Union College
Union | Digital Works

Honors Theses Student Work

6-2020

Avian Community Organization Changes Along a Gradient of Scrub-Oak Structure in the Albany Pine Bush Preserve

Sean Rigney
Union College - Schenectady, NY

Follow this and additional works at: https://digitalworks.union.edu/theses

Recommended Citation

Rigney, Sean, "Avian Community Organization Changes Along a Gradient of Scrub-Oak Structure in the Albany Pine Bush Preserve" (2020). *Honors Theses*. 2495.
https://digitalworks.union.edu/theses/2495

This Union College Only is brought to you for free and open access by the Student Work at Union | Digital Works. It has been accepted for inclusion in Honors Theses by an authorized administrator of Union | Digital Works. For more information, please contact digitalworks@union.edu.

Avian Community Organization Changes Along a Gradient of Scrub-Oak Structure in the Albany Pine Bush Preserve

By: Sean Rigney

****

Advisor: Steven K. Rice

Union College

June 2020

ABSTRACT

RIGNEY, SEAN

Avian Community Organization Changes Along a Gradient of Scrub-Oak Structure in the Albany Pine Bush Preserve

ADVISOR: Steven K. Rice

The Albany Pine Bush (APB) is a fire-dependent ecosystem that contains a mosaic of shrubland habitats that differ in vegetation community and successional age. Areas are categorized by the APB as pitch-pine scrub-oak barrens, pitch-pine scrub-oak thickets, and mature pitch-pine forests. Despite its sandy nutrient poor soil, the APB is home to a wide range of plants which in turn support a diverse population of animals, such as the federally endangered *Lycaeides melissa samuelis* (Karner Blue Butterfly) and NYS species of concern *Setophaga discolor* (Prairie Warbler). Abundance of six bird species that are indicators of shrubland habitat were recorded and compared to the vegetation composition and structure; birds include the Prairie Warbler, Field Sparrow, Eastern Towhee, Brown Thrasher, Eastern Bluebird, and Eastern Kingbird. Aside from gathering field data of bird and shrubland communities, laser scanning was employed to characterize vegetation structure. While often used for architectural work, many 3D scanners are being repurposed for data collection in the field. Overall, the most observed species of shrubland birds were the Eastern Towhee, Prairie Warbler, and Field Sparrow. Eastern Towhees were the most abundant across the plots, they were the only bird recorded at every site. All bird species were most abundant in the shrub plots with intermediate vegetation density and height. Management and conservation efforts in the ABP should focus on the relationship

between the avian and vegetative communities, and how they respond to the re-integration of prescribed fire events in the APB that lead to mosaic shrublands. The TLS data that was gathered was useful and structural information compared well with field measurements, but ultimately provided no more additional data than what was gathered by manual shrub transects and took roughly the same amount of time due to set-up of the scanner. I believe that TLS can provide a useful tool to conservation management, although for it to replace expert field measurements data analysis would need to be further streamlined.

TABLE OF CONTENTS

LIST OF FIGURES AND TABLES

INTRODUCTION

Habitat loss and degradation has become a global concern as more land is converted from natural landscapes to areas of high human impact. For example, changes in land use, stemming from agriculture or population increase, coupled with invasive species, climate change, and habitat fragmentation threaten somewhere between 10-25% of bird species (Tillman et al. 2017). While conservation programs have had some mixed success over the past decades, it is important that these efforts continue. Only 14% of the land on Earth is under some kind of protection, for biodiversity to be sustained this number needs to increase and hold steady over the coming decades (Tillman et al. 2017). People tend to think of conserving areas that are exotic to them, like tropical forests and grasslands, rather than simply trying to conserve the forest in their backyard. Many on-the-ground-conservation efforts require national and local support, via analyses and actions, usually focused around one threatened species in particular (Tillman et al. 2017). In the Northeastern United States there are scattered pitch-pine scrub-oak ecosystems running from Maine all the way across New Hampshire, Massachusetts, New Jersey, and New York, disrupted throughout via human development (Schlossberg et al. 2010). This ecosystem has been greatly reduced and changed due to anthropogenic reasons like, urban and suburban encroachment, agriculture, fire suppression, and invasive species. These habitats are mostly early successional, shrub-dominated systems continually being recycled by fires, never being fully allowed to age into mature stands of pitch-pine, which will inevitably become a mixed hardwood forest. These pitch-pine ecosystems are extremely valuable both for their innate rare biodiversity and as a refugium for seasonal migrating bird species. As these ecosystems grow smaller and less suitable, declines in rare or endemic species occur, including population declines in the shrubland birds that rely on these habitats. By conserving these pitch-pine barrens we can preserve their rare biodiversity and help reduce anthropogenic impacts on early successional bird populations. Conservation programs have saved at least 31 species of bird from extinction in the past century alone. It is important that conservation programs are thought out fully however, the lands that are managed/protected, their spatial distributions and how natural and undisturbed they are, will determine the success of the program (Tillman et al. 2017).

The Albany Pine Bush is a fire-based ecosystem, the plants and animals there require frequent fire in order to maintain an early successional state. The Albany Pine Bush (ABP) was, most likely, a temperate deciduous forest before Native Americans and settlers altered its ecosystem regimes with fire, fire suppression, resource gathering, and land development (Barnes 2003). The Albany Pine Bush (APB) is a relatively recent addition to conservationist concerns, becoming a focus of local grass roots supporters in the 1970s, being one of about 20 naturally occurring pine-barrens ecosystems in North America (Barnes 2003). The APB is endangered by past fire suppression protocols, invasive species, and fragmentation by nearby urban development. Despite its sandy nutrient poor soil, the APB supports a wide range of plants which in turn support a diverse population of animals, such as the federally endangered *Lycaeides melissa samuelis* (Karner Blue Butterfly) and NYS species of concern *Setophaga discolor* (Prairie Warbler; Barnes 2003). The APB contains 75 wildlife Species of Greatest Conservation Need (SGCN) identified in the State Wildlife Action Plan for New York. Broken down these 75 species include 43 birds, 8 reptiles, 4 butterflies, 5 moths, 4 mammals, 3 amphibians and 3 fish. Although these species of concern can be found in a variety of habitats in the APB the inland pitch pine-scrub oak barrens harbor a majority of threatened species (APBPC 2017).

The APB Preserve undergoes management practices like controlled burnings, mowing, clear cutting, planting of native plants, and use of herbicides to restore and maintain rare habitats in an early successional stage. Through the use of these treatments the APBP commission hopes to restore and maintain viable barrens that can be manipulated through controlled burns only (APBPC 2017). Consequently, the landscape of the APBP is a mosaic of shrublands that differ in vegetation structure and successional age. The vegetative structure of an area is important in determining animal populations within the area. Since plants are primary producers, their structure and distribution will determine the population of the animals that rely on them. As vegetation changes over time following succession, so do their inhabitants. Many species of birds rely on specific vegetation assemblages for their nesting and feeding habits. A key component of supporting shrubland bird populations is maintaining a balance between the amount of land that is kept in a prairie-like, open state dominated by grasses and forbes and land that succeeds towards a scrub-oak dominated shrub community (Schlossberg et al. 2010). Therefore, community data for birds in the APB can inform us about the habitat quality of the landscape. Quality is not always a determinate for the bird species present. Often, birds that rely on shrubland habitats do best when there is a mosaic of successional habitats (Akresh et al 2014). Different species will prefer different vegetative attributes. Height/density of shrub cover may be important for one species because it influences their nesting, meanwhile a different species preference will be mirrored by the vegetative composition because it influences their food supply. Providing a mosaic of habitats also supports competition between migrating birds when they return to previously occupied mating grounds. Older males returning will tend to return to the sites they used the year before, while younger males who are not site faithful will be forced to areas that are perhaps in earlier stages of succession due to a fire a few years before. When these younger males return in the next years the areas they are faithful to will become late successional areas, while a fire has hopefully created new habitat for that seasons younger males (Akresh et al 2014). Aside from being general indicators of habitat quality, bird communities can provide information on the available food caches/prey in the area and, the suitability of different types of roosting sites. The objective of this research is to explore the relationship between bird communities and the vegetation that they depend on by monitoring activity of six shrubland bird species across a gradient of shrub-dominated plots that differ in shrub height and density.

The conservation of this rare pitch pine-scrub oak community and its effects on shrubland birds has been the subject of several recent studies. Schollberg et al. (2010), Bried et al. (2010, 2011), and Akresh et al. (2014), examined the impacts that management and vegetative structure have on the presence of shrublands in these communities. Bried et al. (2010) even devised a more accurate point-count survey method for the shrubland birds of the APB to ensure higher quality data for predictions about shrubland bird's presences.

The present study was designed to determine the significance of woody-shrub structure, particularly density and height in the dominant species *Quercus ilicifolia* and *Q. prinoides*, on the avifauna community of the APB. In addition, this experiment tested the viability of using a terrestrial laser scanner to determine woody-shrub characteristics as opposed to field measurements. I hypothesize that the avifaunal community, represented by six specifically chosen shrubland species, will respond more positively to sites that fit their foraging habits, these will most likely be sites located in the middle of the height/density gradient. These "middle" sites will provide aspects of earlier and later shrub succession that will appeal across the avian community, for instance they will contain enough open grass prairie-like habitats that ground nesting birds will be able to nest under the shorter strata. At the same time, these areas will contain enough mature scrub-oak stands to provide nesting sites for internal shrub-nesters. I predict that sites that have medium sized shrubs that are evenly spaced within prairie-like environments will have the highest recorded bird counts and species richness, seeing as they represent the middle of the APB's mosaic of shrublands. There is a range of ecological niches covered by the afore mentioned species, which will most likely skew the results in favor of those species who show generalist behaviors and are seen across all sites.

Terrestrial laser scanning (TLS) can be used to characterize 3D vegetation structure and monitor changes over relevant spatial and temporal scales. While TLS light detection and ranging (LiDAR) is often thought of for use in commercial surveying, it has been shown to be quite useful for ecological settings as well (Calders et al. 2015, Decuyper et al. 2018). Data from 3D point clouds can help characterize many aspects of vegetation structure, like woody and non-woody growth, tree average height, tree canopy coverage, and areas of refugia (for prey species) and biomass (Muir et al. 2018, Olsoy et al. 2015). An additional aim of this research is to explore the use of TLS LiDAR to quantify the shrub height characteristics for communities in the ABP that differ in successional age. Hopefully expanding on the work done by Muir et al. in 2018, in which they reported difficulties in categorizing shrub strata quantities like height, average height, and density. By comparing data taken from the scans to field measurements we can understand the benefits and drawbacks that this system may bring to the study of shrubland ecology and perhaps lay foundations for the use of this technology in further management processes.

With regard to the Faro terrestrial laser scanner, I predict that the scanner will only provide data that corresponds with field measurements in the plots that have heights within a certain class, ranging from 0 to 3 meters. Once the plots begin to have too much shrub growth and/or too great a shrub or tree density the scanner will become less useful due to the shading effects of dense foliage.

METHODS AND MATERIALS

Study Sites

The Albany Pine Bush Preserve is ecologically diverse and located between the cities of Albany and Schenectady, New York. It contains 3,300 acres of protected lands varying from Pitch-pine scrub-oak communities to mature oak-pine forests. Pitch pine-scrub oak communities dominate the Albany Pine Bush landscape and have been the focus of conservation efforts to date. These communities 1) are dominated by pitch pine and other species dependent on frequent disturbance by fire; 2) tend to occur on sandy soils that have low nutrients and wide ranges of soil moisture during the growing season; and 3) provide habitat for numerous rare species, especially birds, reptiles, moths and butterflies (APBPC 2017). Within the Preserve, five sites were chosen to match a gradient of succession and scrub-oak height/density; these sites range from Pitch-pine scrub-oak barrens with a recent mowing to pitch-pine scrub-oak thickets with dense shrubs >3m in height. Plots with flat planes were sought after in an attempt to ease the processing of the individual scans taken with the Faro scanner (Faro Focus 3D, Faro Industries, Lake Mary, FL). Pitch pine-scrub oak barrens are similar to shrub-savanna communities with 20 to 60 percent cover of pitch pine, they have fire frequencies of 6-15 years. Scrub oak species (*Quercus illicifolia* and *Q. prinoides*) dominate an open-canopied shrub layer with an ideal average density of approximately 30% cover. Pitch pine-scrub oak thickets resemble barrens in plant species richness, but are at a later stage of succession following biomass reduction and have a much higher cover of scrub oak (>50%), and a lower density of grasses.

Vegetation Data

Shrub transects were conducted at each plot to determine species presence/cover as well as heights of individuals marked in the transect. A 50m tape was drawn out in a direction determined at random, with the midpoint on the plot center, which was also the center point of bird surveys. Five 20m transects perpendicular to this line were established in a stratified random fashion; these combined for a total transect length of $100m^2$. At each meter along the 20m tapes, woody shrubs were recorded for species and height, totaling to 100 data points per site. We used 3-meter long sticks and recorded shrub heights to the nearest 10cm. Three *Quercus* spp. located at the Water Tower site measured over 3 meters and were recorded as 3.5m tall, based on observations by those conducting the measurements. All mature trees that were over 3 meters tall within the plots were identified and measured for species and diameter at breast height (DBH). This data was then analyzed to determine number of possible tree perches for calling or nesting and dominant tree species of the plots. When measuring the DBH of all trees within each plot we considered tree forks below the measurers' breast height to be two individual stems, and thus two separate data points.

Avian Data

Avian community data was collected following protocols developed by the Albany Pine Bush Preserve Commission (APBPC) staff. Primary species counted include *Setophaga discolor* (Prairie Warbler), *Spizella pusilla* (Field Sparrow), *Pipilo erythrophthalmus* (Eastern Towhee), *Toxostoma rufum* (Brown Thrasher), *Sialis sialis* (Eastern Bluebird), and *Tyrannus tyrannus* (Eastern Kingbird). The order of plot sampling was initially arbitrarily and then plots were sampled based on a randomly generated number system. Point counts were conducted following the guidelines of APBPC staff, sampling from the center of each plot where I would stand for approximately 3 minutes to allow the birds to adjust to my presence. After that, for the next 10 minutes I would record at what minute I saw a bird or heard its call and where within my plot I thought it was. A range finder was used to determine distances for visual confirmation. Each plot was visited seven times between May 31st and July 11th. Data was not collected on days when it was raining or extremely windy. Individual birds were identified by call and visual confirmation when possible. The bird survey data was summarized by calculating the frequency (number of visits divided by the number of total visits) for each bird species in each plot, and also by adding the total number of individuals of each species observed within each plot during the survey.

TLS Data

Terrestrial laser scanning was performed at each of the five plots measured for vegetation and bird community structure. At each site three landmark points, tent poles with large Styrofoam balls on the end, were placed 15m from the center point of each plot at West North-West, East North-East, and South. Four scans were then conducted at each plot, which were combined into a single point cloud. The scans conducted as follows: An initial 360° scan from the center point, then 3 180° scans were captured at 25m from the center point at East South-East, West South-West, and North. The Faro scanner was mounted on a ladder and positioned three meters above the ground surface. This was done to increase the scanner's ability to obtain data from shrubs directly around it and reduce the effects of shadowing. The scans were then loaded into Cloud Compare (Cloud Compare, V. 2.6.1, GPL 2019) and stitched together to create single 3D point clouds of each plot. These were then cut and reduced to remove any noise in the data. Scalar fields were generated to determine the average and maximum vegetation heights within the scans and compared with data from field vegetation surveys.

Analysis

Analyses were conducted using Rstudio and JMP. Height distribution frequencies were calculated for total shrub coverage and only *Quercus* spp. coverage using JMP. However, due to the variation of plant species and heights in each plot many of the results were skewed.

RESULTS

Shrub Structure

Shrub transect data separated scrub-oak coverage plots into three categories, high (76%), medium (46-52%), and low (25%) cover (Figure 1). Vegetation community composition was fairly consistent across all the plots, with minor variations in present grasses and early successional trees. All plots contain a majority cover of *Quercus prinoides* and *Q. ilicifolia*, (35-76%), with an additional combination of *Salix humilis*, *Vaccinium corymbosum*, *Ceanothus americanus*, *Comptonia peregrina*, and *Lonicera* species (Table 1). There was a notably high amount of *Vaccinium pallidum*, or Lowbush Blueberry, at the Kings Barren site (Table 1). Sites that fit into the medium category of the scrub-oak gradient had roughly 35-42% coverage of *Q. ilicifolia* and somewhere between 10-15% *Q. prinoides*. Notable is the different variations in the species-specific *Quercus* percentages for Blueberry Hill and the Water Tower. At Blueberry Hill, *Q. ilicifolia* only covered about 15% of the plot, while *Q. prinoides* was within its medium category range of 10%. While at the Water Tower site *Q. ilicifolia* was not far off of its medium category range, *Q. prinoides* was much higher than its medium category range at 28% (Table 1). The average height of the shrubs across the plots ranged from 0.42m to 1.02m, KBE, KBW, and the Water Tower plot all had a mean *Quercus* spp. height of 1.3-1.5m (Table 2); this showed no correlation with cover.

Avian Community Structure

Overall, the most observed species of shrubland birds were Eastern Towhees, Prairie Warblers, and Field Sparrows (Figure 2). Eastern Towhees were the most abundant across the plots at 40% abundance, they were the only bird recorded at every site. The next most abundant bird was the Prairie Warbler at 33%, present at all plots except for the Water Tower plot, and the Field Sparrow at 19% abundance (Table 3). Notable is the increased number of individual Prairie Warblers at Karner Barrens West, which would technically be considered scrub-oak thickets based on the APBPC 2017 Management plan. The three most observed species, Prairie Warbler, Eastern Towhee, and Field Sparrow all had visitational frequencies of 57% or above, up to 100% for Eastern Towhee (Table 3). Per visit there were usually 1-3 of each individual species present in the plot area.

Terrestrial Scans

The scans taken from plots, that were then stitched together were useful for collecting the average shrub height across the plot area (Figure 3). However, vegetation overgrowth and shadowing proved to reduce the scanner's ability to gather data points and hindered our ability to properly stitch multiple scans together. Thus, in areas of overgrowth like the Water Tower plot the scanner became cumbersome and difficult to properly set up for accurate scans. This can be seen in the accuracy of the mean shrub height gathered from the scans (Table 2). In areas like Blueberry Hill and Kings Barren that have relatively open areas and low-moderate shrub height the scanner can provide measurements similar to our field measurement data. Blueberry Hill manual mean shrub heights were 0.42m, and the scanner's mean shrub height was 0.4m. However, when scrub-oak height and density increase above this margin, like in the Water Tower site, the accuracy dwindles, resulting in a mean height difference of 0.7m (Table 2).

When it came to determining the maximum shrub heights in the point cloud the resulting data was quite skewed, showing shrubs in the Water Tower site up to 7.7m (Table 2).

FIGURES AND TABLES

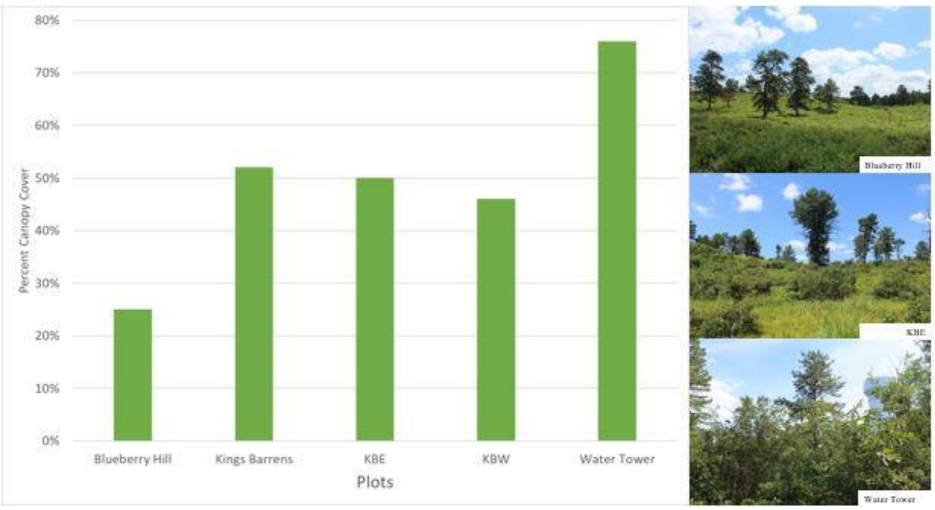

Figure 1. Percent canopy cover of *Quercus* spp. across the 5 plot sites. Canopy cover was determined by taking the number of vegetation points for *Quercus* spp. and dividing that by the total number of vegetation points per plot. Images above correspond to Blueberry Hill, Karner Barrens East, and the Water Tower site and were self-captured in July.

Table 1. Vegetation community data gathered from manual field transects. Species percentages were determined by dividing total points per species by total number of vegetation points. Total cover is representative of the number of points out of 100 containing one or more shrub/forbes species.

Species	Blueberry Hill	Kings Barrens	Karner Barrens East	Karner Barrens West	Water Tower
Quercus ilicifolia	15%	42%	36%	35%	48%
Quercus prinoides	10%	10%	14%	11%	28%
Salix humilis	1%	2%	6%	4%	1%
Vaccinium corymbosum	9%	-	24%	24%	62%
Ceanothus americanus	12%	6%	1%	5%	-
Comptonia peregrina	-	2%	7%	27%	-
Lonicera	11%	3%	-	1%	-
Quercus rubra	1%	-	-	-	1%
Salix humilis var. tristis	-	4%	4%	-	-
Vaccinium pallidum	1%	22%	-	-	-
Rosa setigera	-	1%	4%	-	-
Prunus serotinus	4%	-	-	-	5%
Pinus rigidus	-	-	-	1%	3%
Corylus americanus	2%	-	-	-	1%
Vaccinium angustifolium	1%	-	-	-	-
Hamamelis	-	2%	-	-	-
Prunus pumila	-	-	1%	-	-
Robinia psuedoacacia	-	1%	-	-	-
Lyonia ligustrina	-	-	5%	-	-
Celastrus scandens	-	-	-	-	1%
Populus tremuloides	-	-	-	5%	-
Cornus alternifolia	5%	-	-	-	-
Amelanchier arborea	-	-	-	1%	-
Cornus racemosa	-	-	-	6%	-
Amelanchier canadensis	-	-	1%	-	-
Total Cover:	64%	67%	71%	80%	94%

Table 2. Percent cover of *Quercus* spp. and mean heights for general shrubs & *Quercus* shrubs alongside the mean and maximum shrub height recorded on the Cloud Compare scans.

Plots	Percent *Quercus* Coverage	Mean Height of Shrubs (m)	Mean Height of *Quercus* Shrubs (m)	Mean Height of Shrubs in Point Cloud (m)	Maximum Shrub Height in Point Cloud (m)
Blueberry Hill	0.25	0.42	0.57	0.4	1.7
Kings Barren	0.52	0.67	0.83	0.5	2.4
Karner Barrens East	0.5	1.02	1.5	0.81	3.2
Karner Barrens West	0.46	0.85	1.3	0.98	3.4
Water Tower	0.76	0.98	1.5	1.7	7.7

Figure 2. Total shrubland bird species abundance across all 5 plot sites. Determined by taking the number of individuals seen per species throughout entire experiment and dividing that by the total number of observed birds.

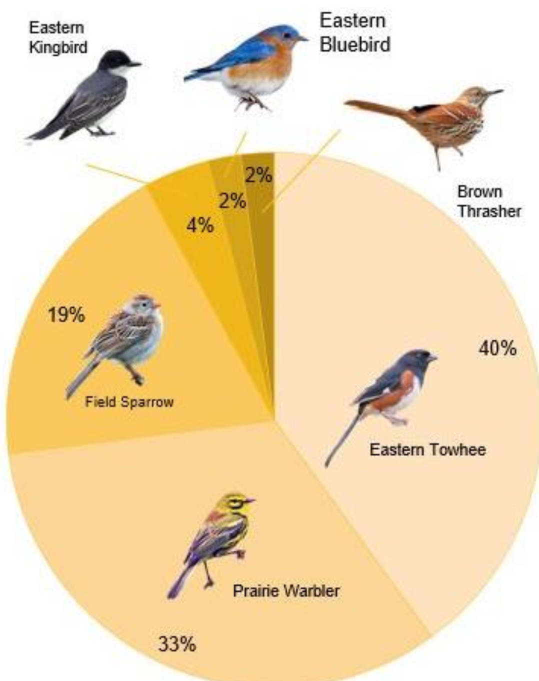

Table 3. Avian community data gathered via point count survey method. Numbers in parenthesis correspond to total number of birds recorded at that plot per species. Numbers before the parenthesis correspond to how many visits, out of the total seven per plot, each species was observed during duration of the experiment.

Species	I. Blueberry Hill	II. Kings Barrens	III. Karner Barrens East	IV. Karner Barrens West	V. Water Tower
Eastern Towhee	1 (2)	7 (12)	7 (13)	6 (8)	7 (14)
Prairie Warblers	1 (1)	5 (12)	6 (11)	6 (16)	0
Field Sparrow	0	4 (6)	6 (10)	4 (7)	0
Eastern Kingbird	0	2 (2)	2 (2)	1 (1)	0
Eastern Bluebird	0	0	1 (1)	1 (1)	0
Brown Thrashers	0	2 (4)	0	0	0

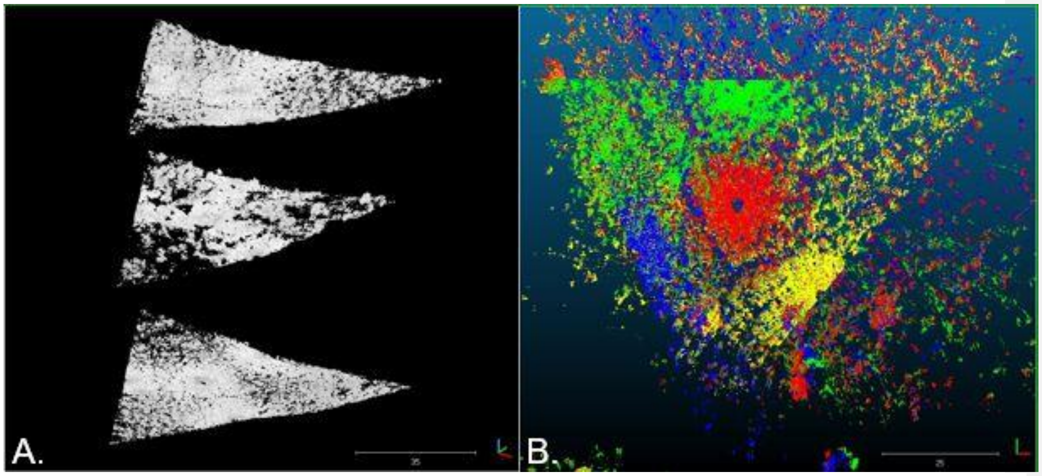

Figure 3. (A) Scans rendered in Cloud Compare of Karner Barrens East, Karner Barrens West, and Kings Barren, descending in that order. (B) Cloud Compare 3D mesh of four individual scans taken at the Kings Barrens site, distinct colors were automatically assigned to individual scans. Red represents the center 360° scan data, while the green, blue, and yellow represent the 180° scans taken at North North-west, North North-East, and South.

Table 4. Avian species information retrieved from *All About Birds,* conservation statuses taken from the APBPC Management Plan.

Species	Habitat	Food Preference	Nesting	Behavior	Conservation Status
Setophaga discolor	Scrub	Insects	Shrub	Foliage gleaner	Declining
Spizella pusilla	Scrub	Insects	Ground	Ground forager	Common (Steep decline)
Pipilo erythrophthalmus	Scrub	Omnivore	Ground	Ground forager	Low
Sialia sialis	Grasslands	Insects	Cavity	Ground forager	Low
Tyrannus tyrannus	Grasslands	Insects	Tree	Flycatching	Low
Toxostoma rufum	Scrub	Omnivore	Shrub	Ground forager	Low

DISCUSSION

The primary goal of this experiment was to determine the significance of woody-shrub structure, particularly density and height of the dominant scrub oak species *Quercus ilicifolia* and *Q. prinoides*, on the avifauna community of the APB. I hypothesized that the avifaunal community would respond more positively to sites that fit their foraging habits, and that these would most likely be located in the middle of the height/density gradient. The avian community data reveals an increased number of species and individual birds in areas containing roughly 50% cover of *Quercus* spp. The average heights of *Quercus* spp. in these medium gradient areas was between 0.8 -1.5m (Table 2). However, these results rely heavily on the most common species Eastern Towhee at 40% abundance, Prairie Warbler at 33%, and Field Sparrow at 19% (Figure 2). With even less effect of the rarer ones of Eastern Blue Bird, Brown Thrasher, and Eastern Kingbird, all between 2-4% abundance (Figure 2). This could be due to a number of ecological factors that will be discussed below.

Most shrubland birds require a gradient of successional forest environments, ranging from barrens mostly populated by grasses and forbes to more mature stands of scrub-oaks and pitch-pine (Schlossberg et al. 2010, Akresh et al. 2014). These varying habitats provide different benefits for different species. For instance, an area like Kings Barrens provides small stature shrubs that are spread out, providing good nesting opportunities for birds like Field Sparrows or Prairie Warblers. Kings Barren also however, provides barrens that may appeal to Eastern Towhees who both forage and nest on the ground. What the mosaic of vegetation provides species with is multiple habitats that will confer better success across a range of different bird species, communities form around what birds will succeed more than others in that particular habitat. In Schlossberg et al.'s work in 2010 they found that birds responded both to the structure of the vegetation, preferring large shrubs or lower stature shrubs, as well as vegetation composition. Bried et al. (2011) mentions that while Brown Thrashers, Field Sparrows, and Prairie Warblers are good indicators, other birds like Eastern Towhees, Grey Catbirds, and Song Sparrows are more likely to use shrub-dominated habitats. This may in part explain why KBW, KBE, and Kings Barrens had such high species diversity and bird abundance. Birds that are specific to shorter stature shrubs, like Prairie Warblers, will occupy these shrublands, but they are not the only ones who will take advantage of the area. We do not know what other species were present at our sites because avian data collection was extremely focused on six shrubland species. Schlossberg et al.'s (2010) research also highlighted vegetation composition because there was a correlation for a handful of birds for factors like invasive species and overall species composition. Applicable to my research is the fact that Schlossberg et al. (2010) found no relation between Eastern Towhees and vegetation composition. This could explain in part the Eastern Towhees prominence across all of my plot sites. Schlossberg et al. (2010) also discussed in their results that the Eastern Towhee responding most positively for areas with high average heights of vegetation. It's possible that the Towhees have a preference for thickets and tall shrubs. Another reason as to why they were the only species of the six in my focus group to be recorded inhabiting the Water Tower site (Table 3). The correlation of specific vegetation and their heights with specific species abundances shows how shrubland birds are unique in their preferences for successional shrubland habitat. Thus, the main focus in shrubland habitat research should look towards habitat features shrubland birds prefer, and what kind of disturbances maintain these habitats. The identification and characterization of species-habitat relationships is vital for the implementation of effective habitat-based wildlife management (Bried et al. 2011).

A notable observation that I made in the field was that Eastern Bluebirds and Eastern Kingbirds I sighted were always sighted perched on dead pitch-pine trees. It's possible that both of these birds have a preference for the presence of the dead trees, using them to call from or even for homes. KBW and KBE were the only plots containing dead trees within the plot to perch on, while on the route to the Kings Barrens plot there were a few dead trees, however none within the plot. The Eastern Kingbirds could possibly be using these trees to hunt, whereas the Eastern Bluebirds may be using these trees to nest (Table 4).

Plant succession produces new and different habitats; however, it is vital that these stages occur in a gradient that produces a mosaic of vegetation compositions and structures across the landscapes. The more efforts conservation centers put into creating these mosaic habitats, through management plans, the more diverse and healthier the environments they conserve will be. Milne (1985) made quantitative observations abouts the APB's plant community characteristics, like composition and structure, and about the relationship of successional patterns to the abiotic environment. At the time such information was relatively unavailable. However, the Albany Pine Bush has since taken steps to better understand the valuable ecosystem they manage as is shown in an opinion article by Bried et al. (2014) titled "Why Pine Barrens Restoration Should Favor Barrens Over Pine". Nonetheless, Milne's work provides a useful baseline for what vegetation populations were present in the APB in 1985. Only 6 out of 20 of Milne's (1985) plots were characteristic of the pitch pine-scrub oak structure for pine barrens. A second distinct community type was large stands of Black locust, an invasive nitrogen fixing tree, most commonly found on sites of agricultural abandonment. One of the early management goals of the APBPC was to reduce amount of Black locust stands (APBPC 2017). The remaining samples were characteristic of mixed or emerging hardwood forests, consisting of deciduous trees, shrubs, and multiple species of pine. These areas usually showed evidence that they were at one-point barrens, but through suppression of disturbance factors deciduous trees were able to overtake the area transitioning into a mixed age forest (Milne 1985).

However, current management action undertaken by the APBPC has sought to return the APB to its characteristic communities in the pitch-pine scrub-oak ecosystems, ranging from open barrens to pitch-pine forests. Management aims for a goal of 2,000 acres of habitats that can be routinely maintained by prescribed fire (APBPC 2017). To begin this process management had to find the safest and most cost-effective way to restore overgrown stands to post-fire barrens, without endangering nearby urban developments with fire. Areas of overgrowth can harbor large amounts of fuel, old woody growth/leaves, that can feed a fire ultimately making it 10x worse than if it occurred in a properly regulated barren. This is successfully done through a mixture of mowing and use of herbicides, this combination initiates the early shrubland stage, characterized by 30-35% scrub-oak coverage (Bried et al. 2010). Our vegetation transects show how these numbers are close to be achieved at multiple sites, or simply that these are more mature sites that are nearing a time for a burn. Kings Barrens, KBE, and KBW all had *Quercus* coverage that was roughly 50%, indicating that within the next few years they would be viable sites for ABPPC fire treatment (Table 1). Blueberry Hill had previously been mowed, within 3 months of the start of this research, and then burned during the experiment; this treatment can be seen in the 25% coverage of *Quercus* shrubs (Table 1). The hope is that once initiated these areas can be maintained by regular intervals of prescribed fires.

Where, then, does this management plan leave shrubland birds? According to Bried et al. (2010) in order to properly execute habitat-based wildlife management it is vital to understand species-habitat relationships. With this in mind, Bried et al. (2010) determined that there are two primary methods that accurately can assess shrubland bird abundance: (1) is to include enough data points to cover roughly 3% of the study area combined with 5 or more visits to each point. (2) is to reduce the data points to 2% of the study area and increase the number of visits to at least 10. This is crucial to know for future studies looking at the abundance of shrubland birds as conservation practices increase in scale. Schlossberg et al. (2010) have already shown how variable shrubland bird species can be in their preferences of vegetational structure. One notable difference that Schlossberg et al. (2010) pointed out in their research is the preferences of Eastern Towhee's and Prairie Warblers. Eastern Towhee's are omnivores, they eat a variety of foods and nest on the ground, and are a common site in the APB (Table 3). On the other hand, Prairie Warbler's are a more specific species, requiring sparse scrub-oak barrens to build their nests in scrub-oaks, these scrub-oaks also provide prime areas for their gleaning food strategy (Table 3). Prairie Warblers have been a prime target for studies looking into the relationships between shrubland birds and their ever-dwindling habitat, and as such were my primary species of focus. Addition of the Eastern Towhee, Field Sparrow, Brown Thrasher, Eastern Bluebird, and Eastern Kingbird into my research was suggested by Jason Bried (Director of the APBPC). The Prairie Warbler thus served as a starting point for my research into the correlation between management practices, vegetation structure, and shrubland bird abundances.

A second goal of this experiment was to determine the viability of using a terrestrial laser scanner to determine woody-shrub characteristics as opposed to field measurements. I made use of terrestrial lidar to quantify shrub characteristics that are usually gathered using basic field measurements. I had hypothesized that the terrestrial scanner would be useful up to a point when shading and shrub interference reduced the accuracy of the scans. We found this to be true, as *Quercus* shrubs increased in density and size (Figure 1) scans became harder to mesh and therefore, harder to collect accurate data from. Terrestrial laser scanning (TLS) has already been used in multiple studies by Muir et al. (2018), Decuyper et al. (2018), and Olsoy et al. (2014) to attempt to characterize vegetative structure in study areas. The benefits of TLS can be seen in faster data collection and less observer error, however Muir et al. (2018) found that the set-up of the laser equipment and its transport could possibly take just as long as field measurements by an expert. In addition to this, when taking a single scan of an area not all attributes are scanned, for instance a partial scan of a tall tree, which leads to a reduction in accuracy. This problem can be solved by taking multiple scans of a single area and using reference points like reflective panels (or Styrofoam balls in my case) to later stitch together the point cloud of the area (Muir et al. 2018). TLS is thus still a work in progress in the field of conservation ecology and requires more research to determine more effective and accurate methods of gathering data. Decuyper et al. (2018) demonstrated the viability of TLS in their research of structural differences in forests of Ethiopia. They examined how conservation management practices affected the parameters of forest structure for intact forests, plantations, silvopasture and coffee forests. TLS was used to gather vertical and horizontal vegetative structure data such as canopy height, gap distribution, vegetative layers and the plant area volume density (PAVD). Olsoy et al. (2014) used TLS to attempt to quantify a change in biomass for dryland sagebrush ecosystems in the Western U.S. Their data showed that TLS is a successful tool in monitoring vegetative ecosystem change over an extended period of time and can be appropriated to fit multiple dryland ecosystems. However, Olsoy et al. (2014) also suggest that multiple scans may be necessary to properly acquire data about an area that has dense overgrowth vegetation. Despite our use of multiple scans when creating meshes of the separate plots there were still large discrepancies in the data between scan heights and manual field heights. The values were either lower, like the 0.20m difference at

KBE, or higher like the 0.70m difference at the Water Tower plot (Table 2). Use of the scanner was put to its real test at the Water Tower site, where adjustments were often required, i.e. removal of branches, tying down of shrubs, and even repositioning of our reference points. While vegetation density and shadowing reduce the possible number of areas where TLS can be put to use, I believe that as technology becomes more streamlined it will become more compact and stronger to the point where they can be used in areas of dense vegetation.

Anthropogenic activities continue to diminish the fragile inland shrubland ecosystems of the North Eastern United States it becomes more and more vital for research to be conducted on how to best manage the remaining shrublands. Shrubland birds have been declining throughout these habitats due to the effects of human activity and the reduction of viable nesting sites. The Prairie Warbler is a species of conservation concern due to the loss of its preferred habitat of natural pine and oak barrens, dune shrubs, and early successional scrub-oak habitat, including regenerating clear-cuts, and abandoned agricultural land due to developmental encroachment, habitat degradation, and the maturation of their successional habitats lacking prescribed fires. These migratory birds rely on these habitats to breed during the spring. The Prairie Warbler breeding range is almost completely restricted to the eastern U.S. from southern New England west to Indiana and Missouri and south to Texas and the Gulf Coast states (Wells 2007). The Albany Pine Bush Commission, in past years, have conducted population surveys in order to keep track of new fledglings and returning birds. By doing so they can keep track of populations and ensure that the habitat these birds need is available. While this initiative occurred mainly in 2009 and 2010, there has not been much update on the current populations of these birds. Research done by Akresh et al. (2015) into the preferences of Prairie Warblers showed that across a gradient of habitats, some being recently managed, some maturing, and some disturbed, the warblers preferred scrub oak habitat 4 or 5 years into its successional growth. Older birds were more site faithful and would return earlier to claim their preferred habitats. This would leave the newer, lesser habitats for younger males to use, possibly affecting their reproductive success or survival rate. However, with sites needing to be burned or mowed, birds would occasionally be pushed off of their habitat into the surrounding patches. Akresh et al. (2015) found no evidence of over-crowding of other habitats though and reasoned that the warblers would be able to make use of less suitable habitat until their preferred habitat was once again available. This shows again how important it is to take specific species behaviors into account when managing conservation areas. Within the APB scrub oak habitat, vegetation is found at different age and structures (Figure 1). Prairie Warblers were present across four out of the 5 plots, indicating good quality habitats, luckily under the management of the APBPC (Table 3).

Commented [SR1]: Very nice....

I believe that further research focused over a wider area, similar to Schlossberg et al.'s (2010) work, looking at a wider range of species would be valuable information for the APBPC as they continue to use prescribed fire burns in the Albany Pine Bush. Watching specific areas and monitoring species and individuals over a number of years would provide useful, and I believe positive, information about the well-being of one of the APB's most loved ecosystems.

ACKNOWLEDEMENTS

I would like to thank the Union College Student Research Grant for providing the funding necessary for this project. As well as Cole Belmont for his insight and access to Union Makerspace. Special thanks to Neil Gifford and Steve Campbell at the Albany Pine Bush Preserve for granting access to our study sites and providing knowledge on the habitats and communities. I would also like to thank Professor Jeffery Corbin for his support and advice about computational methods and Alyssa Silbey for helping me finishing our vegetation transects with me. Of course, none of this would have been possible without Professor Steven Rice for his support, knowledge, humor, and friendship.

REFERENCES

APBPC. (2017). Management Plan and Final Environmental Impact Statement for the Albany Pine Bush Preserve Update. Albany Pine Bush Preserve Commission, Albany, NY.

Akresh, M., King, D., & Brooks, R. (2015). Demographic response of a shrubland bird to habitat creation, succession, and disturbance in a dynamic landscape. *Forest Ecology and Management*, 336 (C), 72–80

Barnes, J. (2003). *Natural history of the Albany Pine Bush: Albany and Schenectady counties, New York, including a field guide and trail map*. Albany, N.Y: New York State Museum, University of the State of New York, State Education Dept.

Bried, J., & Gifford, N. (2010). Mowing and Herbicide of Scrub Oaks in Pine Barrens: Baseline Data (New York). *Ecological Restoration*, 28 (3), 245–248

Bried, J., Langwig, K., Dewan, A., & Gifford, N. (2011). Habitat associations and survey effort for shrubland birds in an urban pine barrens preserve. *Landscape and Urban Planning*, *99*(3-4), 218–225

Bried, J; Patterson, W; Gifford, N. (2014). Why Pine Barrens Restoration Should Favor Barrens Over Pine. *Restoration Ecology*, 22 (4), 442-446

Calders, K., Schenkels, T., Bartholomeus, H., Armston, J., Verbesselt, J., & Herold, M. (2015). Monitoring spring phenology with high temporal resolution terrestrial LiDAR measurements. *Agricultural and Forest Meteorology*, 203, 158–168

Cornell University (n.d.). Online bird guide, bird ID help, life history, bird sounds from Cornell. Retrieved from https://www.allaboutbirds.org/

Decuyper, M., Mulatu, K., Brede, B., Calders, K., Armston, J., Rozendaal, D., … Bongers, F. (2018). Assessing the structural differences between tropical forest types using Terrestrial Laser Scanning. *Forest Ecology and Management*, 429, 327–335

Milne, B. (1985). Upland Vegetational Gradients and Post-Fire Succession in the Albany Pine Bush, New York. *Bulletin of the Torrey Botanical Club*, 112 (1), 21-34

Muir, J; Phinn, S; Eyre, T, & Scarth, P. (2018) Measuring plot scale woodland structure using terrestrial laser scanning. *Remote Sensing in Ecology and Conservation*, 4 (4), 320-338

Olsoy, P., Glenn, N., Clark, P., & Derryberry, D. (2014). Aboveground total and green biomass of dryland shrub derived from terrestrial laser scanning. *ISPRS Journal of Photogrammetry and Remote Sensing*, 88 (C), 166–173

Olsoy, P; Forbey, J; Rachlow, J; Nobler, J; Glenn, N; & Shipley, L. (2015) Fearscapes: Mapping Functional Properties of Cover for Prey with Terrestrial LiDAR. *BioScience*, 65 (1), 74-80

Schlossberg, S., King, D., Chandler, R., & Mazzei, B. (2010). Regional Synthesis of Habitat Relationships in Shrubland Birds. *Journal of Wildlife Management*, *74*(7), 1513–1522

Tillman, D; Clark, M; Williams, D; Kimmel, K; Polasky, S & Packer, C. (2017). Future threats to biodiversity and pathways to their prevention. Nature, 73 (546), 73-81

Wells, J. (2007). *Birder's conservation handbook 100 North American birds at risk*. Princeton, N.J.: Princeton University Press.