Status and Habitat Use of the Wayne's Black-throated Green Warbler in the Northern Portion of the South Atlantic Coastal Plain

Bryan D. Watts[1,*], Barton J. Paxton[1], and Fletcher M. Smith[1]

Abstract - *Dendroica virens waynei* (Wayne's Warbler) is a unique, disjunct subspecies of *Dendroica viren virens* (Black-throated Green Warbler) that is restricted to the South Atlantic Coastal Plain from southeastern Virginia to South Carolina. We surveyed a network of 265 fixed-radius plots to examine seasonal occurrence, spatial distribution, and patterns of habitat use by Black-throated Green Warblers. Survey plots were chosen to represent the full gradient of forest types within the region. Plots were surveyed 7 times between early April and mid-June, 2001. Detections of Black-throated Green Warblers began in early April, increased to a peak in late April, and then declined throughout May and early June. Birds were detected during 251 (13.5%) of 1862 point counts conducted. Detections were widespread and included 114 of 266 (52.6%) survey plots. Forest composition had a significant influence on the distribution of breeding sites. The frequency of plots classified as breeding sites was higher than expected for plots containing *Pinus taeda* (Loblolly Pine), *Chamaecyparis thyoides* (Atlantic White Cedar), and *Taxodium distichum* (Bald Cypress). The density of these tree species within survey plots was significantly higher for plots classified as breeding sites compared to plots classified as unoccupied. This response was particularly significant when all three tree species were combined.

Introduction

Dendroica virens waynei Bangs (Wayne's Warbler) is a unique, disjunct subspecies of *Dendroica virens virens* (Gmelin) (Black-throated Green Warbler) (AOU 1957, Bangs 1918). The nominate race breeds in coniferous forests across the northern latitudes of North America and through the higher elevations of the Appalachians (Morse 1993). The Wayne's form is smaller than the nominate race and has a distinctly smaller bill. Wayne's Warbler has a much smaller breeding range and is restricted to the South Atlantic Coastal Plain from southeastern Virginia to South Carolina. Along much of this range, the population is confined to a fairly narrow band within the outer coastal plain (Sprunt 1953). This population is 500 km east of the Appalachian population and 1200 m lower in elevation.

The factors that led to the isolation of the Wayne's form from the nominate race are not known. It is possible that this subspecies was originally associated with the extensive stands of *Chamaecyparis thyoides* (L.) B.S.P. (Atlantic White Cedar) that were once an important component of the region's plant community. These stands were similar in form to the coniferous forests where *D. v. virens* currently breeds. Wayne's Warbler appears to reach its highest density from southeastern Virginia through northeastern North Carolina. This region was the

[1]Center for Conservation Biology, College of William and Mary and Virginia Commonwealth University, Williamsburg, VA 23187. [*]Corresponding author - bdwatt@wm.edu.

former location of the most extensive tracts of white cedar (Ashe 1894). More than 100,000 acres of this habitat were harvested in the area in the late 1800s and early 1900s for the shingle industry. This event virtually eliminated this unique plant community from the region. The vegetation that has reclaimed many of the historic sites after harvest is dominated by hardwoods rather than white cedar (Frost 1987).

Most of the extensive stands of Atlantic White Cedar were harvested prior to the description of the Wayne's form to science. How much the current pattern of habitat use (and our perceptions of habitat requirements) is influenced by the absence of white cedar is unknown. In the latter half of the twentieth century, the Wayne's subspecies has been suggested to utilize the entire gradient of forest types from Atlantic White Cedar to *Taxodium distichum* L. (Bald Cypress) to mixed deciduous forest (Meanley 1977; E.F. Potter, North Carolina Museum of Natural Sciences, Raleigh, NC, unpubl. data; Sprunt 1953). The population has also been suggested to have a close association with non-alluvial cypress swamps.

No recent attempts have been made to determine the status and distribution of Wayne's Warblers within the core of their breeding range (i.e. southeastern Virginia, coastal North Carolina). Once suggested to be a fairly common breeding species within the Dismal Swamp (Meanley 1977), researchers now suggest that they have disappeared over the past 10–15 years from the northern portion and have declined substantially in the southern portion (B. Meanley and D. Schwab, Great Dismal Swamp National Wildlife Refuge, Suffok, VA, unpubl. data). No attempts have been made to clarify the influence of forest composition on distribution. The two primary objectives of this field project were 1) to assess the general status and distribution of the Wayne's Warbler within the northern portion of the South Atlantic Coastal Plain (particularly focused on US Fish and Wildlife Service [FWS] refuge lands), and 2) to determine if there are habitat elements that may help to explain current distribution patterns.

Study Area

We conducted this study within the Alligator River National Wildlife Refuge (NWR), Pocosin Lakes NWR, and Dismal Swamp NWR (Fig. 1). These properties are located within the coastal plain of southeastern Virginia and northeastern North Carolina. Alligator River and Pocosin Lakes NWRs are located on the peninsula of land bounded to the north by the Albemarle Sound and to the south by the Pamlico River. The Great Dismal Swamp is located east of the Suffolk scarp and west of US Route 17.

We established a network of 265 survey plots distributed throughout the broad study area. The network included 154 plots on or within the vicinity of Alligator River NWR, 83 plots on or within the vicinity of Great Dismal Swamp NWR, and 29 plots on Pocosin Lakes NWR. We clustered survey plots in "mini-routes" (groups of 20–30 points) to maximize survey efficiency. We assessed potential field sites during March of 2001. Information was collected through a combination of road surveys, aerial photographs, and meetings with refuge personnel. During this phase, we attempted to 1) determine the distribution of forest types targeted within the study, and 2) evaluate survey efficiency of various field options (i.e. assess roadway condition and access and evaluate site clustering). We chose sites in late March that were accessible and could support a cluster of 20–30 point-count locations.

We based final selection of study plots within larger areas on forest type. Target forest types represented the full forest gradient within refuge lands. Categories included: 1) PPP = *Pinus serotina* Micheaux (Pond Pine) pocosin, 2) HDWD = hardwood dominated, 3) MIX = pine/hardwood mix, 4) PIN = pine dominated, 5) CED = white cedar component, and 6) CYP = Bald Cypress component. Tall pocosins with Pond Pine form over relatively shallow peat deposits and are characterized by high above-ground plant biomass. Characteristic plant species include *Liquidambar styraciflua* L. (Sweet Gum), *Acer rubrum* L. (Red Maple), *Ilex glabra* L. (Gallberry), *Leucothoe racemosa* L. (Fetter Bush), and *Myrica cerifera* L. (Wax Myrtle). Hardwood-dominated plots were those where

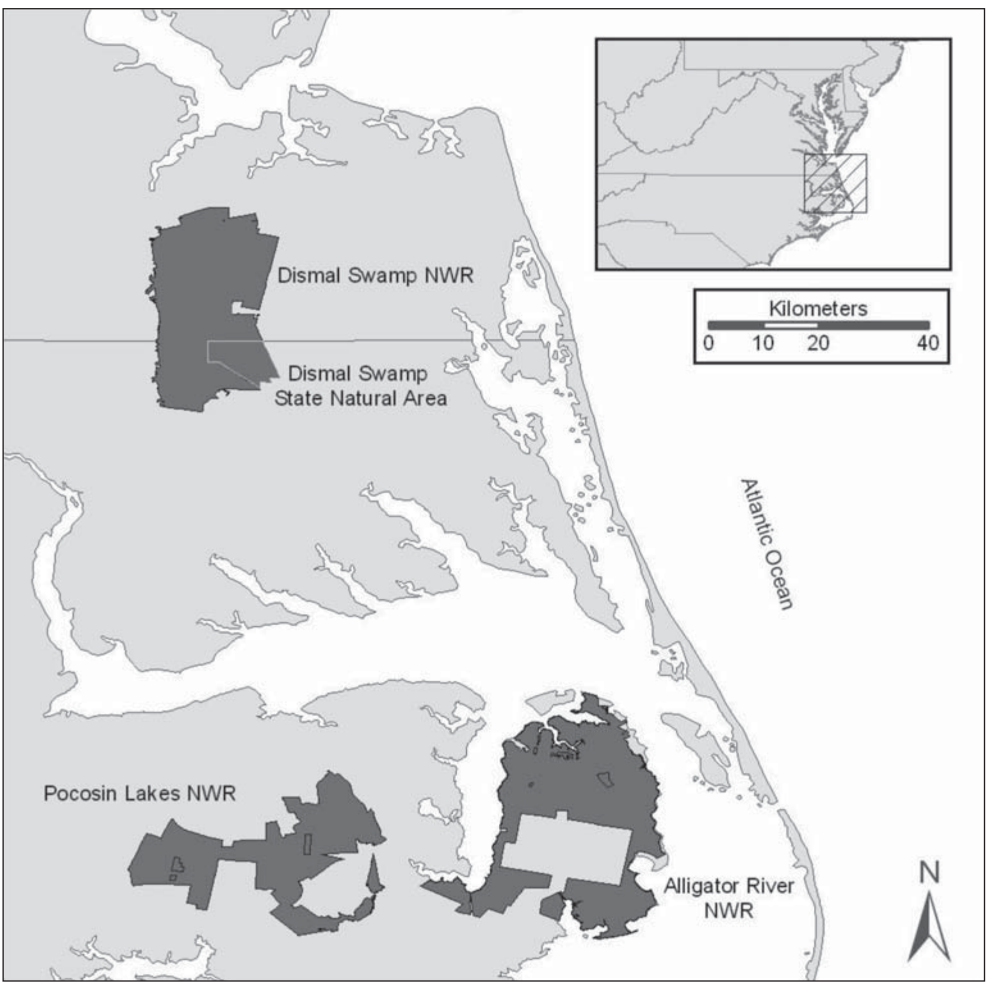

Figure 1. Map of study area. Black areas indicate conservation lands containing all survey plots. The number of survey plots by geographic area was 154, 83, and 29 for Alligator River NWR, Great Dismal Swamp NWR, and Pocosin Lakes NWR, respectively.

an estimated 75% or more of the canopy-forming stems were hardwood. Most abundant trees included Red Maple and Sweet Gum. Mixed pine/hardwood plots had relatively even numbers of *Pinus taeda* L. (Loblolly Pine) and hardwood stems. Pine-dominated plots were those where an estimated 75% or more of the canopy-forming stems were Loblolly Pine. White cedar plots were those that contained at least a minor component of white cedar trees. Bald Cypress plots were those containing at least a minor component of Bald Cypress. It was not possible to locate an adequate sample of plots that were dominated by either white cedar or Bald Cypress. Initial selection of forest types for plot placement was done by visual inspection of forest composition (Table 1). Due to the unique character of the three refuge properties, balance of forest types by geographic area was not possible (Table 1). We established survey plots in late March and early April. We positioned plots along roadways with a minimum separation of 0.5 km.

Methods

Bird surveys

We used a fixed-radius point-count technique to measure bird density and frequency of occurrence. A survey plot (point count) consisted of a 50-m radius circle with a wire flag located at its center. We conducted surveys along roadways with the plot centers positioned at the road edge. The plot was split in half along the road axis. Birds detected within the 50-m radius plot were recorded either as within the focal half or within the remainder. We used birds detected within the focal half of plots for habitat comparisons.

Bird surveys were conducted by a single observer standing at the plot center and counting all birds seen or heard within a 5-min period. Birds detected were stratified according to time, period, and location. We subdivided the count periods into an initial 3-min period and a subsequent 2-min period. We recorded birds as either within or beyond the 50-m radius. We conducted plot surveys in 11-d time blocks, where all points within the network were surveyed within each block. We completed seven survey rounds between 8 April and 12 June 2001. Plots covered by individual observers were rotated between time blocks to disperse any observer bias. We alternated the order of surveys within "mini-routes" between time blocks to reduce the impact of time-of-day effects. We conducted surveys between 0.5 and 4.5 hrs after sunrise on days with no precipitation and wind speeds of less than 24 kph.

Table 1. The number of survey plots by habitat type and geographic area.

Habitat type	Pocosin Lakes	Alligator River	Great Dismal Swamp
Pond Pine pocosin	27	5	0
Hardwood dominated	2	18	31
Pine/hardwood mix	0	49	12
Pine dominated	0	31	9
Cedar component	0	28	21
Cypress component	0	23	10

Vegetation sampling

We measured vegetation structure/composition within a sub-sample of "occupied" and "unoccupied" (with respect to breeding Black-throated Green Warblers; see below) survey plots. Selection of survey plots for sampling was based on occupation, habitat type, and geographic area. We attempted to balance samples between habitats and refuges. We included all habitats in the selection except Pond Pine pocosin, as no birds were detected within this habitat type during the course of the study. Since this habitat type was concentrated within Pocosin Lakes NWR, no samples were taken from this property. We measured vegetation between 27 June and 26 July 2001.

We sub-sampled vegetation within two plots established within each 50-m radius survey plot. We stratified each sub-plot to include a 5-m-radius plot embedded within a larger 11.4-m-radius plot. We took vegetation samples from the focal half of the survey plot. We positioned the center of each vegetation plot 30 m from the center of the point count in two different directions (each >90° apart). The initial direction for the first vegetation plot was chosen randomly from the center of the point count.

We collected vegetation data on two different levels within circular plots. We counted all large woody plants (>8 cm dbh) and dead standing stems (snags) by species and stem-diameter class (diameter classes included 8–22, 23–38, and >38 cm dbh), and estimated canopy cover and canopy height over the entire 11.4-m-radius plot. We used a convex densiometer to estimate percent canopy cover and a clinometer to measure canopy height. We collected data on understory vegetation within the 5-m-radius plot. We stratified counts of understory vegetation to include stems, shrubs, and saplings >0.5 m in height and <8 cm dbh.

Data analysis

Breeding sites. Identification of breeding sites for Wayne's Warblers using point-count data alone was complicated by several opposing factors. The first of these is the potential for overlap between the two subspecies (*D. v. virens* and *D. v. waynei*) within the study area. The Wayne's subspecies is one of the earliest arriving neotropical migrants within the region. Within the study areas, individuals begin to arrive on breeding territories in late March to early April (Meanley 1977). At this time, most *D. v. virens* individuals are believed to be still on winter territories (Morse 1993, Sprunt 1953). *Dendroica v. virens* does not migrate through comparable latitudes until mid-April. There remains confusion as to whether or not and the extent to which *D. v. virens* migrates through the breeding range of *D. v. waynei*. Some authors suggest that *D. v. virens* winters primarily within Central America between Mexico and Panama and that most individuals migrate north via a land route through Mexico and Texas, then continue on an inland track to the Appalachians and northern breeding areas (Morse 1993, Oberholser 1974, Stevenson 1957). This route suggests that the probability of contact between these two subspecies in the spring would be low. If true, virtually all of the individuals encountered within the study areas would be *D. v. waynei*. This view is supported by Sprunt (1953), who indicates that records of *D. v. virens* are completely absent from the south Atlantic Coast and suggests that *D. v. waynei* likely winters in a distinct location that is in closer proximity to the breeding grounds. It has been suggested that *D. v. waynei* winters in western Cuba (AOU 1957). However, other authors (E.F. Potter, unpubl. data) who have worked within the study area suggest that *D. v. virens* does move through the region, although there is no suggestion as to the winter origin or breeding destination of such individuals. The primary differences between *D. v. virens* and *D. v. waynei* are bill and body size (Bangs 1918). There are no song or appearance differences that would allow for simple separation in the field (Morse 1993, Sprunt 1953). At present, there is no way to determine the subspecies designation of birds detected within the area between mid-April and early May. Birds detected from late March through mid-April may clearly be assigned to *D. v. waynei* due to subspecific differences in the timing of migration. Birds detected after the first week of May may also be assigned to *D. v. waynei* because by then *D. v. virens* are likely all on their breeding grounds.

A second complicating factor is the early breeding season of *D. v. waynei* and the rapid diminution of singing. The Wayne's subspecies is one of the earliest nesting neotropical migrants within the region. Nests with eggs have been documented within the Great Dismal Swamp as early as 4 April (Meanley 1977). E.F. Potter (unpubl. data) observed a marked decline in singing apparently related to the hatching of eggs. Singing is not common after mid-May. This pattern suggests that there is a considerable reduction in detection probability through the month of May. The implication is that although birds detected in May could be definitively assigned to *D. v. waynei*, the probability of detecting breeding birds is much reduced.

In light of the factors outlined above, we developed rules for assigning occupancy status to survey plots based on point counts. We analyzed detection patterns to facilitate this process. We delineated three occupancy classes including 1) breeding location (occupied), 2) potential breeding location, and 3) no breeding location (unoccupied). We considered sites to be breeding locations if birds were detected after mid-May or where birds were detected during 3 out of the 7 survey rounds. Analysis of detection patterns illustrated that these conditions were related. Virtually all points having at least 3 separate detections also had detections after mid-May. This level of consistency supports the contention that these represent breeding locations. We considered sites to be potential breeding locations if fewer than 3 detections were made with all detections prior to mid-May. We considered sites to be unoccupied if birds were never detected.

Vegetation parameters. We derived several parameters describing vegetational structure from vegetation sub-samples. These included mean canopy height (CANH), % canopy cover (CANC), canopy tree density (CAND), sub-canopy tree density (SUBD), sapling density (SAPD), and understory density (UND) (Table 2). We did not include floristic information in the analysis, with the exception of canopy composition. We derived parameters separately for the density of hardwood, pine, white cedar, and Bald Cypress stems that were >22 dbh. We compared vegetation parameters between sites that were classified as occupied and unoccupied. We excluded potential breeding sites from the analysis.

Analysis. Due to the relatively small plot size, variation in breeding density recorded was very low. Incidences where multiple individuals were detected within a single plot were rare. For this reason, we assessed temporal and geographic patterns using frequency of occurrence where survey plots were the statistical units. We evaluated potential relationships with vegetation characteristics by comparing mean values using site-occupancy class (occupied vs unoccupied) as the grouping parameter. We used Kilmogorov-Smirnov tests to compare distributions relative to normality for each vegetation parameter. We transformed all non-normal parameters using three standard functions (including log[X = 1], $[X]^{1/2}$, and arcsine [X]) and retested. We evaluated significance between occupied and unoccupied survey plots using an F-test for all parametric variables and Mann-Whitney U test for all nonparametric variables.

Results

We encountered 335 Black-throated Green Warblers during point counts. We detected birds during 251 (13.5%) of 1862 point counts conducted. Detections were widespread and included 114 of 266 (52.6%) survey plots.

Detections of Black-throated Green Warblers were not evenly distributed among survey rounds (Fig. 2). A substantial number of detections were made in the first survey round, indicating that earliest arrivals were prior to the beginning or during the first round. Work within the area leading up to the first survey suggests that birds began to arrive approximately 2 days prior to the initiation of the first round. Detections increased during the month of April, reaching a peak in late April to early May. At this time, birds were detected within 23% of all survey plots on Alligator River NWR. It remains unclear if this peak represents

Table 2. Description of structural vegetation parameters measured within survey plots within Alligator River NWR and Great Dismal Swamp NWR (June–July 2001).

Parameter	Description
Understory density (UND)	Density (*n*/ha) of woody stems and shrubs >0.5 m in height and <8 cm dbh. Estimate from two 5-m radius plots.
Sapling density (SAPD)	Density (*n*/ha) of tree stems >0.5 m in height and <8 cm dbh. Estimate from two 5-m radius plots.
Sub-canopy density (SUBD)	Density (*n*/ha) of tree stems between 8 and 22 cm dbh. Estimate from two 11.4-m radius plots.
Canopy density (CAND)	Density (*n*/ha) of tree stems >22 cm dbh. Estimate from two 11.4-m radius plots.
Canopy height (CANH)	Average height (m) of canopy-forming stems. Estimate from 4 samples measured with clinometer within survey plot.
Canopy cover (CANC)	Average canopy cover (%) measured at 4 cardinal directions with convex densiometer. Estimates taken within two 11.4-m plots.
Hardwood density (HDWD)	Density (*n*/ha) of hardwood stems >22 cm dbh. Estimate from two 11.4-m radius plots.
Pine density (PIND)	Density (*n*/ha) of pine stems >22 cm dbh. Estimate from two 11.4-m radius plots.
White cedar density (CEDD)	Density (*n*/ha) of white cedar stems >22 cm dbh. Estimate from two 11.4-m radius plots.
Bald Cypress density (CYPD)	Density (*n*/ha) of bald cypress stems >22 cm dbh. Estimate from two 11.4-m radius plots.
Conifer density (COND)	Density (*n*/ha) of conifer stems >22 cm dbh. Estimate from two 11.4-m radius plots.

the continued arrival or increased activity of *D. v. waynei* or the passage of *D. v. virens*. Detections steadily declined throughout the month of May. This decline may represent a diminution of singing on the part of breeding residents, the passage of *D. v. virens* moving toward breeding locations to the north, or both.

Black-throated Green Warblers did not use survey plots of different habitat types according to their availability (Fig. 3) (χ^2 = 31.7, df = 5, P < 0.001). Birds were detected less than expected within Pond Pine pocosin and hardwood-dominated plots and more than expected within plots with white cedar and Bald Cypress. Occupied and unoccupied survey plots differed with respect to both vegetation structure and canopy composition (Table 3). Occupied plots had significantly higher canopy cover (df = 119, F-statistic = 6.6, P = 0.011) and lower understory density (df = 119, F-statistic = 7.8, P = 0.006). These two factors are negatively correlated suggesting the obvious relationship that the shading of higher canopy cover leads to a reduction in understory vegetation. The influence of forest type on the distribution of breeding sites is suggested by the difference between occupied and unoccupied survey plots in the amount of conifers in the canopy. For example, the difference between occupied and unoccupied plots in the density of large pines was nearly significant (df = 119, Mann-Whitney U-statistic = 1452.5, P = 0.055). The difference in the density of large cedar (df = 119, Mann-Whitney U-statistic = 1569.5, P = 0.045) and cypress (df = 119, Mann-Whitney U-statistic = 1533.0, P = 0.032) stems in the canopy was signifi-

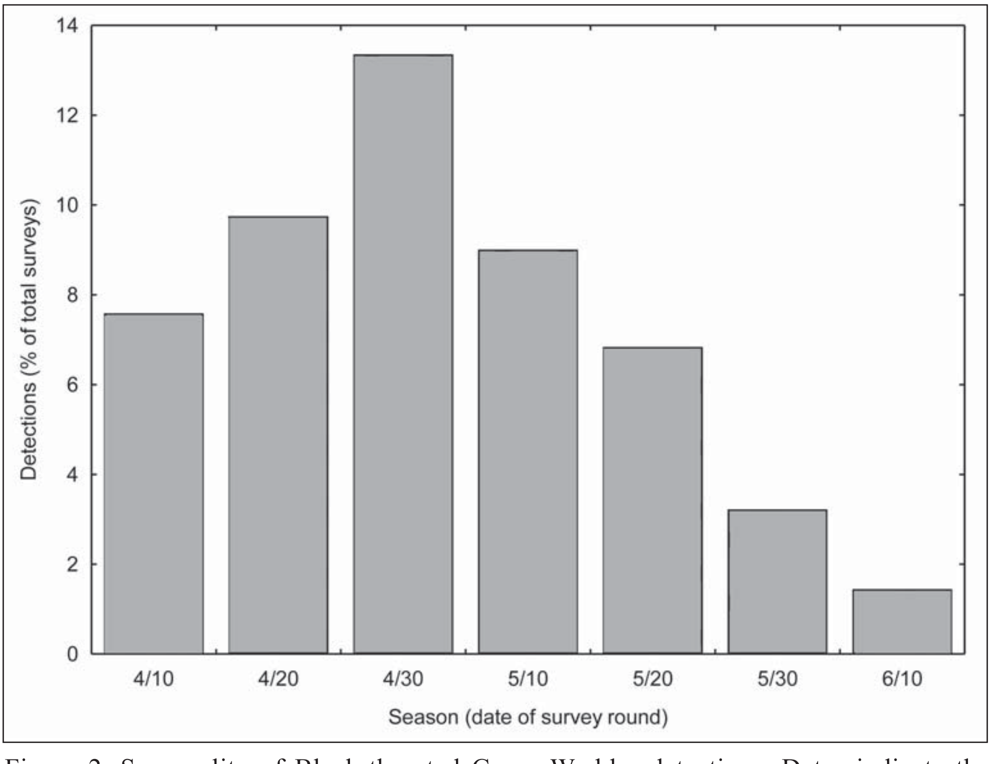

Figure 2. Seasonality of Black-throated Green Warbler detections. Dates indicate the beginning of survey blocks. The same network of survey plots (n = 266) was surveyed during each time block.

cant. When pines, cedar, and cypress stems are combined, the resulting parameter (COND) difference between occupied and unoccupied plots was highly significant (df = 119, F-statistic = 13.8, P = 0.003).

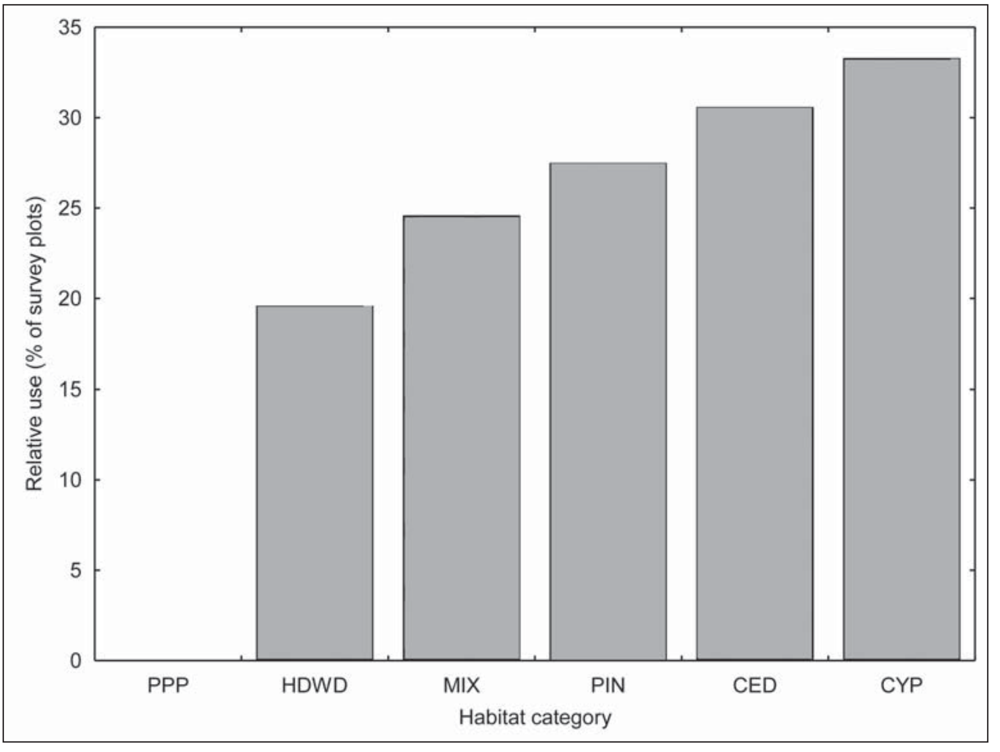

Figure 3. Relative frequency of Black-throated Green Warbler detections by habitat type. See Table 1 for sample sizes by habitat.

Table 3. Comparisons of vegetation parameters between occupied and unoccupied survey plots (see Table 2 for parameter abbreviations). Statistics are F-values unless otherwise specified. Mean values presented are individuals/ha.

Parameter	Occupied (mean ± SE; n = 54)	Unoccupied (mean ± SE; n = 67)	Statistic	P-value
Structural				
UND	15,456.0 ± 896.60	19,820.0 ± 1201.80	7.8	0.006
SAPD	2025.0 ± 441.40	1409.0 ± 178.60	1.9	0.167
SUBD	732.9 ± 66.47	620.9 ± 48.32	1.9	0.166
CAND	192.7 ± 11.02	173.5 ± 8.01	2.1	0.152
CANH	17.2 ± 0.51	19.1 ± 0.55	6.0	0.016
CANC	84.3 ± 1.14	79.1 ± 1.58	6.6	0.011
Composition				
HDWD	108.4 ± 13.11	105.4 ± 8.45	0.1	0.842
PIND	69.1 ± 10.01	43.0 ± 7.59	1452.5[A]	0.055
CEDD	28.0 ± 10.10	8.6 ± 4.40	1569.5[A]	0.045
CYPD	9.5 ± 3.05	2.7 ± 1.24	1533.0[A]	0.032
COND	106.7 ± 12.00	54.3 ± 8.16	13.8	0.003

[A]Mann-Whitney U statistic.

Discussion

The Wayne's subspecies of the Black-throated Green Warbler currently breeds from southeastern Virginia along the coast south to approximately Charleston, SC. Throughout much of this range, the species breeds in very low densities. An exception to this pattern is the Great Dismal Swamp, where the species was reported to be a fairly common breeder from the 1950s through 1970s (Meanley 1977), and Dare County within the Albemarle-Pamlico peninsula, where high breeding densities were recorded in the early 1980s (E.F. Potter, unpubl. data). Results from this study support recent suggestions (B. Meanley and D. Schwab, unpubl. data) that the population within the Great Dismal Swamp has declined. Although the species does continue to breed within the Swamp, none of the 83 points surveyed were classified as breeding sites based on criteria developed here. In contrast, the breeding population within the Alligator River NWR and Dare Bombing Range was found to be similar to that reported in the early 1980s (E.F. Potter, unpubl. data). This location may support one of the highest breeding densities of any area within the subspecies range.

No Black-throated Green Warblers were detected within Pocosin Lakes NWR. Nearly all of the survey plots established within the refuge were Pond Pine pocosin habitat. This species is known to utilize this habitat within the Albemarle-Pamlico peninsula (E.F. Potter, unpubl. data). In addition, the species is documented to occur well west of the study area (Wilson and Watts 2000). It is possible that the lack of use reflects the fragmented nature of these patches or their condition (e.g., tree density, stand age).

Birds began to arrive within study areas during the first week of April. This timing is consistent with other accounts that have listed arrival dates within the southern portion of the breeding range in mid- to late March (Sprunt 1953, Wayne 1910) and within the northern portion of the breeding range at the end of March or early April (Meanley 1977). Detection rates increased throughout April and then began to decline through May and into early June. This pattern is also consistent with previous authors who stated that the species does not become common within the region until mid- to late April (Meanley 1977, Sprunt 1953). Singing rates have been suggested to diminish rapidly after chicks hatch, which may partially account for the decline in detection rates through May. In support of this, E.F. Potter (unpubl. data) stated "in late May and early June, full song was rarely heard after 0900 EDT."

The peak in birds in late April may represent the passage of the nominate subspecies *D. v. virens* through the region. The timing of this peak would be consistent with breeding times reported for populations to the north in New England. E.F. Potter (unpubl. data) indicates that birds were detected in numerous locations in mid-April in coastal North Carolina, where no birds were detected at later dates, suggesting the presence of transients. Sprunt (1953) points to the dearth of records of Black-throated Green within the extreme southeast in spring and suggests that *D. v. virens* does not likely pass through the range of *D. v. waynei*. *Dendroica v. virens* winters primarily within Central America between Mexico and Panama, and most individuals apparently migrate north via a land route through Mexico and Texas and continue on an inland track to the Appalachians and northern breeding areas (Stevenson 1957). However, Black-throated Green Warblers do winter throughout the Caribbean and south Florida in low numbers (e.g., Emlen 1977, Morse 1993). *Dendroica v. waynei* has been suggested to winter in western Cuba (AOU 1957). The taxonomic origin of other populations that winter in the Caribbean has not been clearly documented. Confusion remains about the level and timing of overlap between these subspecies. For example, does *D. v. virens* winter within the Caribbean? Are *D. v. virens* and *D. v. waynei* geographically isolated on the winter grounds? What is the geographic range of *D. v. waynei* on the winter grounds? Because *D. v. waynei* is a small, unique population that is geographically isolated on the breeding grounds, understanding the risks that it faces within the winter range has conservation significance.

Black-throated Green Warblers occurred across the full gradient of habitat types from hardwood-dominated sites to sites supporting a Bald Cypress component. However, birds were not detected with the same frequency across all habitat types. Within this gradient, there was a lower frequency of occurrence within hardwood-dominated sites. In addition, survey plots classified as breeding sites had significantly higher densities of conifers including Loblolly Pine, Atlantic White Cedar, and Bald Cypress. These results are consistent with impressions expressed by other observers. In South Carolina, Wayne's Warblers are suggested to be associated with non-alluvial patches of Bald Cypress (Curson et al. 1994, Sprunt 1953). E.F. Potter (unpubl. data) indicates that a common trait among territories that she observed in coastal North Carolina was the presence of pines and or Bald Cypress. She emphasizes the occurrence of mature trees, a characteristic that is common to other accounts (Sprunt 1953).

The unique complex of habitats within the outer coastal plain from southeastern Virginia through the Carolinas supports a number of unique avian forms. Like the Wayne's Black-throated Green Warbler, these forms include endemic subspecies and disjunct populations. For example, an isolated population of *Dendroica cerulea* Gmelin (Cerulean Warblers) occurs along the lower Roanoke River and Chowan Basin (Lynch 1981). A distinct form of *Dendroica discolor* Vieillot (Prairie Warbler) that breeds within tall pocosin and forested habitats occurs in coastal Virginia and North Carolina (Meanley 1977, Nolan et al. 1999). An unusually dense population of *Helmitheros vermivorum* (Gmelin) (Worm-eating Warbler) breeds in flat pine plantations and pocosins compared to steep, hardwood slopes elsewhere in the species' range (Watts and Wilson 2005). *Vermivora bachmanii* Audubon (Bachman's Warbler) has been suggested to have a close association with *Arundinaria gigantea* Walter (Cane) thickets within the region (Remsen 1986). Virtually all of these forms appear to winter exclusively in the Caribbean. As with other species of conservation concern, populations that winter exclusively on small isolated islands are subject to dramatic declines if land-use changes are not in their favor. From a conservation perspective, it is important to determine the risks that the Wayne's form of the Black-throated Green Warbler faces on both the breeding and winter grounds.

Acknowledgments

We thank Chuck Hunter, Bob Noffsinger, and Keith Watson for the opportunity to conduct this study. Dennis Stewart, Wendy Stanton, Cynthia Britton, Teresa Cherry, and

Dennis Helms provided insight into potential field sites and logistical support within study areas. We appreciate the dedicated efforts of Sean Flint and William Sbrega in conducting bird surveys and measuring vegetation under very difficult field conditions. Lydia Whitaker, Carlton Adams, Renee Peace, Anne Womack, Gloria Sciole, Mark Roberts, and Cheryl Pope provided administrative support. Financial support was provided by the US Fish and Wildlife Service (Region 4) and the Center for Conservation Biology at the College of William and Mary. We thank the editor and two anonymous reviewers for helpful comments on an earlier draft of this manuscript.

Literature Cited

American Ornithologists Union (AOU). 1957. The A.O.U. checklist of North American birds. American Ornithologists Union, Lord Baltimore Press, Baltimore, MD.

Ashe, W.W. 1894. The forests, forest lands, and forest products of eastern North Carolina. North Carolina Geological Survey Bulletin No. 5. Raleigh, NC.

Bangs, O. 1918. A new race of the Black-throated Green Wood Warbler. Proceedings of the New England Zoological Club 6:93–94.

Curson, J., D. Quinn, and D. Beadle. 1994. Warblers of the Americas: An Identification Guide. Houghton Mifflin Company, New York, NY.

Emlen, J.T. 1977. Land bird communities of Grand Bahama Island: The structure and dynamics of an avifauna. Ornithological Monograph 24. American Ornithologists' Union, Washington, DC.

Frost, C.C. 1987. Historical overview of Atlantic White Cedar in the Carolinas. Pp. 257–263, *In* A. D. Laderman (Ed.). Atlantic White Cedar Wetlands. Westview Press, Boulder, CO.

Lynch, J.M. 1981. Status of the Cerulean Warbler in the Roanoke River basin of North Carolina. Chat 45:29–35.

Meanley, B. 1977. Birds of the Dismal Swamp, Virginia–North Carolina. Raven 48:3–25.

Morse, D.H. 1993. Black-throated Green Warbler (*Dendroica virens*). No. 55, *In* A. Poole and F. Gill (Eds.). The Birds of North America. The Academy of Natural Sciences, Philadelphia. PA, and The American Ornithologists' Union, Washington, DC.

Nolan, V., Jr., E.D. Ketterson, and C.A. Buerkle. 1999. Prairie Warbler (*Dendroica discolor*). No. 455, *In* A. Poole and F. Gill (Eds.). The Birds of North America. The Academy of Natural Sciences, Philadelphia. PA, and The American Ornithologists' Union, Washington, DC.

Oberholser, H.C. 1974. The Bird Life of Texas, Volume 2. University of Texas Press, Austin, TX.

Remsen, J.V., Jr. 1986. Was Bachman's Warbler a bamboo specialist? Auk 103:216–219.

Sprunt, A., Jr. 1953. Wayne's Black-throated Green Warbler. US National Museum Bulletin 203:308–316.

Stevenson, H.M. 1957. The relative magnitude of the trans-gulf and circum-gulf spring migrations. Wilson Bulletin 69:39–77.

Watts, B.D., and M.D. Wilson. 2005. The use of pine plantations by Worm-eating Warblers in coastal North Carolina. Southeastern Naturalist 4:177–187.

Wayne, A.T. 1910. Birds of South Carolina. Charleston Museum of Natural History. Charleston, SC.

Wilson, M.D., and B.D. Watts. 2000. Breeding-bird communities of the Parker Tract Hardwood Forest Swamps. Center for Conservation Biology Technical Report, CCB-TR-00-04. College of William and Mary, Williamsburg, VA. 49 pp.