackbird detections in northern New England, 2014.

Site	Coleoptera	Diptera	Ephemeroptera	Hemiptera	Lepidoptera	Megaloptera	Odonata	Plecoptera	Trichoptera
4	1	3	2	0	0	0	2	0	0
5	0	2	2	0	0	1	1	0	1
6	1	76	9	0	0	2	0	0	1
9 ^a	0	1	0	0	0	0	3	0	0
20	0	8	0	0	0	0	0	0	0
22 ^a	0	12	1	0	0	0	1	0	0
25	1	3	1	0	0	0	0	0	1
26 ^a	0	23	0	0	0	0	0	0	0
29	0	6	0	0	0	0	6	0	0
32	1	13	0	0	0	0	1	0	0
33	0	4	5	0	0	0	0	0	1
34	1	8	3	1	0	0	0	0	3
35	0	7	0	0	0	0	0	0	1
36	4	19	0	0	0	1	0	0	0
37	0	4	2	0	0	6	0	0	2
42	0	16	13	0	0	4	3	0	2
46	0	9	2	0	0	0	2	0	4
47	0	1	3	0	0	0	1	0	10
51	0	14	0	0	0	0	2	0	2
52	0	3	0	0	0	0	1	0	0
53	4	15	107	0	0	0	1	0	7
54	0	3	3	0	0	0	1	0	2
55 ^a	0	15	3	0	0	0	1	0	0
57	0	6	1	0	0	0	4	0	0
59	3	13	8	0	0	0	8	0	0

^a Specimens were pooled from two, rather than three, samples.

Table 17: Summary statistics and results of a 2-sample Poisson rate test for difference between the maximum invertebrate specimen abundance per survey per Order from three aquatic macroinvertebrate surveys per site for sites used^a by Rusty Blackbirds (RUBL) versus undetected^b sites in northern New England, 2014.

Order	RUBL detected			RUBL undetected			Poisson Rate Test			
	Max count	N	Rate	Max count	N	Rate	Estimate for difference ^c	95% Lower Bound	Z	p-value ^d
Amphipoda	112	35	3.2000	28	25	1.1200	2.0800	1.4729	5.64	0.0000
Aranae ^e	4	35	0.1143	3	25	0.1200	-0.0057	-0.1534	-0.06	0.5250
Coleoptera	49	35	1.4000	16	25	0.6400	0.7600	0.3387	2.97	0.0020
Collembola ^e	143	35	4.0857	0	25	0.0000	4.0857	3.5237	11.96	0.0000
Diptera	789	35	22.5429	284	25	11.3600	11.1829	9.4589	10.67	0.0000
Ephemeroptera	74	35	2.1143	165	25	6.6000	-4.4857	-5.4226	-7.88	1.0000
Hemiptera ^e	8	35	0.2286	1	25	0.0400	0.1886	0.0403	2.09	0.0180
Hirudinea ^{e, f}	1	35	0.0286	6	25	0.2400	-0.2114	-0.3793	-2.07	0.9810
Lepidoptera ^e	2	35	0.0571	0	25	0.0000	0.0571	-0.0093	1.41	0.0790
Megaloptera ^e	5	35	0.1429	14	25	0.5600	-0.4171	-0.6848	-2.56	0.9950
Oligochaeta ^{e, f}	5	35	0.1429	0	25	0.0000	0.1429	0.0378	2.24	0.0130
Odonata	110	35	3.1429	38	25	1.5200	1.6229	0.9845	4.18	0.0000
Plecoptera ^e	7	35	0.2000	0	25	0.0000	0.2000	0.0757	2.65	0.0040
Trichoptera	74	35	2.1143	37	25	1.4800	0.6343	0.0654	1.83	0.0330
Veneroida ^e	8	35	0.2286	29	25	1.1600	-0.9314	-1.3099	-4.05	1.0000

^a Considered used if at least one Rusty Blackbird was detected at least once during three surveys

^b Considered undetected if no Rusty Blackbirds were detected during any of the three surveys.

^c Rate for RUBL detected – RUBL undetected sites.

^d Significant p-values ($\alpha = 0.05$) are bolded.

^e The normal approximation may be inaccurate for small total number of occurrences.

^f Subclass, rather than Order.

Table 18: Spearman rank coefficients (r_s) for maximum abundance of aquatic macroinvertebrate specimens per Order and continuous site covariates with significant ($p < 0.05$) correlations in bold. Invertebrates were surveyed in northern New England, 2014.

Order	Elevation	Size	Percent			
			Open water	Mud	Water depth	Percent softwood
Coleoptera	0.047	0.302	0.127	-0.101	-0.138	0.022
Collembola	0.091	-0.123	0.066	-0.09	0.094	-0.126
Diptera	-0.045	0.16	-0.279	-0.075	-0.178	0.137
Ephemeroptera	0.049	-0.271	-0.054	0.063	0.061	-0.061
Hemiptera	0.191	0.115	-0.129	-0.22	0.073	0.026
Lepidoptera	0.204	0.075	-0.145	-0.083	0.038	0.011
Megaloptera	-0.061	-0.316	-0.005	0.196	-0.186	-0.127
Odonata	-0.14	0.231	0.046	-0.068	-0.107	-0.014
Plecoptera	0.158	0.017	-0.142	-0.031	-0.182	-0.153
Trichoptera	0.21	-0.218	0.081	-0.258	0.126	0.009
Amphipoda	0.171	0.196	0.25	-0.083	0.213	0.128
Aranae	-0.149	-0.069	-0.006	-0.07	-0.200	0.076
Hirundea	0.02	0.12	-0.18	0.016	0.144	0.126
Oligochaeta	0.162	-0.199	0.026	0.026	0.075	-0.218
Veneroida	0.332	-0.166	-0.113	-0.101	0.074	-0.098

Figures



Figure 1: Cartographic model showing steps used to digitize survey wetlands, calculate wetland size, and calculate land cover within a 500 meter buffer.

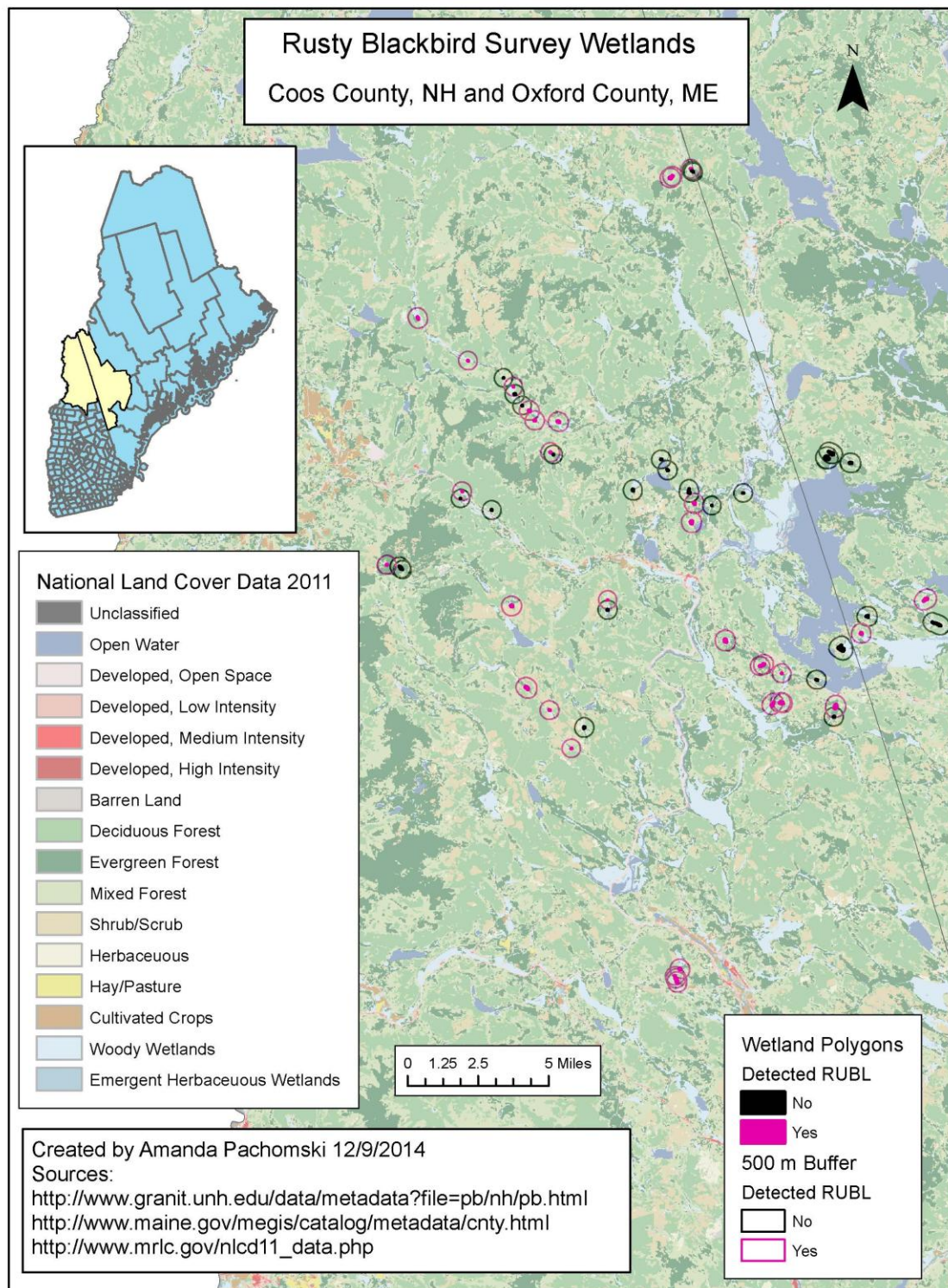


Figure 2: Habitat land cover classes of the study area and digitized polygons of wetlands surveyed for Rusty Blackbirds in northern New England in 2014.

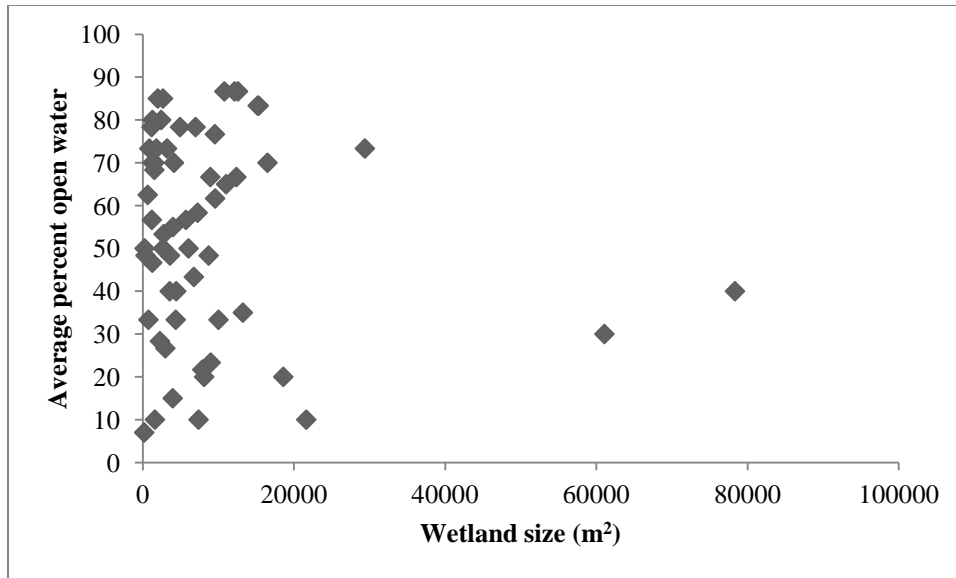


Figure 3: Wetland size and mean percent open water of northern New England wetlands surveyed in 2014. Percent open water was visually estimated by the observer in the field; open water included large pools of standing water and did not include puddles or shallow, disconnected tracts of shallow water with emergent vegetation.

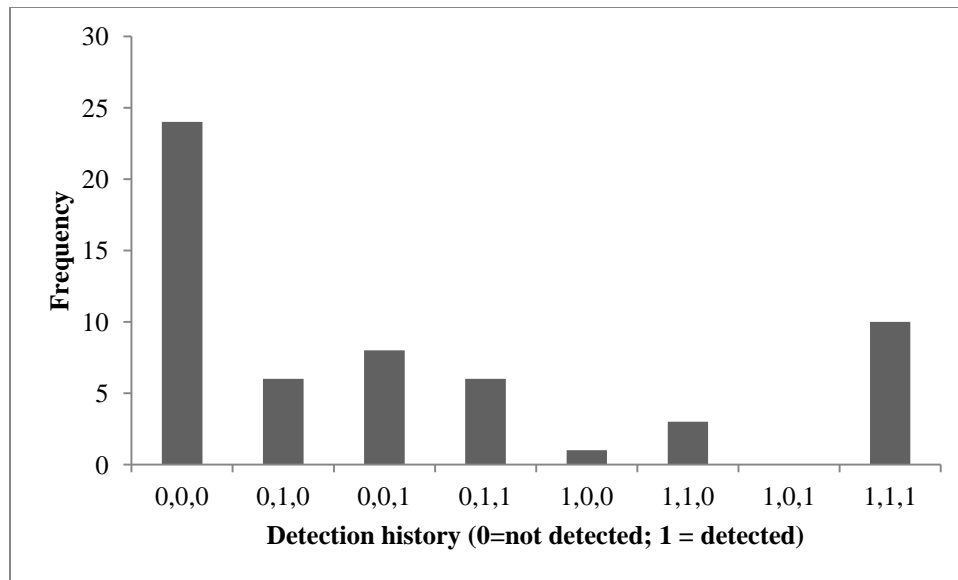


Figure 4: Histogram of detection histories for three 30 minute occupancy surveys for Rusty Blackbirds at 58 sites in northern New England in 2014. Two sites were excluded because they were only surveyed twice.

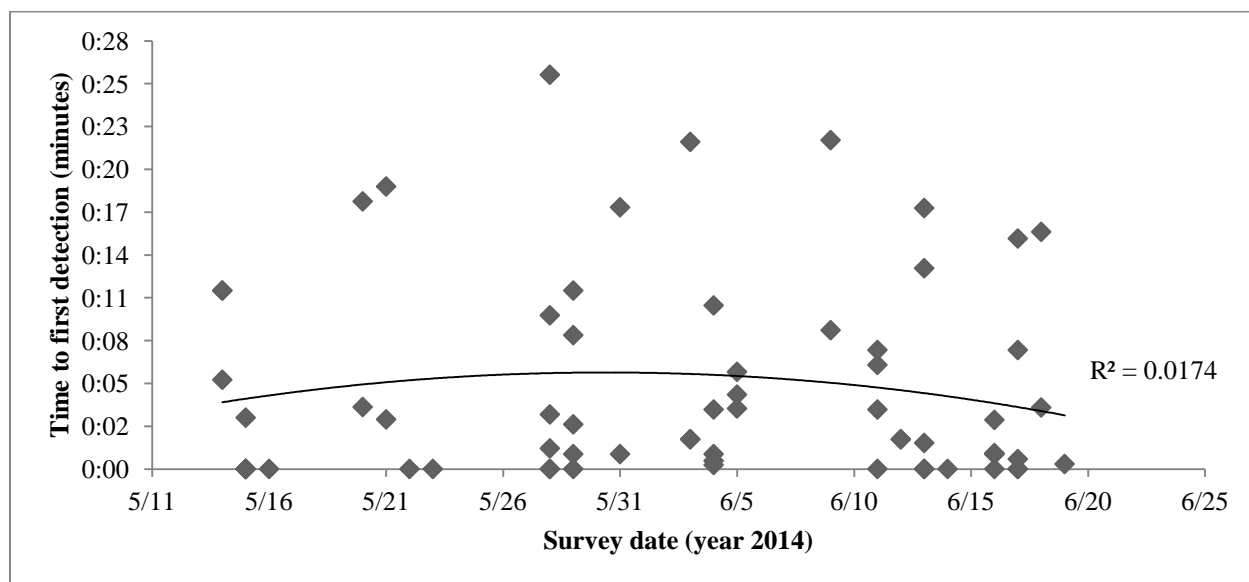


Figure 5: Time to first detection of Rusty Blackbirds by survey date in northern New England in 2014 for surveys during which one or more individuals were detected.

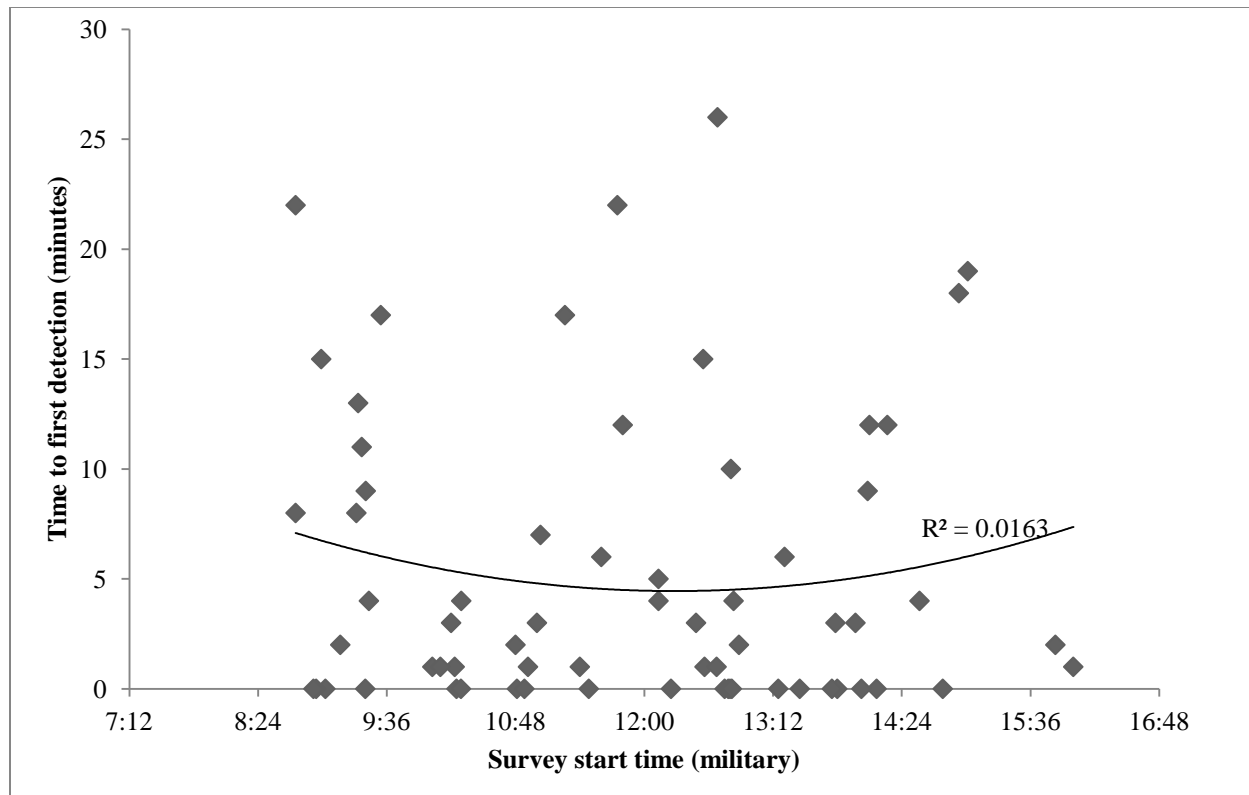


Figure 6: Time to first detection of Rusty Blackbirds by survey start time in northern New England in 2014 for surveys during which one or more individuals were detected.



Figure 7: Photo of a male Rusty Blackbird using an emergent log as a perch for foraging in deep water (>1 m). Photographed by Devon Cote in Coos County, New Hampshire in 2013.

Appendices

Appendix A: Coordinates of wetlands surveyed for Rusty Blackbirds in northern New England in 2014.

	Site Name	Latitude	Longitude
site 1	B Pond New	44.738165	-70.976165
site 2	Bear's Crown	44.706467	-71.096964
site 3	Bear's Eye	44.70592	-71.095148
site 4	Between Greenough	44.836684	-71.132315
site 5	Big Greenough	44.830693	-71.160047
site 6	Bill's Cabin	44.85917	-71.20968
site 7	Black Bluff	44.944447	-71.278738
site 8	Blake Island	44.730009	-71.039897
site 9	Boat Ramp Lower	44.69185	-71.06168
site 10	Boat Ramp Upper	44.697172	-71.058688
site 11	Bungy Pond	44.826468	-71.346919
site 12	Central Beaver Pond	44.816698	-71.119284
site 13	Closton Hill	44.58734	-71.217065
site 14	Closton Spur Lower	44.584532	-71.221341
site 15	Closton Spur Middle	44.58337	-71.22091
site 16	Closton Spur Upper	44.581779	-71.221145
site 17	Conner	44.720488	-71.090672
site 18	Corser Brook	44.860963	-71.211319
site 19	Danfino	44.894325	-71.225274
site 20	Deer Mountain	44.719429	-71.238508
site 21	Dixi	44.8786	-71.215375
site 22	Dixi Clear Cut	44.88761	-71.22227
site 23	Dixi North	44.884559	-71.217703
site 24	Dixville East	44.85303	-71.2802
site 25	Dixville Notch	44.849798	-71.282371
site 26	Dixville Spur Major	44.839803	-71.262846
site 27	Eroll Hill Flats	44.743553	-71.123999
site 28	Four Mile Culvert	44.874286	-71.199221
site 29	Hayward Marsh	44.723223	-70.970663
site 30	Hilltop East	44.726939	-71.104587
site 31	Hilltop West	44.726939	-71.104587
site 32	Interior Beaver Pond	44.822806	-71.121013
site 33	Kelsey Lower	44.821994	-71.336403
site 34	Kelsey Upper	44.822642	-71.33701
site 35	Little Greenough	44.842677	-71.134854
site 36	Long Pond	44.81288	-71.10769
site 37	Magalloway Bend	44.815172	-71.083466
site 38	Mile 10.8	44.89799	-71.2246

	Site Name	Latitude	Longitude
site 39	Mile 13	44.917118	-71.251367
site 40	Mud Hole Hill Lower	44.981701	-71.07296
site 41	Mud Hole Hill Upper	44.980695	-71.07449
site 42	Nathan Pond	44.903851	-71.229785
site 43	Newell Brook Fork	44.732974	-71.259815
site 44	Newell Junction	44.711019	-71.251246
site 45	North Millsfield	44.789299	-71.266382
site 46	Parmachenee Lower	44.980652	-71.058027
site 47	Parmachenee Middle	44.981554	-71.05871
site 48	Parmachenee Upper	44.982591	-71.059487
site 49	Round Pond Annex	44.806545	-71.125015
site 50	Sandflat Bridge Lower	44.705679	-71.103501
site 51	Sargent Cove	44.712441	-71.06716
site 52	Sturtevant East	44.815655	-71.003154
site 53	Sturtevant North New	44.822453	-71.014873
site 54	Sturtevant North Old	44.820172	-71.01738
site 55	Sweat Outlet 1	44.775047	-71.199718
site 56	Sweat Outlet 5	44.780036	-71.198316
site 57	Tidswell Bend	44.725642	-71.046481
site 58	Tidswell East	44.729168	-71.026803
site 59	Tyler Brook	44.737477	-71.019803
site 60	Windmill Crotch	44.747417	-71.272194

Appendix B: Methods and findings of a pilot study of Rusty Blackbirds in northern New England in 2013.

In 2013, as a pilot study, I collected aquatic invertebrate samples from 23 wetlands used by Rusty Blackbirds in a 1,253.5 km² area within Coos County, NH (A.1). Sites were located both within Umbagog National Wildlife Refuge and land privately managed by Wagner Forest Management Ltd. We conducted passive surveys for Rusty Blackbirds at 22 beaver-influenced wetlands. Our primary study objectives were: 1) to study the relationship of forestry practices to foraging site selection using multi-scale habitat characteristics; and 2) to investigate the relationship between aquatic invertebrate composition and abundance to foraging site selection. Because I wasn't able to get timber harvest history for all of my sites, I wasn't able to focus my research on the relationship between Rusty Blackbird occupancy and forestry practices. So, I instead used the summer of 2013 to test out occupancy survey methods and to do the first surveys (to my knowledge) of aquatic invertebrates at my selected boreal wetlands.

During the first two weeks of May, I worked with Carol Foss of the Audubon Society of New Hampshire and the rest of her team to scout for Rusty Blackbirds that had recently migrated back to their breeding grounds. From April 29 to May 13, I scouted previously used and potential new sites for Rusty Blackbirds. On May 10 the first Rusty Blackbird nest of the season was located. Upon finding a site with Rusty Blackbirds, Carol's team worked to find the nest and monitor its productivity. Meanwhile, I continued to survey my wetland sites, recording Rusty Blackbird detection or non-detection, behavior, and habitat characteristics. I surveyed each site four times, during each two-week period: incubation, nestling, fledgling and post-fledgling. During each visit I sat near the edge of open water to record Rusty Blackbird detection and behavior for one hour. These were completed from May 14 to June 30.

I conducted bi-weekly, 60 minute Rusty Blackbird surveys at each site to document presence/ absence and time spent foraging. To capture potential changes in foraging activity throughout different stages of the breeding season, each site was sampled four times: once during the incubation period, once during the nestling period, and twice after the chicks fledged. Following the recommendation of Luke Powell, I began each survey with an eight minute long time frame during which I recorded all Rusty Blackbird, Common Grackle, and Red-winged Blackbird vocalizations and sightings.

Also, following each hour-long activity survey I recorded data on pond water depth, changes in water level, air temperature, and weather. In addition, to quantify the availability and richness of Rusty Blackbird prey throughout the breeding season, I collected aquatic invertebrate samples following each Rusty Blackbird survey. We collected each aquatic macroinvertebrate sample from the edge of open water at the southernmost end of the wetland using ten sweeps of a D-frame dip net. These samples were stored in 70% ethanol and then later identified to Family.

Rusty Blackbirds in New Hampshire are vocal throughout the day. My data suggest that detectability is not dependent on time of day. Such information will aid researchers in designing future Rusty Blackbird studies. Also, I observed very low detection rates following the two weeks after chicks fledged, or after June 16. Based on previous radio-telemetry data, this decrease was likely observed because Rusty Blackbird families often leave the immediate vicinity of their nest sites after chicks fledge (Carol Foss, pers. comm. 2013).

From July 8 to July 30 I collected data on the vegetation communities surrounding the studied beaver ponds. To capture differences in vegetation composition within the lowland-upland interface I surveyed vegetation along two 50 m transects, heading from the pond's edge to the upland forest (A.2.). Within each transect I identified and estimated percent cover for plant

species within 1 m x 1 m squared plots, placed along the 1 m, 5 m, 10 m, 25 m, and 50 m transect points. Also, when possible, I surveyed 1 m x 1 m plots along an aquatic vegetation transect at 1 m and 5 m into the open water of the ponds. Within each plot I identified vegetation species and estimated percent cover for plants within 1 m² plots. I measured the DBH of all trees greater than 2 cm DBH. Because these surveys were very time consuming and because new research found that Rusty Blackbirds selected habitat on the larger landscape scale (Buckley 2013), I decided not to survey vegetation during my 2014 field season.

During my surveys, I detected Rusty Blackbirds at 21 out of 23 sites. On average, I detected Rusty Blackbirds after 6.812 minutes of surveying, with a maximum time to first detection of 25.25 minutes. Because of my very small sample size of the number of sites without detected Rusty Blackbirds, I was unable to use my 2013 data to model wetland use using occupancy analysis. However, this pilot study allowed me to learn to navigate my study area and better design my research for 2014. I found that Rusty Blackbird detection largely decreased during my last survey period, which was over two weeks after the first nest fledged chicks. Many Rusty Blackbird families left the nesting area after their chicks fledged. Because of this, I decided to drop this fourth survey period for 2014.

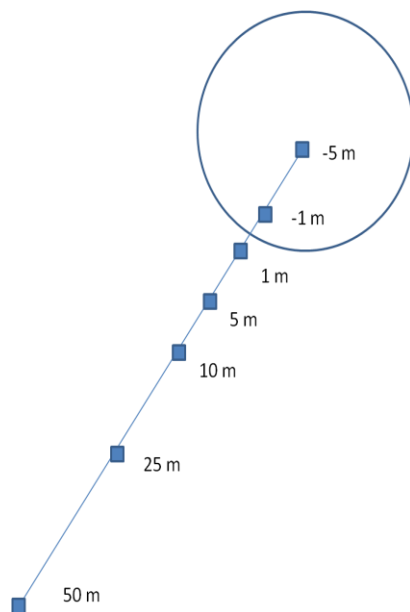
During my surveys I unexpectedly came across one emaciated, recently deceased, previously banded Rusty Blackbird. Staff from the Audubon Society of New Hampshire delivered the specimen to the University of New Hampshire, where a necropsy revealed that the specimen likely died of a *Yersinia pseudotuberculosis* bacterial infection

B.1. Sites surveyed for Rusty Blackbirds in northern New England in 2013.

Site Name	Latitude	Longitude
Bungy Pond	44.82647	-71.346919
Central Beaver Pond	44.8167	-71.119284
Closton Bend	44.5866	-71.210322
Closton Hill	44.58734	-71.217065
Closton Spur Lower	44.58453	-71.221341
Corser Brook	44.86096	-71.211319
Dixi	44.8786	-71.215375
Erroll Hill Flats	44.74355	-71.123999
Hilltop East	44.72694	-71.104587
Hilltop West	44.72696	-71.102100
Horne Brook East	44.9926	-71.115382
Horne Brook West	44.99333	-71.117895
Interior Beaver Pond	44.82281	-71.121013
Kelsey Lower	44.82199	-71.336403
Little Dead Diamond	44.97232	-71.150513
Lost Valley 1	44.959371	44.959371
Lost Valley 2	44.958696	-71.157776
Magalloway Bend	44.81517	-71.083466
Mile 13	44.91712	-71.251367
Mollidgewock Original	44.72247	-71.113478
Mud Hole Hill Lower	44.9817	-71.07296

Nathan Pond	44.90385	-71.229785
Parmachenee Middle	44.98155	-71.05871

B.2. Diagram of vegetation transect near and within a wetland (circle) surveyed in northern New England, 2013 (not to scale).

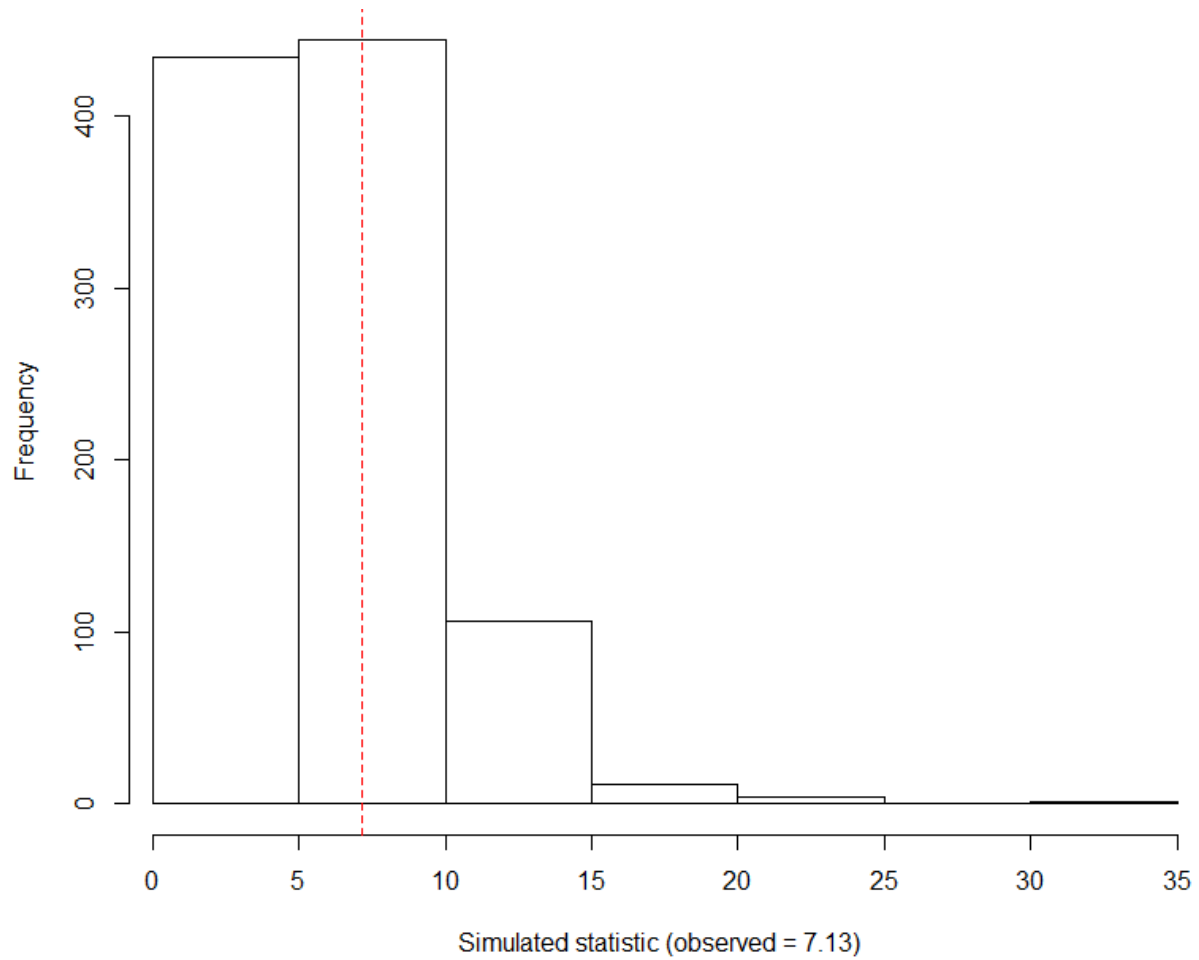


B.3. Timeline of Rusty Blackbird nesting activity in northern New Hampshire, 2013.

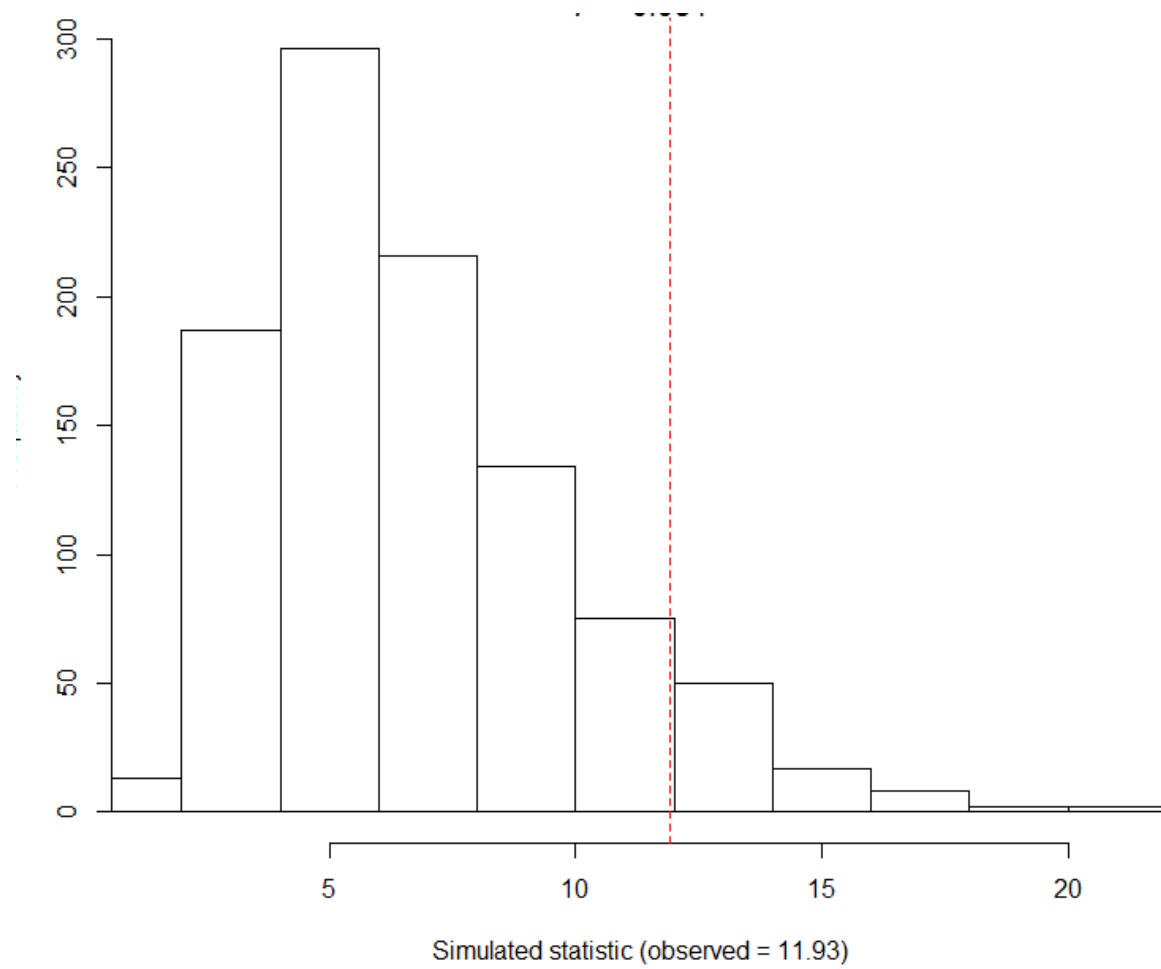
Time Period	Dates
Incubation	May 11- May 24
Nestling	May 25- June 7
Fledgling 1	June 8- June 21
Fledgling 2	June 22- July 4

Appendix C: Mackenzie- Bailey Goodness of Fit Tests

C.1. Histogram of bootstrapped chi-square statistics produced by the Mackenzie-Bailey goodness of fit test with 1,000 bootstrapped samples for the global detectability model ($p = 0.326$).



C.2. Histogram of bootstrapped chi-square statistics produced by the Mackenzie-Bailey goodness of fit test with 1,000 bootstrapped samples for the global occupancy model ($p = 0.081$).

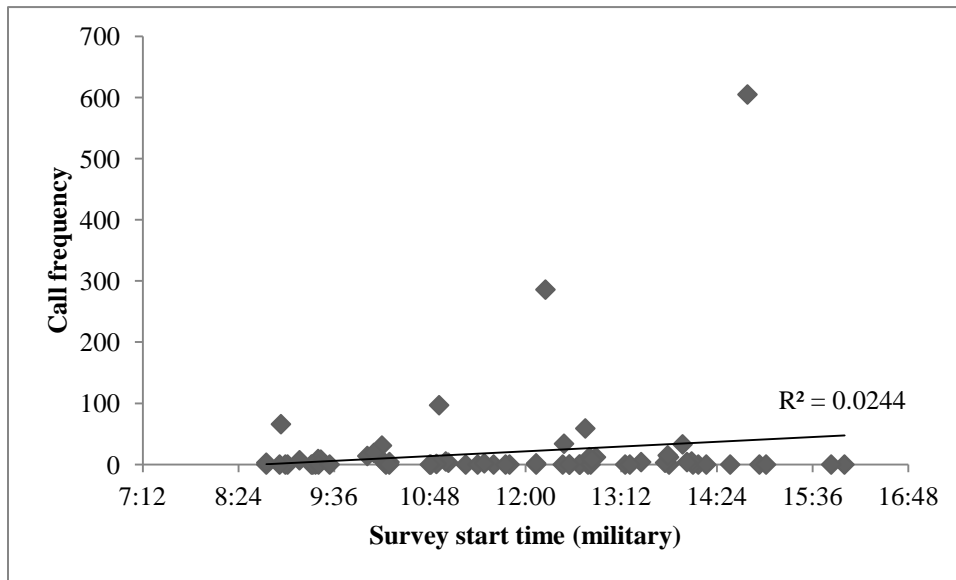


Previous research suggested that Rusty Blackbird detectability varied with time of day (Powell et al. 2008). Standard avian point count protocol recommends surveying songbirds early in the morning, when songbirds are usually most vocal (Ralph et al. 1995). However, based on anecdotal observations, I found that territorial Rusty Blackbirds vocalize throughout the day. Understanding a songbird's vocalization behavior has important implication for study design, as it affects surveyors' ability to detect songbirds. To quantify changes in vocalization frequency throughout the day, I recorded the number of chucks and "ker-glees", or songs, that I heard during the first nine minutes of each 30 minute survey.

D.1. Survey start time and Rusty Blackbird song frequency, recorded as the number of “kerglees” heard within the first 9 minutes of 30 minute surveys during which I detected Rusty Blackbirds in northern New England in 2014.



D.2. Survey start time and Rusty Blackbird call frequency, recorded as the number of “chucks” heard within the first 9 minutes of 30 minute surveys during which I detected Rusty Blackbirds in northern New England in 2014.



Appendix E: An experimental approach to quantify the observer's ability to acoustically detect Rusty Blackbirds over increasing distances.

Estimating Rusty Blackbird song loudness:

I previously used the SPLnFFT sound pressure meter app (iTunes) to record sound pressure in the field at varying distances from live Rusty Blackbirds. I observed 50 dBA from 22 meters away with little background noise but was unable to accurately attribute the pressure to the Rusty Blackbirds because of moderate winds. So, I then took multiple recordings of singing Rusty Blackbirds using the ZOOM recorder and analyzed recordings in Raven Lite 1.0 (available at <http://www.birds.cornell.edu/brp/raven/ravenversions.html>). At 12 meters away, Rusty Blackbird songs had a max sound pressure level of 125 dB.

Field simulation of acoustic detections:

I played a CD of Rusty Blackbird calls and chucks at a distance of 1 meter away from two ZOOM H2N Handy Recorders. I adjusted the volume and recorded the calls and chucks onto the ZOOM recorder as 96-KHz, 34-bit uncompressed WAV files and analyzed max sound pressure level (in dB) via Raven Lite 1.0 software until the new recordings mimicked appropriate sound pressure levels (max 103 dB).

I used the ZOOM recorders on mid-side stereo mode at max volume to play Rusty Blackbird song and chuck recordings at 20, 40, 60, 80, and 100 meters away from two observers at both upwind and downwind from the observers. Recorders were held at approximately breast height with the sound directed towards the observers. Observers recorded time of Rusty Blackbird detection, number of songs heard, and whether or not they could hear chucks. I conducted the first trial in a field near a road but avoided playback while cars could be heard passing by.

During the field simulation, observers could detect chucks from a farther distance but had difficulty hearing songs. In actual field surveys, Rusty Blackbird songs seem to carry over greater distances than chucks. Speaker height might be an issue as well as speaker quality and recorder sound quality.

Curriculum Vitae
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Education

College of Environmental Science and Forestry, State University of New York
Master of Science, Fish and Wildlife Biology and Management, expected May 2017
GPA: 4.00/4.00

Binghamton University, State University of New York
Bachelor of Science, Environmental Studies- Ecosystems, with Honors, Cum Laude, May 2012
GPA: 3.65/4.00

Current Position

Audubon New York, Oyster Bay, NY
Long Island Bird Conservation Manager, June 2015- present

Experience

SUNY College of Environmental Science and Forestry, Syracuse, NY
Graduate Teaching Assistant, August 2013- May 2015

SUNY Research Foundation, Errol, NH
Rusty Blackbird Research Analyst, May 2013- August 2013

Cornell Cooperative Extension of Suffolk County, Riverhead, NY
Viticulture Program Assistant, September 2012- December 2012

Highstead Foundation, Redding, CT
Ecology Research Intern, June 2012- August 2012

La Hesperia Organic Farm and Cloud Forest Reserve, Ecuador
Intern, April 2011-May 2011

National Park Service, Fire Island National Seashore, NY
GS 3 Interpretation Ranger, June 2010- August 2010; May 2011- August 2011

SUNY Binghamton, Binghamton, NY
Undergraduate Teaching Assistant, August- December 2010

The Student Conservation Association, Fire Island National Seashore, NY
Junior Ranger Ambassador Intern, June 2009- August 2009

Unpublished Reports, Theses, and Presentations

“Foraging habitat characteristics, prey diversity, and detectability of breeding Rusty Blackbirds: implications for land and wildlife management in the Northern Forest” (talk). Pachomski, A.P. and McNulty, S.A. The Wildlife Society Conference. Winnipeg, Manitoba, Canada 2015

“Applied field techniques for collecting black-legged ticks (*Ixodes scapularis*) for disease ecology research” (poster). Pachomski, A.P., Darcy, J.M. II, Garruto, R.M. Binghamton Biomedical Research Conference. Binghamton, NY 2012

“Climate change and *Borrelia burgdorferi* presence in the NYS Southern Tier: a call for Lyme disease prevention policy.” Undergraduate thesis. Binghamton, NY 2012