A Management Technique for Monitoring the Creation of Habitat for Shrubland Birds: The Use of a Modified Robel Pole for Reliable Vegetation Assessment

THE UNIVERSITY OF RHODE ISLAND COLLEGE OF THE ENVIRONMENT AND LIFE SCIENCES

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1. ABSTRACT

Shrub birds, as well as the shrub habitat they breed in, are declining throughout New England. To manage these habitats it is important to use effective vegetation monitoring techniques. In 2005/2006 as part of a state management plan, the Rhode Island Department of Environmental Management implemented forest management activities in 17 sites to improve shrub habitat in Big River Management Area, Rhode Island. Bird count surveys were conducted before the sites were managed. In the current study, we conducted bird counts in 2013 to determine if shrub birds increased in the area. We also conducted vegetation surveys using a modified Robel pole in the 17 managed sites and assessed landscape characteristics using GIS. Pairwise tests indicate shrub bird abundance in 2013 was significantly higher than shrub bird abundance in 2005. Abundance of two birds species was significantly related to vegetation attributes, and abundance of five bird species was significantly related to landscape level characteristics. Individual species results are comparable to vegetation preferences from past studies. We conclude a modified Robel pole is a viable technique for measuring shrub vegetation when creating habitat for shrub birds.

2. INTRODUCTION

"Shrub" is a habitat type that includes the early successional stage of forests, where the understory vegetation dominates due to a lacking of a forest canopy. The understory can consist of young trees, woody shrubs and grasses and forbs (DeGraaf and Yamanski, 2003; NRCS, 2007; Hunter et al. 2001). Shrub habitat can include forest clear cuts, abandoned farmlands or fields, restored mine fields or utility right of ways (Askins, 2001; Bulluck and Buehler, 2006; King et al., 2009). This habitat is adaptable and can be found under many conditions from dry, upland areas where the dominant species are cottonwoods (*Populus* spp.), oaks (*Quercus* spp.) and willows (*Salix* spp.) to wetlands where species such as arrowoods (*Viburnum*, spp.), dogwoods (*Cornus* spp.) and swamp rose (*Rosa palustris)* are found (NRCS, 2007). Shrub habitat provides nesting and foraging vegetation for breeding birds and New England cottontail (*Sylvilagus transitionalis*), hunting areas for predators such as barn owls and hawks, as well as buffers wetlands and riparian areas from the harmful pesticide runoff of agricultural farms. In New England there are 41 bird species that use shrub habitat to breed, most using clearcuts throughout the successional changes up to 20 years post cut when an opening will become a forest again (Schlossberg and King, 2007).

Prior to European colonization in the United States, shrub habitat was a common landscape and provided prime habitat to native wildlife (NRCS, 2007). Now, however, shrub habitat is decreasing at an alarming rate in New England and will continue to shrink without active forest management (Buffum et al., 2011).

Before European settlers arrived in New England, landscape management was minimal. Hurricanes thinned forests, beavers created openings near wetlands and forest fires burned old growth and left acres of open land for new growth to begin again. The only anthropogenic disturbance was Native Americans burning areas that had not seen a wildfire for years (Lorimer, 2001; Lorimer and White, 2003). In the middle 1700s, colonists began clearing forests to agriculture. By the middle of the 19th century well over two-thirds of New England had been cleared by settlers (Litvaitis, 2003). Anthropogenic efforts continually cleared forests, making most of New England open fields and probably provided a continuously rotating successional habitat (Litvaitis, 1993). However, soils in New England are not viable for agriculture and farmers began to desert their Eastern homes for more fertile soil out West, abandoning their open fields. These fields have continued to grow, unmanaged, into mature forests for the last 100 years (Litvaitis, 1993).

In New England, much of the forest is privately owned, so the predominant shrub habitat management technique is clearcutting. However, social perceptions of clearcuts are generally negative (Askins, 2001). Prior to European settlement of New England in the 1700s, much of the forest clearing was created by beavers, wildfires, flooding and Native American agricultural practices (DeGraaf and Yamasaki, 2003). Now, however, most clearcutting activities are associated with logging or wildfires. Many environmental organizations aim to halt companies which harvest timber, or spread awareness about the destructions of forest fires, and so these activities are seen as "non-environmental". Furthermore, shrub areas are aesthetically unattractive to many people and the wildlife that lives is shrub habitats tend to be shy and withdrawn, making these habitats unappealing to many landowners (Askins, 2001). Consequently, it is difficult to motivate landowners to create clearcuts on their property and it is important for research to show both the benefit of clearcuts to shrub birds and the ease of managing an effective shrub habitat.

Shrub birds exhibit strong site fidelity, with individuals returning to the same breeding site annually (Schlossberg, 2009). Therefore declines in shrub habitat can have detrimental impacts on wildlife populations specific to that habitat patch. A major concern for conservation biologists is the decline in shrub bird populations; the percentage of shrub birds identified as high priority conservation status is higher than either grassland birds or forest birds (Dettmers, 2003). Based on population trend estimates from the Breeding Bird Survey (BBS) routes conducted in New England, at least 16 shrub species are experiencing significant declines in the region (Sauer et al., 2012) (Table 1).
There is a concern that conservation efforts designed to create shrub openings will be sufficiently large enough to provide high quality for avian species that specialize in shrub habitats (Askins et al., 2007; DeGraaf & Yamansaki, 2003). Shake et al. (2012) used an occupancy analysis to determine that most shrub species have a minimum area requirement of 1 ha of shrub habitat.

There is considerable interspecific variation in habitat preferences among birds that specialize in shrub habitat (Fink et al., 2006). For instance, Schill and Yahner (2009) found that Chestnut-sided Warblers (*Setophaga pensylvanica)* select areas based on shrub density, Field Sparrows (*Spizella pusilla)* prefer areas based on percent ground cover of low vegetation, and the abundance of Indigo Buntings (*Passerina cyanea*) was affected by both shrub density and percent ground cover of shrub vegetation. Even the type of opening (silvicultural vs. wildlife) affects the distribution and abundance of shrub birds as the type of opening contains different types of vegetation growth (King et al., 2009). Wildlife openings with more fern and forb cover are preferred by Gray Catbirds (*Dumetella carolinensis*), Yellow Warblers (*Dendroica petechial*) and Northern Cardinals (*Cardinalis cardinalis*). Silvicultural openings, on the other hand, promote growth of dense shrubs, Prairie Warblers (*Dendroica discolor*) prefer these openings.

Table 1. **Annual population trends of shrub birds in New England from 1966-2011 based on Breeding Bird Surveys (Sauer et a. 2012). Only species with significant (P < 0.05) population declines are shown.**

Species	Adjusted annual rate of change	Number of routes	Unadjusted Annual Rate of change	Lower 95% CI	Upper 95% CI
Northern Bobwhite	-9.5	116	-9.6	-10.3	-8.9
White-throated Sparrow	-8.8	25	-9.1	-10.8	-7.3
Golden-winged Warbler	-6.9	14	-10.8	-18.3	-4.3
American Woodcock	-5.6	47	-6.2	-9.6	-3.1
Field Sparrow	-5.5	131	-5.5	-6.1	-4.9
Eastern Towhee	-5.4	134	-5.4	-5.9	-4.8
Nashville Warbler	-5.2	24	-6.2	-11.1	-2.3
Brown Thrasher	-4.6	131	-4.6	-5.2	-4.0
Prairie Warbler	-4.1	120	-4.1	-5.2	-2.9
Chestnut-sided Warbler	-2.8	56	-2.8	-3.7	-1.8
Yellow-breasted Chat	-2.5	75	-2.5	-3.5	-1.9
Blue-winged Warbler	-2.4	71	-2.4	-3.6	-0.5
Common Yellowthroat	-2.0	134	-2.0	-2.4	-1.7
Song Sparrow	-1.4	133	-1.4	-1.8	-1
White-eyed Vireo	-1.3	100	-1.3	-1.8	-0.7
House Wren	-0.9	132	-0.9	-1.5	-0.2

Shrub vegetation changes throughout the years following a cut (Thompson & DeGraaf, 2001). Initially following a clear-cut, stem densities are very low and continue to increase as more trees and shrubs grow, until about 7-10 years post-cut, at which point some of the shrubs become tall enough to create canopy cover, which kills off other shrubs competing for sunlight; consequently, shrub densities decrease. Throughout the successional changes in vegetation composition, structure and density following a cut, shrub birds show different patterns of inhabiting the area, with different species inhabiting the area at different vegetation heights and growth (Schlossberg & King, 2009). For instance, White-throated Sparrow (*Zonotrichia albicollis*), Indigo Bunting and Song Sparrow (*Melospiza melodia*) all have peak populations within the first five years of growth and then decrease abundance in the site. Whereas, Chestnut-sided Warblers, Mourning Warblers (*Oporornis philadelphia*) and Alder Flycatchers (*Empidonax alnorum*) have low abundance levels after the initial cut then their populations increase until about ten years after the cut where their abundance peaks, then starts to decline. This seems to indicate that bird population patterns follow successional patterns.

Because bird species have unique vegetation requirements, it is important to measure unique vegetation characteristics. Several studies have examined the relationship between vegetation characteristics and shrub species through various shrub vegetation measurement techniques (Table 2).

Table 2. **Vegetation measurements and methods from studies examining shrub vegetation characteristics with shrub bird abundance or frequency.**

Study	Samples per Patch	Vegetation Characteristic	Measurement Technique	Result
Schlossberg et al. (2010)	20 samples per 50m point count circle	Vegetation Height	Unknown	Eastern Towhee positively related to height; Alder flycatcher, Yellow warbler and Field sparrow negatively related to height
		Percent Shrub Cover (low and high height)	Visual Estimate	Field sparrow and Song sparrow negatively associated with high cover, Eastern towhee and Common yellowthroat negatively associated with low cover
King et al. (2008)	20 samples per 50m point count circle	Vegetation Height	Unknown	Silvicultural openings contained taller shrubs, Prairie warbler more dense than lower shrub areas
Schill & Yahner (2009)	Measured 5m radius out from every nest	Percent woody and herbaceous ground cover	Visual Estimate	Positively associated with Field Sparrows (both) and Indigo buntings (woody)
		Shrub density	Stem counts	Positively associated with Chestnut-sided warblers and Indigo buntings
Askins et al. (2007)	One 25m transect from center of 50m point count circle	Density	Counted number of contacts between pole and vegetation along a 25m transect	Positively associated with Blue-winged warbler and Chestnut-sided warbler
		Height	Meter stick	Lower vegetation positively associated with shrub birds as a group
Anderson and Shugart Jr. (1974)	Unknown	Vegetation Density	Dry and weigh	Great variation between many shrub species
Annand and Thompson III (1997)	16 plots per site	Shrub Density	Counting Stems	Prairie Warblers, Indigo Buntings and Field Sparrows associated with dense openings
Conner et al. (1983)	0.5m x 0.5m grids spaced 50m apart in each site	Shrub Density	0.5m x 0.5m gridded board	Prairie Warblers associated with low vegetation density

Schlossberg (2007) determined that shrub bird habitat preferences were based on three factors: (1) vegetation structure, (2) plant species composition, and (3) topographic position. Shrub vegetation can be collected in a variety of ways (Table 2). Visual estimates tend to be not as accurate as when using measurement equipment and line estimates can be time consuming (Godinez-Alvarez et al., 2008). To develop a measurement technique that is both rapid and accurate, I propose a method of using a modified Robel pole (Robel et al., 1970), traditionally used for range management, to measure shrub vegetation structure.

Uresk and Benzon (2007) outline a protocol for using a modified Robel pole (Robel et al, 1970) when collecting vegetation measurements in grassland habitats. They randomly sampled points in their study area and used both a modified Robel pole technique and an herbage clipping technique, in which they dried vegetation samples for 48 hours, to compare the different methods. They found a strongly positive relationship between using a Robel pole and a clipping technique. Therefore, a modified Robel pole can be a viable vegetation measurement technique.

My objective was to use a modified Roble pole to measure vegetation characteristics in the Big River Management Area seven years after forest management activities were conducted to improve shrubland habitat, RI and to compare these characteristics with shrub bird abundance in the area. I compare the results from this study to habitat models of avian shrub specialists developed by Schlossberg and King (2007), who conducted a comprehensive review and meta-analysis of shrub birds in New England. Specifically, I hoped to gather information on the vegetation relationships of five target species from RI DEM's management plan (Big River Biological Diversity Project, 2006, Table 3), Prairie Warbler, Blue-winged Warbler (*Vermivora cyanoptera*), Indigo Bunting, Eastern Towhee (*Pipilo erythrophthalmus*) and Field Sparrow. Schlossberg and King (2007) conducted a meta-analysis and described these habitat preferences of these same species (Table 3). Ideally, results based on Robel pole measurements should result in similar conclusions. I then discuss the merits of the use of a modified Robel pole and the consistency of results with Schlossberg and King's (2007) findings.

Table 3. **Habitat preferences for five target species of RI DEM management plan (2006) as outlined by Schlossberg and King, (2007).**

Species	Habitat
Prairie Warbler	Open shrubby areas
Blue-winged Warbler	Dense herbaceous (low) vegetation
Indigo Bunting	Moderately dense shrub (high) vegetation, dense herbaceous (low) vegetation
Eastern Towhee	Open habitats, dense shrub (high) vegetation
Field Sparrow	Grassy areas, moderate grassy/herbaceous (low) cover

3. STUDY AREA

The Big River Management Area (41° 39' N and 71° 33' W) consists of 3,480 ha of land owned by the state of Rhode Island's Water Resources Board in West Greenwich, R.I. In the 1960's the Water Resource Board acquired the land and condemned the area for the purpose of flooding it to create a drinking reservoir. The U.S. Environmental Protection Agency eventually halted that plan, but the ownership remains under the Water Resources Board, and the BRMA mostly sits as an undeveloped piece of public property mainly used for public activities such as fishing and dirt bike racing (www.wrb.ri.gov).

In 2005, the RI Department of Environmental Management received funding from the USDA-Natural Resources Conservation Services Wildlife Habitat Incentive Program to create silvicultural openings in BRMA. The RI DEM management plan targeted shrub habitat creation for at risk shrub species. In total, 17 sites were managed, resulting in a cumulative total of approximately 45 ha of shrub habitat (Figs. 1-9). Appendix 1 provides the geographic coordinates for the center points of the 17 study sites and two control sites that were not managed. Selective harvesting culls unhealthy old and undesirable trees from sites to create room for growth of more advantageous trees, shrubs and herbaceous cover. New and younger growth creates habitat for shrub species. The Rhode Island Department of Environmental Management sought to promote shrub bird abundance and specifically targeted five 5 at risk species: Prairie warbler, Blue-winged warbler, Indigo bunting, Eastern towhee and Field sparrow (Big River Biological Diversity Project, 2006).

Figure 1. **Location of 17 sites managed for shrub habitat in Big River Management Area, West Greenwich, RI.**

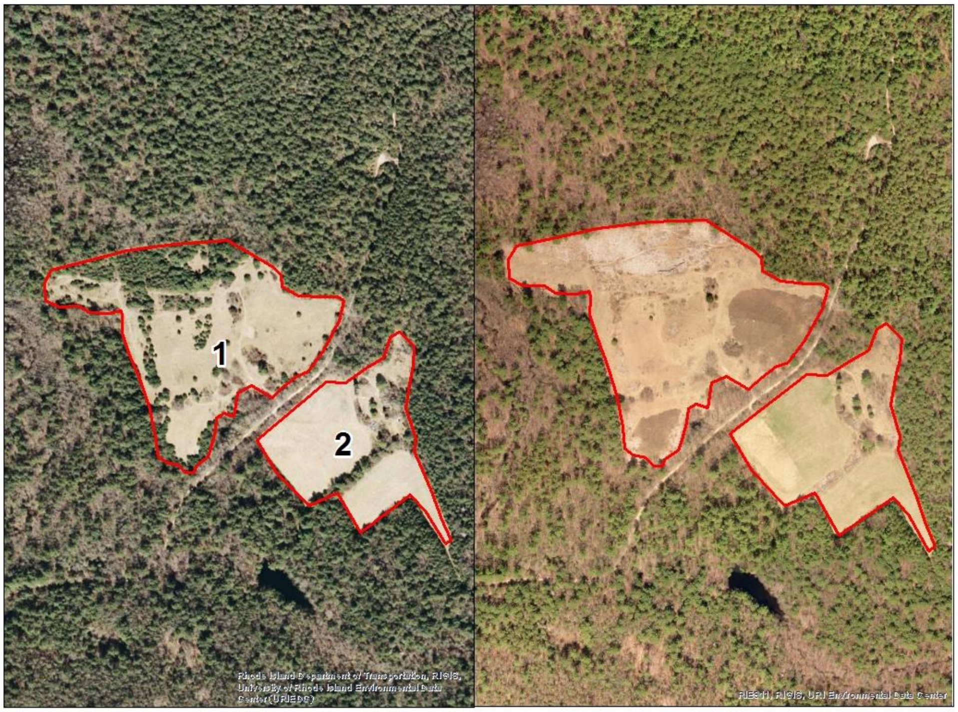

Figure 2. **Aerial photographs of sites 1 and 2 from 2004 (left) and 2008 (right). Sites are close enough together the shrub patches extended into each other's point count circles and are therefore calculated as the same patch area (8.74ha).**

Figure 3. **Aerial photographs of sites 3 (0.73ha) and 4 (1.29ha) from 2004 (left) and 2008 (right).**

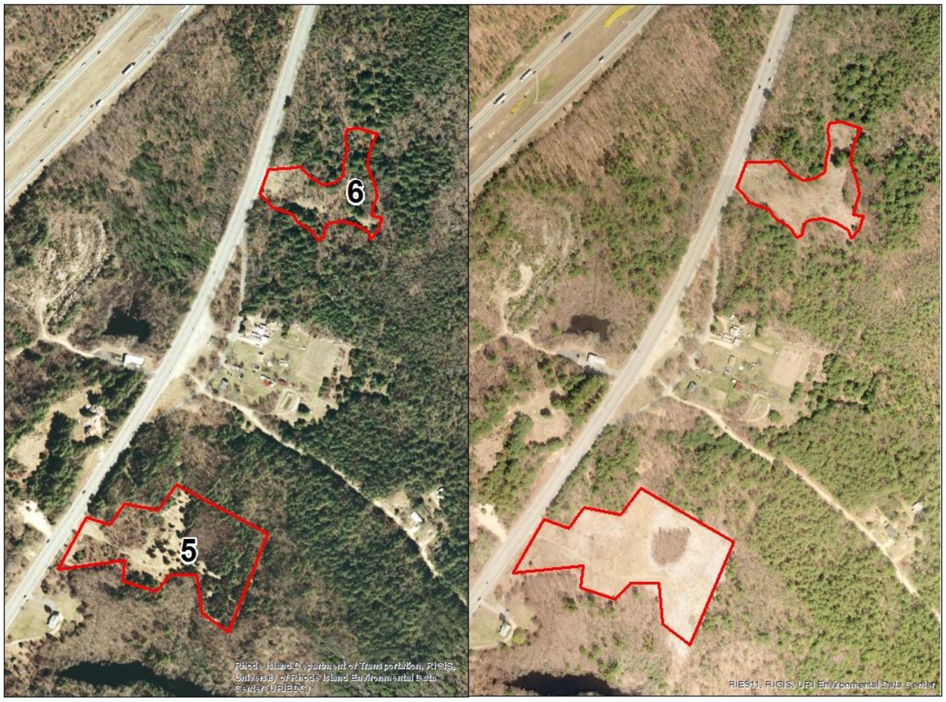

Figure 4. **Aerial photographs of sites 5 (2.55ha) and 6(0.91ha) from 2004 (left) and 2008 (right).**

Figure 5. **Aerial photographs of sites 7 (1.88ha) and 8 (1.22ha) from 2004 (left) and 2008 (right).**

Figure 6. **Aerial photographs of sites 9 (4.71ha) and 10 (10.62ha) from 2004 (top) and 2008 (bottom). Site 10 was large enough to conduct 2 bird point counts and was therefore split into site 10E and 10W.**

Figure 7. **Aerial photographs of sites 11 (1.97ha) and 12(0.87ha) from 2004 (left) and 2008 (right).**

Figure 8. **Aerial photographs of sites 13 (3.58ha) and 14 (2.80ha) from 2004 (left) and 2008 (right).**

Figure 9. **Aerial photographs of sites 17 (1.79ha) and 19 (1.38ha) from 2004 (left) and 2008 (right).**

4. METHODS

Bird Surveys

We surveyed 19 (17 managed and 2 unmanaged) sites in Big River Management Area by conducting fixed-radius point counts (100m) in 2005 before the sites were cut and in 2013. Point count stations were flagged with tape and spaced a minimum of 100m apart to avoid overlap of sites. To minimize observer bias, three investigators went to all 19 sites three times each in both 2005 and 2013. To reduce any temporal bias in detection probabilities, during each time period investigators rotated the order of sites visited so that sites were not surveyed at the same time of day every survey.

Surveys were conducted between 0600-1000 hrs. After arriving at the site investigators waited for three minutes to ensure any birds that may have been disturbed settle. Counts then lasted for ten minutes, during which the observer recorded all birds detected seen or heard within the 100m radius, and also recorded distance (m) from the observer and habitat (shrub, grass, forest) where the bird was detected.

Vegetation Surveys

Vegetation surveys of the 17 managed sites were conducted in July and August 2013. At each site I recorded shrub density using a modified Robel pole (Robel et al., 1970). The pole consisted of a piece of pvc pipe, 2.5cm diameter and 2m tall, with alternating colors of tape every 10cm. Visual obstruction measurements were made from a distance of 4m from the pole with the observer bending over to read the height at 1m off the ground. The percent obstruction of shrub was estimated, using the 10cm sections as guides, to the nearest 5%. For example, if five 10cm sections of the pole were covered and half of one 10cm section was covered, percent obstructed would be 55%. Percent obstruction was estimated for the bottom (0-1m) half of the pole (defined as low obstruction) and the top (1-2m) half of the pole (defined as high obstruction). I also measured the height of vegetation cover, visually estimated to the nearest 5cm using the 10cm sections. For example, if the bottom two sections (20 cm) of the pole were completely obstructed with vegetation and the first half of the third section (5 cm) was obstructed, vegetation cover would be 25cm. At each pole station I took four readings, one in each cardinal direction (E, W, N, S) of low obstruction, high obstruction and ground cover. I then averaged these four measurements to estimate low obstruction, average high obstruction and height ground cover for that pole station. At each pole station I also recorded canopy height to the nearest 0.5 m using the Robel pole and dominant vegetation species. The initial pole station was at the bird point count location at each site, then spaced 20m (by pacing) along estimated transects running in each cardinal direction until the pole stations either ran into forest, water or road. Low obstruction was the average percent low obstruction (0-1m) of the Robel pole at each site. High obstruction was the average percent high obstruction (1-2m) of the Robel pole at each site. Canopy height was the average canopy height recorded at each site. Obstruction height was the average height of vegetation obstruction at each site.

GIS Analysis

Total patch size and percent shrub habitat of each site were computed using aerial photographs from 2008 in ArcGIS 10.1. Percent shrub habitat was found by categorizing all habitat within the 100m point count circle as either shrub, forest or grass. Total hectares of shrub habitat was then divided by 3.14 (ha in a 100m radius circle) to calculate the percent shrub habitat within the 100m radius point count circle. The managed patch was delineated and total ha in each patch was calculated. Sites 1 and 2 and sites 10E and 10W were close enough together that the patches extended into each other's point count circle and were therefore computed to be the same patch area.

Data Analysis

Shrub bird abundance was the sum of all shrub birds detected at the 19 sites categorized as Southern New England shrub birds by Schlossberg and King, 2007 (Table 4). We also detected a Yellow-billed Cuckoo in 2013 that is categorized as Northern New England shrub species that we included in the analysis. In both 2005 and 2013 abundance was summed for the three count periods, except sites 16, 17 and 18 which were only visited twice in 2005, therefore just the first two visits in 2013 were summed.

I estimated change in bird abundance, frequency (percentage of sites where the species was detected) and species richness of non-shrub birds and shrub birds between 2005 (pre-treatment) and 2013 (post-treatment), controlling for 2 sites (16 and 18) that were not cut in 2005. There were a total of 17 managed sites and two control sites.

Table 4. **Thirty species of birds classified as shrub specialists in southern New England by Schlossberg and King (2007)**

Species		
Ruffed Grouse	Northern Mockingbird	Common Yellowthroat
Northern Bobwhite	Brown Thrasher	Canada Warbler
American Woodcock	Cedar Waxwing	Yellow-breasted Chat
Whip-poor-will	Blue-winged Warbler	Eastern Towhee
Ruby-throated Hummingbird	Golden-winged Warbler	Field Sparrow
Willow Flycatcher	Nashville Warbler	Song Sparrow
White-eyed Vireo	Yellow Warbler	Dark-eyed Junco
Carolina Wren	Chestnut-sided Warbler	Northern Cardinal
House Wren	Prairie Warbler	Indigo Bunting
Gray Catbird	Black-and-white Warbler	American Goldfinch

I used IBM SPSS Statistics v. 20 to conduct statistical analysis. I used the non-parametric Wilcoxon paired signed rank test to compare the total change in bird abundance, frequency and species richness. I tested for relationship between the vegetation parameters using a Pearson product-moment coefficient. To assess relationships between vegetation characteristics and avian use of plots in Big River, I transformed the data into a Poisson distribution and ran generalized linear model regressions for each of the vegetation variables (low obstruction, high obstruction, canopy height, obstruction height, percent shrub habitat and patch size) on shrub bird abundance as a group and on each of the detected shrub bird species in 2013.

5. RESULTS

Vegetation Analysis in 2013

The managed sites (those cut in 2006) had an average shrub patch size of 3.79ha (SE = 0.19, range = 0.73 to 10.62) with three sites (3, 6, 12) < 1 ha (Table 5). The average percent early successional habitat within the 100m point count circles was 53% (SE = 1.24; range = 18% to 92%). The average percent low obstruction was 43% (SE = 0.88, range = 25% to 96%).The average percent high obstruction was 13% (SE= 0.77, range= 0% to 45%). Canopy height was an average of 2.5m (SE= 2.54, range= 0.8m to 6m). Obstruction height was an average of 38.1cm (SE=6.4, range=20.1-133.5).

There was a strong positive correlation between canopy height and high obstruction (r=0.462, p=0.046), patch size and percent shrub habitat (r=0.810, p<0.001) and high obstruction and low obstruction (r=0.654, p<0.01). There was a strong negative correlation between percent shrub habitat and canopy height (r=-0.573, p=0.010) and patch size and canopy height (r=-0.565, p=0.012). There was a strong positive correlation between obstruction height and low obstruction (r=0.940, p<0.001) and obstruction height and high obstruction (r=0.592, p=0.008).

I recorded an average of 13 (range =4-20) Robel pole stations per site. Each pole station took approximately two minutes to complete; each site took roughly 1-2 hours to collect the vegetation data. I used a compass to navigate along transects, however, sometimes there was impenetrable shrub that I had to circumnavigate resulting in transects that were not completely straight. Site 18 had a large area I was unable to survey (possibly 20mx20m) at a pole station which altered the direction of transect lines. At site 6, cardinal directions from the point count station took me immediately into forest, so I missed a substantial portion of shrub habitat for vegetation collection.

Table 5. **Vegetation characteristics and shrub bird abundance for each of the 17 managed sites.**

Site	Number of Pole Stations	Percent Low Obstruction	Percent High Obstruction	Canopy Height (m)	Obstruction Height (cm)	Percent Shrub Habitat (ha in 100m circle)	Patch Size (ha)
1	19	24.88	2.24	1.11	21.3	91.60 (2.88)	8.74
2	18	30.07	6.53	1.78	26.2	79.55 (2.50)	8.74
3	7	32.86	2.86	6	20.5	18.39 (0.58)	0.73
4	11	33.07	2.39	2.27	23.9	37.53 (1.18)	1.29
5	16	55.23	10.7	2.07	50.0	59.10 (1.86)	2.55
6	4	37.63	7.19	2	42.2	20.69 (0.65)	0.91
7	9	26.67	0	0.81	21.3	50.95 (1.60)	1.88
8	11	33.86	5.34	3.55	25.6	38.69 (1.22)	1.22
9	15	33.17	12.7	1.77	20.1	56.44 (1.77)	4.71
10E	19	50.39	4.34	1.56	43.4	72.76 (2.29)	10.62
10W	17	40	4.56	1.29	28.8	82.15 (2.58)	10.62
11	14	49.23	33.08	4.86	33.6	60.53 (1.90)	1.97
12	8	54.22	45.16	4.75	39.1	27.53 (0.87)	0.87
13	20	41.13	10.38	1.85	33.3	86.97 (2.73)	3.58
14	11	53.86	11.93	2.05	46.4	49.07 (1.54)	2.80
17	10	40.5	22.63	2.55	38.0	44.36 (1.39)	1.79
19	6	95.83	45.83	2.92	133.5	25.02 (0.79)	1.38

Bird Occupancy 2005 and 2013

Non-shrub species experienced no significant change in abundance from 2005 to 2013 (Table 6). Shrub species abundance in the 17 managed sites did increase significantly from 2005 to 2013 ($z=2.679$, $p=0.007$). Although the number of control sites (2) was too small to permit statistical analysis, it is worth noting that shrub species abundance did not change significantly in the two unmanaged sites from 2005 to 2013. Non-shrub species richness was not significantly different between 2005 and 2013. Shrub bird species richness had a moderately significant increase from 2005 to 2013 ($z=1.804$, $p=0.071$).

Table 6. Abundance and species richness of shrub and non-shrub birds in 2005 and 2013.

	2005				2013			
Site	**Shrub Species**	**Shrub Abundance**	**Non-Shrub Species**	**Non-Shrub Abundance**	**Shrub Species**	**Shrub Abundance**	**Non-Shrub Species**	**Non-Shrub Abundance**
1	9	22	6	11	9	24	8	10
2	4	7	13	22	7	22	7	14
3	5	10	6	15	6	15	10	17
4	5	9	7	11	6	12	8	19
5	11	25	7	9	8	29	10	18
6	7	12	10	24	7	8	12	20
7	3	6	11	21	5	7	14	25
8	6	10	13	32	7	14	9	17
9	7	18	10	15	10	33	4	10
10E	4	12	7	12	8	21	10	15
10W	6	17	9	20	7	23	10	17
11	4	9	6	15	6	18	7	9
12	6	7	17	29	9	20	16	20
13	8	17	14	26	8	20	16	44
14	7	15	12	28	9	26	17	25
17	4	5	10	17	7	18	12	19
19	8	28	13	26	6	15	9	18

Six shrub bird species experienced significant change in abundance from 2005 to 2013 (Table 7), Cedar Waxwing was moderately significant (p=0.067). Five of these species significantly increased abundance, 2 (Black-and-white Warbler and Blue-winged Warbler) significantly decreased from 2005 to 2013.

Table 7. **Significant shrub bird changes in abundance, 2005-2013, Cedar Waxwing only moderately significant. RI DEM target species in bold and italicized. Range and Median are species abundance per site in 2005 and 2013.**

	2005		2013				
Species	**Range**	**Median**	**Range**	**Median**	***Z***	**p**	**r**
Cedar Waxwing	0-7	1	0-6	2	1.83	0.067	0.42
Prairie Warbler	0-5	1	0-8	3	3.09	0.002	0.71
Carolina Wren	0-0	0	0-1	0	2.00	0.046	0.46
Yellow Warbler	0-1	0	0-4	0	2.16	0.031	0.49
Black-and-white Warbler	0-1	0	0-0	0	-2.00	0.046	0.46
Blue Winged Warbler	0-5	0	0-0	0	-2.04	0.041	0.47
Indigo Bunting	0-1	0	0-4	1	2.65	0.008	0.61

Bird Occupancy and Vegetation Attributes in 2013

Total shrub bird abundance in 2013 was positively associated with percent low obstruction (B=0.007, p<0.05), percent shrub habitat (B=0.011, p<.001) and patch size (B=0.061, p<.001), (Table 8). Shrub bird species richness in 2013 was not significantly predicted by any of the vegetation parameters.

For individual Poisson regressions, I used shrub species that were detected in at least seven of the 19 sites, which totaled 10 shrub bird species (Table 8). Of these, six were significantly related to at least one vegetation parameter, and four were significantly related to more than one. Four species were related to percent shrub habitat (Figure 10, Figure 11, Figure 13) and four species were related to patch size (Figure 10, Figure 11, Figure 12, Figure 13). One species was related to both low obstruction and obstruction height and one species was related (negatively) to both high obstruction and canopy height (Figure 11).

Table 8. **Poisson linear regressions (R^2) for shrub species as a group and shrub species that were detected in at least 7 of the sites. Significant regressions in bold. Target species in bold and italicized. Note: *p<.05, **p<.01, ***p<.001.**

Species	Low Obstruction	High Obstruction	Canopy	Obstruction Height	Percent Shrub Habitat	Patch Size
All Shrub	**.007***	.000	-.078	0.002	**.011*****	**.061*****
Gray Catbird	.012	.012	.030	0.007	.006	-.007
Cedar Waxwing	**.023*****	.019	.078	**0.013*****	-.002	-.026
Yellow Warbler	-.006	-.029	-.478	-0.002	**.040****	.129
Prairie Warbler	-.001	-.021	-.192	-0.007	**.020*****	**.125*****
Common Yellowthroat	.013	.011	-.138	0.005	.014	.007
Northern Cardinal	.007	.005	-.104	0.005	.003	.016
Indigo Bunting	-.021	**-.080***	**-.845***	-0.017	**.032****	**.192****
Eastern Towhee	.000	.005	.116	-0.011	.010	**.077***
Field Sparrow	.014	-.014	-.529	0.003	**.020***	**.131***
American Goldfinch	.000	.006	-.207	-0.001	.001	.049

Target species for the RI DEM management plan included Prairie Warbler, Blue-winged Warbler, Indigo Bunting, Eastern Towhee and Field Sparrow (2006). I graphed abundance per site for each species with all 6 parameters to examine individual relationships. Blue-winged Warblers were not detected in 2013.

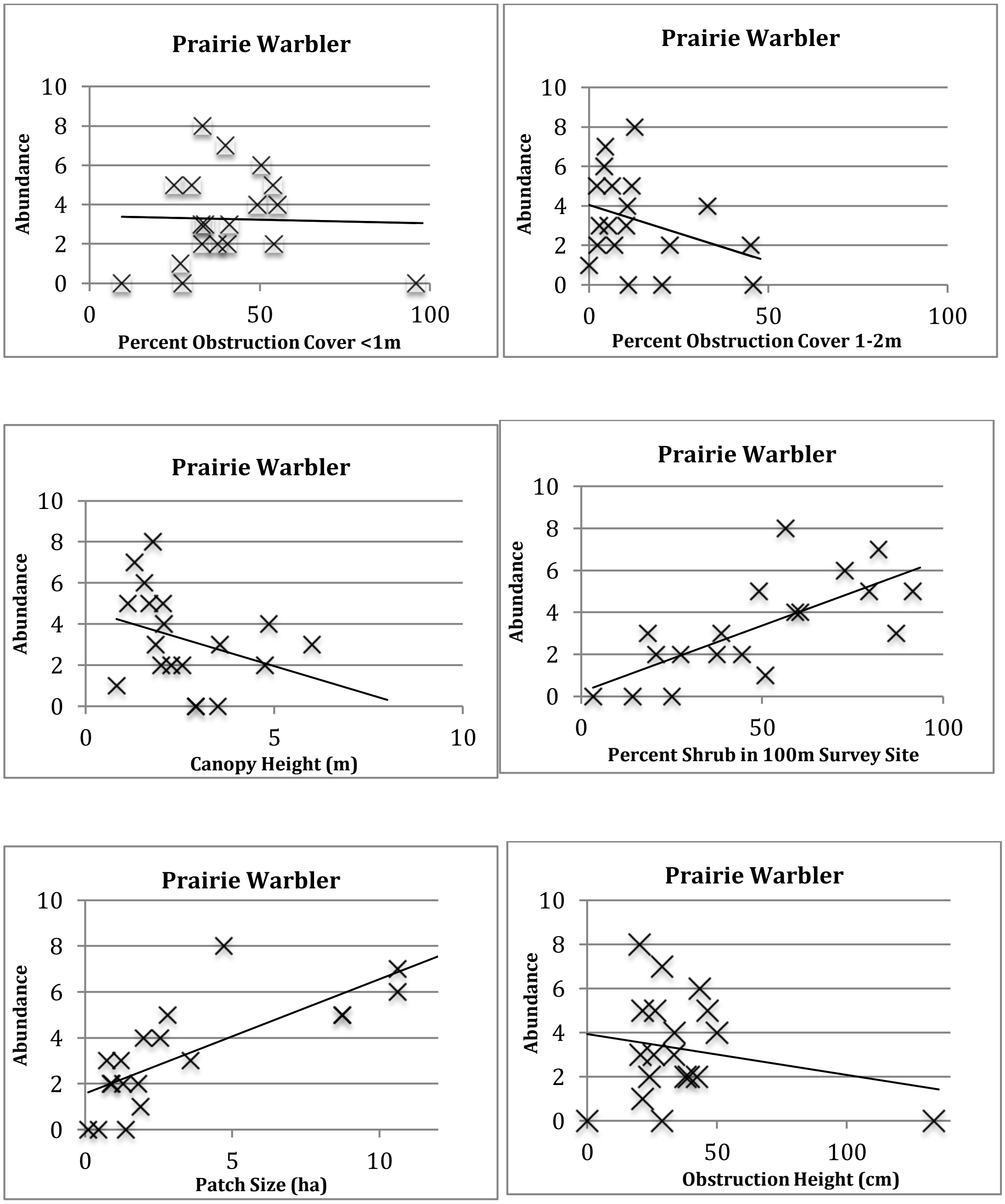

Figure 10. **Graphs showing the relationship between habitat characteristics (low obstruction, high obstruction, canopy height, percent shrub habitat, patch size, obstruction height) and Prairie Warbler abundance. Relation with both percent shrub habitat and patch size is positively significant.**

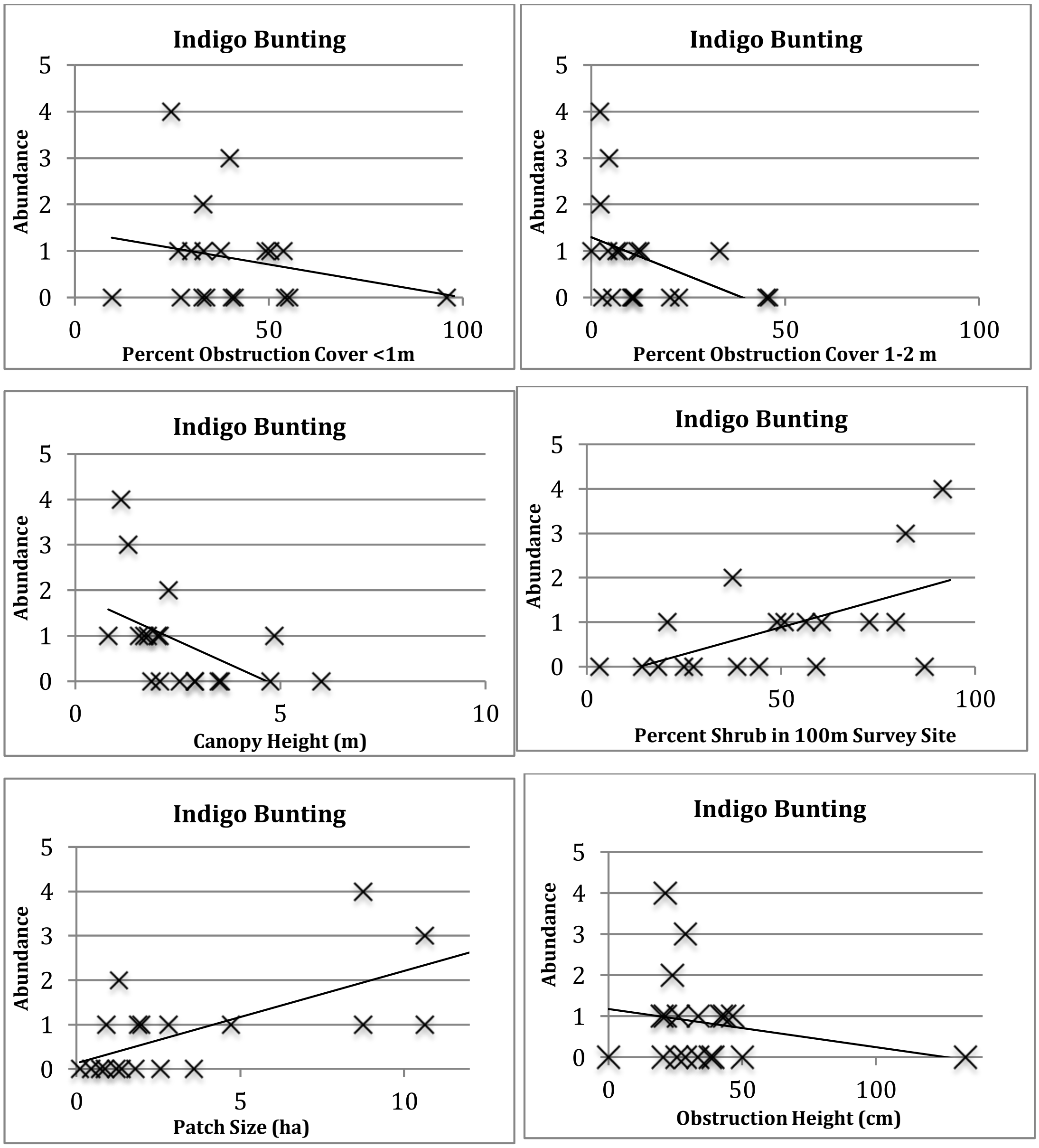

Figure 11. **Relationship between habitat characteristics (low obstruction, high obstruction, canopy height, percent shrub habitat, patch size, obstruction height) and Indigo bunting abundance. Relation with both percent shrub habitat and patch size is positively significant. Relation with both high obstruction and canopy height is negatively significant.**

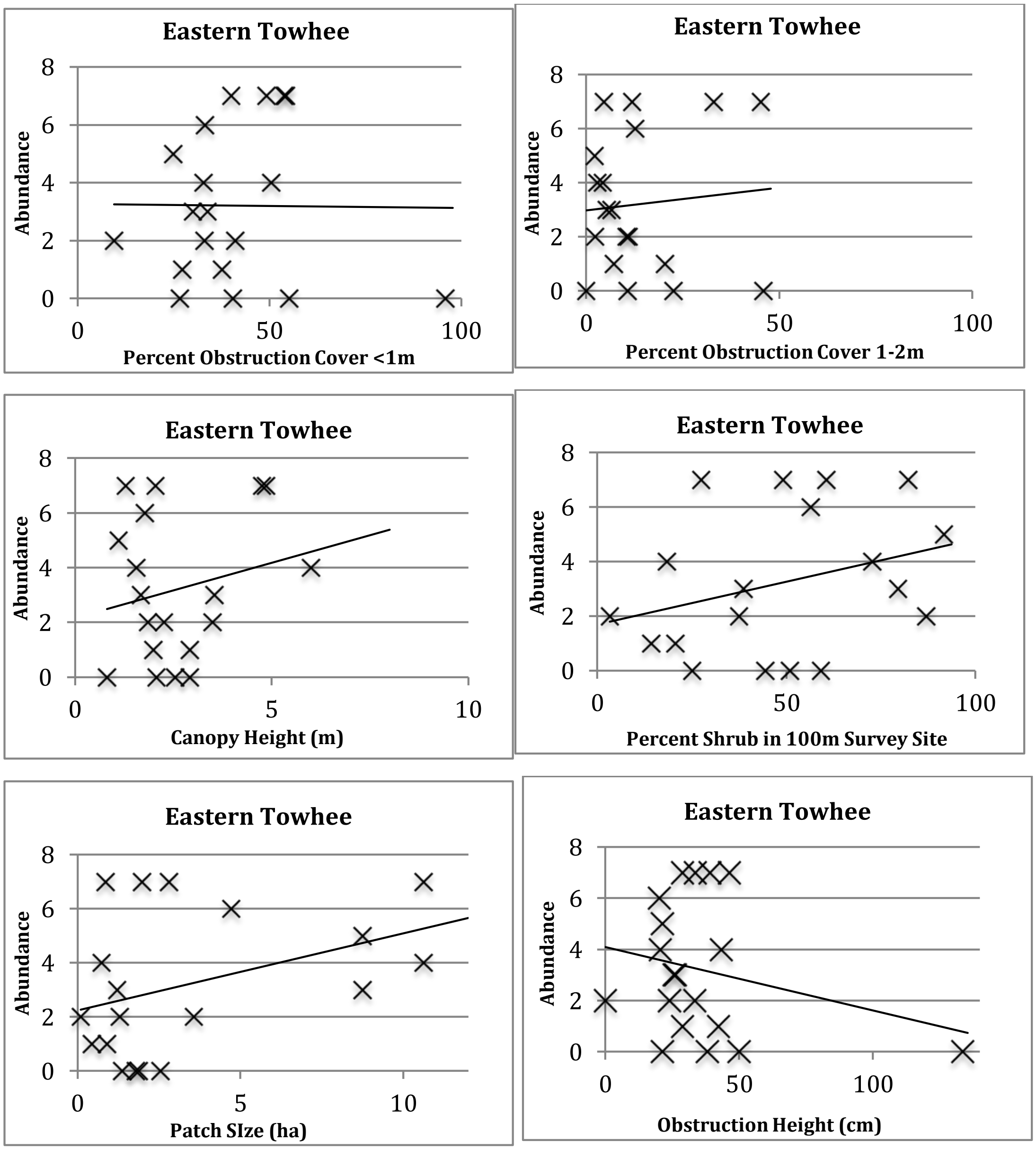

Figure 12. **Graphs showing the relationship between habitat characteristics (low obstruction, high obstruction, canopy height, percent shrub habitat, patch size, obstruction height) and Eastern towhee abundance. Relation with percent shrub habitat is positively significant.**

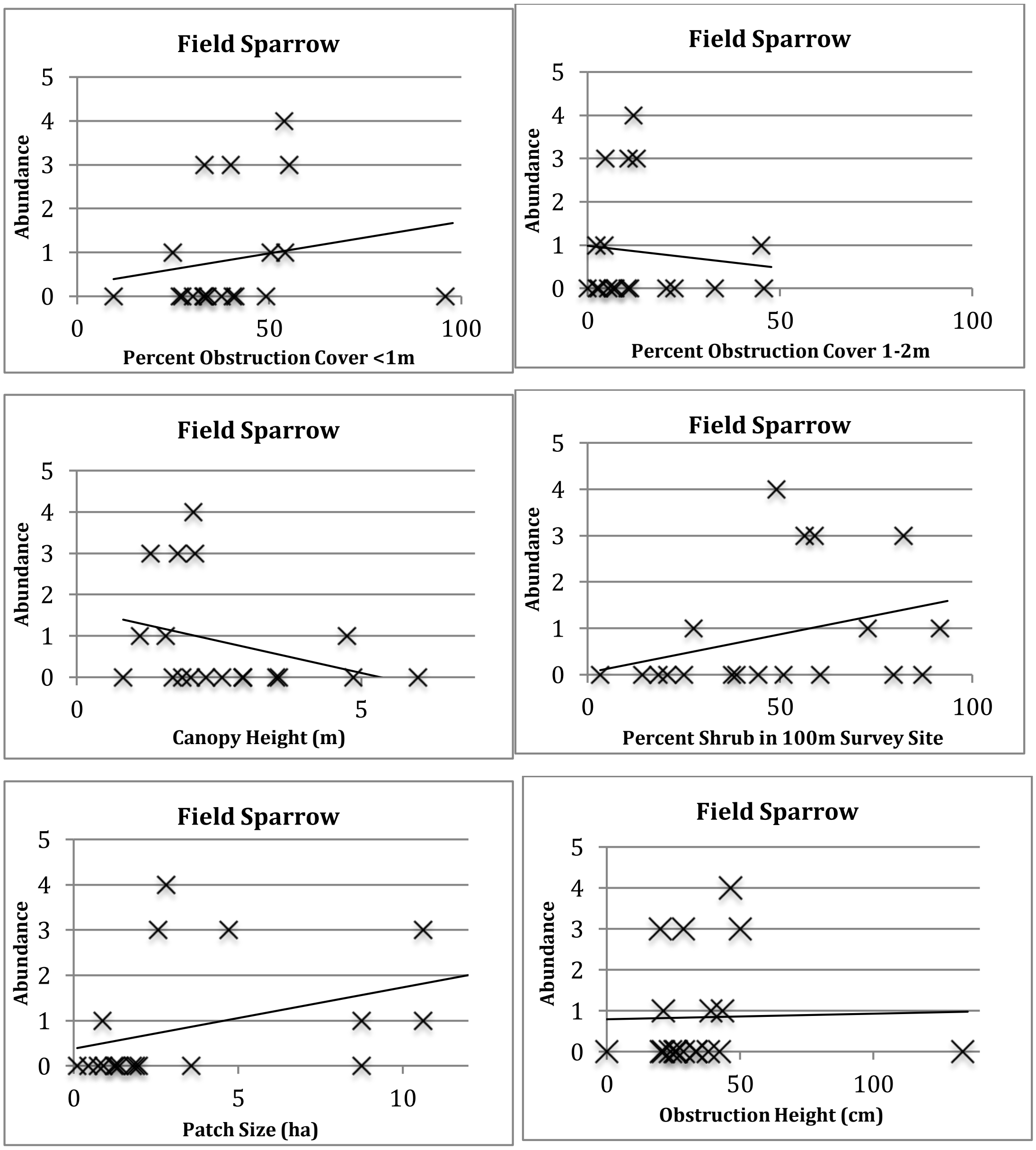

Figure 13. **Graphs showing the relationship between habitat characteristics (low obstruction, high obstruction, canopy height, percent shrub habitat, patch size, obstruction height) and Field sparrow abundance. Relation with both percent shrub habitat and patch size is positively significant.**

6. DISCUSSION

Vegetation Analysis in 2013

The use of a Robel pole to measure vegetation variables was very easy and required little knowledge or training. Pole stations took an average of two minutes to collect four egetation characteristics. Sites were completed in 1-2 hours, depending on how dense the shrub was from pole station to pole station. One point to be careful of was to not walk in the path of visual estimate for density reading. Someone must hold the pole for the observer to make visual estimates, and that person must try to get to the center of the pole station without disrupting any vegetation. The only equipment required to carry was the pole, which allowed for hassle free collection, as shrub vegetation can be very difficult to get through.

Our shrub had dense low vegetation; high vegetation was not as dense. Our plots were relatively small, three were smaller than 1ha, which Shake et al. (2012) found to be a minimum area requirement for shrub birds. However, percent shrub cover in the patches averaged around 53%, so while the patches were smaller they offered a high amount of shrub habitat. Many of the sites had shrub habitat that was mainly composed of herbaceous cover which provided higher density of low vegetation, an important component of shrub habitat (Schlossberg & King, 2007).

Bird Occupancy in 2005 and 2013

Shrub bird abundance increased from 2005 to 2013, while non-shrub bird abundance did not. This suggests that the site management in 2006 provided more habitat for shrub birds, consequently their abundances increased. It is interesting to note that two, Prairie Warblers and Eastern Towhees, of RI DEM’s five target species had frequencies higher than 0.5 in 2005 before management practices. In 2013 those two target species remained at frequencies greater than 0.5, in addition, Indigo Buntings were detected at more than half of the sites. Target species Blue-winged Warblers was detected in 2005 but was not detected in 2013.

Bird Occupancy and Vegetation Attributes in 2013

Shrub birds, as a group, were positively related to low obstruction, percent shrub habitat and patch size. Six of the 17 shrub species detected had a significant relationship with one of the vegetation parameters. Cedar Waxwings were related to low vegetation density and obstruction height. Degraaf and Yamanski (2003) reported that Cedar Waxwings move into an area two years after a cut, when vegetation is still low. Murphy et al., (1997) also found failed Cedar Waxwing nests correlated with taller shrub canopy, indicating a preference for breeding in lower shrub.

Indigo Buntings were negatively related to high vegetation density and canopy height, indicating they tend to avoid tall, dense shrubs. This concurs with Schlossberg and King’s (2007) meta-analysis, who classified Indigo Buntings as decreasers, which they defined as birds that come in after a cut and thereafter continue to decline in population. Schill (2009) found the abundance of Indigo Buntings related to percent ground cover of any vegetation. Bulluck and Buehler (2006) and King et al (2008) found Indigo Bunting populations were higher in habitats with ferns, forbs and grasses. Both these studies suggest Indigo Buntings prefer dense, low vegetation cover. I found Indigo Buntings to also be positively related to patch size and percent shrub habitat within the point count circle. King et al. (2009) found that Indigo Bunting abundances were higher in wide utility right of ways, which seems to indicate they prefer larger shrub habitats. However, Schill (2009) also found that Indigo Bunting abundance was related to blackberry cover, and King et al. (2008) noted that Indigo Buntings were found in areas with higher invasive species, so it is possibly Indigo Buntings may be related to a particular vegetation species. Sites 1 and 10E, where Indigo Bunting abundances were highest, were the two largest sites and lacked berry bushes, composed mostly of herbaceous cover and tall grass. It may be useful to further investigate the relationship between these shrub birds and vegetation species.

Prairie Warblers were positively related to percent shrub habitat and patch size. This agrees with research by Shake et al. (2012) who concluded Prairie Warblers are related to patch size. King et al. (2009) also found Prairie Warblers to be related to utility right of way widths, again indicating larger shrub habitat size.

Eastern Towhees were positively related to patch size, similar to both Shake's et al. (2012) and Askins et al. (2007) findings that Eastern Towhees preferred larger shrub areas. Schlossberg and King (2007) suggests Eastern Towhees and Prairie Warblers are modal species, meaning they have low population numbers immediately post cut, peak around 10 years post cut then continue to experience population declines. This curvilinear relationship with habitats after a cut may be reasons why neither species were related to either low or high vegetation densities.

Yellow warblers were related to percent shrub habitat. Schlossberg and King (2007) determined Yellow Warblers prefer dense shrubs, and King et al. (2008) determined Yellow Warblers were found more in wildlife openings containing ferns and grasses, as opposed to silvicultural openings containing shrubs. My results seem to suggest that, regardless of height, Yellow Warblers may just prefer a homogenous shrub habitat.

Field Sparrows were related to percent shrub habitat and patch size. King et al. (2009) determined Field Sparrows to be predicted by corridor width, again indicating a preference for larger shrub patch size.

One source of error with the analysis I conducted for this study is the degree of collinearity between vegetation parameters. Since I ran each regression independently the results would not have been affected, but interpretation can be difficult. For instance, since Big River sites were fairly small, a majority of the sites probably fell within the point count circle, therefore it would make sense that patch size and percent shrub habitat were positively correlated. Patch size is a good indicator of shrub bird species in literature (Shake et al., 2012; King et al., 2009) and therefore may have held a majority of the weight for species that were positively related to percent shrub habitat. However, it is odd that high obstruction and low obstruction are positively correlated. One reason for this may be the height of my modified Robel pole. I categorized high obstruction as 1-2m off the ground, some research has suggested that the minimum height for high vegetation should be around 1.5m (Schlossberg et al., 2010; Willson, 1974). I found no significant relation between Field Sparrows and low obstruction, however, past studies have found significance (King et al., 2009; Schill and Yahner, 2009; Schlossberg et al., 2010). This may be due to the low threshold I set for high shrub density (1m). Both percent shrub habitat and patch size were negatively related to canopy height (again, showing strong evidence for collinearity between those two variables). This seems intuitively correct as shrub areas tend to have low canopy heights. My data suggests that small patch sizes (<10ha) may have very little vegetation variation. Larger patch sizes should have greater variation and could have significant differences between size, shrub patchiness (percent shrub habitat) and canopy height.

I recorded an average of 13 Robel pole stations per site. This number was dependent on when the cardinal direction line I navigated ran into forest. Some sites may not have had enough pole stations to adequately summarize the average vegetation. For instance, site 6 only had four pole stations (Table 5) as each direction immediately brought me into the forest. It is important to use random points to collect vegetation (so no one type of habitat, say dense shrub, becomes unintentionally oversampled) but sampling on a transect may not be an optimal choice. Some studies use a fixed number of random points in all sites (Schlossberg et al., 2010; King et al., 2008), but this does not take into account size of the site. A site that is 20ha should have more vegetation sample points than a site of 3ha. Perhaps a useful parameter for future work would be to sample a fixed number of vegetation points per every 1ha or so.

The Robel pole is a user friendly, quick method for collecting relatively accurate and precise information on shrub structure. It can be very time consuming to measure shrub vegetation in habitat patches with dense shrubs, as walking transect lines through dense shrubs can sometimes be near impossible. Sampling points throughout the patch is a more time economic choice of vegetation monitoring and a Robel pole provides a relatively rapid method of measuring vegetation characteristics. A majority of the significant relationships I found were between shrub birds and landscape level characteristics (patch size, percent shrub habitat). This could have been due to the height of my modified pole or the distribution of pole stations along the cardinal lines. I would recommend Robel poles being 3m high and splitting low and high obstruction at 1.5m. I would also recommend using random points per area; our original goal was to use 21 pole stations (five in each cardinal direction and one center station) per site. Our average patch size was roughly 4ha, instead of running pole stations along a directional tract, I would recommend five random pole stations per ha.

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Appendix 1. Coordinates of Center-points of 17 Study Sites and two Control Sites

Site	UTM (Zone 19)		Note
1	281934	4610394	Study site
2	282109	4610279	Study site
3	281046	4610308	Study site
4	281104	4610114	Study site
5	280964	4611857	Study site
6	281258	4612296	Study site
7	281579	4613112	Study site
8	282554	4613629	Study site
9	287072	4614818	Study site
10w	286483	4614568	Study site
10e	286660	4614695	Study site
11	285780	4612850	Study site
12	285871	4612653	Study site
13	285287	4612430	Study site
14	285281	4612857	Study site
15	284234	4611574	Control – unmanaged site
17	282800	4613232	Study site
18	281876	4615452	Control – unmanaged site
19	280653	4611473	Study site