2013 Annual Report:
Golden-cheeked Warbler *(Setophaga chrysoparia)*
Monitoring Program
Balcones Canyonlands Preserve



Photo by Gil Eckrich, Fort Hood

City of Austin
Austin Water Utility
Wildland Conservation Div.
Balcones Canyonlands Preserve
Austin, Texas

Travis County
Department of Transportation &
Natural Resources
Balcones Canyonlands Preserve
Austin, Texas

U.S. Forest Service
Northern Research Station
Department of Fisheries &
Wildlife Sciences
University of Missouri
Columbia, Missouri

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2013 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 2013 field season. This was the sixteenth year of golden-cheeked warbler monitoring on the City of Austin's Balcones Canyonlands Preserve (BCP) tracts. It was the third 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 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. Further, this project will build on existing monitoring and research, including previous warbler survey data and work being conducted by Baylor University to estimate woodland stand age, successional pathways, and fire histories within the BCP. This research will provide a foundation for the models and will be used to evaluate how land use changes have affected habitat quality. Preliminary findings to date are consistent with other research that golden-cheeked warblers depend on large blocks of closed canopy Ashe juniper-oak woodlands with a healthy understory. Development of the population viability and habitat suitability models will commence following this third year of the USFS project.

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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 (*Juniperus ashei* - *Quercus* spp.) habitat occurs (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 for the incidental "take" of habitat loss due to development and to facilitate the local recovery of the warbler and seven other endangered 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 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). 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, habitat, and management 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 2013 field season continued the collaborative effort 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, including canopy cover and woodland stand age, in which the warbler breeds on the BCP. BCP staff, managing partners, and volunteers also worked to refine and implement monitoring protocols to ensure the information collected can be utilized in the modeling project. Additionally, USFS researchers are continuing efforts to refine a point count methodology to provide reliable estimates of warbler density and abundance across the BCP. Existing species and habitat monitoring protocols will continue to be evaluated and revised as necessary to ensure data collection is adequate for development of the viability models.

METHODS

A detailed description of the demographic methods used during the 2013 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 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 and dispersal. 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 third year of point count surveys and vegetation surveys at each point on a 250-meter grid of points. A preliminary report of the 2012 survey results is provided in Exhibit K.

Intensive Study Plots

During field season 2013, 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 1,026 hectares. Intensive study plots were located within six of the seven BCP macrosites (all but the Pedernales macrosite). The Motocross Park ("Bike Park") in Emma Long Metropolitan Park and the Coldwater tract in the North Lake Austin macrosite were included in the intensive monitoring sites to continue the pilot study initiated in 2010 to further evaluate the effects of recreation. 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 21 percent of the BCP in 2013.

Table 1. Intensive study plots for each macrosite within the Balcones Canyonlands Preserve, Travis County, Texas, field season 2013.

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)	85					
Sunset Valley (COA)	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 (LCRA, TC)			40.5			
Vireo Ridge (TC)			42			
Vista Point (TC)			40.5			
Emma Long Bike Park (COA)				99		
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 September 2013)	2,470	2,020	3,658	2,266	1,644	188
% of macrosite intensively surveyed*	~6%	~10%	~5%	~11%	~5%	~96%

* 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 1417.5 ha, see Exhibit B).

Site Description

The topography and vegetation of the surveyed tracts 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), stand ages, slope and aspect, habitat patch sizes, proximity to urban development, and land management activities. Resources used included aerial photos, preliminary stand age maps produced by Baylor University, and mapped vegetation types from Phase 1 of the Texas Ecological Systems Classification (http://morap.missouri.edu/Projects.aspx?ProjectId=57).

Golden-cheeked Warbler Monitoring on Intensive Study Plots

Color Banding

Color banding was conducted in conjunction with territory mapping on all of the 18 intensive study plots, from March 11 through May 16. 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), after hatch-year (AHY) according to Pyle (1997)), 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 2011-2013 is provided in Exhibit D.

Territory Delineation and Density. Surveys on each intensive study plot were conducted at least twice a week from mid-March through late May to delineate territories (dates used: March 15-May 25) and once or twice 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 number of 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. 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 and displayed so that territories could be delineated. Territorial boundaries for each male were delineated using minimum convex polygons in ArcGIS.

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 on 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. Territory density is calculated as the number of territories (using Verner's counting method) per hectare (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. The percentage of ASY and AHY males was also estimated for each plot. A summary of the 2009-2013 age structure data is provided in Exhibit F.

Return Rate. Return rates are based on the total number of color-banded adults present in 2012 (including returns from previous years and those banded in 2012) that were observed again in 2013. Return rates were derived for field seasons 2010 through 2013, and details on returning adults are provided for each study plot. A summary of the 2009-2013 return rates for warbler males is presented in Exhibit G.

Pairing and Reproductive Success. For field season 2013, 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. 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. 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 per hectare). 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 successfully bred. A summary of the 2009-2013 reproductive success data is presented in Exhibit H.

Breeding success, productivity, and fecundity 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) has 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 determine its fate and number of fledglings produced. If nest fate was not observed directly, a nest within a banded male's territory was assumed to have been successful only if that male was observed tending young after the anticipated fledging date. Otherwise, the fate of the nest was recorded as unknown.

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 2011-2013 vegetation data for warbler nests is presented in Exhibit I.

Surveys for Banded Warblers Outside 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 volunteers in twenty-six teams conducted surveys on approximately 1296 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 properties where surveys were conducted, total area surveyed, and the survey effort for each tract, 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 initiated at the Bike Park in 2010 and continued through 2013. The control site in the Davis *et al.* study included the Forest Ridge 40.5-ha plot. The Coldwater tract was added as another control site in 2010. The Bike Park has a high trail density, is composed of open and closed-canopy trails, and allows the use of both mountain bikes and motorized dirt bikes during the warbler breeding season. The Bike Park is on the east

side of City Park Road, northeast of the Emma Long intensive study plot. The Coldwater tract lies to the north of Emma Long Metropolitan Park. It contains Ashe juniper-oak woodlands as well as open areas with bare ground and shrubby growth that are currently not suitable warbler habitat. While there is no public access to the Coldwater tract, some closed-canopy trails and abandoned open-canopy ranch roads exist.

Warblers were color banded to determine territory size and configuration, pairing success, breeding success, and nest success, consistent with the Davis *et al.* 2010 study and following the methods employed on other intensive monitoring plots. Additionally, point counts surveys were conducted across the Bike Park and Coldwater for all bird species to help evaluate survey methods and provide comparative data on the bird community on each tract. These data will be incorporated into the models to assess warbler population viability and habitat suitability across the BCP. Major limitations of the pilot study include 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.).

Pilot Study to Evaluate the Vickery Method

Several recently completed and on-going 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 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. However, no study has been performed to determine the accuracy of this method at correctly predicting warbler reproductive success.

During the 2013 field season, seven volunteers conducted surveys using the Vickery method on three intensive study plots with low and high warbler densities (Barton Creek, Canyon Vista, Vista Point). Two volunteers were assigned to each plot and conducted surveys independent of each other and of the intensive monitoring methods. The goal of the study was to initiate data collection to compare the number, distribution, and reproductive success of warbler territories derived using the Vickery method with the intensive monitoring data of color-banded warblers. Surveys were conducted once a week between March 15 and June 15, for approximately 4 to 6 hours following sunrise, during conditions conducive to detecting warblers (i.e. little to no precipitation, winds $\leq$12 miles/hour). During the first two visits, volunteers conducted transect surveys on their assigned plot to identify the number and location of each territory. On each of the subsequent surveys, volunteers attempted to re-locate each warbler male detected during the transect surveys (and any newly detected males) to delineate territories and determine reproductive success. For each visit, volunteers were instructed to spend 30 to 60 minutes to collect at least 3 locations, spread 15m apart, of each detected male and to record any behaviors indicative of reproductive activity using the following rankings to determine reproductive success:

Rank	Description
0	Male not detected
1	Male detected
2	Female detected
3	Evidence of nest building, or the female was observed laying or incubating eggs
4	Adult observed carrying food to presumed nestlings
5	One or more host warbler fledglings observed with the pair

Data entry and analyses followed the same methods used for the intensive monitoring to delineate territories, with the addition of the Vickery ranks used to determine reproductive success for each territory. Results from the 2013 field season are presented in Exhibit J. A summary of survey hours is provided in Exhibit B.

RESULTS AND DISCUSSION

Intensive Study Plots

Territory Densities and Locations. A total of 233 territories were identified in field season 2013, including 179.5 full + 0.5 edge territories for all 18 intensive study plots (an average estimated density of 0.17 territories per hectare for the combined 1,026-ha study plots, ranging from 0 to 0.62 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 are presented in Table 2 for field season 2013 (a summary of territory data for field seasons 2009-2013 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 2013. 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	4	10	7	0.17
Gus Fruh/Sunset Valley	1	1	1	0.01
Bull Creek Macrosite				
3M/St. Edwards	13	26	19.5	0.48
Canyon Vista	7	22	14.5	0.36
Forest Ridge	8	14	11	0.27
Butler	18	32	25	0.62
Hamilton West	5	11	8	0.20
Cypress Creek Macrosite				
Baker Sanctuary	6	14	10	0.25
Lake Perspectives/McGregor	6	11	8.5	0.21
Vireo Ridge	9	11	10	0.24
Vista Point	10	17	13.5	0.33
North Lake Austin Macrosite				
Coldwater	10	13	11.5	0.11
Bike Park	5	13	9	0.09
Emma Long	11	20	15.5	0.38
South Lake Austin Macrosite				
Double J&T	2	4	3	0.07
Reicher	3	6	4.5	0.11
West Austin Macrosite				
Wild Basin/Vireo Preserve	8	8	8	0.04
Total/Average	**126**	**233**	**179.5**	**0.17**

[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 (99 ha), Coldwater (107 ha), Vireo Ridge (42 ha), and Wild Basin/Vireo Preserve (180 ha).

The Butler plot had the greatest increase in the number of territories (0.62 territories/ha in 2013, up from 0.43 territories/ha in 2012 and 2011), while Forest Ridge had the greatest decrease (0.27 territories/ha in 2013, down from 0.44 territories/ha in 2012, and 0.41 territories/ha in 2011). While the Butler plot had an increased number of territories, the number of SY males decreased (see Exhibit F), suggesting the

increase may have been due to emigrating ASY males displaced from other areas. The decrease in territories at Forest Ridge may have been due to large areas of tree mortality following the 2011 drought, since most of the territories avoided those areas in 2013.

Color Banding. A total of 110 warblers were banded in 2013, including 104 males and 6 females (Table 3). Of the 104 males, 34 percent were ASY, 65 percent were SY, and 1 percent were AHY. Of the 6 females, 50 percent were ASY and 50 percent were SY.

Table 3. Number of golden-cheeked warblers banded within the Balcones Canyonlands Preserve, Travis County, Texas, field season 2013.

Plot Name	No. Males Banded in 2013			No. Females Banded in 2013			Total No. Banded, 2013
	SY	ASY	AHY	SY	ASY	AHY	
Barton Creek Macrosite							
Barton Creek	3	2	0	0	0	0	5
Gus Fruh/ Sunset Valley	3	0	0	0	0	0	3
Bull Creek Macrosite							
3M/St. Edwards	8	5	0	0	0	0	13
Canyon Vista	6	3	0	0	0	0	9
Forest Ridge	3	1	0	0	1	0	5
Butler	9	7	1	0	1	0	18
Hamilton West	5	1	0	1	0	0	7
Cypress Creek Macrosite							
Baker Sanctuary	2	1	0	0	0	0	3
Lake Perspectives/ McGregor	3	1	0	0	0	0	4
Vireo Ridge	2	0	0	0	1	0	3
Vista Point	4	2	0	0	0	0	6
North Lake Austin Macrosite							
Coldwater	5	2	0	0	0	0	7
Bike Park	5	2	0	0	0	0	7
Emma Long	0	5	0	1	0	0	6
South Lake Austin Macrosite							
Double J&T	4	0	0	0	0	0	4
Reicher	2	3	0	0	0	0	5
West Austin Macrosite							
Wild Basin/ Vireo Preserve	4	0	0	1	0	0	5
Total	**68**	**35**	**1**	**3**	**3**	**0**	**110**

Age Structure. We identified 233 territories on the 18 intensive study plots in 2013, including 158 territorial males (68%) that were banded from 2009 through 2013, and 75 unbanded males (32%) (Table 4). Of the 158 banded males within the 18 study plots, 64 percent were ASY, 35 percent were SY, and 1 percent were AHY. Forest Ridge, Baker Sanctuary, Vireo Ridge, Vista Point, and Emma Long had the highest percentages of ASY males (71-100%), while Sam Hamilton, Coldwater, Bike Park, and Double J & T had the highest percentages of SY males (50-100%). 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, as well as differing capture probabilities (SY males tend to be easier to capture than ASY males, which could underestimate the number of ASY males on a given plot).

Table 4. Golden-cheeked warbler age structure data for all banded territorial males observed within 18 intensive study plots on the Balcones Canyonlands Preserve, Travis County, Texas, field season 2013.

Plot Name	SY Males	ASY Males	AHY Males	Total Banded Males	Total Unbanded Males	% Banded Males
Barton Creek Macrosite						
Barton Creek	2 (40%)	3 (60%)	0	5	5	50
Gus Fruh/Sunset Valley	1(100%)	0	0	1	0	100
Bull Creek Macrosite						
3M/St. Edwards	7(39%)	11 (61%)	0	18	8	69
Canyon Vista	5 (31%)	11 (69%)	0	16	6	73
Forest Ridge	1 (11%)	8 (89%)	0	9	5	64
Butler	8(36%)	13 (59%)	1 (5%)	22	10	69
Hamilton West	5(63%)	3 (38%)	0	8	3	73
Cypress Creek Macrosite						
Baker Sanctuary	2 (25%)	6 (75%)	0	8	6	57
Lake Perspectives/McGregor	3 (33%)	6 (67%)	0	9	2	82
Vireo Ridge	2 (22%)	7 (78%)	0	9	2	82
Vista Point	4 (29%)	10 (71%)	0	14	3	82
North Lake Austin Macrosite						
Coldwater	4 (50%)	4 (50%)	0	8	5	62
Bike Park	5 (71%)	2 (29%)	0	7	6	54
Emma Long	0	10 (100%)	0	10	10	50
South Lake Austin Macrosite						
Double J&T	4(100%)	0	0	4	0	100
Reicher	1(25%)	3(75%)	0	4	2	67
West Austin Macrosite						
Wild Basin/Vireo Preserve	2 (33%)	4 (67%)	0	6	2	75
Total	**56 (35%)**	**101 (64%)**	**1 (1%)**	**158**	**75**	**68%**

Return Rates. The overall return rate of color-banded warbler males (both males banded in 2012 and banded male returns from previous years) in 2013 was 47 percent, up from 41 and 44 percent in 2011 and 2010, respectively, but down from 56 per cent in 2012 (Table 5). Observed returns of banded males by plot in 2013 are presented in Table 6.

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 2013 was 38 percent, up from 23 and 33 percent in 2012 and 2011, respectively, but lower than the 100 percent return rate in 2010 (Table 5). None of the six females banded in 2009 or 2010 were observed in 2013 (Table 5, 7).

Table 5. Return rates for male and female golden-cheeked warblers banded in 2009-2012 within the Balcones Canyonlands Preserve, Travis County, Texas, field season 2013.

# Banded/Returning Males	**2009**	**2010**	**2011**	**2012**	**2013**
Males Banded	101	91	162	94	104
Male Returns from 2009	--	44	19	7	2
Male Returns from 2010	--	--	37	22	11
Male Returns from 2011	--	--	--	93	43
Male Returns from 2012	--	--	--	--	43
Total Banded Males	101	135	218	216	203
Total Male Returns	--	44	56	122	0
Male Return Rates	**--**	**44%**	**41%**	**56%**	**46%**

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

Table 6. Return data for male golden-cheeked warblers banded in 2009-2012 for each intensive study plot within the Balcones Canyonlands Preserve, Travis County, Texas, field season 2013.

Plot Name	Males Banded 2009	2009 Male Returns in 2013	Males Banded 2010	2010 Male Returns in 2013	Males Banded 2011	2011 Male Returns in 2013	Males Banded 2012	2012 Male Returns in 2013	Total Male Returns in 2013
Barton Creek Macrosite									
Barton Creek	6	0	7	1	3	0	7	1	2
Gus Fruh / Sunset Valley	--	--	--	--	--	--	--	--	--
Bull Creek Macrosite									
3M/St. Edwards	22	2	11	0	16	5	12	7[1]	14
Canyon Vista	--	--	--	--	15	4[2]	10	5	9
Forest Ridge	16	0	6	1	18	6	4	0	7
Butler	21	0	11	0	10	2	13	8	10
Hamilton West	4	0	11	0	11	3	4	2	5
Canyon Creek*	15	0	8	1	--	--	--	--	1
Ribelin*	--	--	6	1	--	--	--	--	1
Cypress Creek Macrosite									
Baker Sanctuary	--	--	--	--	11	2	9	4	6
Lake Perspectives/ McGregor	--	--	--	--	7	4	5	3	7
Vireo Ridge	--	--	--	--	10	3	7	5	8
Vista Point	--		--	--	17	3	6	4	7
North Lake Austin Macrosite									
Coldwater	--	--	13	3	8	0	2	0	3
Bike Park	--	--	8	1	12	1	8	1	3
Emma Long	14	0	3	1	10	4	3	1	6
South Lake Austin Macrosite									
Double J&T	1	0	3	1[3]	2	0	2	0	1
Reicher	--	--	--	--	3	0	1	1	1
Bohls*	2	0	4	1	--	--	--		1
West Austin Macrosite									
Wild Basin/ Vireo Preserve	--	--	--	--	9	6[4]	1	1[5]	7
Total	**101**	**2**	**91**	**11**	**162**	**43**	**94**	**43**	**101**

*Not one of the intensive study plots in 2013, 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 at Forest Ridge; [2] one male resighted at Travis County's Bunten tract; [3] one male resighted at 3M/St. Edwards, [4] one male resighted near Forest Ridge; and [5] one male resighted near 3M/St. Edwards.

Table 7. Return data for female golden-cheeked warblers banded in 2009-2012 for each intensive study plot within the Balcones Canyonlands Preserve, Travis County, Texas, field season 2013.

Plot Name	Females Banded 2009	2009 Female Returns in 2013	Females Banded 2010	2010 Female Returns in 2013	Females Banded 2011	2011 Female Returns in 2013	Females Banded 2012	2012 Female Returns in 2013	Total Female Returns in 2013
Barton Creek Macrosite									
Barton Creek	0	0	1	0	0	0	0	0	0
Gus Fruh /Sunset Valley	--	--	--	--	--	--	--	--	--
Bull Creek Macrosite									
3M/St. Edwards	1	0	1	0	1	0	1	0	0
Canyon Vista	--	--	--	--	0	0	0	0	0
Forest Ridge	0	0	1	0	1	0	4	3	3
Butler	1	0	0	0	0	0	2	0	0
Hamilton West	0	0	0	0	0	0	0	0	0
Canyon Creek*	1	0	0	0	--	--	--	--	0
Ribelin*	--	--	0	0	--	--	--	--	0
Cypress Creek Macrosite									
Baker Sanctuary	--	--	--	--	2	0	1	0	0
Lake Perspectives/ Gregor	--	--	--	--	1	0	0	0	0
Vireo Ridge	--	--	--	--	0	0	0	0	0
Vista Point	--		--	--	1	1	0	0	1
North Lake Austin Macrosite									
Coldwater	--	--	0	0	0	0	1	0	0
Bike Park	--	--	0	0	0	0	0	0	0
Emma Long	0	0	0	0	2	1	0	0	1
South Lake 3Austin Macrosite									
Double J&T	0	0	0	0	0	0	0	0	0
Reicher	--	--	--	--	0	0	0	0	0
Bohls*	0	0	0	0	--	--	--		0
West Austin Macrosite									
Wild Basin/ Vireo Preserve	--	--	--	--	0	0	0	0	0
Total	**3**	**0**	**3**	**0**	**8**	**2**	**9**	**3**	**5**

*Not one of the intensive study plots in 2013, but cursory surveys conducted to resight color-banded individuals.

Dispersal. Of the 106 male and female warblers banded in 2009 through 2012 and observed in 2013 (tables 5-7), BCP staff and volunteers documented 5 dispersal events of more than 1 km (5%) both within and among habitat patches (Table 8). Two dispersal events were of males that were aged SY in 2012 and returned to new sites in 2013; the other three were males that were aged ASY in 2012. One was banded on Double J&T in 2010, and not seen after that year until sighted on St. Edwards in March 2013. Dispersal distances ranged from 1.6 to 14.7 kilometers and occurred within macrosites (1 event of 1.6 km) and between macrosites (4 events, ranging from 6.8 to 14.7 km). The remaining 101 color-banded warblers returning in 2013 (95%) returned to or remained within or near the same study plot, suggesting high site fidelity and low dispersal rates among adult warblers.

BCP staff surveyed both the intensive study plots and the 100-meter buffer around each study plot (where access was available). In addition, 26 teams of 40 volunteers devoted over 686 hours and covered nearly 1300 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.

Table 8. Observed dispersal events for golden-cheeked warblers banded in 2009-2012 within the Balcones Canyonlands Preserve, Travis County, Texas, field season 2013.

Plot Where Banded	Date Banded	Age in 2012	Sex	Resighting Location(s)	Approx. Dispersal Distance
3M	3/23/12	SY	M	Forest Ridge	1.6 km
Canyon Vista	3/17/11	ASY	M	Bunten tract	6.8 km
Double J&T	3/24/10	ASY	M	3M/St. Edwards	14.7 km
Wild Basin	4/24/11	ASY	M	near Forest Ridge	9.6 km
Wild Basin	4/10/12	SY	M	east of 3M/St. Edwards	11 km

Pairing and Reproductive Success. In 2013, a total of 233 territories were monitored for pairing and reproductive success on the 18 intensive study plots (Table 9). The average pairing and breeding success observed for all territories was 87 percent (range 50-100%) and 63 percent (range 0-89%), respectively, down from 97 percent (83-100%) and 74 percent (0-100%) observed in 2012. While no fledglings were observed again on the Gus Fruh/Sunset Valley plot, two unsuccessful nests were documented for the pair that established a territory. For the plots where reproduction was observed, the 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; range 17-18 territories). Plots in the Barton Creek, South Lake Austin, and West Austin macrosites had the fewest territories producing one or more fledglings (range 0-5 territories).

At least 394 fledglings were observed in 140 territories with known reproductive success (estimates exclude 10 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 463 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 (Forest Ridge, Butler, 3M/St. Edwards, Canyon Vista) and North Lake Austin (Emma Long) macrosites produced the greatest number of fledglings (28-50/36-61 observed/adjusted fledglings; density 0.62-1.0/0.63-1.16 observed/adjusted fledglings/ha), while study plots in smaller habitat patches (Gus Fruh/Sunset Valley, Wild Basin/Vireo Preserve) and/or more open woodlands (Double J&T) had the lowest reproductive output (0-9/0-11 observed/adjusted fledglings; density 0-0.12/0-0.12 observed/adjusted fledglings/ha).

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 9. Golden-cheeked warbler reproductive success on 18 intensive study plots on the Balcones Canyonlands Preserve, Travis County, Texas, field season 2013. Data are based on observations for both full and edge territories. See Methods section for calculations. Territories for which pairing and 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	10	9 (10)	90	7 (10)	70	2.4 / 2.7	3.4 / 3.9	24 / 27	0.43 / 0.48
Gus Fruh/ Sunset Valley	1	1 (1)	100	0 (1)	0	0/0	0	0	0
Bull Creek Macrosite									
3M/St. Edwards	26	17 (26)	65	17 (26)	65	1.5 / 1.7	2.2 / 2.6	38 / 44	0.62 / 0.72
Canyon Vista	22	18 (18)	100	13 (20)	65	2.0 / 2.0	3.0 / 3.0	39 / 39	0.63 / 0.63
Forest Ridge	14	12 (14)	86	10 (14)	71	2.0 / 2.6	2.8 / 3.7	28 / 37	0.62 / 0.77
Butler	32	26 (29)	90	18 (31)	58	1.6 / 2.0	2.8 / 3.4	50 / 61	1.00 / 1.16
Hamilton West	11	11 (11)	100	9 (11)	82	1.8 / 2.6	2.2 / 3.2	20/ 29	0.38 / 0.53
Cypress Creek Macrosite									
Baker Sanctuary	14	13 (14)	93	7 (14)	50	1.1 / 1.6	2.3 / 3.2	16/ 23	0.28 / 0.38
Lake Perspective/ McGregor	11	10 (11)	91	7 (11)	64	1.8 / 2.2	2.9 / 3.5	20 / 24	0.37 / 0.42
Vireo Ridge	11	11 (11)	100	8 (9)	89	2.8 / 3.2	3.1 / 3.6	25/ 29	0.56 / 0.64
Vista Point	17	17 (17)	100	9(17)	53	1.6 / 1.6	3.0 / 3.0	27 / 27	0.52 / 0.52
North Lake Austin Macrosite									
Coldwater	13	7 (12)	58	6 (12)	50	1.6 / 1.6	3.2 / 3.2	19 / 19	0.18 / 0.18
Bike Park	13	12 (13)	92	9 (13)	69	2.0 / 2.5	2.9 / 3.6	26 / 32	0.16 / 0.20
Emma Long	20	16 (18)	89	10 (17)	59	2.0 / 2.1	3.4 / 3.6	34 / 36	0.63 / 0.68
South Lake Austin Macrosite									
Double J&T	4	2 (4)	50	2 (4)	50	1.5/1.5	3.0/3.0	6/6	0.12 /0.12
Reicher	6	6 (6)	100	5 (6)	83	2.2/3.1	2.6 / 3.8	13 / 19	0.20 / 0.32
West Lake Austin Macrosite									
Wild Basin/Vireo Preserve	8	6 (7)	86	3 (7)	43	1.3 / 1.6	3.0 / 3.7	9 / 11	0.05 / 0.06
Total/Avg.	**233**	**194 (222)**	**87%**	**140 (223)**	**63%**	**1.8 / 2.1**	**2.8 / 3.3**	**394 / 463**	**0.38 / 0.45**

*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 per hectare.

Nest Data

USFS, BCP staff, and BCP partners found and monitored a total of 154 active warbler nests during the 2013 field season (Table 10). The first nests were found on March 18, the last nest was found on June 14, and the final fledging date of the observed nests was June 17. Ninety-six nests fledged one or more young (62%), 51 nests failed (33%), and 7 had an unknown fate (5%).

Table 10. Fates of monitored golden-cheeked warblers nests within the Balcones Canyonlands Preserve, Travis County, Texas, field season 2013. Successful nests include any nest that fledged ≥1 young.

Plot Name	Total No. Nests	Failed Nests	No. Successful Nests	No. Nests Unknown Fate
Barton Creek Macrosite				
Barton Creek	11	3 (27%)	8 (73%)	0
Gus Fruh/Sunset Valley	2	2	0	0
Bull Creek Macrosite				
3M/St. Edwards	8	2 (25%)	6 (75%)	0
Canyon Vista	17	6 (35%)	8 (47%)	3(18%)
Forest Ridge	9	0	9 (100%)	0
Butler	16	5 (31%)	10 (63%)	1(6%)
Hamilton West	10	3(30%)	7(70%)	0
Cypress Creek Macrosite				
Baker Sanctuary	5	2(40%)	3 (60%)	0
Lake Perspectives/McGregor	3	1 (33%)	2 (67%)	0
Vireo Ridge	9	2(22%)	7 (78%)	0
Vista Point	23	13(56%)	8 (35%)	2 (9%)
North Lake Austin Macrosite				
Coldwater	4	1(25%)	3(75%)	0
Bike Park	12	5(42%)	7 (58%)	0
Emma Long	14	4 (29%)	10(71%)	0
Cortaña*	1	0	1 (100%)	0
South Lake Austin Macrosite				
Double J&T	2	0	2(100%)	0
Reicher	6	4(67%)	2 (33%)	0
West Austin Macrosite				
Wild Basin/Vireo Preserve	2	1(50%)	1 (50%)	0
Total	**154**	**52 (34%)**	**96 (62%)**	**6 (4%)**

*Not one of the intensive study plots in 2013.

The majority of nests were found in Ashe juniper (58%), followed by cedar elm (16%) and live oak (15%). Twelve nests were also found in shin oak (8%), and five in Texas red oak (3%) (Table 11). Nest tree height for all tree species averaged 9.3 meters, and DBH averaged 26.4 centimeters. Nest height averaged 7.4 meters. Canopy cover averaged 92.1 percent. Nests found in Ashe juniper and live oak tended to be more successful (73% and 71%, respectively) than nests found in other tree species.

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 success. Analyses include effects of landscape metrics (i.e., land use, stand age, habitat composition, amount of edge) and more localized effects. Results of the second year of data (2012) are presented in Exhibit K.

Table 11. Summary of vegetation data collected for 144 of the 154 Golden-cheeked Warbler nests found within the Balcones Canyonlands Preserve, Travis County, Texas, field season 2013.

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)	83 (58%)	8.5 (4 – 16.9)	28.3 (7.5 – 84)	6.9 (2.1 – 16.2)	92.1 (49.7 – 99.7)	61 (73%)
Ulmus crassifolia (Cedar Elm)	23 (16%)	10.5 (6.8 – 15.2)	22.7 (12 – 33)	8.7 (5.5 – 14.1)	92.9 (80.5 – 99.7)	12 (52%)
Quercus fusiformis (Live Oak)	21 (15%)	8.6 (5.8 – 12.3)	25.3 (10.5 – 50)	6.7 (4.8 – 9.2)	91.0 (48.4 – 98.4)	15 (71%)
Quercus sinuata var. *breviloba* (Shin Oak)	12 (8%)	8.5 (5.8 – 14.6)	19.2 (9.4 – 48)	6.9 (5.4 – 8.5)	91.6 (81.5 – 100)	7 (58%)
Quercus buckleyi (Texas Red Oak)	5 (3%)	10.5 (7.11 – 15.1)	35.1 (17 – 69)	8.1 (6.3 – 11.2)	94.5 (82.6 – 100)	1 (20%)
Totals	**144**	**9.3 (4 – 16.9)**	**26.4 (7.5 - 84)**	**7.4 (2.1 – 16.2)**	**92.1 (48.4 – 100)**	**96**

Vickery Method Evaluation

From the pilot study conducted this year, a few general conclusions can be drawn (Exhibit J). The observers on each plot derived very different results in the number of territories, pairing success, and breeding success. Territories drawn by the Vickery method do not coincide in size, geographic position, or number with those drawn from intensive monitoring of color-banded individuals. Pairing success and breeding success were greatly underestimated by the Vickery surveyors.

Parasitism

No observations of Brown-headed Cowbird (*Molothrus ater*) parasitism of warbler nests or of adult warblers feeding cowbird chicks were reported in 2013.

Other Observations

Overall, pairing and breeding success were lower in 2013 compared with 2012, and territories appeared to avoid areas with significant tree mortality. This may have resulted in a lower number of territories on the Forest Ridge plot. At the same time, the Butler plot experienced an increase in the number of territories but a decrease in the number of SY males, suggesting an emigration of older males displaced from other areas. These observations could be attributed at least in part to delayed effects of the 2011 drought. Biologists will continue to monitor the warbler populations to determine whether these trends continue. Nest building also appeared to be delayed in 2013, and continued later into the season, than in previous years.

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 2013 field season, which was a drier year than 2012.

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 on the ground, and fledglings were often seen in dense mid-story vegetation and near or on the ground. Each field season, BCP staff videotape and/or photograph adults tending newly-fledged young that are unable to fly well, 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 2009-2013 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.

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EXHIBITS

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), 2013.

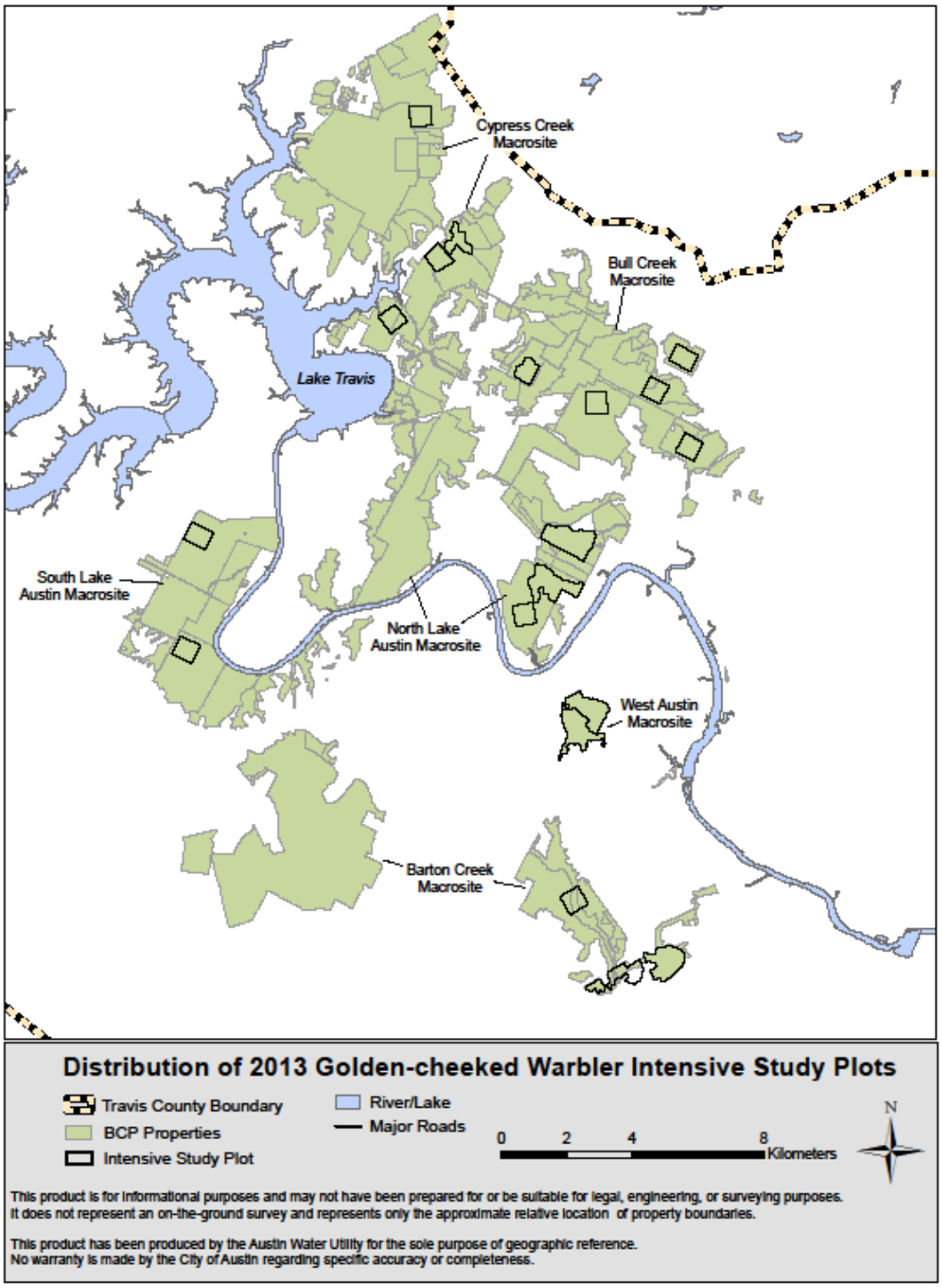


Figure 1

Exhibit A: Minimum Convex Polygons Representing Estimated Golden-cheeked Warbler Territory Boundaries for Intensive Study Plots (Figures 2-18), 2013 (continued).

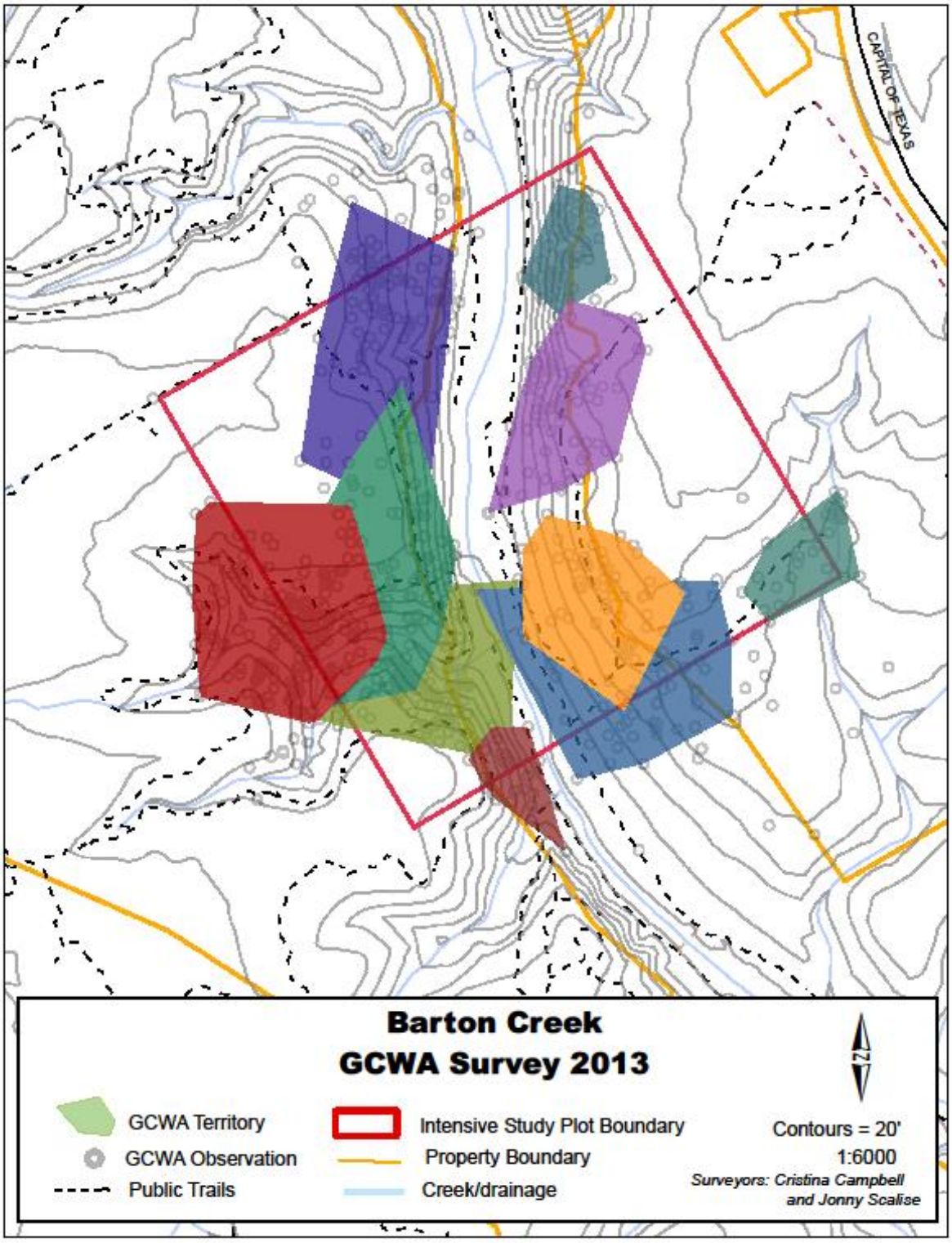


Figure 2

Exhibit A: Minimum Convex Polygons Representing Estimated Golden-cheeked Warbler Territory Boundaries for Intensive Study Plots (Figures 2-18), 2013 (continued).

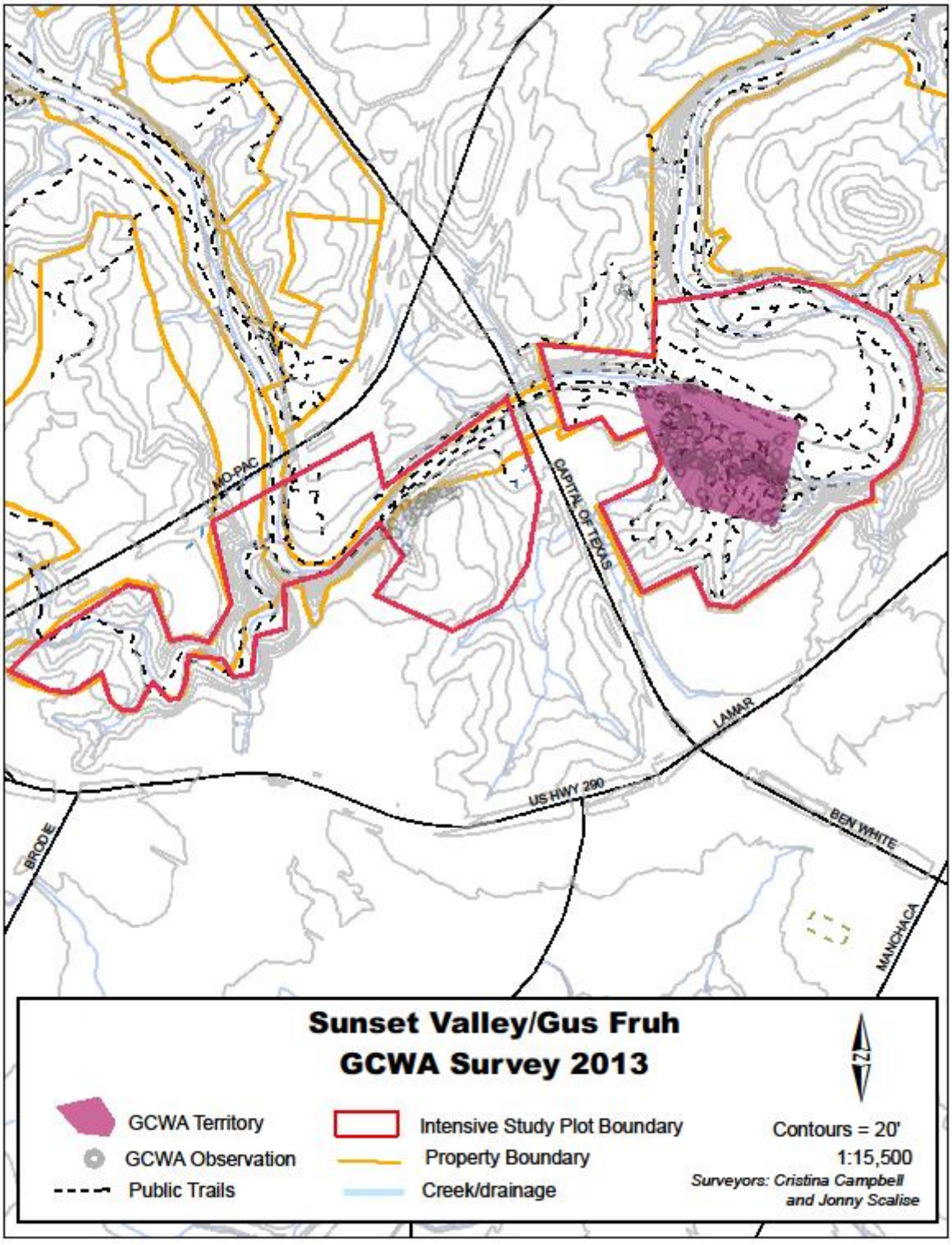


Figure 3

Exhibit A: Minimum Convex Polygons Representing Estimated Golden-cheeked Warbler Territory Boundaries for Intensive Study Plots (Figures 2-18), 2013 (continued).

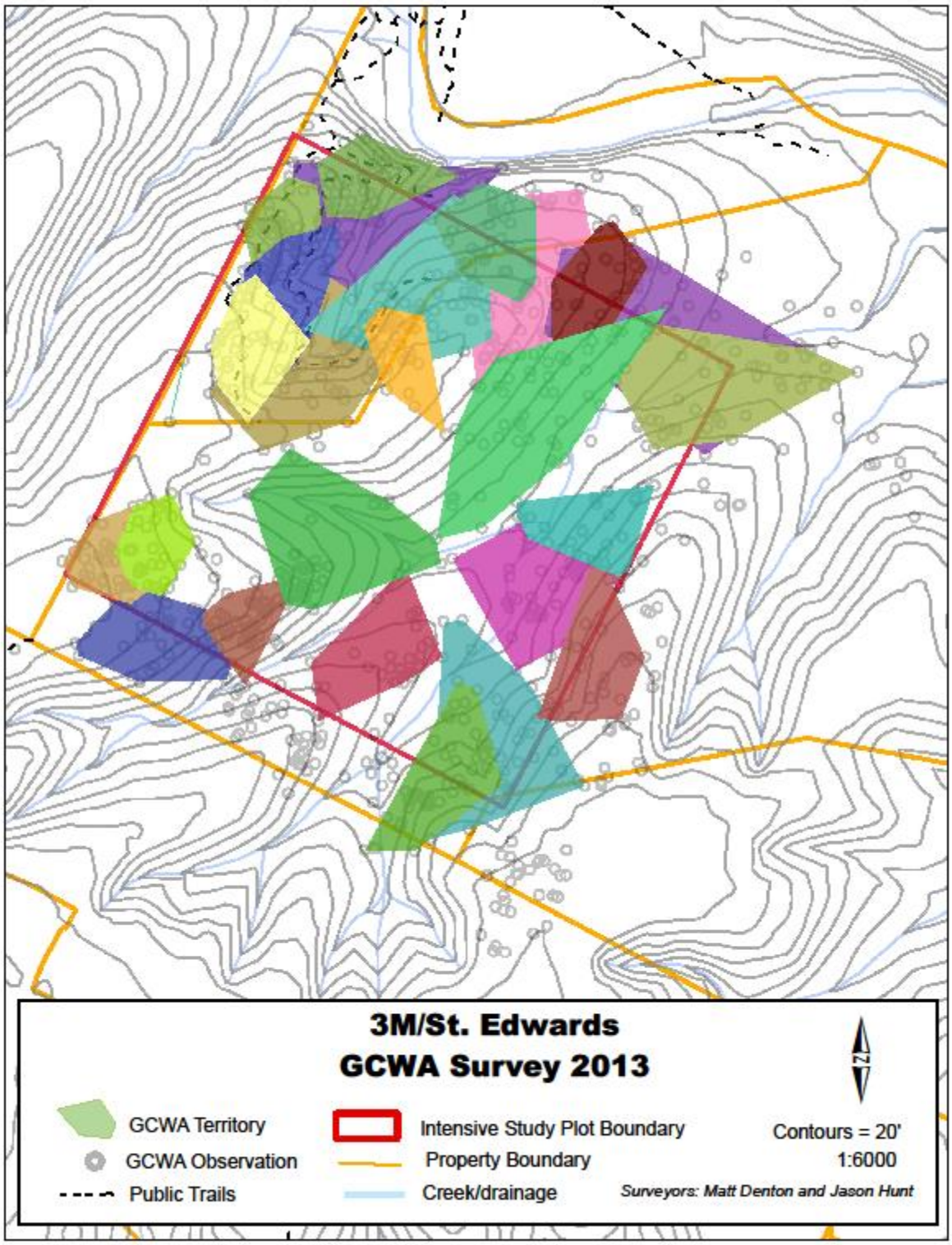


Figure 4

Exhibit A: Minimum Convex Polygons Representing Estimated Golden-cheeked Warbler Territory Boundaries for Intensive Study Plots (Figures 2-18), 2013 (continued).

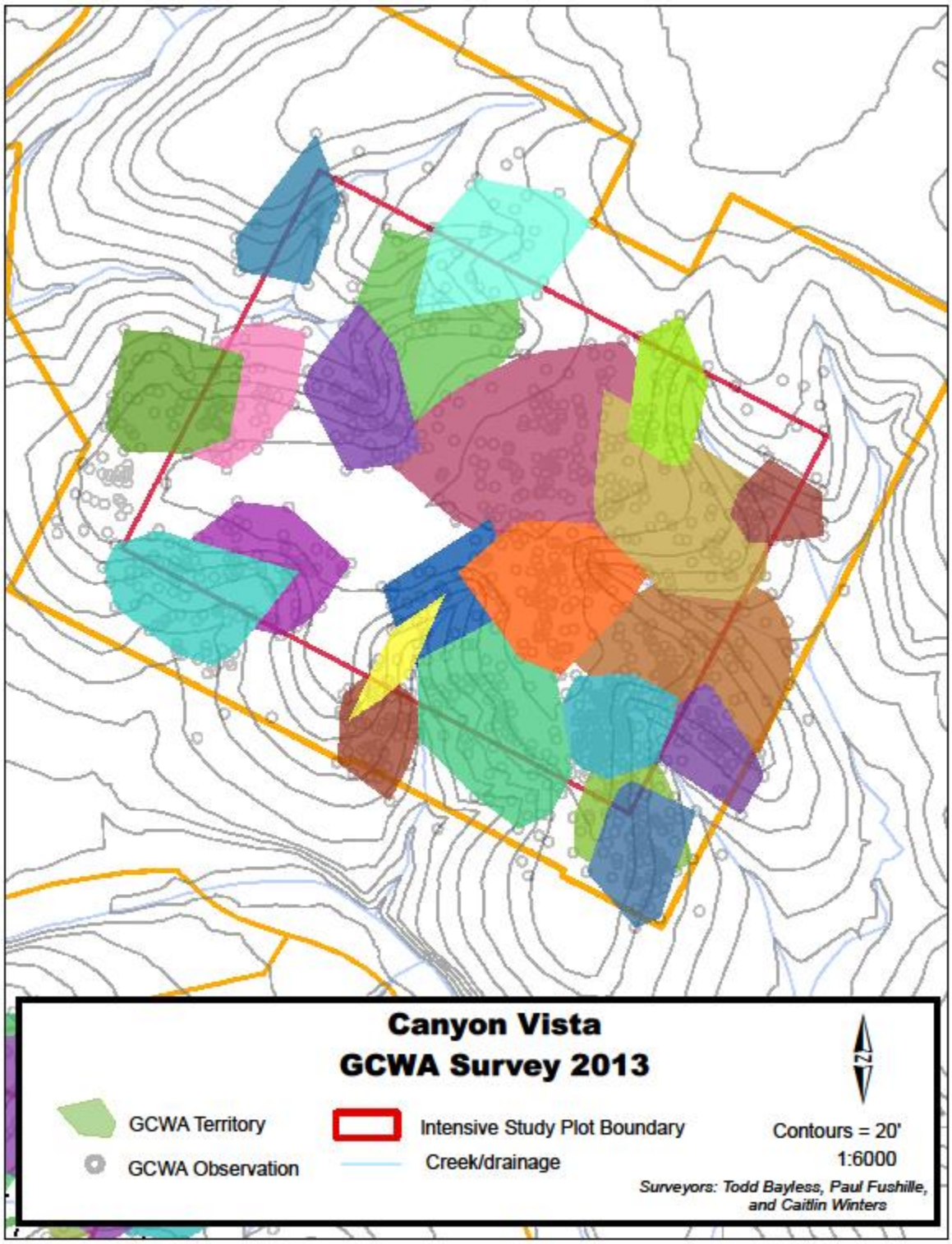


Figure 5

Exhibit A: Minimum Convex Polygons Representing Estimated Golden-cheeked Warbler Territory Boundaries for Intensive Study Plots (Figures 2-18), 2013 (continued).

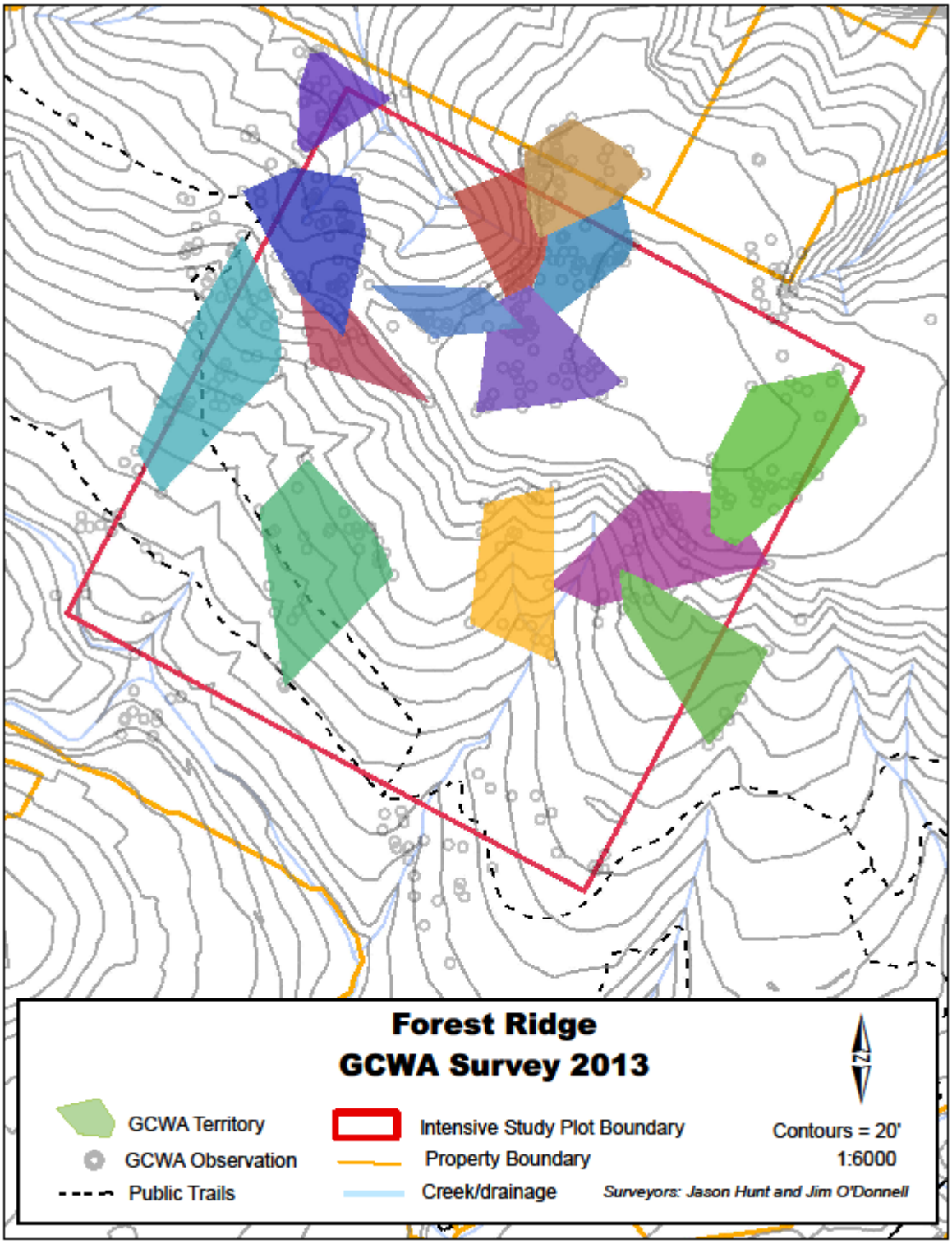


Figure 6

Exhibit A: Minimum Convex Polygons Representing Estimated Golden-cheeked Warbler Territory Boundaries for Intensive Study Plots (Figures 2-18), 2013 (continued).

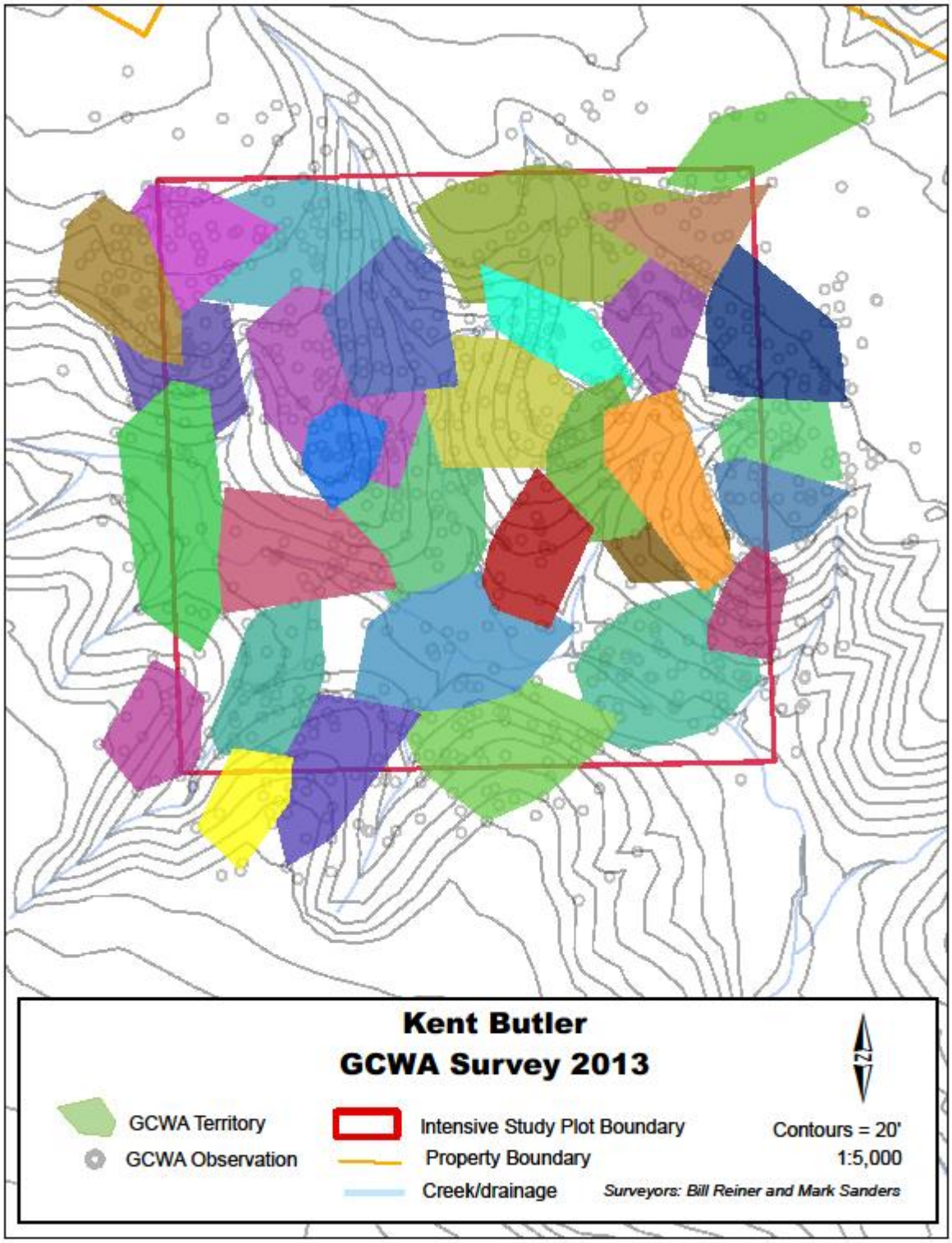


Figure 7

Exhibit A: Minimum Convex Polygons Representing Estimated Golden-cheeked Warbler Territory Boundaries for Intensive Study Plots (Figures 2-18), 2013 (continued).

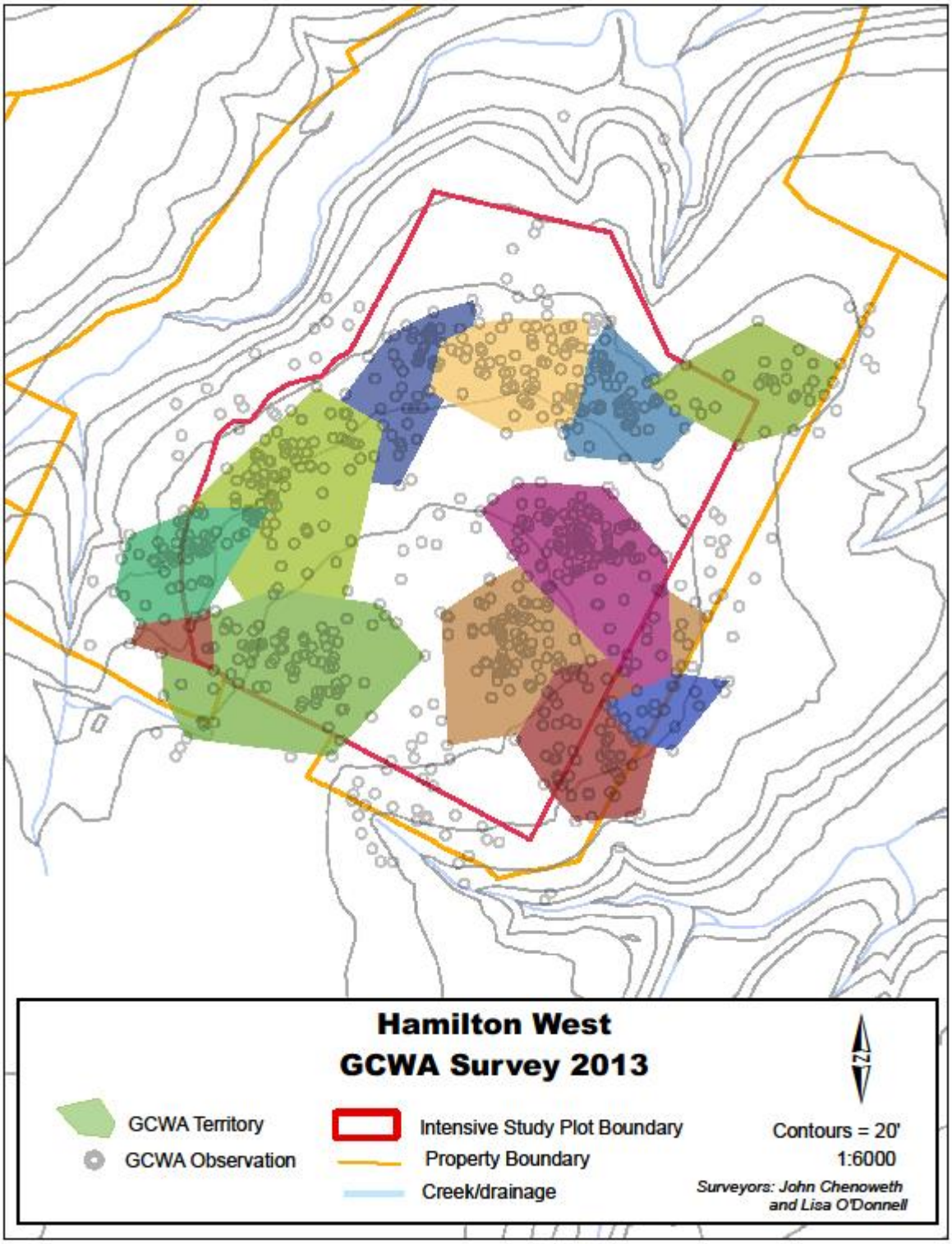


Figure 8

Exhibit A: Minimum Convex Polygons Representing Estimated Golden-cheeked Warbler Territory Boundaries for Intensive Study Plots (Figures 2-18), 2013 (continued).

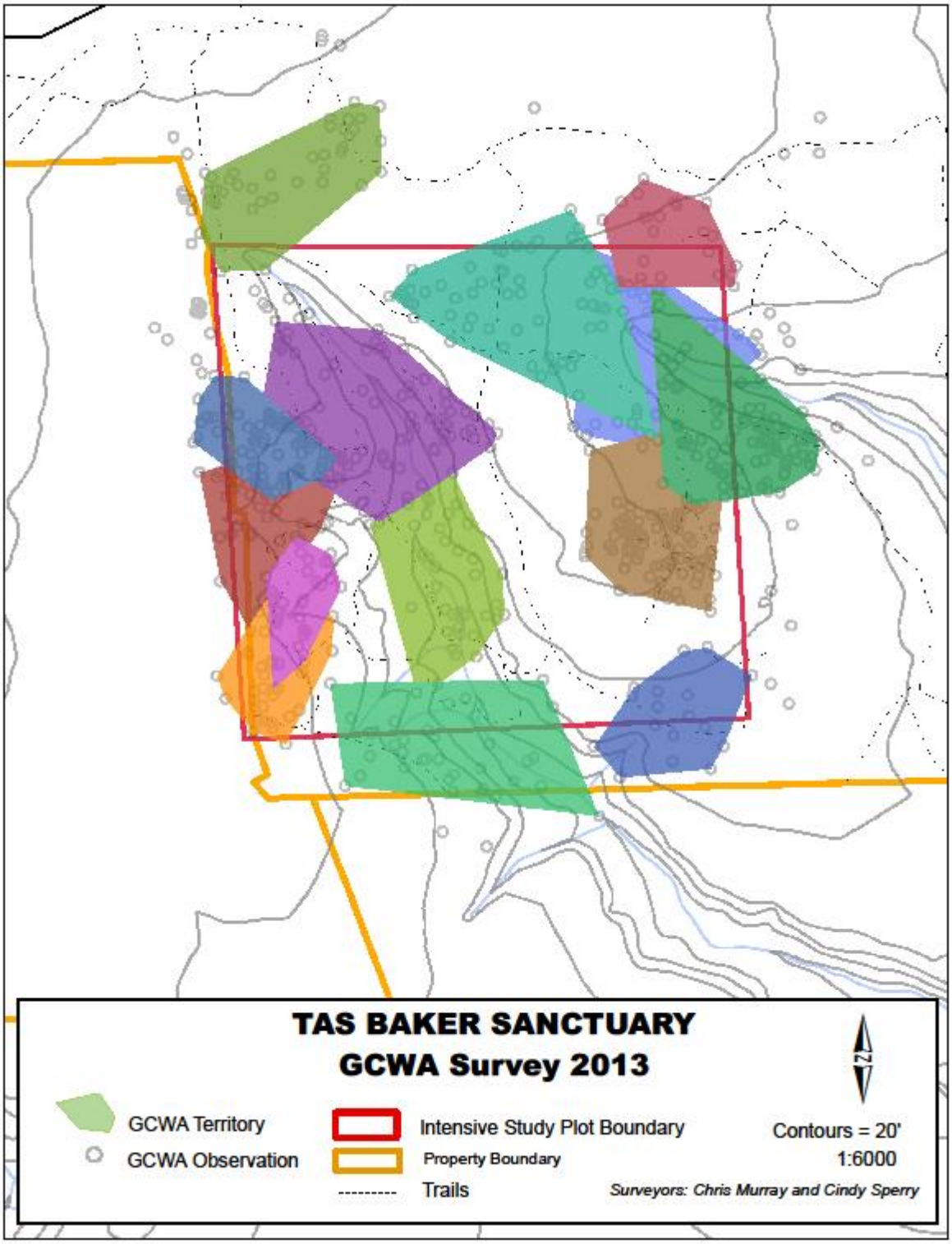


Figure 9

Exhibit A: Minimum Convex Polygons Representing Estimated Golden-cheeked Warbler Territory Boundaries for Intensive Study Plots (Figures 2-18), 2013 (continued).

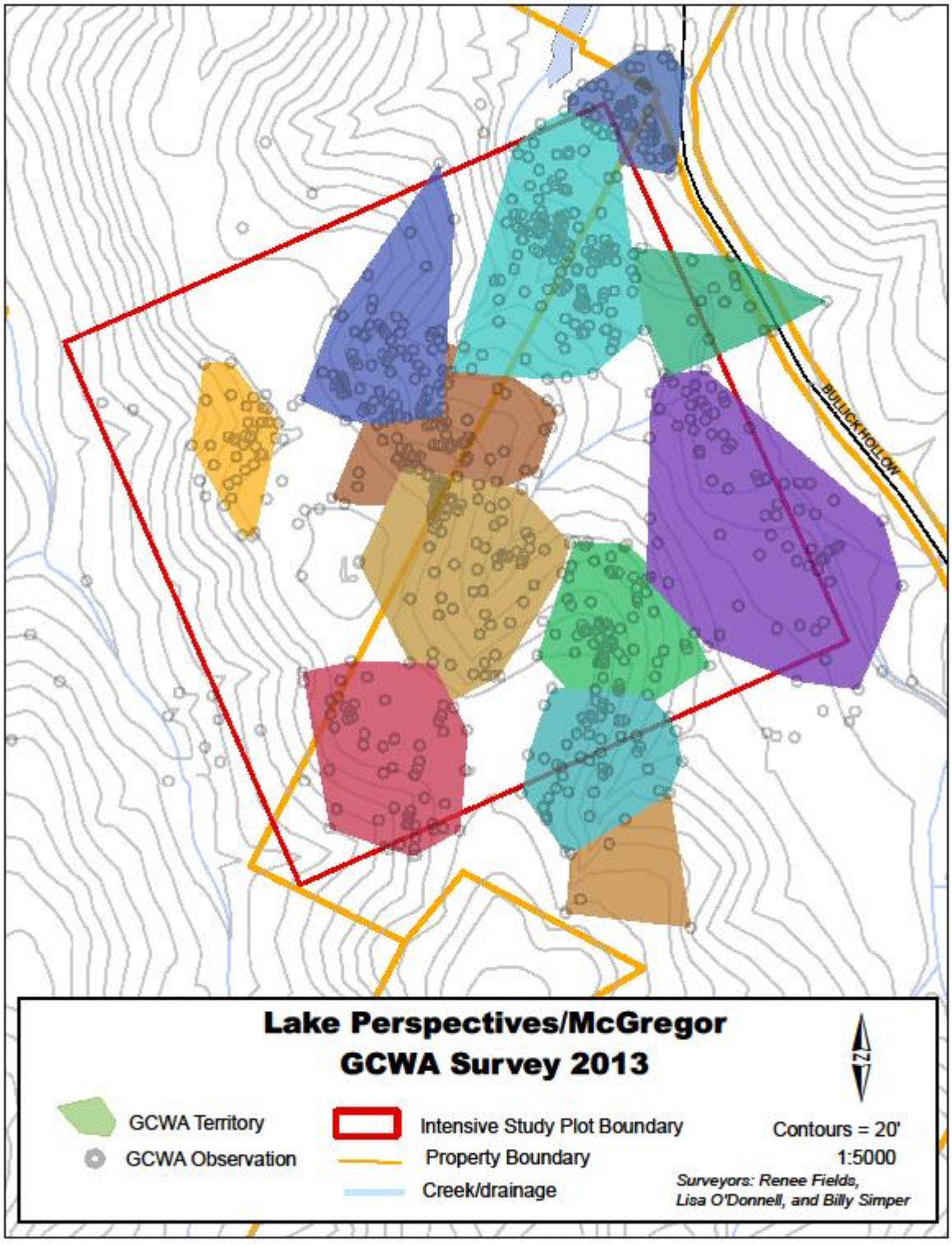


Figure 10

Exhibit A: Minimum Convex Polygons Representing Estimated Golden-cheeked Warbler Territory Boundaries for Intensive Study Plots (Figures 2-18), 2013 (continued).

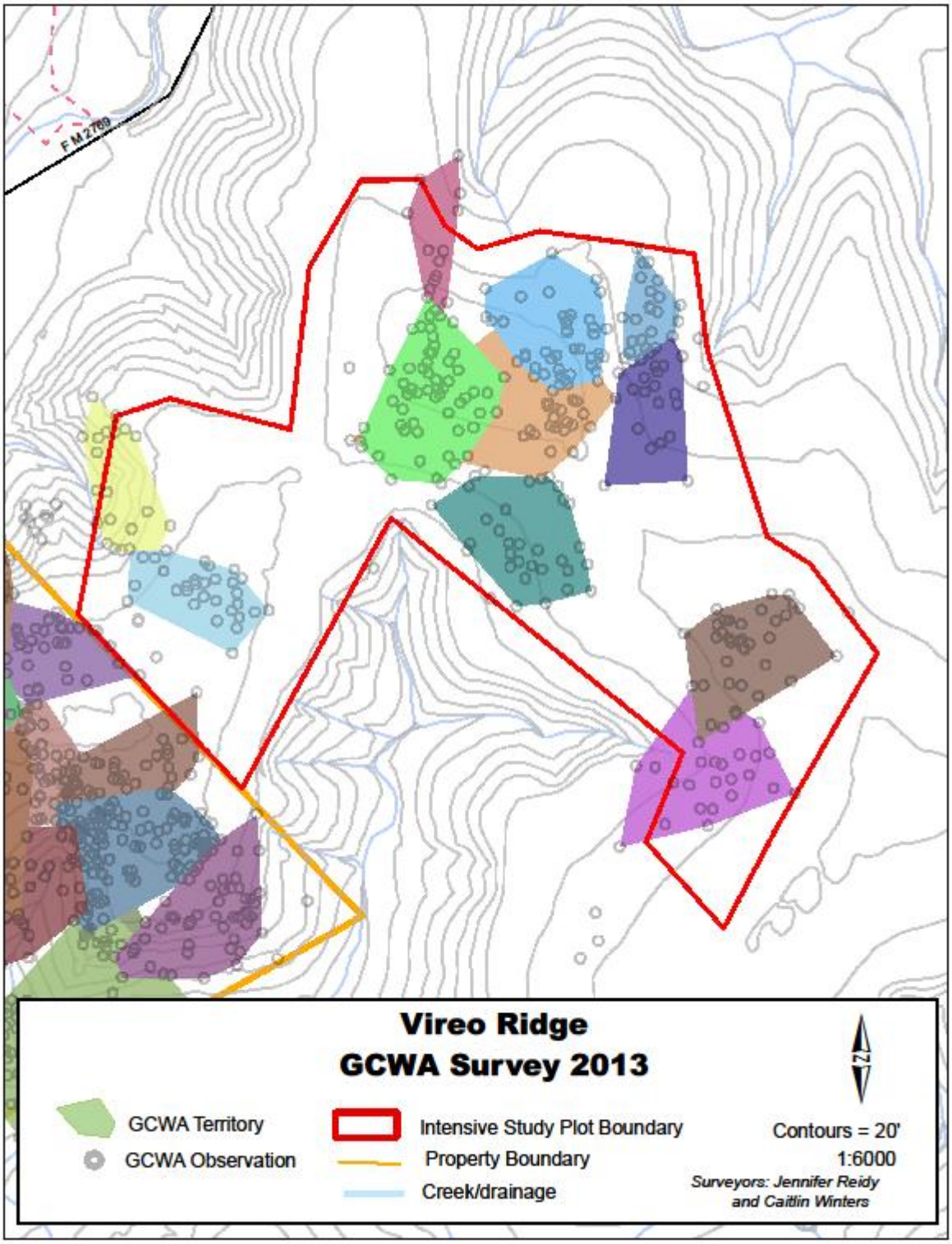


Figure 11

Exhibit A: Minimum Convex Polygons Representing Estimated Golden-cheeked Warbler Territory Boundaries for Intensive Study Plots (Figures 2-18), 2013 (continued).

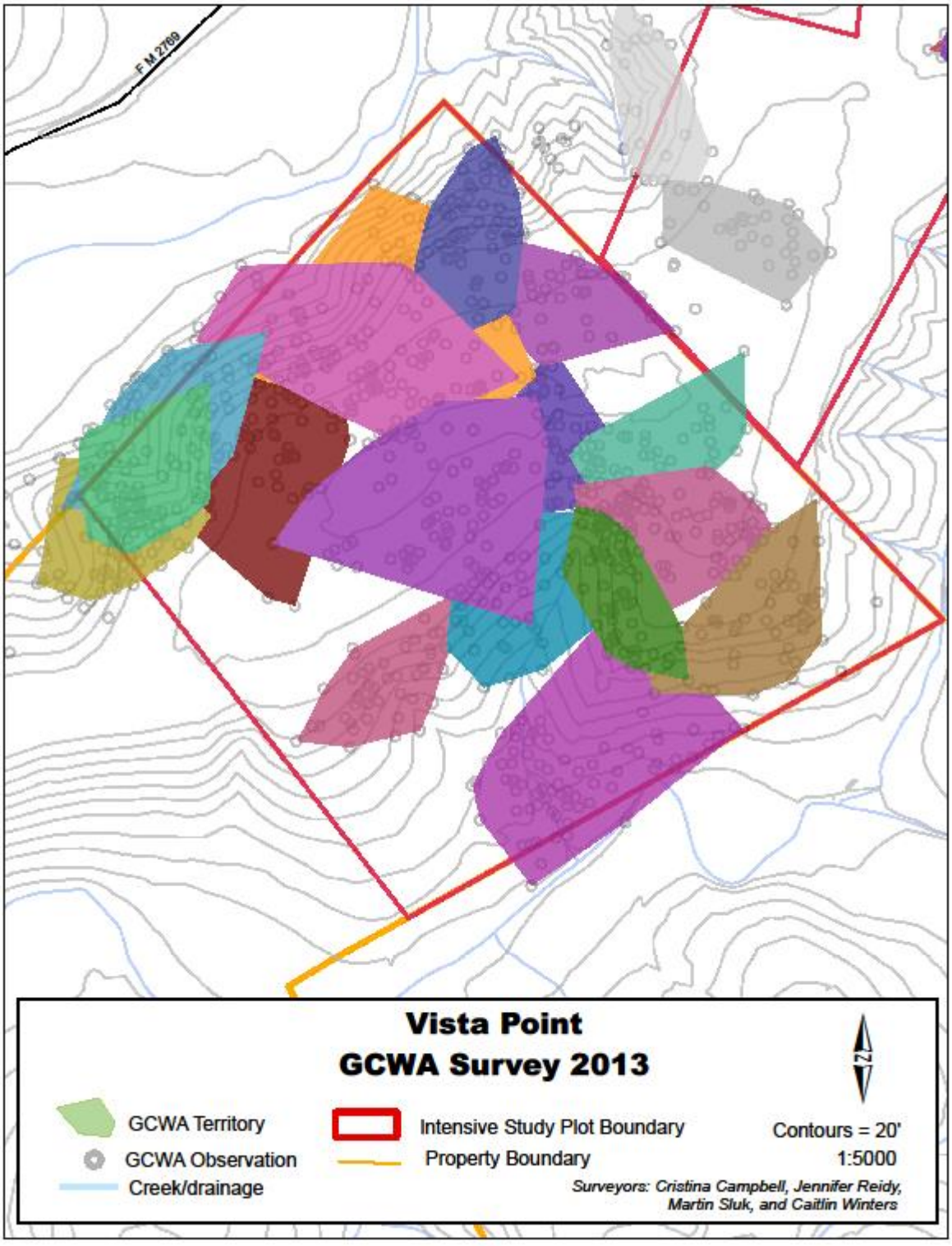


Figure 12

Exhibit A: Minimum Convex Polygons Representing Estimated Golden-cheeked Warbler Territory Boundaries for Intensive Study Plots (Figures 2-18), 2013 (continued).

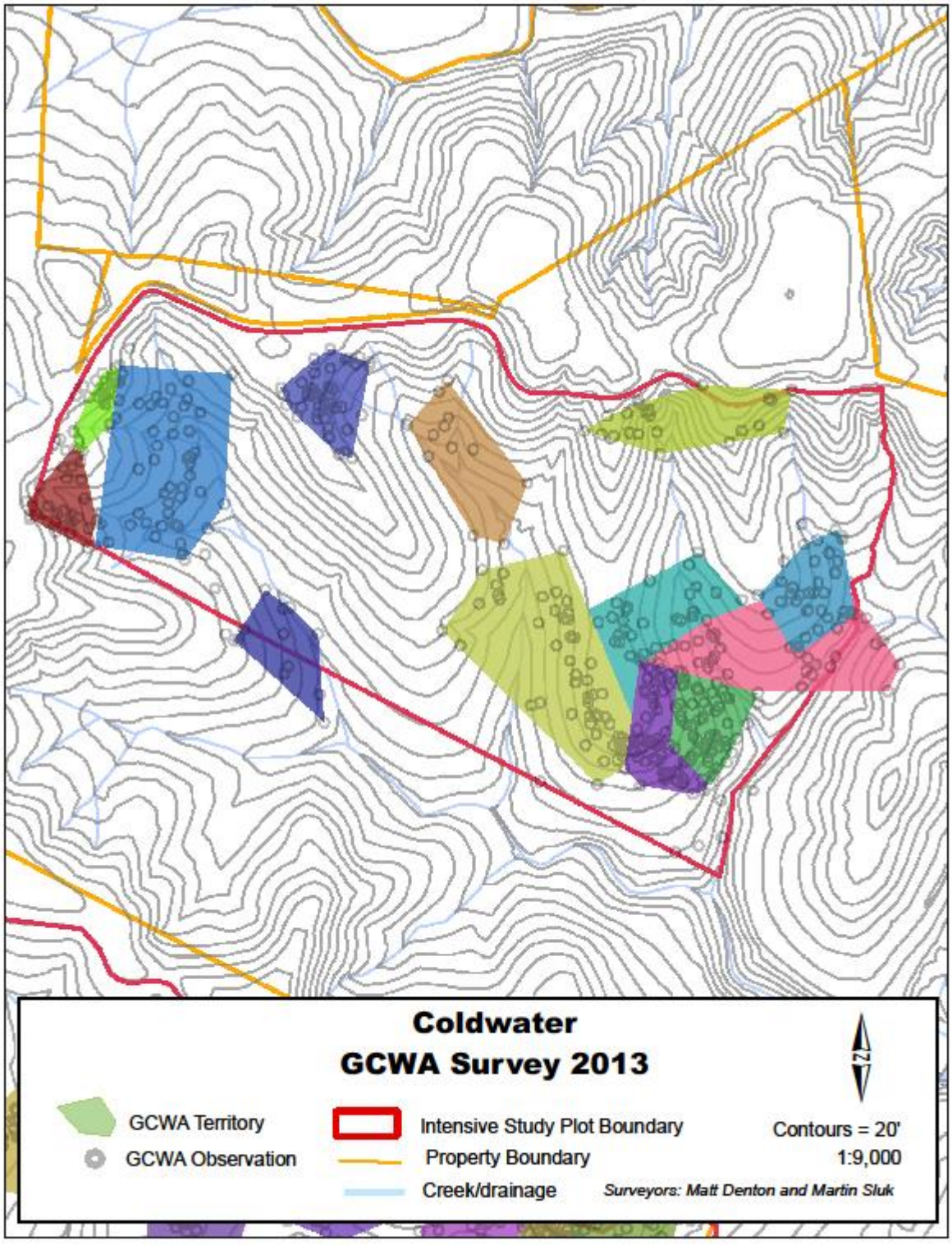


Figure 13

Exhibit A: Minimum Convex Polygons Representing Estimated Golden-cheeked Warbler Territory Boundaries for Intensive Study Plots (Figures 2-18), 2013 (continued).

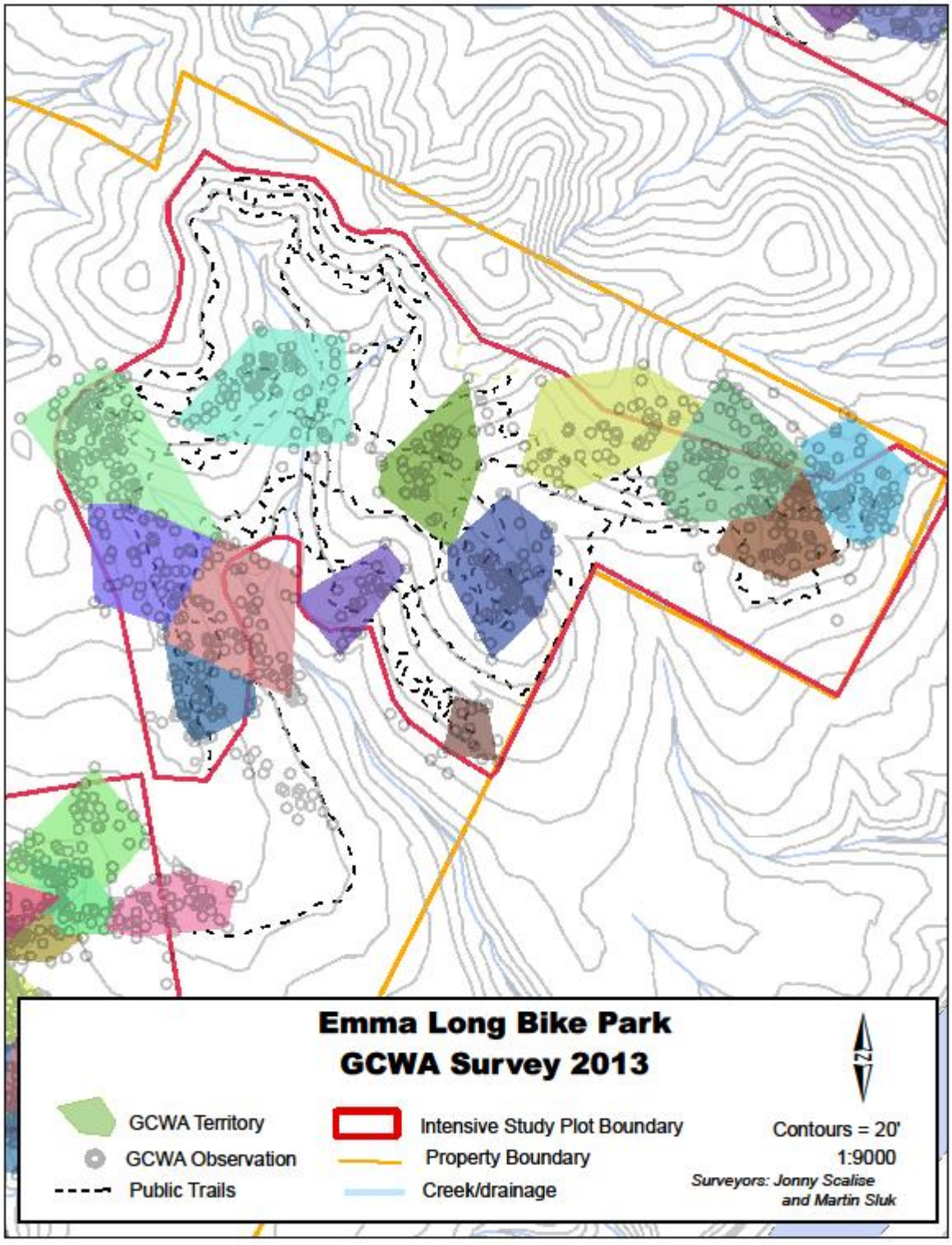


Figure 14

Exhibit A: Minimum Convex Polygons Representing Estimated Golden-cheeked Warbler Territory Boundaries for Intensive Study Plots (Figures 2-18), 2013 (continued).

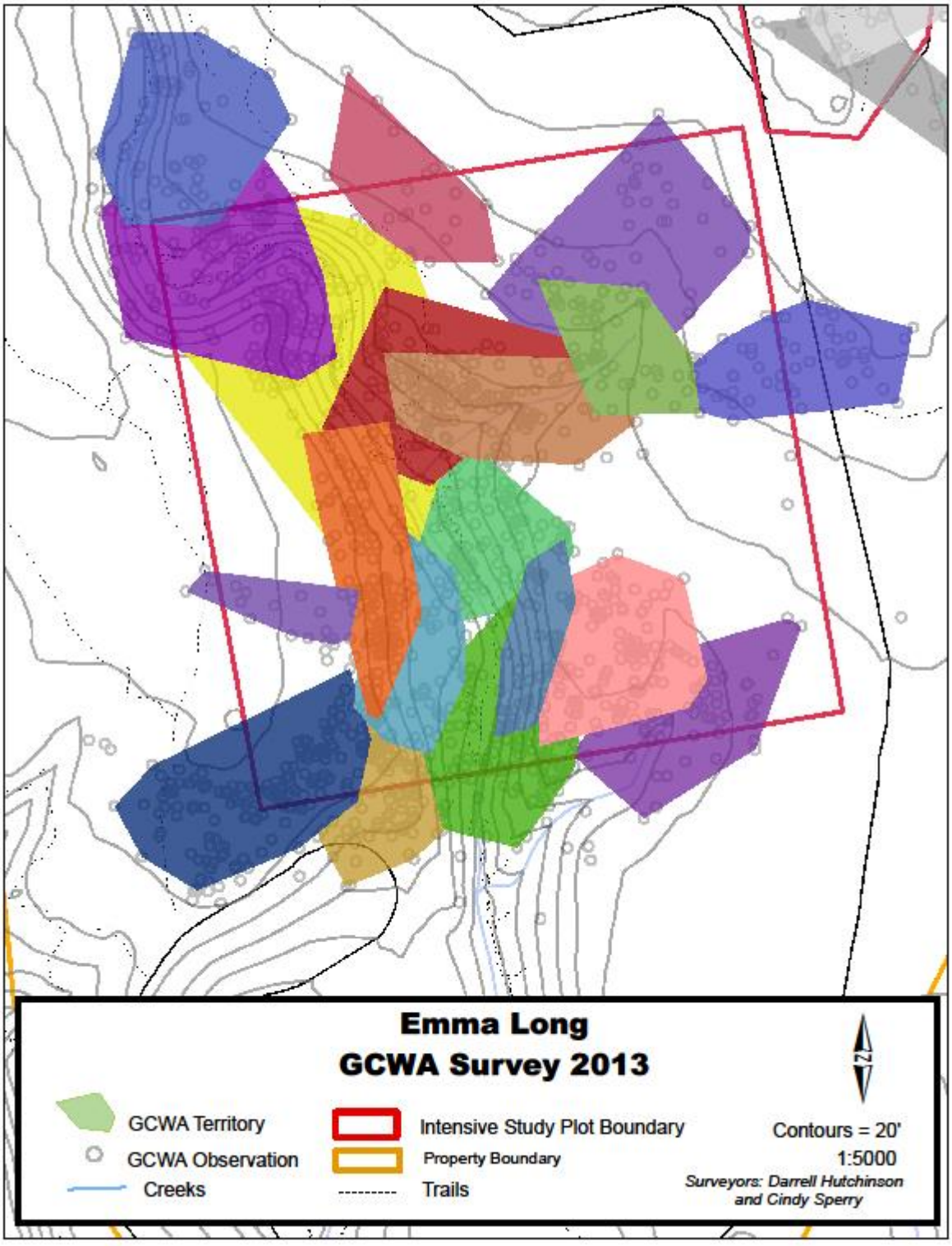


Figure 15

Exhibit A: Minimum Convex Polygons Representing Estimated Golden-cheeked Warbler Territory Boundaries for Intensive Study Plots (Figures 2-18), 2013 (continued).

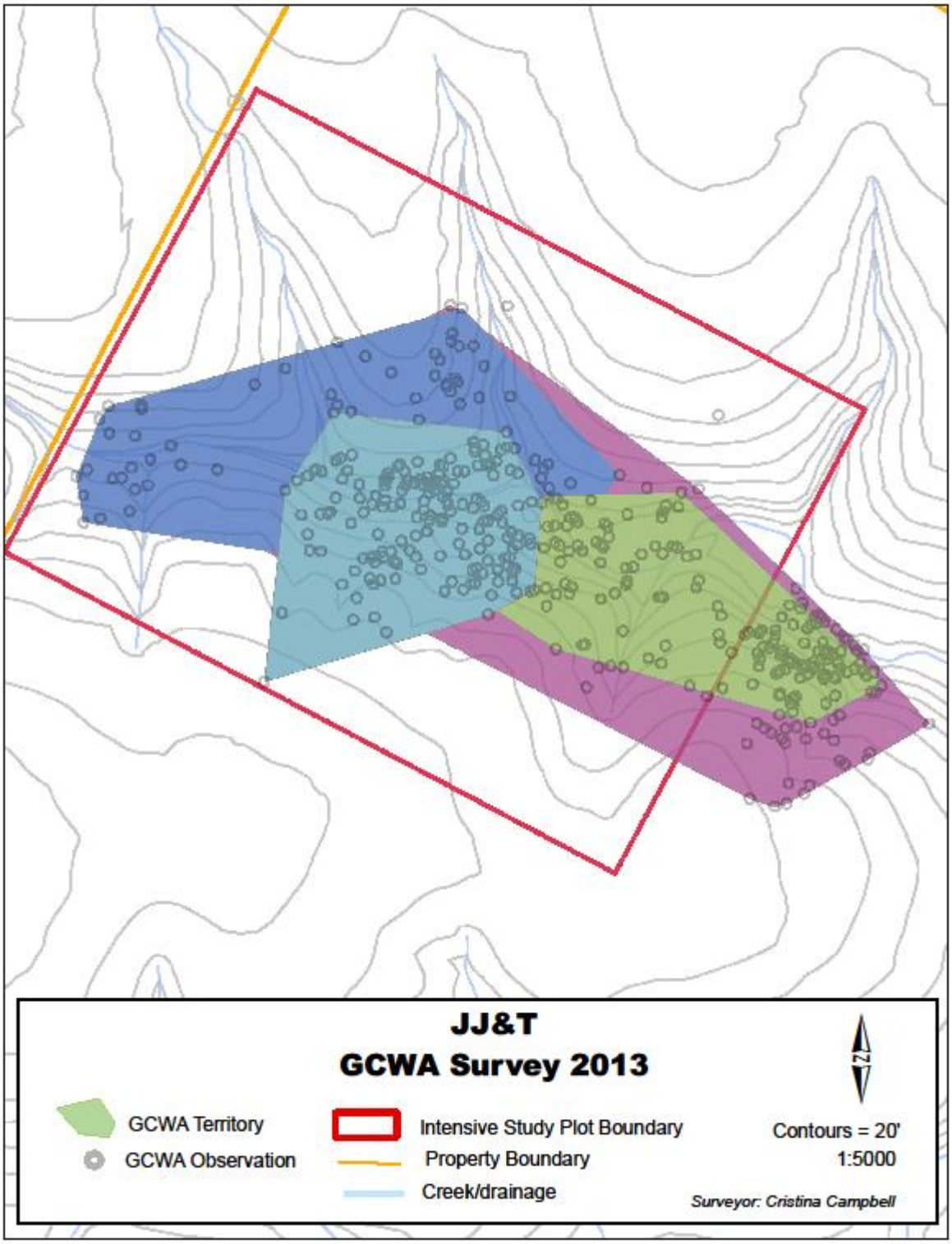


Figure 16

Exhibit A: Minimum Convex Polygons Representing Estimated Golden-cheeked Warbler Territory Boundaries for Intensive Study Plots (Figures 2-18), 2013 (continued).

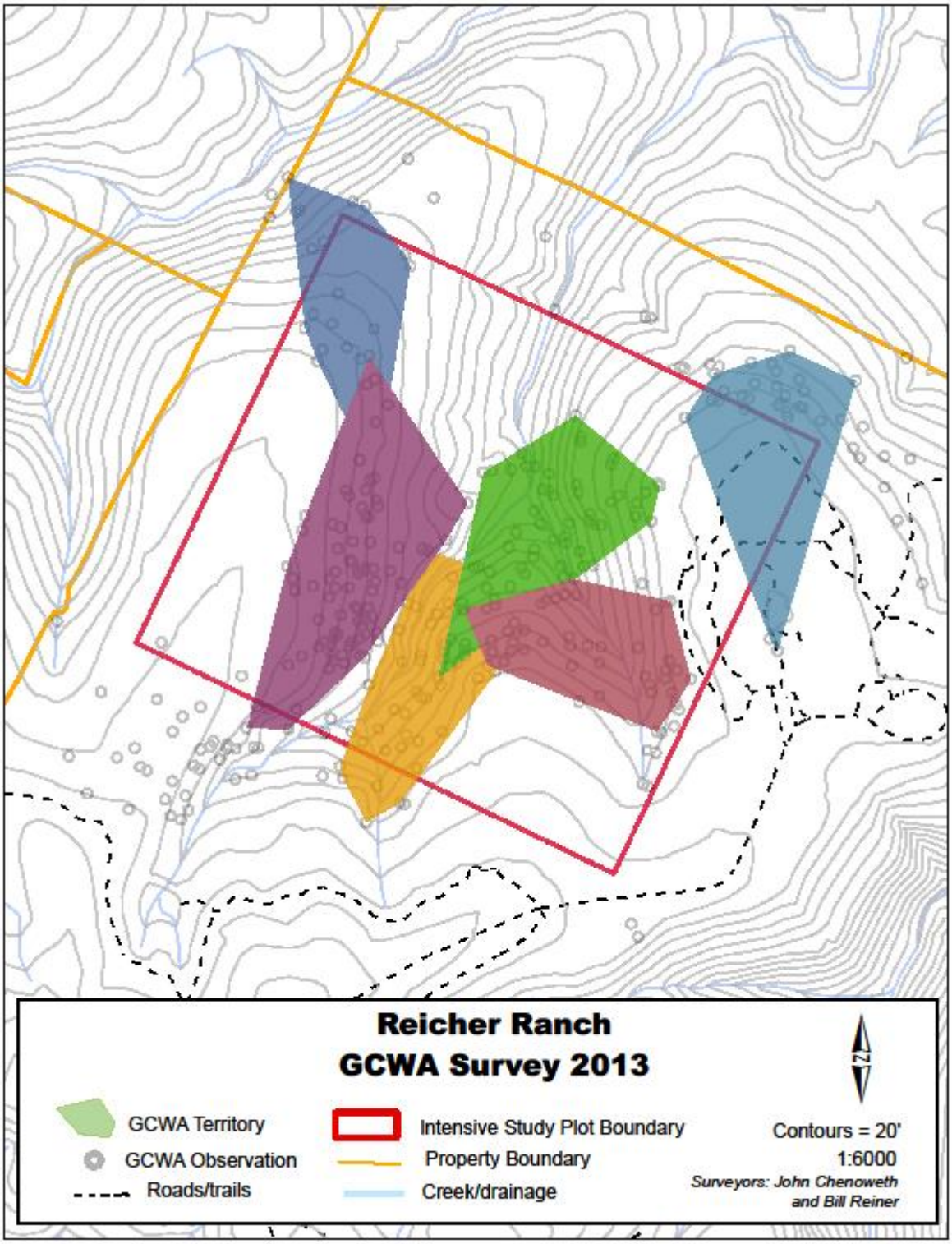


Figure 17

Exhibit A: Minimum Convex Polygons Representing Estimated Golden-cheeked Warbler Territory Boundaries for Intensive Study Plots (Figures 2-18), 2013 (continued).

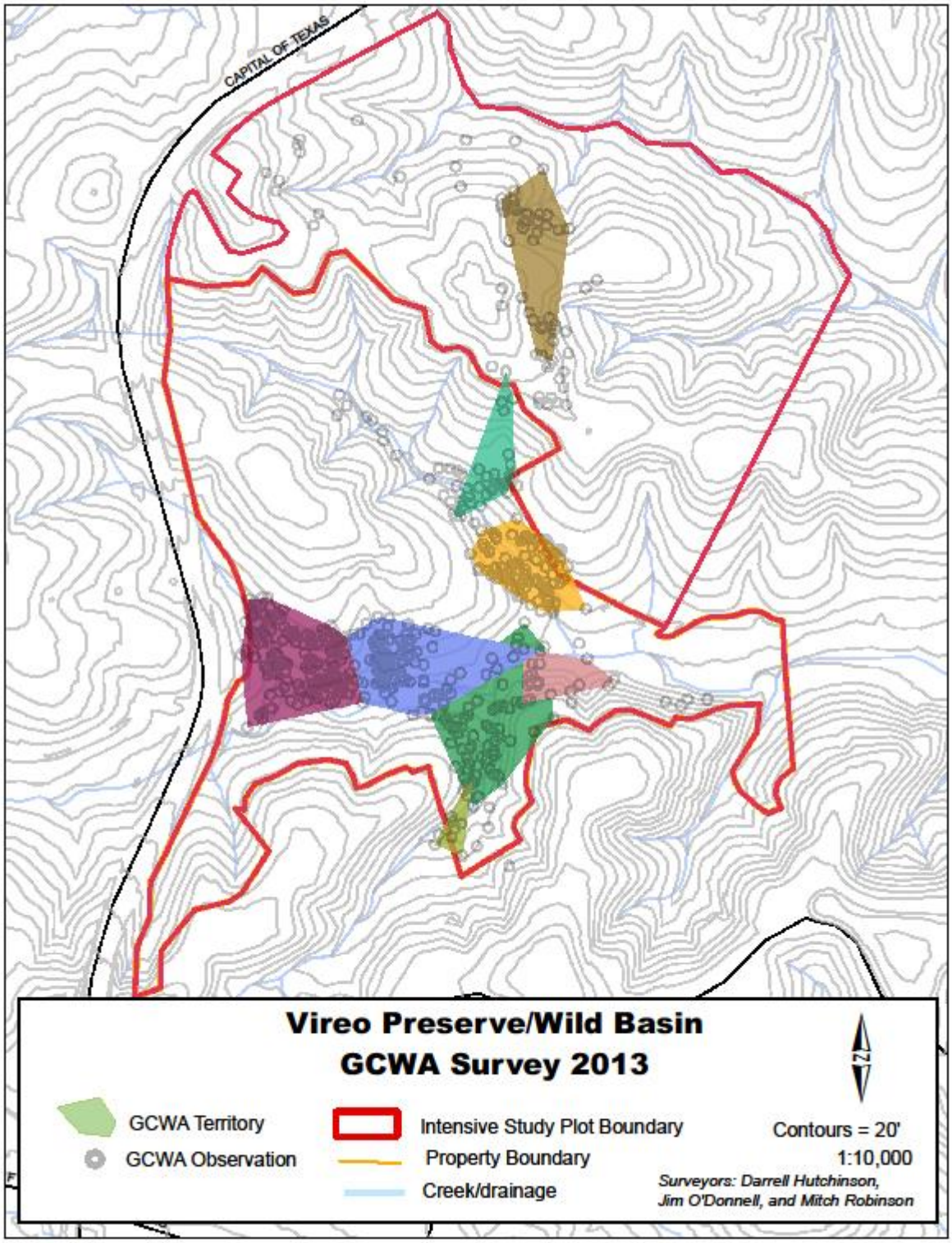


Figure 18

Exhibit B: Summary of Golden-cheeked Warbler Survey Effort on the Balcones Canyonlands Preserve, Travis County, Texas, Field Season 2013.

Intensive Study Plots	Lead Surveyor(s)	Survey Hours (March 11-June 17)	Area Surveyed (hectares)
Barton Creek Macrosite			
Barton Creek	Jonny Scalise, COA Cristina Campbell, USFS	310.0	40.5 + buffer
Gus Fruh/ Sunset Valley	Jonny Scalise, COA Cristina Campbell, USFS	62.0	85 + 27
Bull Creek Macrosite			
3M/St. Edwards	Jason Hunt, Matt Denton, COA	430.0	40.5 + buffer
Canyon Vista	Todd Bayless, Paul Fushille, TC Caitlin Winters, USFS	413.0	40.5 + buffer
Forest Ridge	Jason Hunt, Jim O'Donnell, COA	344.0	40.5 + buffer
Butler	William Reiner, Mark Sanders, COA	390.0	40.5 + buffer
Hamilton West	John Chenoweth, Lisa O'Donnell, COA	251.0	40.5 + buffer
Cypress Creek Macrosite			
Baker Sanctuary	Cindy Sperry, COA Chris Murray, Travis Audubon	238.0	40.5 + buffer
Lake Perspectives/McGregor	Renee Fields, William Simper, TC Lisa O'Donnell, COA	222.0	40.5 + buffer
Vireo Ridge	Jennifer Reidy, Caitlin Winters,USFS	128.0	42
Vista Point	Cristina Campbell, Jennifer Reidy, Martin Sluk, Caitlin Winters, USFS	361.00	40.5 + buffer
North Lake Austin Macrosite			
Bike Park	Martin Sluk, USFS Jonny Scalise, COA	446.0	99
Coldwater	Martin Sluk, USFS Matt Denton, COA	351.0	107
Emma Long	Darrell Hutchinson, Cindy Sperry, COA	466.5	40.5 + buffer
South Lake Austin Macrosite			
Double J&T	Cristina Campbell, USFS	173.0	40.5 + buffer
Reicher	John Chenoweth, William Reiner, COA	185.0	40.5 + buffer
West Austin Macrosite			
Vireo Preserve/Wild Basin	Darrell Hutchinson, Jim O'Donnell, Lisa O'Donnell, COA Mitch Robinson, St. Edwards/Wild Basin	250.0	180
	Total	**5020.5**	**1,026 + buffers**

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

Exhibit B: Summary of Golden-cheeked Warbler Survey Effort on the Balcones Canyonlands Preserve, Travis County, Texas, Field Season 2013 (continued).

Resighting Plots	Surveyor(s)	Survey Hours (March 15-May 25)	Area Surveyed (Hectares)
Barton Creek Macrosite			
Barton Creek Northwest	Shelia Hargis Laurie Foss	34.00	40.5
Barton Creek Southwest	Jacquie Ferrato Ellie Loggins	35.00	40.5
Barton Creek Southeast	Angela Amlin Andrea Julian	21.00	40.5
Bull Creek Macrosite			
Butler East	Christina Williams	13.50	40.5
Butler Northwest Long Canyon	Joseph Hunt Mike Rogan	44.50	81
3M Northeast Hamilton West	Paul Brick Tere Sariol	26.00	81
Butler Southeast Butler Southwest	Jeff Mundy	27.50	81
3M South	Amanda Burke	12.50	40.5
3M Southeast	Deborah Blackburn	18.50	40.5
Hamilton Northeast	Adrian Johnson	22.00	40.5
Hamilton Southeast	Will Burch, Megan Barron, Sarah Richter	--	40.5
Forest Ridge Northeast	Skye Sneed	18.00	40.5
Forest Ridge Southwest Forest Ridge Northwest	Jim Weber Lynne Weber	72.00	81
Forest Ridge Southeast	Claire Parra Stacey Marcus	24.00	40.5
Interplot	Erica Gammill	19.00	40.5
Canyon Vista	Elena Pinto-Torres Bruce Calder	20.00	40.5
Canyon Creek 40.5-Hectare plot	Mark Sanders, COA	39.00	40.5
Ribelin 40.5-Hectare plot	Travis County staff	--	40.5
North Lake Austin Macrosite			
Emma Long East	Charlie Davis Katherine Ross	12.00	40.5
Emma Long West	Katherine Watson	14.00	40.5
Emma Long South	Amy Tsay	18.50	40.5
South Lake Austin Macrosite			
Bohls 40.5-Hectare plot	Jason Hunt, COA	31.50	40.5

COA = City of Austin

Exhibit B: Summary of Golden-cheeked Warbler Survey Effort on the Balcones Canyonlands Preserve, Travis County, Texas, Field Season 2013 (continued).

Resighting Plots	Surveyor(s)	Survey Hours (March 15-May 25)	Area Surveyed (Hectares)
Cypress Creek Macrosite			
Baker Sanctuary North Baker Sanctuary Southeast	Nancy Norman	19.00	81
Baker Sanctuary-- LCRA Northwest	Katherine Ross	18.50	40.5
Baker Sanctuary --LCRA Southwest	Leigh Jandle Joe Jandle	29.5	81
Lake Perspectives Northwest	Shaw McMahon	17.50	40.5
Vista Point Southeast	Steve Janda, Jeff Paull, Mark Wilson	28.00	40.5
Vista Point Southwest	Nevin Durish	18.00	40.5
Vireo Ridge	Kaolin Young Dustin Jones	33.00	40.5
Total		**686**	**1417.5**

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Exhibit B: Summary of Golden-cheeked Warbler Survey Effort on the Balcones Canyonlands Preserve, Travis County, Texas, Field Season 2013 (continued).

Vickery Plots	Surveyor(s)	Survey Hours (March 17-June 10	Area Surveyed (Hectares)
Barton Creek	Grady Terry/Lauren Seagroves	46.75	40.5
Barton Creek	Kelsey Peta	33	40.5
Canyon Vista	Julie Webber	61.68	40.5
Canyon Vista	Lauren Cody	32	40.5
Vista Point	Desirée LaVigne	50.25	40.5
Vista Point	Katheryn Watson	65.15	40.5
Total		**288.83**	**243**

Exhibit C: Golden-cheeked Warbler Intensive Study Plot Protocol, Balcones Canyonlands Preserve, 2013.

Objective: To delineate Golden-cheeked Warbler (GCWA) 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 15 - 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 re-sighting birds not re-sighted during the mapping visit. 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 2013)**. 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 2013 field season will have prior experience conducting Golden-cheeked 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 2013)** 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 2013)**.

Exhibit D: Summary of Golden-cheeked Warbler Banding Data for Intensive Study Plots on the Balcones Canyonlands Preserve, Travis County, Texas, Field Seasons 2009-2013.

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
Gus Fruh/ Sunset Valley	2009	--	--	--
	2010	--	--	--
	2011	0	0	0
	2012	0	0	0
	2013	3	0	3
3M/ St. Edwards	2009	22	1	23
	2010	11	1	12
	2011	16	1	17
	2012	12	1	13
	2013	13	0	13
Canyon Vista	2009	--	--	--
	2010	--	--	--
	2011	15	0	15
	2012	10	0	10
	2013	9	0	9
Forest Ridge	2009	16	0	16
	2010	6	1	7
	2011	18	1	19
	2012	4	4	8
	2013	4	1	5
Butler	2009	21	1	22
	2010	11	0	11
	2011	10	0	10
	2012	13	2	15
	2013	17	1	18
Hamilton West	2009	4	0	0
	2010	11	0	11
	2011	11	0	11
	2012	4	0	4
	2013	6	1	7
Baker Sanctuary	2009	--	--	--
	2010	--	--	--
	2011	11	2	13
	2012	9	1	10
	2013	3	0	3
Lake Perspectives/ McGregor	2009	--	--	--
	2010	--	--	--
	2011	7	1	8
	2012	5	0	5
	2013	4	0	4
Vireo Ridge	2009	--	--	--
	2010	--	--	--
	2011	10	0	10
	2012	7	0	7
	2013	2	1	3

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
Vista Point	2009	--	--	--
	2010	--	--	--
	2011	17	1	18
	2012	6	0	6
	2013	6	0	6
Coldwater	2009	--	--	--
	2010	13	0	13
	2011	8	0	8
	2012	2	1	3
	2013	7	0	7
Bike Park	2009	--	--	--
	2010	8	0	9
	2011	12	0	12
	2012	8	0	8
	2013	7	0	7
Emma Long	2009	14	0	14
	2010	3	0	3
	2011	10	2	12
	2012	3	0	3
	2013	5	1	6
Double J&T	2009	1	0	1
	2010	3	0	3
	2011	2	0	2
	2012	2	0	2
	2013	4	0	4
Reicher	2009	--	--	--
	2010	--	--	--
	2011	3	0	3
	2012	1	0	1
	2013	5	0	5
Wild Basin/ Vireo Preserve	2009	--	--	--
	2010	--	--	--
	2011	9	0	9
	2012	1	1	2
	2013	4	1	5
Bohls	2009	2	0	2
	2010	4	0	4
	2011	--	--	--
	2012	--	--	--
	2013	--	--	--
Canyon Creek	2009	15	1	16
	2010	8	0	8
	2011	--	--	--
	2012	--	--	--
	2013	--	--	--
Ribelin	2009	--	--	--
	2010	4	0	4
	2011	--	--	--
	2012	--	--	--
	2013	--	--	--

Exhibit E: Summary of Golden-cheeked Warbler Territory Data for Intensive Study Plots on the Balcones Canyonlands Preserve, Travis County, Texas, Field Seasons 2009-2013. 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
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
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
Canyon Vista	2009	--	--	--	--
	2010	--	--	--	--
	2011	10	22	16	0.40
	2012	6	23	14.5	0.36
	2013	7	22	14.5	0.36
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
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
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
Baker Sanctuary	2009	--	--	--	--
	2010	--	--	--	--
	2011	5	16	10.5	0.26
	2012	8	12	10	0.25
	2013	6	14	10	0.25
Lake Perspectives/ McGregor	2009	--	--	--	--
	2010	--	--	--	--
	2011	5	10	7.5	0.19
	2012	4	10	7	0.17
	2013	6	11	8.5	0.21
Vireo Ridge	2009	--	--	--	--
	2010	--	--	--	--
	2011	7	13	10	0.25
	2012	12	16	14	0.24
	2013	9	11	10	0.24

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
Vista Point	2009	--	--	--	--
	2010	--	--	--	--
	2011	15	17	16	0.40
	2012	13	20	14	0.24
	2013	10	17	13.5	0.33
Coldwater	2009	--	--	--	--
	2010	12	12	12	0.11
	2011	11	16	13.5	0.14
	2012	7	12	9.5	0.09
	2013	10	13	11.5	0.11
Bike Park	2009	--	--	--	--
	2010	9	9	9	0.09
	2011	12	15	13.5	0.14
	2012	12	17	14.5	0.15
	2013	5	13	9	0.09
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
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
Reicher	2009	--	--	--	--
	2010	--	--	--	--
	2011	3	4	3.5	0.09
	2012	2	6	4	0.10
	2013	3	6	6	0.11
Wild Basin/ Vireo Preserve	2009	--	--	--	--
	2010	--	--	--	--
	2011	8	11	9.5	0.05
	2012	6	6	6	0.03
	2013	8	8	8	0.04

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 2009-2013.

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

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

.

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

Exhibit G: Summary of Golden-cheeked Warbler Return Rates for Males Banded on Intensive Study Plots, Balcones Canyonlands Preserve, Travis County, Texas, Field Seasons 2009-2013.

Plot Name	Survey Year	Males Banded	2009 Returning Males	2010 Returning Males	2011 Returning Males	2012 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
Gus Fruh/ Sunset Valley	2009	--	--	--	--	--	--
	2010	--	--	--	--	--	--
	2011	0	--	--	--	--	--
	2012	0	--	--	--	--	--
	2013	3	--	--	--	--	--
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
Canyon Vista	2009	--	--	--	--	--	--
	2010	--	--	--	--	--	--
	2011	15	--	--	--	--	--
	2012	10	--	--	9	--	9
	2013	9	--	--	4	5	9
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
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
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
Baker Sanctuary	2009	--	--	--	--	--	--
	2010	--	--	--	--	--	--
	2011	11	--	--	--	--	--
	2012	9	--	--	4	--	4
	2013	3	--	--	2	4	6
Lake Perspectives/ McGregor	2009	--	--	--	--	--	--
	2010	--	--	--	--	--	--
	2011	7	--	--	--	--	--
	2012	5	--	--	5	--	5
	2013	4	--	--	4	3	7
Vireo Ridge	2009	--	--	--	--	--	--
	2010	--	--	--	--	--	--
	2011	10	--	--	--	--	--
	2012	7	--	--	5	--	5
	2013	2	--	--	3	5	8

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	Total Returning Males
Vista Point	2009	--	--	--	--	--	--
	2010	--	--	--	--	--	--
	2011	17	--	--	--	--	--
	2012	6	--	--	11	--	11
	2013	6	--	--	3	4	7
Coldwater	2009	--	--	--	--	--	--
	2010	13	--	--	--	--	--
	2011	8	--	5	--	--	5
	2012	2	--	4	4	--	8
	2013	7	--	3	0	0	3
Bike Park	2009	--	--	--	--	--	--
	2010	8	--	--	--	--	--
	2011	12	--	2	--	--	2
	2012	8	--	2	8	--	10
	2013	7	--	1	1	1	3
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
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
Reicher	2009	--	--	--	--	--	--
	2010	--	--	--	--	--	--
	2011	3	--	--	--	--	--
	2012	1	--	--	1	--	1
	2013	5	--	--	0	1	1
Wild Basin/ Vireo Preserve	2009	--	--	--	--	--	--
	2010	--	--	--	--	--	--
	2011	9	--	--	--	--	--
	2012	1	--	--	7	--	7
	2013	4	--	--	6	1	7
Bohls	2009	2	--	--	--	--	--
	2010	4	0	--	--	--	0
	2011	--	0	1	--	--	1
	2012	--	0	1	--	--	1
	2013	--	0	1	--	--	1
Canyon Creek	2009	15	--	--	--	--	--
	2010	8	2	--	--	--	2
	2011	--	0	4	--	--	4
	2012	--	0	5	--	--	5
	2013	--	0	1	--	--	1
Ribelin	2009	--	--	--	--	--	--
	2010	6	--	--	--	--	--
	2011	--	--	4	--	--	4
	2012	--	--	0	--	--	0
	2013	--	--	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 2009-2013. 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
Gus Fruh/ Sunset Valley	2009	--	--	--	--
	2010	--	--	--	--
	2011	0	0	0	0
	2012	0	0	0	0
	2013	100	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
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
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
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
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
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
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
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

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
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
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
Bike Park	2009	--	--	--	--
	2010	89	56	8 / 18	0.08 / 0.18
	2011	92	58	24 / 27	0.23 / 0.25
	2012	100	100	33 / 38	0.28 / 0.33
	2013	92	69	26 / 32	0.16 / 0.20
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
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
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
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

Exhibit I. Summary of Vegetation Data Collected for Golden-cheeked Warbler Nests Found within the Balcones Canyonlands Preserve, Travis County, Texas, field seasons 2011-2013.

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)	265 (66%)	7.9 (2.2 – 16.9)	27.5 (7 – 89.5)	6.3 (2 – 16.2)	88.0 (49.7 – 99.7)	174 (66%)
Ulmus crassifolia (Cedar Elm)	45 (11%)	10.5 (4.8 – 18.3)	25.0 (12 - 53)	8.6 (3.3 – 15.4)	88.6 (64.8 – 99.7)	26 (58%)
Quercus fusiformis (Live Oak)	64 (16%)	8.7 (4 – 13.9)	26.7 (10.5 – 80)	6.6 (3.1 – 11.6)	83.5 (34.9 – 99.2)	39 (61%)
Quercus sinuata var. *breviloba* (Shin Oak)	18 (5%)	8.8 (4.3 – 16.6)	21.0 (9.4 – 48)	6.8 (3.5 – 8.5)	90.6 (80.7 – 100)	10 (56%)
Quercus buckleyi (Texas Red Oak)	6 (2%)	10.0 (7.1 – 15.1)	34.5 (17 – 69)	7.6 (5 – 11.2)	94.4 (82.6 – 100)	1 (17%)
Ulmus americana (American Elm)	1 (0%)	23.8	28.5	21.4	93.8	1 (100%)
Juglans major (Arizona walnut)	1 (0%)	9.8	29.0	7.8	97.9	1 (100%)
Totals	**400**	**8.4 (2.2 – 23.8)**	**26.8 (7 – 89.5)**	**6.7 (2.0 – 21.4)**	**87.6 (34.9 – 100)**	**252**

Exhibit J. Results of Vickery Method Surveys and Comparison with Intensive Monitoring Data on Three Intensive Study Plots on the Balcones Canyonlands Preserve, Travis County, Texas (Figures 1-4), 2013.

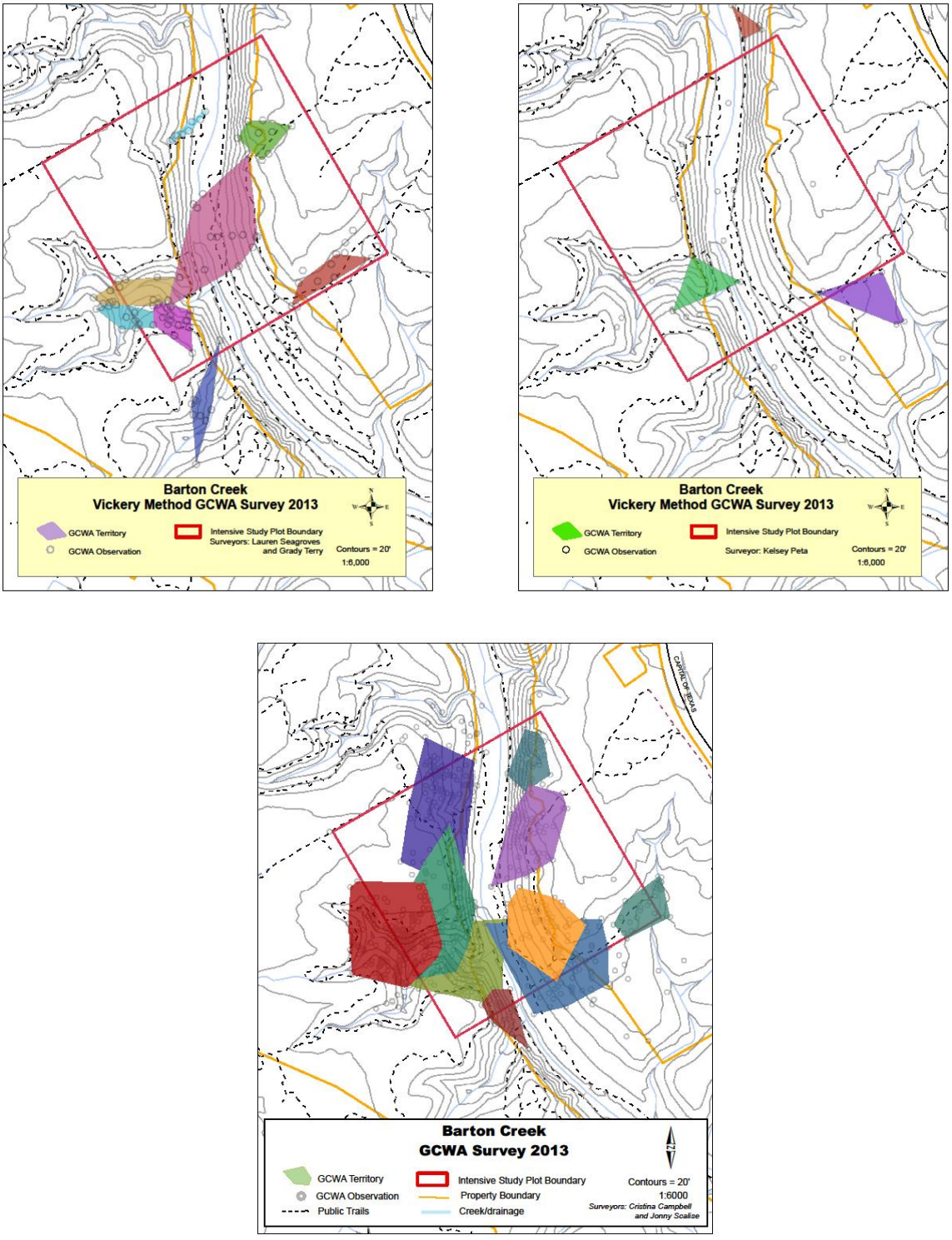


Figure 1. Minimum Convex Polygons Representing Estimated Golden-cheeked Warbler Territory Boundaries from Independent Surveys Using the Vickery Method and Intensive Monitoring for the Barton Creek 40.5-ha plot.



Figure 2. Minimum Convex Polygons Representing Estimated Golden-cheeked Warbler Territory Boundaries from Independent Surveys Using the Vickery Method and Intensive Monitoring for the Canyon Vista 40.5-ha plot.

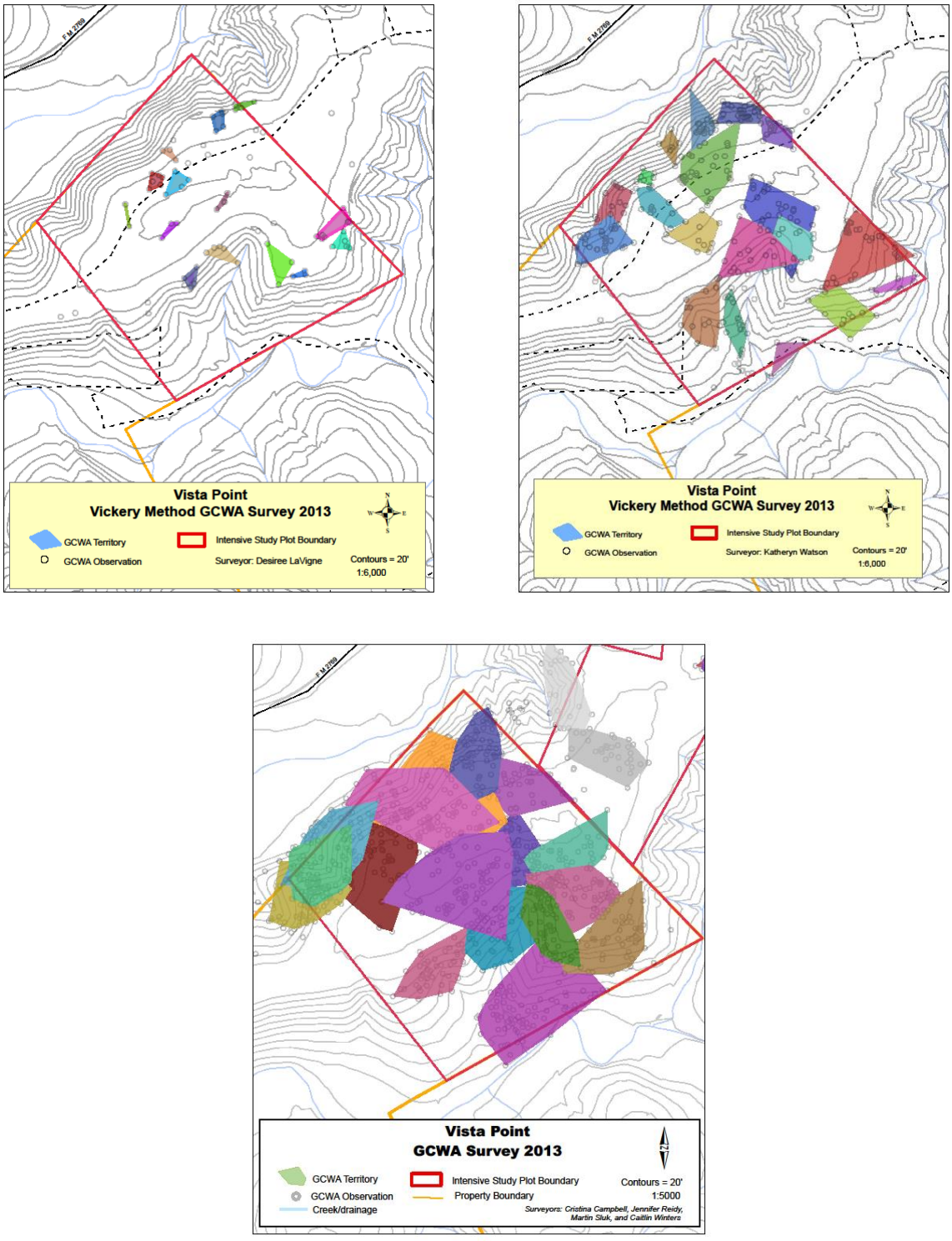
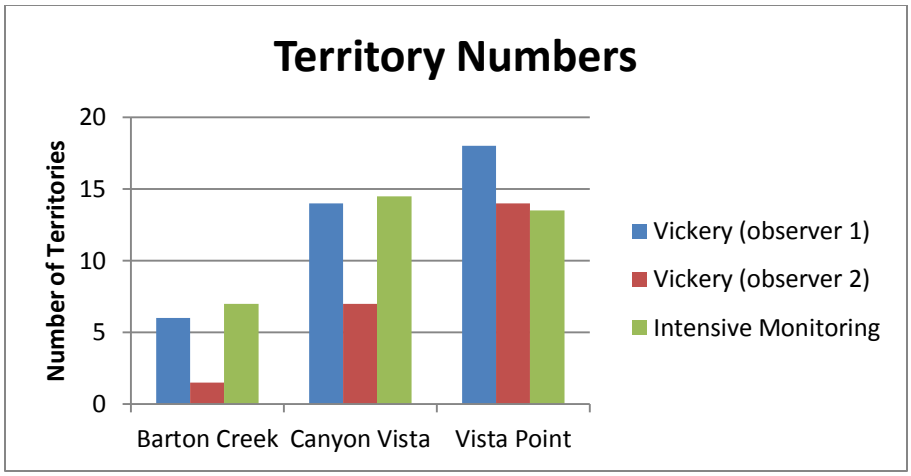
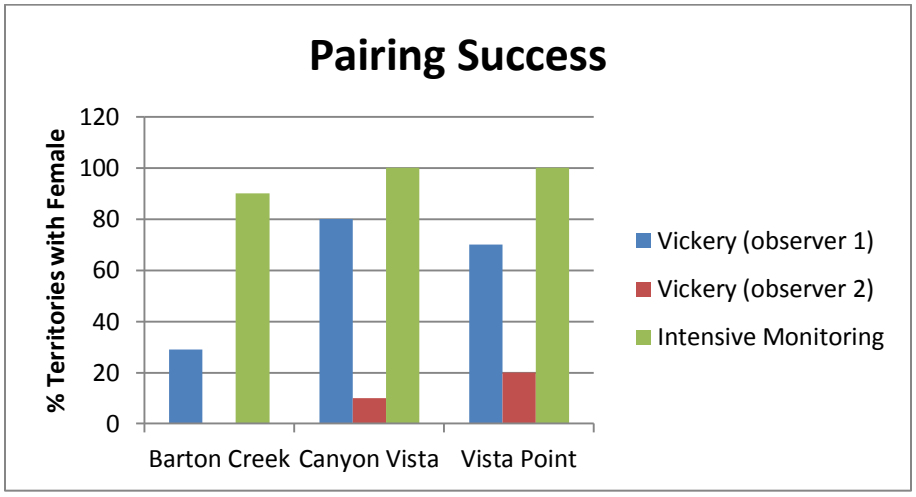


Figure 3. Minimum Convex Polygons Representing Estimated Golden-cheeked Warbler Territory Boundaries from Independent Surveys Using the Vickery Method and Intensive Monitoring for the Vista Point 40.5-ha plot.





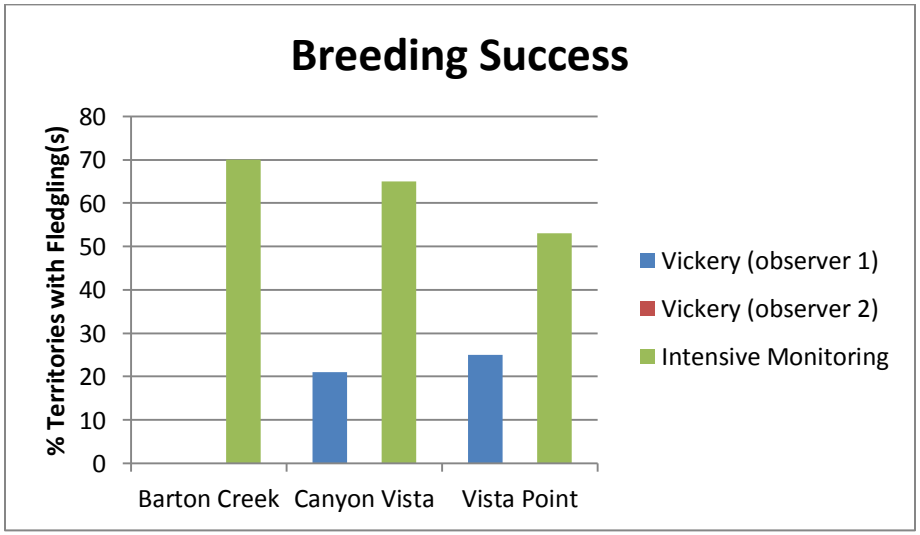


Figure 4. Comparison of Territory Number, Pairing Success, and Breeding Success for Independent Surveys Conducted using the Vickery Method and Intensive Monitoring.

Exhibit K: Golden-cheeked Warbler Population Viability and Habitat Suitability within the Balcones Canyonlands Preserve, Progress Report for Year 2 (2012).

GOLDEN-CHEEKED WARBLER POPULATION VIABILITY AND HABITAT SUITABILITY WITHIN THE BALCONES CANYONLANDS PRESERVE: YEAR 2 PROGRESS REPORT, FEBRUARY 2013

Jennifer L. Reidy, Research Specialist, Department of Fisheries and Wildlife Sciences, 302 Anheuser-Busch Natural Resources Building, University of Missouri, Columbia, MO 65211
Frank R. Thompson, III, Research Biologist, U.S.D.A. Forest Service Northern Research Station and Department of Fisheries and Wildlife Sciences, 202 Anheuser-Busch Natural Resources Building, University of Missouri, Columbia, MO 65211
Lisa O'Donnell, City of Austin, Austin Water Utility, Wildland Conservation Division, Balcones Canyonlands Preserve, Austin, Texas

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 2, we continued our collaborative effort with cooperating partners to implement field methods initiated in 2011. We collected demographic data on the intensive monitoring plots chosen in 2011. Additionally, we completed avian and vegetation surveys across the preserve. We present preliminary results from the model-predicted density estimates from point counts and nest survival estimation based on 2 years, and summaries of the point count and nest vegetation surveys, nest monitoring, and productivity for 2012.

Methods

Abundance-We created a point grid with 250-m spacing and randomly located it on BCP in ArcMap 9.3, 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 decrease 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 connectedness (see Fig. 1). Just as we did in 2011, we selected every third transect to be surveyed in year 2 (2012).

We conducted 10-min, unlimited-radius point counts from 10 mins post-sunrise until ~1100 from April 16-May 14, 2012 (our sampling window was approx. 1 week later than 2011 because warblers arrived on plots later). We used 10-min counts because they permit us to flexibility in exploring several alternative approaches to modeling abundance including time-of-detection models, which require several time intervals to model detection probability. 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 bird species identification prior to conducting surveys; additionally they were tested for species identification and distance estimation.

We measured vegetation composition and structure at each point following 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 (woody stems >10 cm high and <2.5 cm at 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 for four categories, shrub, grass/forb, bare/rock/debris, and litter in a 5-m radius around the point. We

averaged juniper and oak/hardwood tree height in each quadrant in an 11.3-m radius. We measured dbh of all live stems > 2.5 cm with a Biltmore stick in an 11.3-m radius from the point in the following categories: junipers, live oaks, Texas red oaks, shin oaks, and other trees. We measured dbh of all stems that forked below 1.3 m and calculated basal area for each species group for a plot as the sum of the cross sectional area of all stems with a measured dbh (Husch et al. 2003). 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 those same tree categories. We noted dbhs of all stems that were part of the same multi-stemmed juniper tree so either City of Austin (2013) or Forest Service (2012) protocols can be used to estimate base diameters where desired in the future.

We calculated landscape metrics in ArcMap 10.0 and Fragstats using the Texas Ecological Systems phase 1 vegetation classification. We calculated the proportion of total forest and 3 forest types (juniper-dominated, mixed, hardwood-dominated [deciduous and live oak]) at three spatial scales: 500-m, 1-km, and 5-km radius around each survey point. We also calculated edge density (the interface between forest and non-forest) in a 500-m radius from each point. We will reconsider the best radii for summarizing landscape statistics from 100 m to 5 km with the 2011-2013 data.

We estimated detection probability and density using hierarchical distance-based models in the program unmarked (Fiske and Chandler 2011). This method allows simultaneous estimation of the detection probability and density. We truncated data to include detections of warblers within 125 m of the point to remove outliers (upper 5-10% of distances), which permits better fitting of the detection function. 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, three standard distance-based detection functions used with point counts (Buckland et al. 2001). The variables of interest were observer, time since sunrise, temperature, and day of year. We then brought forward the most supported key function and detection variables into our habitat and landscape models. We evaluated multi-collinearity for each model and did not include correlated variables in individual models. We evaluated support for 19 vegetation models and 24 landscape models (Table 1) using an information-theoretic approach by ranking the ΔAIC_c and corresponding Akaike's weights (w_i). We used the most supported models to predict golden-cheeked warbler density for different values of the habitat and landscape variables, and in ArcMap 10.0 we used the most supported landscape covariates to create a density map of the BCP at a 10-m pixel resolution. We ran 100 iterations of a parametric bootstrap to incorporate uncertainty in the predicted densities.

Productivity-We searched for nests and fledglings of golden-cheeked warblers on 18 intensive monitoring plots (21-107 ha) situated on 7 of the 9 patches (or 5 of 6 macrosites) and follow standard monitoring protocols (Martin et al. 1997). Nests were 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, following modified BBIRD protocol (Martin et al. 1997). We calculated the nest height and the dbh and height of the tree stem the nest was in. If the nest was in a multi-stemmed juniper tree we noted all dbhs that were from that tree so the City of Austin protocol can be used to estimate base diameter. 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. 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 used an information-theoretic approach to evaluate candidate models representing our *a priori* predictions about factors affecting golden-cheeked warbler nest survival. We developed 11 models and

ranked model support by Akaike's weights (w_i). We included day of year and nest stage in every model because they are known to affect golden-cheeked warbler nest survival (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 (confirmed by verifying nest contents or adult behavior) and intervals (eggs or nestlings) in analyses. We estimated daily survival using the logistic exposure method with a binomial response for each monitoring interval (success=1, failure=0). We predicted nest survival as a function of the variables in the most supported model by varying each variable across the observed range of values while holding other variables at their mean. We will explore support for additional variables such as nest tree species with the 2011-2013 data.

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.

Results

Abundance-Two observers completed 39 point transects comprised of 341 points and detected a total of 190 golden-cheeked warblers in 2012, totaling 731 points (Fig. 1) and 479 males over the 2 years. We combined the 2011 and 2012 data and analyzed the complete dataset. We found the most support for observer affecting detection probability and the overall detection probability was 0.27 (Fig. 2). The most supported habitat model with 52% of the model support included the variables tree basal area, canopy cover, slope, tree height, total woody stem density, and litter ground cover (Table 2). Density of golden-cheeked warblers was positively related to juniper basal area (Fig. 3) and oak basal area (Fig. 4), non-juniper height (Fig. 5), canopy cover (Fig. 6), and slope (Fig. 7). The most supported landscape model included the variables forest cover in 500-m and edge density in 500-m (Table 3). Density of golden-cheeked warblers was positively related to forest cover (Fig. 8) and negatively to edge density (Fig. 9). The model with the most supported habitat and landscape variables received more support than the model with only habitat or landscape variables, a model with variable site (representing the nine patches), and a null model (Table 4). Predicted density was 0.24 (0.02-0.29). Density was highest in Bull Creek and lowest in Barton Creek Habitat Preserve and West Austin (Fig. 10). Using the best landscape model, we created a spatially-explicit density distribution map for the BCP (Fig 11). Point count vegetation measurements are summarized in Table 5. We will compare density estimates from the point count models to abundance from spot mapping on intensive monitoring plots after the 2013 season.

Productivity-We located 151 nests in 2012, of which we confirmed at least one fledgling from 90 nests (60%) and followed standard nest monitoring and analysis protocols . We followed standard nest monitoring and analysis protocols and did not include nests before they could be confirmed active by the presence of an egg or nestling and deleted the final monitoring interval for two nests with unknown fates Martin et al. 1997, Schaffer 2004). We monitored 256 active nests for 2011-2012 (Fig. 12). Daily nest survival based on 1102 monitoring intervals was 0.971 (0.961-0.979) and period survival for the 25-day nesting cycle was 0.478 (0.366-0.582). The most supported model included the variable slope in addition to the temporal variables (Table 6). Nest survival declined throughout the season but rebounded for very late nests (Fig. 13). Nest survival decreased for nests on steeper slopes (Fig. 14). Nest vegetation measurements are summarized in Table 7. We monitored a total of 235 territories, of which we assigned a territory success fate to 213. We documented 477 fledglings on the intensive monitoring plots. Productivity was 2.24 young per territory and 3.04 young per successful territory.

Conclusions

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). This study is the first to our knowledge to develop a spatially-explicit abundance 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 habitat measurements. We generated predictions of density across the entire BCP based on results of the avian surveys using the relationship we found between abundance and landscape metrics. We plan to validate our density predictions by: 1) comparing our predictions to spot-mapping results, and 2) using our current model to predict density at points we plan to sample during year 4 and 5. The final density distribution map will be based on field-based vegetation measurements, LIDAR, and landcover classifications. Based on the number of point count transects completed in 2011 and 2012, it will take a total of 5 years total to survey abundance across the entire preserve if cooperators choose to continue this project through the 2015 field season. However, we may be able to produce models that perform well from a smaller sample of points and will evaluate model performance after each successive season. Based on results from year 1 that provided evidence that the landscape-scale metrics we used were adequate for predicting abundance at large, contiguous patches, but were not adequate to predict abundance at smaller, more fragmented patches (based on the comparison between territory mapping and predicted abundance), we calculated landscape metrics to address patch fragmentation and isolation. We will continue to improve landscape sampling in future years.

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 and 2012 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 effort 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. The nest survival analysis highlighted the need to locate nests earlier in the cycle, preferably in the building stage, and for better monitoring. 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 outside of the BCP in future years to allow greater inference to a broader area, especially in sites with lower quality habitat. Additionally, we identified a need to increase intensive sampling in areas of lower canopy cover, increased slopes, more non-juniper forest, and more fragmentation, either on or off BCP, so we can better understand how these factors affect abundance and productivity and produce better estimates.

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Figure 1. Locations of point counts completed within 9 patches (green=CCN, yellow=CC, purple=BU, light blue=NLAM, red=WA, magenta=BC, medium blue=BCHP, pink=SLAM, orange=C) on Balcones Canyonlands Preserve, Austin, Texas during April-May 2011 and 2012. Blue circles were surveyed in 2011 and red points were surveyed in 2012.

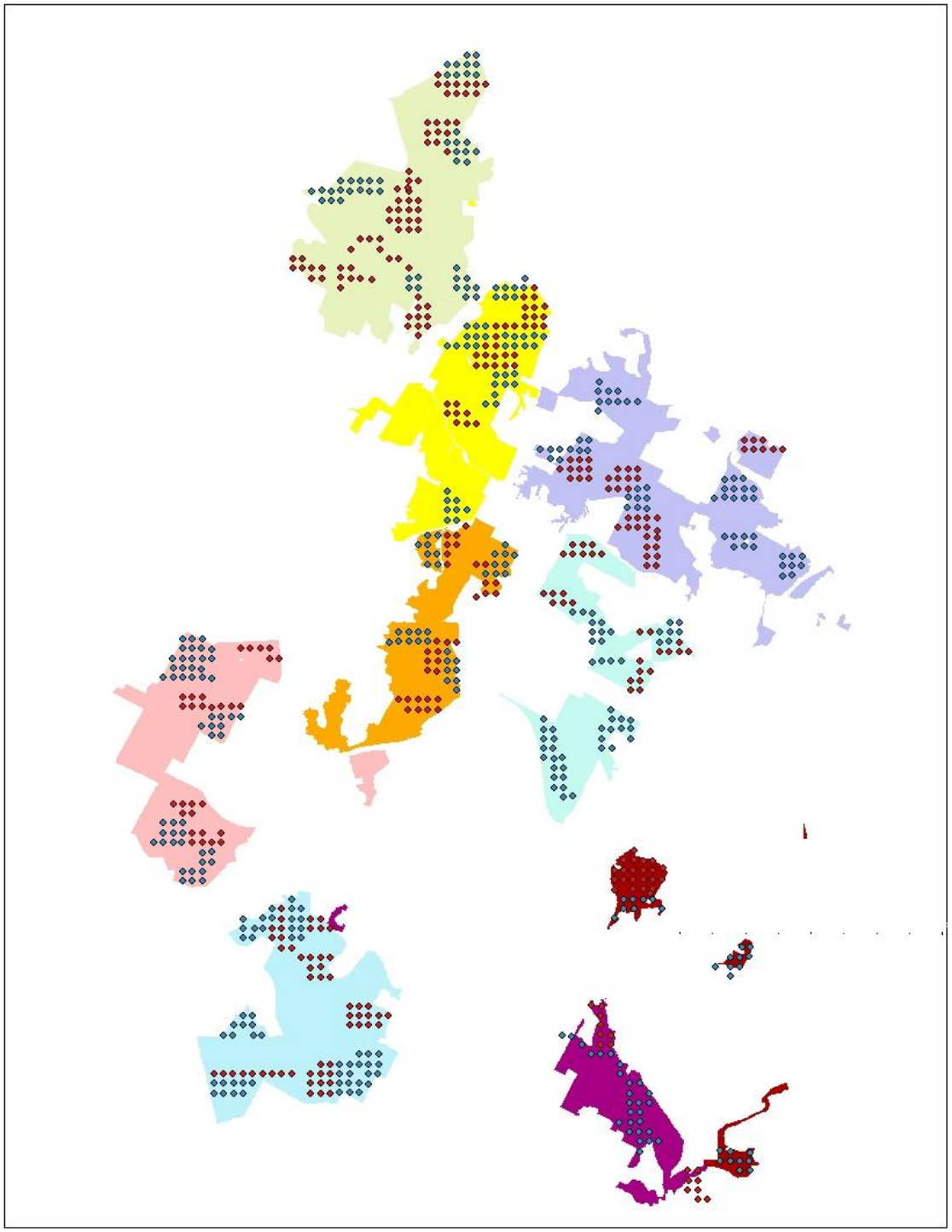


Figure 2. Plot of detection probability averaged across four observers for points surveyed across Balcones Canyonlands Preserve, Austin, Texas, during April-May 2011 and 2012.

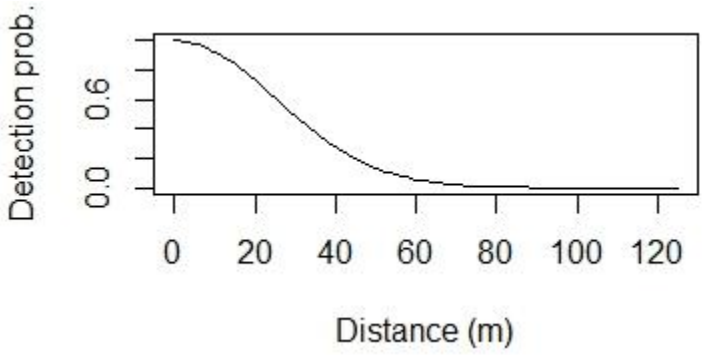


Figure 3. Predicted density of golden-cheeked warblers as a function of basal area of junipers on Balcones Canyonlands Preserve, Austin, Texas during April-May 2011 and 2012.

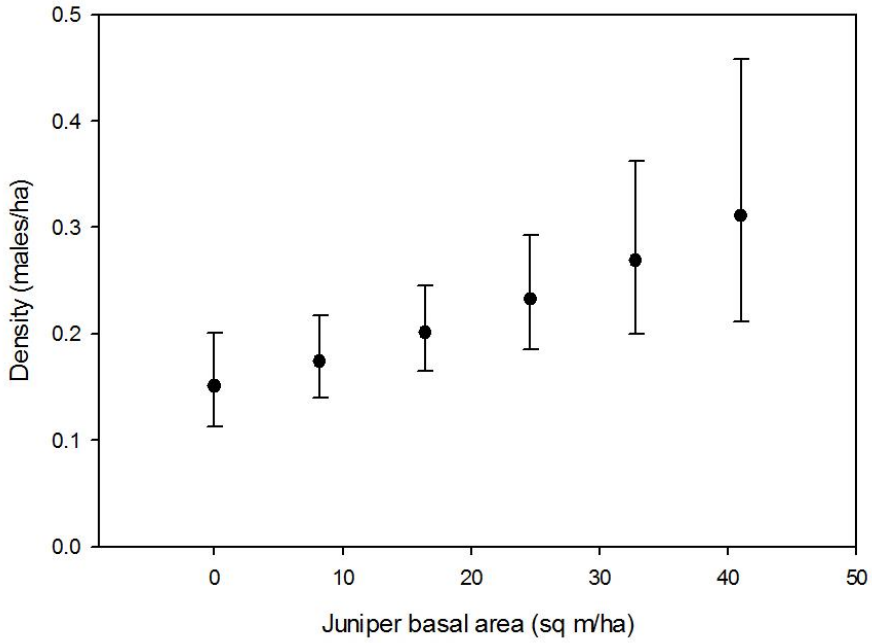


Figure 4. Predicted density of golden-cheeked warblers as a function of basal area of oaks on Balcones Canyonlands Preserve, Austin, Texas during April-May 2011 and 2012.

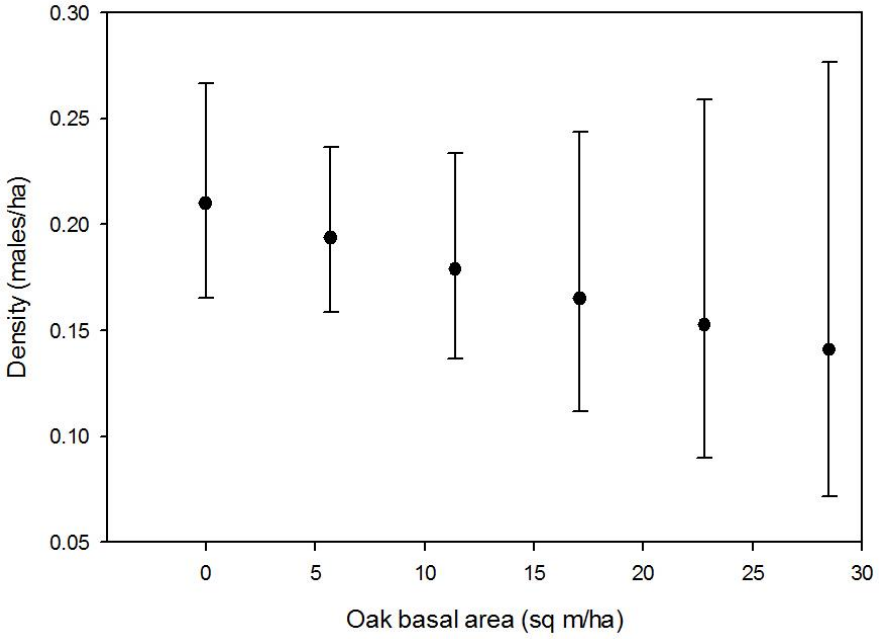


Figure 5. Predicted density of golden-cheeked warblers as a function of non-juniper height on Balcones Canyonlands Preserve, Austin, Texas during April-May 2011 and 2012.

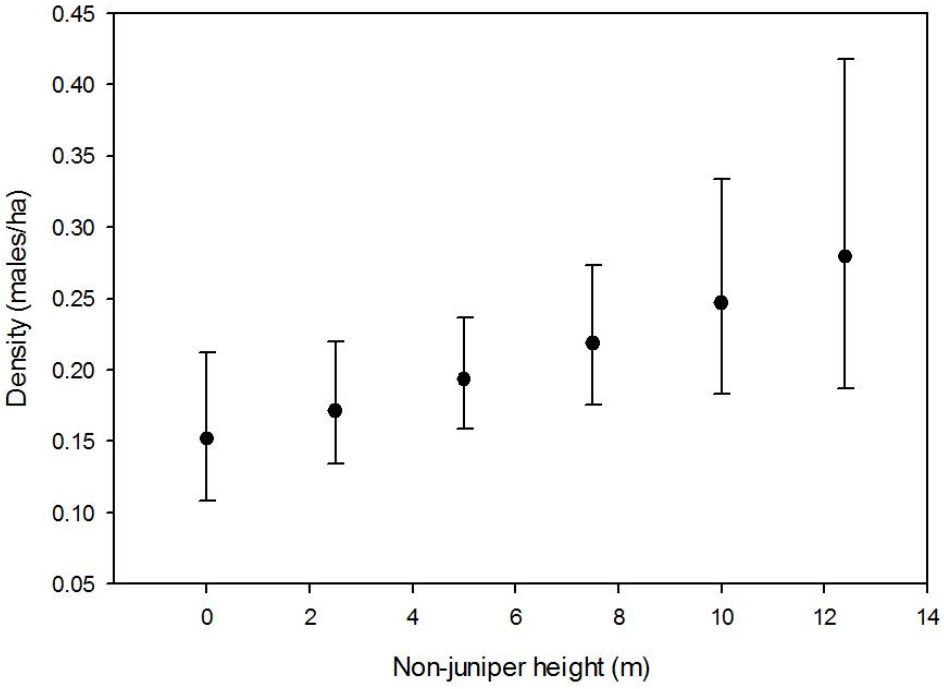


Figure 6. Predicted density of golden-cheeked warblers as a function of local canopy cover on Balcones Canyonlands Preserve, Austin, Texas during April-May 2011 and 2012.

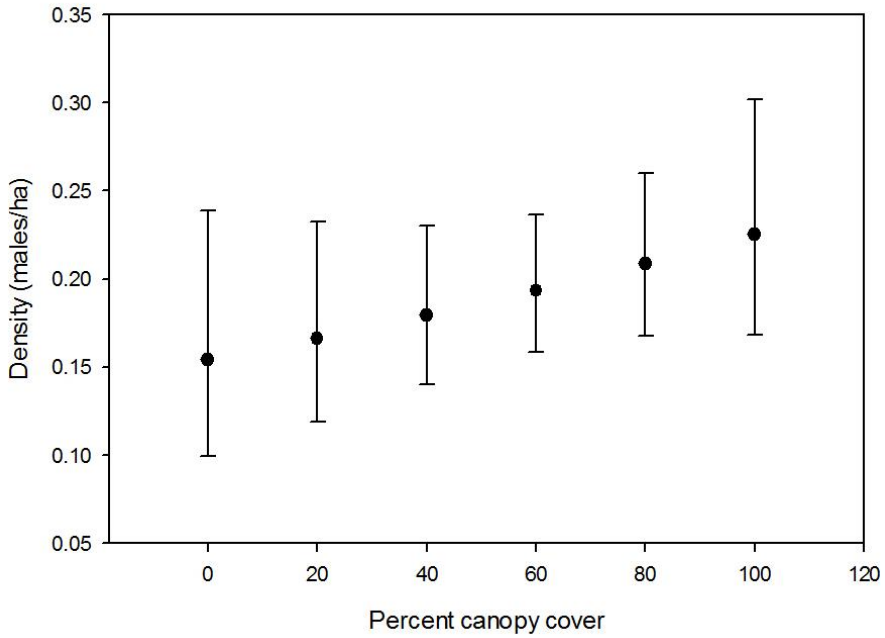


Figure 7. Predicted density of golden-cheeked warblers as a function of slope on Balcones Canyonlands Preserve, Austin, Texas during April-May 2011 and 2012.

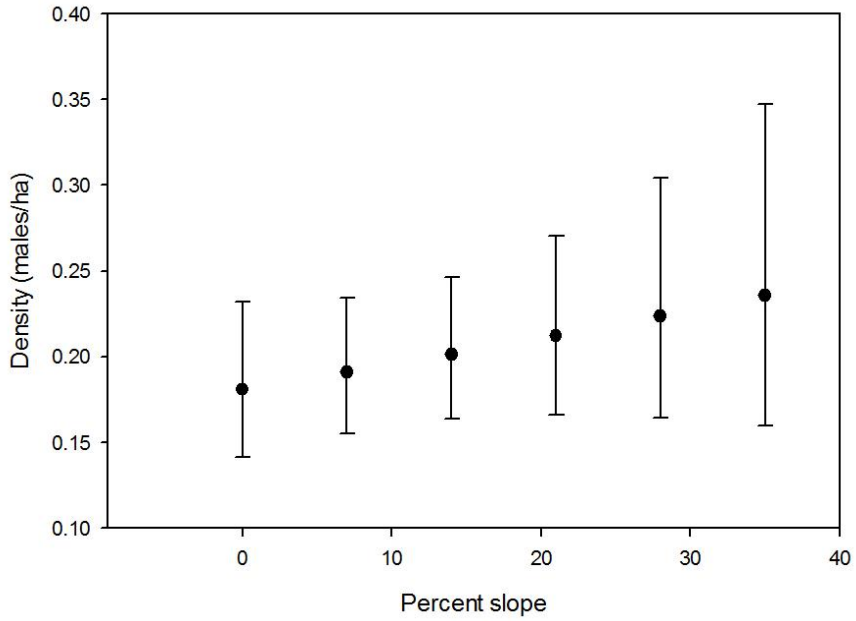


Figure 8. Predicted density of golden-cheeked warblers as a function of total forest cover in the 500-m radius around points on Balcones Canyonlands Preserve, Austin, Texas during April-May 2011 and 2012.

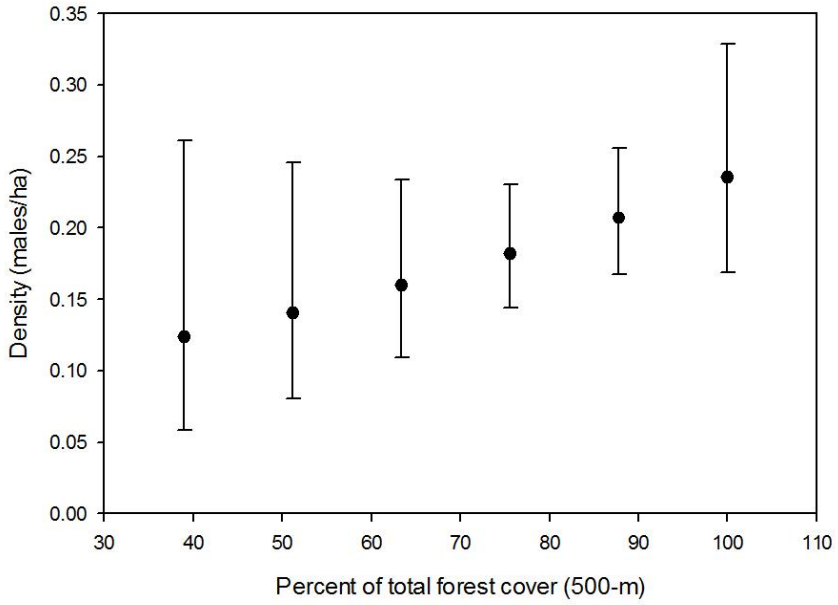


Figure 9. Predicted density of golden-cheeked warblers as a function of edge density in the 500-m radius around points on Balcones Canyonlands Preserve, Austin, Texas during April-May 2011 and 2012.

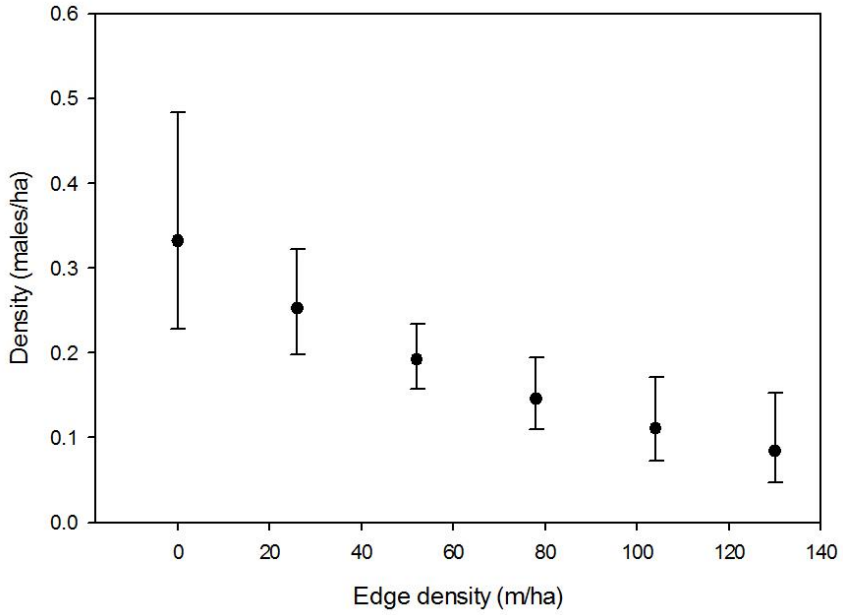


Fig. 10. Predicted density of golden-cheeked warblers at nine patches on Balcones Canyonlands Preserve, Austin, Texas during April-May 2011 and 2012; patches are mapped and labelled in Figure 1.

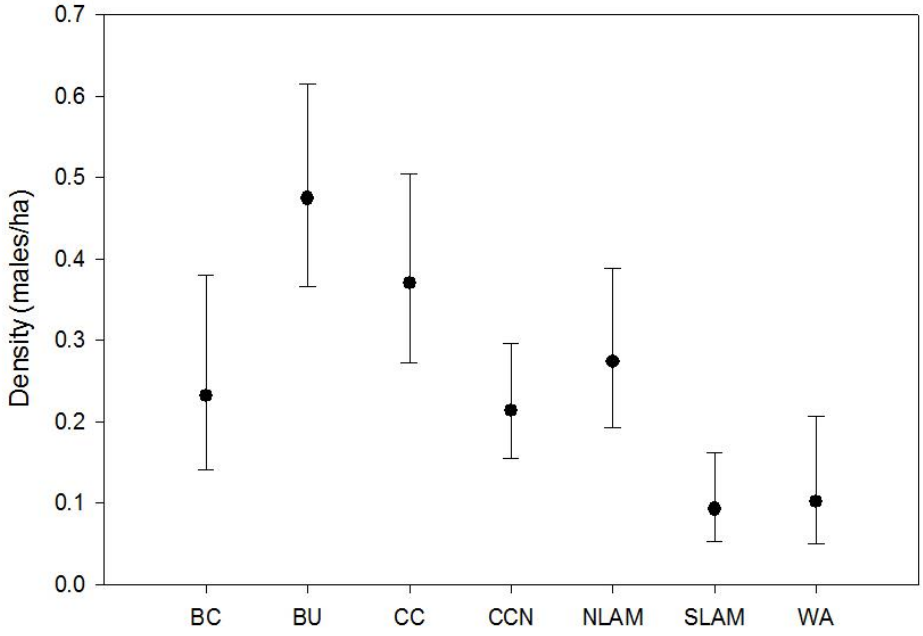


Figure 11. Predicted density distribution map (easting on the x-axis and northing on the y-axis) of golden-cheeked warblers on Balcones Canyonlands Preserve, Austin, Texas during April-May 2011-2012.

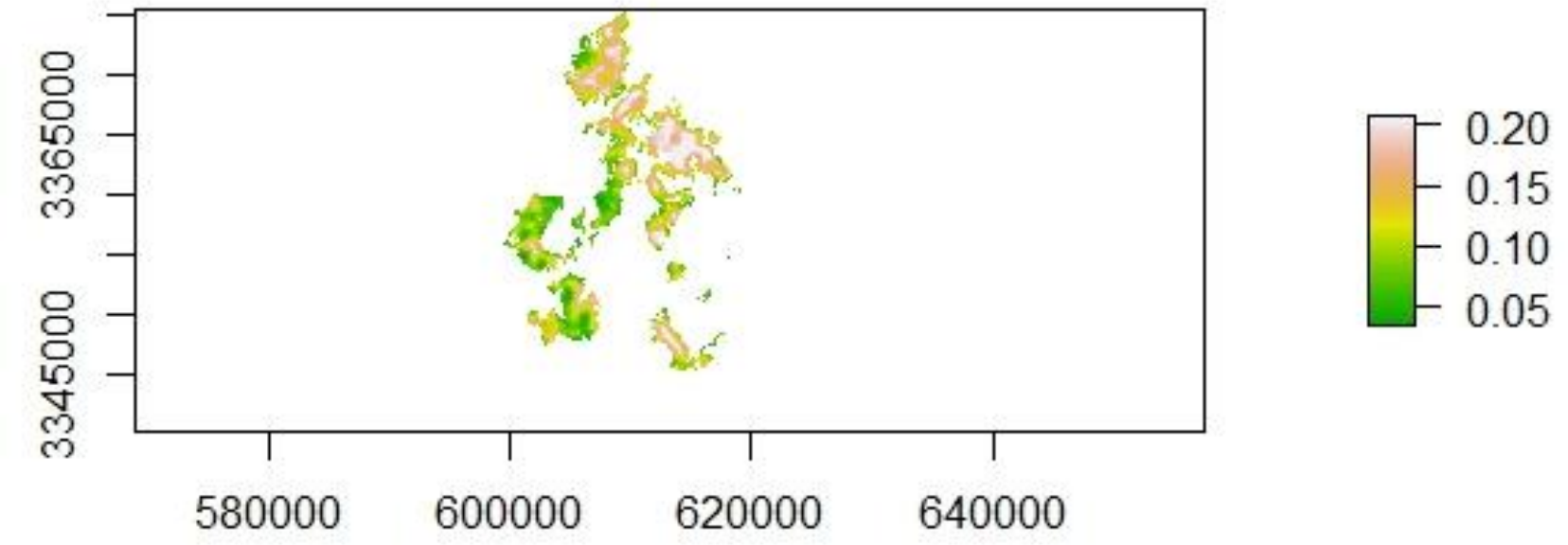


Figure 12. Locations of nests monitored within 9 patches (color-coded) on Balcones Canyonlands Preserve, Austin, Texas during April-May 2011 and 2012. Blue circles were nests monitored in 2011 and red points were monitored in 2012.

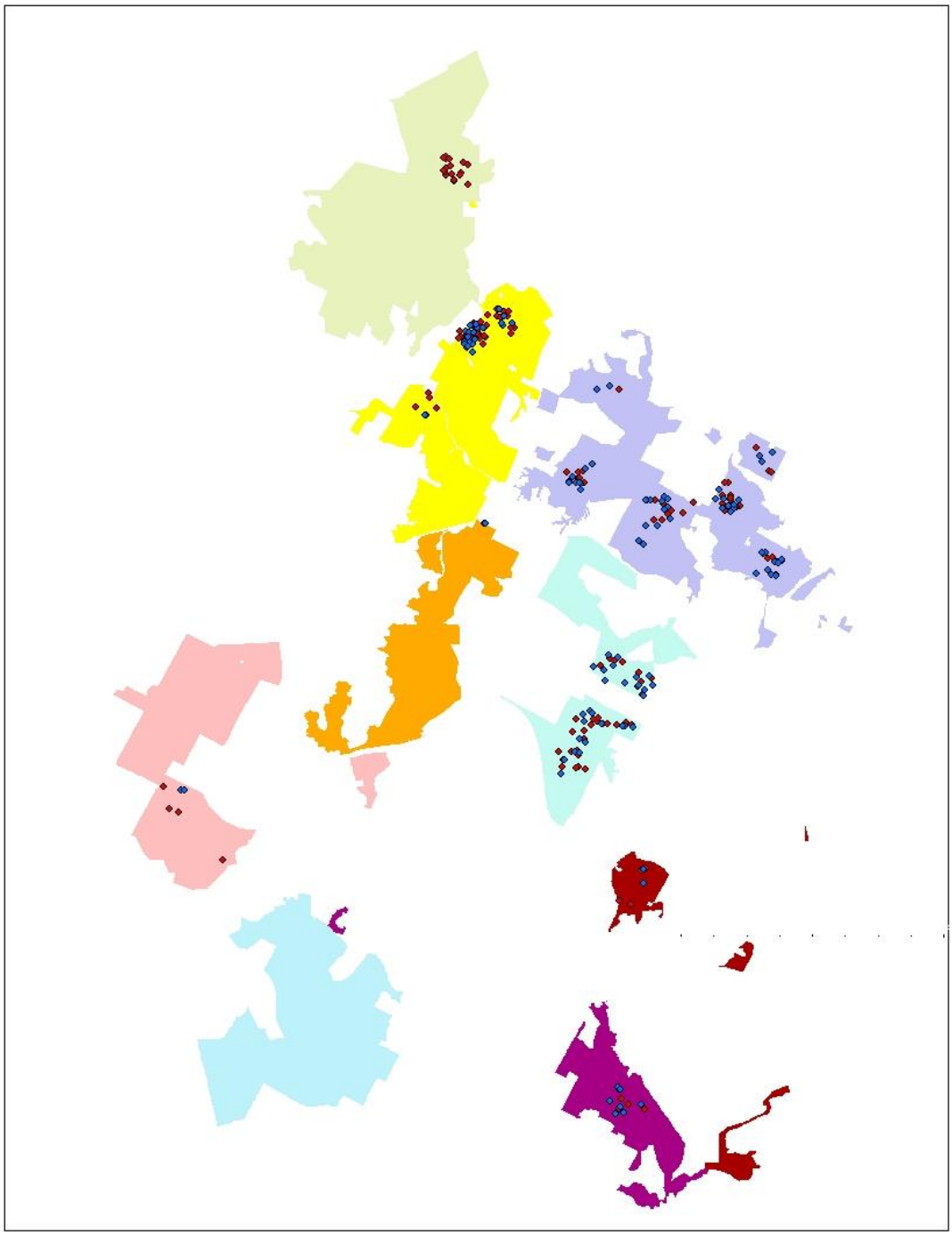


Figure 13. Daily nest survival of golden-cheeked warblers as a function of day of year on Balcones Canyonlands Preserve, Austin, Texas from March-June 2011 and 2012.

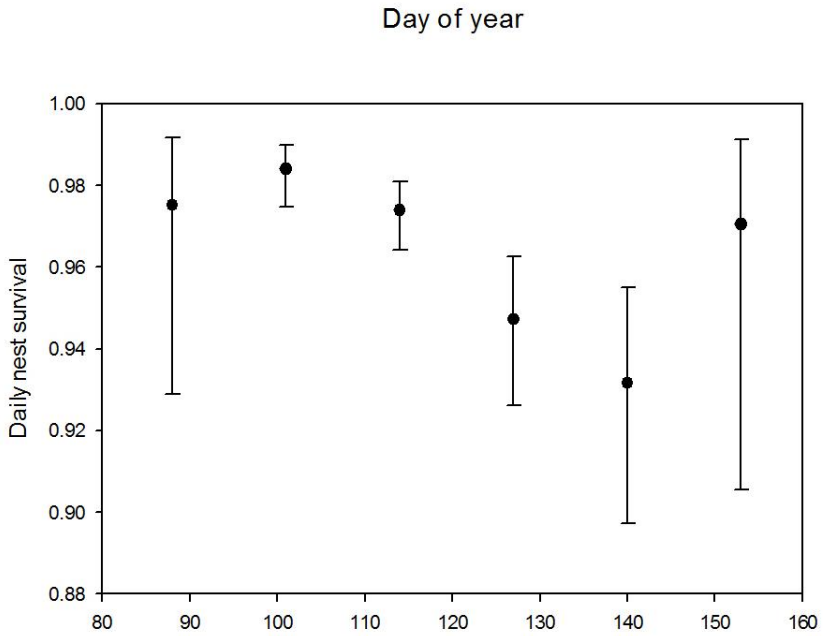


Figure 14. Period nest survival of golden-cheeked warblers as a function of slope on Balcones Canyonlands Preserve, Austin, Texas from March-June 2011 and 2012.

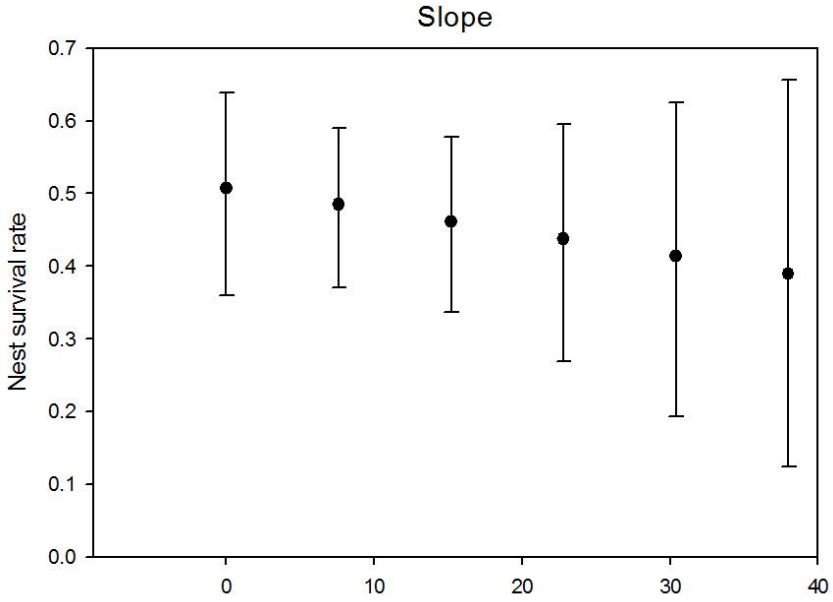


Table 1. Model name and variables evaluating habitat and landscape effects on density of golden-cheeked warblers on Balcones Canyonlands Preserve, Austin, Texas during April-May 2011 and 2012. The model description includes the most supported variable affecting detection probability (OBSERVER) followed by the variables of interest (1 represents the intercept).

Model name	Model description
Habitat	
obs_null	~OBSERVER ~1
obs_canc	~OBSERVER ~canopy cover
obs_slope	~OBSERVER ~slope
obs_asju	~OBSERVER ~basal area of juniper
obs_junhgt	~OBSERVER ~average juniper height
obs_oakhgt	~OBSERVER ~average non-juniper height
obs_junsize	~OBSERVER ~juniper tree size[1]
obs_treesize	~OBSERVER ~tree size[2]
obs_canc.slope	~OBSERVER ~canopy+slope
obs_canc.hgt	~OBSERVER ~canopy+average juniper height+average non-juniper height
obs_canc.litter	~OBSERVER ~canopy+litter ground cover
obs_canc.ssddec	~OBSERVER ~canopy+deciduous woody stems
obs_treesize.slope	~OBSERVER ~tree size+zslope
obs_treesize.hgt	~OBSERVER ~tree size+average juniper height+average non-juniper height
obs_treesize.litter	~OBSERVER ~ tree size +litter ground cover
obs_treesize.ssdasju	~OBSERVER ~tree size+juniper woody stems
obs_treesize.hgt.slope	~OBSERVER ~tree size+average juniper height+average non-juniper height +slope
obs_habglobal	~OBSERVER ~tree size+canopy+slope+ average juniper height +average non-juniper height +total woody stems+litter ground cover
obs_habglobal1	~OBSERVER ~basal area[3]+canopy+slope+average juniper height +average non-juniper height +total woody stems+litter ground cover
Landscape	
obs_null	~OBSERVER ~1
obs_edge	~OBSERVER ~edge density 500
obs_forest500	~OBSERVER ~forest cover 500
obs_jun500	~OBSERVER ~juniper cover 500
obs_mixed500	~OBSERVER ~mixed forest cover 500
obs_other500	~OBSERVER ~other forest 500
obs_forest1k	~OBSERVER ~forest cover 1k
obs_jun1k	~OBSERVER ~juniper cover 1k
obs_mixed1k	~OBSERVER ~mixed forest cover 1k
obs_other1k	~OBSERVER ~other forest 1k
obs_juniper500.edge	~OBSERVER ~juniper cover 500+edge density 500
obs_mixed500.edge	~OBSERVER ~mixed forest cover 500+edge density 500
obs_juniper1k.edge	~OBSERVER ~juniper cover 1k+edge density 500
obs_mixed1k.edge	~OBSERVER ~mixed forest cover 1k+edge density 500

obs_forest500.edge	~OBSERVER	~forest cover 500+edge density 500
obs_other500.edge	~OBSERVER	~other forest 500+edge density d500
obs_forest1k.edge	~OBSERVER	~forest cover 1k+edge density 500
obs_other1k.edge	~OBSERVER	~other forest 1k+edge density 500
obs_jun500.mixed500.edge	~OBSERVER	~juniper cover 1k+mixed forest cover 1k+edge density 500
obs_jun500.mixed500.other500	~OBSERVER	~juniper cover 1k+mixed forest cover 1k+other woods 500
obs_jun1k.mixed1k.edge	~OBSERVER	~juniper cover 1k+mixed forest cover 1k+edge density 500
obs_jun1k.mixed1k.other500	~OBSERVER	~juniper cover 1k+mixed forest cover 1k+other forest cover 500
obs_jun1k.mixed1k.forest500	~OBSERVER	~juniper cover 1k+mixed forest cover 1k+forest cover 500
obs_jun1k.mixed1k.edge.other500	~OBSERVER	~juniper cover 1k+zmixed forest cover1k+edge density 500+ other forest cover 500

[1] juniper tree size = small junipers+medium junipers+large junipers

[2] tree size = small junipers+medium junipers+large junipers+small live oaks+medium live oaks+large live oaks+small deciduous+medium deciduous+large deciduous

[3] basal area = juniper basal area+non-juniper basal area

Table 2. Number of parameters (K), AIC, and model support for models evaluating habitat effects on density of golden-cheeked warblers on Balcones Canyonlands Preserve, Austin, Texas during April-May 2011 and 2012.

Model name	K	AIC	ΔAIC	w_i	cum w_i
obs_habglobal1	14	2356.97	0	0.52	0.52
obs_treesize.hgt	16	2358.49	1.52	0.24	0.76
obs_treesize.hgt.slope	17	2360.46	3.49	0.09	0.86
obs_habglobal	20	2360.59	3.61	0.09	0.94
obs_canc.hgt	8	2362.36	5.39	0.04	0.98
obs_treesize.litter	15	2365.23	8.26	0.01	0.98
obs_canc	6	2366.02	9.05	0.01	0.99
obs_canc.litter	7	2367.75	10.78	0.00	0.99
obs_canc.ssddec	7	2367.84	10.87	0.00	0.99
obs_canc.slope	7	2368.02	11.04	0.00	1
obs_treesize	14	2369.05	12.08	0.00	1
obs_treesize.ssdtotal	15	2370.54	13.56	0.00	1
obs_treesize.slope	15	2371.05	14.07	0.00	1
obs_junsize	8	2371.42	14.45	0.00	1
obs_asju	6	2371.58	14.6	0.00	1
obs_junhgt	6	2378.55	21.58	0.00	1
obs_oakhgt	6	2383.05	26.08	0.00	1
obs_null	5	2409.56	52.58	0.00	1
obs_slope	6	2409.56	52.59	0.00	1

Table 3. Number of parameters (K), AIC, and model support for models evaluating landscape effects on density of golden-cheeked warblers on Balcones Canyonlands Preserve, Austin, Texas during April-May 2011 and 2012.

Model name	K	AIC	ΔAIC	w_i	cum w_i
obs_forest500.edge	7	2313.61	0	0.39	0.39
obs_edge	6	2316.47	2.86	0.09	0.48
obs_mixed500.edge	7	2316.67	3.06	0.08	0.56
obs_mixed1k.edge	7	2316.84	3.23	0.08	0.64
obs_other500.edge	7	2317.03	3.42	0.07	0.71
obs_forest1k.edge	7	2317.18	3.57	0.07	0.78
obs_juniper1k.edge	7	2318.1	4.5	0.04	0.82
obs_jun500.mixed500.edge	8	2318.34	4.73	0.04	0.85
obs_jun1k.mixed1k.edge	8	2318.34	4.73	0.04	0.89
obs_juniper500.edge	7	2318.35	4.74	0.04	0.93
obs_other1k.edge	7	2318.4	4.79	0.04	0.96
obs_jun1k.mixed1k.edge.other500	9	2319.29	5.69	0.02	0.99
obs_jun1k.mixed1k.forest500	8	2320.32	6.71	0.01	1
obs_forest500	6	2325.25	11.64	0.00	1
obs_jun500.mixed500.other500	8	2337.55	23.94	0.00	1
obs_jun1k.mixed1k.other500	8	2337.55	23.94	0.00	1
obs_other500	6	2349.64	36.03	0.00	1
obs_forest1k	6	2355.99	42.39	0.00	1
obs_mixed1k	6	2365.97	52.36	0.00	1
obs_mixed500	6	2368.29	54.68	0.00	1
obs_other1k	6	2376.48	62.87	0.00	1
obs_null	5	2409.56	95.95	0.00	1
obs_jun1k	6	2409.64	96.04	0.00	1
obs_jun500	6	2410.76	97.15	0.00	1

Table 4. Number of parameters (K), AIC, and model support for models evaluating habitat, landscape, and site effects on density of golden-cheeked warblers on Balcones Canyonlands Preserve, Austin, Texas during April-May 2011 and 2012.

Model name	K	AIC	ΔAIC	w_i	cum w_i
obs_hab.land[1]	16	2295.06	0	1.00	1
obs_forest500.edge	7	2313.61	18.55	0.00	1
obs_site	13	2330.83	35.77	0.00	1
obs_habglobal1	14	2356.97	61.92	0.00	1
obs_null	5	2409.56	114.5	0.00	1

[1] obs_hab.land = ~OBSERVER ~basal area+canopy+slope+average juniper height+average oak heigt+total woody stems+litter ground cover+ forest cover 500+edge density 500

Table 5. Summary of vegetation measurements collected at 388 points surveyed on Balcones Canyonlands Preserve in 2011. See methods for description of measurements.

Variable	N	Mean	Std Dev	Median	Min	Max	LCL	UCL
Slope	339	8.988201	7.964502	7	0	43	8.137328	9.839074
Aspect	338	166.2189	105.2849	156	0	358	154.9543	177.4836
Canopy cover	341	63.35558	34.02501	78.64583	0	99.73958	59.73133	66.97983
Juniper height	341	5.797263	1.837321	5.8825	0	11.2	5.601557	5.992969
Non-juniper height	341	5.111658	2.963697	5.5975	0	15.01	4.795974	5.427343
Shrub	341	5.076246	6.219193	3.25	0	42.75	4.413796	5.738697
Bare	341	23.56012	14.66887	20	2	75.25	21.99763	25.1226
Litter	341	59.50733	19.19659	62	4.5	95	57.46256	61.5521
Herb	341	15.74267	14.91567	10.25	0	87.5	14.15389	17.33144
Woody stems:								
Juniper	341	1291.97	1594	762	0	12065	1122.19	1461.76
Live oak	341	784.346	2844.71	0	0	37973	481.3357	1087.36
Other oaks	341	1159.39	4900.21	0	0	52197	637.4311	1681.34
Other deciduous	341	2157.51	3798.05	635	0	30226	1752.95	2562.07
exotic	341	19.36657	161.2436	0	0	2667	2.19136	36.54178
total non-juniper	341	4120.61	7050.95	1397	0	53594	3369.56	4871.66
total	341	5412.58	7142.64	3302	0	53594	4651.77	6173.4
Basal area:								
Juniper	341	13.24844	8.698464	12.7583	0	52.07337	12.32191	14.17498
Cedar elm	341	0.355527	1.569914	0	0	19.84701	0.188304	0.522749
Juniper snag	341	0.883609	2.294144	0.169352	0	19.14801	0.639243	1.127975
Snag	341	0.511779	0.974435	0.031416	0	5.600871	0.407984	0.615573
Live oak	341	2.527655	4.485504	0.363247	0	32.864	2.049872	3.005438
Other	341	0.257775	0.825165	0	0	6.890396	0.169881	0.345669
Red oak	341	0.984653	2.338489	0	0	17.84572	0.735564	1.233742

Shin oak	341	0.266635	0.936407	0	0	9.792443	0.166892	0.366379
Total	341	17.64069	10.36636	17.04363	0	59.30051	16.53649	18.74488
Patch size	341	12093.68	24280.6	3191.69	0.21	117622.6	9507.38	14679.98
Percent land covers:								
Juniper forest 500	341	54.21994	21.53045	52	2	98	51.92658	56.5133
Live oak forest 500	341	1.049853	2.258417	0	0	13	0.809293	1.290414
Mixed forest 500	341	29.66276	21.47243	27	0	87	27.37557	31.94994
ColdDec forest 500	341	0.478006	1.6043	0	0	12	0.30712	0.648891
Deciduous forest 500	341	0.897361	2.453933	0	0	17	0.635975	1.158747
Post_oak_forest500	341	0.140763	1.157131	0	0	15	0.017508	0.264017
Other 500	341	9.768328	11.78941	5	0	63	8.512553	11.0241
Juniper shrub 500	341	3.348974	7.399021	1	0	57	2.560851	4.137096
Shrubland 500	341	0.202346	0.787845	0	0	11	0.118427	0.286265
Barren 500	341	0.102639	1.036691	0	0	17	-0.00779	0.213065
Juniper forest 1k	341	48.41056	15.99839	50	14	87	46.70645	50.11466
Live oak forest 1k	341	1.686217	2.283847	1	0	12	1.442948	1.929486
Mixed forest 1k	341	29.22874	16.4578	26	1	76	27.4757	30.98178
Deciduous forest 1k	341	1	1.597793	0	0	9	0.829808	1.170192
Post oak forest 1k	341	0.152493	0.681845	0	0	6	0.079864	0.225121
Other 1k	341	14.88856	12.01246	12	0	59	13.60903	16.1681
ColdDec forest 1k	341	0.665689	1.231795	0	0	6	0.534482	0.796897
Juniper shrub 1k	341	3.178886	4.989427	1	0	29	2.647426	3.710345
Shrubland 1k	341	0.351906	0.792931	0	0	4	0.267445	0.436367
Barren 1k	341	0.260997	1.252963	0	0	12	0.127535	0.394459
Juniper foest 5k	341	32.6393	6.35208	34	9	43	31.96269	33.3159
Live oak forest 5k	341	2.14956	1.086512	2	1	7	2.033828	2.265292
Mixed forest 5k	341	22.00293	7.209674	22	8	36	21.23498	22.77089
Deciduous forest 5k	341	1.290323	0.454578	1	1	2	1.241902	1.338743

Post oak forest 5k	341	0.143695	0.351296	0	0	1	0.106276	0.181114
Other 5k	341	36.24633	8.225732	34	22	71	35.37015	37.12252
ColdDec forest 5k	341	1.304985	0.609439	1	0	3	1.24007	1.369901
Juniper shrub 5k	341	2.668622	2.389656	2	0	9	2.414082	2.923161
Shrubland 5k	341	0.498534	0.518054	0	0	2	0.443352	0.553715
Barren 5k	341	0.821114	0.694703	1	0	2	0.747117	0.895112
Edge density 100	340	31.76824	56.20552	0	0	279.3651	25.77252	37.76395
Edge density 500	341	44.89194	32.86752	37.6633	0	137.1143	41.39099	48.3929

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 2011 and 2012. All models include day of year and nest stage. K is the number of parameters, ΔAICc is the difference between the top model AIC_c and the model of interest (top model $\Delta AIC_c=0$), and Akaike's weights (w_i). AIC_c of the top model was 531.42.

Model Label	Model description	K	ΔAIC_c	w_i
Slope	Day of year^3 + nest stage+slope	6	0	0.243
Null	Day of year^3+nest stage	5	0.923	0.153
Tree + shrub	Day of year^3+nest stage+basal area+total woody stems	7	1.566	0.111
Shrub	Day of year^3+nest stage+total woody stems	6	1.602	0.109
Slope + canc	Day of year^3+nest stage+slope+canopy	7	1.658	0.106
Edge	Day of year^3+nest stage+edge density 500	6	1.747	0.101
Forest	Day of year^3+nest stage+juniper forest 500+mixed forest 500	7	2.333	0.076
Canopy	Day of year^3+nest stage+canopy	6	2.897	0.057
Landscape	Day of year^3+nest stage+juniper forest 500+mixed forest 500+edge density 500	8	3.757	0.037
Nest area	Day of year^3+nest stage+slope+canopy+nest height juniper height	12	7.451	0.006
Global	Day of year^3+nest stage+slope+canopy+nest height+juniper height+oak height+basal area+total woody stems+juniper forest 500+mixed forest 500+edge density 500	17	14.164	0

Table 7. Summary of vegetation measurements collected at golden-cheeked warbler nests located on Balcones Canyonlands Preserve, Austin, Texas in June 2012.

Variable	N	Mean	Std Dev	Median	Min	Max	LCL	UCL
Tree height	149	8.77	2.50	8.60	4.10	23.76	8.37	9.18
Nest height	148	6.88	2.21	6.58	2.70	21.36	6.52	7.24
Distance to main trunk	141	48.41	107.87	0.00	0.00	650.00	30.45	66.37
Tree dbh	148	23.83	8.95	22.25	9.00	57.00	22.38	25.28
Slope	148	10.32	8.61	8.00	0.00	38.00	8.92	11.72
Nest cover	138	46.30	19.35	45.17	5.33	98.33	43.04	49.56
Canopy cover	148	87.35	10.63	90.10	47.66	99.74	85.62	89.07
Juniper height	149	7.55	2.16	7.58	0.00	13.14	7.20	7.90
non-juniper height	149	7.36	2.98	7.50	0.00	13.85	6.88	7.84
Shrub	149	6.89	11.08	3.50	0.00	100.00	5.10	8.69
Grass	149	5.27	6.91	2.25	0.00	35.00	4.15	6.39
Forb	149	5.05	8.27	1.75	0.00	48.75	3.71	6.39
Bare	149	24.54	15.84	22.25	0.00	94.25	21.98	27.11
Litter	149	62.12	18.48	65.00	0.00	95.75	59.12	65.11
Woody stems:								
Juniper	148	603.25	897.15	254.00	0.00	5842.00	457.51	748.99
Live oak	148	189.64	608.35	0.00	0.00	3810.00	90.82	288.47
Shin oak	148	965.37	3001.52	0.00	0.00	20193.00	477.79	1452.96
Red oak	148	246.28	960.97	0.00	0.00	8763.00	90.17	402.38
Exotic	148	18.02	82.49	0.00	0.00	762.00	4.62	31.42
Other canopy	148	217.10	594.81	0.00	0.00	4699.00	120.48	313.73
Other shrub	148	1886.98	2687.14	889.00	0.00	20320.00	1450.47	2323.49
Total non-juniper	148	3523.39	4533.71	1778.00	0.00	23241.00	2786.91	4259.87
total	148	4126.64	4650.60	2540.00	0.00	23368.00	3371.17	4882.11
Basal area:								
Juniper	149	17.89	8.76	18.16	0.00	41.74	16.47	19.31
Live oak	149	2.39	4.01	0.45	0.00	24.31	1.74	3.04
Other	149	0.46	1.46	0.05	0.00	12.39	0.22	0.69
Shin oak	149	0.58	1.13	0.00	0.00	5.07	0.40	0.76
Red oak	149	1.13	2.24	0.00	0.00	11.29	0.77	1.50
Cherry	149	0.11	0.47	0.00	0.00	3.63	0.04	0.19
Cedar elm	149	0.61	1.75	0.00	0.00	13.00	0.32	0.89
Total non-juniper	149	5.28	4.69	3.84	0.00	24.36	4.52	6.04
Total	149	23.17	8.61	22.47	0.00	48.89	21.77	24.56