BioOne RESEARCH EVOLVED

Characteristics of Vegetation Used by Golden-Cheeked Warblers in Central Texas

Author(s): Ashley M. Long , J. Cal Newnam , Melanie R. Colón , Kathryn N. Smith-Hicks and Michael L. Morrison

Source: Southeastern Naturalist, 15(1):153-161.
Published By: Eagle Hill Institute
DOI: http://dx.doi.org/10.1656/058.015.0116
URL: http://www.bioone.org/doi/full/10.1656/058.015.0116

BioOne (www.bioone.org) is a nonprofit, online aggregation of core research in the biological, ecological, and environmental sciences. BioOne provides a sustainable online platform for over 170 journals and books published by nonprofit societies, associations, museums, institutions, and presses.

Your use of this PDF, the BioOne Web site, and all posted and associated content indicates your acceptance of BioOne's Terms of Use, available at www.bioone.org/page/terms_of_use.

Usage of BioOne content is strictly limited to personal, educational, and non-commercial use. Commercial inquiries or rights and permissions requests should be directed to the individual publisher as copyright holder.

BioOne sees sustainable scholarly publishing as an inherently collaborative enterprise connecting authors, nonprofit publishers, academic institutions, research libraries, and research funders in the common goal of maximizing access to critical research.

Characteristics of Vegetation Used by Golden-cheeked Warblers in Central Texas

Ashley M. Long[1,*], J. Cal Newnam[2], Melanie R. Colón[3], Kathryn N. Smith-Hicks[3], and Michael L. Morrison[3]

Abstract - *Setophaga chrysoparia* (Golden-cheeked Warbler; hereafter Warbler) breeds in oak–juniper woodland across central Texas. Our knowledge of Warbler-habitat associations remains limited to a small number of long-term study sites. However, ecological conditions within Warbler habitat may vary by geographic location. We estimated vegetation characteristics at 24 sites occupied by Warblers and at 80 Warbler nests and compared site and nest vegetation across natural regions. We found differences in vegetation volume at sites and nests across regions. We also found differences across regions in canopy height at sites, but no differences in canopy height at nests. Tree species richness and diversity and the proportion of *Juniperus ashei* (Ashe Juniper) used by Warblers at sites and nests varied across regions. Our study identifies geographic variation in Warbler habitat characteristics across the species' breeding range.

Introduction

Setophaga chrysoparia (Golden-cheeked Warbler; hereafter Warbler) is a federally endangered songbird that breeds exclusively in central Texas (Fig. 1; USFWS 1990). Warbler breeding habitat consists of mature oak–juniper woodland and includes *Juniperus ashei* J. Buchholz (Ashe Juniper), a tree species that Warblers require for nesting, oaks (e.g., *Quercus fusiformis* Small [Texas Live Oak], *Q. stellata* Wangenh. [Post Oak], *Q. buckleyi* Nixon & Dorr [Texas Red Oak]), and various other hardwoods (Kroll 1980, Ladd and Glass 1999, Pulich 1976). In 1990, the US Fish and Wildlife Service cited habitat loss and degradation as the primary threats to Warblers (USFWS 1990). Since the listing decision, researchers have used remotely sensed data to identify general features of Warbler habitat across the species' breeding range (Collier et al. 2012, DeBoer and Diamond 2006), and some have quantified associations between Warbler population metrics and vegetation characteristics at specific locations. However, with few exceptions (Klassen et al. 2012, Kroll 1980, Magness et al. 2006, Stewart et al. 2014), published field-based information regarding vegetation structure and composition within Warbler breeding habitat and at nest sites remains limited to study sites in and near Austin in Travis and Hays counties (Reidy et al. 2009) and at the Fort Hood Military Reservation in Coryell and Bell counties (Dearborn and Sanchez 2001, Marshall et al. 2013, Peak 2007, Peak and Thompson 2013, Sperry et al. 2009).

[1]Institute of Renewable Natural Resources, Texas A&M University, College Station, TX 77843. [2]Texas Department of Transportation, PO Box 15426, Austin, TX 78761. [3]Department of Wildlife and Fisheries Sciences, Texas A&M University, College Station, TX 77843. *Corresponding author - ashley.long@ag.tamu.edu.

Manuscript Editor: Frank Moore

Our goal was to supplement existing natural history information by describing vegetation used by Warblers across regions with varying climate, soil type, land-surface form, and plant assemblages. We estimated vegetation volume, canopy height, proportion of vegetation composed of Ashe Juniper, tree species richness, and tree species diversity on study sites occupied by Warblers and compared these vegetation metrics across 5 natural regions where environmental conditions and plant species structure and composition were relatively homogenous. We similarly compared Warbler nest-vegetation characteristics across 3 natural regions. Our study quantifies Warbler-habitat associations at sites located across the species' breeding range, which may help inform region-specific conservation and management strategies for this species.

Field Site Description

We conducted our research from 1995 to 1997 at 24 study sites within the Warbler's breeding range in central Texas (Fig. 1). We selected these study sites because they encompassed known Warbler nesting habitat, were spatially separated across the Warbler's breeding range, and had land owners or park managers amenable to Warbler research on their properties. For comparison purposes, we categorized our study sites by 5 natural subregions (hereafter "regions"; LBJ School of Public Affairs 1978). We used these regions because they represent spatial units where environmental conditions (e.g., climate, landforms, soils) and the resulting vegetation assemblages are relatively homogenous. From north to south these regions included: (1) Western Cross Timbers, woodland dominated by Post Oaks, *Quercus marilandica* Muenchh. (Blackjack Oak), and *Carya* spp. (hickories) interspersed with tall and midgrass prairie; (2) Grand Prairie, historically tallgrass prairie with upland deciduous forest, now heavily encroached by Ashe Juniper and *Prosopis glandulosa* Torr. (Honey Mesquite); (3) Llano Uplift, woodland with Live Oak, Honey Mesquite, Post Oak, Blackjack Oak, and *Ulmus crassifolia* Nutt. (Cedar Elm) with Ashe Juniper and Texas Red Oak found on slopes; (4) Balcones Canyonlands, southeastern boundary of the Edward's Plateau with species-rich deciduous woodland and Texas Live Oak–Ashe Juniper woodland on slopes; and (5) Live Oak–Mesquite Savanna, open woodland dominated by Ashe Juniper, Texas Live Oak, Texas Red Oak, and Honey Mesquite (Diamond 1997, Griffith et al. 2004, LBJ School of Public Affairs 1978, Omernik and Griffith 2008).

Methods

From 1 March to 15 June, 2 observers simultaneously searched each study site for Warblers and Warbler nests as part of a concurrent study relating Warbler behavior to vegetation structure and composition (Newnam 2008). We visited each study site at least once per week and conducted Warbler surveys from 06:30–15:30. We used survey tape to mark the locations of our initial encounters with focal male Warblers and to mark the locations of Warbler nests. At the end of the Warbler breeding season, we returned to the marked locations and conducted vegetation surveys across each study site and at each nest site. Due to logistical constraints, we did not continuously monitor the nests over the course of the breeding season; thus, outcomes of the Warbler nests are unknown.

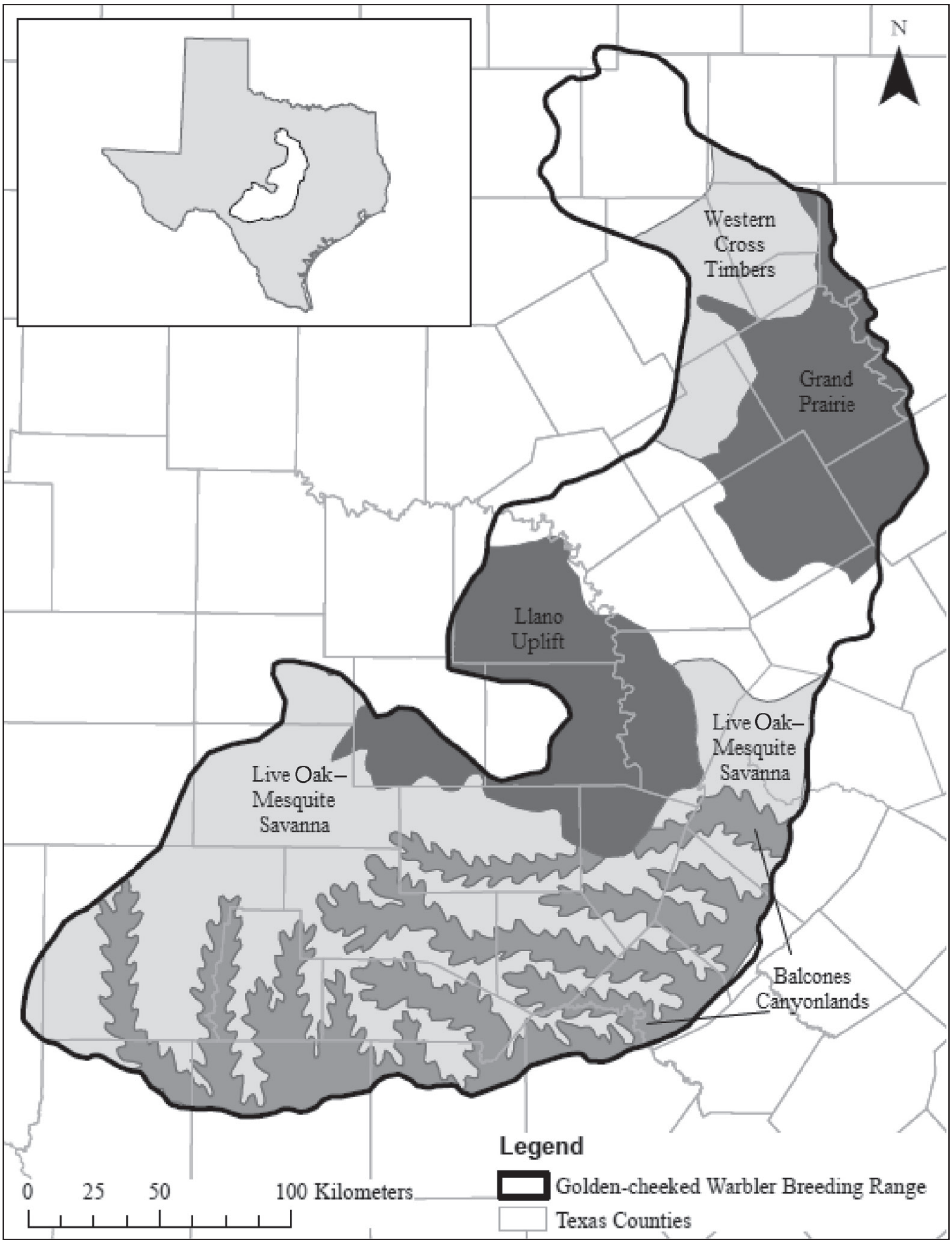

Figure 1. *Setophaga chrysoparia* (Golden-cheeked Warbler) breeding range and natural regions surveyed during 1995–1997 to examine habitat associations for the species in central Texas.

We estimated total vegetation volume (TVV) across sites following Mills et al. (1991). At each vegetation sampling point, we established a transect that consisted of 2 perpendicular 20-m lines, marked by ropes on the ground, which intersected on the mid-point. We used initial encounters as center points for transects to ensure complete coverage of all areas used by Warblers across study sites. We randomly determined the direction of transects from the marked location by spinning a screwdriver on a clipboard. At 2-m increments along each transect (n = 20 sampling points per transect), we erected a 6-m retractable pole (13 mm in diameter) and counted the number of vegetation intercepts with the pole (i.e., "hits") for each decimeter column, noting the plant species for each hit. We summed and recorded the number of total hits per species for each meter layer per point on the transect. We then summed the total number of hits per species recorded for each 20-point transect. We divided this number by 200 to obtain an average value for each transect (i.e., mean TVV per transect; m^3/m^2) and calculated the associated 95% confidence intervals (95% CI). TVV estimates for a transect could exceed 1 m^3/m^2, because hits in all meter layers of the canopy were combined.

In addition to TVV, we visually estimated the maximum height of the canopy (m) at each sampling point along the transect using the retractable pole. We used these data to calculate the mean maximum canopy height and associated 95% CIs per transect. We used our hit data to determine plant species richness (S) for each site (i.e., the total number of plant species recorded along transects at each site; Krebs 1999) and calculated the Shannon-Weiner diversity index (H') per site based on the number of plant species present and plant species abundance (i.e., the number of hits per plant species; Krebs 1999). Given the importance of Ashe Juniper as a nesting and foraging substrate for Warblers (Ladd and Gass 1999, Pulich 1976), we also calculated the relative proportion of Ashe Juniper across all transects per study site.

To describe vegetation used by Warblers at nesting locations, we extended four 20-m lines in each cardinal direction from the point on the ground directly below each nest site. From the center point of each line (meter 10), we established a perpendicular line as described above and sampled vegetation every 2 m along each of the 4 transects (n = 20 sampling points per transect). We recorded hit and maximum-height data similar to methods described for study sites. We used these data to calculate mean TVV, mean maximum canopy height, and their associated 95% CIs across the 4 nest transects, resulting in 1 value per vegetation metric per nest. We also calculated S, H', and the proportion of Ashe Juniper across all nests per study site.

We compared mean TVV and mean maximum canopy height across regions separately for sites and nests using one-way analysis of variance (ANOVA; Zar 1999:177). When results of the ANOVA indicated statistically significant differences among regions, we used Tukey's HSD and 95% CIs to evaluate statistically significant differences among groups (Zar 1999:208). We summarized and described S and H' at study sites and nests across regions. We then compared the proportion of Ashe Juniper across all combinations of regions for sites and nests separately using a 2-sample test for proportions (Zar 1999:562) and presented results for all pairs with >20% difference in the proportion of Ashe Juniper between regions. We conducted all statistical analyses using Program R v3.2.2 (R Core Development Team 2013).

Results

We found statistically significant differences in mean TVV ($F_{4,402}$ = 2.71, P = 0.03) and mean maximum canopy height ($F_{4,402}$ = 4.21, P < 0.01) across regions (Fig. 2). Mean TVV was ~11% higher at sites located in the Balcones Canyonlands when compared to the Llano Uplift (Fig. 2). Mean maximum canopy height was ~1.5 times taller in the Balcones Canyonlands and Live Oak–Mesquite regions when compared to the Grand Prairie region (Fig. 2). *S* at study sites was generally lower in the more northern Western Cross Timbers and Grand Prairie regions when compared to other regions (Table 1). *H'* was generally higher in the Llano Uplift and Balcones Canyonlands regions when compared to the other regions included in our study (Table 1).

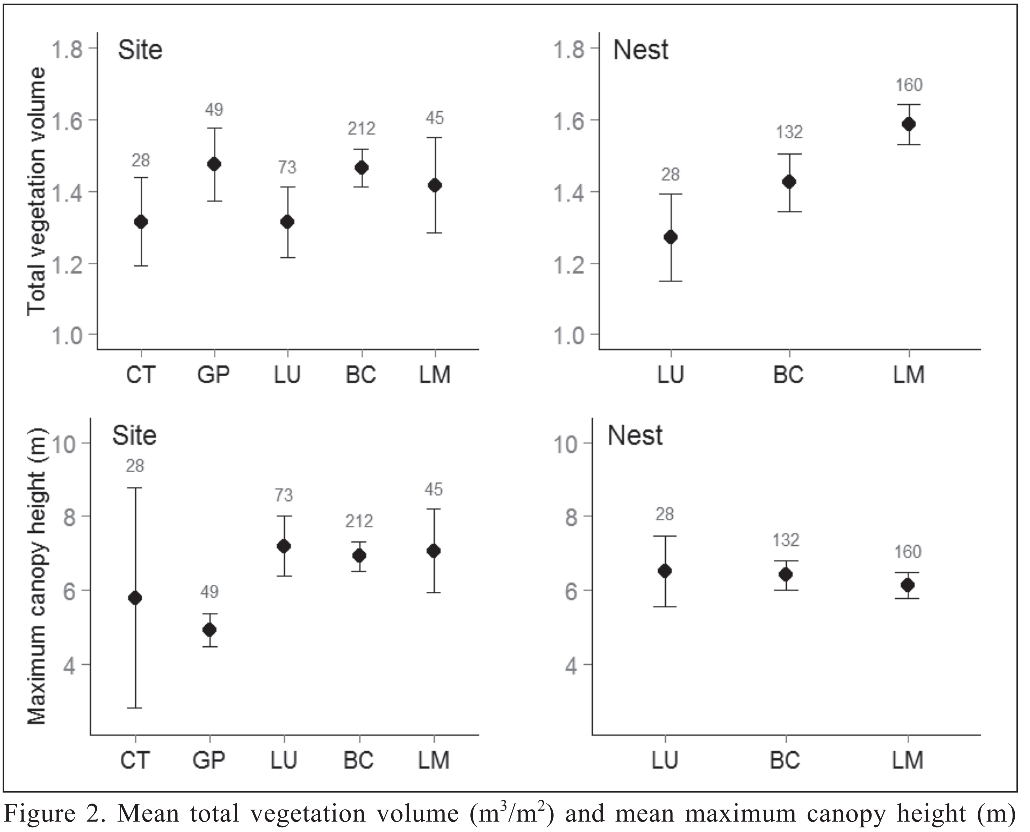

Figure 2. Mean total vegetation volume (m^3/m^2) and mean maximum canopy height (m) at *Setophaga chyrsoparia* (Golden-cheeked Warbler) sites and nests in central Texas (1995–1997). Sites and nests are divided into natural regions as follows: CT = Western Cross Timbers, GP = Grand Prairie, LU = Llano Uplift, BC = Balcones Canyonlands, LM = Live Oak–Mesquite Savanna. Transect and nest sample sizes per natural region are identified above each mean and associated 95% confidence interval.

We found a statistically significant difference between the proportions of Ashe Juniper at study sites for each pair of regions (Table 1). The Llano Uplift region had a lower proportion of Ashe Juniper when compared to the other regions (Table 1). Specifically, the proportion of Ashe Juniper at study sites was 26–42% lower in the Llano Uplift when compared to the Western Cross Timbers ($\chi^2 = 2215.81$, $P < 0.01$), Grand Prairie ($\chi^2 = 2858.54$, $P < 0.01$), Balcones Canyonlands ($\chi^2 = 1387.11$, $P < 0.01$), and Live Oak–Mesquite Savanna ($\chi^2 = 1820.51$, $P < 0.01$) regions. We also found that the proportion of Ashe Juniper at study sites was ~20% lower in the Balcones Canyonlands when compared to the Grand Prairie ($\chi^2 = 1061.22$, $P < 0.01$).

We collected vegetation data at 80 Warbler nests across 3 of the 5 regions we surveyed. Mean TVV at nests was ~10% and ~25% higher in Live Oak–Mesquite Savanna regions when compared to the Balcones Canyonlands and Llano Uplift regions, respectively ($F_{2,317} = 10.24$, $P < 0.01$; Fig. 2). Mean maximum canopy height at nest sites was not significantly different across regions ($F_{2,317} = 0.67$, $P = 0.49$; Fig. 2). *S* at nests was similar across the regions included in our study (Table 1). However, *H'* was higher in the Llano Uplift region when compared to the Balcones Canyonlands and Live Oak–Mesquite Savanna regions (Table 1). The proportion of Ashe Juniper at nests was 74% and 85% higher in the Balcones Canyonlands ($\chi^2 = 1085.26$, $P < 0.01$) and Live Oak–Mesquite Savanna ($\chi^2 = 2283.21$, $P < 0.01$) regions, respectively, when compared to the Llano Uplift (Table 1).

Discussion

Our descriptive study demonstrates that there is geographic variation in vegetation used by Warblers on their breeding grounds in central Texas. While we did not observe latitudinal or longitudinal patterns associated with mean TVV and mean maximum canopy height at sites across the Warbler's breeding range, tree species diversity at sites and nests was higher in the centrally located Llano Uplift when compared to the other regions. We also found that the proportion of Ashe Juniper at sites and nests was lower in the centrally located Llano Uplift when compared to the other regions included in our analyses. Conservation and management of the Warbler often focuses on the importance of canopy cover to this species. However, the occurrence of Warblers may be more tightly linked

Table 1. Tree species richness, tree species diversity, and proportion of *Juniperus ashei* (Ashe Juniper) at sites and nests occupied by *Setophaga chrysoparia* (Golden-cheeked Warbler) in central Texas (1995–1997).

	Richness		Diversity		Juniper	
Region	Sites	Nests	Sites	Nests	Sites	Nests
Western Cross Timbers	11	NA	1.22	NA	0.64	NA
Grand Prairie	9	NA	1.22	NA	0.67	NA
Llano Uplift	18	12	1.89	1.67	0.39	0.35
Balcones Canyonlands	23	15	1.81	1.45	0.53	0.61
Live Oak–Mesquite Savanna	18	15	1.57	1.32	0.58	0.65

to Ashe Juniper cover than to canopy cover overall (DeBoer and Diamond 2006), and the strength and shape of relationships between Ashe Juniper and Warbler responses may depend on the tree species composition found therein (Long 2014). Our research provides evidence that these vegetation characteristics vary across the range and suggests we should consider this variation with respect to future management and research plans.

Unfortunately, we do not have information on Warbler nest outcomes during our study. However, differences in site- and nest-scale vegetation characteristics can influence avian reproductive success, most often via nest concealment from predators (Martin 1993). Fink (1996) reported that highly exposed artificial Warbler nests had 29% lower survival than highly concealed nests in the central portion of the Warbler's breeding range. Fink (1996) and Sperry et al. (2009) also found a positive relationship between nest height and Warbler nest survival at some locations (but see Reidy et al. 2009). Other factors linked to vegetation structure and composition, such as predator assemblage (Reidy et al. 2009, Sperry et al. 2009) or food abundance (Marshall et al. 2013), can influence relative avian productivity across habitats. Additional range-wide studies to examine how site-specific vegetation characteristics drive nest-site selection and subsequent nest success may aid regional conservation and management efforts for this species.

Acknowledgments

Access to land for this study was provided by D. Riskind, M. Lockwood, and many park superintendents of the Texas Parks and Wildlife Department, as well as C. Abbruzzese of the City of Austin, P. Sunby, S. Paulson, and private landowners. We thank D. Booher for management of the field crews, P. Lee for data-management support, and field technicians B. Archer, M. Bailey, J. Brawner, C. Chisum, K. Couch, G. Oliver, K. Newcomb, A. Sugeno, D. Sugeno, D. Ricks, and D. Thompson for their contributions to this project. We are also grateful to K.A. Arnold, R.D. Slack, W.E. Grant, F.E. Smeins, J.A. Butcher, and B. Collier for their previous assistance with this project.

Literature Cited

Collier, B.A., J.E. Groce, M.L. Morrison, J.C. Newnam, A.J. Campomizzi, S.L. Farrell, H.A. Mathewson, R.T. Snelgrove, R.J. Carroll, and R.N. Wilkins. 2012. Predicting patch occupancy in fragmented landscapes at the rangewide scale for an endangered species: An example of an American warbler. Diversity and Distributions 18:158–167.

Dearborn, D.C., and L.L. Sanchez. 2001. Do Golden-cheeked Warblers select nest locations on the basis of patch vegetation? Auk 118:1052–1057.

DeBoer, T.S., and D.D Diamond. 2006. Predicting presence–absence of the endangered Golden-cheeked Warbler (*Dendroica chrysoparia*). Southwestern Naturalist 51:181–190.

Diamond, D.D. 1997. An old-growth definition for western juniper woodlands: Texas Ashe Juniper-dominated or -codominated communities. Report SRS-15. US Department of Agriculture, Forest Service, Southern Research Station, Asheville, NC. 15 pp.

Fink, M.L. 1996. Factors contributing to nest predation within habitat of the Golden-cheeked Warbler, Travis County, Texas. M.Sc. Thesis. Texas A&M University, College Station, TX. 98 pp.

Griffith, G.E., S.A. Bryce, J.A. Comstock, A.C. Rogers, B. Harrison, S.L. Hatch, and D. Bezanson. 2004. Ecoregions of Texas. Available online at ftp://ftp.epa.gov/wed/ecoregions/pubs/TXeco_Jan08_v8_Cmprsd.pdf. Accessed online 5 January 2015.

Klassen, J.A., M.L. Morrison, H.A. Mathewson, G.G. Rosenthal, and R.N. Wilkins. 2012. Canopy characteristics affect reproductive success of Golden-cheeked Warblers. Wildlife Society Bulletin 36:54–60.

Krebs, C.J. 1999. Ecological Methodology. Second edition. Addison-Welsey Educational Publishers, Inc., Menlo Park, CA. 624 pp.

Kroll, J.C. 1980. Habitat requirements of the Golden-cheeked Warbler: Management implications. Journal of Range Management 33:60–65.

Ladd, C., and L. Gass. 1999. Golden-cheeked Warbler (*Setophaga chysoparia*). The Birds of North America. Number 420.

LBJ School of Public Affairs. 1978. Preserving Texas' natural heritage. Policy Research Project Report 31. University of Texas, Austin, TX.

Long, A.M. 2014. The influence of tree species composition on songbird abundance and productivity. Ph.D. Dissertation. Texas A&M University, College Station, TX. 78 pp.

Magness, D.R., R.N. Wilkins, and S.J. Hejl. 2006. Quantitative relationships among Golden-cheeked Warbler occurrence and landscape size, composition, and structure. Wildlife Society Bulletin 34:473–479.

Marshall, M.E., M.L. Morrison, and R.N. Wilkins. 2013. Tree species composition and food availability affect productivity of an endangered species: The Golden-cheeked Warbler. Condor 115:882–892.

Martin, T.E. 1993. Nest predation among vegetation layers and habitat types: Revising the dogmas. American Naturalist 141:887–913.

Mills, G.S., J.B. Dunning, Jr., and J.M. Bates. 1991. The relationship between breeding-bird density and vegetation volume. Wilson Bulletin 103:468–479.

Newnam, J.C. 2008. Habitat use by the Golden-cheeked Warbler in Texas. Ph.D. Dissertation. Texas A&M University, College Station, TX. 45 pp.

Omernik, J., and G. Griffith. 2008. Ecoregions of the United States: Level IV (EPA). Available online at http://www.eoearth.org/view/article/152243. Accessed 5 January 2015.

Peak, R.G. 2007. Forest edges negatively affect Golden-cheeked Warbler nest survival. Condor 109:628–637.

Peak, R.G., and F.R. Thompson III. 2013. Amount and type of forest cover and edge are important predictors of Golden-cheeked Warbler density. Condor 115:659–668.

Pulich, W.M. 1976. The Golden-cheeked Warbler: A bioecological study. Texas Parks and Wildlife Department, Austin, TX. 172 pp.

R Core Development Team. 2013. R: A language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Austria.

Reidy, J.L., F.R. Thompson III, and R.G. Peak. 2009. Factors affecting Golden-cheeked Warbler nest survival in urban and rural landscapes. Journal of Wildlife Management 73:407–413.

Sperry, J.H., D.A. Cimprich, R.G. Peak, and P.J. Weatherhead. 2009. Is nest predation on two endangered bird species higher in habitats preferred by snakes? Ecoscience 16:111–118.

Stewart, L.R., M.L. Morrison, M.R. Hutchinson, D.N. Appel, and R.N. Wilkins. 2014. Effects of a forest pathogen on habitat selection and quality for the endangered Golden-cheeked Warbler. Wildlife Society Bulletin 38:279–287.

US Fish and Wildlife Service (USFWS). 1990. Endangered and threatened wildlife and plants; final rule to list the Golden-cheeked Warbler. Federal Register 55:53153–53160. Available online at http://ecos.fws.gov/docs/federal_register/fr1804.pdf. Accessed 5 January 2015.
Zar, J.H. 1999. Biostatistical Analysis. Fourth Edition, Prentice Hall, Englewood, NJ. 663 pp.