2014 Annual Report:
Golden-cheeked Warbler *(Setophaga chrysoparia)*
Monitoring Program
Balcones Canyonlands Preserve



Photo by Gil Eckrich

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2014 Golden-cheeked Warbler Monitoring Program

Balcones Canyonlands Preserve Annual Report

This report summarizes the results of the Golden-cheeked Warbler (*Setophaga chrysoparia*) endangered species monitoring program for the 2014 field season. This was the seventeenth year of Golden-cheeked Warbler monitoring on the City of Austin's Balcones Canyonlands Preserve (BCP). It was the fourth year of a five-year agreement with the U.S. Forest Service (USFS) to develop models to better understand factors influencing the long-term viability of the Golden-cheeked Warbler and its habitat and to predict the fate of both under various management scenarios within the BCP. This collaborative project includes the USFS, University of Missouri, City of Austin, Travis County, BCP managing partners (Lower Colorado River Authority, St. Edwards University/Wild Basin, Travis Audubon Society, The Nature Conservancy), and a team of volunteers all playing key roles and contributing data. Preliminary findings to date are consistent with research on Fort Hood (Peak and Thompson 2013, 2014) that large blocks of mature, closed-canopy Ashe juniper (*Juniperus ashei*) and oak (*Quercus* spp.) woodlands support higher densities of Golden-cheeked Warblers and these adults are more productive and more site-faithful than adults in more fragmented woodlands. Development of the population viability and habitat suitability models commenced following the third year of the USFS project.

ACKNOWLEDGEMENTS

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INTRODUCTION

Background

The Golden-cheeked Warbler (Warbler) is a neotropical migrant passerine that breeds only in central Texas where mature Ashe juniper-oak woodlands occur (Ladd and Gass 1999). Due to accelerating loss of breeding habitat over the past several decades, the Warbler was listed as federally endangered by the U.S. Fish and Wildlife Service in 1990 (USFWS 1990). Warbler habitat in western Travis County is widely considered to be some of the highest quality and least fragmented of any county within this species' limited breeding range. Rapid westward expansion of development from the City of Austin led to the creation of the Balcones Canyonlands Conservation Plan (a Habitat Conservation Plan) and issuance of a 10(a)(1)(B) permit in 1996 by the U.S. Fish and Wildlife Service to the City of Austin and

Travis County to mitigate habitat loss due to development and to facilitate the recovery of the Warbler and other endangered and rare species (USFWS 1996). The permit requires a minimum of 12,300 hectares (30,428 acres) of endangered species habitat in western Travis County be set aside as a preserve (the BCP) for these species. The BCP is owned and managed by a number of public and private entities, including the City of Austin, Travis County, Lower Colorado River Authority, The Nature Conservancy, Travis Audubon Society, and St. Edwards University/Wild Basin. Because the Balcones Canyonlands Conservation Plan allows for the loss of over 70 percent of the Warbler's habitat in Travis County, management of the remaining habitat within the BCP is critical and must promote habitat sustainability, regeneration, and restoration to support a viable breeding population.

The Warbler requires large blocks of mature, closed-canopy woodlands for nesting and raising young (USFWS 1992, Peak 2007, Reidy et al. 2008, Peak and Thompson 2014). Active habitat management requires minimizing threats to this species, including disturbance from human activities; declining oak regeneration from white-tailed deer, feral hogs, and oak wilt; non-native plants; and nest predators (USFWS 1996). Because the Warbler requires mature woodlands, habitat regeneration could take decades to recover if negatively impacted by a poorly designed program (Biological Advisory Team 1990). Given the complexity of the threats to the Warbler, a more sophisticated analysis of the species and its habitat is needed to ensure effective management strategies are implemented.

Objectives

The Balcones Canyonlands Conservation Plan (USFWS 1996) states that "baseline monitoring will be gathered in accordance with the Land Management Guidelines and approved land management plans, and should concentrate on determining basic population levels on preserve lands, key population parameters, and other ecological parameters that may affect the target species." The Tier IIA-7 Land Management Plan (BCP 2007) identifies the following goals and objectives: "The Warbler population within the BCP will be monitored through a regional program to determine population size, territory density and trends, distribution, productivity, use of marginal habitat, and to determine the effects of habitat manipulation, urbanization, and recreation."

In February 2011, the City of Austin entered into a five-year agreement with the USFS to provide population viability and habitat suitability modeling for the Warbler populations within the BCP (Reidy and Thompson 2010). The USFS project focuses on four primary questions:

1) What is the absolute abundance of the Warbler on the BCP and on individual macrosites?
2) How do demographics (e.g. density, productivity, survival) vary with landscape and habitat factors?
3) How viable are these populations?
4) How do various management scenarios influence population viability?

Answers to these questions are important to ensure the long-term viability of the Warbler, which is the goal of the Balcones Canyonlands Conservation Plan. In order to fill these knowledge gaps, understand species' response to management, and provide reasonable demographic measures based on real data for modeling population growth and persistence, more intense monitoring across the BCP is necessary. The

2014 field season continued the collaborative efforts initiated in 2011 to collect data on fecundity, recruitment, dispersal, abundance, and survival on a series of intensive study plots that cover a variety of habitat types in which the Warbler breeds on the BCP.

METHODS

A detailed description of the demographic methods used during the 2014 field season is described in Reidy and Thompson (2010). The methods closely followed the protocols outlined in the Tier IIA-7 land management plan guidelines (BCP 2007), but required intensive territory monitoring, including more frequent surveys of color-banded birds for territory delineations, and nest searching and monitoring. Population and productivity trends of color-banded individuals were tracked on a series of intensive study plots. BCP partners collected data on territory density, territory size and location, age structure, pairing success, breeding success, and productivity for each plot. BCP staff and volunteers also made a concerted effort to search for color-banded Warblers outside of the intensive study areas to gather data on site fidelity, dispersal, and return rates. Nests were located and monitored throughout the field season, and vegetation measurements were collected at each nest site at the end of the field season.

Point Counts

To estimate Warbler density and abundance across the BCP, USFS staff conducted a fourth year of point count surveys and vegetation surveys. A preliminary report summarizing the 2013 survey results and predicted density from cumulative surveys conducted from 2011-2013 is provided in Exhibit K.

Intensive Study Plots

During field season 2014, an effort was made to intensively monitor as much of the BCP as possible given staff and resource limitations, to include previously established study sites, and to capture a diversity of habitats across the BCP. Warblers were banded and their territories were mapped on 18 intensive study plots, including twelve 40.5-hectare plots and six plots ranging from 27 to 180 hectares in size (Table 1, Exhibit A), and totaling about 1,027 hectares (because Gus Fruh and Sunset Valley are neighboring plots with similar habitat, data for these plots are combined into one plot in the results section). Intensive study plots were located within six of the seven BCP macrosites (all but the Pedernales macrosite). In addition, a 100-meter buffer was established around each of the 40.5-hectare study plots (where access was permitted) to expand the search area for color-banded Warblers and obtain additional information on return rates, dispersal, and territory size and configuration. While staff limitations prevented inclusion of the Bohls, Canyon Creek, and Ribelin plots in the intensive monitoring effort, City of Austin BCP staff and volunteers conducted cursory surveys to resight color-banded Warblers on Bohls and Canyon Creek, and Travis County BCP staff continued to monitor the Ribelin plot. In addition, volunteers searched for banded Warblers outside the intensive study plots and 100-meter buffers to obtain additional information on return rates and dispersal.

The intensive monitoring plots covered about eight percent of the existing BCP. Including the 100-meter buffers around each 40.5-ha plot (where access was allowed) and additional areas surveyed by volunteers to search for color-banded Warblers, surveys for this project covered about 23 percent of the BCP in 2014 (Table 1).

Table 1. Intensive study plots for each macrosite within the Balcones Canyonlands Preserve, Travis County, Texas, field season 2014.

Plot Name, Ownership, and Size (hectares)	Barton Creek Macrosite	Bull Creek Macrosite	Cypress Creek Macrosite	No. Lake Austin Macrosite	So. Lake Austin Macrosite	West Austin Macrosite
Barton Creek (COA)	40.5					
Gus Fruh (COA)[1]	85					
Sunset Valley (COA)[1]	27					
3M/St. Edwards (COA)		40.5				
Canyon Vista (TC)		40.5				
Forest Ridge (COA)		40.5				
Butler (COA)		40.5				
Hamilton West (COA)		40.5				
Baker Sanctuary (Travis Audubon)			40.5			
Lake Perspectives/ McGregor (TC/LCRA)			40.5			
Vireo Ridge (TC)			46[2]			
Vista Point (TC)			40.5			
Emma Long Bike Park (COA)				96		
Coldwater (COA)				107		
Emma Long (COA)				40.5		
JJ&T (COA)					40.5	
Reicher (COA)					40.5	
Wild Basin/Vireo Preserve (COA, Wild Basin, St. Edwards, TC)						180
Total # BCP Hectares Owned (as of November 2014)[3]	2,479	2,021	3,658	2,265	1,643	188
% of macrosite intensively surveyed[4]	~6%	~10%	~4%	~11%	~5%	~96%

[1]Data for the Gus Fruh and Sunset Valley are combined into one plot in the results section.
[2]Plot boundaries vary slightly from year to year, and plot size has increased from 42 to 46 hectares since the plot was initially established in 2011; results for each year are based on the plot dimensions for that year.
[3]Does not include the Pedernales macrosite (105 ha).
[4]Does not include the 100-m buffers around the study plots (approx. 30 ha for each of the twelve 40.5-ha plots, where access was allowed, totaling about 360 ha), resighting on the Canyon Creek, Bohls, and Ribelin 40.5-ha plots (121.5 ha), or the resighting areas beyond the buffers (about 1370 ha, see Exhibit B).

Site Description

The topography and vegetation of the BCP are typical of the eastern edge of the Edwards Plateau. Steep, wooded canyons and riparian corridors dissect drier upland vegetation. Most streams are intermittent, though a few have a permanent water source, such as a perennial spring. The predominant vegetation association is mature Ashe juniper-oak woodlands, except at Hamilton West, Vireo Ridge, and Vireo Preserve, where the habitat includes more open canopy.

Woodlands in western Travis County were logged in the late 1800s and early 1900s and are currently in various stages of recovery (Bray 1904, Keddy-Hector 1996). After clearing, much of the topsoil was lost due to subsequent goat and cattle overgrazing and erosion. On some steep slopes, this soil loss has greatly reduced the revegetation potential. Current and past over-browsing by white-tailed deer (*Odocoileus virginianus*) has reduced understory floral diversity and species abundance (Russell et al. 2001, Russell and Fowler 2004). Evidence of browse is visible on the majority of BCP tracts. A paucity of certain deciduous woody species is also evident throughout the BCP.

In woodlands and forests, the canopy is dominated by Ashe juniper, Texas red oak (*Q. buckleyi*), plateau live oak (*Q. fusiformis*), shin oak (*Q. sinuata* var. *breviloba*), escarpment black cherry (*Prunus serotina* var. *eximia*), Texas ash (*Fraxinus texensis*), and cedar elm (*Ulmus crassifolia*). Aside from seedlings of the canopy trees, common understory species include Carolina buckthorn (*Frangula caroliniana*), yaupon holly (*Ilex vomitoria*), red buckeye (*Aesculus pavia* var. *pavia*), Mexican buckeye (*Ungnadia speciosa*), Lindheimer silk-tassel (*Garrya ovata* var. *lindheimeri*), and elbowbush (*Forestiera pubescens*). Descriptions of individual plots can be found in Abbruzzese and Koehler (2003) and the Tier III Land Management Plans for each property.

In selecting the intensive study plot locations, an effort was made to represent a diversity of habitat types across the BCP, including vegetation types (i.e., evergreen, deciduous, and mixed evergreen-deciduous forests), slope and aspect, habitat patch sizes, proximity to urban development, and land management activities. Resources used included aerial photos and mapped vegetation types from Phase 1 of the Texas Ecological Systems Classification (http://morap.missouri.edu/index.php/texas-ecological-systems-classification/).

Golden-cheeked Warbler Monitoring on Intensive Study Plots

Color Banding

Color banding of adult GCWAs was conducted in conjunction with territory mapping on all of the 18 intensive study plots, from March 19 through May 9. Methods consisted of mist netting within a male Warbler's territory using playback of a tape-recorded male Warbler's song to attract the bird to the net. Although a few females were caught using this method, most of the Warblers captured were males. All Warblers captured in mist nets were marked with a unique combination of a U.S. Geological Survey (USGS) numbered aluminum band and auxiliary color bands to allow identification of each individual. The biological staff at Ft. Hood Military Reservation issued the color-band combinations. Other data collected during banding included date, time, banding location, temperature, and weather conditions. Individuals were sexed and aged (second-year (SY), after second-year (ASY), or after hatch-year (AHY) according to Pyle (1997) and Peak and Lusk (2009)), using data sheets developed by Ft. Hood staff. Each Warbler was photographed just prior to release to document band combinations. A summary of banding data for 2009-2014 is provided in Exhibit D. Jennifer Reidy (University of Missouri) also banded 50 nestlings in 2014; methods and results are summarized in Exhibit J.

Territory Delineation and Density. Surveys on each intensive study plot were conducted at least twice a week from March 15 through May 25 to delineate territories and at least once a week from May 25 through June 15 to gather data on reproductive success. During each visit, biologists attempted to identify the color combination of each banded Warbler, obtain multiple locations for each male to assist with delineating territory boundaries, and determine the presence of a female, nest, and/or fledglings for each territory. To allow adequate time to collect these data and minimize observer bias, plots with five or more Warblers were surveyed by two or more biologists. Exhibit B lists the lead surveyors and survey hours for each intensive study plot.

To delineate territory size and configuration as accurately as possible, an effort was made to obtain at least 33 locations for each male from March 15 through May 25 (Davis et al. 2010). Observations after May 25 were recorded, but were used to determine productivity and not to delineate territory boundaries. Males were considered territorial if they were observed in the same area on three different days, spread over a three week period, and those locations were separated by 30 meters or more.

Warbler observations were recorded with Garmin global positioning units (GPS), which have an accuracy of 3 to 9 meters. Other sightings were recorded on topographic maps, using a 100-meter Universal Transverse Mercator (UTM) grid. Date, color combination (for observations of banded birds), UTM coordinates, and presence of female, nest, and/or fledglings were recorded for each observation. The data were then entered into ArcGIS® (ESRI, Redlands, California) and displayed so that territories could be delineated. Territorial boundaries for each male were delineated using minimum convex polygons in ArcGIS® 10.2.2.

The number of territories on the study plots was calculated three ways: 1) full territories (territories contained entirely within the plot); 2) full and edge territories, in which each is counted as 1.0 territory; and 3) applying Verner's (1985) method (each full territory counted as 1.0 territory and each edge territory counted as 0.5 territories). Verner's counting method was recommended by Weckerly and Ott (2008) and avoids the upward bias inherent in the IBCC (1970) methodology (both full territories and edge territories counted as 1.0 territory). This study assumes a full territory is one in which a male is observed singing outside the plot no more than once (could be multiple positions on one visit) between March 15 and May 25. A territory is considered outside the plot if the singing male is found within the plot no more than once (could be multiple positions on one visit). An edge territory is one in which the singing male is observed both inside and outside the plot on more than one visit each and where a nest was found within a few meters of the plot boundary. Territory density is calculated as the number of territories (using Verner's counting method) divided by the plot size (Exhibit E).

The Warbler monitoring program and data collection protocols are described in detail in Reidy and Thompson (2010), the Balcones Canyonlands Preserve Land Managers Handbook, Tier IIA, Chapter VII: Monitoring of the Golden-cheeked Warbler (BCP 2007); the City of Austin Golden-cheeked Warbler and Black-capped Vireo Monitoring Program (Abbruzzese and Koehler 2003); and Exhibit C of this

document. As with previous years, no playback tapes of Warbler songs or calls were used during this season's monitoring, except for the purpose of mist netting and color banding.

Age Structure. To calculate age structure for each study plot, the number of territorial SY males was divided by the total number of territorial males with a known age (i.e., color-banded males only). The percentage of ASY and AHY males was also estimated for each plot. A summary of the 2009-2014 age structure data is provided in Exhibit F.

Return Rate. Return rates are based on the total number of color-banded adults present in 2013 (including returns from previous years and those banded in 2013) that were observed again in 2014. Return rates were derived for field seasons 2010 through 2014, and details on returning adults are provided for each study plot. A summary of the 2009-2014 return rates for Warbler males is presented in Exhibit G.

Pairing and Reproductive Success. For field season 2014, mated status and reproductive success are reported for both full and edge territories. Territories for which mated status and reproductive success were undetermined are not included in the analyses for these parameters. A male was determined to be paired if he was observed associating with a female, observed tending young, or a nest was located for that male. Pairing success is the number of males determined to have paired with a female divided by the total number of territories with known pairing status. A territory was considered to have had breeding success if the male or female was observed tending one or more fledglings. Breeding success is the number of territories determined to have produced at least one fledgling divided by the total number of territories with known breeding status. Reproductive success is presented as the total number of observed and adjusted number of fledglings (described below) for each plot and as a density estimate using Verner's (1985) method (number of fledglings per full + 0.5 territories divided by the plot size). To allow for comparison with previous years, productivity is also presented in two ways: as the sum of all fledglings divided by the total number of territories with known reproductive success, and as the sum of all fledglings divided by the number of pairs that produced at least one or more fledglings. A summary of the 2009-2014 reproductive success data is presented in Exhibit H.

Breeding success and productivity are generally believed to represent minimum estimates only because nests and fledglings are difficult to locate. Females and males often split their broods and can travel long distances from nests shortly after their young have fledged. In addition, young are often difficult to detect unless they are vocalizing. Reidy et al. (2008) documented a mean number of 3.6 young fledged per successful nest in the Bull Creek and North Lake Austin macrosites. This estimate was applied to those territories where the number of fledglings was uncertain to obtain adjusted estimates of the number of young produced and productivity estimates. Since the estimate of 3.6 young fledged per nest may be high for some habitat patches, the actual number of fledglings is likely somewhere between the observed and adjusted values.

Nest monitoring. Biologists located nests from mid-March through mid-June while working within and near the study plots. UTM coordinates were recorded for each nest location using Garmin GPS units, and

flagging was placed at least five meters from the nest to mark its location. Staff monitored each nest every few days to confirm activity and nest stage, and more often as the anticipated fledge date approached. Staff attempted to confirm fledglings within two days of fledging, but continued to monitor a territory for evidence of fledging for all nests that were confirmed active until at least day 8. A nest was considered successful only if one or both adults was detected tending to fledglings. If nesting activity ceased prior to possible fledging, we recorded the nest fate as failed. If nesting activity ceased around the time of anticipated fledging, and the pair was not detected or rarely detected for the remainder of the breeding season, we recorded nest fate as unknown. In addition to determining nest fate, staff searched for all fledglings produced for successful territories to calculate reproductive success.

Once young had fledged, nest site and nest patch characteristics were recorded following methods developed by Reidy (2007). Data were recorded on the nest tree species, nest height from the ground to the rim of the nest, nest tree height, diameter at breast height (DBH), and canopy cover. Nest and tree heights were obtained in meters using a clinometer, and DBH was measured in centimeters using a Biltmore stick. For trees with multiple trunks, DBH was measured as the largest trunk plus one-half of each of the smaller trunks (City of Austin 2013). Canopy cover was estimated using a densiometer. Other nest site and nest patch data, including distance of the nest to the main trunk, average height of junipers and oaks, nest cover, percent ground cover, slope, and stem density, were also collected. A summary of the 2011-2014 vegetation data for Warbler nests is presented in Exhibit I.

Surveys for Banded Warblers Outside of Intensive Study Plots

Surveys were conducted to search for and identify color-banded Warblers in areas outside of the intensive study areas (plots plus buffers). Forty-three volunteers in 27 teams conducted surveys on approximately 1,370 hectares. For each survey, observers were directed to allow approximately six hours per visit for each 40.5 hectares of habitat for a minimum of three visits. The list of resighting plots where surveys were conducted and the survey effort for each plot are reported in Exhibit B.

Pilot Study to Further Examine Effects of Recreation

During the 2002 and 2003 field seasons, Davis et al. (2010) conducted a study to evaluate the effects of mountain biking on the Warbler at the Bike Park and Forest Ridge within the BCP, and at Fort Hood. The study found that Warbler territory sizes were 1.5 times larger, nest success was lower, and nest abandonment was higher in areas with bikes compared to non-biking sites. The study concluded that fragmentation and alteration of habitat from mountain bike trails may reduce the quality of nesting habitat. While disturbance from mountain biking was not reflected in the daily activity budgets of Warblers, direct observations of Warbler encounters with mountain bikers documented a flushing response of over 20 meters.

To document both temporal and spatial changes in Warbler demographics, a follow-up study was conducted at the Bike Park in 2010-2011, and results were reported in Appendix H of City of Austin et al. (2012). Major limitations of the pilot study included small sample sizes (low numbers of Warblers) and lack of quantitative data on recreational activities (including number of recreational users per day, type(s)

of activities, pathways taken through the BCP tracts, etc.). However, the Bike Park continues to be monitored as one of the plots in the USFS study, and these data will be incorporated into the models to assess Warbler population viability and habitat suitability across the BCP.

Study to Evaluate the Vickery Method

Several studies have been conducted to examine how various habitat characteristics affect warbler distribution and reproductive success, including minimum patch size (Butcher et al. 2010), road and construction noise (Lackey et al. 2011), canopy closure, tree species composition (Klassen et al. 2012), and landscape features (Marshall et al. 2012). These studies relied on a reproductive index, known as the "Vickery method" (Vickery et al. 1992), to relate warbler productivity to the factors of interest. The Vickery method uses a ranking of observed reproductive activity to establish reproductive success rather than relying on nest monitoring. During the 2013 and 2014 field seasons, we compared results using the Vickery method to our intensive territory monitoring. Results are presented in Reidy et al. (2014).

RESULTS AND DISCUSSION

Intensive Study Plots

Territory Densities and Locations. A total of 247 territories were identified in field season 2014, including 189 territories using Verner's (1985) method for all 18 intensive study plots (an average estimated density of 0.18 territories per hectare for the combined 1,027-ha study plots, ranging from 0.03 to 0.49 territories/ha). Territory densities were highest in closed-canopy woodlands of the largest habitat patches (Bull Creek and Cypress Creek macrosites), and lowest in the small habitat patches surrounded by urban development, including the Gus Fruh and Sunset Valley portions of Barton Creek, and in the West Austin macrosite. Data on territory numbers and densities for field season 2014 are presented in Table 2 (a summary of territory data for field seasons 2009-2014 is presented in Exhibit E).

Table 2. Golden-cheeked Warbler territory number and estimated territory density (per hectare) for each of the 18 intensive study plots on the Balcones Canyonlands Preserve, Travis County, Texas, field season 2014. See Methods section for calculations.

Plot Name	No. of Full Territories	No. of Full and Edge Territories	No. of Full Territories + (0.5 x Edge Territories)[1]	Territory Density Per Hectare[1]
Barton Creek Macrosite				
Barton Creek	5	12	8.5	0.21
Gus Fruh/Sunset Valley	2	4	3	0.03
Bull Creek Macrosite				
3M/St. Edwards	12	28	20	0.49
Canyon Vista	8	23	15.5	0.38
Forest Ridge	9	19	14	0.35
Butler	15	20	17.5	0.43
Hamilton West	5	12	8.5	0.21
Cypress Creek Macrosite				
Baker Sanctuary	5	12	8.5	0.21
Lake Perspectives/McGregor	4	10	7	0.17
Vireo Ridge	12	13	12.5	0.27
Vista Point	9	19	14	0.35
North Lake Austin Macrosite				
Coldwater	7	13	10	0.09
Bike Park	12	19	15.5	0.16
Emma Long	9	17	13	0.32
South Lake Austin Macrosite				
Double J&T	3	5	4	0.10
Reicher	5	11	8	0.20
West Austin Macrosite				
Wild Basin/Vireo Preserve	9	10	9.5	0.05
Total/Average	**131**	**247**	**189**	**0.18[2]**

[1]Calculation based on Verner's counting method. All plots average 40.5 ha except for Gus Fruh (85 ha), Sunset Valley (27 ha), Bike Park (96 ha), Coldwater (107 ha), Vireo Ridge (46 ha), and Wild Basin/Vireo Preserve (180 ha).

[2]Calculated for the combined study area (189 full + 0.5 edge territories/1,027 ha).

Densities within the intensive study plots typically experience an annual variation of ±0.07 males/hectares (Exhibit E). The Butler and Forest Ridge plots both experienced greater changes in 2013 (an increase of 0.19 males/ha and a decrease of 0.17 males/ha, respectively, from 2012) but returned to pre-2013 densities in 2014 (Table 2, Exhibit E). The Reicher plot, which typically has had stable densities (0.09-0.11 males/ha observed from 2011-2013), increased to 0.20 males/hectare in 2014. Annual variation may be due to observer differences, changes in habitat conditions within or outside the plot, immigration/emigration of birds from or to surrounding areas, differences in age structure, return rates, prior reproductive success, and/or other factors. However, our sampling design minimized observer bias because we used multiple biologists for plots with five or more Warblers and the majority of Warblers were color-banded. Additionally, biologists assigned observations of Warblers that were not resighted as unknown unless they were confident of the identity (e.g., unusual song or plumage, behavior, attending nest or young, isolation from other males).

Color Banding. A total of 132 Warblers were banded in 2014, including 113 males and 19 females (Table 3). Of the 113 males, 37 percent were ASY, 62 percent were SY, and 1 percent were AHY. Of the 19 females, 26 percent were ASY, 58 percent were SY, and 16 percent were AHY. In addition, Jennifer Reidy (University of Missouri) banded 50 nestlings, of which 39 (78%) were resighted as fledglings, and at least one fledgling was resighted from each nest (N = 16); results are summarized in Exhibit J.

Table 3. Number of Golden-cheeked Warblers banded within the Balcones Canyonlands Preserve, Travis County, Texas, field season 2014.

Plot Name	No. Males Banded in 2014			No. Females Banded in 2014			Total No. Banded, 2014
	SY	ASY	AHY	SY	ASY	AHY	
Barton Creek Macrosite							
Barton Creek	2	3	0	0	0	0	5
Gus Fruh/ Sunset Valley	4	0	0	0	0	0	4
Bull Creek Macrosite							
3M/St. Edwards	13	6	0	1	2	0	22
Canyon Vista	4	5	0	0	1	0	10
Forest Ridge	3	3	0	2	1	0	9
Butler	7	5	0	1	0	1	14
Hamilton West	4	2	0	3	1	0	10
Cypress Creek Macrosite							
Baker Sanctuary	0	3	0	0	0	1	4
Lake Perspectives/ McGregor	2	2	0	1	0	0	5
Vireo Ridge	4	2	0	0	0	0	6
Vista Point	1	0	0	0	0	0	1
North Lake Austin Macrosite							
Coldwater	6	1	0	1	0	0	8
Bike Park	10	2	0	1	0	0	13
Emma Long	3	3	0	0	0	1	7
South Lake Austin Macrosite							
Double J&T	0	1	0	0	0	0	1
Reicher	3	2	1	0	0	0	6
West Austin Macrosite							
Wild Basin/ Vireo Preserve	4	2	0	1	0	0	7
Total	**70**	**42**	**1**	**11**	**5**	**3**	**132**

Age Structure. We identified 247 territorial males on the 18 intensive study plots in 2014, including 164 color-banded males (66%) and 83 unbanded males (34%) (Table 4). Of the 164 banded males within the 18 study plots, 62 percent were ASY, 37 percent were SY, and 1 percent were AHY. Baker Sanctuary, Butler, Double J&T, and Vista Point had the highest percentages of ASY males in 2014 (81-100%), while Gus Fruh/Sunset Valley, Coldwater, and the Bike Park had the highest percentages of SY males (60-100%). The number of SY males appears to have declined over the past few years on both the Butler and

Baker Sanctuary plots. The different age structures observed among plots may be due to the influence of habitat characteristics on the recruitment of young territorial males, emigration of older males displaced due to habitat loss in other areas, and/or other factors.

Table 4. Golden-cheeked Warbler age structure data for all color-banded territorial males observed within 18 intensive study plots on the Balcones Canyonlands Preserve, Travis County, Texas, field season 2014.

Plot Name	SY Males	ASY Males	AHY Males	Total Banded Males	Total Unbanded Males	% Banded Males
Barton Creek Macrosite						
Barton Creek	2 (25%)	6 (75%)	0	8	4	67
Gus Fruh/Sunset Valley	4 (100%)	0	0	4	0	100
Bull Creek Macrosite						
3M/St. Edwards	11 (55%)	9 (45%)	0	20	8	71
Canyon Vista	3 (25%)	9 (75%)	0	12	11	52
Forest Ridge	3 (27%)	8 (73%)	0	11	8	58
Butler	3 (19%)	13 (81%)	0	16	4	80
Hamilton West	4 (50%)	4 (50%)	0	8	4	67
Cypress Creek Macrosite						
Baker Sanctuary	0	9 (100%)	0	9	3	75
Lake Perspectives/McGregor	2 (29%)	5 (71%)	0	7	3	70
Vireo Ridge	3 (43%)	4 (57%)	0	7	6	54
Vista Point	1 (9%)	10 (91%)	0	11	8	58
North Lake Austin Macrosite						
Coldwater	6 (60%)	4 (40%)	0	10	3	77
Bike Park	9 (69%)	4 (31%)	0	13	6	68
Emma Long	3 (33%)	6 (67%)	0	9	8	53
South Lake Austin Macrosite						
Double J&T	0	3 (100%)	0	3	2	60
Reicher	3 (38%)	4 (50%)	1 (12%)	8	3	73
West Austin Macrosite						
Wild Basin/Vireo Preserve	4 (50%)	4 (50%)	0	8	2	80
Total	**61 (37%)**	**102 (62%)**	**1 (1%)**	**164**	**83**	**66**

Return Rates. The overall return rate of color-banded Warbler males (males banded in 2013 plus banded male returns from previous years) in 2014 was 46 percent, consistent with return rates observed in 2010, 2011, and 2013 (41-46%), but lower than the return rate observed in 2012 (56%) (Table 5). Observed returns of banded males by plot in 2014 are presented in Table 6. None of the males banded in 2009 were observed in 2014.

Females are typically more challenging to capture and observe, so the number of females banded each year and return rates observed in subsequent years is much lower than for males, and sample sizes are small. The overall return rate of color-banded Warbler females in 2014 was 45 percent, up from 23-38 percent in 2011-2013, but lower than the 100 percent return rate in 2010 (Table 5). None of the females banded in 2009 were observed in 2014.

Table 5. Return rates for male and female Golden-cheeked Warblers banded in 2009-2013 within the Balcones Canyonlands Preserve, Travis County, Texas, field season 2014.

# Banded/Returning Males	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**
Males Banded	101	91	162	94	104	111
Male Returns from 2009	--	44	19	7	2	--
Male Returns from 2010	--	--	37	22	11	4
Male Returns from 2011	--	--	--	93	43	21
Male Returns from 2012	--	--	--	--	43	19
Male Returns from 2013	--	--	--	--	--	50
Total Banded Males	101	135	218	216	203	205
Total Male Returns	--	44	56	122	99	94
Male Return Rates	**--**	**44%**	**41%**	**56%**	**46%**	**46%**

# Banded/Returning Females	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**
Females Banded	3	3	8	10	6	18
Female Returns from 2009	--	3	2	0	0	--
Female Returns from 2010	--	--	0	0	0	1
Female Returns from 2011	--	--	--	3	2	2
Female Returns from 2012	--	--	--	--	3	0
Female Returns from 2013	--	--	--	--	--	2
Total Banded Females	3	6	13	13	11	23
Total Female Returns	--	3	2	3	5	5
Female Return Rates	**--**	**100%**	**33%**	**23%**	**38%**	**45%**

Table 6. Return data for male Golden-cheeked Warblers banded in 2010-2013 for each intensive study plot within the Balcones Canyonlands Preserve, Travis County, Texas, field season 2014.

Plot Name	Males Banded 2010	2010 Male Returns in 2014	Males Banded 2011	2011 Male Returns in 2014	Males Banded 2012	2012 Male Returns in 2014	Males Banded 2013	2013 Male Returns in 2014	Total Male Returns in 2014
Barton Creek Macrosite									
Barton Creek	7	0	3	0	7	1	5	4	5
Gus Fruh / Sunset Valley	--	--	0	--	0	--	3	0	0
Bull Creek Macrosite									
3M/St. Edwards	11	0	16	1	12	4[1]	13	6[2,3]	11[1,2,3]
Canyon Vista	--	--	15	2[4]	10	0	9	5[5]	7[4,5]
Forest Ridge	6	1	18	2	4	0	4	1	4
Butler	11	0	10	1	13	3	17	10	14
Hamilton West	11	0	11	3	4	1	6	1	5
Canyon Creek*	8	0	--	--	--	--	--	--	0
Ribelin*	6	1	--	--	--	--	--	--	1
Cypress Creek Macrosite									
Baker Sanctuary	--	--	11	2	9	3	3	2	7
Lake Perspectives/ McGregor	--	--	7	2	5	1	4	1	4
Vireo Ridge	--	--	10	2	7	3[6]	2	2	7[6]
Vista Point	--	--	17	2	6	2	6	6	10
North Lake Austin Macros2ite									
Coldwater	13	1	8	0	2	0	7	3[7]	4[7]
Bike Park	8	0	12	0	8	0	7	2	2
Emma Long	3	1	10	3	3	0	5	1	5
South Lake Austin Macrosite									
Double J&T	3	0	2	0	2	0	4	2	2
Reicher	--	--	3	0	1	0	5	3	3
Bohls*	4	0	--	--	--	--	--	--	0
West Austin Macrosite									
Wild Basin/ Vireo Preserve	--	--	9	1	1	1[8]	4	1	3[8]
Total	**91**	**4**	**162**	**21**	**94**	**19**	**104**	**50**	**94**

*Not one of the intensive study plots in 2014, but cursory surveys conducted to resight color-banded individuals.

The following sites include male returns to a different location from where they were banded: [1]one male resighted on Forest Ridge, [2]one male resighted on Canyon Vista, [3]one male resighted on Butler, [4]one male resighted on Travis County's Bunten tract, [5]one male resighted on Forest Ridge, [6]one male resighted on Vista Point, [7]one male resighted on Emma Long, [8]one male resighted near 3M/St. Edwards.

Table 7. Return data for female Golden-cheeked Warblers banded in 2010-2013 for each intensive study plot within the Balcones Canyonlands Preserve, Travis County, Texas, field season 2014.

Plot Name	Females Banded 2010	2010 Female Returns in 2014	Females Banded 2011	2011 Female Returns in 2014	Females Banded 2012	2012 Female Returns in 2014	Females Banded 2013	2013 Female Returns in 2014	Total Female Returns in 2014
Barton Creek Macrosite									
Barton Creek	1	0	0	0	0	0	0	0	0
Gus Fruh /Sunset Valley	--	0	--	0	--	0	0	0	0
Bull Creek Macrosite									
3M/St. Edwards	1	0	1	0	1	0	0	0	0
Canyon Vista	--	0	0	0	0	0	0	0	0
Forest Ridge	1	1	1	0	4	0	1	1	2
Butler	0	0	0	0	2	0	1	0	0
Hamilton West	0	0	0	0	0	0	1	1	1
Canyon Creek*	0	0	--	0	--	0	--	0	0
Ribelin*	0	0	--	0	--	0	--	0	0
Cypress Creek Macrosite									
Baker Sanctuary	--	0	2	0	1	0	0	0	0
Lake Perspectives/ McGregor	--	0	1	0	0	0	0	0	0
Vireo Ridge	--	0	0	0	0	0	1	0	0
Vista Point	--	0	1	1	0	0	0	0	1
North Lake Austin Macrosite									
Coldwater	0	0	0	0	1	0	0	0	0
Bike Park	0	0	0	0	0	0	0	0	0
Emma Long	0	0	2	1	0	0	1	0	1
South Lake 3Austin Macrosite									
Double J&T	0	0	0	0	0	0	0	0	0
Reicher	--	0	0	0	0	0	0	0	0
Bohls*	0	0	--	0	--	0	--	0	0
West Austin Macrosite									
Wild Basin/ Vireo Preserve	--	0	0	0	1	0	1	0	0
Total	**3**	**1**	**8**	**2**	**10**	**0**	**6**	**2**	**5**

*Not one of the intensive study plots in 2014, but cursory surveys conducted to resight color-banded individuals.

Dispersal. Of the 99 male and female Warblers banded in 2009 through 2013 that were observed in 2014 (tables 5-7), BCP staff and volunteers documented one new dispersal event of more than 1 km (1%). A male banded as SY on the Coldwater plot in 2013 returned in 2014 to the Emma Long plot, a distance of about 2 kilometers. The remaining 98 color-banded Warblers returning in 2014 (99%) dispersed distances less than 1 km, remained in the same study plot where they were originally banded, or returned to sites where they dispersed to in 2013, suggesting high site fidelity and low dispersal rates among adults.

BCP staff surveyed both the intensive study plots and the 100-meter buffer around each study plot (where access was available). In addition, 27 teams of 43 volunteers devoted over 564.5 hours and covered approximately 1,370 hectares (Exhibit B) searching for color-banded Warblers outside of the intensive

study areas. Documenting the location of returning Warblers is critical to understanding survival, dispersal, and site fidelity, all of which influence the viability of the Warbler populations.

Pairing and Reproductive Success. In 2014, a total of 247 territories were monitored for pairing and reproductive success on the 18 intensive study plots (Table 8). The average pairing and breeding success observed for all territories was 92 percent (range 0-100%) and 69 percent (range 0-89%), respectively, up from 87 percent (50-100%) and 63 percent (0-89%) observed in 2013. While no fledglings were observed again on the Gus Fruh/Sunset Valley plot, a pair that established a territory outside of the Gus Fruh plot boundary produced two successful nests, each with four fledglings. Plots within mature, closed-canopy woodlands in the Bull Creek macrosite continued to support the highest numbers of territories producing one or more fledglings (3M/St. Edwards, Butler, Canyon Vista, Forest Ridge; range 16-18 territories). The Gus Fruh/Sunset Valley plot in the Barton Creek macrosite, Double J&T plot in South Lake Austin, and the West Austin macrosite had the fewest territories producing one or more fledglings (range 0-3 territories).

Staff detected 499 fledglings from 162 territories with known reproductive success (estimates exclude 13 territories where reproduction was unknown). Applying the Reidy et al. (2008) estimate of 3.6 young fledged per successful nest in the Bull Creek and North Lake Austin macrosites to the number of territories where the number of fledglings was uncertain gives an adjusted total estimate of 577 young fledged. While the observed number of fledglings may be an underestimate, the adjusted number may be upwardly biased. The actual number is likely somewhere between these estimates.

Based on both the observed and adjusted number of fledglings, study plots in closed-canopy woodlands of the largest habitat patches in the Bull Creek (3M/St. Edwards, Butler, Canyon Vista, Forest Ridge), North Lake Austin (Emma Long), and Cypress Creek (Vista Point) macrosites produced the greatest number of fledglings (47-56/50-68 observed/adjusted fledglings; density 0.86-0.98/0.88-1.33 observed/adjusted fledglings/ha), while study plots in smaller habitat patches (Gus Fruh/Sunset Valley, Wild Basin/Vireo Preserve) had the lowest reproductive output (0-3 observed/adjusted fledglings; density 0-0.02 observed/adjusted fledglings/ha).

Warblers at the Vireo Preserve/Wild Basin plot experienced the lowest breeding success since surveys on this plot began in 2011 (11-75%, Exhibit H). While the reasons for the low nesting success are unknown, researchers observed large numbers of Blue Jays (*Cyanocitta cristata*) on Vireo Preserve/Wild Basin in 2014. Although jays were not observed depredating Warbler nests directly, field staff observed them following Warblers during foraging, supplanting perched Warblers, foraging actively close to known Warbler nests, and feeding on nestlings (species undetermined).

A few territories produced double broods. Since documentation of double broods is opportunistic and therefore not consistent, they are not included in the estimated number of fledglings and productivity.

Table 8. Golden-cheeked Warbler reproductive success on 18 intensive study plots on the Balcones Canyonlands Preserve, Travis County, Texas, field season 2014. Data are based on observations for both full and edge territories. See Methods section for calculations. Territories for which pairing and/or reproductive success were unknown are not included in the calculations (actual sample sizes are indicated in parentheses).

Plot Name	No. of Territories	No. of Territories w/ Female	Pairing Success	No. of Territories Producing ≥ 1 Young	Breeding Success	Observed and Adjusted* Productivity	Observed and Adjusted* Productivity Per Successful Territory	Total No. of Fledglings Observed and Adjusted* Fledglings	Density of Observed and Adjusted* Fledglings Per Hectare**
Barton Creek Macrosite									
Barton Creek	12	12 (12)	100	7 (12)	58	1.4 / 1.7	2.4 / 3.0	17 / 21	0.36 / 0.41
Gus Fruh/ Sunset Valley	4	0	0	0	0	0	0	0	0
Bull Creek Macrosite									
3M/St. Edwards	28	28 (28)	100	18 (28)	64	1.9 / 2.4	3.0 / 3.8	54 / 68	0.89 / 1.12
Canyon Vista	23	21 (23)	91	17 (23)	74	2.4 / 2.4	3.3 / 3.3	56 / 56	0.91 / 0.91
Forest Ridge	19	19 (19)	100	16 (18)	89	2.7 / 3.1	3.1 / 3.5	49 / 57	0.89 / 1.02
Butler	20	19 (20)	95	17 (20)	85	2.4 / 3.2	2.8 / 3.7	47 / 64	0.98 / 1.33
Hamilton West	12	12 (12)	100	8 (11)	73	2.5 / 2.5	3.4 / 3.4	27 / 27	0.53 / 0.53
Cypress Creek Macrosite									
Baker Sanctuary	12	11 (11)	100	10 (12)	83	1.8 / 2.8	2.2 / 3.4	22 / 34	0.42 / 0.61
Lake Perspective/ McGregor	10	9 (9)	100	8 (9)	89	2.8 / 3.0	3.1 / 3.3	25 / 27	0.46 / 0.50
Vireo Ridge	13	12 (12)	100	6 (11)	55	1.5 / 2.0	2.8 / 3.7	17 / 22	0.37 / 0.48
Vista Point	19	17 (19)	89	13 (19)	68	2.6 / 2.6	3.8 / 3.8	49 / 50	0.86 / 0.88
North Lake Austin Macrosite									
Coldwater	13	11 (13)	85	7 (13)	54	1.8 / 2.0	3.4 / 3.8	24 / 27	0.18 / 0.19
Bike Park	19	16 (19)	84	10 (17)	59	1.6 / 1.9	2.8 / 3.2	28 / 32	0.24 / 0.26
Emma Long	17	15 (17)	88	13 (16)	81	2.9 / 3.2	3.6 / 3.9	47 / 50	0.94 / 1.01
South Lake Austin Macrosite									
Double J&T	5	5 (5)	100	3 (5)	60	1.8 / 1.8	3.0 / 3.0	9 / 9	0.20 / 0.20
Reicher	11	9 (11)	82	8 (11)	73	2.3 / 2.8	3.1 / 3.8	25 / 30	0.43 / 0.52
West Lake Austin Macrosite									
Wild Basin/Vireo Preserve	10	5 (9)	56	1 (9)	11	0.3 / 0.3	3.0 / 3.0	3 / 3	0.02 / 0.02
Total/Avg.	**247**	**221 (239)**	**92**	**162 (234)**	**69**	**2.1 / 2.5**	**3.1 / 3.6**	**499 / 577**	**0.51 / 0.59**

*Based on mean number of 3.6 young per successful nest (Reidy et al. 2008) for territories where the number of fledglings was uncertain; does not include data from second broods.

**Density based on number of fledglings produced per full + 0.5 territories divided by the plot size.

Nest Data

USFS, BCP staff, and BCP partners found and monitored a total of 185 active Warbler nests within the intensive study plots during the 2014 field season (Table 9). The first nests were found on March 18, and fledging dates for observed nests ranged from April 24 through June 21. Of the 185 nests, 119 fledged one or more young (64%), 57 nests failed (31%), and 9 had an unknown fate (5%).

Table 9. Fates of monitored Golden-cheeked Warblers nests within the Balcones Canyonlands Preserve, Travis County, Texas, field season 2014. Successful nests include any nest that fledged ≥1 young.

Plot Name	Total No. Nests	No. Failed Nests	No. Successful Nests	No. Nests Unknown Fate
Barton Creek Macrosite				
Barton Creek	11	4 (36%)	5 (46%)	2 (18%)
Gus Fruh/Sunset Valley	0	0	0	0
Bull Creek Macrosite				
3M/St. Edwards	15	4 (27%)	11 (73%)	0
Canyon Vista	29	10 (34%)	17 (59%)	2 (7%)
Forest Ridge	7	2 (29%)	5 (71%)	0
Butler	11	2 (18%)	9 (82%)	0
Hamilton West	9	4 (44%)*	5 (56%)	0
Cypress Creek Macrosite				
Baker Sanctuary	8	3 (37%)	5 (63%)	0
Lake Perspectives/McGregor	8	1 (12%)	7 (88%)	0
Vireo Ridge	16	8 (50%)	5 (31%)	3 (19%)
Vista Point	18	3 (17%)	13 (72%)	2 (11%)
North Lake Austin Macrosite				
Coldwater	8	3 (37%)	5 (63%)	0
Bike Park	20	8 (40%)	12 (60%)	0
Emma Long	15	2 (13%)	13 (87%)	0
South Lake Austin Macrosite				
Double J&T	3	1 (33%)	2 (67%)	0
Reicher	5	1 (20%)	4 (80%)	0
West Austin Macrosite				
Wild Basin/Vireo Preserve	2	1 (50%)	1 (50%)	0
Total	**185**	**57 (31%)**	**119 (64%)**	**9 (5%)**

*Includes one nest that fledged a Brown-headed Cowbird.

The majority of nests were found in Ashe Juniper (57%), followed by Live Oak (30%) (Table 10). Nests were found for the first time in 2011-2014 in Escarpment Black Cherry, Sycamore, and Texas Ash. Nest tree height for all tree species averaged 8.5 meters, and DBH averaged 29 centimeters. Nest height averaged 6.7 meters. Canopy cover averaged 87 percent. Nests found in Ashe juniper tended to be more successful (81%) than nests found in Live Oak, Cedar Elm, Shin Oak, and Texas Red Oak. These results are similar to the collective 2011-2014 dataset (N = 572; Exhibit I).

The nest data are part of a growing dataset of nests monitored on the BCP. These data are being used to analyze the relationships between habitat characteristics and nest survival. Analyses include effects of landscape metrics (e.g., habitat composition, amount of edge) and more localized effects (e.g., tree height, stem density). Results through the third year of data (2011-2013) are summarized in Exhibit K.

Table 10. Summary of vegetation data collected for 172 of the 185 Golden-cheeked Warbler nests found within the Balcones Canyonlands Preserve, Travis County, Texas, field season 2014.

Tree Species	Total Nests	Tree Height Avg, Range (m)	Tree DBH Avg, Range (cm)	Nest Height Avg, Range (m)	% Canopy Cover Avg, Range	Successful Nests
Juniperus ashei (Ashe Juniper)	98 (57%)	8.2 (5 – 15.8)	29.3 (7 – 84)	6.5 (2.4 – 11.3)	86 (20 – 96)	79 (81%)
Quercus fusiformis (Live Oak)	51 (30%)	8.3 (4.8 – 12.2)	29.1 (11 – 77.5)	6.8 (4.1 – 10.4)	88 (59 – 96)	30 (59%)
Ulmus crassifolia (Cedar Elm)	9 (5%)	10.4 (7.9 – 12.9)	28.1 (17 – 55)	8.1 (5.7 – 12.1)	87 (63 – 93)	4 (44%)
Quercus sinuata var. *breviloba* (Shin Oak)	7 (4%)	8.8 (6.3 – 10.9)	19.8 (15 – 24.5)	7.0 (5.6 – 8.7)	87 (75 – 95)	1 (14%)
Quercus buckleyi (Texas Red Oak)	3 (2%)	8.7 (7.9 – 9.5)	28.3 (19 – 39.5)	5.8 (4.1 – 7.4)	94 (91 – 96)	1 (33%)
Prunus serotina (Escarpment Black Cherry)	1 (0.05%)	11.2	30.0	9.7	93	1 (100%)
Platanus occidentalis) (Sycamore)	1 (0.05%)	18.9	67.0	11.4	95	1 (100%)
Fraxinus texensis) (Texas Ash)	1 (0.05%)	9.4	21.0	8.3	85	1 (100%)
Juglans major Arizona Walnut	1 (0.05%)	11.1	29.0	7.5	86	0
Totals	**172**	**8.5 (4.8 – 18.9)**	**29.0 (7 – 84)**	**6.7 (2.4 – 12.1)**	**87 (20 – 96)**	**119**

Parasitism

A nest on the Hamilton plot fledged a Brown-headed Cowbird (*Molothrus ater*) in 2014. No other observations of nest parasitism or of adult Warblers feeding cowbird chicks were reported.

Other Observations

Field staff documented at least two cases of polygyny in 2014. Two banded males (one on Barton Creek, one on Vireo Ridge) were confirmed to be paired with two females each. Each male produced fledglings from only one female. This is the second year we have confirmed polygyny on the BCP, providing

additional evidence that polygyny may be more common than previously thought. Polygyny has also been documented on Fort Hood (Peak et al. 2010, Peak and Grigsby 2013).

Field staff has seen males visiting nests of neighboring pairs. We have also observed different males attending the same nest, which was previously unreported. On April 23, 2011, an unbanded SY male and a banded ASY male were observed feeding fledglings from a nest on the Bike Park belonging to the banded male. This SY male was only detected a handful of times and always within the banded male's territory. The two males never countersang and were not observed in territorial disputes. On June 1, 2012, two different banded males were observed bringing food to and feeding young at the same nest during the initial monitoring. The first male fed at 10:00 along with the unbanded female and the second arrived at the nest and fed at 10:07. The nest was inactive during subsequent monitoring.

In 2014, males were also observed feeding young from neighboring territories in addition to their own young. A male on the Vireo Ridge plot fed two banded fledglings from a neighboring pair's nest (see results section in Appendix J). On Kent Butler, a banded fledgling was fed by two different males on the same day (the male whose nest it fledged from and a neighboring male, who was apparently also feeding his own offspring). There was a melee of Warblers in the area at the time – at least five different families, all with fledglings of various ages, had converged in one spot, on the canyon rim above a spring.

Field staff noticed this year that nests were placed in Live Oak and Ashe Juniper early in the season (March 18, 2014 and March 24, 2014, respectively), followed by Shin Oak, Cedar Elm, and Texas Red Oak (April 1-18, 2014), and continued to be found in these nest tree species through early June. Nests in other tree species were found in May and early June. Nest placement in different tree species appears to be due to the amount of leaf foliage and protective cover for the nests. We will examine this more closely in 2015.

Field staff observed a Lesser Goldfinch (*Spinus psaltria*) stealing nesting material from a Warbler nest during the building phase, and Blue-gray Gnatcatchers (*Polioptila caerulea*) stealing nesting material during all phases of the nesting cycle, including building, pre-incubation, nestling, and after nest abandonment. During the pre-incubation stage, female Warblers would chase the Blue-gray Gnatcatchers away from the nest. At one nest on the 3M/St. Edwards plot, field staff observed a female with food in bill, chasing off Blue-gray Gnatcatchers from the nest area for at least seven minutes before approaching the nest and feeding nestlings. After fledging, the nest appeared as though some material had been removed. Field staff has also observed Blue-gray Gnatcatchers disassembling abandoned Warbler nests and reassembling them as Gnatcatcher nests. Blue-gray Gnatcatchers are known to rob nest material from other species as well (Jones et al. 2007).

As in previous years, field staff observed female Warblers mid-story in Ashe junipers and on the ground collecting nesting material. Both males and females were observed collecting food mid-story and on the ground, and fledglings were often seen in dense mid-story vegetation and near or on the ground. In 2014, biologists reported many instances of adults "sanding" their food collections on the ground before

returning to their nest or fledglings. Adults would collect a beak-full of food, fly to an unvegetated area on the ground, rub the food items in the limestone grit/sand, and then fly to their nest or fledglings. Field staff has also observed Warblers on the ground eating "grit" items, including small pieces of shell. Other insectivorous birds, including Wood Warbler species, have been known to ingest grit (Potter 1983), presumably to facilitate digestion or as a mineral (e.g., calcium) supplement (Gionfriddo and Best 1996).

Each field season, BCP staff document adults tending newly-fledged young that are unable to fly well and on or near the ground (for example, photo in Appendix J), highlighting the vulnerability of newly fledged young and the importance of ground habitat to the Warbler, in addition to the tree canopy and mid-story vegetation.

Consistent with Beardmore (1994), adult Warblers appear to shift from foraging primarily in oaks and other hardwoods early in the season to foraging primarily in Ashe juniper later in the season. This shift appears to correspond with timing of young fledging from nests, around late April.

During the 2008 field season, staff videotaped an adult Warbler distraction display (City of Austin 2008), and staff observed male and female Warblers feigning wing injuries in 2009-2014 as well (City of Austin 2009-2011, City of Austin et al. 2012). Warblers displayed this injury-feigning behavior when field biologists were in the vicinity of newly fledged young.

No reports of avian pox, an infectious viral disease characterized by wart-like nodules or lesions on featherless areas of the body, were made for Warblers or other avian species during the 2014 field season, which was a drier year than 2012, when staff made numerous observations of infected individuals.

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Exhibit A: Distribution of Intensive Study Areas (Figure 1) and Minimum Convex Polygons Representing Estimated Golden-cheeked Warbler Territory Boundaries for Intensive Study Plots (Figures 2-18), 2014.
Disclaimer: these products are for informational purposes and may not have been prepared for or be suitable for legal, engineering, or surveying purposes. It does not represent an on-the-ground survey and represents only the approximate relative location of property boundaries. These products have been produced by the Wildland Conservation Division for the sole purpose of geographic reference. No warranty is made by the City of Austin regarding specific accuracy or completeness.

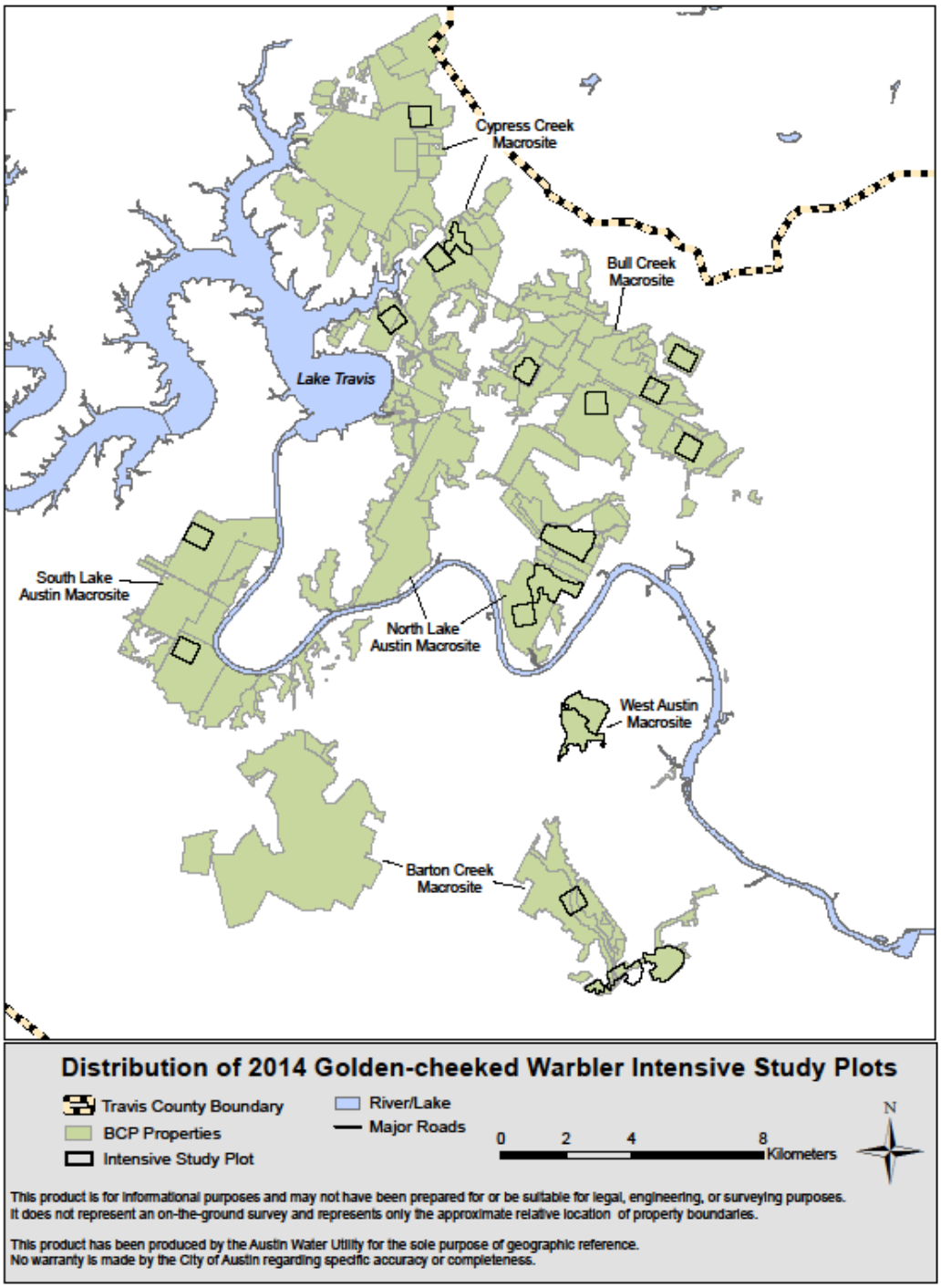


Figure 1

Exhibit A: Minimum Convex Polygons Representing Estimated Golden-cheeked Warbler Territory Boundaries for Intensive Study Plots (Figures 2-18), 2014 (continued).

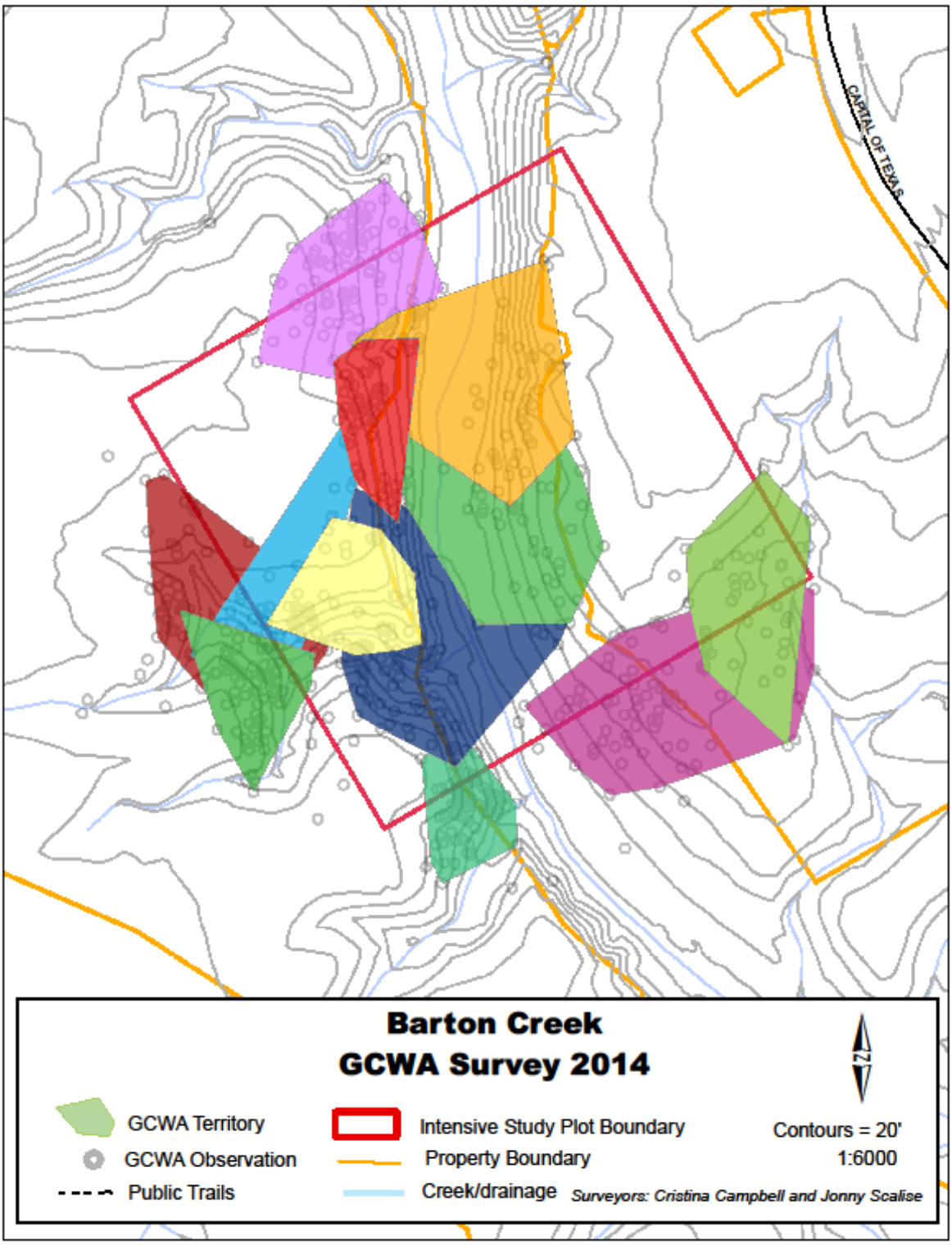


Figure 2

Exhibit A: Minimum Convex Polygons Representing Estimated Golden-cheeked Warbler Territory Boundaries for Intensive Study Plots (Figures 2-18), 2014 (continued).

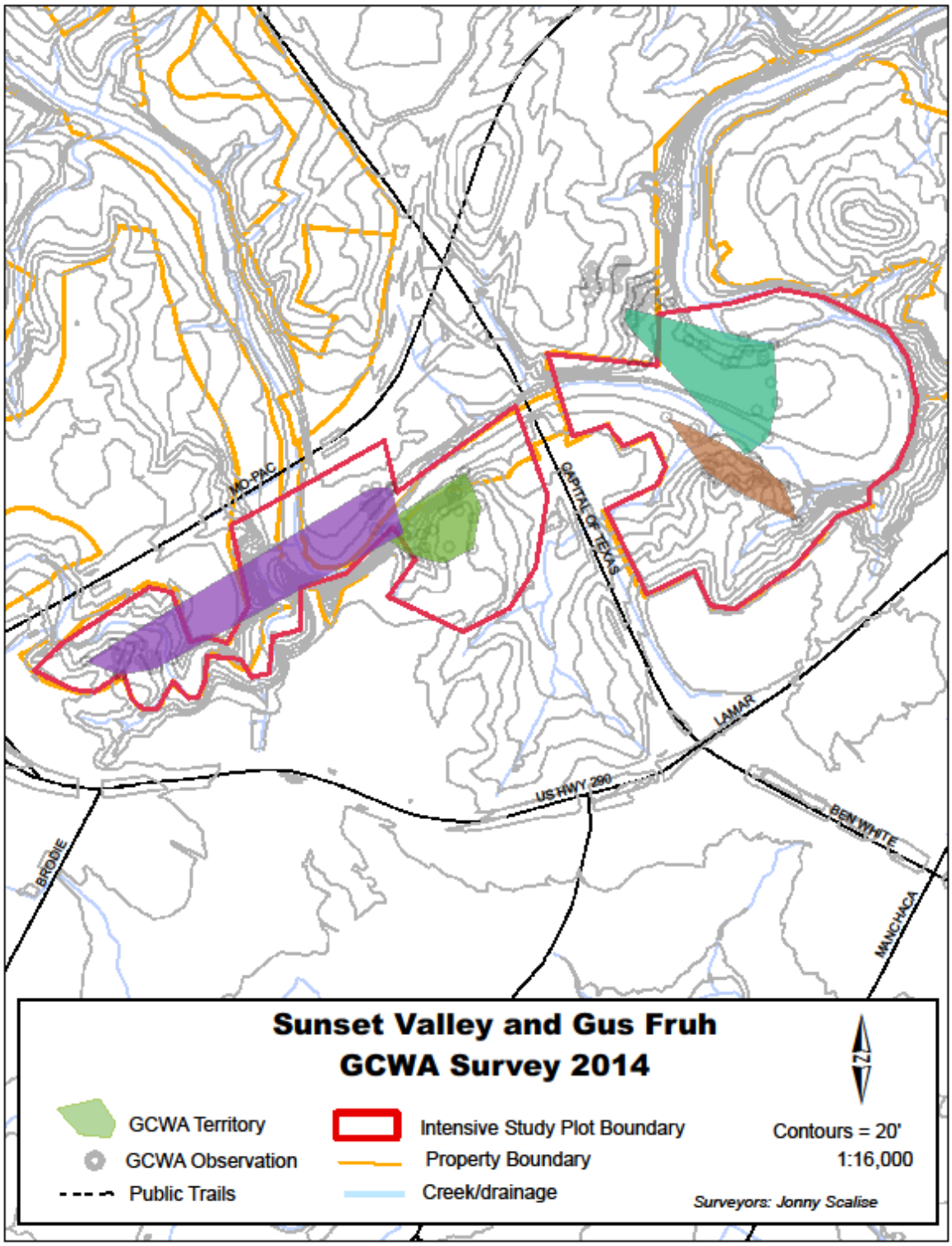


Figure 3

Exhibit A: Minimum Convex Polygons Representing Estimated Golden-cheeked Warbler Territory Boundaries for Intensive Study Plots (Figures 2-18), 2014 (continued).

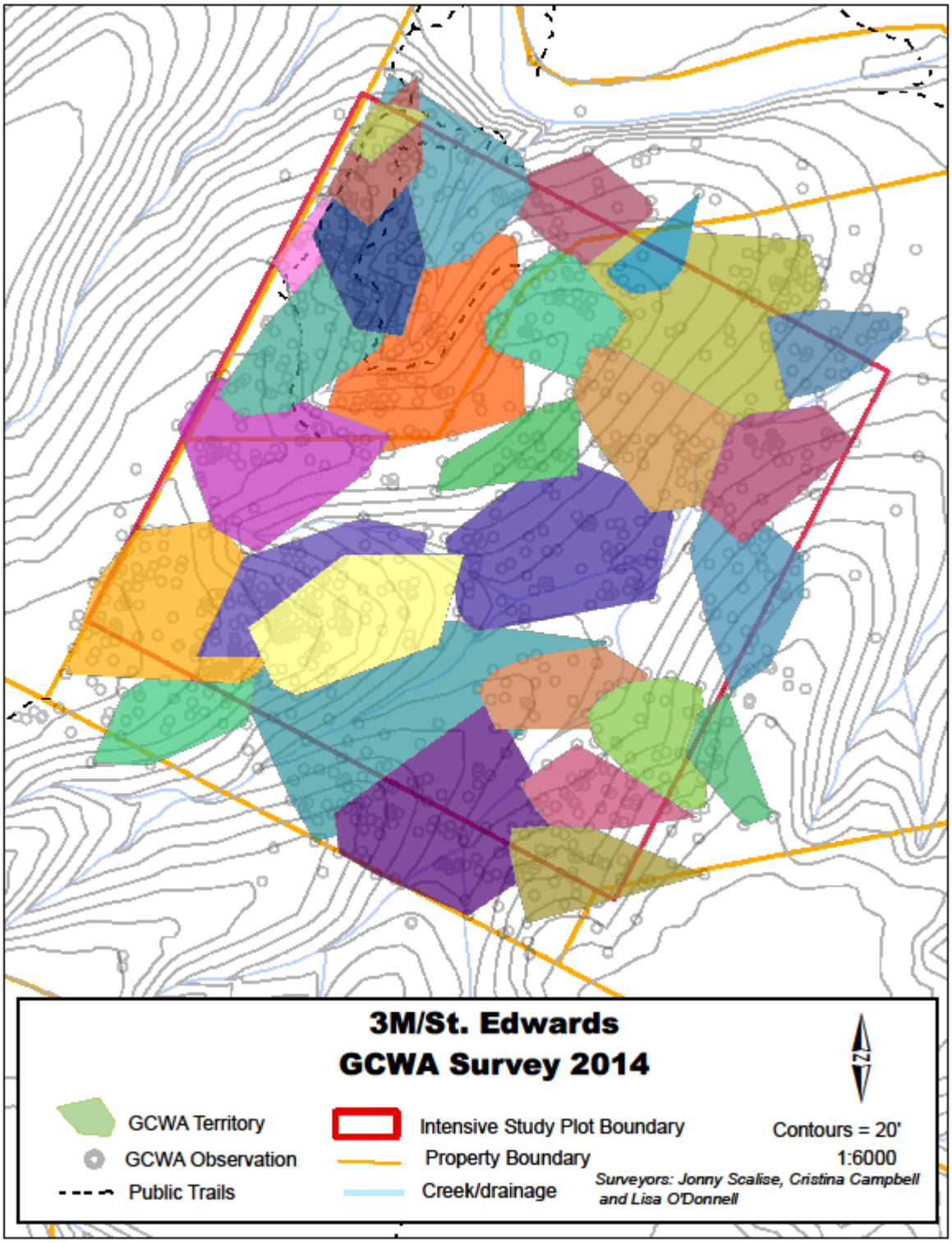


Figure 4

Exhibit A: Minimum Convex Polygons Representing Estimated Golden-cheeked Warbler Territory Boundaries for Intensive Study Plots (Figures 2-18), 2014 (continued).

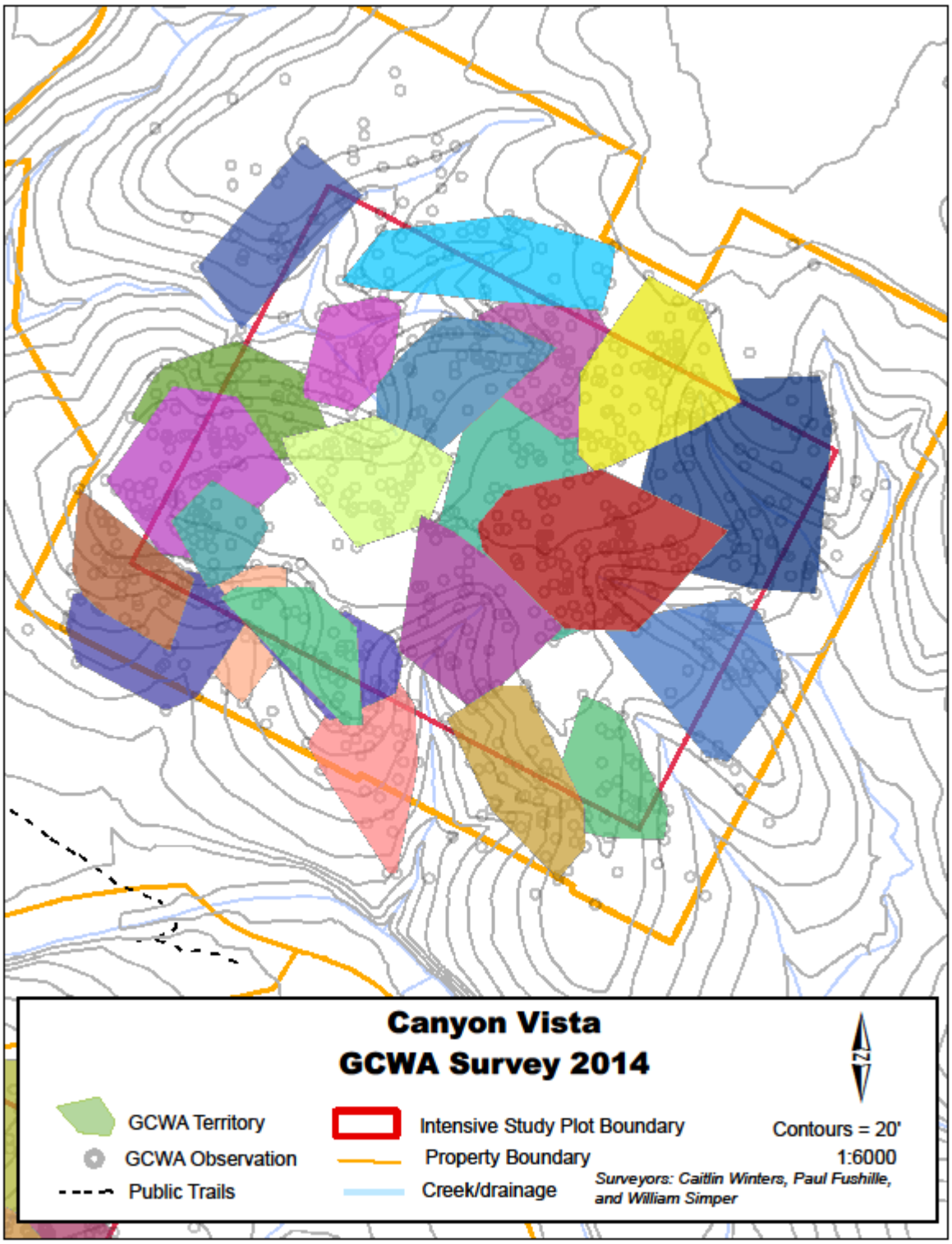


Figure 5

Exhibit A: Minimum Convex Polygons Representing Estimated Golden-cheeked Warbler Territory Boundaries for Intensive Study Plots (Figures 2-18), 2014 (continued).

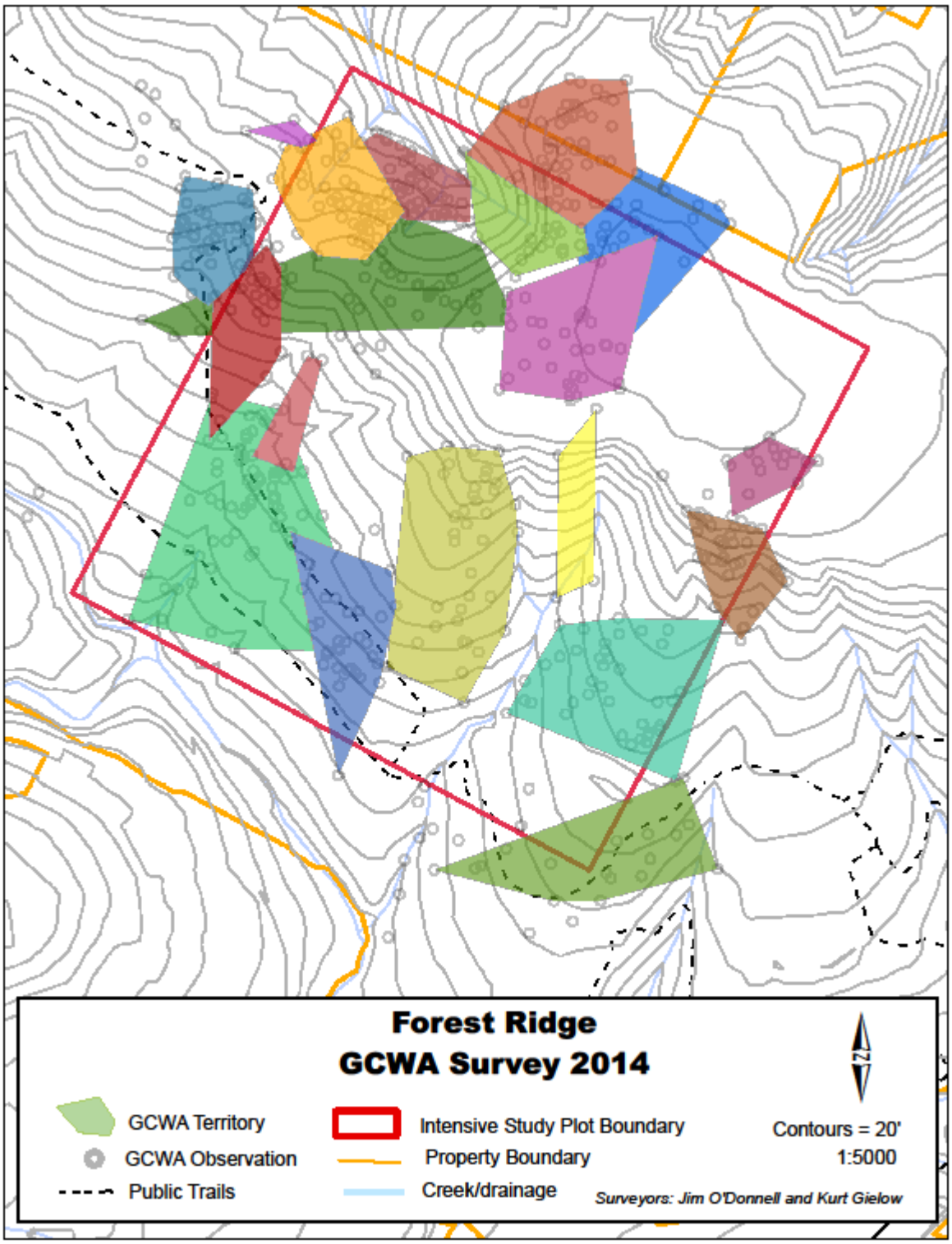


Figure 6

Exhibit A: Minimum Convex Polygons Representing Estimated Golden-cheeked Warbler Territory Boundaries for Intensive Study Plots (Figures 2-18), 2014 (continued).

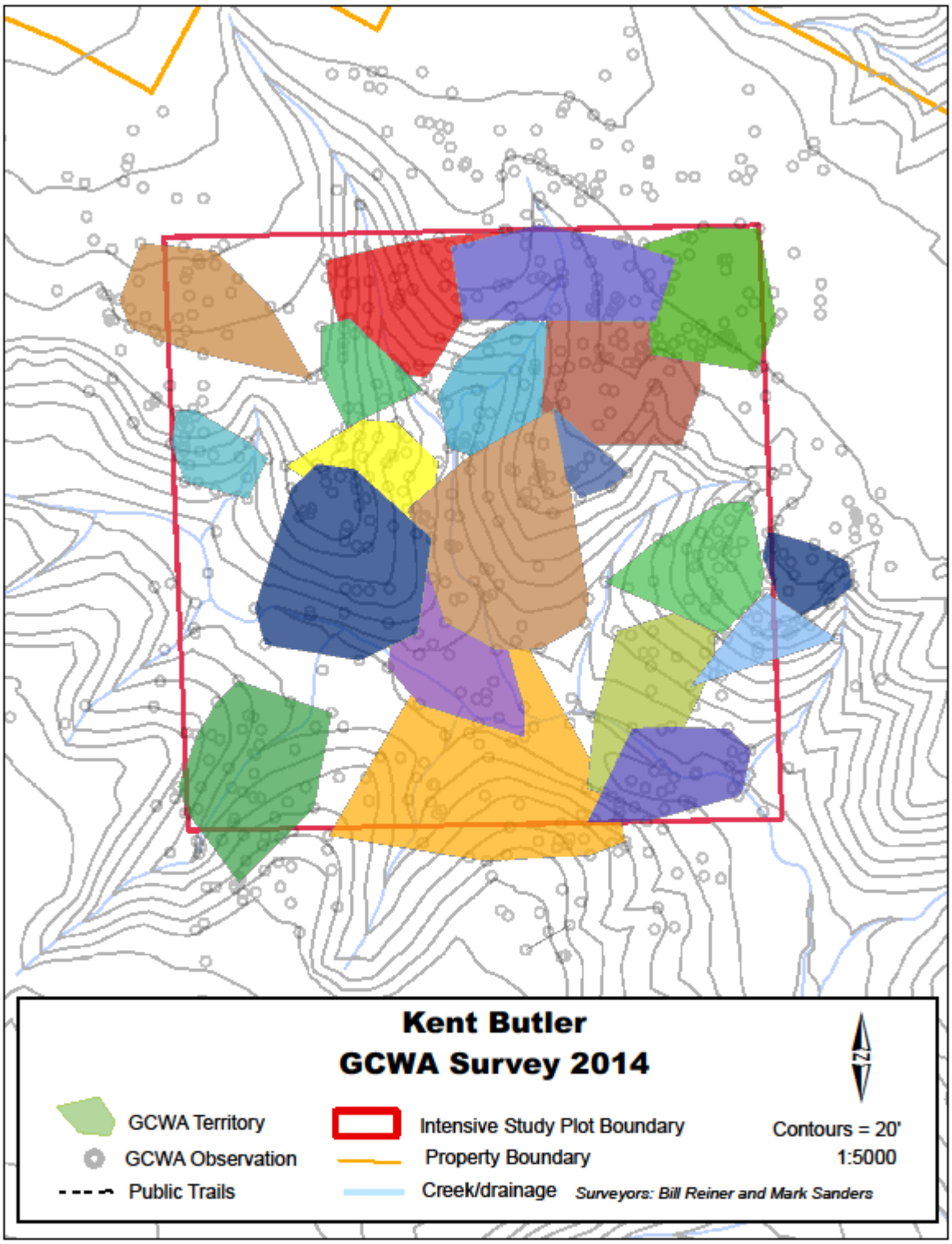


Figure 7

Exhibit A: Minimum Convex Polygons Representing Estimated Golden-cheeked Warbler Territory Boundaries for Intensive Study Plots (Figures 2-18), 2014 (continued).

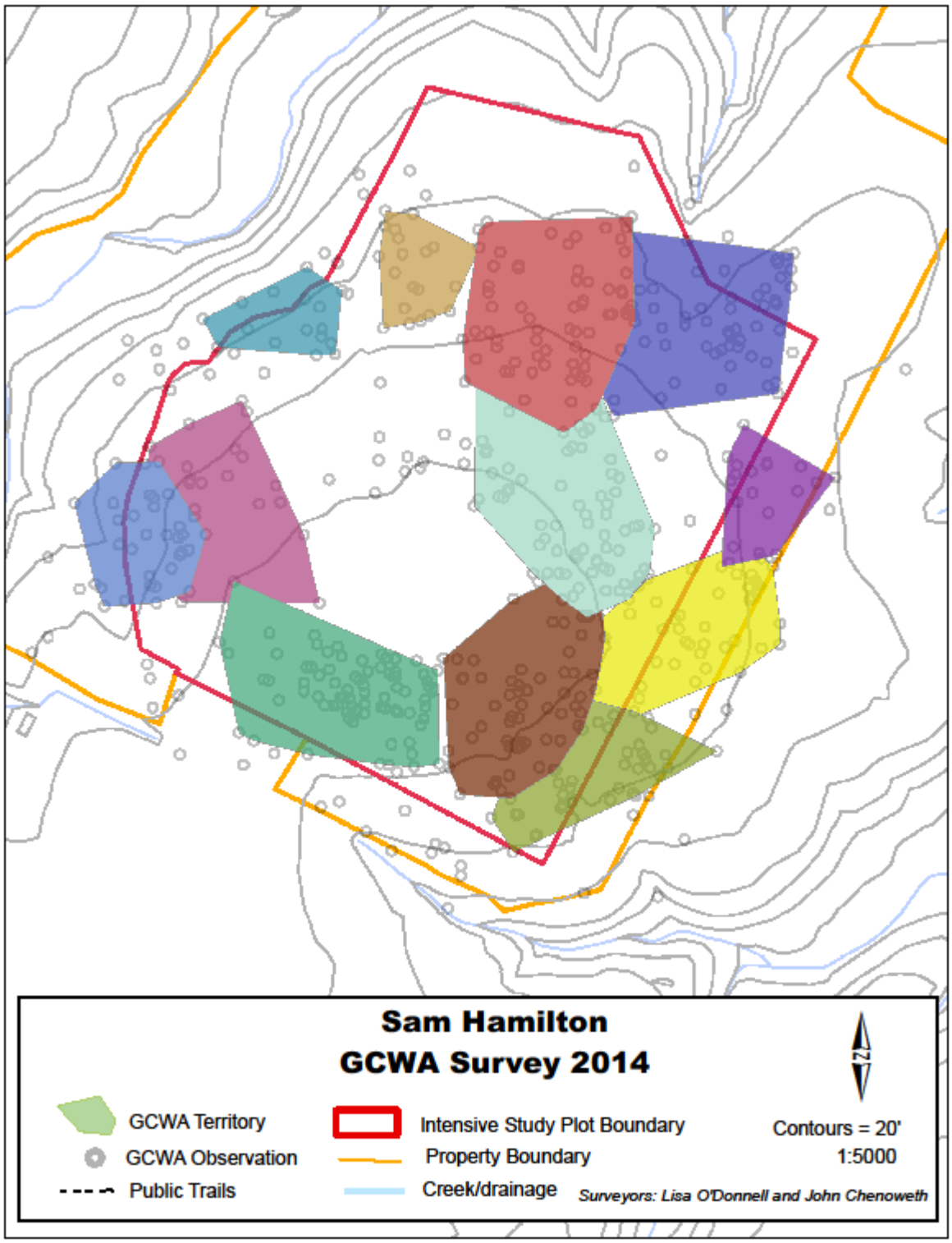


Figure 8

Exhibit A: Minimum Convex Polygons Representing Estimated Golden-cheeked Warbler Territory Boundaries for Intensive Study Plots (Figures 2-18), 2014 (continued).

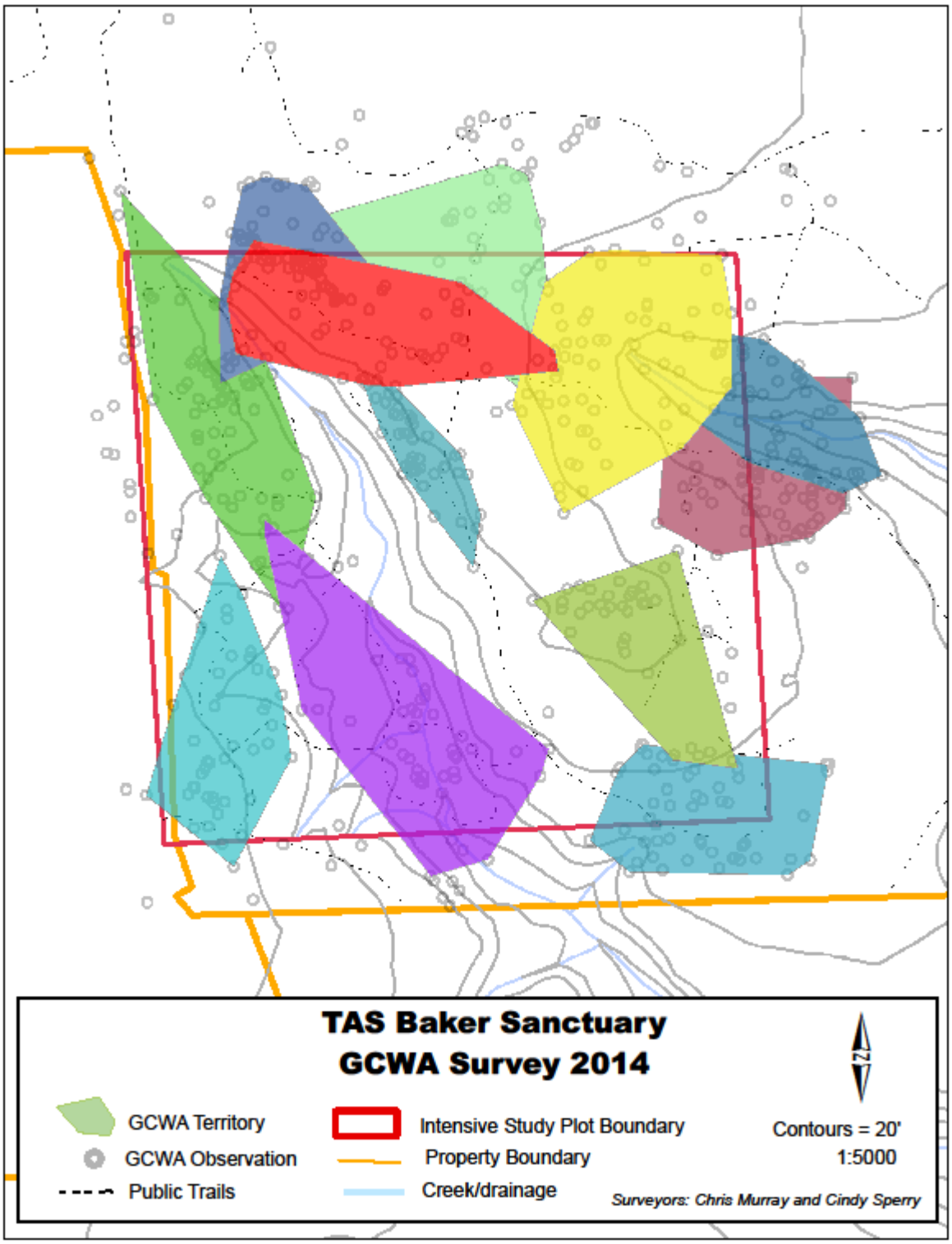


Figure 9

Exhibit A: Minimum Convex Polygons Representing Estimated Golden-cheeked Warbler Territory Boundaries for Intensive Study Plots (Figures 2-18), 2014 (continued).

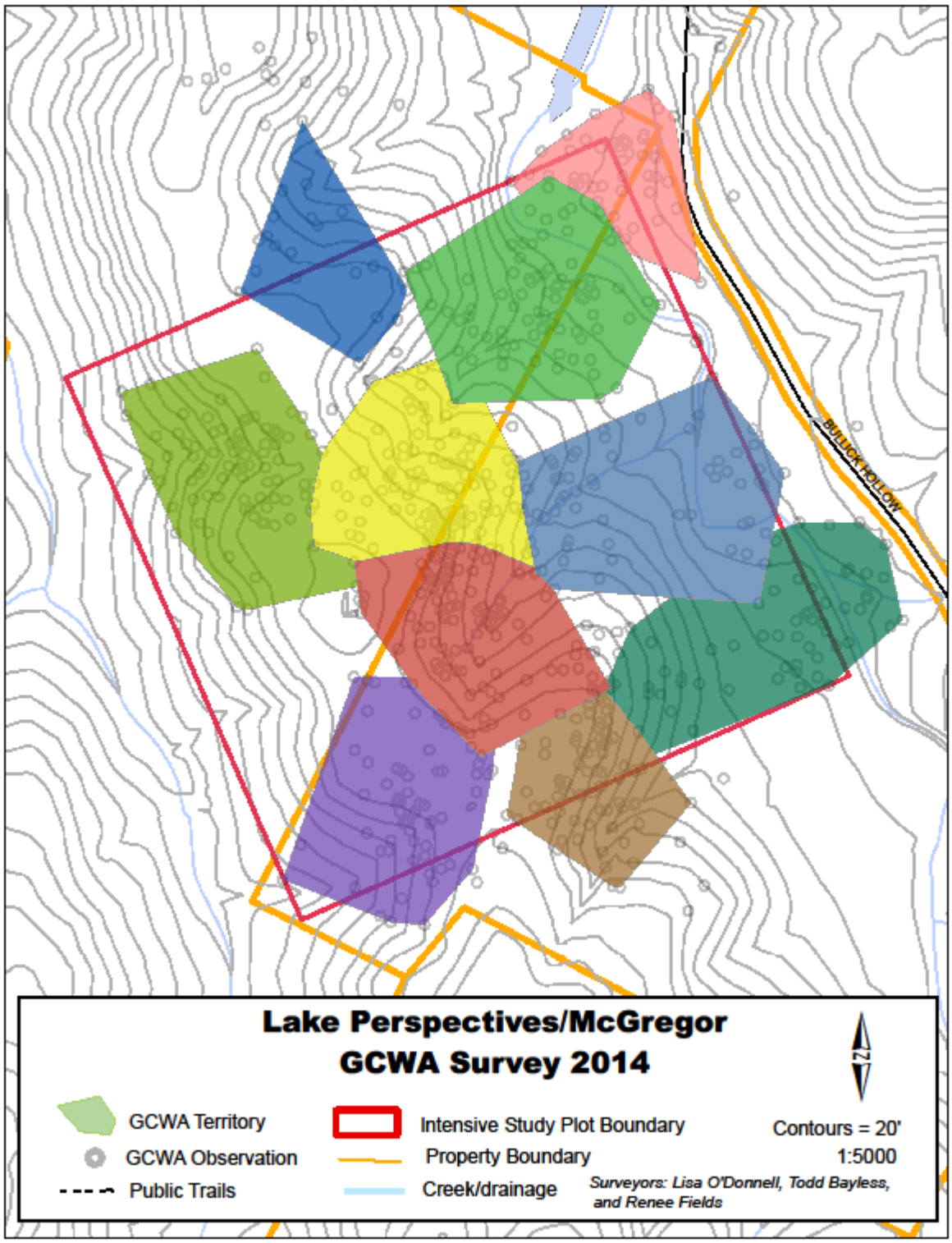


Figure 10

Exhibit A: Minimum Convex Polygons Representing Estimated Golden-cheeked Warbler Territory Boundaries for Intensive Study Plots (Figures 2-18), 2014 (continued).

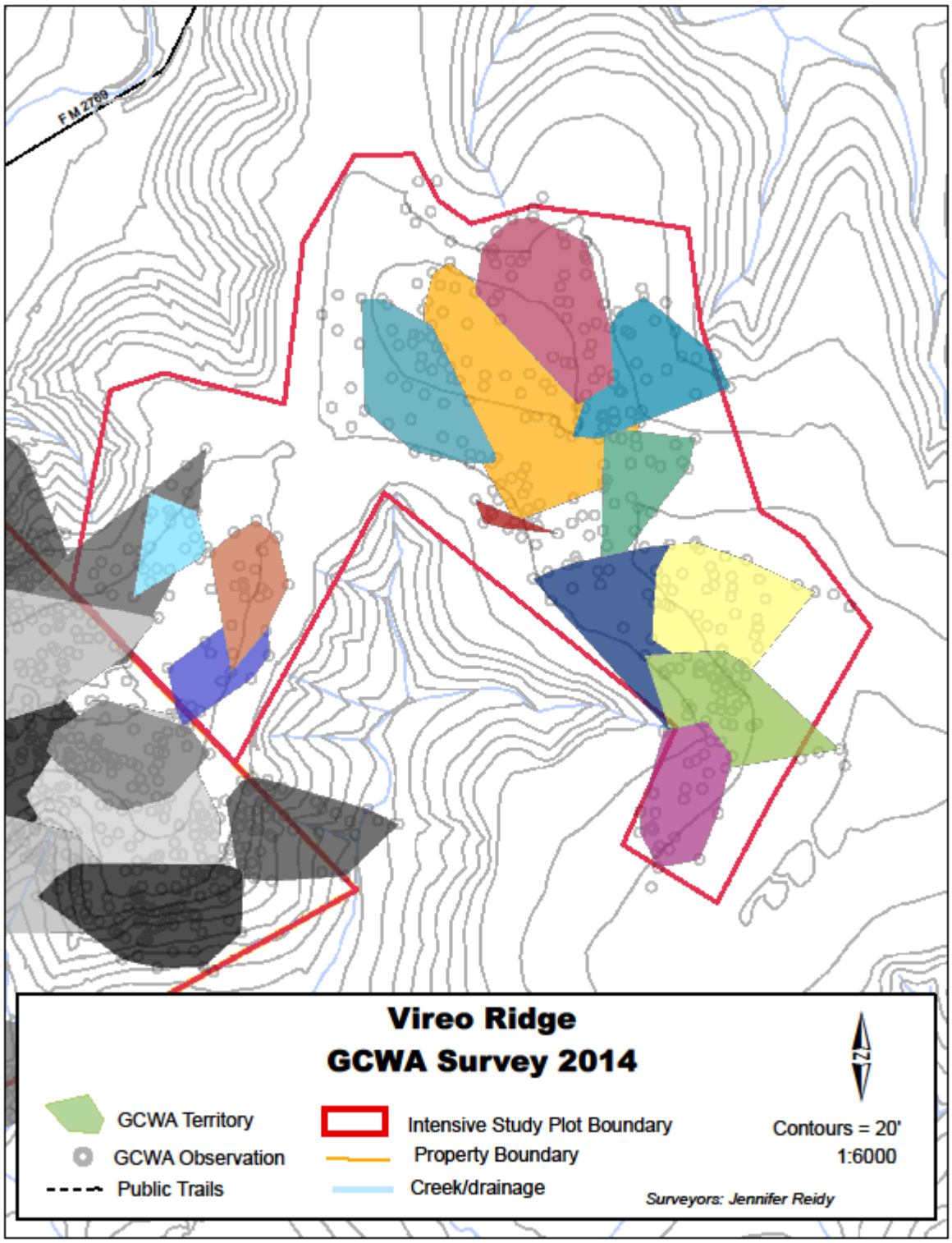


Figure 11

Exhibit A: Minimum Convex Polygons Representing Estimated Golden-cheeked Warbler Territory Boundaries for Intensive Study Plots (Figures 2-18), 2014 (continued).

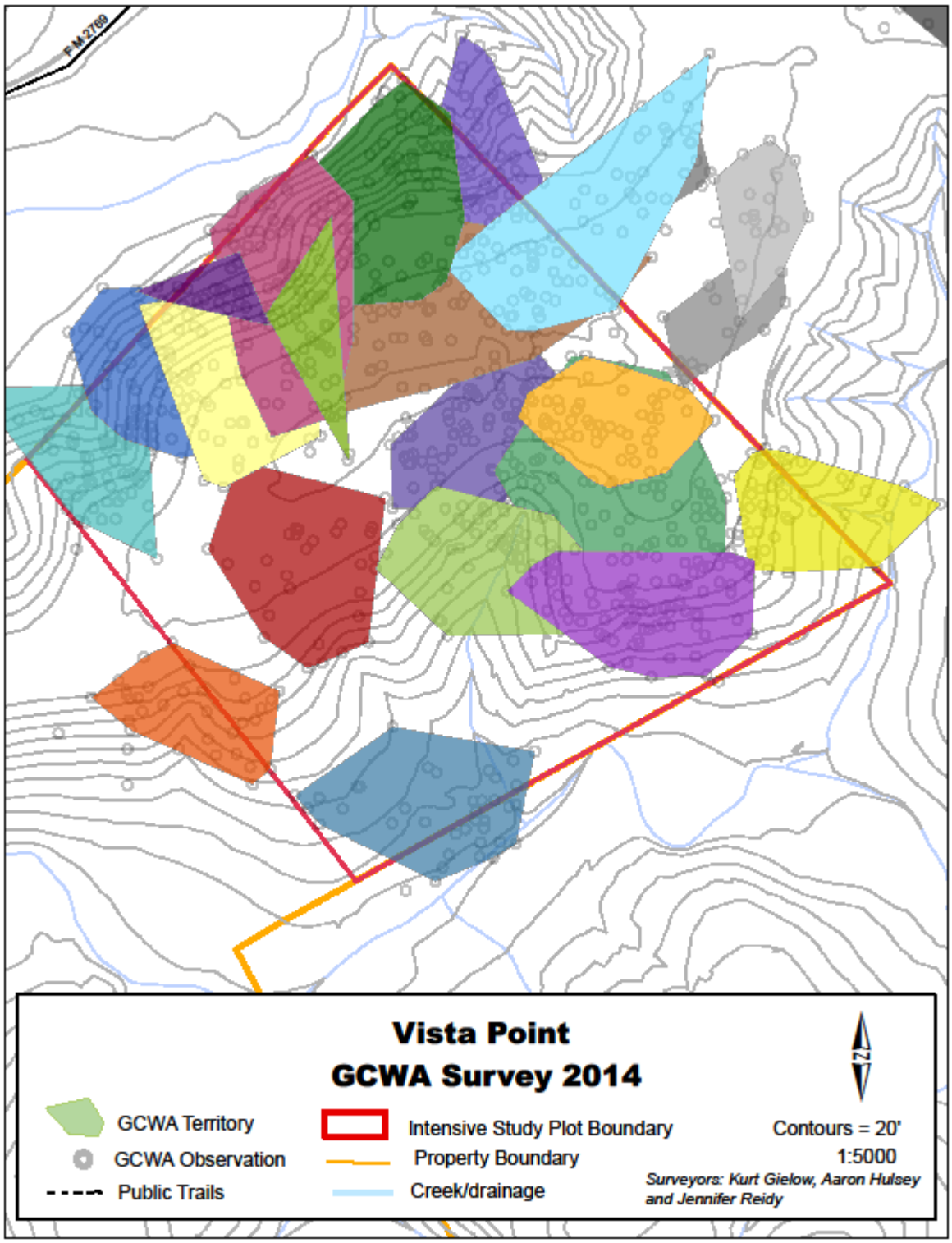


Figure 12

Exhibit A: Minimum Convex Polygons Representing Estimated Golden-cheeked Warbler Territory Boundaries for Intensive Study Plots (Figures 2-18), 2014 (continued).

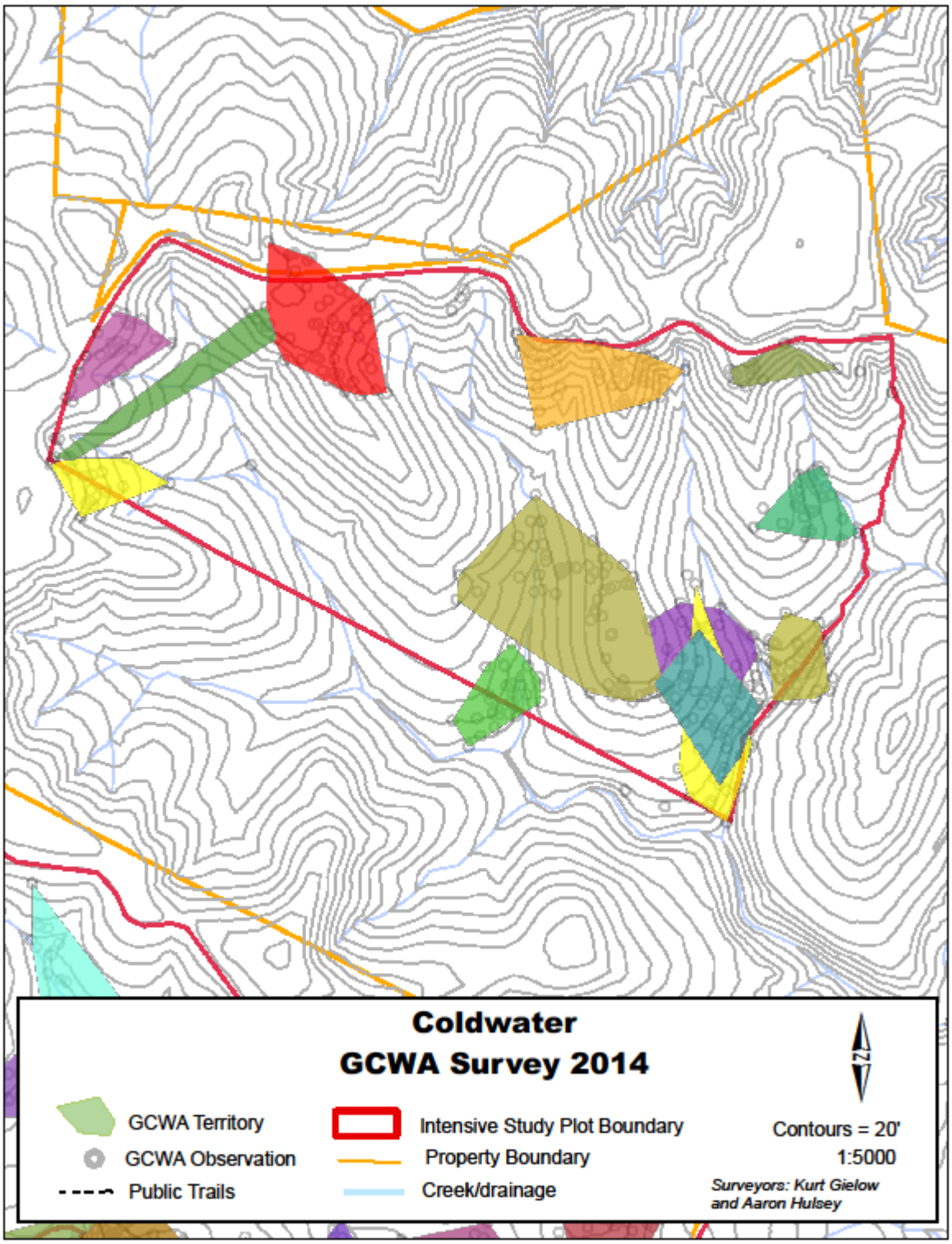


Figure 13

Exhibit A: Minimum Convex Polygons Representing Estimated Golden-cheeked Warbler Territory Boundaries for Intensive Study Plots (Figures 2-18), 2014 (continued).

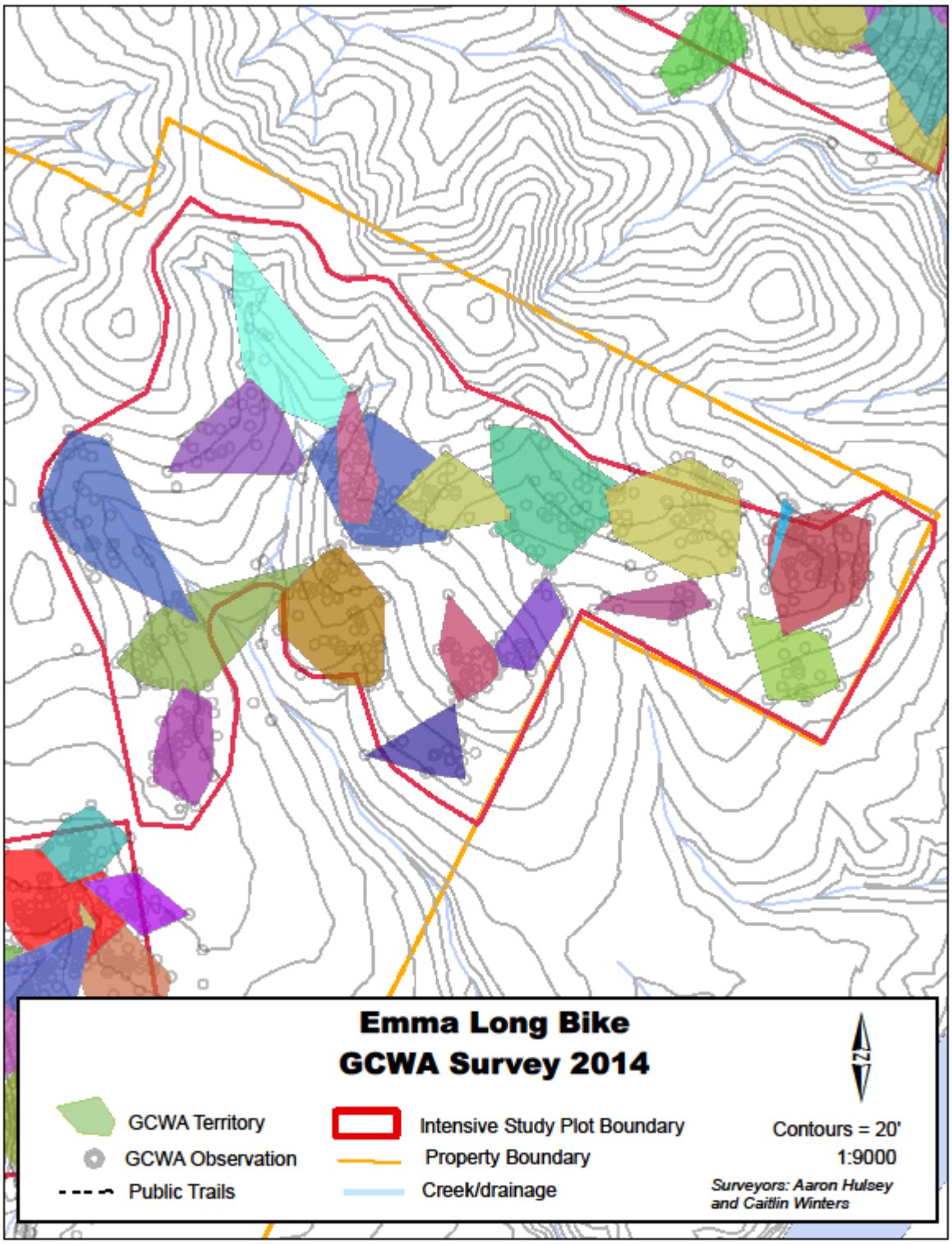


Figure 14

Exhibit A: Minimum Convex Polygons Representing Estimated Golden-cheeked Warbler Territory Boundaries for Intensive Study Plots (Figures 2-18), 2014 (continued).

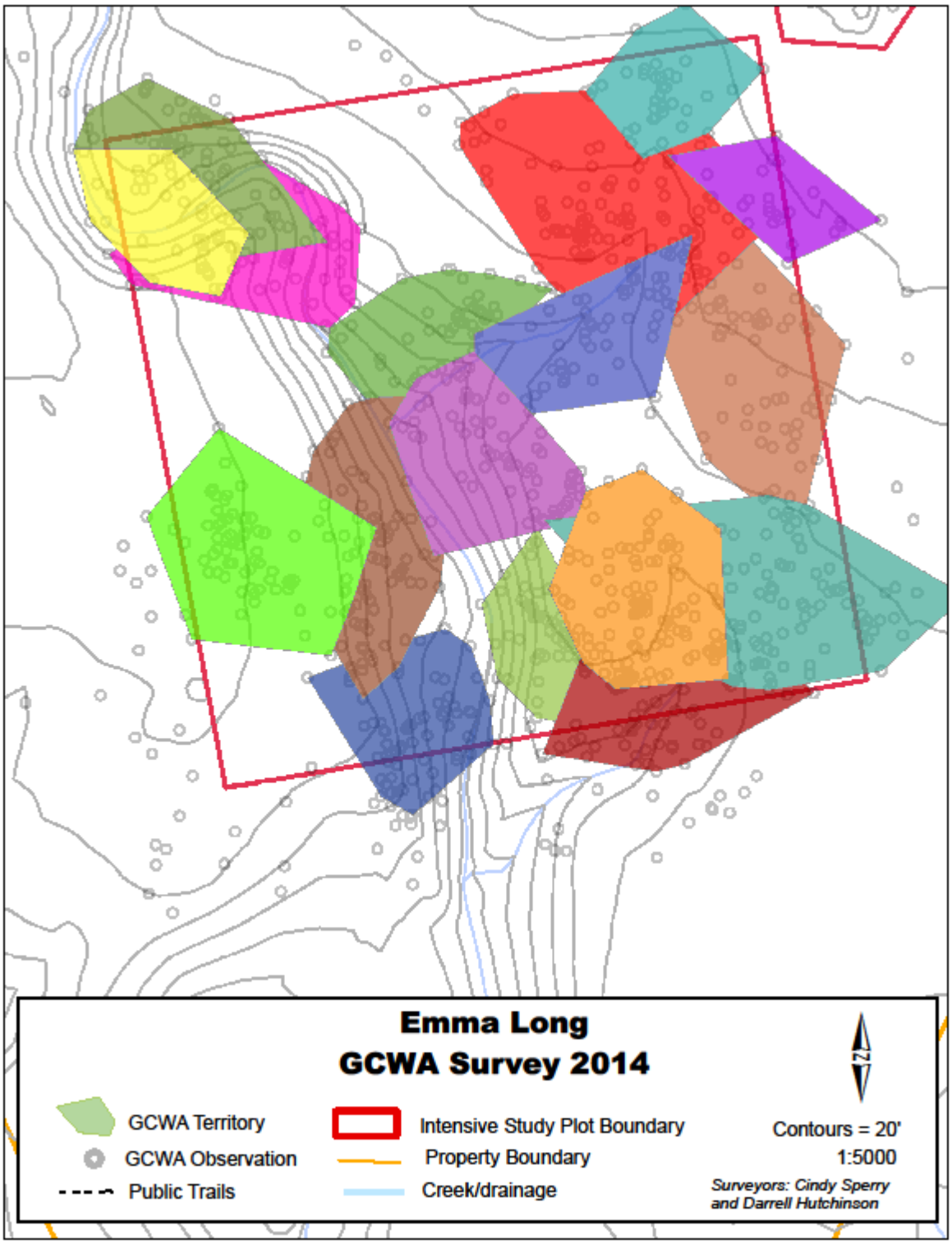


Figure 15

Exhibit A: Minimum Convex Polygons Representing Estimated Golden-cheeked Warbler Territory Boundaries for Intensive Study Plots (Figures 2-18), 2014 (continued).

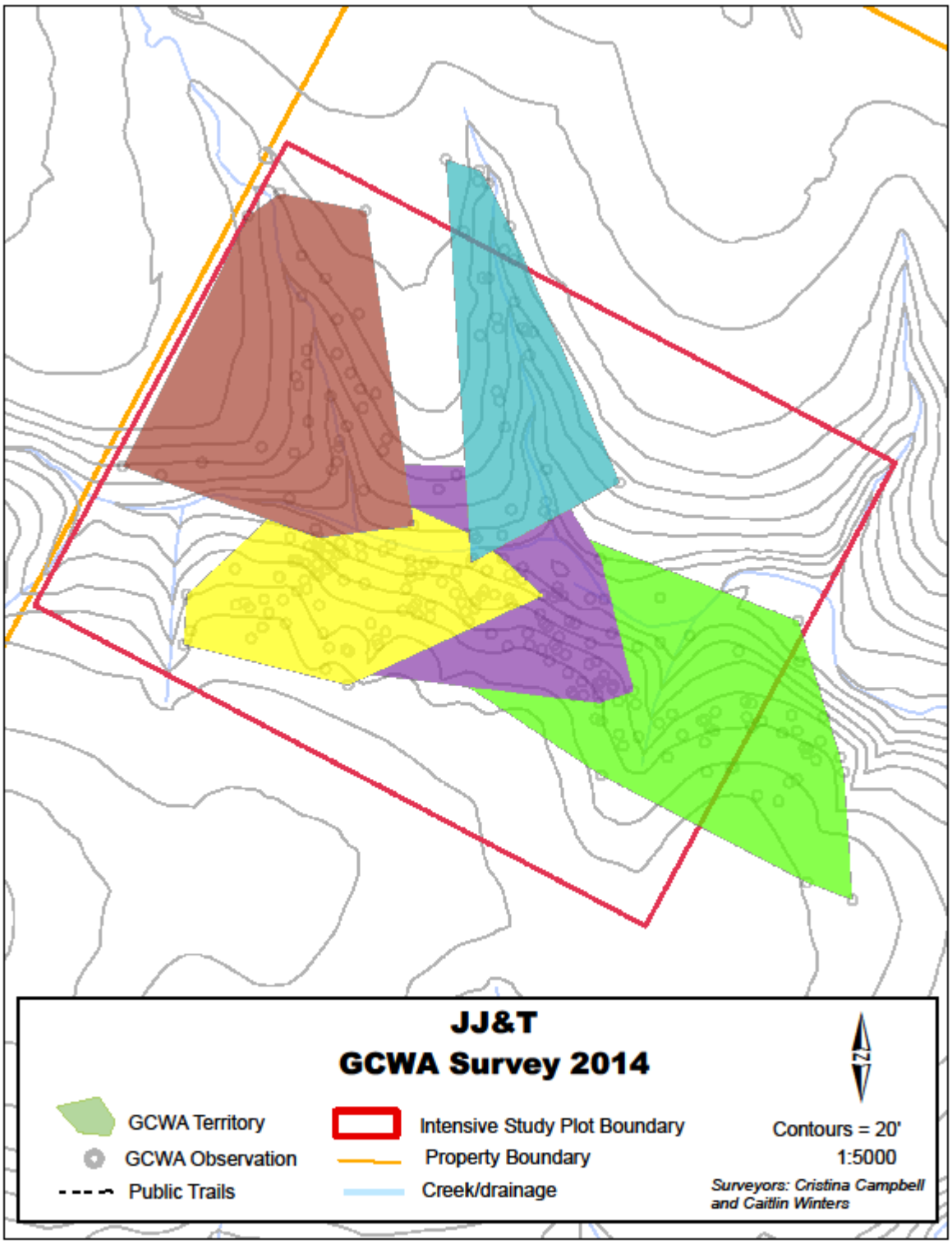


Figure 16

Exhibit A: Minimum Convex Polygons Representing Estimated Golden-cheeked Warbler Territory Boundaries for Intensive Study Plots (Figures 2-18), 2014 (continued).

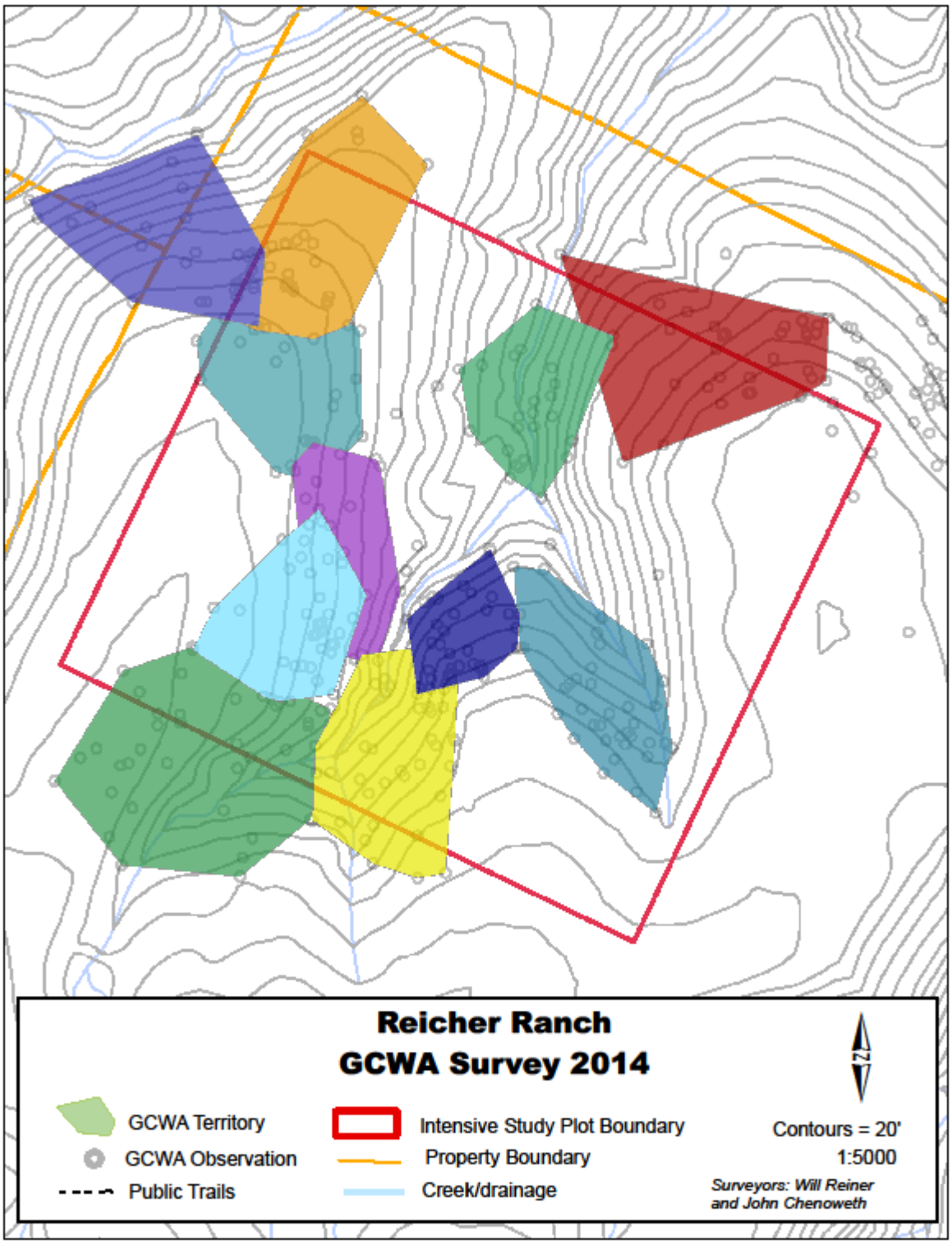


Figure 17

Exhibit A: Minimum Convex Polygons Representing Estimated Golden-cheeked Warbler Territory Boundaries for Intensive Study Plots (Figures 2-18), 2014 (continued).

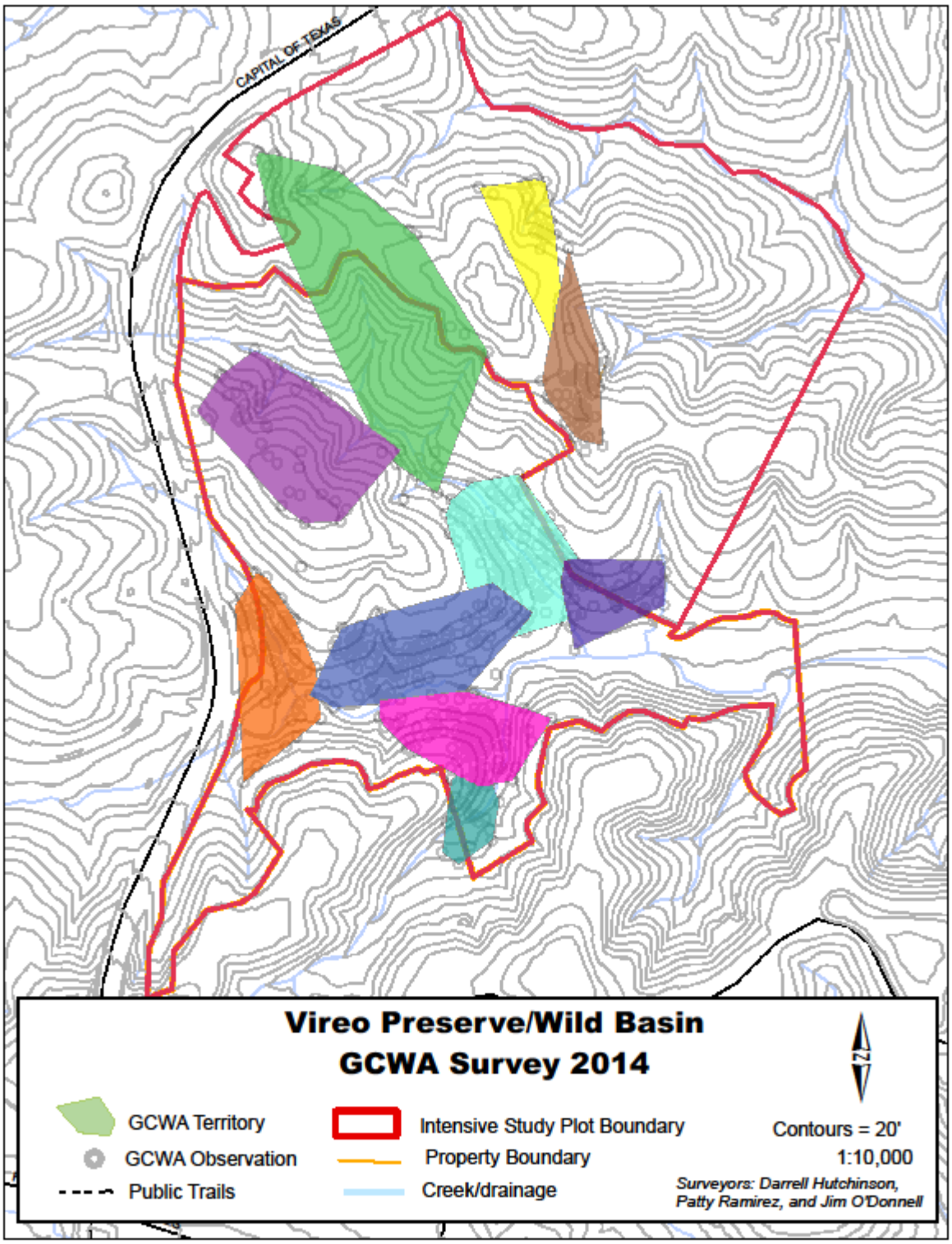


Figure 18

Exhibit B: Summary of Golden-cheeked Warbler Survey Effort on the Balcones Canyonlands Preserve, Travis County, Texas, Field Season 2014.

Intensive Study Plots	Lead Surveyor(s)	Survey Hours (March 11-June 18)	Area Surveyed (hectares)
Barton Creek Macrosite			
Barton Creek	Jonny Scalise, Cristina Campbell, COA	250	40.5 + buffer
Gus Fruh/ Sunset Valley	Jonny Scalise, COA	67	85 + 27
Bull Creek Macrosite			
3M/St. Edwards	Jonny Scalise, Cristina Campbell, COA	419	40.5 + buffer
Canyon Vista	Caitlin Winters, USFS Paul Fushille, William Simper, TC	394	40.5 + buffer
Forest Ridge	Kurt Geilow, USFS Jim O'Donnell, COA	263	40.5 + buffer
Butler	William Reiner, Mark Sanders, COA	299	40.5 + buffer
Hamilton West	John Chenoweth, Lisa O'Donnell, COA	205	40.5 + buffer
Cypress Creek Macrosite			
Baker Sanctuary	Cindy Sperry, COA Chris Murray, Travis Audubon	228	40.5 + buffer
Lake Perspectives/McGregor	Todd Bayless, Renee Fields, TC Lisa O'Donnell, COA	252	40.5 + buffer
Vireo Ridge	Jennifer Reidy, USFS	111	46
Vista Point	Jennifer Reidy, Kurt Gielow, USFS	338	40.5 + buffer
North Lake Austin Macrosite			
Bike Park	Aaron Hulsey, Caitlin Winters, USFS	310	96
Coldwater	Kurt Gielow, Aaron Hulsey, USFS	224	107
Emma Long	Darrell Hutchinson, Cindy Sperry, COA	387	40.5 + buffer
South Lake Austin Macrosite			
Double J&T	Cristina Campbell, COA Caitlin Winters, USFS	100	40.5 + buffer
Reicher	John Chenoweth, William Reiner, COA	205	40.5 + buffer
West Austin Macrosite			
Vireo Preserve/Wild Basin	Darrell Hutchinson, Jim O'Donnell, COA Patty Ramirez, volunteer	240	180
	Total	**4,292**	**1,027 + buffers**

COA = City of Austin, TC = Travis County, USFS = U.S. Forest Service.
Buffers = approx. 30 hectares for each 40.5-ha plot, where access was allowed.

Exhibit B: Summary of Golden-cheeked Warbler Survey Effort on the Balcones Canyonlands Preserve, Travis County, Texas, Field Season 2014 (continued).

Resighting Plots*	Surveyor(s)	Survey Hours (March 15-May 25)
Barton Creek Northwest	Laurie Foss Shelia Hargis	22.5
Barton Creek Far Northwest	Harris Frampton Dustin Jones	15.5
Barton Creek Southeast	Andrea Julian Misa Soliz	18
Barton Creek Southwest	Stacy Marcus	17
3M Northeast	Paul Brick Tere Sariol	11.5
3M South	Beth Banks Omar Garza	13.5
3M Southeast	Deb Blackburn	19
Butler East	Tanya Sommer Christina Williams	18
Butler Northwest	Joseph Hunt Mike Rogan	17
Butler Southeast	Jeff Mundy	16.5
Butler Southwest	Ross Babbitt Julie Webber	16.5
Canyon Creek 40.5-Hectare plot	Nevin Durish Mark Sanders, COA	27
Canyon Vista	Julie Webber	5.5
Forest Ridge Northeast	Kensley Greuter Kaolin Young	17
Forest Ridge Northwest	Jim and Lynn Weber	19
Forest Ridge Southeast	Amanda Padilla Leslie Patterson	18.5
Forest Ridge Southwest	Jim and Lynn Weber	18
Hamilton Northeast	AJ Johnson	19
Hamilton West	Paul Brick Tere Sariol	10
Hamilton Southeast	Megan Barron Angela England Walt Meitzen	26
Interplot (33.4 ha) (between 3M and Forest Ridge plots)	Jennifer Chapman Roger Smith	17
Ribelin 40.5-Hectare plot	Travis County staff	--

*All resighting plots were approximately 40.4 ha except where noted.
COA = City of Austin.

Exhibit B: Summary of Golden-cheeked Warbler Survey Effort on the Balcones Canyonlands Preserve, Travis County, Texas, Field Season 2014 (continued).

Resighting Plots*	Surveyor(s)	Survey Hours (March 15-May 25)
Baker Sanctuary North	Desiree LaVigne	11.5
Baker Sanctuary Southeast	Desiree LaVigne	12.5
Baker Sanctuary – LCRA Northwest	Kat Ross	22.5
Baker Sanctuary – LCRA Southwest	Leigh Jandle	12
Lake Perspectives Northwest	Leigh Jandle	15
Lake Perspectives South	Leigh Jandle	20
Vista Point Southwest	Chris Johnson Jeff Paull	14
Emma Long East	Kat Ross	23
Emma Long West	Bruce Calder Leslyn Dillow	19.5
Emma Long South	Beth Banks Josh Booker	22.5
Long Canyon	Steve Janda Mark Wilson	12
Bohls 40.5-Hectare plot	Ed Fair Christopher Weyenberg	18
Total		**564.5**

*All resighting plots were approximately 40.4 ha except where noted.

Exhibit C: Golden-cheeked Warbler Intensive Study Plot Protocol, Balcones Canyonlands Preserve, 2014.

Objective: To delineate Golden-cheeked Warbler territories as accurately as possible (>33 locations per male) and to document return rates, dispersal, pairing success, breeding success, and productivity (actual number of young per territory) to estimate long-term trends in these parameters. This field season will continue the level of effort to obtain observations of females, nests, and newly-fledged young for each territory to provide more accurate estimates of productivity.

Study Sites: Within each intensive study plot, observers will focus on re-sighting color-banded GCWAs, mapping the location and extent of territories, searching for and monitoring nests, and looking for females and fledglings. In addition, observers responsible for 100-acre study plots will search for color-banded birds within accessible portions of a 100-m buffer around each plot to better ascertain the fate of each banded GCWA and to provide better estimates of the size and extent of edge territories.

Survey Dates: March 1-May 25 (for territory delineations); March 15-June 15 (for documenting reproductive success). Each observer will visit their assigned study plot at least 2 days per week from March 15-May 25 for the purposes of mapping all observed GCWAs, finding and monitoring nests and fledglings, and resighting birds. Separate visits may be required to band territorial males but GCWA observations made during banding attempts are not to be reported as territory observations. Productivity visits will continue at least once a week from May 25-June 15.

Survey Effort for Territory Mapping: 6 hours per 100 acres per week *minimum*. There will be no maximum time constraints. The number of hours devoted to a plot will be based on territory densities, terrain, surveyor's physical condition, etc. Surveyors will take as much time as needed to collect data for each territory (estimate about 45 minutes per territory on each visit). As a general rule, observers should strive to obtain a minimum of 5 locations separated by $\geq$30 meters, up to 10 locations, for birds in each territory per week. This is an additional criterion that fits within the 45+ min time allotment.

Mapping: Observers will obtain GPS locations for, and create hard copy maps of, all GCWA observations for every survey visit, following the Standards for Conducting and Documenting Golden-cheeked Warbler Surveys (COA 2014). Timely and accurate survey maps serve as a means of sharing observation information with other observers assigned to the same study plot, are critical for conducting data QA/QC, and provide important supporting documentation for subsequent analyses and reports.

Staffing: Two observers per plot averaging $\geq$5 territories, with a *minimum* 3 hours/50 acres/person (*minimum* 6 hours total per 100 acres) per week. Two observers will help ensure comprehensive coverage and address potential observer bias issues.

Training: All staff scheduled for the 2014 field season will have prior experience conducting Warbler surveys or be trained by experienced personnel prior to the field season.

Survey Procedures: Observers are to follow the Standards for Conducting and Documenting Golden-cheeked Warbler Surveys (COA 2014) during all field visits. The following additional procedures are specific to surveying intensive survey plots:

1. Surveys should start as soon as possible after sunrise, but not before light levels permit detection of color bands.
2. Each observer will cover half (for plots averaging 5 or more territories) or the entire plot (for plots with <5 territories) at least twice each week. For shared plots, observers will need to coordinate coverage. For the initial visit, observers will split and cover one-half of the plot. For each subsequent week, each observer will rotate the area covered by 90° in a clockwise direction, where this is practical. This will ensure each observer covers the entire plot and begins at a different corner of the plot each week.
3. Volunteers will be recruited to conduct searches for banded GCWAs outside the 100-m buffers surrounding each intensive study plot. These surveys will be conducted at least three times within the season, $\geq$ 2 weeks apart. These surveys will also follow the Standards for Conducting and Documenting Golden-cheeked Warbler Surveys (COA 2014).

Exhibit D: Summary of Golden-cheeked Warbler Banding Data for Intensive Study Plots on the Balcones Canyonlands Preserve, Travis County, Texas, Field Seasons 2009-2014.

Plot Name	Survey Year	No. of Males Banded	No. of Females Banded	Total No. Banded
Barton Creek	2009	6	0	6
	2010	6	1	7
	2011	3	0	3
	2012	7	0	7
	2013	5	0	5
	2014	5	0	5
Gus Fruh/ Sunset Valley	2009	--	--	--
	2010	--	--	--
	2011	0	0	0
	2012	0	0	0
	2013	3	0	3
	2014	4	0	4
3M/ St. Edwards	2009	22	1	23
	2010	11	1	12
	2011	16	1	17
	2012	12	1	13
	2013	13	0	13
	2014	18	3	21
Canyon Vista	2009	--	--	--
	2010	--	--	--
	2011	15	0	15
	2012	10	0	10
	2013	9	0	9
	2014	9	1	10
Forest Ridge	2009	16	0	16
	2010	6	1	7
	2011	18	1	19
	2012	4	4	8
	2013	4	1	5
	2014	6	3	9
Butler	2009	21	1	22
	2010	11	0	11
	2011	10	0	10
	2012	13	2	15
	2013	17	1	18
	2014	12	2	14
Hamilton West	2009	4	0	0
	2010	11	0	11
	2011	11	0	11
	2012	4	0	4
	2013	6	1	7
	2014	6	4	10
Baker Sanctuary	2009	--	--	--
	2010	--	--	--
	2011	11	2	13
	2012	9	1	10
	2013	3	0	3
	2014	2	1	3
Lake Perspectives/ McGregor	2009	--	--	--
	2010	--	--	--
	2011	7	1	8
	2012	5	0	5
	2013	4	0	4
	2014	4	1	5

Exhibit D: Summary of Golden-cheeked Warbler Banding Data, continued.

Plot Name	Survey Year	No. of Males Banded	No. of Females Banded	Total No. Banded
Vireo Ridge	2009	--	--	--
	2010	--	--	--
	2011	10	0	10
	2012	7	0	7
	2013	2	1	3
	2014	6	0	6
Vista Point	2009	--	--	--
	2010	--	--	--
	2011	17	1	18
	2012	6	0	6
	2013	6	0	6
	2014	1	0	1
Coldwater	2009	--	--	--
	2010	13	0	13
	2011	8	0	8
	2012	2	1	3
	2013	7	0	7
	2014	7	1	8
Bike Park	2009	--	--	--
	2010	8	0	9
	2011	12	0	12
	2012	8	0	8
	2013	7	0	7
	2014	12	1	13
Emma Long	2009	14	0	14
	2010	3	0	3
	2011	10	2	12
	2012	3	0	3
	2013	5	1	6
	2014	6	1	7
Double J&T	2009	1	0	1
	2010	3	0	3
	2011	2	0	2
	2012	2	0	2
	2013	4	0	4
	2014	1	0	1
Reicher	2009	--	--	--
	2010	--	--	--
	2011	3	0	3
	2012	1	0	1
	2013	5	0	5
	2014	6	0	6
Wild Basin/ Vireo Preserve	2009	--	--	--
	2010	--	--	--
	2011	9	0	9
	2012	1	1	2
	2013	4	1	5
	2014	6	1	7

Exhibit D: Summary of Golden-cheeked Warbler Banding Data, continued.

Plot Name	Survey Year	No. of Males Banded	No. of Females Banded	Total No. Banded
Bohls	2009	2	0	2
	2010	4	0	4
	2011	--	--	--
	2012	--	--	--
	2013	--	--	--
	2014	--	--	--
Canyon Creek	2009	15	1	16
	2010	8	0	8
	2011	--	--	--
	2012	--	--	--
	2013	--	--	--
	2014	--	--	--
Ribelin	2009	--	--	--
	2010	4	0	4
	2011	--	--	--
	2012	--	--	--
	2013	--	--	--
	2014	--	--	--

Exhibit E: Summary of Golden-cheeked Warbler Territory Data for Intensive Study Plots on the Balcones Canyonlands Preserve, Travis County, Texas, Field Seasons 2009-2014. See Methods section for calculations.

Plot Name	Survey Year	No. of Full Territories	Number of Full and Edge Territories	No. of Full Territories + 50% of Edge Territories	Territory Density per Hectare
Barton Creek	2009	2	8	5.0	0.12
	2010	2	10	6.0	0.15
	2011	4	9	6.5	0.16
	2012	2	7	4.5	0.11
	2013	4	10	7.0	0.17
	2014	5	12	8.5	0.21
Gus Fruh/ Sunset Valley	2009	--	--	--	--
	2010	--	--	--	--
	2011	1	2	1.0	0.006
	2012	0	0	0	0
	2013	1	1	1.0	0.009
	2014	2	4	3.0	0.03
3M/ St. Edwards	2009	9	27	18.0	0.44
	2010	13	26	19.5	0.48
	2011	12	25	18.5	0.46
	2012	14	27	20.5	0.51
	2013	13	26	19.5	0.48
	2014	12	28	20.0	0.49
Canyon Vista	2009	--	--	--	--
	2010	--	--	--	--
	2011	10	22	16.0	0.40
	2012	6	23	14.5	0.36
	2013	7	22	14.5	0.36
	2014	8	23	15.5	0.38
Forest Ridge	2009	10	18	14.0	0.35
	2010	10	20	15.0	0.37
	2011	13	20	16.5	0.41
	2012	13	23	18.0	0.44
	2013	8	14	11.0	0.27
	2014	9	19	14.0	0.35
Butler	2009	11	25	18.0	0.44
	2010	11	20	15.5	0.38
	2011	12	22	17.0	0.43
	2012	11	24	17.5	0.43
	2013	18	32	25.0	0.62
	2014	15	20	17.5	0.43
Hamilton West	2009	--	--	--	--
	2010	2	14	8.0	0.20
	2011	8	20	14.0	0.35
	2012	6	10	8.0	0.20
	2013	5	11	8.0	0.20
	2014	5	12	8.5	0.21
Baker Sanctuary	2009	--	--	--	--
	2010	--	--	--	--
	2011	5	16	10.5	0.26
	2012	8	12	10.0	0.25
	2013	6	14	10.0	0.25
	2014	5	12	8.5	0.21

Exhibit E: Summary of Golden-cheeked Warbler Intensive Study Plot Territory Data, continued.

Plot Name	Survey Year	No. of Full Territories	Number of Full and Edge Territories	No. of Full Territories + 50% of Edge Territories	No. of Territories Per Hectare
Lake Perspectives/ McGregor	2009	--	--	--	--
	2010	--	--	--	--
	2011	5	10	7.5	0.19
	2012	4	10	7.0	0.17
	2013	6	11	8.5	0.21
	2014	4	10	7.0	0.17
Vireo Ridge	2009	--	--	--	--
	2010	--	--	--	--
	2011	7	13	10.0	0.25
	2012	12	16	14.0	0.24
	2013	9	11	10.0	0.24
	2014	12	13	12.5	0.27
Vista Point	2009	--	--	--	--
	2010	--	--	--	--
	2011	15	17	16.0	0.40
	2012	13	20	14.0	0.24
	2013	10	17	13.5	0.33
	2014	9	19	14.0	0.35
Coldwater	2009	--	--	--	--
	2010	12	12	12.0	0.11
	2011	11	16	13.5	0.14
	2012	7	12	9.5	0.09
	2013	10	13	11.5	0.11
	2014	7	13	10.0	0.09
Bike Park	2009	--	--	--	--
	2010	9	9	9.0	0.09
	2011	12	15	13.5	0.14
	2012	12	17	14.5	0.15
	2013	5	13	9.0	0.09
	2014	12	19	15.5	0.16
Emma Long	2009	9	19	14.0	0.35
	2010	10	16	13.0	0.32
	2011	10	16	13.0	0.33
	2012	11	18	14.5	0.36
	2013	11	20	15.5	0.38
	2014	9	17	13.0	0.32
Double J&T	2009	2	3	2.5	0.06
	2010	3	3	3.0	0.07
	2011	3	4	3.5	0.09
	2012	4	4	4.0	0.10
	2013	2	4	3.0	0.07
	2014	3	5	4.0	0.10
Reicher	2009	--	--	--	--
	2010	--	--	--	--
	2011	3	4	3.5	0.09
	2012	2	6	4.0	0.10
	2013	3	6	6.0	0.11
	2014	5	11	8.0	0.20
Wild Basin/ Vireo Preserve	2009	--	--	--	--
	2010	--	--	--	--
	2011	8	11	9.5	0.05
	2012	6	6	6.0	0.03
	2013	8	8	8.0	0.04
	2014	9	10	9.5	0.05

Exhibit F: Summary of Golden-cheeked Warbler Age Structure Data for Territorial Males on Intensive Study Plots on the Balcones Canyonlands Preserve, Travis County, Texas, Field Seasons 2009-2014.

Plot	Survey Year	% SY Males	%ASY Males	%AHY Males	Total No. Banded Males	Total No. Unbanded Males	% Banded Males
Barton Creek	2009	20	60	20	5	3	63
	2010	22	78	0	9	1	90
	2011	0	100	0	6	3	67
	2012	0	100	0	5	2	71
	2013	40	60	0	5	5	50
	2014	25	75	0	8	4	67
Gus Fruh/ Sunset Valley	2009	--	--	--	--	--	--
	2010	--	--	--	--	--	--
	2011	0	0	0	0	2	0
	2012	0	0	0	0	0	0
	2013	100	0	0	1	0	100
	2014	100	0	0	4	0	100
3M/St. Edwards	2009	30	70	0	20	7	74
	2010	38	63	0	16	10	62
	2011	56	44	0	18	7	72
	2012	29	71	0	21	6	78
	2013	39	61	0	18	8	69
	2014	55	45	0	20	8	71
Canyon Vista	2009	--	--	--	--	--	--
	2010	--	--	--	--	--	--
	2011	29	71	0	14	8	64
	2012	18	82	0	17	6	74
	2013	31	69	0	16	6	73
	2014	25	75	0	12	11	52
Forest Ridge	2009	20	73	7	15	3	83
	2010	21	79	0	14	6	70
	2011	35	65	0	17	3	85
	2012	0	100	0	16	7	67
	2013	11	89	0	9	5	64
	2014	27	73	0	11	8	58
Butler	2009	53	29	18	17	8	68
	2010	33	67	0	15	5	75
	2011	62	37	0	16	6	73
	2012	53	42	5	19	5	79
	2013	36	59	5	22	10	69
	2014	19	81	0	16	4	80
Hamilton West	--	--	--	--	--	--	--
	2010	40	60	0	10	4	71
	2011	60	27	13	15	5	75
	2012	29	57	14	7	3	70
	2013	63	38	0	8	3	73
	2014	50	50	0	8	4	67
Baker Sanctuary	2009	--	--	--	--	--	--
	2010	--	--	--	--	--	--
	2011	50	50	0	8	8	50
	2012	50	50	0	10	2	83
	2013	25	75	0	8	6	57
	2014	0	100	0	9	3	75
Lake Perspectives/ McGregor	2009	--	--	--	--	--	--
	2010	--	--	--	--	--	--
	2011	43	57	0	7	3	70
	2012	20	80	0	10	0	100
	2013	33	67	0	9	2	82
	2014	29	71	0	7	3	70

Exhibit F: Golden-cheeked Warbler Intensive Study Plot Age Structure Data for Territorial Males, continued.

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Plot	Survey Year	% SY Males	%ASY Males	%AHY Males	Total No. Banded Males	Total No. Unbanded Males	% Banded Males
Vireo Ridge	2009	--	--	--	--	--	--
	2010	--	--	--	--	--	--
	2011	37	62	0	8	5	62
	2012	15	85	0	13	3	81
	2013	22	78	0	9	2	82
	2014	43	57	0	7	6	54
Vista Point	2009	--	--	--	--	--	--
	2010	--	--	--	--	--	--
	2011	24	76	0	17	0	100
	2012	12	88	0	17	3	81
	2013	29	71	0	14	3	82
	2014	9	91	0	11	8	59
Coldwater	2009	--	--	--	--	--	--
	2010	42	58	0	12	0	100
	2011	54	46	0	13	3	81
	2012	0	89	11	9	3	75
	2013	50	50	0	8	5	62
	2014	60	40	0	10	3	77
Bike Park	2009	--	--	--	--	--	--
	2010	63	38	0	8	1	89
	2011	79	21	0	14	1	93
	2012	29	71	0	14	3	82
	2013	71	29	0	7	6	54
	2014	69	31	0	13	6	68
Emma Long	2009	0	100	0	13	6	68
	2010	11	89	0	9	7	56
	2011	27	73	0	11	5	69
	2012	10	90	0	10	8	56
	2013	0	100	0	10	10	50
	2014	33	67	0	9	8	53
Double J&T	2009	100	0	0	1	2	33
	2010	67	33	0	3	0	100
	2011	100	0	0	2	2	50
	2012	100	0	0	1	3	25
	2013	100	0	0	4	0	100
	2014	0	100	0	3	2	60
Reicher	2009	--	--	--	--	--	--
	2010	--	--	--	--	--	--
	2011	33	67	0	3	1	75
	2012	50	50	0	2	4	33
	2013	25	75	0	4	2	67
	2014	38	50	12	8	3	73
Wild Basin/ Vireo Preserve	2009	--	--	--	--	--	--
	2010	--	--	--	--	--	--
	2011	78	22	0	9	2	82
	2012	20	80	0	5	1	83
	2013	33	67	0	6	2	75
	2014	50	50	0	8	2	80

Exhibit G: Summary of Golden-cheeked Warbler Return Rates for Males Banded on Intensive Study Plots, Balcones Canyonlands Preserve, Travis County, Texas, Field Seasons 2009-2014.

Plot Name	Survey Year	Males Banded	2009 Returning Males	2010 Returning Males	2011 Returning Males	2012 Returning Males	2013 Returning Males	Total Returning Males
Barton Creek	2009	6	--	--	--	--	--	--
	2010	7	4	--	--	--	--	4
	2011	3	1	2	--	--	--	3
	2012	7	1	1	1	--	--	3
	2013	5	0	1	0	1	--	2
	2014	5	0	0	0	1	4	5
Gus Fruh/ Sunset Valley	2009	--	--	--	--	--	--	--
	2010	--	--	--	--	--	--	--
	2011	0	--	--	--	--	--	--
	2012	0	--	--	--	--	--	--
	2013	3	--	--	--	--	--	--
	2014	4	--	--	--	--	0	0
3M/St. Edwards	2009	22	--	--	--	--	--	--
	2010	11	12	--	--	--	--	12
	2011	16	4	3	--	--	--	7
	2012	12	2	1	12	--	--	15
	2013	13	2	0	5	7	--	14
	2014	18	0	0	1	4	6	11
Canyon Vista	2009	--	--	--	--	--	--	--
	2010	--	--	--	--	--	--	--
	2011	15	--	--	--	--	--	--
	2012	10	--	--	9	--	--	9
	2013	9	--	--	4	5	--	9
	2014	9	--	--	2	0	5	7
Forest Ridge	2009	16	--	--	--	--	--	--
	2010	6	7	--	--	--	--	7
	2011	18	3	2	--	--	--	5
	2012	4	1	3	10	--	--	14
	2013	4	0	1	6	0	--	7
	2014	6	0	1	2	0	1	4
Butler	2009	21	--	--	--	--	--	--
	2010	11	10	--	--	--	--	10
	2011	10	7	5	--	--	--	12
	2012	13	3	2	5	--	--	10
	2013	17	0	0	2	8	--	10
	2014	11	0	0	1	3	10	14
Hamilton West	2009	4	--	--	--	--	--	--
	2010	11	2	--	--	--	--	2
	2011	11	1	7	--	--	--	8
	2012	4	0	1	4	--	--	5
	2013	6	0	0	3	2	--	5
	2014	6	0	0	3	1	1	5
Baker Sanctuary	2009	--	--	--	--	--	--	--
	2010	--	--	--	--	--	--	--
	2011	11	--	--	--	--	--	--
	2012	9	--	--	4	--	--	4
	2013	3	--	--	2	4	--	6
	2014	2	--	--	2	3	2	7
Lake Perspectives/ McGregor	2009	--	--	--	--	--	--	--
	2010	--	--	--	--	--	--	--
	2011	7	--	--	--	--	--	--
	2012	5	--	--	5	--	--	5
	2013	4	--	--	4	3	--	7
	2014	4	--	--	2	1	1	4

Exhibit G: Golden-cheeked Warbler Intensive Study Plot Return Rate Data, continued.

Plot Name	Survey Year	Males Banded	2009 Returning Males	2010 Returning Males	2011 Returning Males	2012 Returning Males	2013 Returning Males	Total Returning Males
Vireo Ridge	2009	--	--	--	--	--	--	--
	2010	--	--	--	--	--	--	--
	2011	10	--	--	--	--	--	--
	2012	7	--	--	5	--	--	5
	2013	2	--	--	3	5	--	8
	2014	6	--	--	2	3	2	7
Vista Point	2009	--	--	--	--	--	--	--
	2010	--	--	--	--	--	--	--
	2011	17	--	--	--	--	--	--
	2012	6	--	--	11	--	--	11
	2013	6	--	--	3	4	--	7
	2014	1	--	--	2	2	6	10
Coldwater	2009	--	--	--	--	--	--	--
	2010	13	--	--	--	--	--	--
	2011	8	--	5	--	--	--	5
	2012	2	--	4	4	--	--	8
	2013	7	--	3	0	0	--	3
	2014	7	--	1	0	0	3	4
Bike Park	2009	--	--	--	--	--	--	--
	2010	8	--	--	--	--	--	--
	2011	12	--	2	--	--	--	2
	2012	8	--	2	8	--	--	10
	2013	7	--	1	1	1	--	3
	2014	12	--	0	0	0	2	2
Emma Long	2009	14	--	--	--	--	--	--
	2010	3	9	--	--	--	--	9
	2011	10	3	2	--	--	--	5
	2012	3	0	2	7	--	--	9
	2013	5	0	1	4	1	--	6
	2014	6	0	1	3	0	1	5
Double J&T	2009	1	--	--	--	--	--	--
	2010	3	0	--	--	--	--	0
	2011	2	0	0	--	--	--	0
	2012	2	0	0	0	--	--	0
	2013	4	0	1	0	0	--	1
	2014	1	0	0	0	0	2	2
Reicher	2009	--	--	--	--	--	--	--
	2010	--	--	--	--	--	--	--
	2011	3	--	--	--	--	--	--
	2012	1	--	--	1	--	--	1
	2013	5	--	--	0	1	--	1
	2014	6	--	--	0	0	3	3
Wild Basin/ Vireo Preserve	2009	--	--	--	--	--	--	--
	2010	--	--	--	--	--	--	--
	2011	9	--	--	--	--	--	--
	2012	1	--	--	7	--	--	7
	2013	4	--	--	6	1	--	7
	2014	6	--	--	1	1	1	3

Exhibit G: Golden-cheeked Warbler Intensive Study Plot Return Rate Data, continued.

Plot Name	Survey Year	Males Banded	2009 Returning Males	2010 Returning Males	2011 Returning Males	2012 Returning Males	2013 Returning Males	Total Returning Males
Bohls	2009	2	--	--	--	--	--	--
	2010	4	0	--	--	--	--	0
	2011	--	0	1	--	--	--	1
	2012	--	0	1	--	--	--	1
	2013	--	0	1	--	--	--	1
	2014	--	0	0	--	--	--	0
Canyon Creek	2009	15	--	--	--	--	--	--
	2010	8	2	--	--	--	--	2
	2011	--	0	4	--	--	--	4
	2012	--	0	5	--	--	--	5
	2013	--	0	1	--	--	--	1
	2014	--	0	0	--	--	--	0
Ribelin	2009	--	--	--	--	--	--	--
	2010	6	--	--	--	--	--	--
	2011	--	--	4	--	--	--	4
	2012	--	--	0	--	--	--	0
	2013	--	--	1	--	--	--	1
	2014	--	--	1	--	--	--	1

Exhibit H: Summary of Golden-cheeked Warbler Reproductive Success Data for Full and Edge Territories within Intensive Study Plots on the Balcones Canyonlands Preserve, Travis County, Texas, Field Seasons 2009-2014. See Methods section for calculations.

Plot Name	Survey Year	Pairing Success	Breeding Success	Total No. of Observed and Adjusted Fledglings	Density of Observed and Adjusted Fledglings per Hectare
Barton Creek	2009	75	63	12 / 14	0.22 / 0.27
	2010	100	80	24 / 29	0.40 / 0.44
	2011	100	67	17 / 21	0.33 / 0.40
	2012	100	100	24/ 27	0.37 / 0.44
	2013	90	70	24 / 27	0.43 / 0.48
	2014	100	58	17 / 21	0.36 / 0.41
Gus Fruh/ Sunset Valley	2009	--	--	--	--
	2010	--	--	--	--
	2011	0	0	0	0
	2012	0	0	0	0
	2013	100	0	0	0
	2014	0	0	0	0
3M/ St. Edwards	2009	89	70	46 / 68	0.75 / 1.11
	2010	96	77	49 / 72	1.01 / 1.47
	2011	96	65	35 / 55	0.59 / 0.94
	2012	100	56	48 / 58	0.93 / 1.19
	2013	65	65	38 / 44	0.62 / 0.72
	2014	100	64	54 / 68	0.89 / 1.12
Canyon Vista	2009	--	--	--	--
	2010	--	--	--	--
	2011	73	55	27 / 44	0.52 / 0.81
	2012	100	57	30 / 44	0.43 / 0.63
	2013	100	65	39 / 39	0.63 / 0.63
	2014	91	74	56 / 56	0.91 / 0.91
Forest Ridge	2009	83	78	25 / 50	0.49 / 0.98
	2010	80	65	30 / 47	0.53 / 0.89
	2011	100	74	29 / 47	0.59 / 0.99
	2012	83	74	55 / 65	1.10 / 1.28
	2013	86	71	28 / 37	0.62 / 0.77
	2014	100	89	49 / 57	0.89 / 1.02
Butler	2009	92	72	39 / 65	0.73 / 1.20
	2010	95	70	35 / 50	0.68 / 1.02
	2011	95	67	40 / 50	0.75 / 0.94
	2012	96	79	60 / 71	1.06 / 1.23
	2013	90	58	50 / 61	1.00 / 1.16
	2014	95	85	47 / 64	0.98 / 1.33
Hamilton West	2009	--	--	--	--
	2010	64	57	18 / 29	0.28 / 0.44
	2011	90	50	24 / 24	0.47 / 0/47
	2012	90	78	18 / 23	0.33 / 0.43
	2013	100	82	20 / 29	0.38 / 0.53
	2014	100	73	27 / 27	0.53 / 0.53
Baker Sanctuary	2009	--	--	--	--
	2010	--	--	--	--
	2011	81	63	22 / 36	0.31 / 0.54
	2012	100	83	28 / 28	0.57 / 0.57
	2013	93	50	16 / 23	0.28 / 0.38
	2014	100	83	22 / 34	0.42 / 0.61

Exhibit H: Golden-cheeked Warbler Intensive Study Plot Reproductive Success Data, continued.

Plot Name	Survey Year	Pairing Success	Breeding Success	Total No. of Observed and Adjusted Fledglings	Density of Observed and Adjusted Fledglings per Hectare
Lake Perspectives/ McGregor	2009	--	--	--	--
	2010	--	--	--	--
	2011	100	70	21 / 22	0.37 / 0.40
	2012	100	60	18 / 21	0.37 / 0.40
	2013	91	64	20 / 24	0.37 / 0.42
	2014	100	89	25 / 27	0.46 / 0.50
Vireo Ridge	2009	--	--	--	--
	2010	--	--	--	--
	2011	100	89	22 / 29	0.51 / 0.63
	2012	100	93	37 / 48	0.55 / 0.68
	2013	100	89	25 / 29	0.56 / 0.64
	2014	100	55	17 / 22	0.40 / 0.53
Vista Point	2009	--	--	--	--
	2010	--	--	--	--
	2011	94	75	42 / 45	1.01 / 1.08
	2012	100	63	41 / 42	0.83 / 0.85
	2013	100	53	27 / 27	0.52 / 0.52
	2014	89	68	49 / 50	0.86 / 0.88
Coldwater	2009	--	--	--	--
	2010	92	58	7 / 25	0.07 / 0.24
	2011	100	83	36 / 37	0.31 / 0.31
	2012	100	50	10 / 12	0.07 / 0.09
	2013	58	50	19 / 19	0.18 / 0.18
	2014	85	54	24 / 27	0.18 / 0.19
Bike Park	2009	--	--	--	--
	2010	89	56	8 / 18	0.08 / 0.19
	2011	92	58	24 / 27	0.23 / 0.26
	2012	100	100	33 / 38	0.29 / 0.34
	2013	92	69	26 / 32	0.17 / 0.21
	2014	84	59	28 / 32	0.24 / 0.26
Emma Long	2009	100	84	29 / 58	0.52 / 1.02
	2010	94	63	19 / 36	0.33 / 0.67
	2011	100	100	41 / 52	0.96 / 1.19
	2012	100	94	54 / 62	1.05 / 1.20
	2013	89	59	34 / 36	0.63 / 0.68
	2014	88	81	47 / 50	0.94 / 1.01
Double J&T	2009	0	0	0	0
	2010	67	0	0	0
	2011	75	50	2 / 7	0.04 / 0.13
	2012	100	0	0	0
	2013	50	50	6 / 6	0.12 / 0.12
	2014	100	60	9 / 9	0.20 / 0.20
Reicher	2009	--	--	--	--
	2010	--	--	--	--
	2011	100	100	11 / 12	0.22 / 0.24
	2012	83	67	14 / 16	0.25 / 0.29
	2013	100	83	13 / 19	0.20 / 0.32
	2014	82	73	25 / 30	0.43 / 0.52
Wild Basin/ Vireo Preserve	2009	--	--	--	--
	2010	--	--	--	--
	2011	73	45	9 / 18	0.08 / 0.15
	2012	100	75	7 / 10	0.04 / 0.06
	2013	86	43	9 / 11	0.05 / 0.06
	2014	56	11	3 / 3	0.02 / 0.02

Exhibit I. Summary of Vegetation Data Collected for Golden-cheeked Warbler Nests Found within the Balcones Canyonlands Preserve, Travis County, Texas, Field Seasons 2011-2014.

Tree Species	Total Nests	Tree Height Avg, Range (m)	Tree DBH Avg, Range (cm)	Nest Height Avg, Range (m)	% Canopy Cover Avg, Range	Successful Nests
Juniperus ashei (Ashe Juniper)	363 (63%)	8.3 (2.2 – 16.9)	28 (7 – 89.5)	6.4 (2 – 16.2)	87 (20 – 100)	255 (70%)
Quercus fusiformis (Live Oak)	115 (20%)	8.5 (4 – 13.9)	28 (10.5 – 77.5)	6.8 (3.1 – 11.6)	86 (35 – 99)	69 (60%)
Ulmus crassifolia (Cedar Elm)	54 (9%)	10.5 (4.8 – 18.3)	25 (12 – 55)	8.5 (3.3 – 15.4)	88 (63 – 100)	29 (54%)
Quercus sinuata var. *breviloba* (Shin Oak)	25 (4%)	8.8 (4.3 – 16.6)	20 (9 – 48)	6.9 (3.5 – 8.7)	90 (75 – 100)	11 (44%)
Quercus buckleyi (Texas Red Oak)	9 (2%)	9.6 (7.1 – 15.1)	32 (17 – 69)	7.0 (4.1 – 11.2)	94 (83 – 100)	2 (22%)
Juglans major (Arizona walnut)	2 (<1%)	10.5 (9.8 – 11)	29 (29)	7.7 (7.5 – 7.8)	92 (86 – 98)	1 (50%)
Prunus serotina Escarpment black cherry	1 (<1%)	11.2	30	9.7	93	1 (100%)
Platanus occidentalis Sycamore	1 (<1%)	18.9	67	11.4	95	1 (100%)
Fraxinus texensis Texas Ash	1 (<1%)	9.4	21	8.3	85	1 (100%)
Ulmus americana (American Elm)	1 (<1%)	23.8	28.5	21.4	94	1 (100%)
Totals	**572**	**8.7 (2.2 – 23.8)**	**27.5 (7 – 89.5)**	**6.7 (2.0 – 21.4)**	**87 (20 – 100)**	**371**

Exhibit J: Report on Banding Golden-cheeked Warbler Nestlings on the Balcones Canyonlands Preserve, 2014. Prepared by Jennifer L. Reidy, University of Missouri.



Photo by Jennifer Reidy

Introduction

This report covers activities separate from those conducted by Balcones Canyonlands Preserve (BCP) staff and volunteers. All activities related to banding nestlings were conducted by Jennifer Reidy and one assistant. All handling and banding of nestlings was conducted by Jennifer Reidy. Nest searching and monitoring and fledgling resighting activities were performed by personnel from the BCP and University of Missouri.

Objective

The objective of this research is to collect data on hatch-year (HY) Golden-cheeked Warblers to determine length of dependence on adults, dispersal distances from the natal area within the season, and potentially to gather critical data about dispersal distances and survival over multiple seasons. This report summarizes activities from the first year of banding nestlings.

Justification

Golden-cheeked warblers are an endangered species that nest exclusively in the juniper-oak woodlands of central Texas. Since being added to the endangered species list in 1991, numerous studies have been undertaken to detail breeding (Anders and Dearborn 2004, Peak 2007, Reidy et al. 2009) and wintering (Rappole et al. 1999) ecology. Population viability models (PVA) have been developed to determine the long-term survival of this species and identify which portions of the life cycle a species is most sensitive to in hopes that conservation and management can mitigate these threats. These models use available empirical data such as abundance, nest survival, adult survival, and productivity across time and space and inferred rates for parameters with no existing knowledge such as adult and juvenile dispersal and juvenile survival (both from post-fledge to migration, and from post-fledge to breeding). However, thus far these PVAs have relied on data from only one population, Fort Hood, which has been monitored for >20 years (Alldredge et al. 2004). Fort Hood contains the largest block of protected breeding habitat. Additionally, the study areas are only in mixed woodland, which is thought to provide higher quality breeding habitat than juniper-dominated woodland, but is less common across the breeding range. In order to develop more meaningful PVAs, monitoring data is needed from across the range and all woodland types used for breeding and rearing young. We also need to fill critical data gaps associated with fledglings, known to be the most sensitive parameter for other species of songbirds. We currently lack information on natal dispersal and juvenile survival of golden-cheeked warblers and current PVAs input an inferred estimate for juvenile survival of half that of adult survival. Recent studies on other warblers have demonstrated that juvenile survival is lower than previously thought (McKim-Louder et al.

2013), making it even more critical to gather empirical data on this endangered songbird. The first step in filling these gaps is banding hatch-year birds, with the ultimate goal of utilizing recent advancements in radios and geo-locators to track hatch-year birds during the post-fledgling period and beyond.

Methods

Nest searching—We searched for nests of Golden-cheeked Warblers from late March through early June, 2014. We located nests using a combination of adult behavior and systematic searching. We marked nest locations by hanging a flag from a branch 5-10 m from the nest tree and recording directions from the flag to the nest in our notebooks (and sometimes also on the flag). We monitored active nests every 2-4 days, and more frequently around expected hatch and fledge dates to aid in ageing nest contents. Active nests were those confirmed to have nest contents (typically confirmed by adult behavior rather than viewing into nests).

Color banding nestlings—Once nestlings were determined to be the appropriate age (day 6-8), we visited the nest to confirm the nest was safely accessible and band the nestlings. We monitored the nest from a safe distance to verify the nest was active and allow the adults to tend to the young. During that observation period, we also readied field equipment (datasheets and banding supplies). Immediately after the adults left the nest area, I climbed the nest tree, extracted the nestlings and placed them in a small pliable box with air holes and then in a soft cloth bag, and carried them down to the banding site. I opted to use a small box inside of a bag because it offered a higher degree of safety for transporting the nestlings than a soft-sided bag alone. Once at the banding site, I banded each nestling one-at-a-time with a standard color combination (2-3 colors and 1 USGS numbered aluminum band) while my assistant recorded the data onto the datasheet and took a photo to document the band combination. Immediately after banding, nestlings were returned to the nest and we remained nearby to monitor the nest and verify adults resumed normal feeding behavior at the nest. I banded as many nestlings as were determined to be safely accessible and age-appropriate. Banding was conducted under Bird Banding Laboratory permit 23615 with color combinations coordinated by staff at Fort Hood.

Resighting—We searched for banded fledglings after nests were determined to have fledged. We attempted to resight banded fledglings at least once post-fledgling, and more often when possible. We recorded the color combination of the fledgling, the location (in UTMs), date, and whether it was being attended to by the male, female, or pair, or was independent. We determined the distance between observations of fledglings and the nest they fledged from.

Results

I banded 50 nestlings from 16 nests (mean: 3.1 nestlings per nest). I discovered that leg dimensions were not appropriate for banding on day 6 (legs were too short and wide). However, legs were optimal for banding on day 7 and 8. I attempted to band nestlings on these days, but occasionally the nestlings were aged incorrectly and I extracted nestlings on day 9 or 10. Only one nest was force-fledged, of which I banded three of four young. All nests with banded nestlings were confirmed to fledge. The entire process

(extraction, banding, return) took ~10 min and adults resumed normal behavior during their first or second trip to the nest.

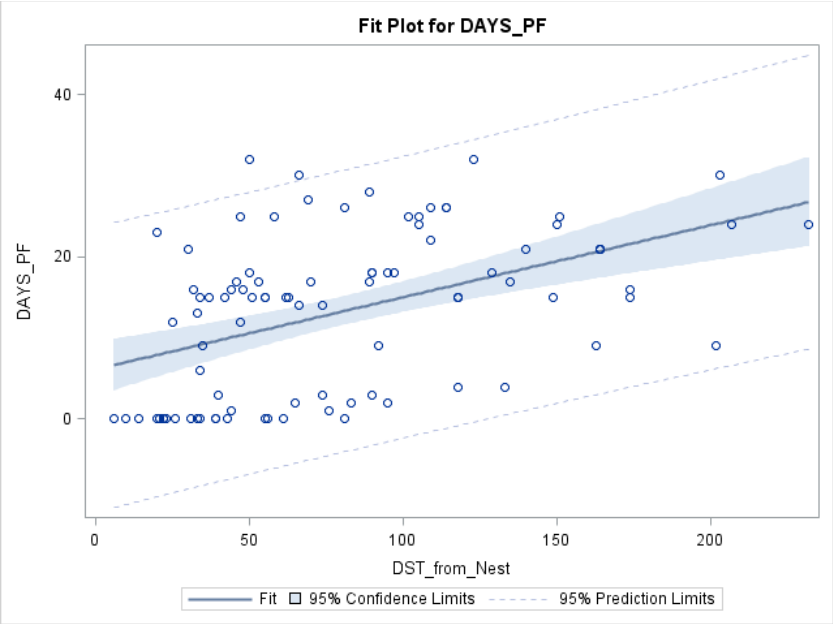
We resighted 39 fledglings (78%), and at least one fledgling from each of the 16 nests. We documented 94 observations of banded fledglings, of which fledglings were detected with males at 60 locations (64%), females at 20 (21%), both adults at 4 (4%) and an unknown adult at 1 (1%). Fledglings were observed independent of adults during the remaining 9 observations (10%). We resighted fledglings an average of 82 ± 52 m from the nest (N = 94 observations, range: 6 to 232 m). On the day of fledge, we resighted fledglings 33 ± 19 m (N = 19 observations, range: 6-81 m) from the nest. Distance from the nest and the number of days since fledge were positively related ($P < 0.0001$; Fig. 1). Observations of independent fledglings were 26 ± 3.6 days after fledgling (N = 9, range: 22-32 days) and 125 ± 62 m (N = 9, range: 50-232 m) from the nest.

Two banded fledglings were observed being attended to and fed by the neighboring male on different occasions. Both fledged from the same nest on the day after the neighboring male's nest fledged. These nests were 133 m apart. One fledgling was fed by the neighboring male 15 days post-fledge and the other fledging was fed by the neighboring male 17 and 24 days post-fledge. The male whose nest these fledglings fledged from was observed going to the nest many times while it was active but was not observed feeding nestlings or fledglings. The female was attending three banded nestlings (the fourth was never detected post-fledge) prior to this. One possibility is that these HY were biologically from the neighboring male and not the territorial male. Another possibility is that the fledglings were not being fed by the territorial male and were attracted to the neighboring male while he was feeding his own young and he subsequently fed any begging fledgling around him. I have often observed adults rejecting begging fledglings that I presumed or knew did not belong to that territory's nest. The extent of extra-pair copulation is unknown in the Warbler.

Conclusions

I was able to safely extract and band 50 HY Golden-cheeked Warblers. No birds were harmed as a result of handling or banding and adults resumed normal feeding behavior shortly after nestlings were returned to the nest. The biggest obstacle to banding a larger number of nestlings was the low number of accessible nests that reached the age mark. However, this represents a considerable achievement in providing additional data regarding HY dispersal and behavior. I expect to band a larger number of HY Golden-cheeked Warblers in spring 2015. The University of Missouri and BCP staff/volunteers will strive to search for these banded HY when they return to Texas as SY birds in spring 2015. Any returns will provide critical information on juvenile dispersal and survival.

Figure 1. Relationship between number of days post fledge ("DAYS_PF") and distance from the nests ("DST_from_nest") for 94 Golden-cheeked Warbler fledgling locations on Balcones Canyonlands Preserve, April-June 2014.



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Exhibit K. Golden-cheeked Warbler Population Viability and Habitat Suitability within the Balcones Canyonlands Preserve, Progress Report for Years 1-3 (2013).

GOLDEN-CHEEKED WARBLER POPULATION VIABILITY AND HABITAT SUITABILITY WITHIN THE BALCONES CANYONLANDS PRESERVE: YEAR 3 PROGRESS REPORT, FEBRUARY 2014

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Background

In 2011, the City of Austin entered into a 5-year agreement with the U.S. Forest Service and University of Missouri to conduct a population viability analysis for Golden-cheeked Warblers on Balcones Canyonlands Preserve (BCP). During year 3, we continued our collaborative effort with BCP partners to continue field studies initiated in 2011. We collected demographic data on the intensive monitoring plots chosen in 2011. Additionally, we completed a third year of avian and vegetation surveys across the preserve. We present preliminary results from the density and nest survival estimation based on 3 years of data, and summaries of the point count and nest vegetation surveys, nest monitoring, and productivity for 2013. We report preliminary adult apparent survival estimates.

Methods

Abundance-We created a point grid with 250-m spacing and randomly overlaid it across the BCP in ArcMap 9.3(ESRI, Redlands, California, USA), resulting in random-systematic coverage of the entire study area. We removed points that were < 50 m from major roads because the plot would be partly composed of roadway and decreased our ability to hear over road noise. We built point transects consisting of 8-12 points based on topography and access. To ensure even coverage each year, we defined 9 patches of interest, based on patch connectivity (see Fig. 1). We selected every third transect to be surveyed in year 3 (2013).

We conducted 5-min, unlimited radius point counts from 10 minutes post-sunrise until ~1100 from 21 April to 14 May 2013. Counts were surveyed in good weather conditions (> 50°, < 12 mph winds, no or light precipitation). At each point, we recorded time of, distance to, and type of (song, call, visual) initial detections of individuals of 10 species, including Golden-cheeked Warblers and Black-capped Vireos. Additionally, we recorded weather information and UTM coordinates. Distances were measured directly or estimated with a laser range-finder. Observers spent 4 weeks in the field collecting vegetation data and

practicing species identification prior to conducting surveys; additionally they were tested for species identification and distance estimation prior to conducting point counts.

We measured vegetation composition and structure at each point using a modified BBIRD protocol (Martin et al. 1997). We averaged canopy cover measured with a densiometer in the four cardinal directions at the point. We counted small stems (live woody stems > 10 cm high and < 2.5 cm at diameter-at-breast-height [dbh]) of junipers, live oaks, other oaks, other deciduous [shrub species], and exotics in a 5-m radius around the point and converted the sums to density per ha. We averaged ground cover estimated in each quadrant in a 5-m radius around the point for four categories: shrub, grass/forb, bare/rock/debris, and litter. We calculated the tree height of the average juniper and non-juniper in each quadrant in an 11.3-m radius using a clinometer and averaged the heights to produce one height for each tree group. We recorded dbh of all Ashe junipers, live oaks, Texas red oaks, shin oaks, and other trees > 2.5 cm with a Biltmore stick in an 11.3-m radius from the point and converted the sums to stand basal area per ha. We also calculated basal area of snags and "juniper snags" (junipers that died as a result of the drought of 2011). Additionally, we calculated stem densities in three stem diameter classes (< 10 cm, 10-15 cm, and > 15 cm) for three tree categories: junipers, live oaks, all others. We chose these categories because juniper is critical for nesting material and nesting sites, and live oaks are an evergreen species and are often associated with more xeric and upland habitat than other trees.

We calculated landscape metrics in ArcMap 10.0 using the Texas Ecological Systems phase 1 vegetation classification (hereafter "TESP1") and LiDAR. TESP1 was developed to provide a high-resolution detailed vegetation classification for central Texas; it was created using 10-m resolution satellite imagery and refining land cover categories with ancillary data such as slope and aspect, landscape position, hydrology, soil, roads and cities data (Texas Parks and Wildlife Department). LiDAR is a remote sensing technology that measures distance by illuminating a target with a laser and analyzing the reflected light and can be used to map canopy structure (Sexton et al. 2009). We obtained 1-m resolution LiDAR data acquired during 206 flight lines of standard density (1.4 meter ground sample distance) from 20 missions in January 2012. The overlap between flight lines was removed to provide a homogeneous coverage, and the coverage was classified to extract a bare earth digital elevation model (DEM). Canopy height was then calculated by subtracting the minimum elevation values (at 2.5 m resolution) from the maximum elevation values (at 1 m resolution) (W. Simper, Travis County, pers. communication). We calculated the following landscape metrics at two spatial scales, 100-m and 1-km radius of each point: proportion of juniper-dominated and mixed juniper-oak woodland, edge density, average canopy cover, and average canopy height. We chose the 100-m scale to provide a measure of habitat structure within the same area as our point counts and the 1-km scale to provide a broader landscape-level view of habitat structure. We used the canopy heights obtained from LiDAR to modify the TESP1 layer to include small openings within vegetation types and better delineate edges with non-forest. We evaluated each 10-m pixel in forest and woodland types in the TESP1 layer and if more than 50% of the 25 2-m resolution pixels from the LiDAR canopy height layer were < 2-m tall we reclassified the TESP1 pixel as open. We

then defined urban and open edge as the boundary between forest and woodland and urban land cover and all other open land, respectively.

We developed hierarchical density models in the R package "unmarked" using the "distsamp" function to estimate a detection probability and Poisson regression to consider covariate effects on density, allowing simultaneous estimation of the detection probability and density (Royle et al. 2004, Fiske and Chandler 2011). The assumptions of distance sampling are: individuals at distance zero are always detected, individuals are detected at their initial location, and distances to the detected individuals are accurately estimated (Buckland et al. 2001). We truncated data to include detections of warblers within 100 m of the point, a standard truncation distance, and we binned distances in 20-m increments. We first evaluated the best fitting key function and several variables we predicted may affect detection probability. The key functions were uniform, hazard-rate, and half-normal; these are standard functions used to predict bird density (Buckland et al. 2001).

We ranked candidate models by AIC_c and evaluated goodness-of-fit for the most-supported model with the Freeman-Tukey test based on a parametric bootstrap for 100 simulations (Fiske and Chandler 2011; Sillett et al. 2012). We compared support for 20 models comprised of the variables observer, time since sunrise, day of year, proportion of juniper and mixed woodland within 100 m of point, and patch. We included observer in 14 models because observer is a well-documented source of detection variation (Peak and Thompson 2013, Reidy et al. 2014b). We attempted to control for variation in singing behavior through our sampling design; however, we considered whether time of day and day of year influenced detectability. We included habitat type in the count radius because we hypothesized that detection could differ between juniper and mixed woodland. We considered patch as a surrogate for unmeasured differences in habitat structure or singing behavior related to bird density. We then brought forward the most supported detection variables into our habitat and landscape models. We evaluated multi-collinearity for the global model and did not include highly correlated variables in individual models (tolerance values < 0.3). We evaluated support for 41 vegetation (field-based) models and 21 landscape (remotely-sensed) models (Table 1) using an information-theoretic approach by ranking the ΔAIC_c and corresponding Akaike's weights (w_i). We then compared a final model set composed of 32 models using the most supported vegetation and landscape variables. To determine support for individual variables, we model-averaged coefficients (Mazerolle 2013) and identified the variables with a $p < 0.15$, one criterion acknowledged in Arnold (2010). We used the most supported model(s) to predict Golden-cheeked Warbler density for different values of the habitat and landscape variables. We ran 100 iterations of a parametric bootstrap to incorporate uncertainty in the predicted densities.

Density distribution map- To create a spatially-explicit density distribution map for the BCP, we used the relationship between Golden-cheeked Warbler density and landscape variables based on the most supported landscape model from the density model set to predict Golden-cheeked Warbler density for each 10-m pixel using ArcMap 10. Using those same predictive relationships, we also estimated density for intensive monitoring plots described below.

Productivity-We searched for nests and fledglings of Golden-cheeked Warblers on 18 intensive monitoring plots (27-180ha) situated on 7 of the 9 patches (or 5 of 6 macrosites) from mid-March through mid-June, 2013. Nests were typically monitored every 2-4 days until the nest fledged young or failed. At the end of the field season, we collected vegetation measurements at each nest. Measurements included all those measured at points and described above, and several unique to nests. We measured the nest height and the nest tree height with a clinometer and measured the dbh of the nest trunk with a Biltmore stick. If the nest tree was multi-trunked, the dbh was recorded two ways: as the main vertical stem leading to the nest and as the sum of the largest stem plus one-half the sum of the other stems. We estimated the distance between the nest and the main trunk along the branch it extended out on. We recorded the distance as zero if the nest was positioned against a main vertical trunk or branch (angle > 45°). We visually estimated nest cover 1 m above, below and in each cardinal direction (as 100% minus the percent of the nest visible) and averaged these to arrive at a single estimate. We also calculated the same landscape metrics used in the abundance analysis and described above.

We collated nest monitoring data from 2005, 2006, and 2009-2013 and used an information-theoretic approach to evaluate candidate models representing our *a priori* predictions about factors affecting Golden-cheeked Warbler nest survival. We developed 31 models and ranked model support by Akaike's weights (w_i). We included year, day of year, and nest stage in every model because they are known to affect Golden-cheeked Warbler nest survival (Peak 2007, Reidy et al. 2009) and we wanted to control for their effect. We assessed whether any of our variables were correlated; correlated variables did not appear in the same model. We considered only active nests (nests known to have at least one egg or nestling during monitoring) and excluded intervals in the building stage for the analysis. We estimated daily survival using the logistic exposure method (Shaffer 2004) with a binomial response for each monitoring interval (success=1, failure=0). We model-averaged nest survival as a function of the variables in the most supported models by varying the variables of interest across the observed range of values while holding other variables at their mean (Shaffer and Thompson 2007).

Once a nest was determined to have fledged, we searched for and attempted to count all fledglings in association with the territorial male or female. If < 4 fledglings were found in initial visits, we continued monitoring in the territory until we were certain of a count or recorded a minimum count. We report productivity as the number of young divided by the number of monitored territories with a known reproductive status.

Adult survival-We color-banded adult Golden-cheeked Warblers within the intensive monitoring plots from March through May 2009-2013. We set up 6-m mist-nets in territories and captured adults by luring them in to the nets using playback of recorded male songs from speakers placed beneath the net. We banded any unbanded Golden-cheeked Warbler we captured, regardless of sex or known territorial status (although we attempted to capture only territorial birds). We began banding on 9 plots in 2009, and expanded to 18 by 2013. Each subsequent year, we have returned to each plot to determine the number of banded birds who returned and were resighted on our plots. We delineated territories for all banded birds

and will determine the dispersal distance for each resighted male and female (distance between yearly territory centroids). We also established a 100-m buffer around the perimeter of all plots where we conducted additional surveys to resight banded birds and delineate territories of "edge" birds (those males whose territories are not completely within the boundaries of the plot). Volunteers trained in resighting color-bands also conducted surveys searching for banded birds beyond the boundaries of the plots and buffers. These volunteers surveyed ~1300 ha in 2013.

Results

Abundance-Two observers completed 35 point transects comprised of 391 points and detected a total of 142 Golden-cheeked Warblers in 2013, totaling 1122 points (Fig. 1) and 621 males from 2011-2013. We combined the 2011-2013 data and analyzed the complete dataset. We found the most support for observer and habitat affecting detection probability and the overall detection probability was 0.27 (Fig. 2). There was substantial model selection uncertainty in the habitat model set (Table 2), but there was strong support for the variables canopy cover (0.24 ± 0.09 SE), large juniper (0.13 ± 0.06 SE), oak height (0.12 ± 0.07 SE), large live oaks (-0.09 ± 0.06) and small stem density of live oaks (-0.17 ± 0.09 SE) and exotics (-0.09 ± .07 SE). There was also model selection uncertainty with the landscape models (Table 3), but we found strong support for the variables proportion of juniper woodland in a 1-km radius (0.15 ± 0.07 SE), proportion of mixed woodland in 1-km radius (0.31 ± 0.07 SE), proportion of juniper woodland in a 100-m radius (0.54 ± 0.16 SE), proportion of mixed woodland in 100-m radius (0.58 ± 0.16 SE), canopy height (0.10 ± 0.09) and edge density in a 100-m radius (-0.37 ± 0.08). The final model set composed of the supported habitat variables and landscape variables showed considerable model selection uncertainty but the variables juniper and mixed proportion in a1-km radius and edge density in a 100-m radius were included in all supported models (Table 4). Predicted density increased with greater proportions of juniper woodland (Fig. 3) and mixed woodland (Fig. 4) in a 1-km radius around the point, and decreased with higher density of non-wooded edge (Fig. 5). Average predicted density was 0.14 (0.12-0.16). Vegetation and landscape summary statistics are provided in Table 5.

Based on the patch-only model, predicted density was highest in Bull Creek and Cypress Creek (south portion) and lowest in South Lake Austin and West Austin (Fig. 6). Average predicted density from point counts was 0.26 versus 0.22 average observed mean density per plot from spot-mapping for 18 intensively monitored plots (Fig. 7). Using the best landscape model, we created a spatially-explicit density distribution map for the BCP (Fig. 8).

Productivity-We monitored 144 active nests in 2013, of which we confirmed at least one fledgling from 96 nests (66%). We deleted nests that failed prior to confirmed post-building activity and right-censored final observations for the three nests with unknown fates. We monitored 555 (400 from 2011-2013) active nests from 2005-2013 (Fig. 9). Daily nest survival based on 2751 monitoring intervals was 0.970 (0.963-0.976) and period survival for the 25-day nesting cycle was 0.472 (0.391-0.549). The most supported model included the variables juniper and non-juniper basal area and these variables were in the top six models comprising 83.8% of the model weight (Table 6). Nest survival varied across years (Fig.

10) and declined throughout the season but rebounded for very late nests (Fig.11). Daily nest survival (DSR) did not differ between nest stages (0.971 [95 CI: 0.960-0.980] versus 0.970 [95% CI: 0.961-0.977] for egg versus nestlings). Nest survival decreased with increasing basal area of non-junipers (DSR from 0.97 to 0.86 across range of tree basal area). Nest vegetation measurements were similar between 2013 and the average of all nests monitored in 2005, 2006, and 2009-2013 (Table 7). Most nests were placed in Ashe junipers (Table 8), highlighting the importance of this tree to the breeding ecology of Golden-cheeked Warblers. We monitored a total of 233 territories, of which we assigned a territory success fate to 222. We documented 394 fledglings from 140 successful territories (63%) on the intensive monitoring plots. Productivity was 1.77 young per territory and 2.81 young per successful territory, which is lower than that documented in 2012 but similar to 2011.

Adult survival- We ran basic models in program MARK to estimate annual adult survival. We initiated color banding in 2009 and have amassed return data for 4 years (2010-2013). However, survival and detection are not separable in the final year, so we currently can estimate survival for 3 years (2010-2012). Predicted adult survival varied by year, but detection probability did not (Table 9). Adult survival was 0.52 (0.41-0.64), 0.44 (0.35-0.53), and 0.61 (0.54-0.68) in 2010, 2011, and 2012, respectively, just slightly higher than the return rates (2010: 45%, 2011: 41%, and 2012: 57%).

Conclusions

We have completed data collection for the first three years of this study and have completed preliminary analyses for predicting Golden-cheeked Warbler density, nest survival, and adult survival across BCP. We will explore relationships between productivity and landscape composition, dispersal, and additional adult survival models during 2014-2015. We reiterate that this progress report presents preliminary results and may not represent final results after the full five years of data collection and final analyses are conducted. For this reason, our conclusions below focus on methods and analyses rather than results.

Most previous research has focused on predicting occupancy rather than abundance and much of that work has relied on remotely-sensed landscape features and no or a few field-based vegetation measurements (DeBoer and Diamond 2006, Watson et al. 2008, Collier et al. 2012). Golden-cheeked warbler abundance across the entire breeding range was recently estimated, but this study did not incorporate a measure of detection probability into their estimate and relied on a random sampling design to negate potential variation in density across woodland types (Mathewson et al. 2012). Golden-cheeked warbler density was also recently estimated for Fort Hood, which contains the most breeding habitat under one management agency (Peak and Thompson 2013). This study used distance sampling to estimate detection probability, but surveys were limited to being within potential breeding habitat and only utilized remotely-sensed metrics to predict density. Our study is the first to our knowledge to develop a spatially-explicit density distribution map built on sampling across all habitat types, not just within juniper-oak woodlands or within a generic forest classification, and utilizing field-based and remotely-sensed measurements to quantify habitat structure. We were able to predict density across the entire BCP from the results of the avian surveys using the relationship we found between density and

landscape metrics. We plan to explore newly developed models that simultaneously model the effects of distance and time of detection when calculating the detection probability. The final density distribution map will be based on field-based vegetation measurements, LiDAR, and landcover classifications.

Most studies investigating reproductive success of Golden-cheeked Warblers have relied on reproductive indices such as the Vickery index (Lackey et al. 2011) or documenting host young being tended by adults (City of Austin 2010). However, tests of the Vickery method have proven it is unreliable and the ultimate rank does not correlate with actual reproductive success (Morgan et al. 2010, Reidy et al. 2014a). Using video monitoring at nests, Reidy et al. (2008) documented a fledgling rate of 3.6 young per successful nest. Yet productivity for successful territories was reported as 2.70 (City of Austin 2011) and 2.68 young (City of Austin 2010). To increase the reliability of productivity estimates, we increased survey effort in 2011-2013 to locate and monitor nests and to locate all fledglings produced for each monitored territory. Each year we have improved our productivity estimates by increasing our field efforts and, more importantly, by monitoring more nests. Fledgling counts for successful territories were higher from territories with a monitored nest versus those without, highlighting the need to locate active nests to collect more accurate data for estimating productivity. We reiterate the need to locate nests earlier in the cycle, preferably in the building stage, and to monitor nests more frequently. Nest monitoring needs to be consistent and occur ~3 days, and more frequently near the predicted hatch and fledge days to increase accuracy of assigning nest stage, nest fate, and ultimately to locate all fledglings produced from a successful nest.

Recommendations

We recommend expanding the point count surveys to areas outside BCP in the final year to sample a broader range of habitat types to expand inference to a broader area. We also suggest surveying sites undergoing active management, such as prescribed burning and juniper thinning/removal. Additionally, we need to shift focus to monitoring productivity in different areas within the BCP, including areas of lower canopy cover, increased slopes, less mature woodland, and greater habitat fragmentation in year 5.

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Figure 1. Locations of point counts completed within 9 patches (color-coded) on Balcones Canyonlands Preserve, Austin, Texas during April-May 2011-2013. Yellow, red, and green circles were surveyed in 2011, 2012, and 2013, respectively.

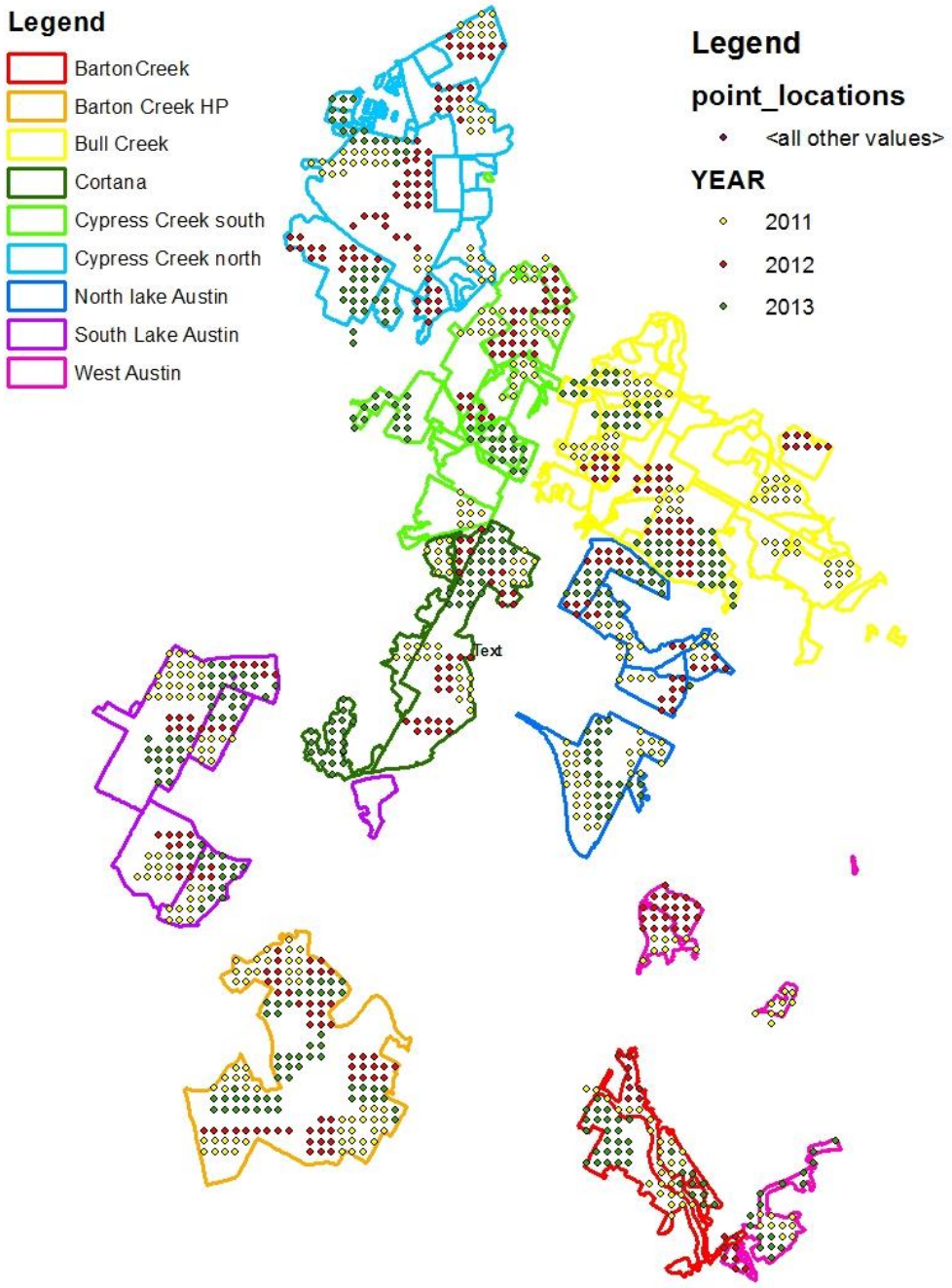


Figure 2. Plot of detection probability averaged across six observers for points surveyed across Balcones Canyonlands Preserve, Austin, Texas, during April-May 2011-2013.

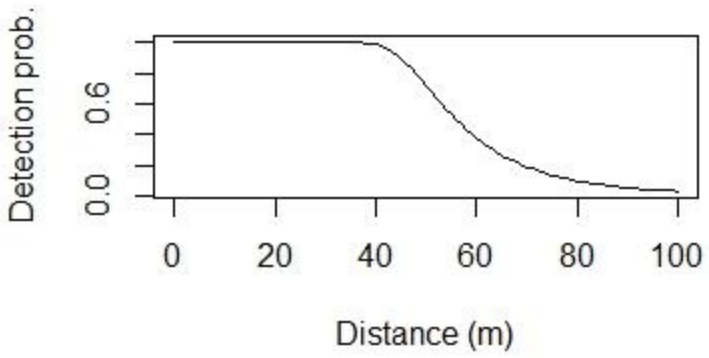


Figure 3. Predicted density of Golden-cheeked Warbler based on distance as a function of remotely-sensed juniper woodland in a 1-km radius around points across Balcones Canyonlands Preserve, Austin, Texas, during April-May 2011-2013.

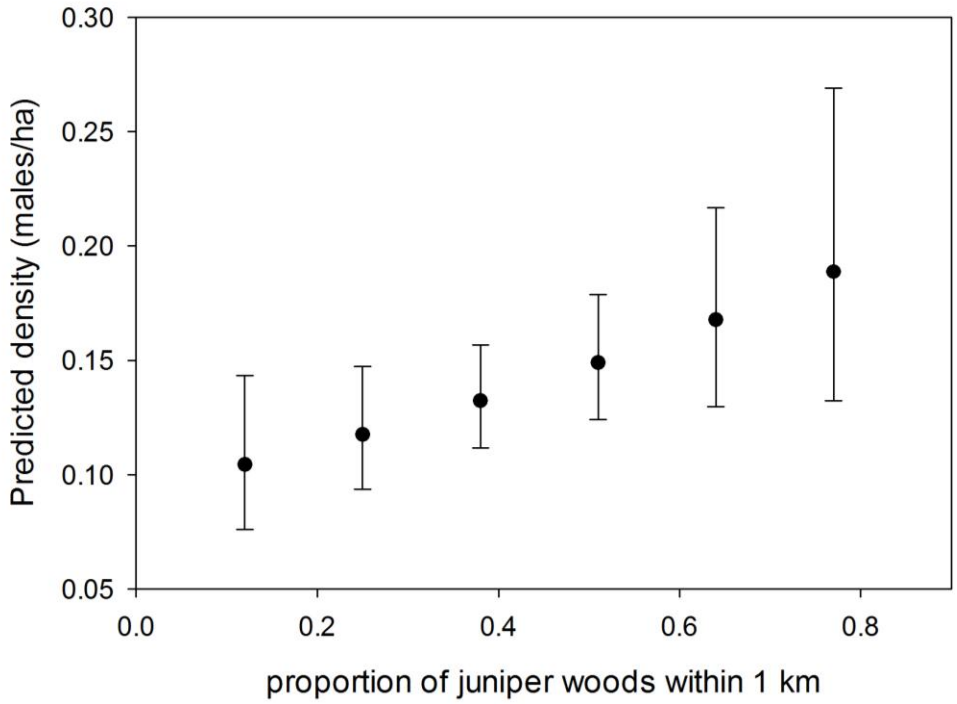


Figure 4. Predicted density of Golden-cheeked Warbler based on distance as a function of remotely-sensed mixed woodland in a 1-km radius around points across Balcones Canyonlands Preserve, Austin, Texas, during April-May 2011-2013.

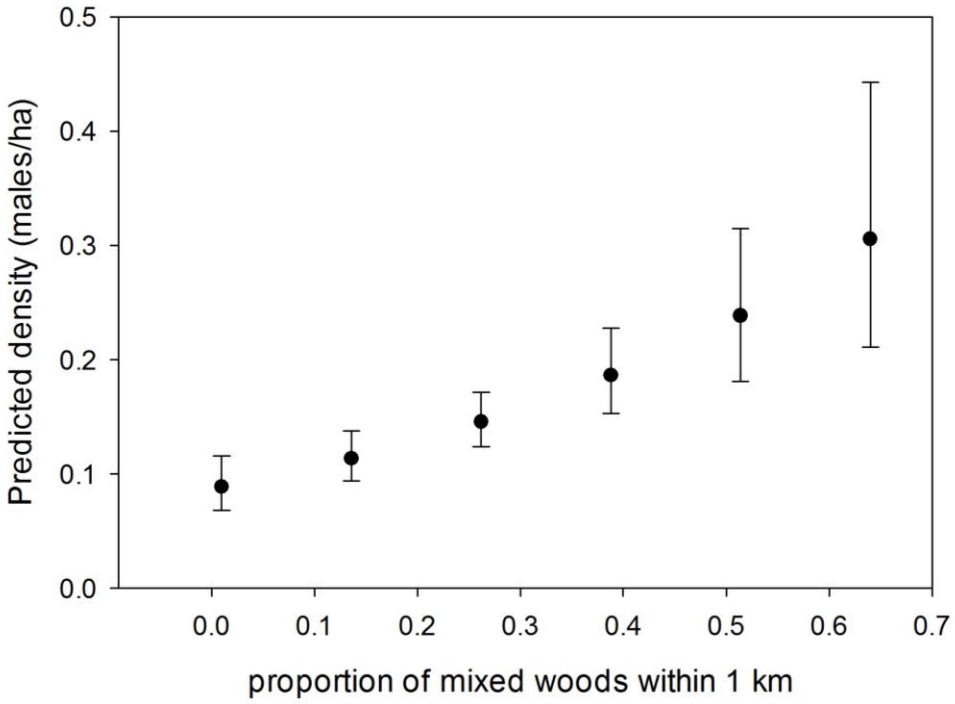


Figure 5. Predicted density of Golden-cheeked Warbler based on distance as a function of remotely-sensed edge density in a 100-m radius around points across Balcones Canyonlands Preserve, Austin, Texas, during April-May 2011-2013.

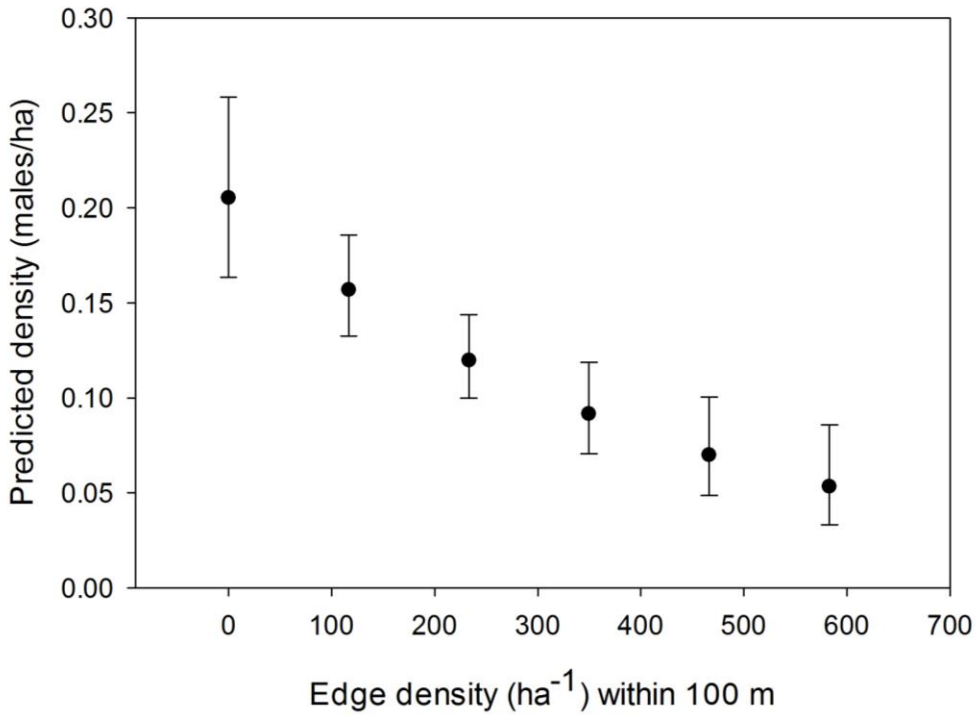


Figure 6. Predicted density of Golden-cheeked Warbler at nine patches based on distance sampling across Balcones Canyonlands Preserve, Austin, Texas, during April-May 2011-2013.

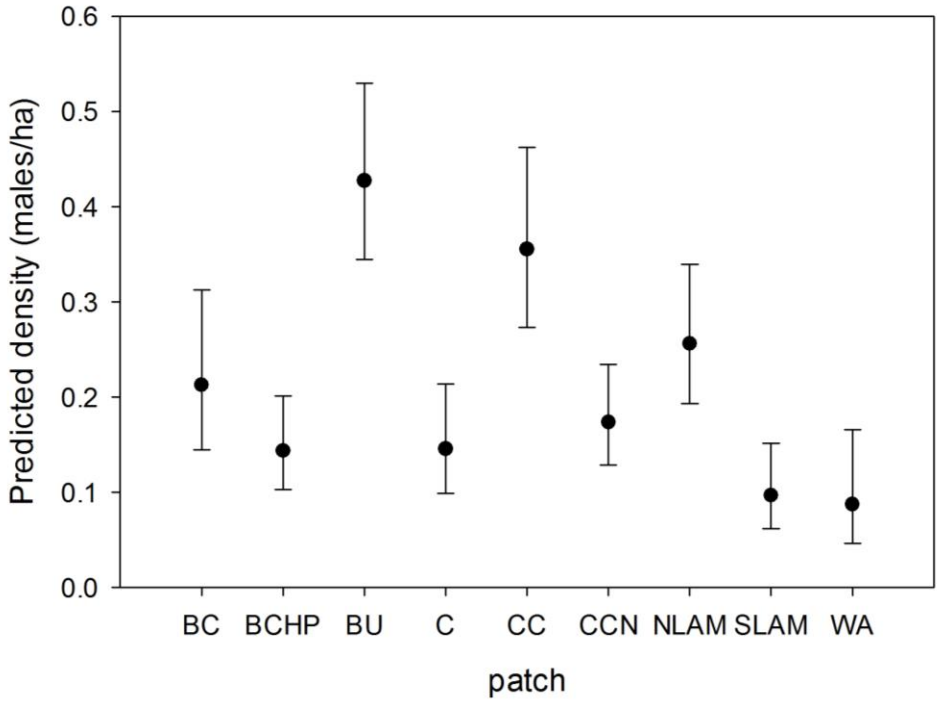


Figure 7. Comparison of predicted density from point counts (y-axis) and mean observed density from spot-mapping (2011-2013) for 18 intensive monitoring plots across Balcones Canyonlands Preserve, Austin, Texas. The line represents a perfect 1:1 correlation between predicted and observed densities.

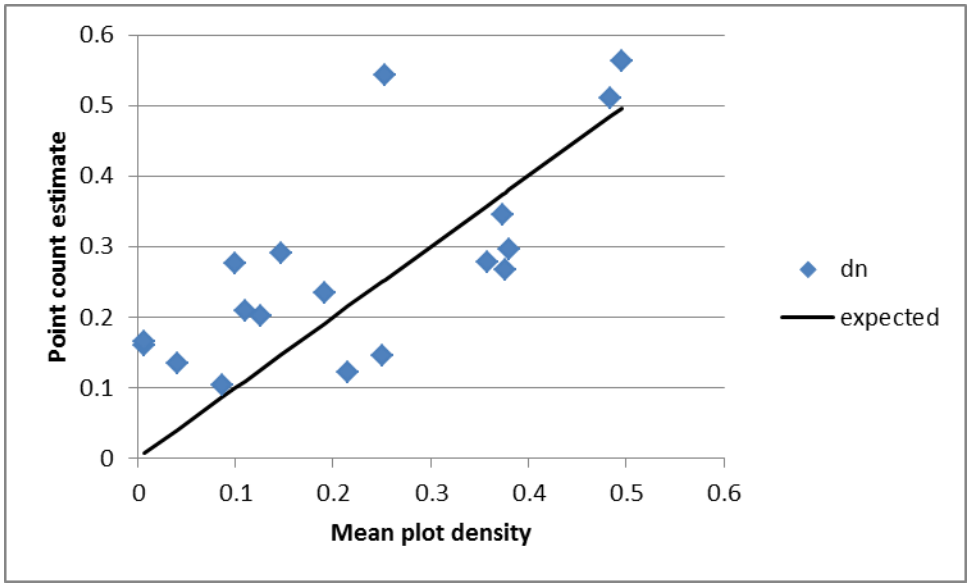


Figure 8. Distribution of Golden-cheeked Warbler density predicted from the top landscape model at nine patches based on distance sampling across Balcones Canyonlands Preserve, Austin, Texas, during April-May 2011-2013.

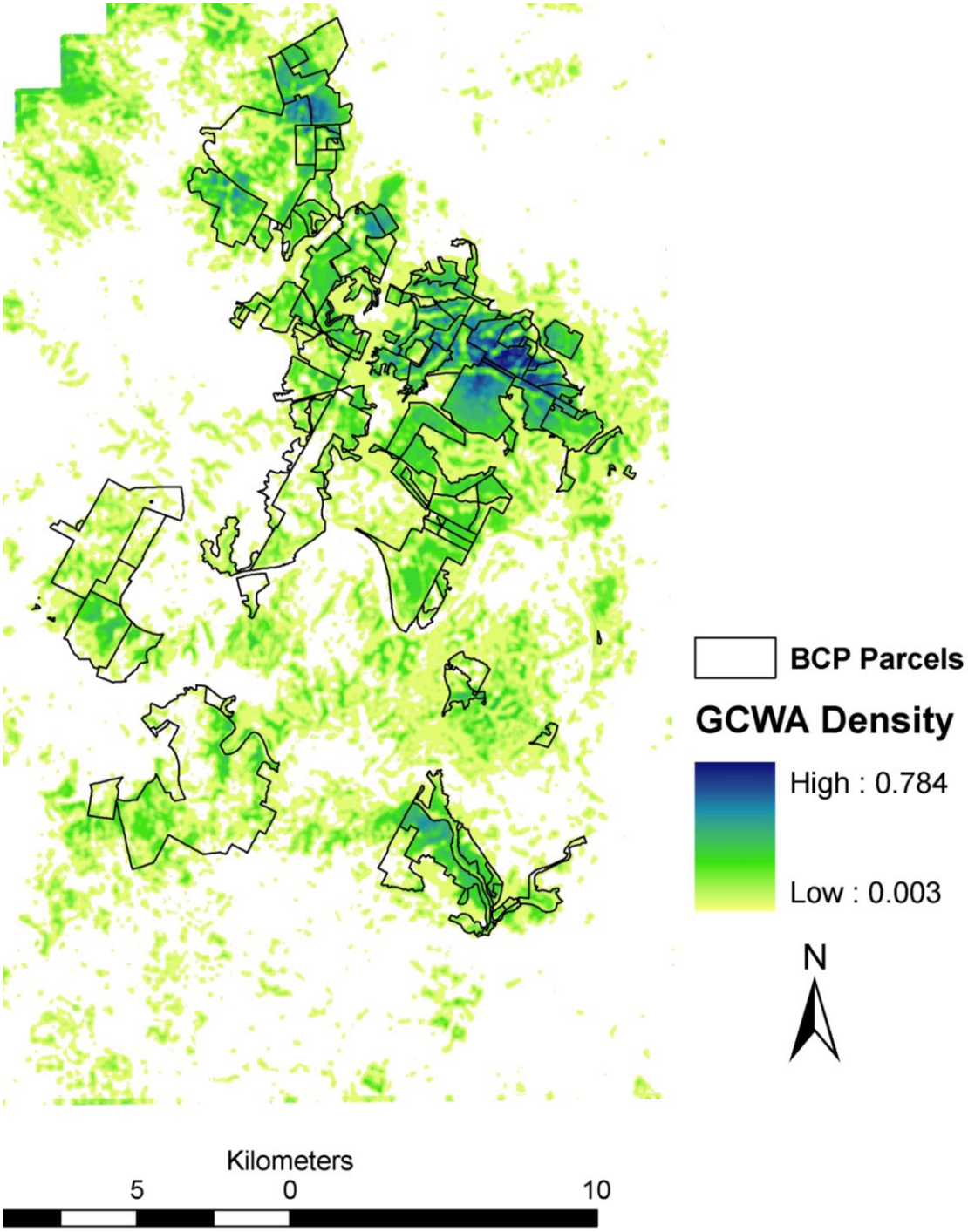


Figure 9. Location of active nests within 9 patches (color-coded) on Balcones Canyonlands Preserve, Austin, Texas, monitored from March-June 2011-2013.

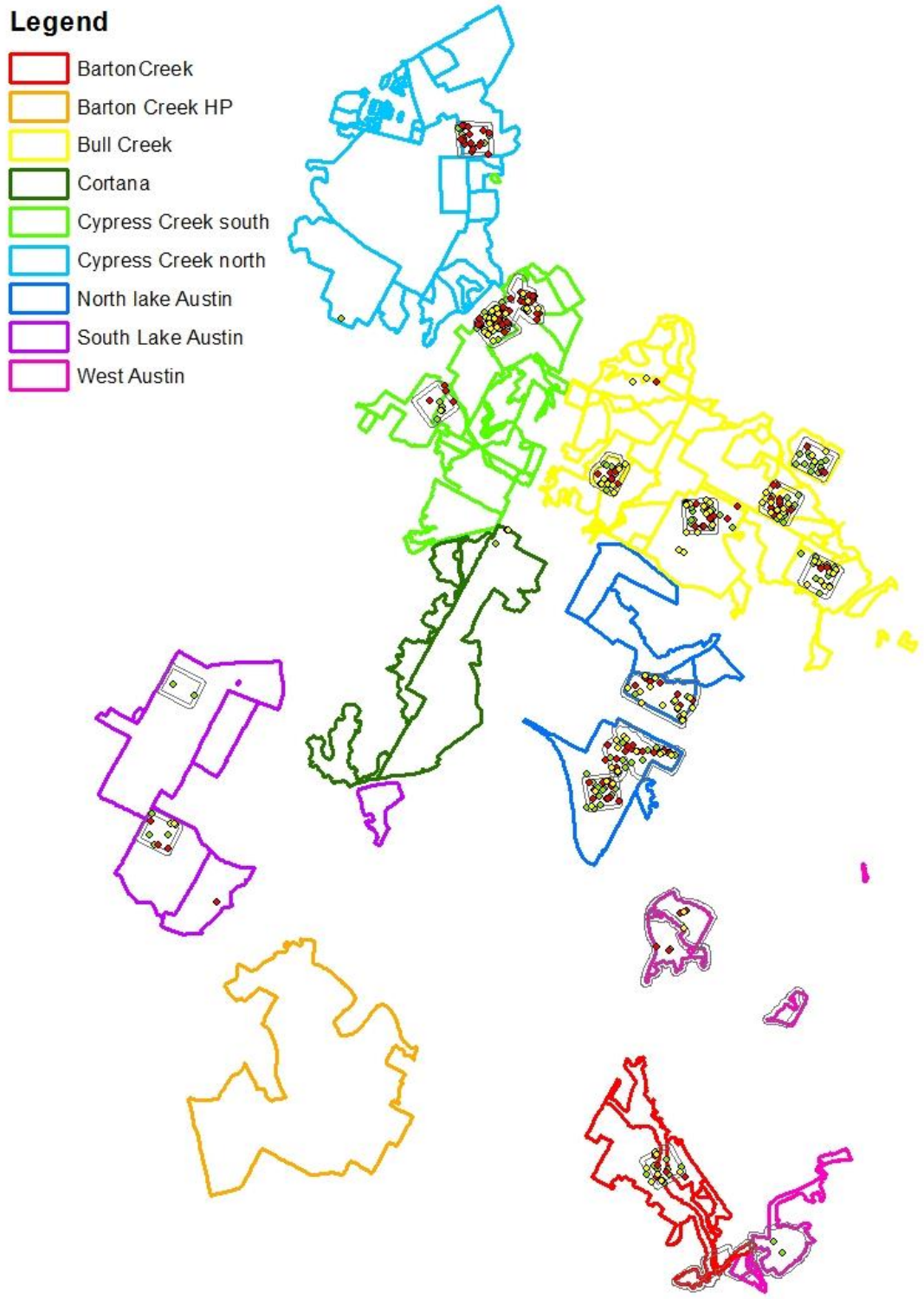


Figure 10. Predicted Golden-cheeked Warbler nest survival as a function of year across Balcones Canyonlands Preserve, Austin, Texas.

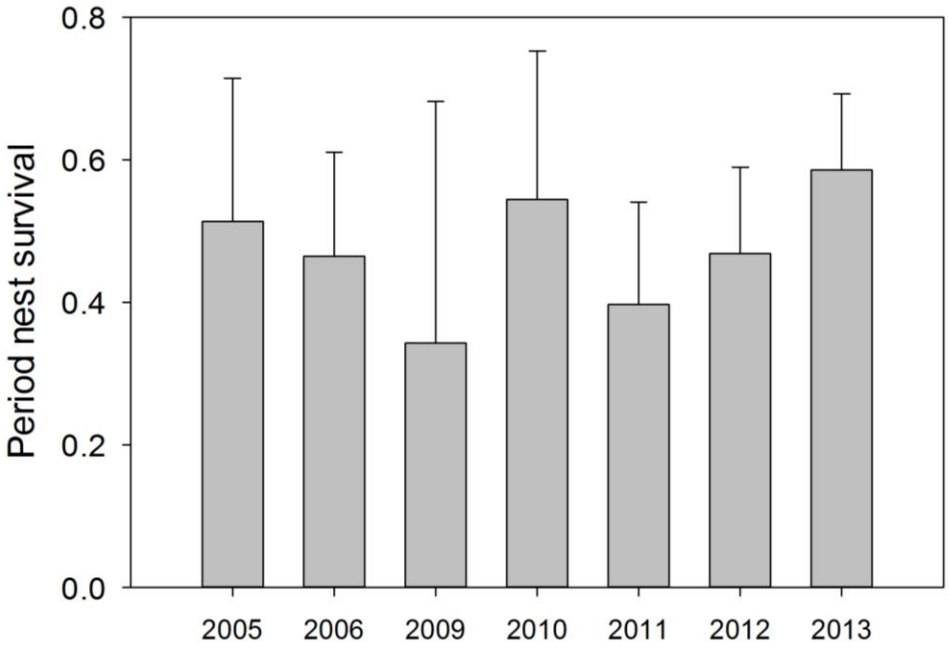


Figure 11. Predicted Golden-cheeked Warbler nest survival as a function of day of year across Balcones Canyonlands Preserve, Austin, Texas, for nests monitored during 2005, 2006, and 2009-2013.

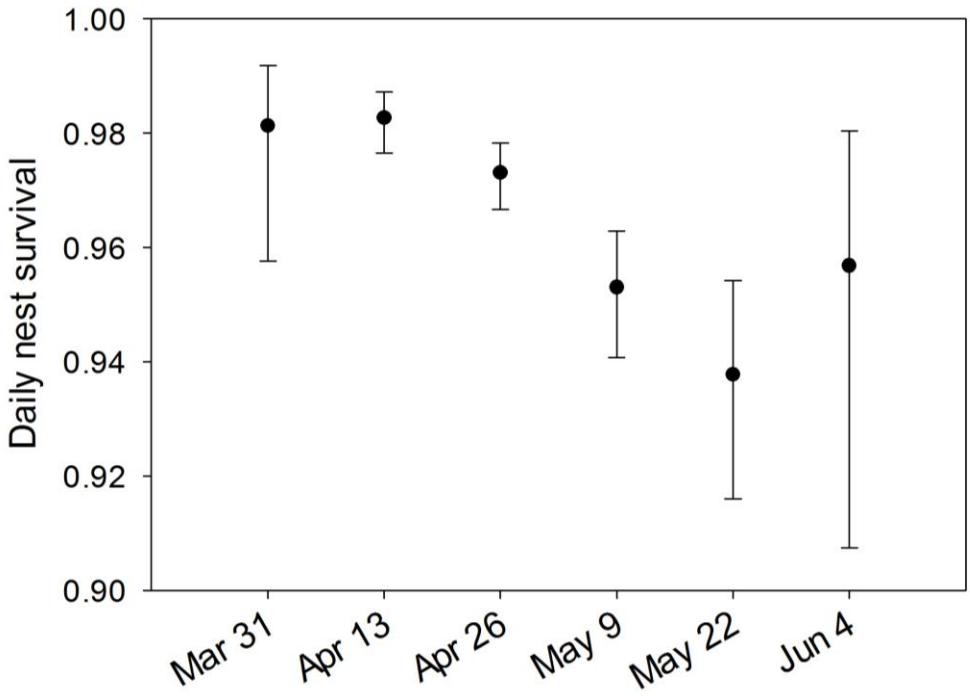


Table 1. Model name and variables evaluating habitat and landscape effects on density of Golden-cheeked Warblers on Balcones Canyonlands Preserve, Austin, Texas, during April-May 2011-2013. The model description includes the variable of interest for the abundance (λ) and detection (σ) process.

Model name	Model description
Habitat models:	
canc.lgtree.hgt	canopy cover + large juniper + large live oak + large deciduous + oak height + juniper height
canc.jun.hgt	canopy cover + large juniper + medium juniper + small juniper + oak height + juniper height
canc.jun	canopy cover + large juniper + medium juniper + small juniper
canc.hgt	canopy cover + oak height + juniper height
canc.smallstems.hgt	canopy cover + live oak small stems + exotics small stems + juniper small stems + oak small stems + other deciduous small stems + oak height + juniper height
canc.slope.hgt	canopy cover + slope + oak height + juniper height
canc	canopy cover
canc.slope.smallstems.hgt	canopy cover + slope + live oak small stems + exotics small stems + juniper small stems + oak small stems + other deciduous small stems + oak height + juniper height
canc.ground.hgt	canopy cover + herb + litter + bare + oak height + juniper height
canc.smallstems	canopy cover + live oak small stems + exotics small stems + juniper small stems + oak small stems + other deciduous small stems
canc.slope	canopy cover + slope
jun.hgt.smallstems	large juniper + medium juniper + small juniper + oak height + juniper height + live oak small stems + exotics small stems + juniper small stems + oak small stems + other deciduous small stems
canc.ground.smallstems.hgt	canopy cover + herb + litter + bare + live oak small stems + exotics small stems + juniper small stems + oak small stems + other deciduous small stems + oak height + juniper height
canc.slope.ground.hgt	canopy cover + slope + herb + litter + bare + oak height + juniper height
canc.hgt.treesize	canopy cover + oak height + juniper height + large juniper + medium juniper + small juniper + large live oak + medium live oak + small live oak + large deciduous + medium deciduous + small deciduous
jun.hgt.slope	large juniper + medium juniper + small juniper + oak height + juniper

	height + slope
canc.slope.smallstems	canopy cover + slope + live oak small stems + exotics small stems + juniper small stems + oak small stems + other deciduous small stems
canc.ground	canopy cover + herb + litter + bare
canc.treesize	canopy cover + large juniper + medium juniper + small juniper + large live oak + medium live oak + small live oak + large deciduous + medium deciduous + small deciduous
canc.slope.hgt.treesize	canopy cover + slope + oak height + juniper height + large juniper + medium juniper + small juniper + large live oak + medium live oak + small live oak + large deciduous + medium deciduous + small deciduous
canc.smallstems.hgt.treesize	canopy cover + live oak small stems + exotics small stems + juniper small stems + oak small stems + other deciduous small stems + oak height + juniper height + large juniper + medium juniper + small juniper + large live oak + medium live oak + small live oak + large deciduous + medium deciduous + small deciduous
canc.slope.ground	canopy cover + slope + herb + litter + bare
canc.ground.smallstems	canopy cover + herb + litter + bare + live oak small stems + exotics small stems + juniper small stems + oak small stems + other deciduous small stems
canc.slope.treesize	canopy cover + slope + large juniper + medium juniper + small juniper + large live oak + medium live oak + small live oak + large deciduous + medium deciduous + small deciduous
habglobal1	juniper basal area + live oak basal area + deciduous basal area + canopy cover + slope + herb + bare + litter + live oak small stems + exotics small stems + juniper small stems + oak small stems + other deciduous small stems + oak height + juniper height
canc.smallstems.treesize	canopy cover + live oak small stems + exotics small stems + juniper small stems + oak small stems + other deciduous small stems + large juniper + medium juniper + small juniper + large live oak + medium live oak + small live oak + large deciduous + medium deciduous + small deciduous
canc.slope.ground.smallstems	canopy cover + slope + herb + litter + bare + live oak small stems + exotics small stems + juniper small stems + oak small stems + other deciduous small stems
canc.ground.treesize	canopy cover + herb + litter + bare + large juniper + medium juniper + small juniper + large live oak + medium live oak + small live oak +

	large deciduous + medium deciduous + small deciduous
jun	large juniper + medium juniper + small juniper
canc.slope.smallstems.treesize	canopy cover + slope + live oak small stems + exotics small stems + juniper small stems + oak small stems + other deciduous small stems + large juniper + medium juniper + small juniper + large live oak + medium live oak + small live oak + large deciduous + medium deciduous + small deciduous
lgtree	large juniper + large live oak + large deciduous
canc.slope.ground.treesize	canopy cover + slope + herb + litter + bare + large juniper + medium juniper + small juniper + large live oak + medium live oak + small live oak + large deciduous + medium deciduous + small deciduous
habglobal	large juniper + medium juniper + small juniper + large live oak + medium live oak + small live oak + large deciduous + medium deciduous + small deciduous + canopy cover + slope + herb + bare + litter + live oak small stems + exotics small stems + juniper small stems + oak small stems + other deciduous small stems + oak height + juniper height
canc.ground.smallstems.treesize	canopy cover + herb + litter + bare+ live oak small stems + exotics small stems + juniper small stems + oak small stems + other deciduous small stems + large juniper + medium juniper + small juniper + large live oak + medium live oak + small live oak + large deciduous + medium deciduous + small deciduous
basalarea	juniper basal area + live oak basal area + deciduous basal area
treesize	large juniper + medium juniper + small juniper + large live oak + medium live oak + small live oak + large deciduous + medium deciduous + small deciduous
smtree	small juniper + small live oak + small deciduous
null	intercept-only
Landscape models:	
foresttype1k.edge.foresttype100	juniper 1k + mixed 1k + edge density 100 + juniper 100 + mixed 100
foresttype1k.edge.forestcover100	juniper 1k + mixed 1k + edge density 100 + forest 100
forestcover1k.edge.foresttype100	forest 1k + edge 100 + juniper 100 + mixed 100
foresttype1k.edge.ccmean100	juniper 1k + mixed 1k + edge density 100 + canopy cover 100
foresttype1k.edge.htmean100	juniper 1k + mixed 1k + edge density 100 + canopy height 100
foresttype1k.ccmean100.htmean100	juniper 1k + mixed 1k + edge density 100 + canopy cover 100 +

	canopy height 100
foresttype1k.ccmean100	juniper 1k + mixed 1k + canopy cover 100
foresttype1k.edge	juniper 1k + mixed 1k + edge density 100
foresttype100.edge	juniper 100 + mixed 100 + edge density 100
foresttype1k.htmean100	juniper 1k + mixed 1k + canopy height 100
foresttype1k.forestcover100	juniper 1k + mixed 1k + forest 100
foresttype1k.foresttype100	juniper 1k + mixed 1k + juniper 100 + mixed 100
ccmean100.edge	canopy cover 100 + edge density 100
ccmean100	canopy cover 100
edge	edge density 100
foresttype100	juniper 100 + mixed 100
forestcover100	forest 100
foresttype1k	juniper 1k + mixed 1k
edge1k	edge density 1k
forestcover1k	forest 1k
null	intercept-only
Habitat and landscape models:	
foresttype1k.edge.foresttype100.canc.ssdlive.ssdexotic.oakhgt	juniper 1k + mixed 1k + edge density + juniper 100 + mixed100 + canopy cover + live oak small stems +exotic small stems + oak height
foresttype1k.edge.foresttype100.canc.ssdlive.ssdexotic	juniper 1k + mixed 1k + edge density + juniper 100 + mixed100 + canopy cover + live oak small stems +exotic small stems
foresttype1k.edge.foresttype100.ssdlive.ssdexotic.oakhgt.zlgjun.zlglive	juniper 1k + mixed 1k + edge density + juniper 100 + mixed100 + live oak small stems +exotic small stems + oak height + large juniper + large live oak
foresttype1k.edge.foresttype100.canc	juniper 1k + mixed 1k + edge density + juniper 100 + mixed100 + canopy cover
foresttype1k.edge.forestcover100.canc	juniper 1k + mixed 1k + edge density +forest 100 + canopy cover
foresttype1k.edge.foresttype100.canc.ssdlive.ssdexotic.oakhgt.zlgjun.zlglive	juniper 1k + mixed 1k + edge density + juniper 100 + mixed100 + canopy cover + live oak small stems +exotic small stems + oak height + large juniper + large live oak
foresttype1k.edge.foresttype100.oakhgt.zlgjun.zlglive	juniper 1k + mixed 1k + edge density + juniper 100 + mixed100 + oak height + large juniper + large live oak
foresttype1k.edge.foresttype100	juniper 1k + mixed 1k + edge density + juniper 100 + mixed100
foresttype1k.edge.foresttype100.canc.ssdlive.ssdexotic.zlgjun.zlglive	juniper 1k + mixed 1k + edge density + juniper 100 + mixed100 +

foresttype1k.edge.foresttype100.canc.oakhgt.zlgjun.zlglive	canopy cover + live oak small stems +exotic small stems + large juniper + large live oak juniper 1k + mixed 1k + edge density + juniper 100 + mixed100 + canopy cover + oak height + large juniper + large live oak
foresttype1k.edge.forestcover100	juniper 1k + mixed 1k + edge density +forest 100
forestcover1k.edge.foresttype100.canc	forest 1k + edge density + juniper 100 + mixed100 + canopy cover
forestcover1k.edge.foresttype100	forest 1k + edge density + juniper 100 + mixed100
foresttype1k.canc.oakhgt.lgjun.lglive	juniper 1k + mixed 1k + canopy cover + oak height + large juniper + large live oak
foresttype1k.canc.oakhgt.ssdlive.ssdexotic	juniper 1k + mixed 1k + canopy cover + oak height + live oak small stems + exotic small stems
foresttype1k.canc.ssdlive.ssdexotic	juniper 1k + mixed 1k + canopy cover + live oak small stems + exotic small stems
foresttype1k.canc.lgjun.lglive.ssdlive.ssdexotic	juniper 1k + mixed 1k + canopy cover + large juniper + large live oak + live oak small stems + exotic small stems
foresttype1k.canc.oakhgt	juniper 1k + mixed 1k + canopy cover + oak height
foresttype1k.canc.lgjun.lglive	juniper 1k + mixed 1k + canopy cover + large juniper + large live oak
foresttype1k.canc	juniper 1k + mixed 1k + canopy cover
foresttype1k.oakhgt.lgjun.lglive.ssdlive.ssdexotic	juniper 1k + mixed 1k + oak height + large juniper + large live oak + live oak small stems + exotic small stems
foresttype1k.oakhgt.lgjun.lglive	juniper 1k + mixed 1k + oak height + large juniper + large live oak
foresttype1k.oakhgt.ssdlive.ssdexotic	juniper 1k + mixed 1k + oak height + live oak small stems + exotic small stems
site	site
foresttype1k.lgjun.lglive.ssdlive.ssdexotic	juniper 1k + mixed 1k + large juniper + large live oak + live oak small stems + exotic small stems
foresttype1k.lgjun.lglive	juniper 1k + mixed 1k + large juniper + large live oak
canc.lgjun.lglive.oakhgt	canopy cover + large juniper + large live oak + oak height
canc.ssdlive.ssdexotic.oakhgt	canopy cover + live oak small stems + exotic small stems
canc.ssdlive.ssdexotic	canopy cover + live oak small stems + exotic small stems + oak height
canc.oakhgt	canopy cover + oak height
canc.lgjun.lglive	canopy cover + large juniper + large live oak
null	intercept-only

Table 2. Number of parameters (K), AIC_c, and model support for distance-based models evaluating habitat effects on density of Golden-cheeked Warblers on Balcones Canyonlands Preserve, Austin, Texas, during April-May 2011-2013.

Model name	K	AIC_c	ΔAIC_c	w_i	cum w_i
canc.lgtree.hgt	16	2808.07	0	0.21	0.21
canc.jun.hgt	16	2808.17	0.11	0.20	0.41
canc.jun	14	2808.68	0.62	0.16	0.57
canc.hgt	13	2809.15	1.09	0.12	0.69
canc.smallstems.hgt	18	2810.16	2.09	0.07	0.76
canc.slope.hgt	14	2811.15	3.09	0.05	0.81
canc	11	2811.62	3.55	0.04	0.84
canc.slope.smallstems.hgt	19	2812.1	4.04	0.03	0.87
canc.ground.hgt	16	2812.78	4.72	0.02	0.89
canc.smallstems	16	2813.31	5.25	0.02	0.91
canc.slope	12	2813.62	5.55	0.01	0.92
jun.hgt.smallstems	20	2813.78	5.71	0.01	0.93
canc.ground.smallstems.hgt	21	2813.86	5.79	0.01	0.94
canc.slope.ground.hgt	17	2814.51	6.44	0.01	0.95
canc.hgt.treesize	22	2814.55	6.49	0.01	0.96
jun.hgt.slope	16	2814.76	6.7	0.01	0.97
canc.slope.smallstems	17	2815.3	7.24	0.01	0.97
canc.ground	14	2815.45	7.39	0.01	0.98
canc.treesize	20	2816.33	8.26	0.00	0.98
canc.slope.hgt.treesize	23	2816.46	8.4	0.00	0.99
canc.smallstems.hgt.treesize	27	2816.77	8.7	0.00	0.99
canc.slope.ground	15	2817.16	9.1	0.00	0.99
canc.ground.smallstems	19	2817.28	9.22	0.00	0.99
canc.slope.treesize	21	2818.11	10.04	0.00	0.99
habglobal1	25	2818.66	10.59	0.00	1
canc.smallstems.treesize	25	2818.69	10.62	0.00	1
canc.slope.ground.smallstems	20	2819.14	11.07	0.00	1
canc.ground.treesize	23	2820.15	12.08	0.00	1
jun	13	2820.21	12.14	0.00	1
canc.slope.smallstems.treesize	26	2820.68	12.61	0.00	1
lgtree	13	2821.28	13.21	0.00	1
canc.slope.ground.treesize	24	2821.37	13.31	0.00	1
habglobal	31	2822.37	14.3	0.00	1
canc.ground.smallstems.treesize	28	2822.39	14.32	0.00	1
basalarea	13	2824.62	16.55	0.00	1
treesize	19	2826.1	18.03	0.00	1
smtree	13	2827.42	19.36	0.00	1
null	10	2832.04	23.97	0.00	1

Table 3. Number of parameters (K), AIC_c, and model support for distance-based models evaluating landscape effects on density of Golden-cheeked Warblers on Balcones Canyonlands Preserve, Austin, Texas, during April-May 2011-2013.

Model name	K	AIC_c	ΔAIC_c	w_i	cum w_i
foresttype1k.edge.foresttype100	15	2722.55	0	0.61	0.61
foresttype1k.edge.forestcover100	14	2724.6	2.06	0.22	0.82
forestcover1k.edge.foresttype100	14	2725.69	3.15	0.13	0.95
foresttype1k.edge.ccmean100	14	2728.06	5.52	0.04	0.99
foresttype1k.edge.htmean100	14	2730.6	8.06	0.01	1
foresttype1k.ccmean100.htmean100	14	2735.84	13.29	0.00	1
foresttype1k.ccmean100	13	2736.31	13.76	0.00	1
foresttype1k.edge	13	2736.31	13.77	0.00	1
foresttype100.edge	13	2738.83	16.29	0.00	1
foresttype1k.htmean100	13	2747.33	24.79	0.00	1
foresttype1k.forestcover100	13	2749.32	26.78	0.00	1
foresttype1k.foresttype100	14	2751.05	28.51	0.00	1
ccmean100.edge	12	2753.79	31.24	0.00	1
ccmean100	11	2760.52	37.98	0.00	1
edge	11	2770.36	47.82	0.00	1
foresttype100	12	2771.01	48.46	0.00	1
forestcover100	11	2776.03	53.48	0.00	1
foresttype1k	12	2795.11	72.57	0.00	1
edge1k	11	2802.7	80.16	0.00	1
forestcover1k	11	2805.49	82.94	0.00	1
null	10	2832.04	109.49	0.00	1

Table 4. Number of parameters (K), AIC_c, and model support for distance-based models evaluating habitat, landscape, and site effects on density of Golden-cheeked Warblers on Balcones Canyonlands Preserve, Austin, Texas, during April-May 2011-2013.

Model name	K	AIC_c	ΔAIC_c	w_i	cum w_i
foresttype1k.edge.foresttype100.canc.ssdlive.ssdexotic.oakhgt	19	2719.55	0	0.23	0.23
foresttype1k.edge.foresttype100.canc.ssdlive.ssdexotic	18	2719.69	0.14	0.22	0.45
foresttype1k.edge.foresttype100.ssdlive.ssdexotic.oakhgt.zlgjun.zlglive	20	2720.79	1.24	0.13	0.58
foresttype1k.edge.foresttype100.canc	16	2721.96	2.41	0.07	0.65
foresttype1k.edge.forestcover100.canc	16	2721.96	2.41	0.07	0.72
foresttype1k.edge.foresttype100.canc.ssdlive.ssdexotic.oakhgt.zlgjun.zlglive	21	2722.3	2.74	0.06	0.78
foresttype1k.edge.foresttype100.oakhgt.zlgjun.zlglive	18	2722.42	2.86	0.06	0.83
foresttype1k.edge.foresttype100	15	2722.55	2.99	0.05	0.89
foresttype1k.edge.foresttype100.canc.ssdlive.ssdexotic.zlgjun.zlglive	20	2722.98	3.42	0.04	0.93
foresttype1k.edge.foresttype100.canc.oakhgt.zlgjun.zlglive	19	2723.85	4.3	0.03	0.96
foresttype1k.edge.forestcover100	14	2724.6	5.05	0.02	0.97
forestcover1k.edge.foresttype100.canc	15	2725.09	5.53	0.02	0.99
forestcover1k.edge.foresttype100	14	2725.69	6.14	0.01	1
foresttype1k.canc.oakhgt.lgjun.lglive	16	2766.27	46.72	0.00	1
foresttype1k.canc.oakhgt.ssdlive.ssdexotic	15	2766.78	47.22	0.00	1
foresttype1k.canc.ssdlive.ssdexotic	15	2767.99	48.44	0.00	1
foresttype1k.canc.lgjun.lglive.ssdlive.ssdexotic	17	2768.1	48.54	0.00	1
foresttype1k.canc.oakhgt	14	2769.28	49.73	0.00	1
foresttype1k.canc.lgjun.lglive	15	2769.61	50.06	0.00	1
foresttype1k.canc	13	2770.71	51.16	0.00	1
foresttype1k.oakhgt.lgjun.lglive.ssdlive.ssdexotic	17	2770.81	51.26	0.00	1
foresttype1k.oakhgt.lgjun.lglive	15	2772.47	52.92	0.00	1
foresttype1k.oakhgt.ssdlive.ssdexotic	15	2779.98	60.42	0.00	1
site	18	2781.33	61.77	0.00	1
foresttype1k.lgjun.lglive.ssdlive.ssdexotic	16	2782.09	62.54	0.00	1
foresttype1k.lgjun.lglive	14	2783.84	64.29	0.00	1
canc.lgjun.lglive.oakhgt	14	2804.42	84.87	0.00	1
canc.ssdlive.ssdexotic.oakhgt	14	2805.33	85.78	0.00	1

canc.ssdlive.ssdexotic	13	2808.42	88.87	0.00	1
canc.oakhgt	12	2809	89.44	0.00	1
canc.lgjun.lglive	13	2809.64	90.09	0.00	1
null	10	2832.04	112.48	0.00	1

Table 5. Summary of vegetation measurements collected at 1122 points surveyed on Balcones Canyonlands Preserve in 2011-2013. See methods for description of measurements.

Variable	Mean	Std Dev	Min	Max	LCL	UCL
slope	9.96	8.42	0.00	47.00	9.47	10.46
aspect	167.91	104.31	0.00	360.00	161.80	174.02
canopy cover	66.81	34.70	0.00	100.00	64.78	68.85
juniper height	6.01	2.16	0.00	19.00	5.88	6.14
oak height	5.31	3.50	0.00	20.57	5.11	5.52
shrub ground cover	5.34	7.89	0.00	76.25	4.88	5.80
bare ground cover	27.37	18.64	0.00	98.75	26.28	28.46
litter ground cover	51.27	24.74	0.00	97.50	49.82	52.72
herb ground cover	18.30	20.00	0.00	100.00	17.13	19.47
small stem density:						
juniper	1141.22	1489.05	0.00	15240.00	1054.00	1228.45
live oak	454.72	1951.03	0.00	37973.00	340.44	569.01
oak	639.52	3217.56	0.00	52197.00	451.05	827.99
other deciduous	1748.36	2984.72	0.00	30226.00	1573.53	1923.20
exotic	57.97	397.69	0.00	5588.00	34.67	81.26
non juniper	2821.90	4785.52	0.00	53594.00	2541.58	3102.22
total	3957.39	4972.96	0.00	53594.00	3666.09	4248.68
tree basal area:						
juniper	14.09	8.79	0.00	61.15	13.58	14.61
elm	0.24	1.27	0.00	19.85	0.16	0.31
juniper snag	0.42	1.66	0.00	19.15	0.32	0.52
snag	0.24	0.73	0.00	6.97	0.20	0.28
live oak	2.28	4.03	0.00	32.86	2.04	2.52
other deciduous	0.78	3.13	0.00	58.93	0.60	0.96
oak	0.01	0.14	0.00	3.35	0.00	0.02
red oak	1.00	2.33	0.00	17.85	0.87	1.14
shin oak	0.26	0.86	0.00	9.79	0.21	0.31
hardwoods	4.48	5.49	0.00	58.93	4.16	4.80

deciduous	2.25	4.32	0.00	58.93	2.00	2.51
total	18.57	10.17	0.00	65.35	17.97	19.16
total snag	0.66	1.98	0.00	22.05	0.55	0.78
tree density:						
lg juniper	7.58	7.01	0.00	39.00	7.17	7.99
md juniper	14.41	10.08	0.00	61.00	13.82	15.00
sm juniper	49.05	37.19	0.00	205.00	46.87	51.22
lg live oak	1.56	2.78	0.00	20.00	1.40	1.72
md live oak	1.05	2.41	0.00	28.00	0.91	1.19
sm live oak	1.30	3.12	0.00	30.00	1.12	1.48
lg deciduous	1.50	2.76	0.00	19.00	1.34	1.67
md deciduous	1.13	2.18	0.00	15.00	1.00	1.26
sm deciduous	4.20	8.33	0.00	84.00	3.71	4.69
meanht100	4.77	1.75	0.00	9.20	4.66	4.87
pcntJuniperm50	0.52	0.39	0.00	1.00	0.50	0.54
pcntMixedm50	0.27	0.37	0.00	1.00	0.25	0.29
pcntNonForstm50	0.17	0.23	0.00	1.00	0.15	0.18
pcntLiveOakm50	0.01	0.07	0.00	1.00	0.00	0.01
pcntDecidm50	0.00	0.03	0.00	0.55	0.00	0.01
pcntJunShrbm50	0.02	0.07	0.00	1.00	0.01	0.02
pcntUrbanm50	0.01	0.06	0.00	1.00	0.00	0.01
pcntColdDecm50	0.00	0.03	0.00	0.48	0.00	0.01
pcntShrblndm50	0.00	0.00	0.00	0.08	0.00	0.00
pcntBarrenm50	0.00	0.04	0.00	1.00	0.00	0.00
pcntPostOakm50	0.00	0.02	0.00	0.47	0.00	0.00
EDOpenm50	160.84	179.53	0.00	776.32	150.32	171.35
EDShrubm50	7.37	26.50	0.00	202.53	5.81	8.92
EDUrbanm50	0.67	5.03	0.00	67.57	0.37	0.96
pcntJuniperm100	0.52	0.34	0.00	1.00	0.50	0.54
pcntMixedm100	0.27	0.32	0.00	1.00	0.25	0.29
pcntNonForstm100	0.17	0.20	0.00	1.00	0.16	0.19
pcntLiveOakm100	0.00	0.04	0.00	0.66	0.00	0.01
pcntJunShrbm100	0.02	0.06	0.00	1.00	0.01	0.02

pcntUrbanm100	0.01	0.04	0.00	0.67	0.01	0.01
pcntDecidm100	0.00	0.02	0.00	0.38	0.00	0.00
pcntColdDecm100	0.00	0.02	0.00	0.29	0.00	0.00
pcntShrblndm100	0.00	0.00	0.00	0.09	0.00	0.00
pcntBarrenm100	0.00	0.01	0.00	0.36	0.00	0.00
pcntPostOakm100	0.00	0.01	0.00	0.31	0.00	0.00
EDOpenm100	175.95	148.35	0.00	705.70	167.26	184.63
EDShrubm100	8.37	21.18	0.00	190.94	7.13	9.61
EDUrbanm100	0.65	3.33	0.00	44.73	0.45	0.84
pcntJuniperm1k	0.42	0.15	0.00	1.00	0.41	0.42
pcntMixedm1k	0.23	0.15	0.00	1.00	0.22	0.24
pcntJunShrbm1k	0.02	0.02	0.00	0.12	0.02	0.02
pcntUrbanm1k	0.04	0.04	0.00	0.31	0.04	0.04
pcntNonForstm1k	0.27	0.13	0.00	1.00	0.27	0.28
pcntColdDecm1k	0.01	0.01	0.00	0.06	0.00	0.01
pcntLiveOakm1k	0.01	0.01	0.00	0.06	0.01	0.01
pcntDecidm1k	0.00	0.01	0.00	0.04	0.00	0.01
pcntPostOakm1k	0.00	0.00	0.00	0.03	0.00	0.00
pcntShrblndm1k	0.00	0.00	0.00	0.01	0.00	0.00
pcntBarrenm1k	0.00	0.00	0.00	0.02	0.00	0.00
EDShrubm1k	12.51	7.06	0.00	35.11	12.10	12.92
EDUrbanm1k	1.39	1.28	0.00	7.55	1.32	1.47
EDOpenm1k	184.12	68.12	12.74	340.31	180.13	188.11
meancc100	80.45	15.86	1.50	99.60	79.52	81.38
gcwawood100	0.79	0.25	0.00	1.00	0.77	0.80
gcwawood1k	0.65	0.16	0.00	1.00	0.64	0.66

Table 6. Support for candidate models evaluating habitat and landscape effects on nest survival of Golden-cheeked Warblers across 20 plots surveyed on Balcones Canyonlands Preserve, Austin, Texas, during March-June 2005, 2006, 2009-2013. All models include year, day of year, and nest stage. K is the number of parameters, ΔAIC_c is the difference between the top model AIC_c and the model of interest (top model ΔAIC_c=0), and Akaike's weights (w_i). AIC_c of the top model was 1192.68.

Model Label	Model description	K	ΔAIC_c	w_i
basalarea	year dayofyear day2 day3 neststage asju nonasju	13	0	0.313
basalarea+treehgt	year dayofyear day2 day3 neststage asju nonasju hgt	14	1.23	0.169
basalarea+edge	year dayofyear day2 day3 neststage asju nonasju edge100	14	1.77	0.129
basalarea+slope	year dayofyear day2 day3 neststage slope asju nonasju	14	1.90	0.121
basalrea+jun100+edge	year dayofyear day2 day3 neststage juniper100 edge100	15	3.38	0.058
basalarea+edge+jun1k	year dayofyear day2 day3 neststage asju nonasju edge100 juniper1k	15	3.77	0.048
edge1k	year dayofyear day2 day3 neststage edge1k	12	4.67	0.030
null	year dayofyear day2 day3 neststage	11	5.21	0.023
basalarea+edge*jun1k	year dayofyear day2 day3 neststage asju nonasju edge100 juniper1k edge100*juniper1k	16	5.45	0.020
canopy100	year dayofyear day2 day3 neststage canopy100	12	6.83	0.010
edge100	year dayofyear day2 day3 neststage edge100	12	6.89	0.010
edge50	year dayofyear day2 day3 neststage edge50	12	6.97	0.010
gcwawood100	year dayofyear day2 day3 neststage gcwawood100	12	7.02	0.009
gcwawood50	year dayofyear day2 day3 neststage gcwawood50	12	7.18	0.009
gcwawood1k	year dayofyear day2 day3 neststage gcwawood1k	12	7.18	0.009
basalarea+year*edge	year dayofyear day2 day3 neststage asju nonasju edge100 edge100*year	20	7.76	0.006
jun50+mixed50	year dayofyear day2 day3 neststage juniper50 mixed50	13	8.66	0.004
landform	year dayofyear day2 day3 neststage slope aspect	13	8.72	0.004
canopy100+edge50	year dayofyear day2 day3 neststage canopy100 edge50	13	8.84	0.004
slope+canopy100	year dayofyear day2 day3 neststage slope canopy100	13	8.84	0.004
jun100+mixed100	year dayofyear day2 day3 neststage juniper100 mixed100	13	8.90	0.004
jun1k+mixed1k	year dayofyear day2 day3 neststage juniper1k mixed1k	13	9.19	0.003
jun1k+mixed1k+edge100	year dayofyear day2 day3 neststage juniper1k mixed1k edge100	14	10.80	0.001
jun100+mixed100+edge100	year dayofyear day2 day3 neststage juniper100 mixed100 edge100	14	10.80	0.001

jun1k+mixed1k+canopy100+edge100	year dayofyear day2 day3 neststage juniper1k mixed1k canopy100 edge100	15	12.58	0.001
jun1k+mixed1k+ht100+edge100	year dayofyear day2 day3 neststage juniper1k mixed1k height100 edge100	15	12.78	0.001
year*edge	year dayofyear day2 day3 neststage edge100 edge100*year	18	14.30	0.000
hab+foresttype	year dayofyear day2 day3 neststage nest_dbh nest_hgt slope aspect cover canopy height asju nonasju juniper100 mixed100 tree	23	16.22	0.000
hab+edge100+canopy100	year dayofyear day2 day3 neststage nest_dbh nest_hgt slope aspect cover canc hgt asju nonasju edge100 canopy100 tree	23	16.85	0
jun100+mixed100+edge100*year	year dayofyear day2 day3 neststage juniper100 mixed100 edge100 edge100*year	20	17.72	0
site	year dayofyear day2 day3 neststage site	34	23.3	0

Table 7. Summary of vegetation measurements collected at Golden-cheeked Warbler nests located on Balcones Canyonlands Preserve, Austin, Texas, in summer 2013 (N = 144) and average across 7 years (2005, 2006, 2009-2013; N = 555).

Variable	2013					Average for 7 years				
	N	Mean	Std Dev	Minimum	Maximum	N	Mean	Std Dev	Minimum	Maximum
Tree height	144	8.92	2.39	4.00	16.92	555	8.42	2.50	2.20	23.76
Nest height	144	7.18	2.15	2.10	16.20	555	6.59	2.34	0.00	21.36
Distance main trunk	144	69.15	146.51	0.00	674.00	555	68.85	135.86	0.00	700.00
Nest DBH	144	23.45	10.99	7.50	71.00	555	23.52	11.00	7.00	80.00
Slope	144	13.69	10.10	1.00	38.00	555	11.49	9.27	0.00	47.00
Aspect	144	182.08	104.62	1.00	358.00	555	176.21	99.51	0.00	360.00
Nest cover	144	63.48	20.24	17.00	100.00	555	50.60	20.42	5.33	100.00
Canopy cover	144	92.13	8.06	48.44	100.00	555	87.29	9.99	34.90	100.00
Height	144	7.77	1.73	3.68	13.10	555	7.62	1.94	3.28	15.35
Tree basal area:										
Juniper	144	16.71	8.13	0.00	41.61	555	20.85	13.10	0.00	116.84
Shin oak	144	0.60	1.12	0.00	5.47	555	0.60	1.24	0.00	9.00
Other	144	2.10	4.99	0.00	44.00	555	1.51	4.41	0.00	50.28
Red oak	144	1.93	3.83	0.00	33.00	555	1.73	4.10	0.00	45.08
Live oak	144	2.55	4.39	0.00	21.62	555	2.98	5.89	0.00	61.52
Non-asju total	144	6.53	5.07	0.00	23.16	555	6.64	7.76	0.00	61.52
total	144	23.74	9.04	5.84	84.00	555	27.31	14.46	0.00	119.54
Tree density:										
Lg juniper	144	11.55	6.35	0.00	30.00	555	11.03	7.29	0.00	47.00
Md juniper	144	10.89	7.59	0.00	35.00	555	11.55	8.51	0.00	46.00
Sm juniper	144	24.95	22.41	0.00	136.00	555	27.99	26.89	0.00	187.00
Lg deciduous	144	2.78	3.28	0.00	15.00	555	1.96	2.78	0.00	15.00
Md deciduous	144	2.44	2.97	0.00	11.00	555	1.93	3.21	0.00	28.00
Sm deciduous	144	8.24	10.37	0.00	51.00	555	6.72	10.44	0.00	70.00
Lg live oak	144	1.72	3.06	0.00	17.00	555	1.64	2.88	0.00	17.00
Md live oak	144	0.82	2.27	0.00	13.00	555	0.68	1.72	0.00	13.00

Sm live oak	144	0.57	2.13	0.00	22.00	555	0.70	2.27	0.00	23.00
% Juniper 50	144	0.53	0.42	0.00	1.00	555	0.61	0.42	0.00	1.00
% Mixed 50	144	0.41	0.40	0.00	1.00	555	0.32	0.40	0.00	1.00
EDOpenm50	144	72.33	126.17	0.00	610.39	555	79.87	137.79	0.00	770.27
EDUrbanm50	144	0.18	2.16	0.00	25.97	555	0.56	5.24	0.00	78.95
EDShrubm50	144	0.00	0.00	0.00	0.00	555	1.69	10.45	0.00	89.74
% Juniper 100	144	0.53	0.38	0.00	1.00	555	0.60	0.38	0.00	1.00
% Mixed 100	144	0.39	0.35	0.00	1.00	555	0.31	0.35	0.00	1.00
EDOpenm100	144	98.28	126.60	0.00	596.77	555	101.91	135.56	0.00	726.11
EDShrubm100	144	0.62	5.14	0.00	57.32	555	2.34	9.74	0.00	66.88
EDUrbanm100	144	0.16	1.88	0.00	22.58	555	0.37	2.89	0.00	38.22
% Juniper 1k	144	0.43	0.18	0.10	0.79	555	0.46	0.20	0.00	1.00
% Mixed 1k	144	0.35	0.20	0.02	0.71	555	0.32	0.21	0.00	1.00
EDOpenm1k	144	144.66	47.94	40.01	270.58	555	137.38	47.45	34.53	270.58
EDShrubm1k	144	7.94	5.27	0.00	23.65	555	8.68	5.42	0.00	23.75
EDUrbanm1k	144	1.12	0.94	0.00	3.97	555	1.24	0.97	0.00	5.50
Mean canopy 100	144	91.22	8.03	57.50	99.60	555	90.74	9.28	46.80	99.70
Mean ht100	144	6.27	1.22	2.50	9.30	555	6.17	1.27	2.20	9.30
Gcwawood50	144	0.95	0.12	0.28	1.00	555	0.93	0.16	0.00	1.00
Gcwawood100	144	0.93	0.11	0.45	1.00	555	0.91	0.15	0.00	1.00
Gcwawood1k	144	0.77	0.09	0.47	0.93	555	0.78	0.11	0.00	1.00
Edge total50	144	72.51	126.24	0.00	610.39	555	82.86	142.04	0.00	770.27
Edge total100	144	99.06	126.57	0.00	596.77	555	103.89	135.22	0.00	726.11
Edge total1k	144	153.72	48.38	46.21	285.42	555	147.19	47.62	40.03	285.42

Table 8. Frequency of tree species used as substrate for Golden-cheeked Warbler nests on Balcones Canyonlands Preserve, Austin, Texas, during 2005, 2006, and 2009-2013.

Tree species	2005	2006	2009	2010	2011	2012	2013	Total	Percent
American Elm	0	0	0	0	0	1	0	1	0.2%
Ashe Juniper	35	66	21	30	76	106	83	417	72.5%
Cedar Elm	0	2	0	3	9	13	23	50	8.7%
Black Cherry	0	0	0	1	0	0	0	1	0.2%
Live Oak	0	7	0	8	18	25	21	79	13.7%
Red Oak	0	0	0	0	1	0	5	6	1%
Shin Oak	0	1	0	1	3	3	12	20	3.5%
Walnut	0	0	0	0	0	1	0	1	0.2%

Table 9. Support for factors affecting adult survival and detection probability from program MARK for banded Golden-cheeked Warblers across Balcones Canyonlands Preserve, Austin, Texas. Phi = survival and pi = detection probability; t = time (year) and c = colony (gender).

Model	K	AIC_c	ΔAIC_c	w_i
{phi(t) pi(.)}	5	954.51	0.00	0.57
{phi(t) pi(t)}	7	955.67	1.17	0.32
{phi(c*t) pi(.)}	9	959.91	5.40	0.04
{phi(c) pi(t)}	6	960.41	5.90	0.03
{phi(c*t) pi(t)}	11	960.99	6.48	0.02
{phi(c) pi(.)}	3	961.44	6.93	0.02