ORNITOLOGIA NEOTROPICAL 23: 347–354, 2012

POPULATION DISTRIBUTION, DENSITY AND HABITAT PREFERENCE OF THE CERULEAN WARBLER (*SETOPHAGA CERULEA*) IN THE DELAWARE WATER GAP NATIONAL RECREATION AREA

Shannon Curley[1], Terry Master[1] & Gregory George[2]

[1]Department of Biological Sciences, East Stroudsburg University, 200 Prospect Street, East Stroudsburg, PA 18301
[2]Department of Biological Sciences, Delaware Valley College, 700 East Butler Avenue, Doylestown, PA 18901

Resumen. – **Distribución poblacional, densidad y preferencia de hábitat de la Reinita Cerúlea *(Setophaga cerulea*) en el Área Nacional de Recreación del Paso de Agua de Delaware. –** Recientemente, el rango de reproducción de la Reinita Cerúlea se ha expandido a bosques de crecimiento secundario y **a** tierras convertidas a la agricultura en el noreste de los Estados Unidos donde, de acuerdo al Estudio de Aves Reproductivas, la población está incrementando. A pesar de esta expansión en una parte del rango, la población como un todo está todavía en rápida declinación, suponiendo de esta manera que la calidad del hábitat reemplaza a la importancia de la expansión del mismo. El Área Nacional de Recreación del Paso de Agua de Delaware (ANRD) constituye una muestra de la reciente ocupación de hábitat en el noreste. Encontramos Reinitas Cerúleas anidando en densidades relativamente bajas, en comparación con el centro de la distribución en Virginia Occidental, en la mayoría de las partes australes y centrales del parque donde la especie fue confirmada. En uno de los sitios de estudio en particular, Freeman Tract Road, las densidades de anidación compiten con aquellas del centro de la distribución de la especie. Las parcelas de muestreo en los territorio se caracterizaron por un predominio más alto de lo esperado de nogal negro (*Juglans nigra*) y sicómoro americano (*Platanus occidentalis*) mientras que el roble rojo del norte (*Quercus rubra*) y especies de árboles siempreverdes fueron menos predominantes que en parcelas ubicadas al azar. Las parcelas territoriales también exhibieron un estrato arbustivo más desarrollado y alto. El hábitat reproductivo ocupado recientemente en el noreste, tal como el de ANRD, pueden de esta manera servir como una fortaleza en el futuro de la población y como un sitio de estudio para establecer esfuerzos que lleven a comprender los requerimientos de hábitat de la Reinita Cerúlea en el noreste de los Estados Unidos.

Abstract. – Recently, the breeding range of the Cerulean Warbler has expanded into second-growth forest and converted agricultural land in the northeastern United States where, according to the Breeding Bird Survey, the population is increasing. Despite this expansion in one part of its range, the population as a whole is still in rapid decline implying that habitat quality supersedes habitat expansion in importance. The Delaware Water Gap National Recreation Area (DEWA) is representative of recently occupied northeastern habitat. We found Cerulean Warblers breeding at relatively low densities, compared to their core range in West Virginia, in most of the southern and central portions of the park to which the species was confined. On one particular study site, the Freeman Tract Road, breeding densities did rival those of the species' core range. Sampling plots within territories were characterized by a higher than expected prevalence of black walnut (*Juglans nigra*) and American sycamore (*Platanus occidentalis*) while northern red oak (*Quercus rubra*) and evergreen tree species were less prevalent than on randomly placed plots. Territorial plots also exhibited a more developed and taller shrub layer. Recently occupied northeastern breeding habitat, such as DEWA, may thus serve as a population stronghold in the future and as a study site for efforts to further understand Cerulean Warbler habitat requirements in the northeastern U.S.

Key words: Cerulean Warbler, Distribution, Habitat Preference, Population Density

INTRODUCTION

The Cerulean Warbler (*Setophaga cerulea*) is a neotropical migrant songbird of conservation concern. Habitat fragmentation as a result of human activity has impacted much if its breeding range, consequently, the population is experiencing the most rapid rate of decline of any neotropical migrant songbird (Sauer *et al.* 2004). Simultaneously, the breeding range has expanded into secondary-growth forest and converted agricultural land in the northeastern United States where, according to the Breeding Bird Survey, the population is increasing. Despite this expansion in a portion of its range, the population as a whole is still in rapid decline implying that habitat quality supersedes habitat expansion in importance. This study, designed to document abundance, distribution and habitat preferences in representative northeastern habitat, was conducted in The Delaware Water Gap National Recreation Area (DEWA).

METHODS

Study Site. DEWA consists of nearly 70,000 acres on both the New Jersey and Pennsylvania sides of the Delaware River, including parts of Sussex and Warren counties in New Jersey and Monroe, Northampton and Pike counties in Pennsylvania. The Park protects 40 miles of the Delaware River, the longest major undammed river in the east and one of the cleanest large rivers in the United States. It is composed of a mosaic of habitats, including active agricultural land, river islands, palustrine wetlands, early successional habitats, hemlock-lined stream ravines and secondary but maturing upland and riparian deciduous forest. Preliminary surveys in 2006 (T. Master, unpublished data), conducted in an area known as the Freeman Tract Road, revealed relatively high densities of Cerulean Warblers in a localized area, thus warranting further investigation of abundance and distribution within the entire park.

Transects. One km transect surveys were conducted within DEWA from 3–30 June 2009 and 26 May–28 June 2010 using a modified Emlen transect protocol (Emlen 1977). Each transect was located along roads or trails that ran parallel to the Delaware River. Placement of these transects was determined by overlaying a 2 km^2 block grid over 2002 DEWA orthophotography using ArcView GIS® 9.1. Blocks were numbered and evaluated for habitat composition. Transects were placed in a stratified random fashion within blocks that met our predetermined criteria based on known habitat preferences of the Cerulean Warbler. Transects were traversed between 05:30–08:30 am. During each transect survey, any visual or auditory cues from Cerulean Warblers were recorded as well as the direction of the recording (either to the left or right side of the transect center line), estimated distance from the transect centerline and the time of the recording. Only observations that occurred within 50m laterally from the transect centerline were recorded in order to minimize difficulties with cue attenuation at greater distances (Ralph *et al.* 1995). During the 2009 field season, 10 transects were traversed three times each for a total of 30 transect traverses. During the 2010 field season, four additional transects were added and all 14 transects were traversed four times for a total of 56 transect traverses. Densities were determined by employing spot mapping of the registrations within the given area of each transect.

Ad hoc roadside surveys were also conducted opportunistically to supplement transect data in order to get an accurate representation of overall Cerulean Warbler distribution within DEWA. Sites were revisited on separate, but never consecutive, days to further monitor Cerulean Warbler activity. Territory presence, whether detected by transect traverses or ad hoc surveys, was determined when Cerulean Warbler activity was recorded on at least three separate occasions at the same location. Both

methods were used to determine distribution in the park, only transect surveys were used to calculate territorial densities.

Vegetation Surveys. A vegetation analysis was conducted during the summer of 2010 on randomly located and territorial plots in order to help determine if vegetation variables varied between random and occupied territory plots. For territory vegetation plots, favorite song trees (trees where a Cerulean Warbler was frequently seen singing or trees where activity was pronounced) were used as the center point of the vegetation plot. Five stratified random vegetation plots were surveyed every 200m on each transect. Each plot was randomly placed on the left or right side of the transect line using a coin flip and a random number table was used to determine how far the plots would be placed laterally from the transect centerline at10m intervals up to 40m on either side of the centerline. We used a modified BBird Protocol (Martin *et al.* 1997) to measure vegetation variables including tree species composition, diameter at breast height (DBH), Ecological Importance Values (IV) (by adding relative density, relative frequency and relative dominance values determined from tree basal areas), foliage height distribution and shrub layer height. A Pearson's Chi-squared analysis using R statistical language (R Development Core Team 2011) was used to determine if significant differences existed between tree species composition in random and territory plots. A subdivided contingency table was also used in R to determine which tree species had the most influence over tree species composition in territory plots. Tree species occurring more or less frequently than expected were determined from the IV values for Cerulean Warbler territories by subtracting random plot IVs from territory plot IVs. The residual numbers from these calculations were either positive or negative. Positive values indicated trees occurring more frequently in territory plots than expected based on their availability within random plots. Foliage height distribution and estimated shrub layer height and coverage were also recorded for all plots. T-tests were conduced using Microsoft Excel© and IBM SPSS© (version 18.0) to evaluate differences in foliage height distribution and shrub height.

RESULTS

Distribution. In 2009 and 2010 Cerulean Warblers were confirmed breeding within DEWA. In 2009, 22 singing males were recorded from both transects and ad hoc roadside surveys and in 2010, 68 singing males were observed (Fig. 1). In both years, the locations of Cerulean Warbler territories were confined to the southern and central portions of DEWA.

Density. In 2009, Cerulean Warblers were detected on four of the ten transects ($\bar{\chi}$ = 0.20, SE = 0.041) (Fig. 1). In 2010, eight of the 14 transects had Cerulean Warbler territories ($\bar{\chi}$ = 0.24, SE = 0.075) (Fig. 2). Other than a single transect in 2009, all transects with Cerulean Warbler territories in 2009 also had territories present in 2010. All transects in 2009 without Cerulean Warbler registrations and activity showed no activity in 2010 either. All transects with no activity in either year occurred in the northern portion of DEWA.

Habitat Preference. Tree species composition was significantly different in random versus territory plots (χ^2 = 187.2, df = 14, $p \leq 0.001$). Tree species that contributed most to these differences were black walnut (*Juglans nigra*) (BLWA), American sycamore (*Platanus occidentalis*) (SYCA), sugar maple (*Acer saccharum*), (SUMA), green ash (*Fraxinus pennsylvanica*) (GRAS) and slippery elm (*Ulmus rubra*) (SLEL) Tree species that occurred more frequently on territory plots than expected

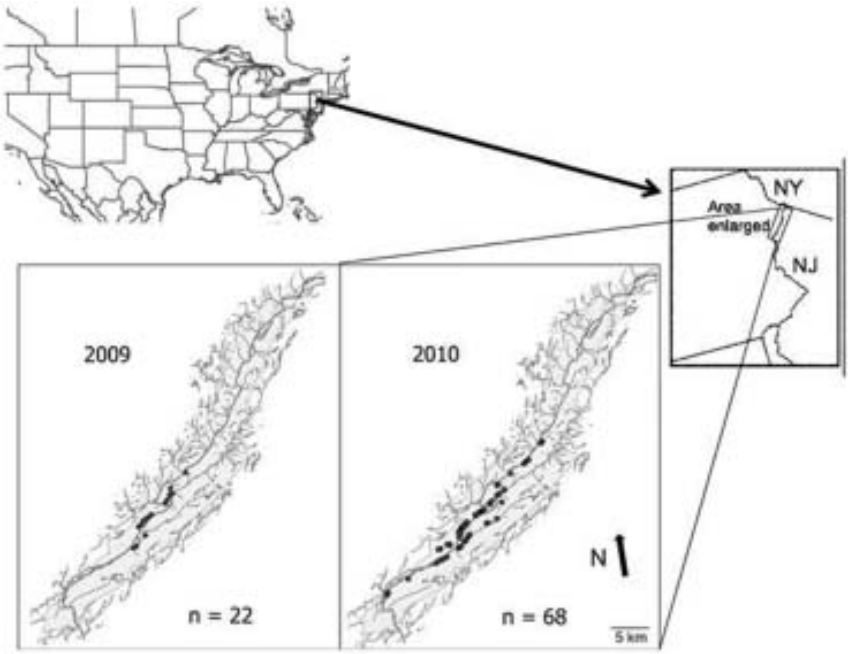

FIG. 1. Cerulean Warbler population distribution within the Delaware Water Gap National Recreation Area in 2009 and 2010.

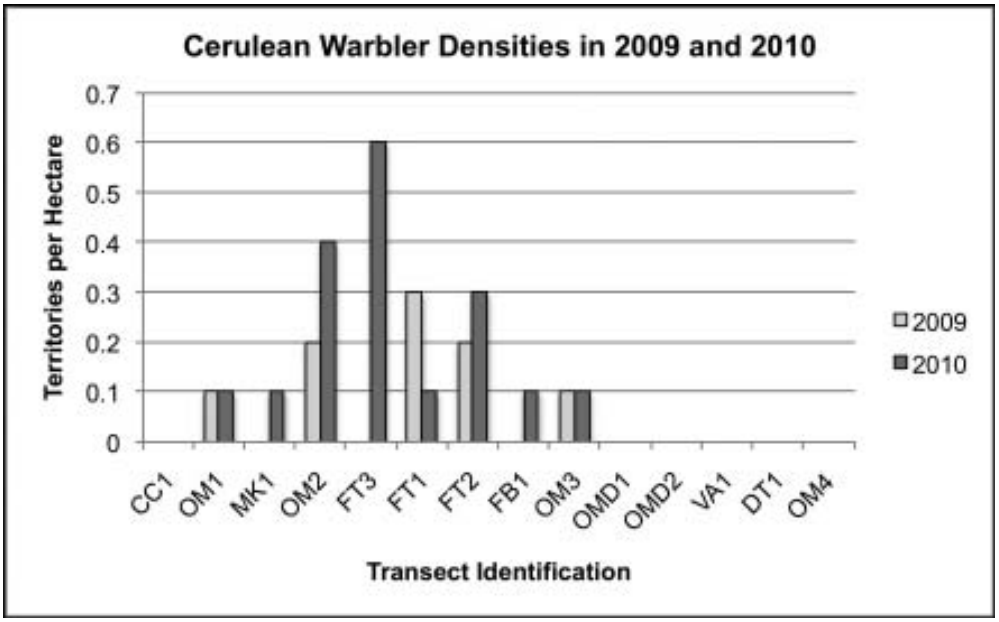

FIG. 2. Cerulean Warbler densities in the Delaware Water Gap National Recreation Area in 2009 and 2010. Transects ordered from southern most to northern most from right to left.

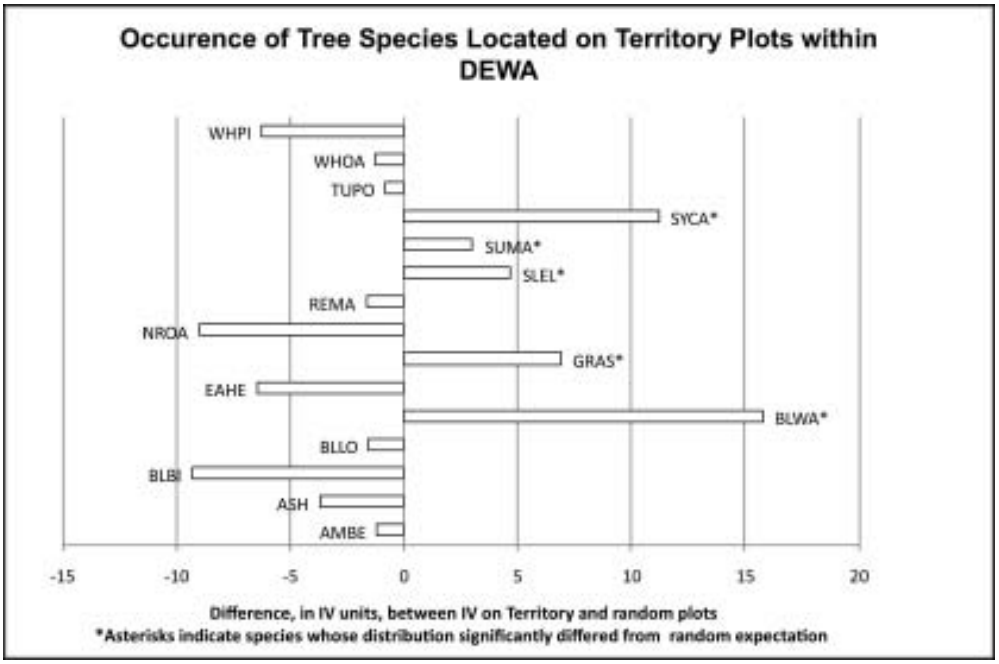

FIG. 3. Occurrence of tree species on territory plots. Positive values indicate more frequent occurrence than expected while negative values indicate less frequent occurrence than expected when compared to random plots. Species: American beech (*Fagus grandifolia*)(AMBE), Ash spp. (ASH), black birch (BLBI), black locust (*Robinia pseudoacacia*) (BLLO), black walnut (BLWA), eastern hemlock (EAHE), green ash (GRAS), northern red oak (NROA), red maple (*Acer rubrum*) (REMA), slippery elm (SLEL), sugar maple (SUMA), American sycamore (SYCA), tulip poplar *(Liriodendron tulipifera)(*TUPO), white oak (WHOA) and white pine (WHPI).

included BLWA, GRAS SYCA, SLEL and SUMA. Tree species that occurred less frequently than expected included northern red oak (*Quercus rubra*)(NROA), black birch (*Betula lenta*) (BLBI), eastern hemlock (*Tsuga canadesis*)(EAHE) and white pine (*Pinus strobus*) (WHPI) (Fig. 3).

There was no significant difference in foliage distribution at any height interval between territory and random plots ($p = 0.84$). The distribution of foliage was generally consistent among transects, with the majority of the vegetation occurring at the sub-canopy and canopy level.

The mean shrub height in territory sites was 2.1m versus 1.0m in random plots and was significantly higher in territory plots ($p < 0.0001$). Thus, occupied Cerulean Warbler habitat was characterized by the presence of several deciduous tree species occurring more frequently than expected compared to random plots, a total lack of evergreen species and a well-defined shrub layer, indicating the presence of canopy gaps.

DISCUSSION

In both 2009 and 2010, breeding was confined to the southern and especially the central portion of DEWA. At least in part, this restricted spatial distribution might be explained by their habitat preferences and breeding ecology, including a tendency to demonstrate site fidelity and clustered territoriality (Colorado &

Cuadros 2004, Jones *et al.* 2004, Moreno *et al.* 2006, Bakermans 2008, Roth & Islam 2008). On transects where coniferous tree species, primarily white pine and eastern hemlock, were among the dominant tree species, no Cerulean Warbler activity was recorded.

Densities were generally lower than expected based on the preliminary 2006 surveys done on the Freeman Tract Road (T. Master, unpublished data). However, densities at this site during the current study were comparable, and in some cases higher, than those reported from the core of the species' breeding range in West Virginia (cf. Weakland & Wood 2005) and from Hamel (2000).

The tree species that occurred most frequently in territories and was most commonly used as a song perch within DEWA was black walnut. Black walnut is described as a shade intolerant tree, that has to be a dominant or co-dominant species within a mixed-species stand in order to persist (Baker 1948). In DEWA, black walnut exhibits late leaf-out. A study by Barg *et al.* (2006) found that bitternut hickory (*Carya cordiformis*) was a preferred song post for Cerulean Warblers in Ontario. This species also exhibits late leaf-out like our black walnut. They suggested that tree species with late leaf-out may be coveted as song posts by providing less acoustic hindrance for song transmission and increased visibility for monitoring for conspecifics. At a microhabitat scale, Cerulean Warblers have been shown to prefer particular tree species within their territories even though these species may not be particularly common in surrounding habitat. George (2008) found that Cerulean Warblers preferred foraging in chestnut oaks, hickories and maples in West Virginia.

The northern red oak was the tree species occurring least frequently on territories compared to random plots and was in fact among the most common species generally. George (2008) found that Cerulean Warblers did not select northern red oak for foraging. This may be related to food resource availability, however conclusive evidence for this explanation has remained elusive.

ACKNOWLEDGMENTS

Thanks are due to the Pennsylvania State System of Higher Education and the East Stroudsburg University Faculty Development and Research Committee for funding this project. I would also like to thank Jeff Shreiner and the DEWA Park Resource and Research Planning Office for their permission to conduct our research. Joe Yuhas, Don Detwiler and Matt Bouboulis generously assisted me in the field and Nick Ernst provided technical support.

REFERENCES

Baker, Frederick S. 1948. A revised tolerance table. J. Forest. 47: 179–181.

Bakermans, M. H. 2008. Demography and habitat use of Cerulean Warblers on breeding and wintering grounds. Ph.D. diss. Ohio State Univ., Columbus, Ohio, USA.

Barg, J. J., D. M. Aiama, J. Jones, & R. J. Robertson. 2006. Within-territory use and microhabitat selection by male cerulean warblers (*Dendroica cerulea*). Auk 123: 795–806.

Colorado, G. J. & T. Cuadros. 2004. Habitat Use in Wintering Grounds by Cerulean Warbler (*Dendroica cerulea*) in Native Vegetation and Agroecosystems in the Western Cordillera, Northern Colombia. Final report presented to The Nature Concervancy – TNC. Medellin, Colombia.

Emlen, J. T. 1977. Estimating breeding season bird densities from transect counts. Auk 94: 455–468.

George, G.A. 2008. Foraging ecology of male Cerulean Warblers and other neotrpoical migrants. Ph.D. diss., West Virginia Univ., Morgantown, West Virginia, USA.

Hamel, P. B. 2000. Cerulean Warbler (*Dendroica cerulea*). *In* Poole, A., & F. Gill (eds). The Birds

of North America, No. 511. The birds of North America, Inc., Philadelphia, Pennsylvania, USA.

Jones, J., J. J. Barg, T. S. Sillett, M. L. Veit, & R.J. Robertson. 2004. Minimum estimates of survival and population growth for Cerulean warblers (*Dendroica cerulea*) breeding in Ontario, Canada. Auk 121: 15–22.

Larkin, J. L., P. B. Wood, T. J. Boves, J. Sheehan, D. A. Buehler, P. D. Keyser, A. D. Rodewald, T. A. Beachy, M. H. Bakermans, A. Evans, G. A. George, M. E. McDermott, F. L. Newell, K. A. Perkins, M. White, & T. B. Wigley. 2012. Breeding season concerns and response to forest management: Can forest management produce more breeding birds? Ornitol. Neotrop. 23(Suppl.): xxx–xxx.

Martin, T. E. & C. J. Conway. 1994. Breeding Bird (BBIRD) field protocol. Montana Cooperative Wildlife Research Unit, University of Montana, Missoula, MT.

Moreno, M. I., A. Morales, & J. Velasquez. 2006b. Evaluation of the range and distribution of *Dendroica cerulea* in Colombia. Fundación ProAves de Colombia. Final Report and Presenation to the The Nature Consevancy. June 2006.

Ralph, C. J., S. Droege, & J. R. Sauer. 1995. Managing and monitoring birds using point counts: standards and applications. Pp. 161–168 *In* Ralph, C. J., J. R. Sauer & S. Droege, (eds.) Monitoring Bird Populations by Point Counts. USDA Forest Service Gen. Tech. Rep. PSW-149.

Roth, K. L., & K. Islam. 2008. Habitat selection and reproductive success of Cerulean Warblers in Indiana. Wilson J. Ornithol. 120: 105–110.

Sauer J. R., J. E. Hines, & J. Fallon. 2004. The North American Breeding Bird Survey, results and analysis 1966-2003. Version 2004.1. USGS Patuxent Wildlife Research Center, Laurel, Maryland. USA.

Weakland, C. A., & P. B. Wood. 2005. Cerulean Warbler (*Dendroica cerulea*) microhabitat and landscape-level habitat characteristics in southern West Virginia. Auk 122: 497–508.