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MONITORING BIRDS AND HABITAT IN EARLY-SUCCESSIONAL SITES IN CONNECTICUT

A Thesis Presented

by

BENJAMIN A. MAZZEI

Submitted to the Graduate School of the
University of Massachusetts Amherst in partial fulfillment
of the requirements for the degree of

MASTER OF SCIENCE

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Wildlife and Fisheries Conservation

MONITORING BIRDS AND HABITAT IN EARLY-SUCCESSIONAL SITES IN CONNECTICUT

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BENJAMIN A. MAZZEI

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David I. King, Chair

Stephen DeStefano, Member

Scott Schlossberg, Member

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DEDICATION

To those who wake up when it is still dark to venture out and hear the morning come alive.

ACKNOWLEDGMENTS

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Thanks to my wife, Erin, who endured many days and weekends of me looking at a computer and not doing much else.

ABSTRACT

MONITORING BIRDS AND HABITAT IN EARLY-SUCCESSIONAL SITES IN CONNECTICUT

DECEMBER 2008

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Early-successional bird species are showing alarming declines across the Northeast and particularly in New England. Utilizing limited resources to the best advantage of these declining bird species is a vital task for land managers. In 2006 and 2007, I collected bird abundance and habitat information from 87 points in early-successional habitat in Connecticut. The objective of this effort was to evaluate the relationships between the habitat variables collected at a plot using the point intercept method and the associated bird abundance at the plot. A second objective was to compare two different methods of characterizing early-successional habitat in explaining the variance in bird abundance. A plot-based method based on the BBIRD protocol from Montana Cooperative Wildlife Research Unit and the point intercept method were compared. Finally, I designed and created a database written in Microsoft Access which was used to standardize data entry, aid in the sharing of data and to calculate summary statistics to assist habitat managers in making conservation decisions.

The habitat variables were grouped according to composition and structure to analyze bird-habitat relationships. Low broadleaved shrubs, broadleaved shrubs, fern/forbs, conifers, broadleaved trees and invasives, as well as average height for shrubs and trees were used for the analysis. Nine focal early-successional species that are showing general trends of decline were chosen from the list of all birds seen or heard. Bird abundance and detectibility covariates were modeled with the habitat variables using N-mixture models (2004). Up to 24% of the variation of the best models (based upon AICc) was explained by the predictors I investigated. Five of the 9 birds showed a positive correlation to a shrub category variable. Fern/forbs, graminoids and invasives were found to exert less influence on the abundance of these scrub-shrub birds. Results indicated that the date of the survey affected the detectibility of only 5 of the species, and vegetation height only affected one of the species. Overall correlations indicate that these nine shrubland dependent species utilize a structurally complex habitat including broadleaved shrubs less 2 meters in height and than 2-5 meters in height and herbaceous forbs and graminoids. Invasive plants were found to be positively correlated to 2 of the 9 species possibly warranting additional work on the affects of these species on early-successional birds.

Thirty-one of the total 87 point count points were selected for the comparison between the BBIRD and point intercept method. I choose six focal early-successional species for the analysis: indigo bunting, blue-winged warbler, chestnut-sided warbler, yellow warbler, prairie warbler and the common yellowthroat. The point intercept and BBIRD methods explained on average the same amount of variability in the data, and models from each data set included nearly the same number of variables, on average. Thus, we conclude these two vegetation sampling methodologies were essentially equivalent in summarizing important characteristics of scrub-shrub bird habitats. In the field, the BBIRD method took on average almost twice as long to complete as the point intercept method. Because in this study the two methods were similar in the amount of the bird abundance variance they explained and because the BBIRD method takes substantially longer to complete, I recommend that the point intercept method be considered an acceptable method for managers to use to characterize the relationships between early-successional bird species and their habitat.

An important step in the successful conservation of declining early-successional bird species is the creation of database management systems and the coordination and cooperation amongst agencies that can stem from the use of these databases. The database I created ensures standardized data entry for data collected from multiple sites over many years. The database takes this data and can be queried for whatever particular information a manager needs. Percent cover of vegetation and invasives, average height of vegetation, and bird abundance are summarized and graphically displayed by the database. Ease of operation, ability to query and ability to share the information makes this database an important tool in the successful conservation of declining species.

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CHAPTER 1

HABITAT ASSOCIATIONS OF SCRUB-SHRUB BIRDS IN CONNECTICUT

1.1 Introduction

Early-successional habitat across much of New England has decreased in amount over the last century (Askins 2001, Thompson and Degraaf 2001, Trani et al. 2001, Brooks 2003, Dettmers 2003). Declines in early-successional habitats are associated with declines in bird species that use these early-successional habitats (Vickery 1991, Askins 1993, Hunter et al. 2001). A large portion of the birds that use early-successional habitats are habitat specialists that are not present in adjacent mature forests (Askins 1993, Hunter et al 2001, Degraaf and Yamasaki 2003). Early-successional birds are specific to the structure of the vegetation at a site and will find the habitat unsuitable as the composition and height at a site continue to grow, usually within 8-10 years after the initial disturbance for clearcuts (Brawn et al. 2001, Thompson and DeGraaf 2001, Trani et al 2001, Schlossberg and King *In Press*).

Early-successional habitat has historically been created through fire, wind events, disease, beaver flooding and anthropogenic influences (Brawn et al 2001, Thompson and DeGraaf 2001, Schlossberg and King 2007). Because some of these processes (e.g. fire, beaver flooding) present risks to people and property in populated areas and others are less predictable in their occurrence (wind events, disease), anthropogenic methods have played an increasingly important role in creating and maintaining early-successional habitat (Schulte and Neimi 1998, Thompson and DeGraaf 2001, Schlossberg and King 2007**).** Today, habitat managers are largely responsible for the creation and maintenance of this vital scrub-shrub community.

The Northeast in particular, has shown substantial declines in shrubland-dependent species (Witham and Hunter 1992, Livaitis 2001). In response to the loss of both shrubland-dependent birds and their associated habitat, state, federal and non-profit agencies are increasing the amount of resources that are being allocated for the conservation of these species and their habitat (Defalco et al 2005, U.S.NABCI 2007). It is vital then to create the most species appropriate habitat that will benefit the largest number of shrubland specialists and to understand the microhabitat variables in enough detail to focus management at a particular site to benefit the conservation of a declining species. Recent observations indicate that scrub-shrub bird communities differ among types of scrub-shrub habitats and management regimes (Askins 2001, Bulluck and Buehler 2006, King et al. 2008).

Because scrub-shrub birds differ in their relationship to habitat conditions and management regime, mangers benefit from quantitative information on scrub-shrub bird habitat use and their response to management. A major problem with the successful conservation of threatened bird species is the proper determination of what habitat is important (Sherry and Holmes, 1996). For managers to understand and evaluate the effect of their practices, it is important for them to have quantitative information on what habitat conditions are correlated with scrub-shrub birds (U.S.NABCI 2007). If we can determine that a suite of variables, in terms of both structure and composition, have a strong relationship with specific species of birds that we are interested in conserving, then we can manage the appropriate habitat in a way that best serves their recovery.

My study sought to answer the following question: Which habitat variables or groups of habitat variables explain the most variance in scrub-shrub bird abundance. This information will help managers focus their efforts to create suites of vegetation types at sites to benefit specific early-successional birds of conservation need.

1.2 Study area and methods

1.2.1 Study area

The study was undertaken at 17 scrub-shrub sites distributed across the state of Connecticut. Connecticut is the second smallest New England state (12,975 km^2) but has the second largest population in New England. The Eastern, Central, and Southern portions of the state are fairly flat and generally under100 meters above sea level while the Northwest of the state is quite hilly with elevation up to 610 meters above sea level. As a result, study sites varied in topography from one end of the state to the other. Some sites consisted of level floodplain fields along the Connecticut River while others were sloped shrublands found in the foothills of the Berkshires in the Northwest of the state.

Sites were either state owned lands or part of a program called the Land-owner Incentive Program ("LIP"), which is a program that provides federal money administered through the state to private landowners. LIP encourages state and private landowner partnerships through agreements that include matching grant finances to manage the private land for species at risk. The LIP sites were selected based upon the most significant potential impact for species that are on the Connecticut's endangered, special concern and watch lists. The state-owned land consists of Wilderness Management Areas, State Forests, and State Parks.

Scrub-shrub habitats in the form of "wildlife openings" were created from reclaimed apple orchards, abandoned agricultural fields, or clearcuts. Mechanical treatments such as mowing and cutting as well as chemical applications of herbicide were implemented to maintain early seral stages at the wildlife openings on a 4-10 year cycle. More frequent treatments are carried out at sites that contain high cover of invasive species. Treatments are generally undertaken outside of the breeding season for early-successional birds though some limited agricultural haying activities on grassland dominated areas does occur between June-August. The sites generally consist of mixture of woody species including deciduous (*Prunus, Acer, Betula, Quercus*) and coniferous (*Juniperus, Pinus*) saplings and shrubs, some mixed grasses and sedges, invasive species and other herbaceous cover (*Rubus spp., Soladigo spp.*), less than 1.5 meters in height. Graminoids at the sites are generally a mix of warm season grasses (*Andropogon sp., Panicum sp.*) and cold season grasses (*Phleum sp., Festuca sp., Poa sp., Dactylis sp., Phalaris sp.*) with some rushes (*Juncus sp*) and sedges (*Carax sp.).* Sites ranged in size from 3.2 – 162 ha in size, and were therefore larger than the minimum size for which area effects occur in these scrub-shrub bird species (Schlossberg and King 2007).

1.2.2 Bird surveys

Birds were sampled from May 20 through July 1, 2006 and 2007 at 87 points by a single observed using 10-minute, 50-m. radius point counts. Each point was visied on 3 seperate days between the hours of 0530 and 0930. Each point was surveyed buring early, mid, and late morning to help account for detectibility of birds that sing more strongly at various times of morning (Ralph et al. 1997). Points within sites were ≥250 meters apart. Surveys were not conducted during weather that would affect the reliability of the count, such as steady rain or high wind.

1.2.3 Vegetation sampling

Habitat characteristics were measured at all 87 bird sampling points during July through August 2006 and 2007 using a modified point intercept method (King et al. 2008). This method has been shown to be an efficient and effective methodology that compares favorably with other widely used methods for characterizing scrub-shrub habitats (Chapter 2). Four 50-m. transects are established at each point radiating in the cardinal directions from the center of the bird survey point. At 10 m. increments along each transect, observers proceeded left or right of the centerline as determined by a coin-toss for a random number of meters between 0 and 25, selected using the random-number table, to a sampling point at which maximum vegetation height and species were recorded. We used a sighting tube with cross hairs to determine which vegetation species was intercepted (James and Shugart 1970).

1.2.4 Statistical analysis

Habitat data for the point intercept method were placed into groups based upon commonalities in growth and structure and to a lesser degree frequency of occurrence (King et al. 2008). Five categories of cover were created including low broadleaved shrubs (<2 m tall), broadleaved shrubs (2-5m tall), broadleaved trees (>5 m tall), forbs (including ferns), invasives and graminoids (including sedges and rushes) (King el al 2008). In addition, we included average height of shrubs and trees for each plot. Cover of conifers (trees and shrubs combined) was left out for this analysis because of its low occurrence within the plots.

Variables were tested to check for normality and log-transformed as appropriate. To address collinearity within the habitat variables, Pearson correlations were computed, and if variables were found to be correlated ($r > 0.70$), the member of the pair that had a higer Akaike's information criterion, AIC, was dropped.

I accounted for individuals present but not detected by using N-mixture models (Royle 2004) to limit bias that can stem from using raw point counts (Thompson 2002). N-mixture models allow the inclusion of covariates that influence abundance and detectibility. The modeling was done in the free software package R and used the repeated count data to estimate detection probability assuming a binomial distribution while at the same time modeling abundance in the poisson family of distributions (Royle 2004, Chandler 2006). Model selection was based upon a manual forward-selection process and a lowest corrected Akaike's information criterion AIC (Burnham and Anderson 2002). Univariate models of bird abundance as a function of each variable were compared to the null model. If the model had a lower AIC_c than the null model, the covariate was included in the next round. I modeled bird abundance as a function of habitat variables, and as a function of date, shrubs height and tree height (observer was constant through out data collection so it was not included).

The model tests a difference in abundance among the two years allowing the model to predict abundance seperately for each year. Including interactions of the other variables with year, allowed the model to estimate the coefficients for each year, which is equal to the results if the data was analyzed seperately for each year, except that it is more parsimonious and allows a direct test of differences among years (Royle 2005).

1.3 Results

I detected 2,444 birds of 84 species during the study. Of these, nine of the most abundant scrub-shrub species were included in the analyses: blue-winged warbler, common yellowthroat, chestnut-sided warbler, eastern towhee, field sparrow, gray catbird, indigo bunting, prairie warbler and yellow warbler. These nine scrub-shrub birds are of concern because they are birds that are showing general trends of decline according to the Breeding Bird Survey (BBS) and are dependent upon early-successional habitats that are declining regionally (Trani et al. 2001).

Predictor variables of abundance varied amongst the 9 focal species (Table 1.2). Abundance of 5 of the 9 species was positively related to one or more shrub variables (Table 1.3). Blue-winged warbler, eastern towhee and prairie warbler were positively associated with low broadleaved shrubs, prairie warbler and indigo bunting were positively associated with broadleaved shrub, and common yellowthroat, chestnut-sided warbler and eastern towhee were positively correlated with height of shrubs (Table 1.3).

Fern/forb, graminoids and invasives were found to exert less influence on the abundance of these scrub-shrub birds. The most supported models for chestnut-sided warblers and gray catbirds showed the species negatively correlated with graminoids, while field sparrows were positively correlated with graminoids (Table 1.3). The covariate fern/forb was found in the best models for blue-winged warbler and field sparrow, indicating that these species were negatively related with ferns/forbs. Invasives were found in the top model for just two species, the yellow warbler and gray catbird, which were positively related to percent cover of invasives.

Up to 24% of the variation in abundance, (based upon AIC_c) was explained by the predictors I investigated, though the most supported models for some species (field sparrow and indigo bunting) did not explain as much variation (Table 1.2). The $NagR^2$ values indicate that other predictors not investigated in this study (i.e. landscape variables, patch size), maybe explaining additional variation in bird abundance and worthwhile to include in future analysis. Common yellowthroat was the only species for which habitat associations differed between survey years (Table 1.3).

Although overall detectibility was not strongly affected by any of the covariates, detection probabilities for individual focal species were influenced by date and vegetation height (Table 1.3). The detection probability of common yellowthroats was positively correlated with the height of the vegetation and the date of the survey, and detection rates of blue-winged warblers, yellow warblers, prairie warblers and indigo bunting decreased with survey date (Table 1.3).

1.4 Discussion

In general, the bird and habitat correlations that I found in this study were supported by similar observations from other studies on early-successional birds. As I expected for this group of shrubland-dependent species, a shrub-category variable was significant for over half of the species. For example, chestnut-sided warblers, praire warblers, gray catbirds, and indigo buntings in our study were found to be positively influenced by shrub cover as well in Maine (Titterington et al. 1979, Hagan and Meehan 2002), in Vermont (Thompson and Capen 1988) and in Minnesota (Niemi and Hanowski 1984). The results from this study further indicate that managers should try to maintain habitat with shrubs less than 2 meters in height, which were positively correlated with blue-winged warblers, eastern towhees and praire warblers, as well as shrubs that are 2-5 meters in height, which were positively correlated with chestnut-sided warblers and indigo buntings. This heterogenous shrub layer could be acheived by focusing on rotating management (i.e. mowing, burning) between portions of a unit in a given year.

Two species, yellow warbler and gray catbird, showed a positive correlation with invasive species. King et al. (2008) also reported a positive correlation between scrub-shrub birds (although different species; blue-winged warbler and indigo buntings), and invasives. This positive correlation with invasives species is interesting because most studies indicate that invasive plants negatively affect breeding birds (Benoit and Askins 1999, Lundgren et al 2004, Schmidt 2005). I did not collect data on bird fitness (e.g. nesting success); therefore it is possible that the negative effects of invasive plants could still be manifest on bird reproduction, despite positive effects on abundance, which would constitute an “ecological trap”. Alternatively, it is possible that gray catbirds and yellow warblers could be benefiting from nutritional value of the soft mast or increased structure for nesting or predator avoidance, as suggested for gray catbirds nesting in invasives (Johnson and Best, 1980, Schmidt et al. 2005).

Contrary to my expectations, detectibility appeared to be largely unaffected by habitat characteristics (Johnson 1995, Thompson et al. 1998; Nichols et al. 2000, Anderson 2001; Table 1.2). Common yellowthroat was the only species whose detectibility was positively affected by vegetation height, potentially because of its tendency to utilize shrubs to call from, increasing detectibility. Of the other covariates I used to adjust for detectibility (Table 1.1), only the date of the survey was correlated with the abundance estimates (5 of the 9 species showed this trend, table 1.2), probably due to the reported reduction of song later in the season (Slagsvold 1977, Hau 1998). This emphasizes the importance of conducting surveys during the early part of the breeding season and incorporating repeated visits to a site. (Thompson and Schwalback 1995, Betts et al 2005). My finding that habitat structure had little effect on detectibility suggests that uncorrected point counts are generally a reliable survey method for studies with relatively similar habitat that require relative abundance among habitats or conditions and not actual abundance estimates (Bart et al 2004, Betts et al 2005, Johnson 2008).

Although generally scrub-shrub birds in this study were positively correlated with different heights of shrub cover, some where positively correlated with low shrubs, others with high shrubs, and some with other habitat variables, like forb or grass cover and even invasives. This presents managers with the question of how to manage habitat for scrub-shrub birds at these sites, given that many species have divergent habitat needs. Some potential strategies would be to maintain a variety of different conditions by including different types of scrub-shrub habitats such as reclaimed old fields and clearcuts, which accommodate different bird species (Bulluck and Buehler 2006, King et al. 2008), employing different vegetation management methods, such as mechanical treatments versus fire, which are known to create different habitat conditions (Chandler 2006), and maintaining habitat patches in different stages of succession, which differ in habitat conditions and bird species composition (DeGraaf 1991, Schlossberg and King *In Press*). The results from this study indicate that managers should focus on creating a mosaic of vegetation structure within a site which includes some grasses, forbs and residual canopy trees as well as a high percentage of shrub species. Creating a heterogeneous vegetation complex comprised of mixed species and various height forms will benefit the largest number of declining shrubland dependent species (DeGraaf and Yamasaki, 2003). If resources are available, the habitat complex at specific sites can be transitioned across the vegetation gradient from more broadleaved trees for singing perches which has been shown to directly benefit species like the indigo bunting (Yahner 2003) to more open habitat for species such as field sparrow (Schlossberg and King 2007).

Table 1.1

Covariates used in the n-mixture and abundance analysis that influence bird abundance and bird detectibility.

Abundance covariates	**Detectibility covariates**
low broadleaved shrub cover	date
broadleaved shrub cover	height shrubs
broadleaved tree cover	height trees
invasives cover	
graminoids cover	
fern/forb cover	
height of shrubs	
height of trees	
year	

Table 1.2
Most supported models and models within a delta 2 of best models showing the amount of variance explained (nagR2) and corrected AICc. Covariates in bold are variables affecting detectibility while all others were used to determine affect on abundance.

Species	**Supported models**	**nagR^2**	**AIC$_c$**	**ΔAIC$_c$**	***w*$_i$**
Chestnut-sided warbler	Height shrub+graminoid	11.4	527.86	0	0.22
	Height shrub+graminoids+broadleaved tree	12.4	528.00	0.14	0.21
	Height shrub+low broadleaved shrub+broadleaved tree	12.1	528.62	0.75	0.15
	Height shrub+broadleaved tree	10.6	529.25	1.39	0.11
Blue-winged warbler	Low broadleaved shrub+Fern/forb + *Date*	12.8	627.58	0	0.37
	Low broadleaved shrub+*Date+Height shrub*	12.1	628.84	1.26	0.20
	Low broadleaved shrub+*Date*	10.8	629.29	1.72	0.16
Field sparrow	Fern/forb+Graminoid	3.6	410.70	0	0.15
	Fern/forb	2.1	410.99	0.30	0.12
	Low broadleaved shrub	2.03	411.05	0.36	0.12
	Fern/forb+Low broadleaved shrub	2.9	411.70	1.00	0.09
Eastern Towhee	Low broadleaved shrub+Height shrub	24.3	657.23	0	0.23
	Low broadleaved shrub+Height shrub+Broadleaved tree	24.9	657.97	0.75	0.16
	Low broadleaved shrub+Graminoid	23.9	658.01	0.78	0.16
	Low broadleaved shrub+Height shrub+Graminoid	25.6	658.53	1.30	0.12
	Low broadleaved shrub+Height shrub+Fern/forb	24.6	658.57	1.34	0.12
Yellow warbler	Invasives+Broadleaved tree+*Date*	21.6	728.04	0	0.48
	Invasives+Height trees+*Date*	21.1	729.21	1.17	0.274
	Invasives+Broadleaved tree+Graminoid+*Date*	21.8	729.92	1.89	0.19
Gray catbird	Invasives+Graminoid	14.0	899.25	0	0.47
	Invasives+Graminoid+*Height shrub*	14.2	900.92	1.67	0.21
Common yellowthroat	Year + *Date + Height shrubs*	10.9	1067.37	0	0.51
Prairie warbler	Low broadleaved shrub + Broadleaved shrub + *Date*	24.4	295.81	0	0.28
	Low broadleaved shrub+Broadleaved shrub+Invasives	23.9	296.61	0.80	0.197
	LblshBlsh.Hgtlblsh I think you need to spell this out. Also, what does the "." Signify?	23.9	296.68	0.87	0.18
	Low broadleaved shrub+Broadleaved shrub	22.7	296.73	0.92	0.17
Indigo bunting	Broadleaved shrub + *Date*	3.7	587.76	0	0.21
	Date	2.14	588.35	0.58	0.16
	Broadleaved shrub	1.61	589.24	1.48	0.10

Table 1.3

Covariates in best models showing regression coefficients and standard error.

Species	Variables	Coefficients	Standard Error
Chestnut-sided warbler	height shrub	0.195	2.84028E-05
Dendroica pensylvanica			
	graminoid	-0.117	9.14603E-06
Blue-winged warbler	low broadleaved shrub	0.191	4.51961E-05
Vermivora pinus			
	fern/forb	-0.013	2.14E-09
	date	-0.018	1.72E-09
Field sparrow	fern/forb	-0.016	5.87E-09
Spizella pusilla			
	graminoid	0.097	1.64819E-05
Eastern towhee	height shrub		1.49074E-06
Piplio eurythropthalmus		0.096	
	low broadleaved shrub	0.425	5.06199E-05
Yellow warbler	Invasives	0.315	2.70839E-05
Dendroica petechia			
	broadleaved tree	-0.211	2.03769E-05
	date	-0.026	2.38E-09
Gray catbird			1.33493E-06
Dumetella carolinenesis	graminoid	-0.116	
	invasives	0.185	1.05971E-05
Common yellowthroat	year	-0.403	0.000417288
Geothylpis trichas			
	date	0.015	5.48E-10
	height shrub	0.112	5.17176E-06
Praire warbler	low broadleaved shrub	0.562	0.000641767
Dendroica discolor			
	broadleaved shrub	0.429	0.000319298
	date	-0.021	2.03464E-08
Indigo bunting	broadleaved shrub	0.038	0.000187282
Passerina cyanea			
	date	-0.014	3.19E-09

CHAPTER 2

A COMPARISON OF TECHNIQUES FOR SAMPLING BIRD HABITAT IN SCRUB-SHRUB SITES IN CONNECTICUT

2.1 Introduction

Scrub-shrub habitat and many of the associated birds have declined across much of North America (Askins 2001, Brooks 2003, Dettmers 2003, Noss et al 1995, Thompson and DeGraaf 2001, Trani et al. 2001). A large proportion of the birds that use early-successional habitats are habitat specialists that are not present in adjacent mature forests (Askins 1993, Degraaf and Yamasaki 2003, Hunter et al 2001). The Northeast in particular has shown substantial declines in shrubland-dependent species (Carter et al 2000, Witham and Hunter 1992, Livaitis 2001). Because early-successional habitats are by their nature ephemeral, regular management is required for their maintenance. An understanding of how management affects habitat and bird abundance is necessary to efficiently allocate scarce management resources.

A major problem with the successful conservation of threatened bird species is the proper determination of what habitat is important (Sherry and Holmes 1996). Thus, for managers to understand and evaluate the effect of their practices, it is important for them to have quantitative information on habitat conditions. This is recognized by the Partners in Flight Research Working Group, who have identified the determination of the most efficient, manner to evaluate critical habitat for declining bird species, in terms of labor, money and methods, as a critical research priority in the next decade (Donovan et al. 2002). Given the variety of methods researchers are using to evaluate habitat characteristics that affect abundance (Jones 2001, Johnson 2007), what method should be employed to most accurately and efficiently record habitat characteristics?

James and Shugart (1970) first proposed that researchers use a standardized protocol for sampling vegetation data in forested habitat to increase the value of the Breeding Bird Censuses and because how the habitat is sampled influences the results and make comparisons among studies difficult. Noon (1979) and Rotenberry and Wiens (1980) proposed to standardize the types of sampling procedures used in forested habitats (e.g James and Shugart 1970, Mueller-Dombois and Ellenberg 1974) for application to other habitats. For example, researchers at the Montana Cooperative Wildlife Research Unit have modified their Breeding Biology Research and Monitoring Database (BBIRD) protocol, originally developed for sampling forested habitats, for use in scrub-shrub habitats. This method, referred to as "BBIRD," uses nested circular plots to measure a wide variety of habitat variables (Montana Coop. Wildlife Res. Un. 1997, Rodewald and Vitz 2005).

While the BBIRD method provides a standardized methodology for habitat characterization, it requires the investment of substantially larger amounts of time and labor than other methods. An alternative to these "plot-based" methods is the point intercept method of classifying vegetation. The point intercept method is used to determine species cover and height in early-successional habitats by taking 20 random vegetation samples along transects running in the cardinal directions within a 50 meter plot (Caratti 2006). According to Mueller-Dombois and Ellenberg (1974), using the cover of different vegetation types from a site is an acceptable method to compare abundances of different plant species (Whittaker 1975). When compared with similar vegetation methods, point intercept method shows the same degree of precision but with less overall sampling time (Floyd and Anderson 1987). The point intercept method is considered more efficient than other techniques (line intercept and quadrat techniques) when cover estimates of the vegetation community are desired (Floyd and Anderson 1987) and is an effective method for characterizing bird habitat selection in northeastern scrub-shrub habitats (King et al. 2008).

Because resources are limited in regards to field research, any methodology that yields an equivalent amount of information with less labor is beneficial. If the more intensive BBIRD method does not result in clearer correlations between habitat parameters at a site and the birds present (James, 1971, Mannan and Meslow 1984), then the adoption of a simpler and more efficient system, such as the point intercept method, might be justified. My research was undertaken to determine the effectiveness and efficiency of the point intercept method of habitat characterization versus the BBIRD method for explaining variation in habitat and bird abundance for scrub-shrub sites. Specifically, we tested the following null hypotheses: 1. There is no difference in the amount of variability in habitat characteristics among sites accounted for by the point intercept method and the plot-based method, and 2. There is no difference in the amount of variability in bird abundance among points accounted for by the point intercept method versus the plot-based method.

2.2 Study area and methods

2.2.1 Study area

The study was undertaken at scrub-shrub sites across the state of Connecticut. The Eastern, Central, and Southern portions of the state are fairly flat with large areas no more than a 100 meters above sea level while the Northwest is quite hilly with elevation up to 610 meters above sea level. As a result, study sites varied in topography from one end of the state to the other, from level floodplain fields along the Connecticut River to fairly sloped uplands found in the foothills of the Berkshires in the Northwest of the state (Table 2.7).

Bird and habitat information was collected at 31 points at 17 sites which were either state-owned lands or private lands managed as part of the Landowner Incentive Program (LIP) which provides federal money administered through the state to private landowners. LIP encourages state and private landowner partnerships through the signing of a contract that includes matching grant finances to manage the private land for species at risk. The LIP sites were selected by the Connecticut Department of Environmental Protection based upon the most significant potential impact for species that are on the Connecticut's endangered, special concern and watch lists. The state-owned land consists of Wilderness Management Areas, State Forests, and State Parks.

Wildlife openings for the state and private sites were created from reclaimed apple orchards, abandoned agricultural fields, or clearcuts. Mechanical treatments such as mowing and cutting as well as chemical applications of herbicide are implemented on a 3-6 year cycle to maintain early seral stages. More frequent treatments occur at sites that contain high cover of invasive species. Treatments are generally undertaken outside of the breeding season for early-successional birds, though limited haying on grassland areas occurs between June and August. Graminoids at the sites are generally a mix of warm season grasses (*Andropogon spp., Panicum spp.*) and cold season grasses (*Phleum spp., Festuca spp., Poa spp., Dactylis spp., Phalaris spp.*) with some rushes (*Juncus spp.*) and sedges (*Carax spp.).* The sites generally consist of mixed tree and shrub species including, *Prunus spp., Acer spp., Betula spp., Quercus spp.* and coniferous (*Juniperus, Pinus spp.*), invasive species, *Rubus spp.* and other herbaceous cover including (*Soladigo spp*.) less than 1.5 meters in height. .

2.2.2 Bird surveys

Birds were sampled from May 20 through July 1, 2006 and 2007 at 87 points by a single observed using 10-minute, 50-m. radius point counts. Each point was visied on 3 seperate days between the hours of 0530 and 0930. Each point was surveyed buring early, mid, and late morning to help account for detectibility of birds that sing more strongly at various times of morning (Ralph et al. 1997). Points within sites were ≥250 meters apart. Surveys were not conducted during weather that would affect the reliability of the count, such as steady rain or high wind. These points were an arbitrarily selected subset of the points at which that data in Chapter 1 were collected. Habitat characteristics were measured at all 31 bird sampling points using both the BBIRD method and the point intercept method. One observer completed all of the vegetation measurements. Time to complete each method for each point was recorded for both methods.

2.2.3 BBIRD method

This method involved setting up four circular 11.3-meter radius plots within the area of the point count at all 31 points where bird abundance was measured. One plot was set directly over the center of the bird point count and the other three were centered 30 meters from the center point 120 degrees apart. The plots are used to count the stems of shrubs and trees (>8” dbh). Shrubs were only counted on plants that were at least 50 cm in height and then only counted at 10 cm above the ground. A stake placed in the center of the plot and rope was used to facilitate accurate counting of shrub stems. The individual species of trees and number of the individual tree species was counted in the plots for the tree variable. In addition, ocular estimates of percent cover were taken in each of the plots for the following: green, shrub, forb, fern, water, moss, downed log, brush, rock and graminoid. In the addition to the measurements taken in the plots, the BBIRD method also utilizes the point-centered quarter method (PCQM) (Mueller-Dombois and Ellenberg 1974), at each of the four plots at each bird survey point to estimate tree and shrub density. The PCQM protocol measures the closest shrub, distance to the species, its height, width and perpendicular width. For PCQM and trees the closest tree species, distance to it, its height, canopy, crown width and DBH were measured.

2.2.4 Point Intercept Method

The point intercept method we used was similar to that used by King et al. (2008) and is conducted by establishing four 50-meter transects radiating in the cardinal directions from each bird survey point. At 10 meter increments along each transect, observers proceeded left or right of the centerline as determined by a coin-toss for a random number of meters between 0 and 25, selected using the random-number table, to a sampling point at which the species type and maximum vegetation height of the intercepted species were recorded. We used a sighting tube with cross hairs to determine which vegetation species was intercepted (James and Shugart 1970). A total of 20 measurements are taken per bird survey point, and percentage cover of different species or other substrates is calculated as the number of contacts with that substrate divided by 20.

2.2.5 Statistical analysis

The number of birds counted was averaged over the three visits for each bird species at each point, and those averages were used as the dependent variables in the analyses. Because bird detections from the point counts are actually a function of abundance and detectibility, some have argued that raw counts should be corrected for detectibility (Rosenstock et al. 2002). Since the goal of this research was to compare the relative performance of the two habitat sampling methods, and we used the same bird data for both analyses, we did not anticipate that detectibility would affect our results, and thus did not adjust the counts for detectibility (Johnson 2008). Only focal scrub-shrub species, as defined by Schlossberg and King 2007, encountered at ≥65% of points were included in the analyses. Six bird species were included in the analysis: blue-winged warbler (*Vermivora pinus*), common yellowthroat (*Geothylpis trichas*), eastern towhee (*Piplio eurythropthalmus*), gray catbird (*Dumetella carolinenesis*), indigo bunting (*Passerina cyanea*) and yellow warbler (*Dendroica petechia*). These six scrub-shrub birds are of concern because they are birds that are showing general trends of decline according to the Breeding Bird Survey (BBS) and are dependent upon early-successional habitats that are declining regionally (Trani et al. 2001).

Habitat data for the point intercept method was placed into groups based upon commonalities in growth and structure (King et al. 2008). Six categories of cover were created including low broadleaved shrubs (<2 m tall), broadleaved shrubs (2-5m tall), broadleaved trees (>5 m tall), cover of conifers (trees and shrubs combined), forbs (including ferns) and graminoids (including sedges and rushes) (King et al. 2008). For each data set, we calculated the average height, so a total of twelve independent variables were used for the point intercept method portion of the analysis.

The BBIRD data was grouped according to the different types of habitat data that were collected. Variables collected were sum of shrub stems (>50 cm in height and then counted at 10 cm), average cover of green vegetation, average cover of graminoids, average cover of shrubs, average cover of forbs and sum of tree stems. Other variables listed in the BBIRD protocol were also measured but were either combined with similar variables (e.g. average cover of graminoids= average cover of grass,sedge and rush) because of low occurrence across sites or left out for this analysis because of the lack of power from the low occurrence of data within sites (e.g. average cover of water).

Additional variables obtained from BBIRD protocol include the following, which are from the point centered quarter method (PCQM) of estimating density (Mueller-Dombois and Ellenberg 1974): Density of shrubs, average height of shrubs, average width of shrubs, average perpendicular width of shrubs, density of trees, average height of trees, average canopy cover of trees, average diameter at breast height (DBH) and average tree crown width. Because of the large number of variables obtained from the BBIRD sampling procedure, I computed Pearson correlations, and if variables were found to be correlated ($r^2 \geq .60$), I retained the variable with the lower

AIC_c value. Variables that were included, as well as the variables that were dropped from the BBIRD are presented in Table 2.1**.** The way in which I interpreted and grouped the point intercept method data was baed off of the work of King and was an arbitrary decision. Had I grouped the point intercept method variables that were analogs for the BBIRD variables from Table 2.1, it is possible that the habitat conditions indicated by the models for each species would have been more similar.

To address the question of whether BBIRD and point intercept method measure the same information, a table was created, Table 2.1, to determine which variables from both vegetation methods where analogous to each other, and the BBIRD habitat variables were correlated with analogous variables from the point intercept method. BBIRD variables were compared with the smaller number of the point intercept method variables and then variables that were determined to measure the same basic habitat information were selected as analogous pairs. Analogous variables for the two methods where than plotted against each other in the program R, using the scatter plot function and analyzed using a Pearson correlation matrix, to determine how closely the variables were correlated.

A principle components analysis (PCA) was conducted separately on the BBIRD and point intercept method data to compare the structure of each data set and how the variables grouped within the loadings. The PCA analysis was run using the free software package R (McGarigal 2008).

To compare the relative effectiveness of each method in summarizing bird habitat data, regressions of mean avian abundance with independent variables from point intercept method and BBIRD were run separately in an all subsets general linear model (McGarigal, 2008) using the statistical package R. The all subsets function runs a series of regressions with the independent variables and narrows down the models to find a minimally adequate model. The all subsets function also selects the predictors which drive the model selection (McGarigal 2008). My analysis bases the model comparison on the Akaike Information Criterion corrected for small sample size (AICc) (Anderson et al 2001). AICc is a preferable method to select models because it accounts for both fit and model complexity (Franklin et al 2001, Johnson and Omland 2004). Once I obtained a minimally adequate model for each of the six birds in the study for each of the habitat methods, I compared the AICc between the BBIRD and point intercept method for each of the six scrub-shrub birds, as well as the number of terms included in the minimally adequate model.

Next, I looked at the importance of the predictors to find out what variables were driving the relationships between the birds and habitat. The variable importance selection for this analysis was based on the weight of evidence across all models containing each variable (McGarigal 2008).

2.3 Results

I found significant correlations for six of the ten analogous variables between the BBIRD and the point intercept methods, and correlations for two more were marginally significant ($0.05<P<0.10$). The correlation matrix indicated a positive correlation for the following analogous pairs: cover of shrubs, cover of graminoids, cover of shrubs and sum of shrub stems, cover of trees and average crown, sum of tree stems and cover of trees, and tree height (Table 2.2). The other four analogous variable pairs, (cover of green, cover of forbs, density of shrubs and cover of shrubs, and height of shrubs) showed a lower degree of correlation (Table 2.2).

The PCA results indicated that both of the habitat datasets, BBIRD and point intercept method, accounted for similar amounts of the variation in the first three axes (Table 2.3). Neither the comparison between the individual variation for each of the first three PC loadings or the cumulative variation explained by the first three PC loadings demonstrated significant differences in the variance and structure of the data for both methods (Table 2.3). Furthremore, the point intercept and BBIRD methods explained on average the same amount of variability in the data, as indicated by the similar AICc values for minimally adequate variables (Table 2.4), and models from each data set included nearly the same number of variables, on average.

Variable importance for each method helped to further determine whether the two methods describe the same habitat (Table 2.5 and table 2.6). BBIRD had tree density >350 cm and a shrub variable (either average shrub cover, average shrub height, sum of shrubs, average width of shrubs or density of shrubs) present in five of the six best models. Blue-winged warbler, common yellowthroat, eastern towhee, gray catbird and indigo bunting all had a significant shrub category variable in the final model for BBIRD (Table 2.5). Yellow warbler is the only one of the six scrub-shrubs birds used in this study that did not have a shrub category variable as a predictor in the final model for BBIRD. All of the bird species (common yellowthroat, eastern towhee, gray catbird, indigo bunting and yellow warbler) except blue-winged warbler had density of trees > 350 cm in the final models for the BBIRD method.

Point intercept method's important variables and best models showed a strong correlation with shrub predictors. Five of the six final best models have a shrub category variable (broadleaved shrub height, broadleaved shrub, low broadleaved shrub height or low broadleaved shrub) as a significant predictor (Table 2.6). Five of the six best models have the variable broadleaved shrub height as an important variable. Eastern towhee, gray catbird and yellow warbler have broadleaved shrub height as the most significant variable. Blue-winged warbler has low broadleaved shrub height as the most significant variable. Common yellowthroat has broadleaved tree height as the most important variable.

The average time to complete the collection of all habitat variables associated with each method was calculated across all 31 points. Point intercept method had a significantly lower average time per point (47.0 minutes, SD 8.6) invested to record the data than did the BBIRD method (94.3 minutes, SD 6.5). The BBIRD method took just about two times as long to complete than did the point intercept method per individual point ($p<.0001$).

2.4 Discussion

The correlation between some of the analogous variables in the BBIRD and point intercept method data is significant because it indicates that the some of the same basic information concerning the habitat at a site is being collected by the two different protocols. Athough generally the two datasets appeared to capture the same information on scrub-shrub bird habitat relationships some of the analogous variables demonstrated no correlation at all.

There are several potential reasons for this lack of correlation between some pairs of analogous variables. One potential reason is that in the BBIRD protocol, habitat is sampled on four 0.04 ha plots on each 50-m radius plot, which is equivalent to ≈ 20% of the plot area, whereas the point intercept samples are dispersed across the plot. The importance of this concentration of sampling in the BBIRD protocol might be accentuated in my sites because habtiat at these sites consisted of a heterogenous mix of herbaceous vegetation, grasses, shrubs and saplings. Measurements taken for habitat cover on subplots dispersed throughout the macroplot have the potential to miss changes in the vegetation structure that a transect method is designed to detect (Caratti 2006). Scrub-shrub habitat is often managed so that it contains a heterogenous vegetation layer that is made up of a stratified layers of grasses, forbs, shrubs, saplings and trees to better meet the needs of a larger number birds (Schulte and Niemi 1998). If managers are attempting to create scrub habitat that is more heterogeneous, in terms of structure and composition, because it is more preferable to a wide range of scrub-shrub birds (Niemi and Hanowski 1984, Thompson and Degraaf 2001), than a method that measures habitat variables across the entire plot is more likely to reflect these changes in variability in the habitat structure. Alternatively, some of the variables measured in the BBIRD protocol are based on ocular estimates, often cited as a problematic way to consistently measure vegetation (Block et al 1987, Block and Brennan 1993, Gotfryd and Hansell 1985), whereas the point intercept method measures cover based off of actual vegetation intercept data. The BBIRD protocol uses ocular estimates for 15 different variables, though we used 7 of those variables in this study since some of those variables were pooled because of similarities or not used because of low occurrence. All of the bird species in this study had one of these ocular estimated variables in their top 5 predictors for the BBIRD method (Table 3.3). Block et al (1987) found that the inconsistencies with ocular estimates lead to underestimation of vegetation types including variables relating to shrubs. This is interesting because the representation of shrub category variables in the BBIRD final models is lower than the corresponding representation of shrub variables in the point intercept models (Table 2.5 and 2.6).

Although the point intercept and BBIRD methods performed similarly well based on AIC_c values and the number of variables included in the minimally adequate models, the efficiency of the BBIRD and the point intercept methods for summarizing bird-habitat relationships was not significantly different. A more parsimonious model, as was found with more of the point intercept method's models, could indicate that fewer variables can explain more, or in some cases just as much of the variance than the BBIRD method best models with more variables. An overfit model or an overly complex model can be the result of having too many variables in the model and can lead to the possibility of wrongly identifying important parameters (Johnson and Omland 2004). A more parsimonious model can also help direct a manager towards a more succinct protocol which only measures habitat characteristics which the birds are responding to.

There was some agreement between the two methods about which habitat characteristics were important to the scrub-shrub bird species we studied. For example, both datasets indicated that common yellowthroats were positively correlated with trees and gray catbirds where positively correlated with shrubs. Also, indigo bunting for both methods showed a negative correlation with shrub cover. Even though there was general agreement between the two methods, there were some bird species for which habitat associations differed between the two methods, which again indicates that the two datasets measure some aspects of the same habitat differently. For example, for blue-winged warblers and eastern towhees BBIRD showed a negative correlation with shrub height while point intercept method showed a positive correlation with shrub height for those species. Further, for gray catbirds, the BBIRD method showed a negative correlation with graminoids while point intercept method showed a positive correlation with graminoids.

In addition, there were differences in the variables which were supported in the analyses of the two data sets. For example, for the BBIRD method, 5 of the 6 final models had the density of trees greater than 350 cm in height as the most important variable. In contrast, the point intercept method had only two models with a most important broadleaved tree term. The correlation of bird abundance with reminant trees, evident from the BBIRD best models, is consistent with the results of a study by Rodewald and Yahner (2000) which indicated that the present of residual trees in clearcuts in Pennsylvania resulted in higher numbers of scrub-shrub birds.

The BBIRD method required on average about twice as long to complete per point as the point intercept method. This is a significant result as it relates to which method managers may choose to employ at sites they are responsible for surveying. It is vital for managers to place emphasis on not only how they are evaluating the important habitat variables for birds but also on the amount of resources and the results they are obtaining from a study (Donovan et al. 2002). This study and analysis indicates that for managers who are interested in gathering information on the abundance of scrub-shrub birds and the relationships they have with habitats, the most efficient method, in terms of labor, would be the point intercept method. For a sample of 50 points visited 3X per season, bird counts might take 15 days (assuming 10 counts per day) and vegetation 5 days using the point intercept method, but 10 days using the BBIRD method. Thus, the use of the BBIRD method in this instance would represent an additional 20% of labor. This result is consistent with the findings of Floyd and Anderson (1987) and Carratti (2006), who reported that point intercept methods yield similar or higher levels of accuracy with substantially less sampling time when compared with other methods.

Another consideration managers may choose to review when deciding on a habitat method is that the BBIRD method is a national program which is widely used by researchers interested in relationships between bird abundance and habitat characteristics. The abilitiy to compare the same set of habitat variables between different studies is useful and is noteworthy when looking at alternatives. This study has indicated that researchers interested in a less labor intensive protocol can consider using the point intercept method and that works just as well at summarizing bird habitat relationships.

In conclusion, my study indicates that 1. there is little difference in efficiency between the BBIRD and point intercept methods, 2. there are reasons to believe that the point intercept method is less prone to errors from ocular estimates and sparse coverage of sample plots, 3. both methods generally indicate similar patterns of habitat selection by birds and 4. the point intercept method requires half the labor of the BBIRD method. Based on these observations, I conclude that the point intercept method be considered a valid methodology for characterizing scrub-shrub bird habitat.

Table 2.1

Analogous variables between the BBIRD protocol and the point intercept protocol

BBIRD	**Point Intercept Method**
Cover of green	Cover of green
Cover of shrubs	*Cover of shrubs*
Cover of forbs	*Cover of forbs*
Cover of graminoids	*Cover of graminoids*
Sum of shrub stems	*Cover of shrubs*
Density of shrubs	*Cover of shrubs*
Average height shrubs	*Average height shrubs*
Average width of shrubs	n/a
Aver. perpend. width shrubs	n/a
Tree crown	*Cover of trees*
n/a	*Cover of conifer*
n/a	*Conifer height*
Average height of trees	*Average height of trees*
Average crown width	n/a
Sum of tree stems	*Cover of trees*
Average Canopy Width	n/a
Average Leaf litter depth	n/a

Table 2.2

Correlation coefficients and P-values derived from a Pearson correlation analysis for analogous variables between the BBIRD and point intercept method.

BBIRD	Point Intercept Method	Correlation coefficient	P-value
Cover of green	Cover of green vegetation	0.32	0.08
Cover of shrubs	Cover of shrubs	0.60	0.0004
Cover of forbs	Cover of forbs	0.29	0.12
Cover of graminoids	Cover of graminoids	0.71	<0.001
Sum of shrub stems	Cover of shrubs	0.40	0.03
Density of shrubs	Cover of shrubs	0.32	0.08
Average height shrubs	Average height shrubs	-0.22	0.24
Average Crown	Cover of trees	0.54	0.002
Average height of trees	Average height of trees	0.63	<0.001
Sum of tree stems	Cover of trees	0.43	0.02

Table 2.3

Results from the Principle Component Analysis (PCA) for the BBIRD data set. Significant PC are shown.

BBIRD	**PC 1**	**PC 2**	**PC 3**
Variance(eigenvalue)	4.14	2.69	2.25
Proportion of Variance	0.26	0.17	0.14
Cumulative Proportion	0.26	0.43	0.57
Point Intercept Method	**PC 1**	**PC 2**	**PC 3**
Variance(eigenvalue)	2.76	2.20	1.77
Proportion of Variance	0.23	0.18	0.15
Cumulative Proportion	0.23	0.41	0.56

Table 2.4
Variables present in the best all subsets model for BBIRD and Point intercept method using corrected AIC values

	Best model	**BBIRD** (AICc)	**Best model**	**Point Intercept** (AICc)
Blue-winged warbler	sum shrub stems+ height shrubs+tree crown width	29.2	broadleaved shrub height+broadleaved tree height+conifer height+ low broadleaved shrub height	18.8
Common yellowthroat	forbs+shrub width+density of trees	51.4	broadleaved tree+broadleaved tree height+conifer height	59.2
Eastern towhee	graminoids+forb+height shrubs+density of trees	47.3	broadleaved shrub height+low broadleaved shrub+conifer	46.7
Gray catbird	sum shrub stems+aver. green+graminoids+density of trees	41.7	broadleaved shrub height+graminoids height+low broadleaved shrub	49.0
Indigo bunting	average green+shrubs+forbs+density of trees	5.1	broadleaved shrub+broadleaved shrub height+conifer height+low broadleaved shrub+low broadleaved shrub height	4.0
Yellow warbler	sum tree stems+density of trees+tree crown width	53.0	broadleaved shrub height+broadleaved tree height	52.3

Table 2.5
Variable present in final minimally adequate model and variables that were within 2 AIC of the best model and BBIRD AICc weights and coefficients.

species	***variable***	***AICc weights***	**Coefficients**
Blue-winged warbler	aver. height shrub	0.141	-0.0009297
	aver. tree crown width	0.153	-0.0008276
	sum shrub stems	0.078	-0.0009297
Common yellowthroat	tree density >350 cm	0.194	1.449813
	aver. forb cover	0.143	0.016331
	aver. width shrub	0.125	0.010840
Eastern towhee	tree density >350 cm	0.157	1.591442
	aver. forb cover	0.144	-0.016674
	aver. graminoids cover	0.144	-0.014104
	aver. height shrub	0.023	-0.002236
Gray catbird	tree density >350 cm	0.368	2.135648
	sum shrub stems	0.361	0.004089
	aver. green cover	0.346	-0.035244
	aver. graminoids cover	0.186	0.010048
Indigo bunting	tree density >350 cm	0.216	-0.650898
	aver. green cover	0.138	0.015974
	aver. shrub cover	0.099	-0.009719
	aver. forb cover	0.079	-0.006339
Yellow warbler	tree density >350 cm	0.225	1.4890021
	sum of tree stems >350 cm	0.171	-0.0051423
	aver. tree crown width	0.149	0.0018389

Table 2.6
Variable present in final minimally adequate model and variables that were within 2 AIC of the best model and point intercept method AICc weights and coefficients.

	variable	***AICc weights***	***Coefficients***
Blue-winged warbler	low broadleaved shrub height	0.377	4.167e-03
	conifer height	0.361	2.660e-04
	broadleaved shrub height	0.285	7.037e-04
	broadleaved tree height	0.17	-1.498e-04
Common yellowthroat	broadleaved tree height	0.178	-2.26e-03
	coniferifer height	0.137	-1.731e-04
	broadleaved tree	0.091	1.5514
Eastern towhee	broadleaved shrub height	0.403	1.8761e-03
	conifer	0.111	2.4703
	low broadleaved shrub	0.09	0.9485
Gray catbird	broadleaved shrub height	0.337	1.6818e-03
	graminoid height	0.282	-0.01101
	low broadleaved shrub	0.129	1.3736
Indigo bunting	broadleaved shrub	0.213	-2.180
	low broadleaved shrub	0.21	-1.170
	conifer height	0.164	-1.089e-04
	broadleaved shrub height	0.147	1.034e-03
	low broadleaved shrub height	0.136	2.296e-03
Yellow warbler	broadleaved shrub height	0.182	-1.232e-03
	broadleaved tree height	0.152	-1.952e-04

Table 2.7
Site name, location, acreage and ownership.

Site Name	**Town**	**Acres**
Barn island WMA	Stonington	60
Bear hill WMA	Bozrah	40
Clarkhurst WMA	Haddam	50
East Glastonbury	Glastonbury	12
Ed Lamb	Ledyard	23
Goshen WMA shrub	Goshen	20
Housatonic WMA	Canaan	40
Kane	Kent	45
Kollar WMA	Tolland	65
Kollar WMA shrub	Tolland	45
Mad river	Winchester	30
Nathan Hill State Forest	Andover	20
Old Newgate Coon Club	Granby	28
Pachaug State Forest	Voluntown	30
Pachaug Shetucket	Voluntown	20
Quinebaug Hatchery	Plainfield	60
Wallingford	Wallingford	48

CHAPTER 3

DEVELOPING A MICROSOFT ACCESS DATABASE FOR DATA ENTRY AND SUMMARY STATISTICS TO AID IN MANAGEMENT DECISIONS

3.1 Introduction

Monitoring species of concern and correctly analyzing the field data can help managers better understand relationships between species of concern and their habitat (Bart and Ralph 2005). Proper monitoring and data management can help identify species at risk and any limiting habitat factors, as well as helping to evaluate when to alter land management activities, where to invest resources, and how to coordinate conservation efforts on a regional and rangewide level (Ruth et al. 2003, Bart 2005, U.S.NABCI 2007). Many state and federal agencies as well as non-profits are increasingly turning to databases to efficiently and accurately store, analyze and coordinate vast quantities of biomonitoring data (Ruth et al. 2003, Bart 2005, U.S.NABCI 2007).

Scrub-shrub habitat is made up of early seral, woody vegetation, forbs and graminoids (Smith 2007). Scrub-shrub habitat across much of New England has decreased in amount, and scrub-shrub habitat are listed as one of the most endangered habitats in the United States (Askins 2001, Brooks 2003, Dettmers 2003, Noss et al 1995, Thompson and Degraaf 2001,Trani et al. 2001). Declines in early-successional habitats are associated with declines in bird species that use these early-successional habitats (Vickery 1991,Askins 1993, Hunter et al 2001,). The northeast in particular, has shown substantial declines in shrubland-dependent species (Witham and Hunter 1992, Livaitis 2001).

According to the U.S. North American Bird Conservation Initiative (NABCI) (2007), one of the four most vital objectives for the successful conservation of birds is the creation of standardized data management systems and the collaboration of database information between various research-oriented agencies. The declining habitat and decreasing bird abundance at these early-successional sites makes it all the more imperative to accurately and efficiently record the habitat characteristics of a site and relate that information to the birds present. If the data is managed in a database format, then not only can the data be shared amongst agencies, but the sharing of data can add power and confidence to predictions about species trends and important core habitat (Ruth et al. 2003, Bart 2005, U.S.NABCI 2007).

For managers to understand and evaluate the effect of their practices, it is important for them to have quantitative information on bird species at risk, which species are of the highest concern, what habitat conditions are correlated to the birds and what specific areas could be focused on for management to provide the greatest impact (U.S.NABCI 2007). If the study and the data management are poorly designed and executed, than managers run the risk of wasting limited resources and equipment and producing erroneous results (Oakley et al 2003, Bart and Ralph 2005). Collecting data accurately and efficiently in the field is the first step in quantifying the relationships that exist between the birds and habitat at a site and achieving regional and rangewide conservation goals (Ratti and Garton 1994). Proper data entry and summary statistics can become important tools for land managers interested in making informed decisions when a long anlaysis is not possible due to either funding or time requirements (Freeman and Ford 2002). In that case, utilizing a database that allows accurate and consistent data entry over many points, at many sites, over many years becomes important (Waddle et al 2003). Once the data is entered into the database, than the manager can than look at trends and manipulate the data through a potentially unlimited number of combinations and gain the ability to share the information (Waddle et al 2003, Bart 2005). As more and more agencies rely upon databases for the management of species trend information and even the prediction of habitat affects on declining species, then the ability to coordinate and collaborate increases significantly as well as the collective power of the data. This coordination and collaboration can lead to increased knowledge among managers and an increased ability to meet conservation objectives for declining species (Defalco et al 2005, Nichols and Williams 2006, U.S.NABCI 2007).

My study is designed to develop a Microsoft Access database for bird and habitat data entry, summary statistics, and land management evaluation to help acheive conservation goals for early-successional habitats. Specifically, the database will allow accurate, consistent bird and habitat data entry for sites over multiple years. The database will be capable of generating summary statistics for bird abundance and habitat characteristics and graphically displaying these trends for interpretation, assisting in evaluating land management decisions and coordination of data with other agencies.

3.2 Study area and methods

3.2.1 Study area

The field data that was used in the creation of the database was collected at scrub-shrub sites across the state of Connecticut during 2006 and 2007. Connecticut is the second smallest New England state but has the second largest population in New England. Connecticut is 12,975 square kilometers in area with the Connecticut River dividing the state in about half. The Eastern, Central, and Southern portions of the state are fairly flat with large areas no more than a 100 meters above sea level while the Northwest of the state is quite hilly with elevation up to 610 meters above sea level. As a result, study sites varied in topography from one end of the state to the other. Some sites consisted of abandoned floodplain fields along the Connecticut River which remain fairly level throughout the site while others are fairly sloped shrublands found in the foothills of the Berkshires in the Northwest of the state.

Bird and habitat information was collected at 30 sites. At these sites, 85 independent points were established a minimum of 250 meters apart for the analysis. Sites ranged from 3.2 to162 hectares in size. Sites are either state owned lands or part of a pioneer program called the Land-owner Incentive Program (LIP). The state owned land consists of Wilderness Management Areas, State Forests, and State Parks. The LIP program brings together the state with private landowners by signing a contract that includes matching grant finances to manage the private land for species at risk. The LIP sites were selected based upon the most significant potential impact for species that are on the Connecticut's endangered, special concern and watch lists. State sites were selected on some of the same criteria used for the LIP sites but also the representation of the full spectrum of patch sizes and vegetation characteristics of early-successional sites in Connecticut was considered. Some of the state sites had previously established survey points but both the state lands and the all of the LIP sites had previously unsurveyed lands for birds and habitat.

3.2.2 Database methods

I created the database using the Access database software from Microsoft. The database's design was formatted after a similar type database designed for Massachusetts Division of Fisheries and Wildlife (MDFW). This database for MDFW has a broader application and includes tables, forms and reports for butterflies and non-wildlife based applications. The wildlife database for Connecticut Department of Environmental Protections (CTDEP) includes applications directed towards the specific management and trends of scrub-shrub birds and their associated habitat.

The database was constructed to have a user-friendly front end that allows the manager to choose which data (bird or habitat) for a site, point or year they wish to view or edit. A switchboard, which is a database menu, appears automatically each time the database is opened, giving the manager the choice to navigate through the above-mentioned items (Figure 3.1). By clicking on an icon, the user can navigate towards their desired application whether it is data entry, database editing or trend viewing.

The database was built by first establishing relationships between tables that are the end location for data collected in the field and entered through the database. Tables called birds, vegetation, sites and points were created and the relationships amongst the tables were edited. (Figure 3.2, Figure 3.3) Primary keys, which are unique for each table and row of data entered, were created for each table. Once the relationships were set up, forms and their controls were established to allow for easy and consistent data entry. A form is an extremely flexible way to view, edit, manipulate and delete data (Prague and Irwin 2002, Simpson et al 2003). A form for bird data and habitat data entry were established (Figure 3.4, Figure 3.5). These forms automatically filtered the raw data and place it in the appropriately labeled table. Controls on the forms were added to allow the user to search and find a selected entry, to advance the form to the next entry, to jump to other forms, to utilize drop down combo boxes, which are drop down menus, to close the form, to edit the form and to enter data (Figure 3.4, Figure 3.5).

Once the data entry forms were created and connected to the associated tables, I then created pivot charts, that would visually allow the user to view trends from the data. Pivot charts are graphical diplays of data that automatically update themselves each time the chart is opened. The pivot charts were based on queries that numerically summarized or partioned the data according to my selected preferences (Figure 3.6). I created queries and then pivot charts for the bird data that included individual graphs for average number of birds per point/site and maxium number of birds per point/site (Figure 3.7). For the habitat data I created queries that included individual graphs for percent cover, average height of vegetation species, percent cover for invasives and average height for invasives species (Figure 3.8). For the vegetation data I created typical bar graphs but also pie chart graphs of the same data (Figure 3.9). Using a pivot chart to create a visual representation of a dataset is useful because of the ease to change how the data is viewed. With minimal adjustment the view of the graph can be changed as well as the site or year or focus of species.

Reports are similar to forms but allow an ease of summarizing and printing data (Prague and Irwin 2002, Simpson et al 2003). Reports were created for the bird data set as well as the habitat data set. Reports called ‘Birds seen or heard’ for a site and for a year was created with the data as well as ‘Percent cover of species’ for a site and for a year (Figure 3.10, Figure 3.11).

Lastly, pictures and graphics were added to improve aesethics of the database and to make it representative of CTDEP. As with most Microsoft applications, font and style are easily adjusted within the database as well as formatting graphics. Overall ease of use, security, future usefulness and functionality were addressed and readdressed many times to ensure the overall success of the project. Once a completed functioning database was created, feedback was collected for CTDEP managers, and adjustments were implemented.

The completed database has met the needs of managers at the CTDEP. It has two different data entry forms, one for birds and one for habitat, (Figure 3.2, Figure 3.3) that allow for a consistent, screened data entry process. These data entry forms are linked to automatically enter the data into the appropriate table. Queries take the data from the tables and computate various summary statistics on the data. Graphs pick up the data from the queries and visually display the information to the user.

3.3 Discussion

One of the more important and often overlooked benefits of the database framework is using it to eliminate mistakes that often plague data entry. With minimal planning time ahead of data entry, a programmer can design a form that checks and only allows a range of input data to be entered. If something is misspelled or labeled incorrectly the database will alert the user. In addition, with the use of drop down boxes, the user can pick from a pre-selected list of appropriate inputs allowing data entry to be standardized. These inputs can be changed by the programmer at a later date to reflect new sites or new species with minimal effort. With consistent data entry, managers can delegate with confidence the task of data entry. In addition, with consistent data entry, time is saved later by not having to recheck different datasets for continuity. Lastly, consistent data entry ensures the trends that accompany the data are reliable from the standpoint that data entry errors are not responsible for distorting the results (Freeman and Ford 2002).

The database has integrated queries so that graphs update themselves automatically when opened. This allows the system to refresh and add new data from more recent studies. The database can accept data from a potentially unlimited number of points and sites over many years and transform it into a simplified graphical format. This allows the managers in Connecticut to expand the sites they are monitoring and gain a more concise understanding of the relationship between the management on the ground that they are undertaking and the affect on the avian populations at their sites across the state.

The structure of the database allows the manager to easily re-query the database tables and view trends of bird abundance across various gradients. For example, for this particular database, there are sites located along a gradient of distance to human population centers. Some sites are within a few miles of the center of Hartford while some of the sites are present in the least-populated part of northwest Connecticut. With minimal adjustment and writing of a few queries, managers could view the data and multi-year abundance levels as a function fo human population densities. Once a basic understanding of the language of the database is gained, there are countless ways to view the data and gain a more robust understanding of the data.

The power of the database as a management tool lies in its ability to manage large amounts of data and, through queries, sort, filter, replace, amend and calculate any number of combinations. The ability of a database to use queries to manipulate and reorganize the data can allow a manager to take different studies and datasets and manage and summarize them. This becomes important when studies are undertaken at different sites or during different years or at different points and still contain useful information. If conservation goals are to be met in relation to species at risk, then database management within regional agencies and across range wide organizations becomes a vital tool (Ruth et al. 2003, Bart 2005, U.S.NABCI 2007). The common language that is used to run most databases allows for a researcher to incorporate previous studies into current experimental designs. The ability of communication through the data management of many different studies can help reduce redundancy and repeated mistakes and instead allow researchers to build upon the knowledge that has already been collected. We not only increase our knowledge base but also our sample sizes. With this increased power, researchers can ascertain with more confidence the predicted response of a species to land management practices or more quickly identify areas where management will benefit the largest number of species (Defalco et al 2005, NCBMW 2006, U.S.NABCI 2007).

Reports are another database object that allows the information from a query to be easily organized and printed or transferred. This database used reports to help summarize data for both the birds and habitat variables. I created a report for the avian data that created a list of birds heard and/or seen at a site for a given year. I also created a report that displayed the percent cover of individual vegetation groups at a site for a given year. The reports can be set up to allow the manager to focus in on a particular site, point, bird or year(s) to extrapolate pertinent information. Again, this is another tool that the database offers which makes accessing the data in meaningful and concise ways more accessible for a manager.

This database produces summary statistics to aid managers in the identification of effects of habitat alteration on bird species of concern. The database takes point count data and uses a query to calculate the mean abundance of birds recorded for a point, the site and for all the years. Percent cover, average height, invasive cover and mean abundance are all calculated within the database. Mean abundance can show a positive correlation with reproductive activity of birds found in early-successional habitat (Betts et al 2005). As long as the study is conducted over a multi-year scale, than the results from point counts and thus the summary statistic can indicate general trends in bird populations (Thompson et al 2002). In instances where actual abudances are required, or there is reason to believe that habitat relationships should be corrected for birds present but not detected, the databse can easily general data files formatted for analyses using N-mixture or other models.

Percent cover and average height of vegetation groups has been used by King et al (2008) to help determine relationships between scrub-shrub birds and habitat. The database uses a query to calculate the percent cover and height derived from the habitat data entered into the vegetation table. This information can be viewed in many graphical formats and is the basis for understanding how the habitat at a site maybe affecting the abundance of species present there.

In conclusion, databases written in universal code further the conservation of declining species and the strength of data trends used by habitat managers to make decisions by allowing consistent, straightforward data entry and management as well as simple data transformations. The use of databases to manage large amounts of data over many years by various non-profit and state and federal agencies allows those concerned with the conservation of scrub-shrub birds to access a significant amount of data which can used to answer large scale questions and help us better understand where to allocate resources for the greatest return.

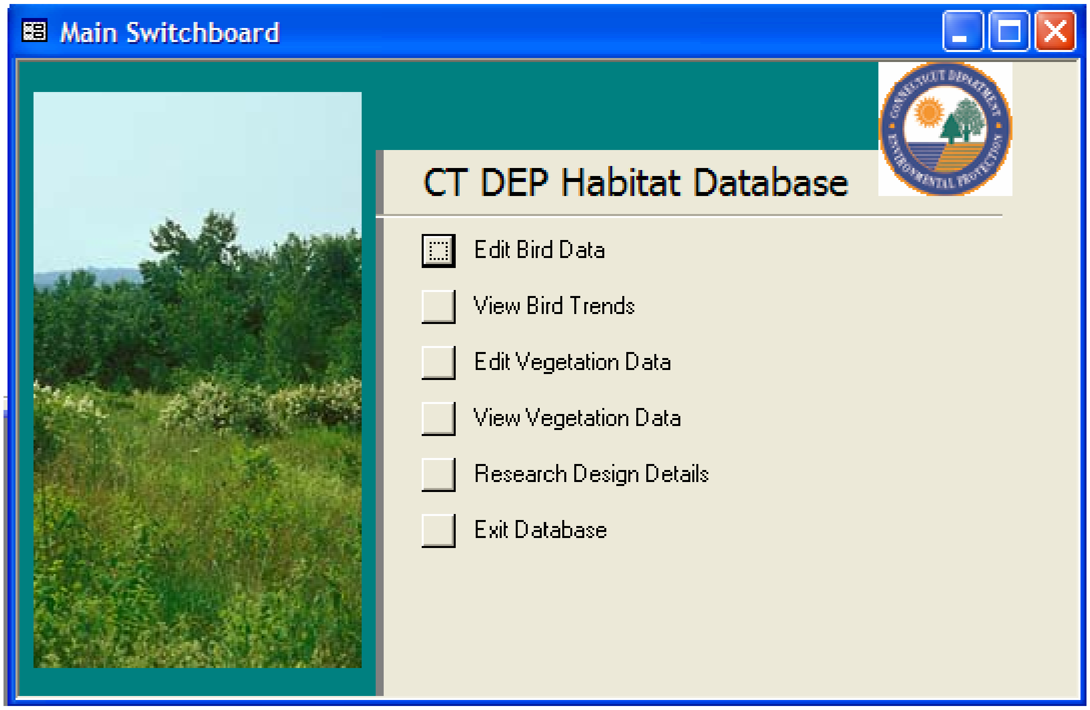


Figure 3.1
Screen-capture of a switchboard screen displayed automatically when the database is opened. Individual tabs permit navigation to different forms within the database.

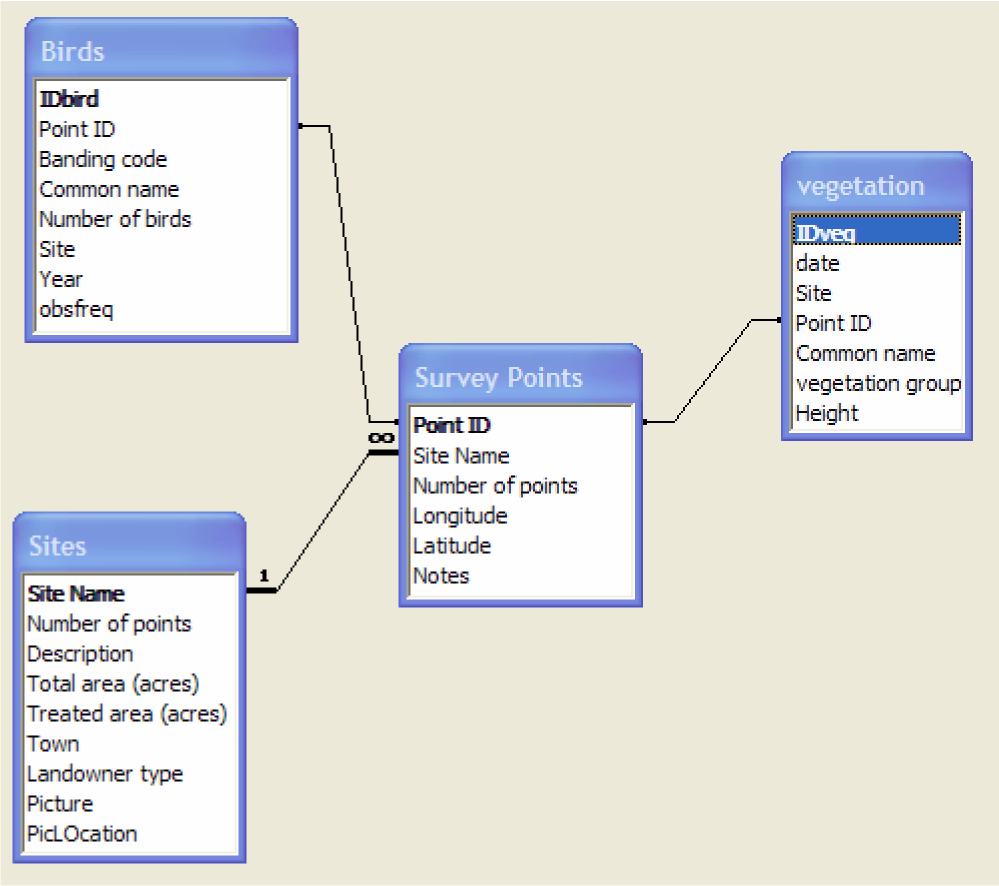
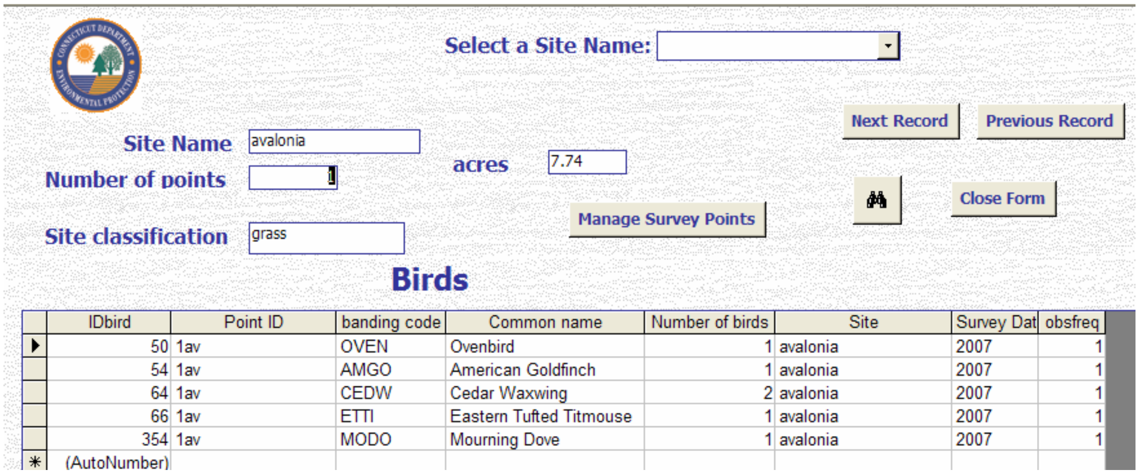


Figure 3.2
Screen capture of the database tables and their relationships to each other. The bold text in each table is the unique primary key for that table.

IDbird	Point ID	banding code	Common name	Number of birds	Site	Year
50	1av	OVEN	Ovenbird	1	avalonia	2007
54	1av	AMGO	American Goldfinch	1	avalonia	2007
55	1bh	BWWA	Blue-winged Warbler	1	bear hill WMA	2007
58	1be	SOSP	Song Sparrow	2	belding	2007
59	1wf	COYE	Common Yellowthroat	1	booker wynchwood farn	2007
61	1wf	YWAR	Yellow Warbler	1	booker wynchwood farn	2007
64	1av	CEDW	Cedar Waxwing	2	avalonia	2007
65	1bh	PRAW	Prairie Warbler	1	bear hill WMA	2007
66	1av	ETTI	Eastern Tufted Titmouse	1	avalonia	2007
67	1bh	CSWA	Chestnut-sided Warbler	1	bear hill WMA	2007

Figure 3.3
Screen-capture of the database table called "Birds" showing how the database stores the raw field data in a columnar format.



Site Name: avalonia

Number of points: 1

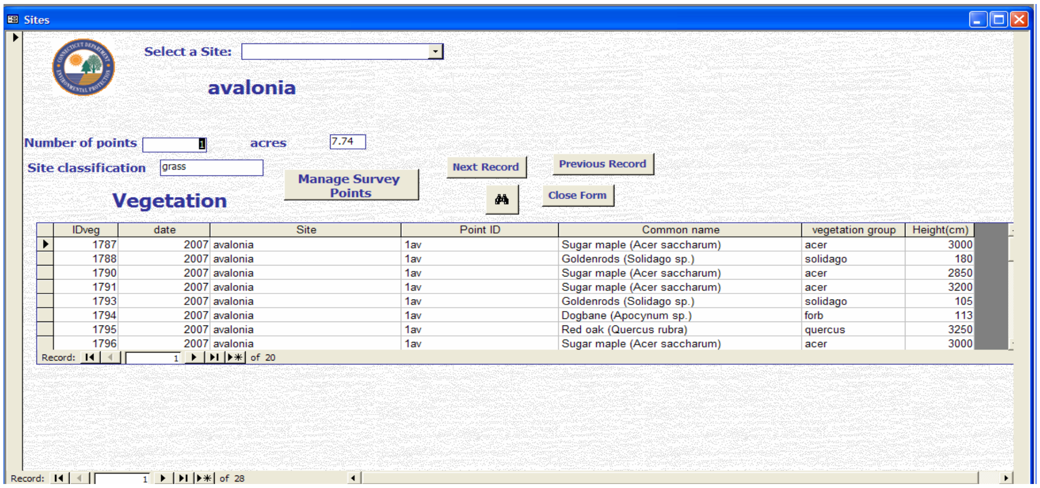
acres: 7.74

Site classification: grass

Birds

IDbird	Point ID	banding code	Common name	Number of birds	Site	Survey Dat	obsfreq
50	1av	OVEN	Ovenbird	1	avalonia	2007	1
54	1av	AMGO	American Goldfinch	1	avalonia	2007	1
64	1av	CEDW	Cedar Waxwing	2	avalonia	2007	1
66	1av	ETTI	Eastern Tufted Titmouse	1	avalonia	2007	1
354	1av	MODO	Mourning Dove	1	avalonia	2007	1
(AutoNumber)							

Figure 3.4
Screen-capture of the bird data entry form. This form is used to manage and standardize the entry of bird field data.



avalonia

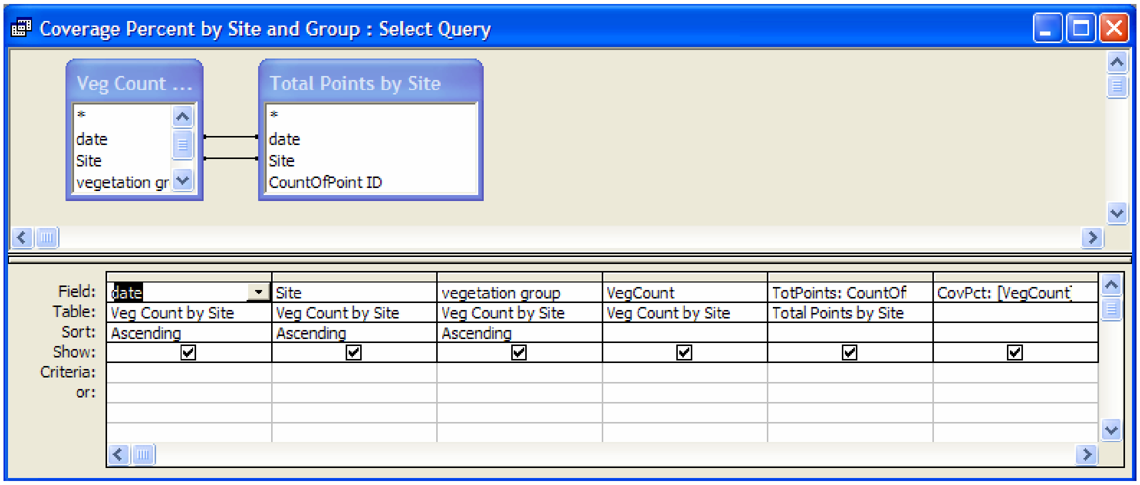
Number of points	1
acres	7.74
Site classification	grass

Vegetation

IDveg	date	Site	Point ID	Common name	vegetation group	Height(cm)
1787	2007	avalonia	1av	Sugar maple (Acer saccharum)	acer	3000
1788	2007	avalonia	1av	Goldenrods (Solidago sp.)	solidago	180
1790	2007	avalonia	1av	Sugar maple (Acer saccharum)	acer	2850
1791	2007	avalonia	1av	Sugar maple (Acer saccharum)	acer	3200
1793	2007	avalonia	1av	Goldenrods (Solidago sp.)	solidago	105
1794	2007	avalonia	1av	Dogbane (Apocynum sp.)	forb	113
1795	2007	avalonia	1av	Red oak (Quercus rubra)	quercus	3250
1796	2007	avalonia	1av	Sugar maple (Acer saccharum)	acer	3000

Figure 3.5

Screen-capture of the habitat data entry form. This form is used to manage and standardize the entry of habitat field data.



Field:	date	Site	vegetation group	VegCount	TotPoints: CountOf	CovPct: [VegCount]
Table:	Veg Count by Site	Veg Count by Site	Veg Count by Site	Veg Count by Site	Total Points by Site	
Sort:	Ascending	Ascending	Ascending			
Show:	☑	☑	☑	☑	☑	☑
Criteria:						
or:						

Figure 3.6

Screen capture of an example of a query created to give results for percent cover. The database query searches the selected tables (in this case “Veg count” and “Total points by site”) for the selected information and computes any calculations that are written for it.

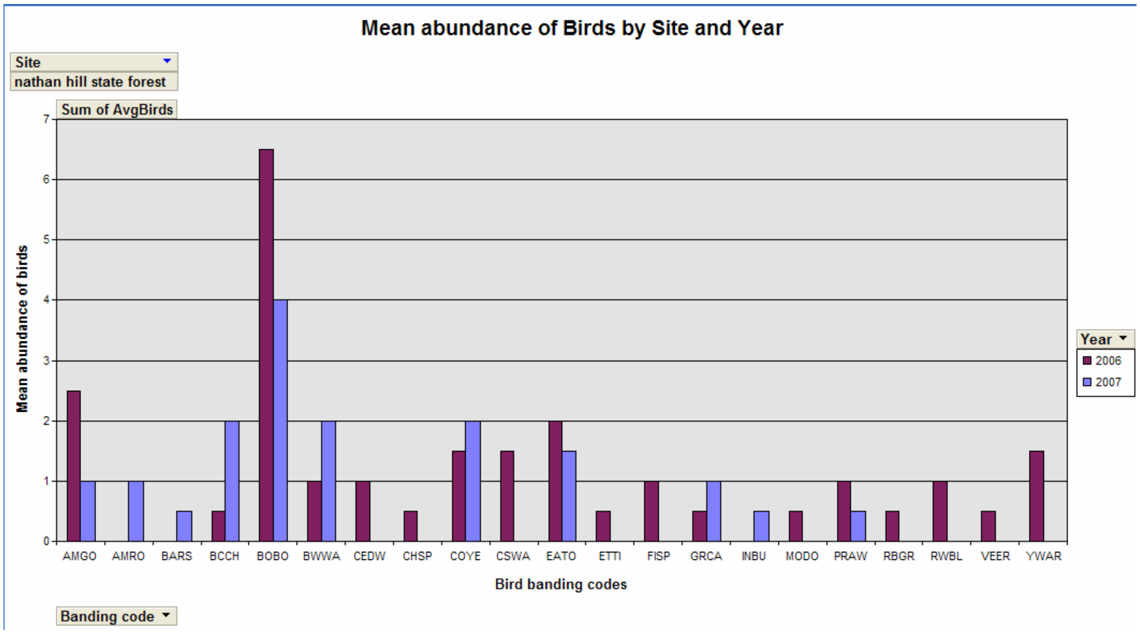


Figure 3.7
Screen-capture for a pivot chart of mean bird abundance. This pivot chart is a different view of a form which was created from a query.

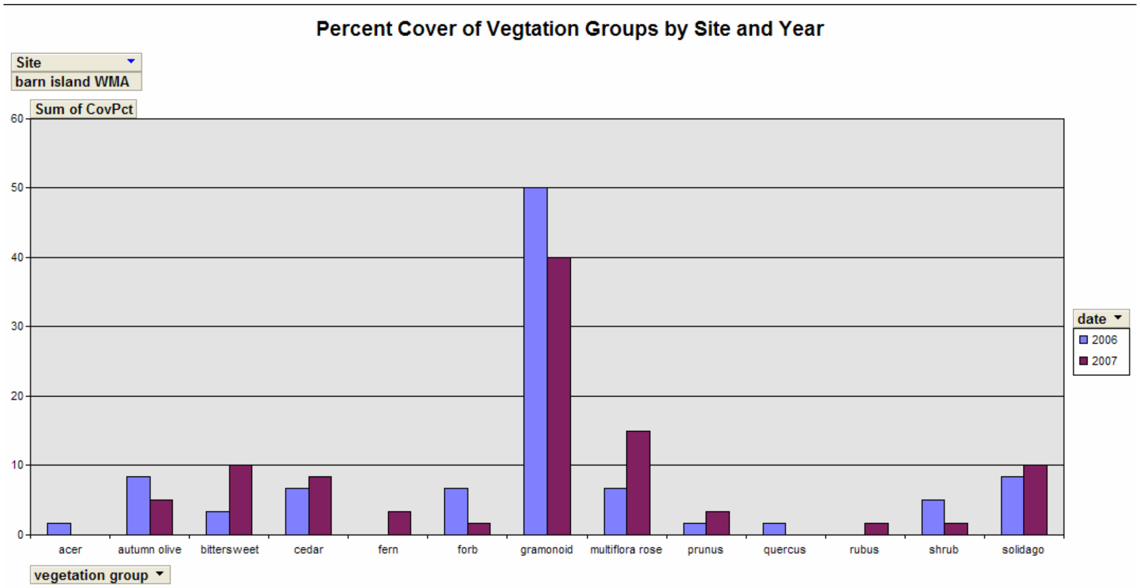


Figure 3.8

Screen-capture for pivot chart for percent cover of vegetation. This pivot chart is a different view of a form which was created from a query.

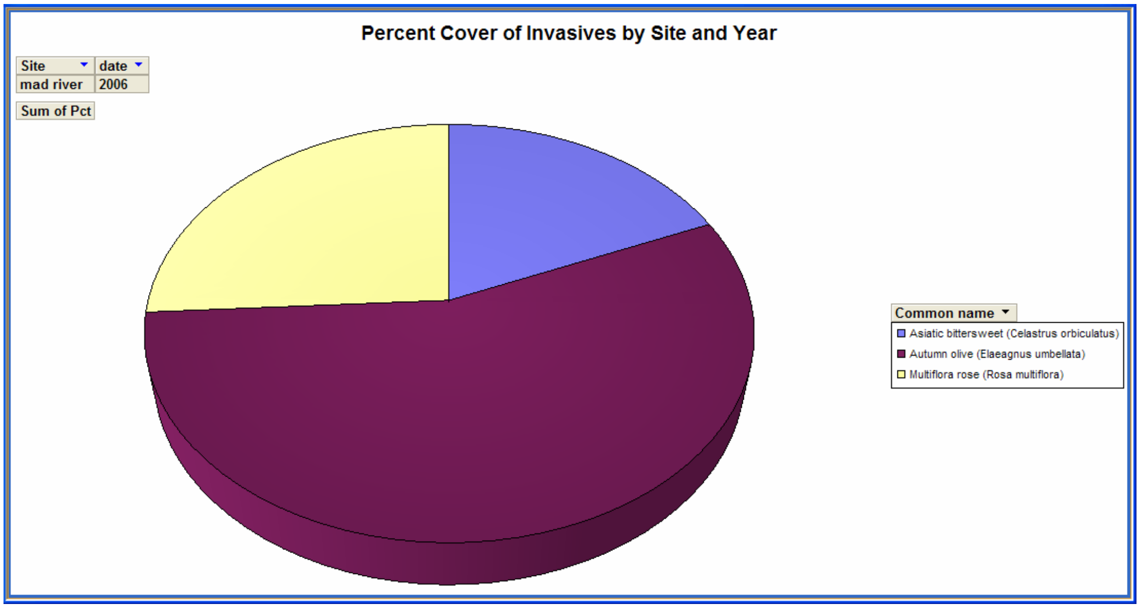
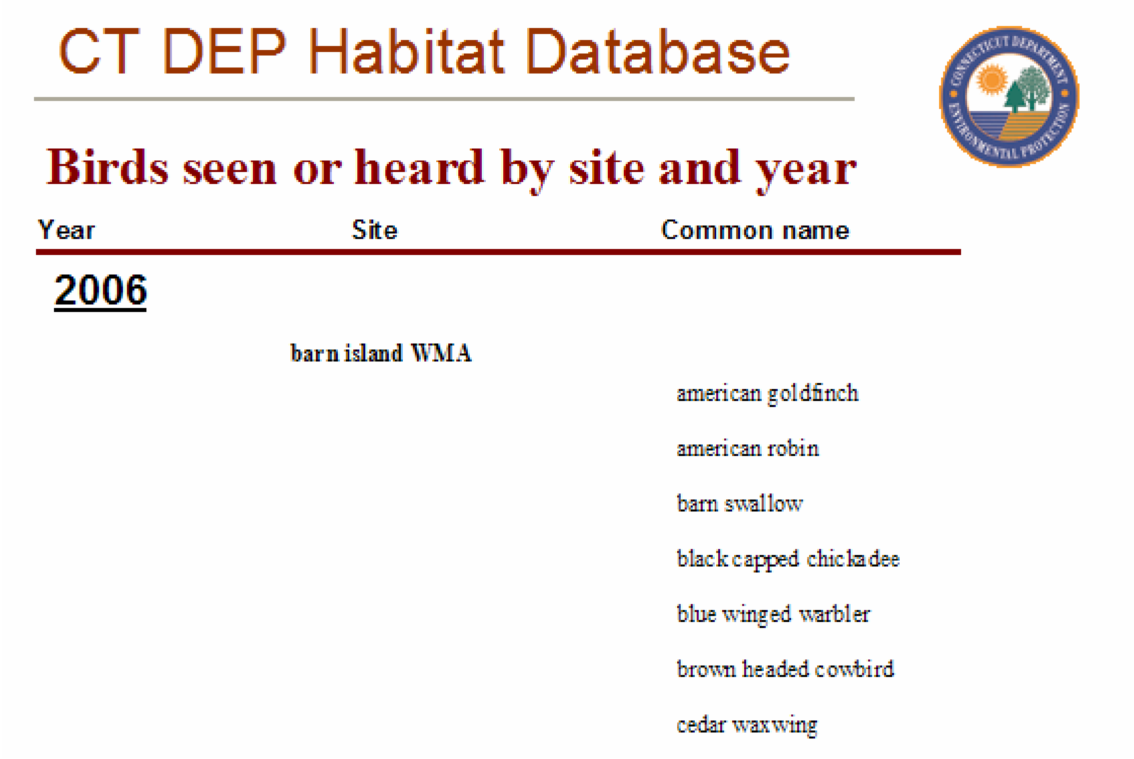


Figure 3.9
Screen-capture of a pie chart for percent cover of vegetation. This figure demonstrates the ease of changing formats within a database structure.

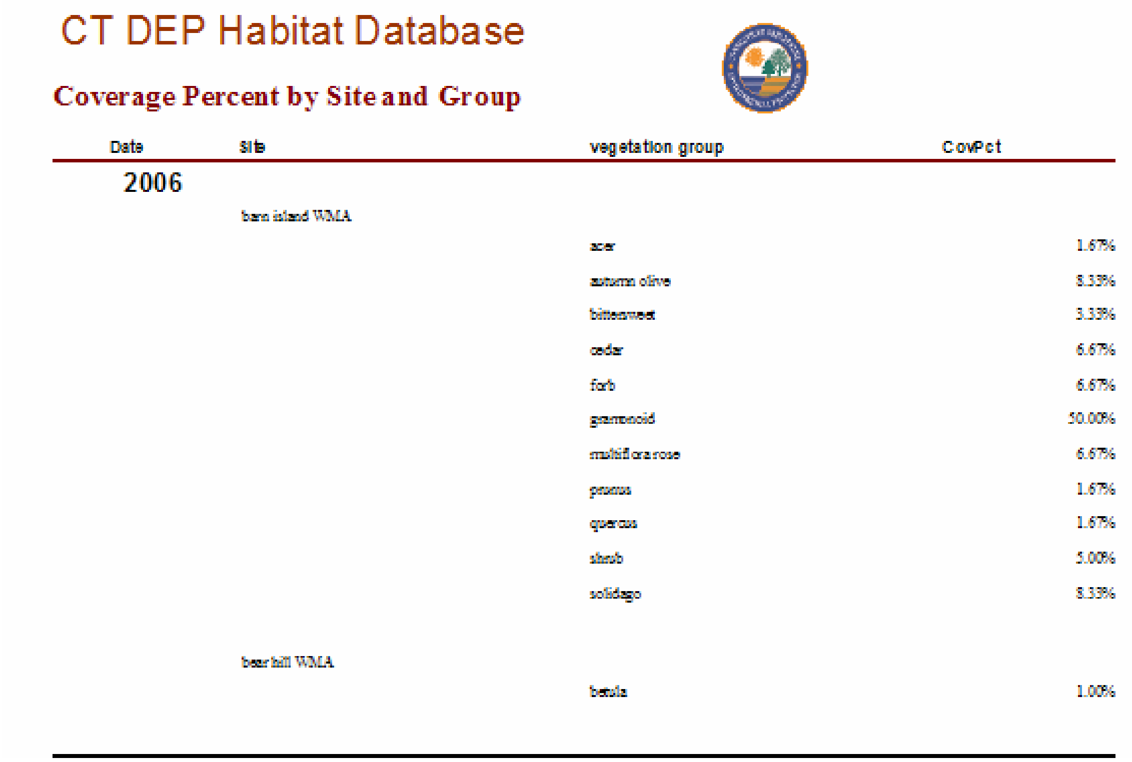


CT DEP Habitat Database

Birds seen or heard by site and year

Year	Site	Common name
2006		
	barn island WMA	
		american goldfinch
		american robin
		barn swallow
		black capped chickadee
		blue winged warbler
		brown headed cowbird
		cedar waxwing

Figure 3.10
Screen-capture of an example of a report for birds heard or seen by site and year. A report is a convenient database format which can be created from simple queries and allows for quick printing.



CT DEP Habitat Database

Coverage Percent by Site and Group

Date	site	vegetation group	CovPct
2006			
	barn island WMA		
		acer	1.67%
		autumn olive	8.33%
		bittersweet	3.33%
		cedar	6.67%
		forb	6.67%
		graminoid	50.00%
		multiflora rose	6.67%
		prunus	1.67%
		quercus	1.67%
		shrub	5.00%
		solidago	8.33%
	bear hill WMA		
		betula	1.00%

Figure 3.11
Screen-capture of an example of a report for percent cover by site and year. A report is a convenient database format which can be created from simple queries and allows for quick printing.

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