2017 Annual Report:
Golden-cheeked Warbler *(Setophaga chrysoparia)*
Monitoring Program
Balcones Canyonlands Preserve



Male Golden-cheeked warbler taking a bath, © Gil Eckrich

City of Austin, Austin Water
Wildland Conservation Division
and
Travis County
Department of Transportation and Natural Resources
Natural Resources and Environmental Quality Division
Balcones Canyonlands Preserve

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Disclaimer: The data and information presented in this report are provisional and subject to revision.

2017 Golden-cheeked Warbler Monitoring Program

Balcones Canyonlands Preserve Annual Report

SUMMARY

This report summarizes the results of the golden-cheeked warbler (*Setophaga chrysoparia*) endangered species monitoring program for the 2017 field season. This was the twentieth year of golden-cheeked warbler monitoring on the Balcones Canyonlands Preserve (BCP). It was also the beginning of a long-term monitoring plan following a 5-year research project with the U.S. Forest Service and University of Missouri to better understand factors influencing the long-term viability of the golden-cheeked warbler within the BCP. Findings from the 5-year study have been published in Reidy et al. (2015, 2016, 2017, in press) and are consistent with research on Fort Hood (Peak 2007, Peak and Thompson 2013, 2014) that large blocks of mature, closed canopy Ashe juniper (*Juniperus ashei*) and oak (*Quercus* spp.) woodlands support higher densities of golden-cheeked warblers and seasonal productivity than in smaller, isolated woodlands. The results of this study demonstrate the importance of demographic data when evaluating a species' status and how even small changes in productivity and survival can affect population viability. The long-term plan is designed to continue collecting key demographic data to promote informed management decisions. Building on the existing long-term datasets will allow land managers to assess the warbler's status within the BCP over time, update the viability models as urbanization continues to expand around the BCP, and inform future population modeling efforts.

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INTRODUCTION

Background

The golden-cheeked warbler (warbler) is a neotropical migrant passerine that breeds only in central Texas where mature Ashe juniper-oak woodlands occur (Ladd and Gass 1999). Due to accelerating loss of breeding habitat, 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 (Biological

Advisory Team 1990, Duarte et al. 2013). Rapid westward expansion of development from the City of Austin led to the creation of the Balcones Canyonlands Conservation Plan (a Habitat Conservation Plan) and issuance of a 10(a)(1)(B) permit in 1996 by the U.S. Fish and Wildlife Service to the City of Austin and Travis County, to mitigate habitat loss due to development and to facilitate the recovery of the warbler and other endangered and rare species (USFWS 1996). The permit requires a minimum of 12,300 hectares (30,428 acres) of endangered species habitat in western Travis County be set aside as a preserve (the BCP) for these species. The BCP is owned and managed by a number of public and private entities, including the City of Austin, Travis County, Lower Colorado River Authority, The Nature Conservancy, Travis Audubon Society, and St. Edwards University/Wild Basin. Because the Balcones Canyonlands Conservation Plan allows for the loss of over 70 percent of the warbler's habitat in Travis County, promoting habitat sustainability, regeneration, and restoration is critical to support a viable breeding population within the BCP.

The warbler requires large blocks of mature, closed-canopy woodlands for nesting and raising young (USFWS 1992; Peak 2007, Peak and Thompson 2013, 2014; Reidy et al. 2016, 2017, in press). Active habitat management within the BCP requires minimizing threats to this species, including disturbance from human activities; declining oak regeneration from white-tailed deer (*Odocoileus virginianus*), feral hogs (*Sus scrofa*), and oak wilt (*Ceratocystis fagacearum*); non-native plants; and nest predators (USFWS 1996). Because the warbler requires mature woodlands, habitat regeneration could take decades if negatively impacted by a poorly designed program (Biological Advisory Team 1990).

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." The 5-year study with the U.S. Forest Service/University of Missouri focused 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?

The long-term monitoring plan is intended to continue collecting demographic data to address the four questions listed above and meet the objectives of the Balcones Canyonlands Conservation Plan and 2007 land management plan.

SITE DESCRIPTION

The topography and vegetation of the BCP are typical of the eastern edge of the Edwards Plateau. Steep, wooded canyons and riparian corridors dissect drier upland vegetation. Most streams are intermittent, though a few have a permanent water source, such as a perennial spring. The predominant vegetation association is mature, closed-canopy Ashe juniper-oak woodlands, although several sites include more open canopy and shrublands.

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 has reduced understory flora 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*).

Study Sites

Staff continued to track population and productivity trends on a set of intensive monitoring plots (City of Austin et al. 2014). Intensive monitoring includes data collection for color-banded warblers to estimate territory density, territory size and location, age structure, pairing success, breeding success, and productivity. Previously established plots that were not intensively monitored in 2017 were treated as re-sighting plots. BCP staff and volunteers also made a concerted effort to search for color-banded warblers outside of the intensive monitoring areas and on the re-sighting plots to gather data on site fidelity, dispersal, and return rates.

Intensive Monitoring Plots. The long-term monitoring plan reduced the number of intensive monitoring plots from 18 during the 5-year study to 12. The long-term plots range in size from 40.5 to 180 ha (Table 1, Exhibit A). An effort was made to distribute plots as evenly as possible across the BCP and in proportion to habitat quality, using canopy height as a proxy. A map of vegetation height for the BCP was derived from 2012 light detection and ranging (LiDAR) data. Canopy heights were divided into six categories: <1, 1-6, 7-10, 11-16, 17-27, >27 feet. In Excel 2013, the proportion of pixels within each height category were tallied for the entire BCP and for the 12 plots to ensure a comparable distribution (Exhibit A). This will allow for extrapolation from the plot data to provide a rough estimate of population size, adult survival, and productivity within the BCP each year.

In addition to the 12 long-term plots, intensive monitoring may be conducted on additional plots contingent on staff and resource availability. In 2017, BCP staff were able to continue intensive monitoring on the Emma Long Motocross Park and Emma Long Expansion plots (Table 1, Exhibit A).

Intensive monitoring plots were located within six of eight BCP macrosites (all but the Pedernales macrosite and recently added Big Sandy Creek macrosite). Each of the 40.5-hectare study plots includes a 100-meter buffer around its perimeter (where access was permitted) to expand the search area for color-banded warblers and obtain additional information on return rates, dispersal, territory size and configuration, and productivity. Intensive monitoring plots covered about seven percent of the BCP. Including the 100-meter buffers around each 40.5-ha plot, re-sighting plots, enumeration plot, and additional areas surveyed by volunteers to search for color-banded warblers, surveys for this project covered about 20 percent of the BCP in 2017 (Table 1).

Re-sighting Plots. Seven previously established plots that were not intensively monitored in 2017, including the 100-m buffers around the 40.5-ha plots, were treated as re-sighting plots (Table 1). These plots will be surveyed each breeding season until no banded birds are found.

Search Efforts for Banded Warblers Outside of Intensive Monitoring/Re-sighting Plots. To obtain additional information on return rates and dispersal outside of the intensive monitoring and re-sighting plots, volunteers searched for color-banded warblers on 32 search areas totaling approximately 1248 hectares (Exhibit B).

Enumerations. An enumeration is a survey of all male warblers in a given area. This methodology provides information on distribution of the species over a large area. Enumeration surveys in 2017 were conducted on the Park West tract, comprising 47 ha (Table 1, Exhibit A). Enumerations provide only rough estimates of territory number due to a limited number of surveys and observations of unbanded birds. Because enumeration survey effort varies among tracts and among years, results are not comparable.

Point Counts. BCP staff conducted point counts on all intensive monitoring plots in 2017. These data will be fitted to models to predict male warbler densities for each plot. Estimates derived from intensive monitoring for each plot will be used to evaluate how well the models predict density across the BCP. O'Donnell et al. (2015) found that three different models over-predicted warbler abundance in areas with low densities. The 2017 surveys are part of a collaborative with the U.S. Fish and Wildlife Service, Fort Hood, and other partners to try to produce accurate model-based estimates at varying warbler densities.

Table 1. Intensive monitoring, re-sighting, and enumeration plots for macrosites within the Balcones Canyonlands Preserve, Travis County, Texas, field season 2017.

Plot Name, Ownership[1], and Size (hectares)	Barton Creek Macrosite	Bull Creek Macrosite	Cypress Creek Macrosite	No. Lake Austin Macrosite	So. Lake Austin Macrosite	West Austin Macrosite
Intensive Monitoring Plots						
Barton Creek (COA)	40.5					
Barton Creek Habitat Preserve (TNC)	81.5					
Forest Ridge (COA)		40.5				
Kent Butler (COA)		40.5				
Hamilton West (COA)		40.5				
Vista Point (TC)			40.5			
Wheless (TC)			40.5			
Emma Long (COA)				40.5		
Emma Long Bike Park (COA)[2]				96		
Emma Long Expansion (COA)[2]				34[3]		
Cortaña (COA)				62		
JJ&T (COA)					40.5	
Reicher (COA)					40.5	
Wild Basin/Vireo Preserve (COA, St. Edwards, TC)						180
Re-sighting Plots						
Gus Fruh/Sunset Valley (COA)	112					
3M/St. Edwards (COA)		40.5				
Canyon Vista (TC)		40.5				
Baker Sanctuary (Travis Audubon)			40.5			
Lake Perspectives/ McGregor (TC/LCRA)			40.5			
Vireo Ridge (TC)			51[4]			
Coldwater (COA)				107		
Enumerations						
Park West (COA)				47		
Total # BCP Hectares Owned (as of November 2017)[5]	2,479	2,025	3,797	2,269	1,643	188
% of macrosite surveyed[6]	9.4%	10%	17.8%	17%	4.9%	96%

[1]COA = City of Austin, LCRA = Lower Colorado River Authority, TC = Travis County, TNC = The Nature Conservancy

[2]Emma Long Bike Park and Emma Long Expansion are not part of the long-term monitoring plan, but will continue to be intensively monitored contingent on staffing and budget.

[3]Plot size corrected from previous report (41 to 34 ha).

[4]Plot boundaries varied slightly from year to year (42 to 51 ha).

[5]Does not include the 100-m buffers around the intensive monitoring/re-sighting plots (approx. 30 ha for each of the thirteen 40.5-ha plots, where access was allowed, totaling about 390 ha), or the search areas beyond the buffers (about 1248 ha, see Exhibit B).

[6]Does not include the Pedernales macrosite (105 ha) or Big Sandy Creek macrosite (384 ha).

METHODS

Golden-cheeked Warbler Monitoring on Intensive Monitoring Plots

Color Banding. Color banding of adult warblers was conducted in conjunction with territory mapping on 14 intensive monitoring plots, from March 15 through May 22, 2017. Methods consisted of mist-netting within a male warbler's territory, using playback of a recorded male warbler's song to attract the bird to the net. Although a few females were caught using this method, most of the warblers captured were males. All warblers captured in mist nets were marked with a unique combination of a U.S. Geological Survey (USGS) numbered aluminum band and auxiliary color bands to allow identification of each individual. The biological staff at Ft. Hood Military Reservation issued the color-band combinations. Other data collected during banding included date, time, banding location, temperature, and weather conditions. Individuals were sexed and aged (second-year [SY], after second-year [ASY], or after hatching-year [AHY] according to Pyle [1997] and Peak and Lusk [2009]), using data sheets developed by Ft. Hood staff. Each warbler was photographed just prior to release to document band combinations.

Territory Delineation. Surveys on each intensive monitoring plot were conducted at least once a week from March 15 through May 25 to delineate territories. One biologist was assigned to map territories on each low-density (<5 territories/40.5 ha) and medium-density plot (5-10 territories/40.5 ha), and two biologists were assigned to map territories on each high-density plot (> 10 territories/40.5 ha). 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 and fledglings for each territory. Exhibit B lists the lead surveyors and survey hours for each intensive monitoring plot. Exhibit C provides details on the 2017 field data collection protocols.

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

Warbler observations were recorded with Garmin global positioning units (GPS), which have an accuracy of 3 to 9 meters. Other sightings were recorded on topographic maps, using a 100-meter Universal Transverse Mercator (UTM) grid. Date; color combination (for observations of banded birds); UTM coordinates; and presence of female, nest, and/or fledglings were recorded for each observation. The data were then entered into ArcGIS® (ESRI, Redlands, California) and displayed so that territories could be delineated. Territorial boundaries for each male were delineated using minimum convex polygons in ArcGIS® 10.3.1.

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 territory). Verner's counting method was recommended by Weckerly and Ott (2008) and

avoids the upward bias inherent in the IBCC (1970) methodology (both full territories and edge territories counted as 1.0 territory). This study assumes a full territory is one in which a male is observed singing outside the plot no more than once (could be multiple positions on one visit) between March 15 and May 25. A territory is considered outside the plot if the singing male is found within the plot no more than once (could be multiple positions on one visit). An edge territory is one in which the singing male is observed both inside and outside the plot on more than one visit each or where a nest was found within a few meters of the plot boundary. Territory density is calculated as the number of territories (using Verner's counting method) divided by the plot size.

Age Structure. To calculate age structure for each study plot, the number of territorial SY, ASY, and AHY males was divided by the total number of territorial males with a known age (i.e., color-banded males only).

Return Rate. Return rates are based on the total number of color-banded adult males present in 2016 (including returns from previous years and those banded in 2016) that were observed again in 2017.

Pairing and Reproductive Success. Surveys to document productivity were conducted from March 15 through June 15. To assist with fledgling counts, a second observer assisted with the weekly surveys on medium-density plots (5-10 territories/40.5 ha) from April 20 through May 25. Two observers conducted weekly surveys on the high-density plots (>10 territories.40.5 ha) through May 25, after which one observer continued to conduct surveys through June 15.

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

Breeding success and productivity are generally believed to represent minimum estimates 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. Based on camera monitoring, Reidy et al. (2008) documented a mean number of 3.6 young fledged per successful nest in the Bull Creek and North Lake Austin macrosites. This estimate was applied to those territories where the number of fledglings was uncertain, and less than 4, 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. In field season 2017, a concerted effort was made to locate and monitor nests on Kent Butler, Emma Long Bike Park, and Emma Long Expansion. Nests were monitored on other intensive monitoring plots as staff and resources allowed. For plots that included a focus on nest searching and monitoring, two observers surveyed the plot/buffer twice a week from March 15 through May 25, and at least one observer surveyed the plot/buffer from May 25 through June 15. UTM coordinates were recorded for each nest location using Garmin GPS units. Staff monitored each nest every few days to confirm activity and nest stage, and predicted the expected fledge date based on nesting phenology, apparent nestling age, and adult behavior. Staff monitored the nest more frequently around the expected fledge date (nestlings $\geq$9 days old); they searched for fledglings for any nest that was no longer active until fledglings were confirmed, until evidence of re-building was confirmed, or until the end of the field season. A nest was considered successful only if one or both adults was detected tending to fledglings. If nesting activity ceased prior to possible fledging, nest fate was recorded as failed. If nesting activity ceased around the time of anticipated fledging, and the pair was not detected or rarely detected for the remainder of the breeding season, nest fate was recorded as unknown. Nest tree species and nest coordinates were collected at each nest at the end of the field season.

Golden-cheeked Warbler Monitoring on Re-sighting Plots

BCP staff and volunteers conducted 4 weekly visits to each re-sighting plot from approximately March 20 through April 15, and one late-season visit to detect dispersing birds (approximately May 15-May 25), for a total of 5 visits. One observer was assigned to plots averaging <10 territories, and two observers were assigned to plots with greater densities. Surveyors visually confirmed the banding status (banded or unbanded) and color combination of all warblers observed within the re-sighting plot (and buffer, if any) and recorded their geographic positions.

Search for Banded Warblers Outside of Intensive Monitoring/Re-sighting Plots

Fifty-one volunteers were tasked with conducting three 6-hour visits from March 15 through May 31 within the 32 search areas. The list of re-sighting plots where surveys were conducted and the survey effort for each plot are reported in Exhibit B.

Enumerations

One City of Austin BCP staff member conducted three enumerations on the Park West tract, between March 30 and May 23, 2017. Incidental sightings of females and fledglings were also recorded. Each survey included roughly one hour for each 25 acres of habitat. Travis County staff also conducted several enumeration surveys, which are reported in "Appendix I: FY 2017 Report on Monitoring Golden-cheeked warblers on Travis County Tracts of the Balcones Canyonlands Preserve" of the FY 2017 BCCP Annual Report.

Point-Count Surveys

Six City of Austin BCP staff conducted point-count surveys on all 12 long-term intensive monitoring plots. In addition, Julie Murray and Anthony Locatelli (Travis County BCP) conducted point counts on Emma Long Bike Park and Emma Long Expansion. Travis County staff also conducted point-count surveys on Travis County BCP tracts, which are reported in "Appendix I" of the FY 2017 BCCP Annual Report.

Point count stations were superimposed on the intensive monitoring plots and placed 250 m apart in a grid. Point counts were conducted between April 4 and April 20. Surveys on the 12 plots were conducted using an independent double-observer method in three groups of two. Pairs surveyed at the same time but as independently as possible and did not alter observations based on the partner's observations.

Point-counts were conducted only when ambient air temperature was 50° F (10° C) or warmer, when there was no or little precipitation, and when wind speeds were < 12 mph. Point-counts were not conducted during moderate or heavy precipitation, dense fog, or windy conditions because these conditions impact detectability of birds. Each point-count lasted five minutes. The time (hour:minute), distance, and direction of all golden-cheeked warblers heard was recorded. A compass and range finder was used to get the most accurate estimates possible. Visual detections were not recorded unless they were accompanied by song. Results will be fitted to models as part of a future effort.

RESULTS

Territory Delineations

A total of 121 territories were identified in field season 2017, including 89.5 territories using Verner's (1985) method for all 14 intensive monitoring plots. This represents an average estimated density of 0.11 territories per hectare for the combined 818 hectares of intensive monitoring plots, ranging from 0.01 to 0.38 territories/ha (Table 2). 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 (West Austin macrosite) and areas with shorter (<11 feet) canopy heights. A summary of the 2009-2017 territory data is provided in Exhibit D.

Densities within the intensive study plots typically experience an annual variation of $\pm$0.07 males/ha. (Exhibit D). Forest Ridge was the only plot that increased in density in 2017. Densities on the other 13 plots either stayed the same or decreased. Notable declines from previous years were observed at Vista Point and Emma Long. The population at Wild Basin/Vireo Preserve has also declined since surveys were initiated in 2011. Annual variation may be due to observer differences, changes in habitat conditions within or outside the plot, immigration/emigration of birds from or to surrounding areas, differences in survival rates, prior reproductive success, and/or other factors. However, the sampling design minimizes observer bias because at least two biologists survey plots with five or more warblers and the majority of warblers are color-banded.

Table 2. Golden-cheeked warbler territory number and estimated territory density (per hectare) within 14 intensive study plots on the Balcones Canyonlands Preserve, Travis County, Texas, field season 2017. 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	3	6	4.5	0.11
Barton Creek Habitat Preserve	0	2	1	0.01
Bull Creek Macrosite				
Forest Ridge	11	20	15.5	0.38
Kent Butler	7	19	13	0.32
Hamilton West	5	9	7	0.17
Cypress Creek Macrosite				
Vista Point	8	14	11	0.27
Wheless	1	4	2.5	0.06
North Lake Austin Macrosite				
Cortaña	4	5	4.5	0.07
Emma Long	3	10	6.5	0.16
Emma Long Bike Park	3	10	6.5	0.07
Emma Long Expansion	4	9	6.5	0.19
South Lake Austin Macrosite				
Double J&T	2	3	2.5	0.06
Reicher	3	6	4.5	0.11
West Austin Macrosite				
Wild Basin/Vireo Preserve	4	4	4	0.02
Total/Average	**58**	**121**	**89.5**	**0.11[2]**

[1]Calculation based on Verner's counting method. All plots average 40.5 ha except for Barton Creek Habitat Preserve (81.5 ha), Bike Park (96 ha), Emma Long Expansion (34 ha), Cortaña (62 ha), and Wild Basin/Vireo Preserve (180 ha).
[2]Calculated for the combined study area (89.5 full + 0.5 edge territories/818 ha).

Color Banding

City of Austin and Travis County staff banded a total of 81 adult warblers (75 males, 6 females) in 2017.

Age Structure

Of the 121 territorial males identified on the 14 intensive study plots in 2017, 93 were color-banded (77%; Table 3). Of these 93 males, 76 percent were ASY and 24 percent were SY. Forest Ridge, Emma Long Expansion, Vista Point, and Wild Basin/Vireo Preserve had the highest percentages of ASY males in 2017 (>90%), while Emma Long Bike Park had the highest percentage of SY males (56%). 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, prior reproductive success (or lack thereof), juvenile and adult survival, and/or other factors. A summary of male age structure on intensive monitoring plots from 2009-2017 is presented in Exhibit E.

Table 3. Golden-cheeked warbler age structure data for color-banded territorial males observed within 14 intensive study plots on the Balcones Canyonlands Preserve, Travis County, Texas, field season 2017.

Plot Name	SY Males	ASY Males	AHY Males	Total Banded Males	Total Unbanded Males	% Banded Males
Barton Creek Macrosite						
Barton Creek	1	4	0	5	1	83
Barton Creek Habitat Preserve	1	0	0	1	1	50
Bull Creek Macrosite						
Forest Ridge	1	12	0	13	7	65
Kent Butler	5	8	0	13	6	68
Hamilton West	3	5	0	8	1	89
Cypress Creek Macrosite						
Vista Point	1	10	0	11	3	79
Wheless	1	2	0	3	1	75
North Lake Austin Macrosite						
Cortaña	1	4	0	5	0	100
Emma Long	2	7	0	9	1	90
Emma Long Bike Park	4	3	0	7	3	70
Emma Long Expansion	0	7	0	7	2	78
South Lake Austin Macrosite						
Double J&T	1	2	0	3	0	100
Reicher	1	3	0	4	2	67
West Austin Macrosite						
Wild Basin/Vireo Preserve	0	4	0	4	0	100
Total	**22**	**71**	**0**	**93**	**28**	**77**

Return Rates

The overall return rate of color-banded warbler males in 2017 was 46 percent (71/155), higher than the return rates observed in 2016 (37%) and 2015 (35%), but within the range of 2010-2014 return rates (41-56%).

Pairing and Reproductive Success

In 2017, a total of 121 territories were monitored for pairing and reproductive success on the 14 intensive study plots (Table 4). The average pairing and breeding success observed for all territories was 90 percent (range 0-100%) and 62 percent (range 0-78%), respectively. Plots within mature, closed-canopy woodlands in the Bull Creek macrosite continued to support the highest numbers of territories producing one or more fledglings (Forest Ridge, Kent Butler; 14 territories). Plots in the Barton Creek and West Austin macrosites had the fewest territories producing one or more fledglings (range 0-4 territories).

Staff detected 204 fledglings from 120 territories with known reproductive success (estimates exclude one territory on Emma Long 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 and less than 4 resulted in an adjusted total estimate of 254 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, Kent Butler) and Cypress Creek (Vista Point) macrosites produced the greatest number of fledglings (31-37/31-51 observed/adjusted fledglings; density 0.60-0.73/0.62-0.99 observed/adjusted fledglings/ha), while the Barton Creek Habitat Preserve and Wild Basin/Vireo Preserve plots had the lowest reproductive output (0-3 observed/adjusted fledglings; density 0-0.02 observed/adjusted fledglings/ha). Warblers at the Barton Creek and Vireo Preserve/Wild Basin plots experienced the lowest breeding success since intensive monitoring surveys on these plots began in 2009-2011 (0-17%, Exhibit F). Breeding success at the Emma Long plot was also low compared to previous years. A summary of the 2009-2017 reproductive success data is presented in Exhibit F.

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

Table 4. Golden-cheeked warbler reproductive success on 14 intensive study plots on the Balcones Canyonlands Preserve, Travis County, Texas, field season 2017. Data are based on observations for both full and edge territories. See Methods section for calculations. Territories for which pairing and/or reproductive success were unknown are not included in the calculations (actual sample sizes are indicated in parentheses).

Plot Name	No. of Territories	No. of Territories w/ Female	Pairing Success	No. of Territories Producing ≥ 1 Young	Breeding Success	Observed and Adjusted* Productivity	Observed and Adjusted* Productivity Per Successful Territory	Total No. of Fledglings Observed and Adjusted* Fledglings	Density of Observed and Adjusted* Fledglings Per Hectare**
Barton Creek Macrosite									
Barton Creek	6	6	100	1	17	0.7 / 0.7	4 / 4	4 / 4	0.10 / 0.10
BCHP	1	0	0	0	0	0	0	0	0
Bull Creek Macrosite									
Forest Ridge	20	20	100	14	70	1.9 / 3.3	2.6 / 3.7	37 / 51	0.73 / 0.99
Kent Butler	19	18	95	14	74	1.8 / 2.5	2.5 / 3.4	35 / 48	0.60 / 0.80
Hamilton West	9	9	100	7	78	2.3 / 3.0	3.0 / 3.8	21 / 27	0.42 / 0.52
Cypress Creek Macrosite									
Vista Point	14	12	86	9	64	1.3 / 1.3	3.4 / 3.4	31 / 31	0.62 / 0.62
Wheless	4	3	75	3	75	0.9 / 0.9	4 / 4	12 / 12	0.15 / 0.15
North Lake Austin Macrosite									
Cortaña	5	4	80	2	40	1.0 / 1.5	2.5 / 3.3	5 / 7	0.08 / 0.11
Emma Long	10	8 (9)	89	4 (9)	44	1.2 / 1.3	3.0 / 3.2	12 / 13	0.20 / 0.20
Emma Bike Park	10	9	90	7	70	1.9 / 2.1	2.7 / 3.0	19 / 21	0.14 / 0.15

Emma Expansion	9	9	100	7	78	1.7 / 2.1	2.1 / 2.7	15 / 19	0.31 / 0.34
South Lake Austin Macrosite									
JJ&T	3	2	67	2	67	1.7 / 2.4	2.5 / 3.6	5 / 7	0.09 / 0.13
Reicher	6	6	100	4	67	1.3 / 2.2	2.0 / 3.3	8 / 13	0.16 / 0.26
West Austin Macrosite									
Wild Basin/Vireo Preserve	4	2	50	0	0	0	0	0	0
Total/Avg.	**121**	**108 (120)**	**90**	**74 (120)**	**62**	**1.7 / 2.1**	**2.8 / 3.4**	**204 / 254**	**0.19 / 0.23**

*Based on mean number of 3.6 young per successful nest (Reidy et al. 2008) for territories where the number of fledglings was uncertain and less than 4; does not include data from second broods.
**Density based on number of fledglings produced per full + 0.5 territories divided by the plot size.

Nest Data

BCP staff and BCP partners found and monitored a total of 98 active warbler nests within the intensive monitoring plots during the 2017 field season. The first nest was found on March 10, and fledging dates for observed nests ranged from April 12 through June 23. Of the 98 nests, 53 fledged one or more young (54.1%), 42 nests failed (42.8%), and 3 had an unknown fate (3.1%). There were no observations of Brown-headed Cowbird (*Molothrus ater*) parasitism at warbler nests in 2017.

Other Observations

We observed a male on territory at the Emma Long plot from 27 March through 23 May 2017 who sang a unique type A-song variant that was unrecognizable as a golden-cheeked warbler song. He was color banded on 29 March and aged ASY. He responded to a broadcast medley of typical golden-cheeked warbler A and B songs. On 13 April, his song rate decreased significantly, suggesting he was paired (Bolsinger 2000), after which he began singing typical B songs, suggestive of territorial defense. BCP staff never observed him with a female, so could not confirm pairing status, nor was he ever seen with fledglings. However, since this male remained and defended a territory throughout the breeding season, he may have been paired and had one or more failed nesting attempts.

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Exhibit A. Distribution of Intensive Monitoring Plots (Figure 1), Canopy Heights (Figure 2), and Minimum Convex Polygons Representing Estimated Golden-cheeked Warbler Territory Boundaries for Intensive Monitoring Plots (Figures 3-16) and Enumerations (Figure 17) within the Balcones Canyonlands Preserve, 2017. Disclaimer: these products are for informational purposes and may not have been prepared for, or be suitable for, legal, engineering, or surveying purposes. It does not represent an on-the-ground survey and represents only the approximate relative location of property boundaries. These products have been produced by the Wildland Conservation Division for the sole purpose of geographic reference. No warranty is made by the City of Austin regarding specific accuracy or completeness.

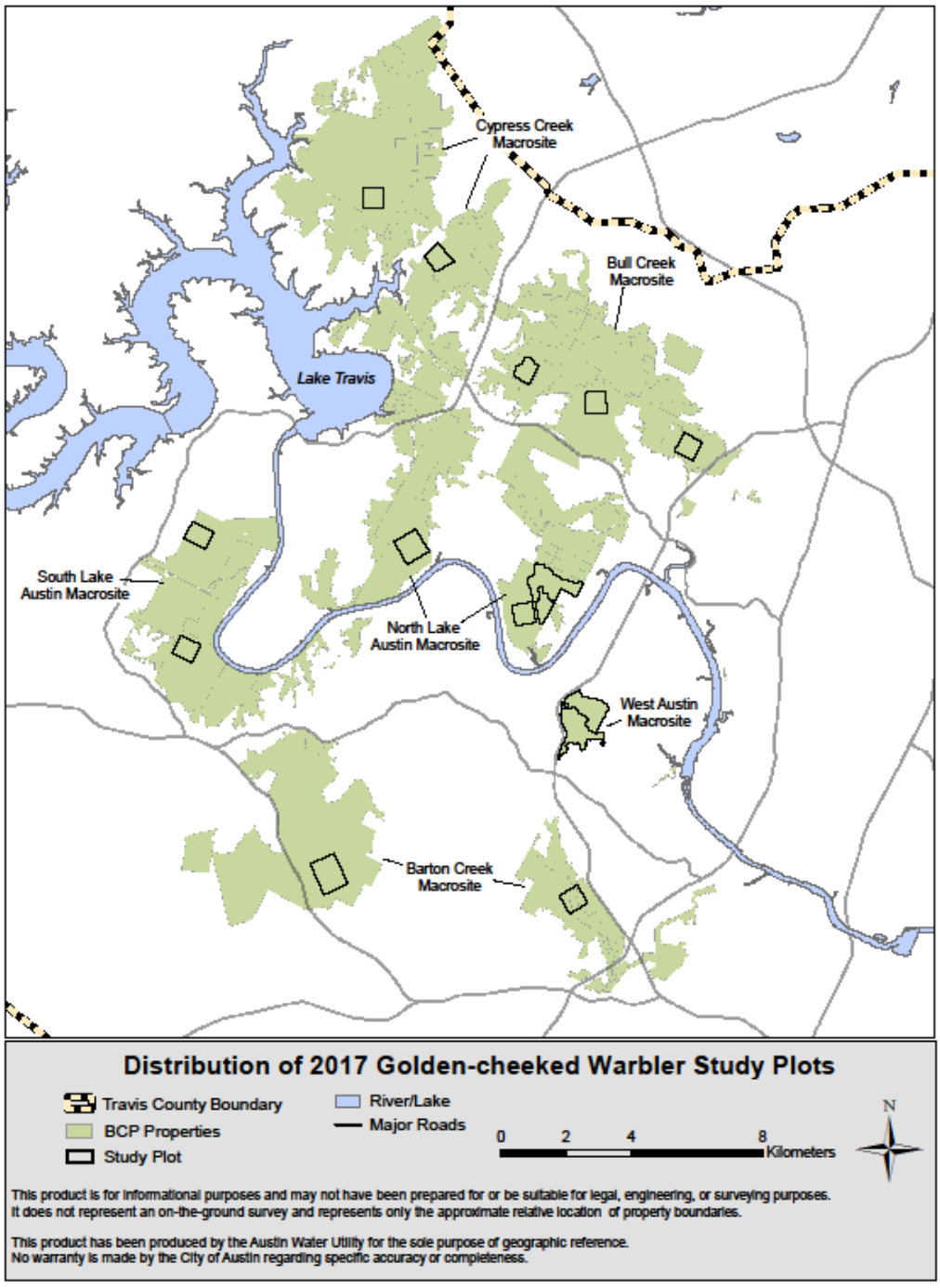


Figure 1

Exhibit A: Proportion of vegetation canopy heights across the Balcones Canyonlands Preserve (BCP) and within each of the 12 long-term intensive monitoring plots (Barton Creek, Barton Creek Habitat Preserve, Cortaña, Emma Long, Forest Ridge, Hamilton West, JJ&T, Kent Butler, Reicher, Vista Point, Wheless, Wild Basin/Vireo Preserve; does not include short-term intensive monitoring plots, re-sighting plots, or enumeration plots).

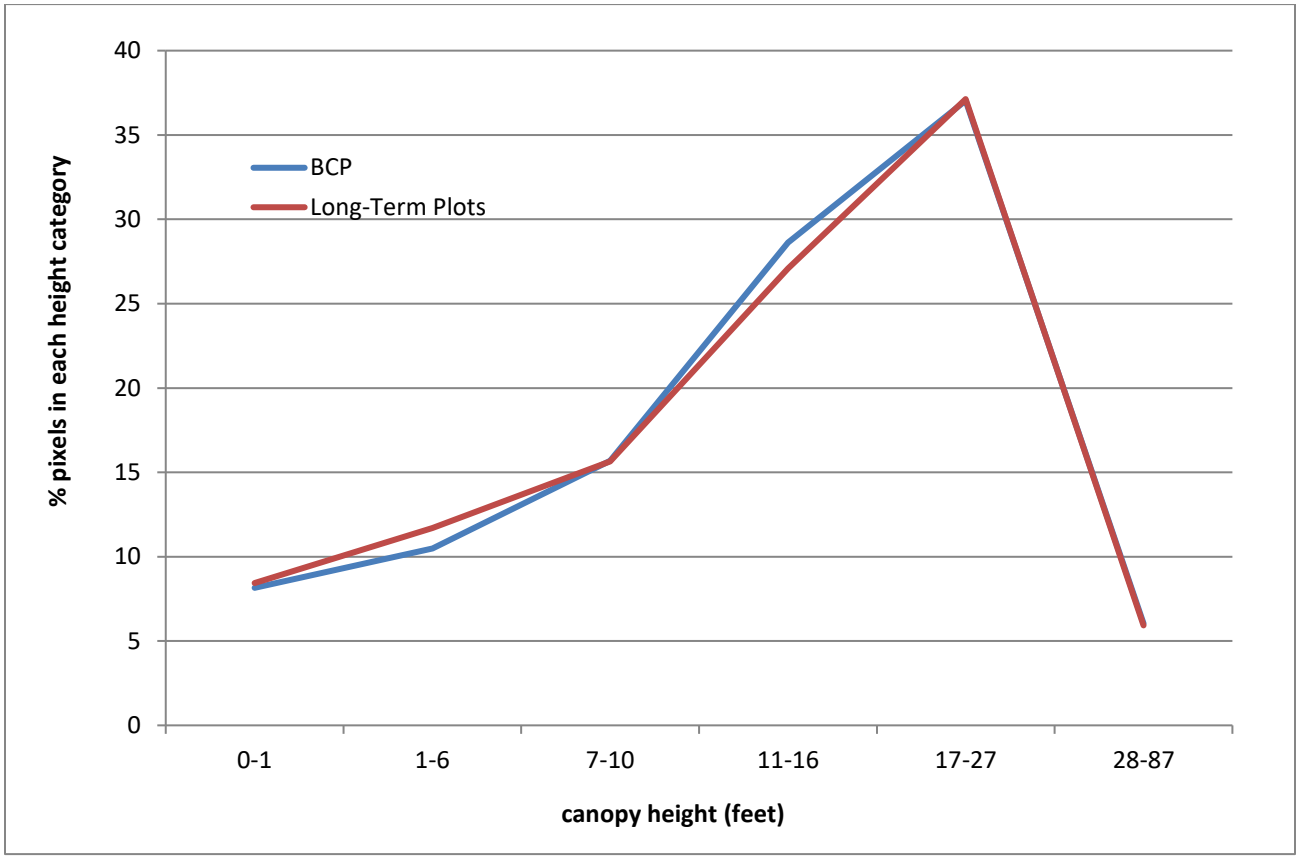


Figure 2

Exhibit A: Minimum Convex Polygons Representing Estimated Golden-cheeked Warbler Territory Boundaries for Intensive Monitoring Plots (Figures 3-16), 2017. Open circles outside of colored polygons represent observations of male warblers that did not have enough information, such as identification of color band combinations or contemporaneous vocalizations, to assign to a territory.

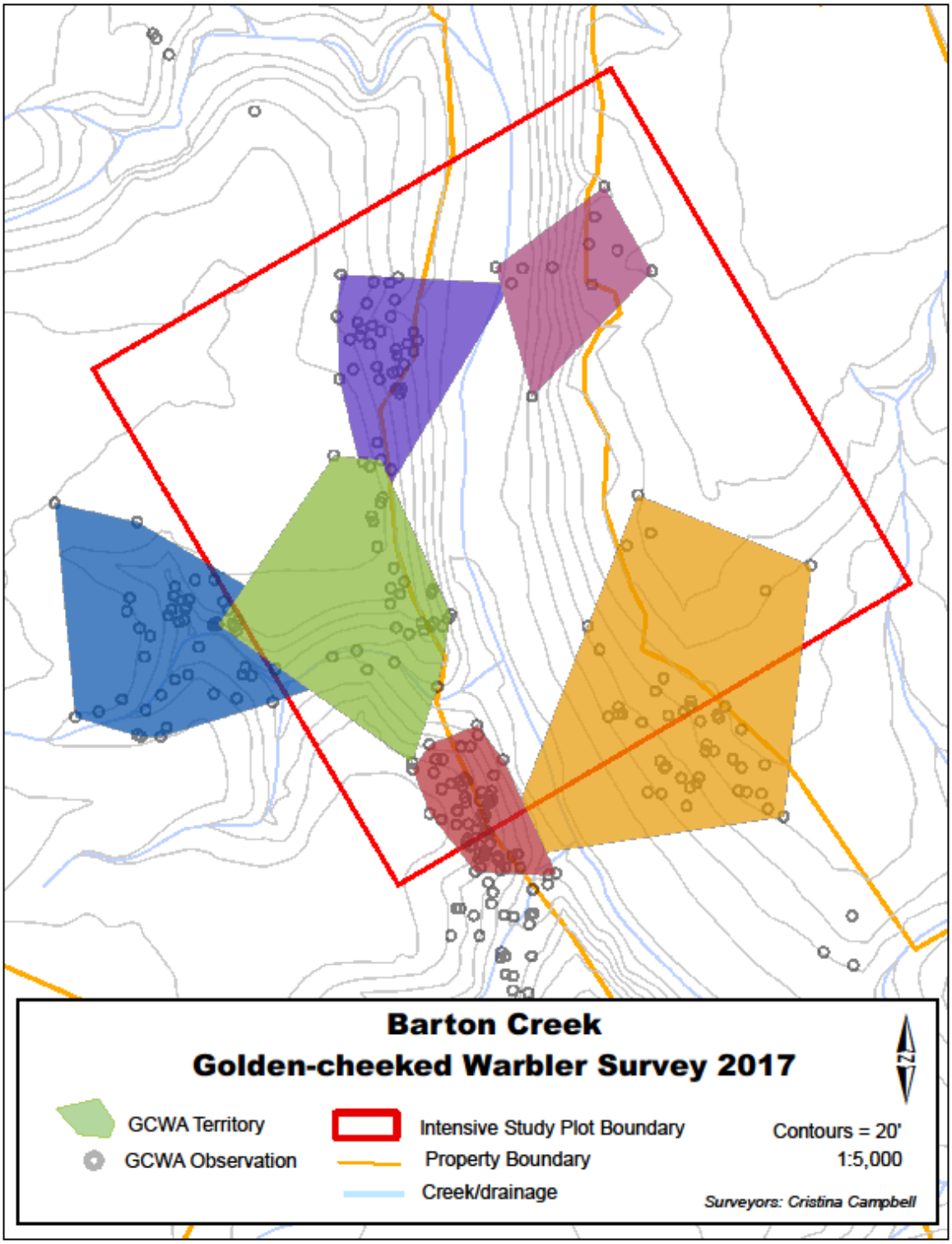


Figure 3

Figure 2

Exhibit A: Minimum Convex Polygons Representing Estimated Golden-cheeked Warbler Territory Boundaries for Intensive Monitoring Plots (Figures 3-16), 2017 (continued).

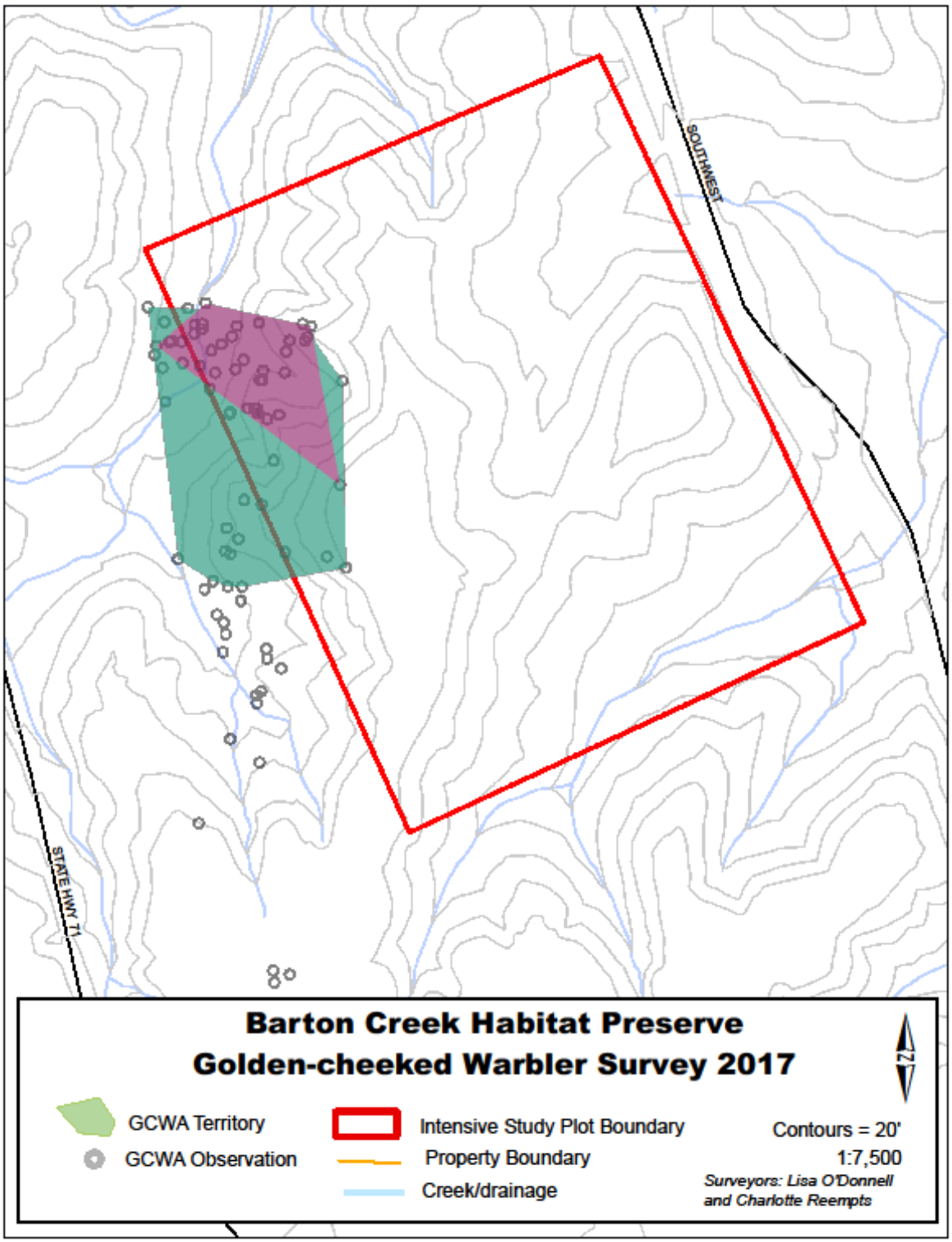


Figure 4

Exhibit A: Minimum Convex Polygons Representing Estimated Golden-cheeked Warbler Territory Boundaries for Intensive Monitoring Plots (Figures 3-16), 2017 (continued).

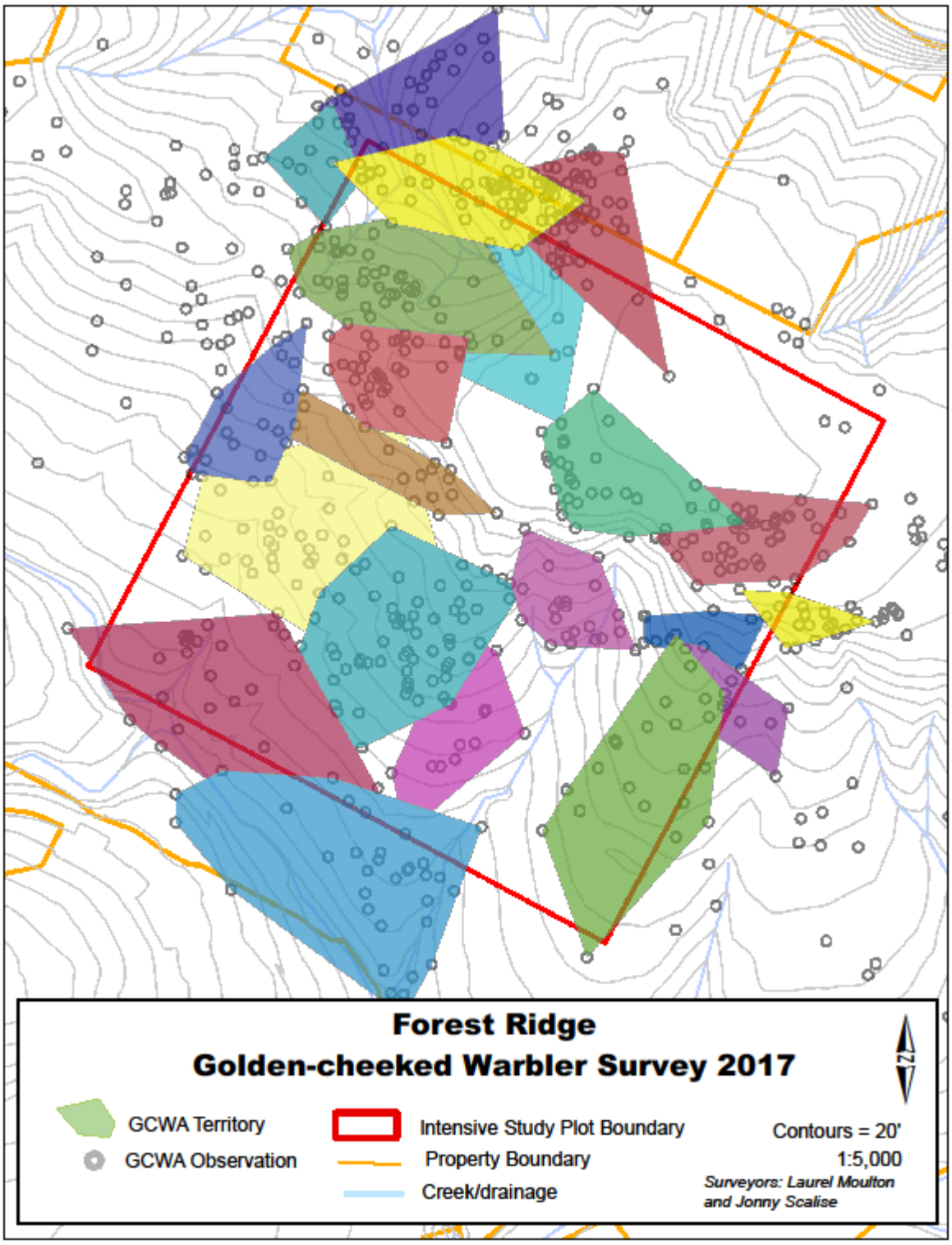


Figure 5

Exhibit A: Minimum Convex Polygons Representing Estimated Golden-cheeked Warbler Territory Boundaries for Intensive Monitoring Plots (Figures 3-16), 2017 (continued).

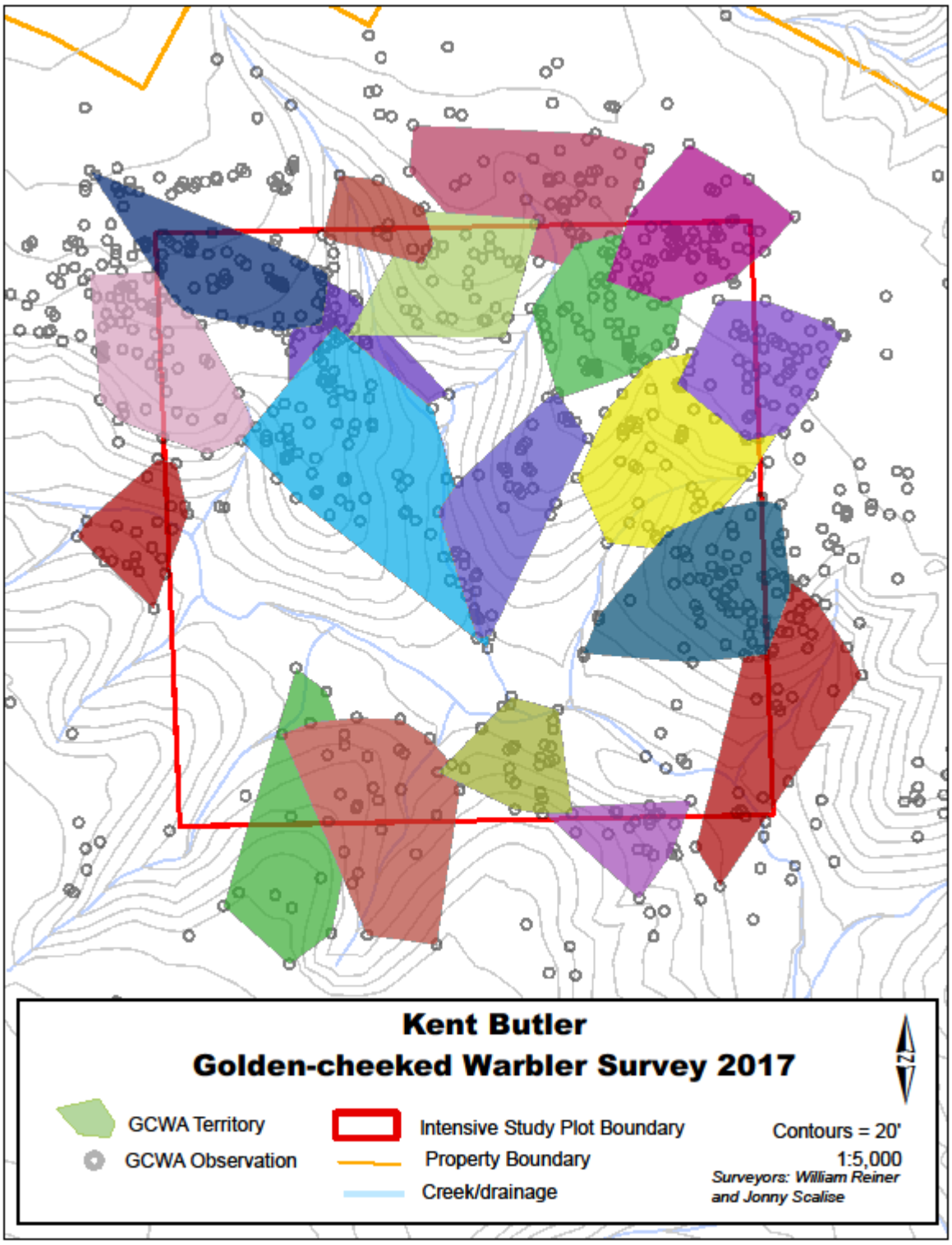


Figure 6

Exhibit A: Minimum Convex Polygons Representing Estimated Golden-cheeked Warbler Territory Boundaries for Intensive Monitoring Plots (Figures 3-16), 2017 (continued).

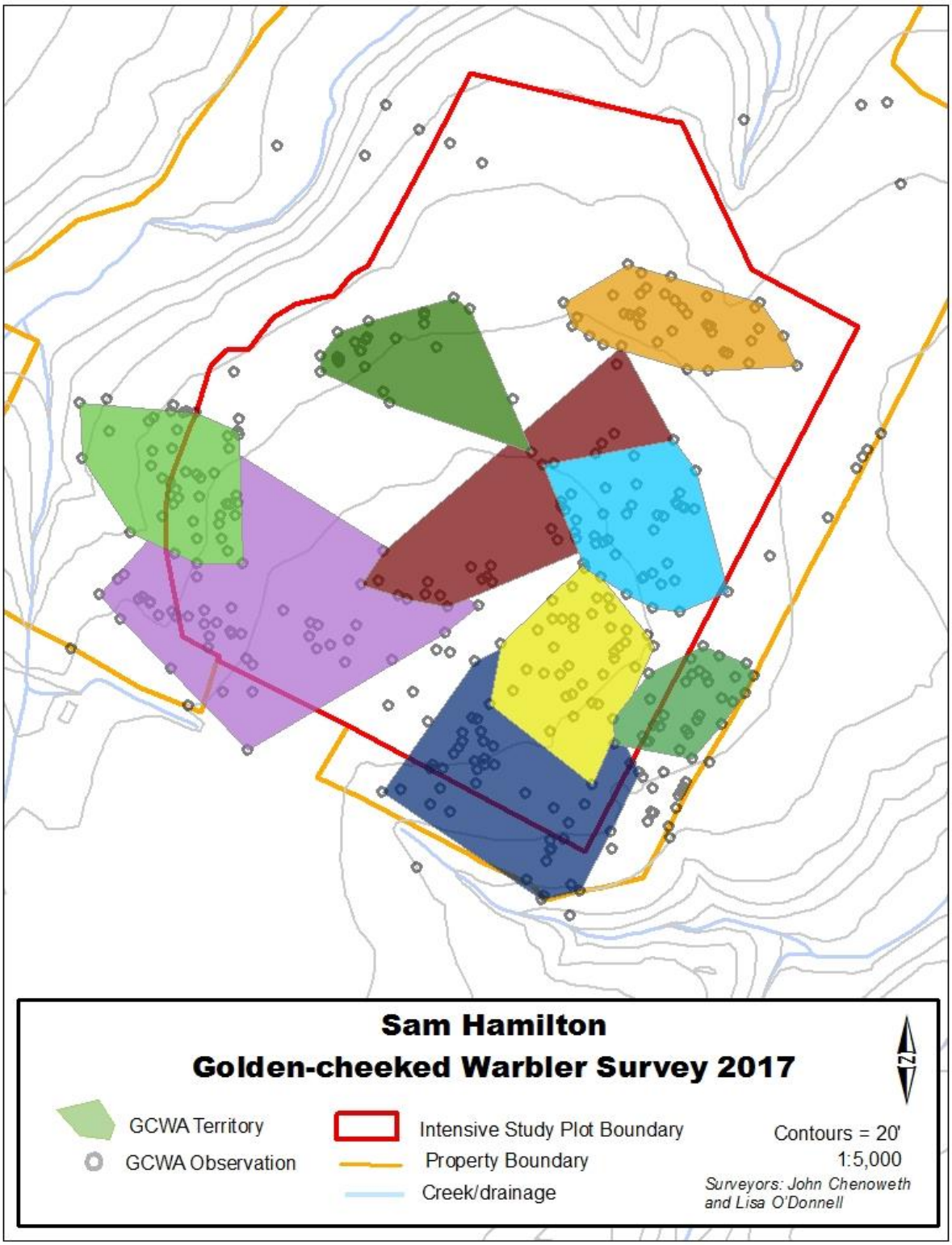


Figure 7

Exhibit A: Minimum Convex Polygons Representing Estimated Golden-cheeked Warbler Territory Boundaries for Intensive Monitoring Plots (Figures 3-16), 2017 (continued).

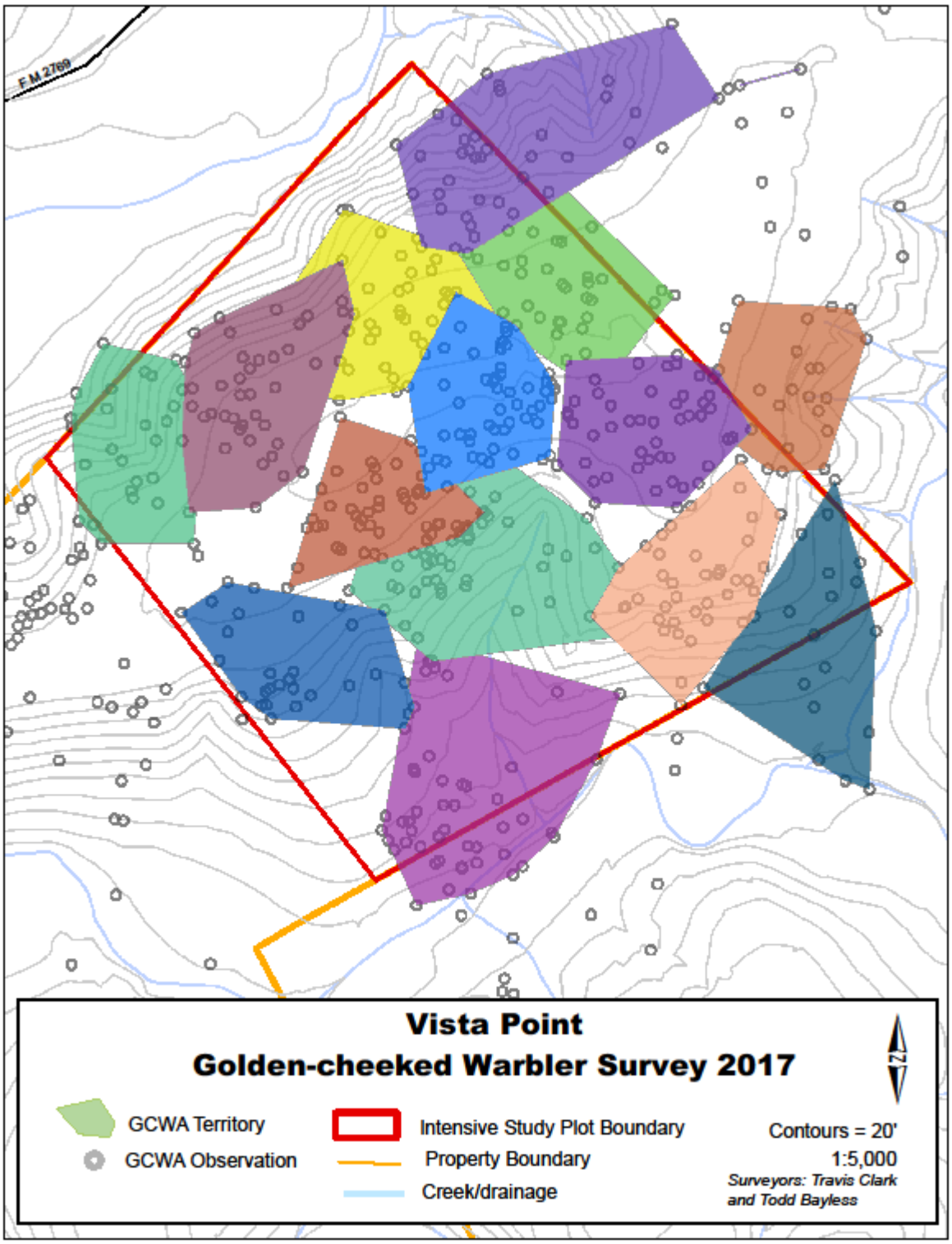


Figure 8

Exhibit A: Minimum Convex Polygons Representing Estimated Golden-cheeked Warbler Territory Boundaries for Intensive Monitoring Plots (Figures 3-16), 2017 (continued).

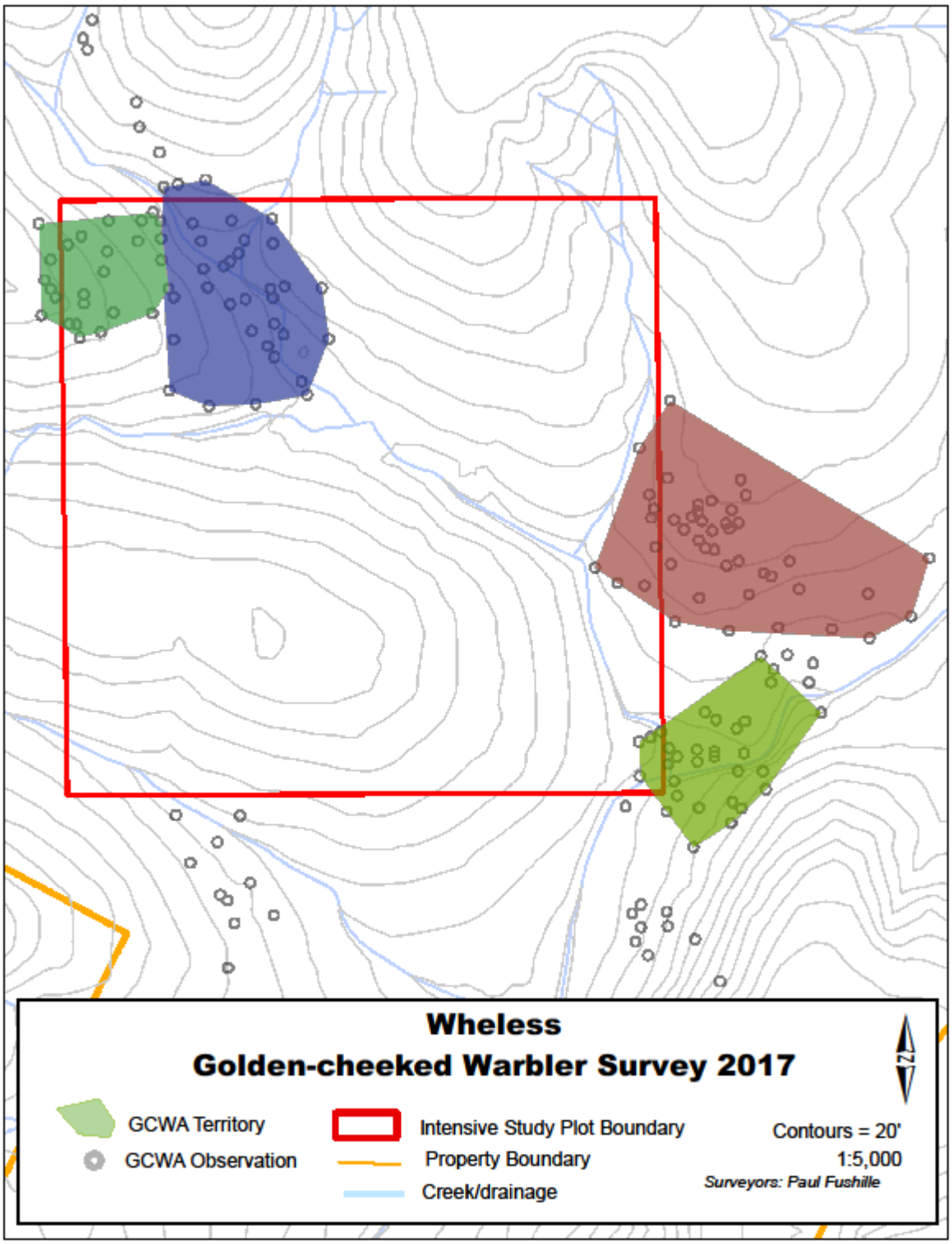


Figure 9

Exhibit A: Minimum Convex Polygons Representing Estimated Golden-cheeked Warbler Territory Boundaries for Intensive Monitoring Plots (Figures 3-16), 2017 (continued).

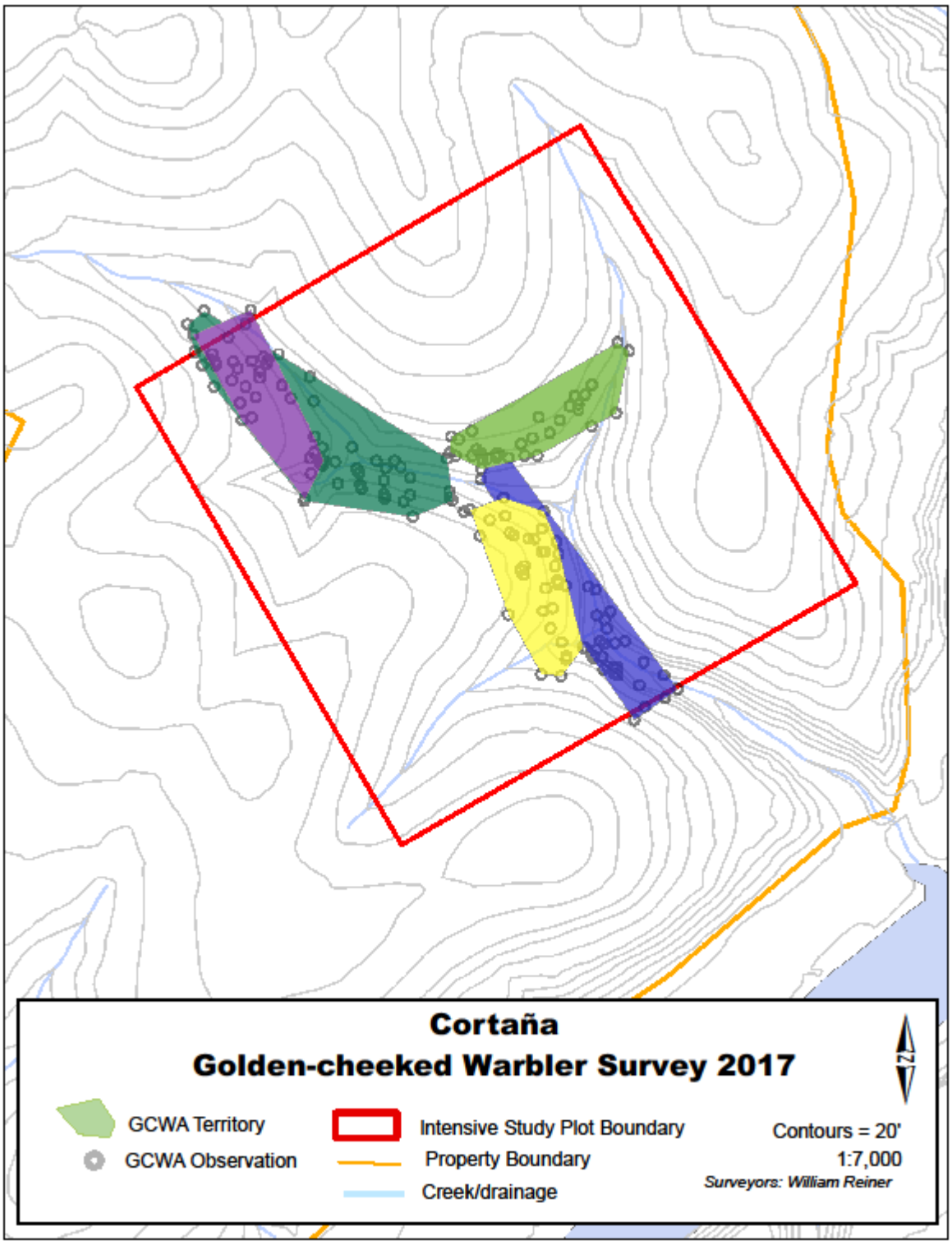


Figure 10

Exhibit A: Minimum Convex Polygons Representing Estimated Golden-cheeked Warbler Territory Boundaries for Intensive Monitoring Plots (Figures 3-16), 2017 (continued).

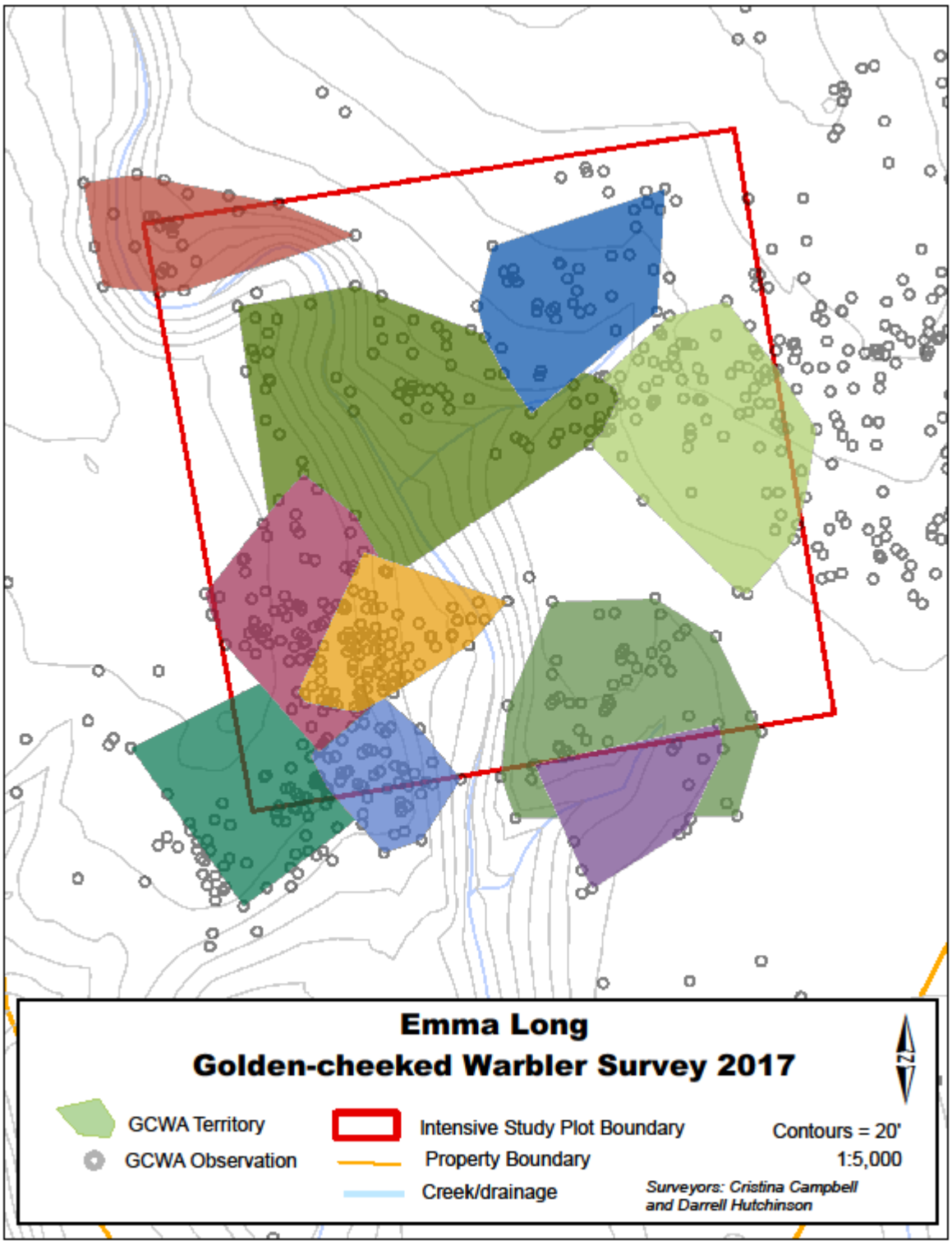


Figure 11

Exhibit A: Minimum Convex Polygons Representing Estimated Golden-cheeked Warbler Territory Boundaries for Intensive Monitoring Plots (Figures 3-16), 2017 (continued).

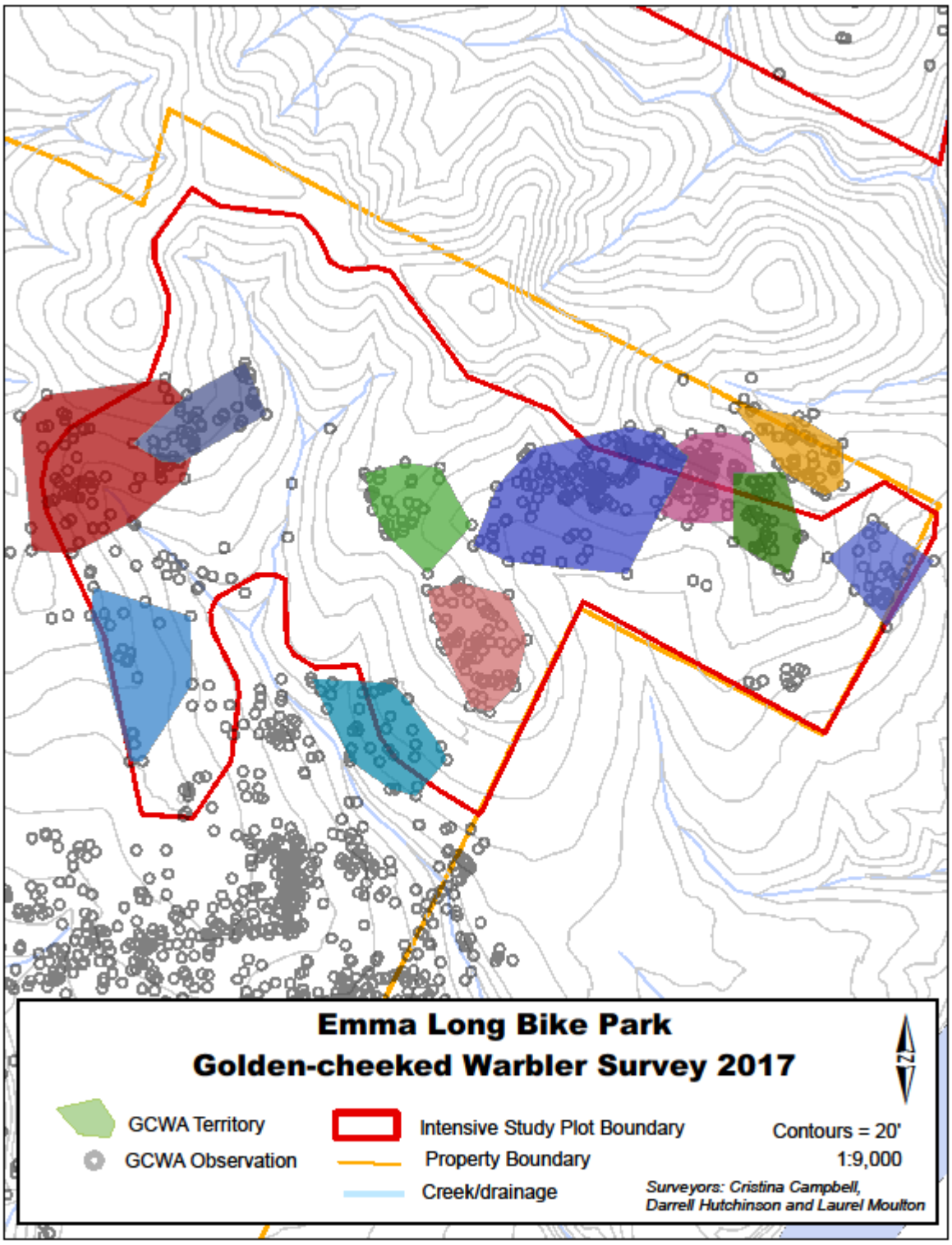


Figure 12

Exhibit A: Minimum Convex Polygons Representing Estimated Golden-cheeked Warbler Territory Boundaries for Intensive Monitoring Plots (Figures 3-16), 2017 (continued).

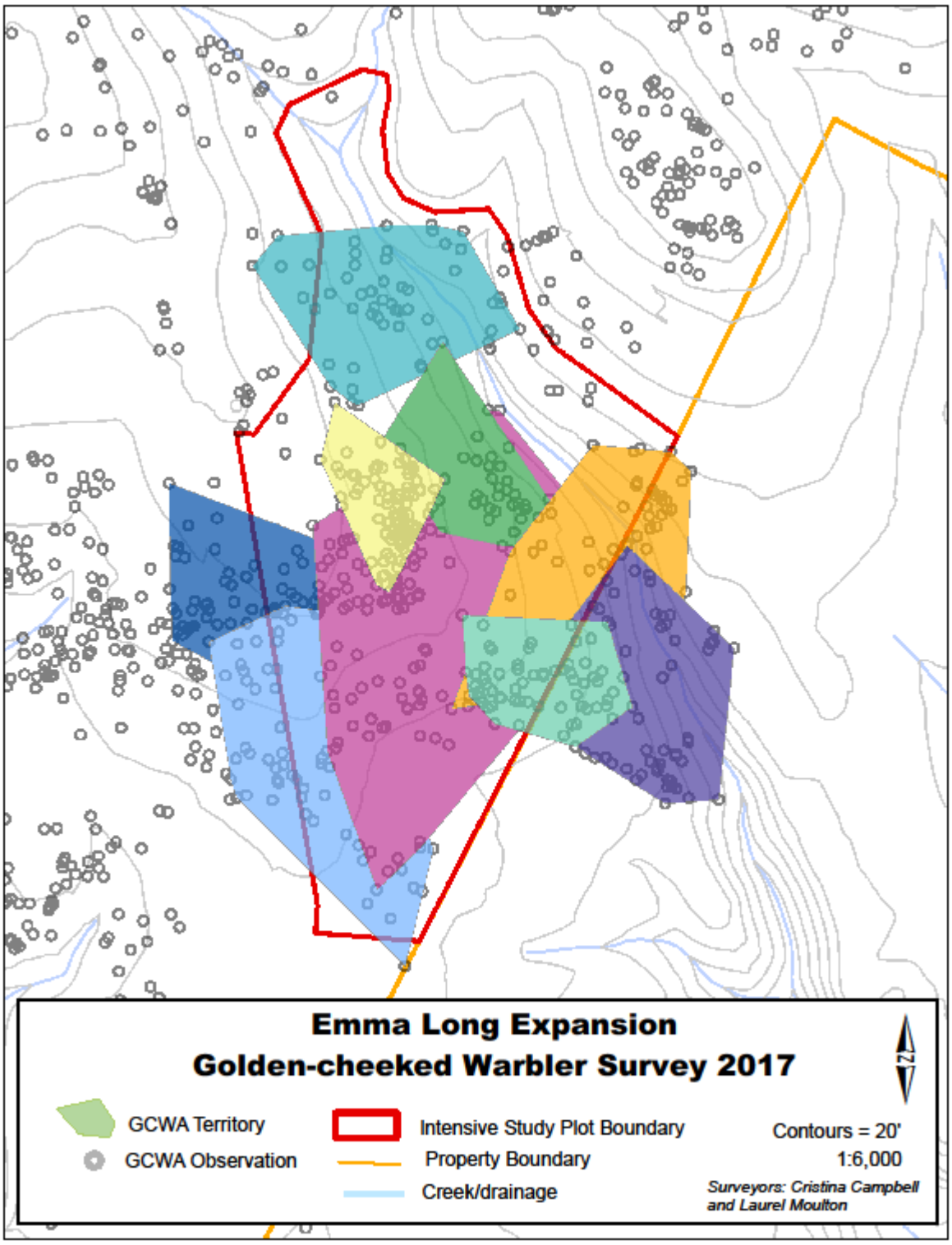


Figure 13

Exhibit A: Minimum Convex Polygons Representing Estimated Golden-cheeked Warbler Territory Boundaries for Intensive Monitoring Plots (Figures 3-16), 2017 (continued).

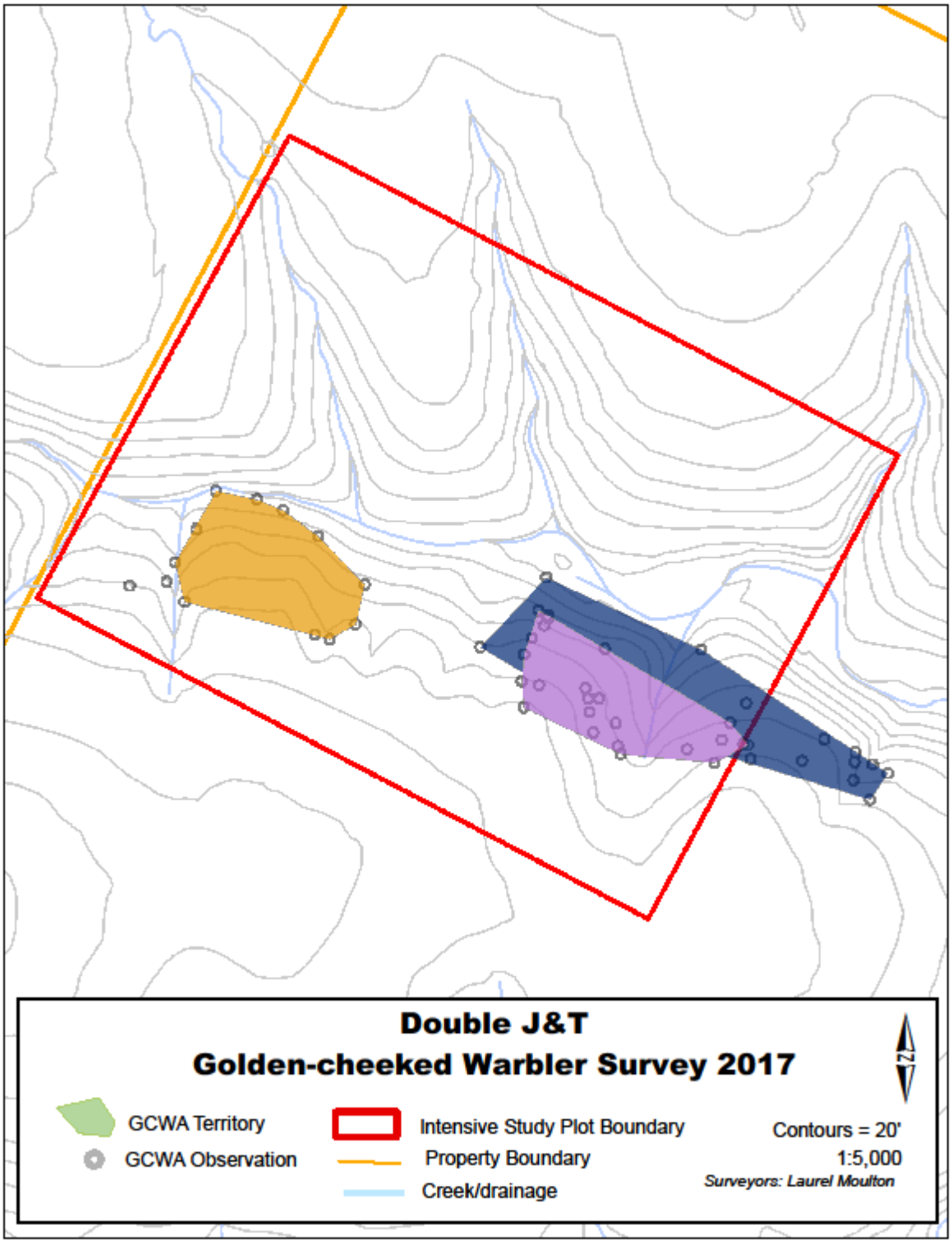


Figure 14

Exhibit A: Minimum Convex Polygons Representing Estimated Golden-cheeked Warbler Territory Boundaries for Intensive Monitoring Plots (Figures 3-16), 2017 (continued).

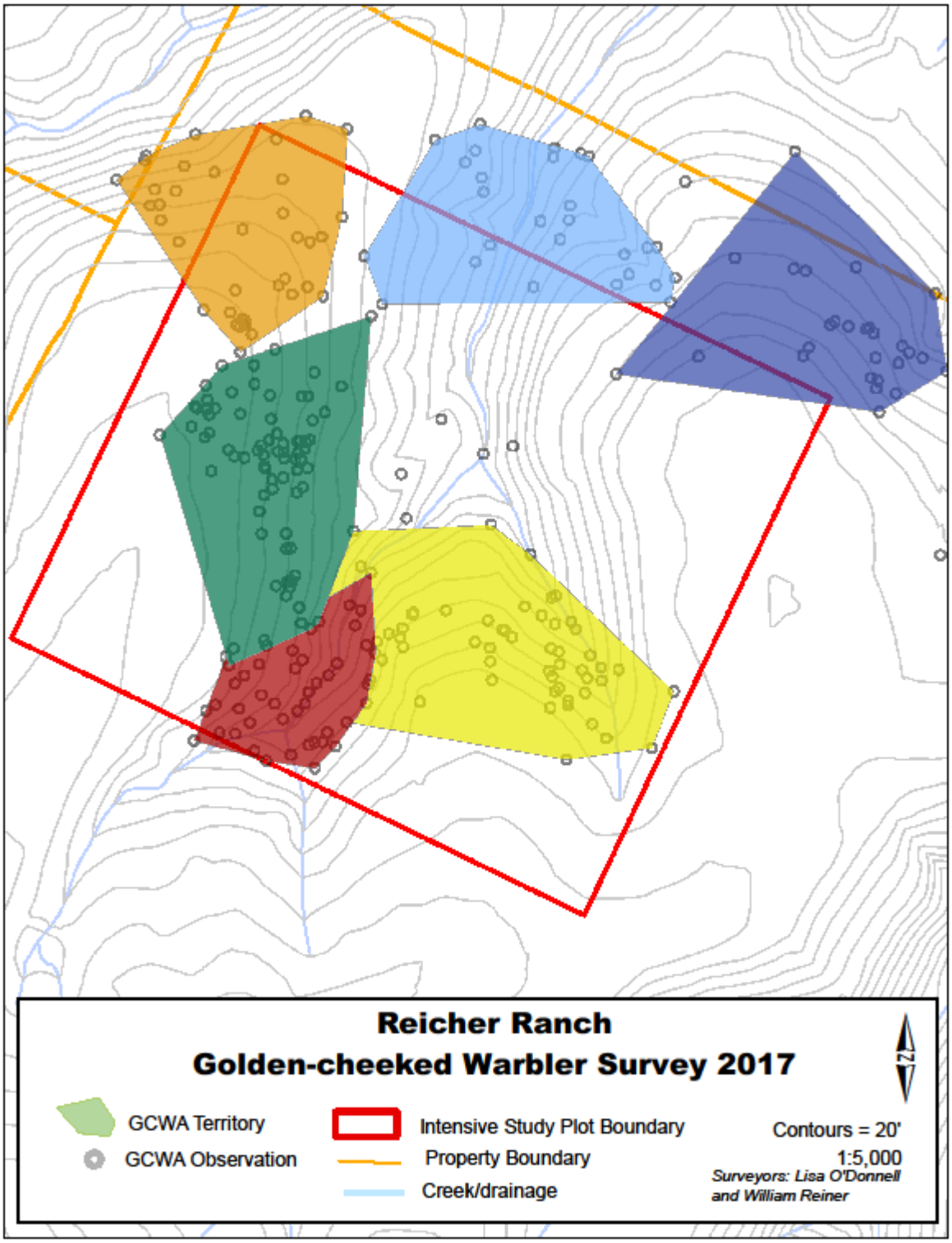


Figure 15

Exhibit A: Minimum Convex Polygons Representing Estimated Golden-cheeked Warbler Territory Boundaries for Intensive Monitoring Plots (Figures 3-16), 2017 (continued).

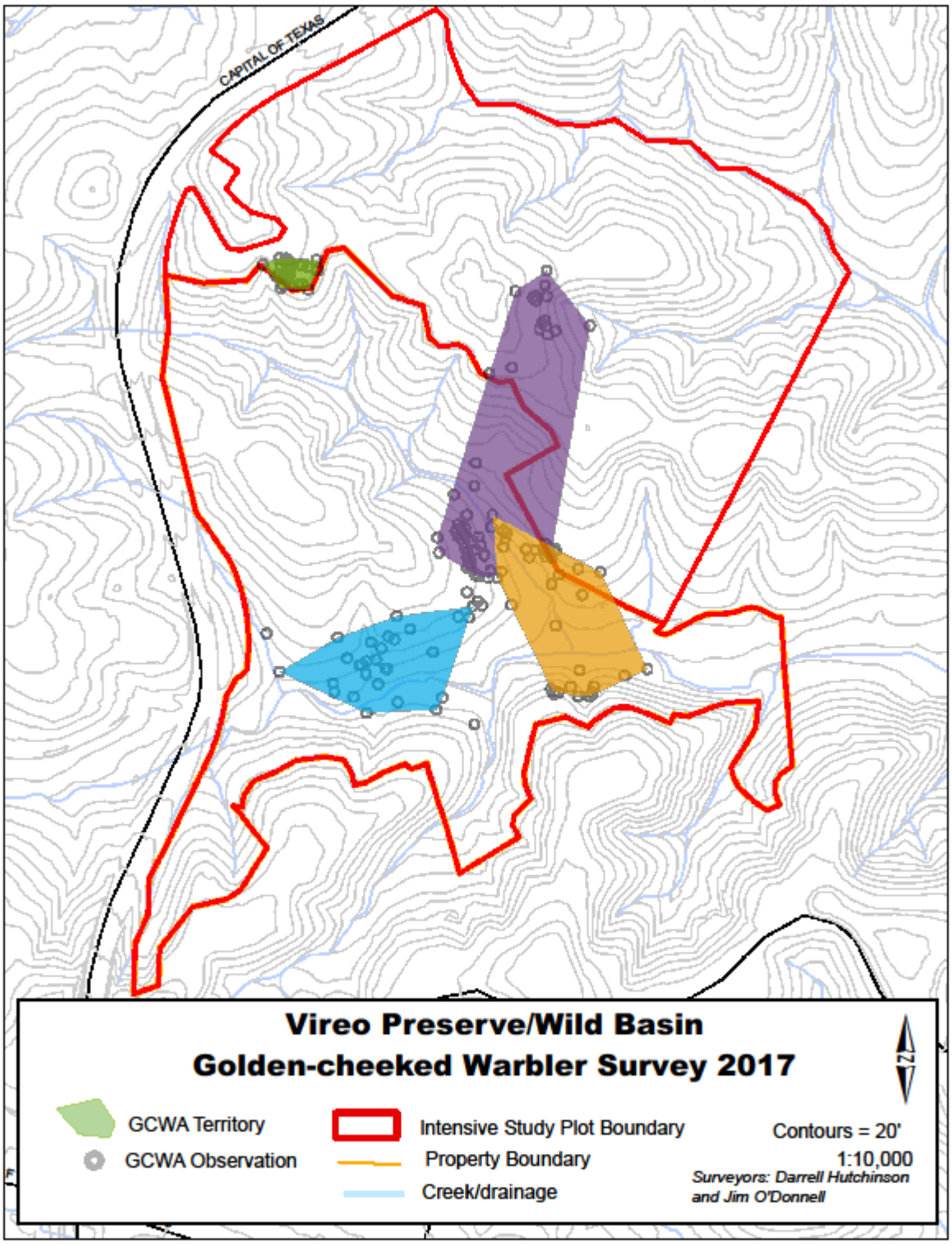


Figure 16

Exhibit A: Minimum Convex Polygons Representing Estimated Golden-cheeked Warbler Territory Boundaries for Enumeration Plot (Figure 17), 2017. Colored circles/polygons displayed on the map represent best approximations of individual bird territories; polygons were used to represent best approximation of individual bird territories when enough information was available. Colored circles represent individual male warblers when enough information was not available to form a polygon.

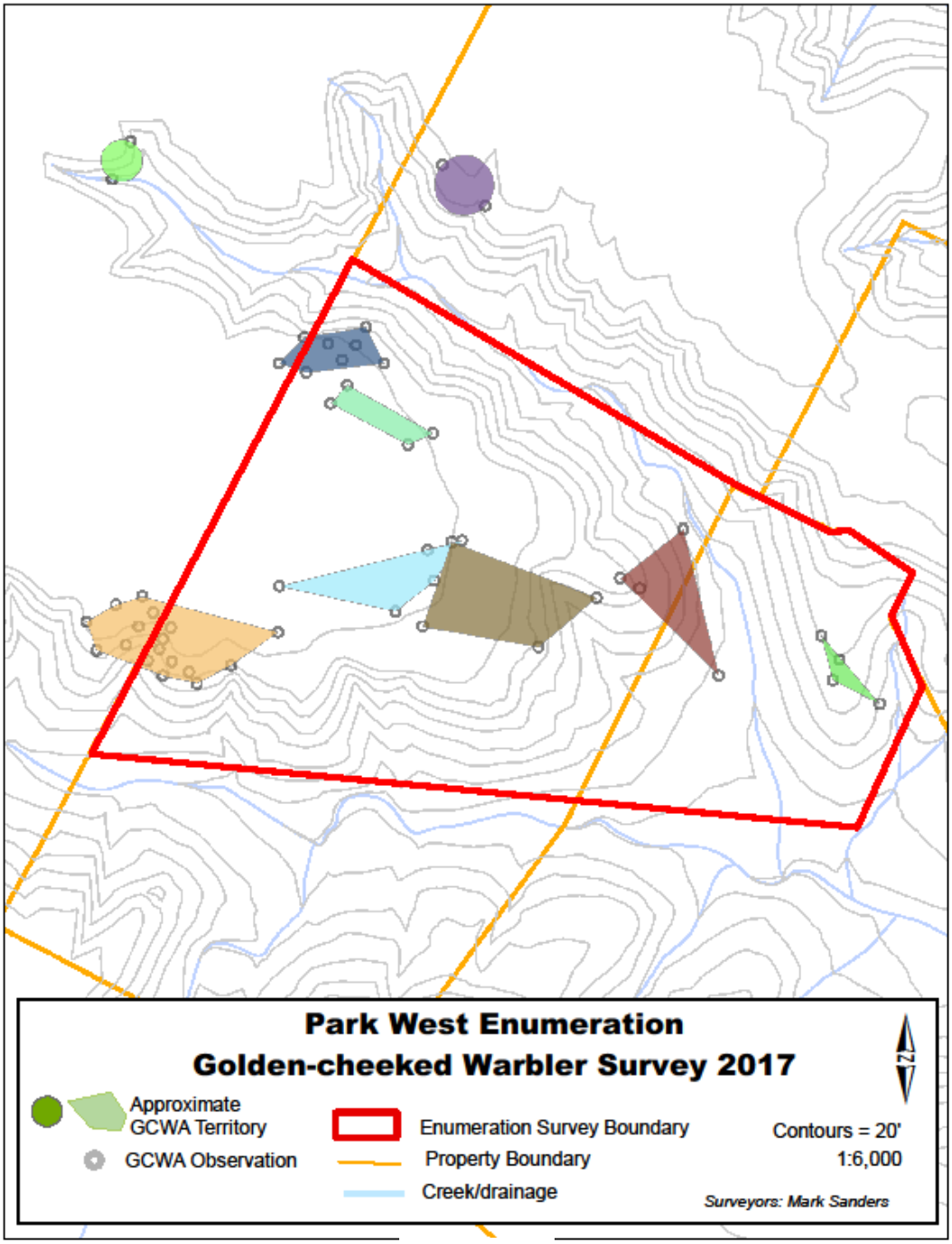


Figure 17

Exhibit B: Summary of Golden-cheeked Warbler Survey Effort on the Balcones Canyonlands Preserve, Travis County, Texas, Field Season 2017.

Intensive Monitoring Plots	Lead Surveyor(s)	Survey Hours (March 11-June 18)	Area Surveyed (hectares)
Barton Creek Macrosite			
Barton Creek	Cristina Campbell (COA)	115.5	40.5 + buffer
BCHP	Lisa O'Donnell (COA) Charlotte Reemts (TNC)	58	81.5
Bull Creek Macrosite			
Forest Ridge	Jonny Scalise, Laurel Moulton (COA)	396	40.5 + buffer
Kent Butler	William Reiner, Jonny Scalise (COA)	475.25	40.5 + buffer
Hamilton West	John Chenoweth, Lisa O'Donnell (COA)	119.75	40.5 + buffer
Cypress Creek Macrosite			
Vista Point	Travis Clark, Todd Bayless (TC)	143.75	40.5 + buffer
Wheless	Paul Fushille (TC)	71.5	40.5
North Lake Austin Macrosite			
Emma Long	Darrell Hutchinson, Cristina Campbell (COA)	220.95	40.5 + buffer
Emma Long Bike Park	Darrell Hutchinson, Cristina Campbell, Laurel Moulton (COA)	571.05	96
Emma Long Expansion	Darrell Hutchinson, Cristina Campbell, Laurel Moulton (COA)		34
Cortaña	William Reiner (COA)	98.25	62
South Lake Austin Macrosite			
Double J&T	Laurel Moulton (COA)	37.5	40.5 + buffer
Reicher	Lisa O'Donnell, William Reiner (COA)	114	40.5 + buffer
West Austin Macrosite			
Vireo Preserve/Wild Basin	Darrell Hutchinson, Jim O'Donnell (COA)	149	180
	Total	**2570.5**	**818 + buffers**

COA = City of Austin, TC = Travis County, TNC = The Nature Conservancy. Buffers = approx. 30 hectares for each 40.5-ha plot, where access was allowed.

Exhibit B: Summary of Golden-cheeked Warbler Survey Effort on the Balcones Canyonlands Preserve, Travis County, Texas, 2017 Field Season (continued).

Re-sighting Plots	Surveyor(s)	Survey Hours (March 15-May 25)	Area Surveyed (hectares)
Barton Creek Macrosite			
Gus Fruh/Sunset Valley	David Brady (volunteer), Marli Claytor (volunteer), Mark Sanders (COA)	55.5	85 + 27
Bull Creek Macrosite			
3M/St. Edwards	John Chenoweth, Mark Sanders (COA)	53.25	40.5 + buffer
Canyon Vista	Aaron Boone (volunteer), Chuck Sexton (volunteer), Todd Bayless, Travis Clark (TC)	75.25	40.5 + buffer
Cypress Creek Macrosite			
Baker Sanctuary	Cindy Sperry (volunteer), Joe Jandle (volunteer), Chuck Sexton (volunteer)	67.5	40.5 + buffer
Lake Perspectives	Jim & Lynne Weber (volunteers)	30.0	40.5 + buffer
Vireo Ridge	Paul Fushille, Linda Laack, Anthony Locatelli (TC)	40.25	51
North Lake Austin Macrosite			
Coldwater	Jim O'Donnell, Lisa O'Donnell (COA)	34.25	107
	Total	356	**432.0 + buffers**

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

Exhibit B: Summary of Golden-cheeked Warbler Survey Effort on the Balcones Canyonlands Preserve, Travis County, Texas, 2017 Field Season (continued).

Search Areas*	Surveyor(s)	Search Areas*	Surveyor(s)
3M Northeast	Angela England Laurie Winnette Jasmine Mills	Hamilton Northeast	Adrian Johnson
3M South	Brian Miller Dale Thompson	Hamilton West	Paul Brick
3M Southeast	Eric Attwood	Hamilton Southeast	Chris Harper
Baker Sanctuary North (45.1 ha)	Kathrine Ross	Interplot (33.4 ha) (between 3M and Forest Ridge plots)	Kathleen Collins Mary Gilroy
Baker Sanctuary Southeast (33.2 ha)	Tam Tran	Kent Butler East	Andy and Ellen Filtness, Gloria Wilson
Baker Sanctuary Northwest (32.9 ha)	Heather Valey	Kent Butler Northwest	Alan Alley Janet Reed Tracy White
Baker Sanctuary Southwest	Amanda Andrews Traci Ibarra Leigh Jandle	Kent Butler Southeast	Jeff Mundy
Barton Creek Northwest	Shelia Hargis Cheryl McGrath	Kent Butler Southwest	Alan and Heidi Carlin
Barton Creek Southeast (37.5 ha)	Amanda Hargrave	Lake Perspectives Northwest (30.2 ha)	Joe and Leigh Jandle
Barton Creek Southwest	Stacy Marcus	Lake Perspectives South (31.8 ha)	Leigh Jandle
Barton Creek downstream	David Brady	Long Canyon	Eric Mansker, Brian Miller
Canyon Vista (23.2 ha)	Paul Clements Ranleigh Hirsh	Vireo Ridge (46.3 ha)	Elena Pinto-Torres
Emma Long West	Laura Springer Peg Wallace	Vista Point Southeast	David Brady
Emma Long South	Joseph Hunt Larry Thatcher	Vista Point Southwest (43.6 ha)	Nevin Durish
Forest Ridge Northeast	Audrey Archer Janel Nye Michael Jewell		
Forest Ridge Northwest	Jim and Lynne Weber		
Forest Ridge Southeast	Kristen Bayley Brian Gold Jenny Samford		
Forest Ridge Southwest	Jim and Lynne Weber		

*All search areas were approximately 40.4 ha except where noted.

Exhibit C: Golden-cheeked Warbler Intensive Monitoring Plot Protocol, Balcones Canyonlands Preserve, 2017.

Objective: To delineate golden-cheeked warbler territories as accurately as possible (>33 locations per male) and to document return rates, dispersal, pairing success, breeding success, and productivity (number of young per territory) to estimate long-term trends in these parameters.

For the 2017 field season, a concerted effort will also be made to locate and monitor nests and count fledglings on a select number of plots (for COA BCP, this will include the Kent Butler 100-acre plot, Emma Long Bike Park, and Emma Long Expansion).

Study Sites: Within each intensive study plot, observers will focus on re-sighting color-banded warblers, mapping the location and extent of territories, 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 provide better estimates of the size, extent, and breeding success of edge territories.

Survey Dates: March 15 - May 25 (for territory delineations); March 15-June 15 (for documenting reproductive success). Separate visits may be required to band territorial males but warbler observations made during banding attempts are not to be reported as territory observations.

Survey Effort for Territory Mapping: 6 hours per 100 acres per visit *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. and the time needed to cover the entire survey area. Surveyors will take as much time as needed to collect data for each territory and obtain a minimum of 33 locations separated by at least 30 meters for each territorial male by May 25.

Mapping: Observers will obtain GPS locations for, **and** create hard copy maps of, all warbler observations for **every** survey visit, following the **Standards for Conducting and Documenting Golden-cheeked Warbler Surveys (COA 2017)**. 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:

- For low density plots (<5 territories/100 acres): one observer will survey the plot/buffer once a week from March 15-June 15.
- For medium density plots (5-10 territories/100 acres): one observer will survey the plot/buffer once a week from March 15-June 15. To assist documenting fledglings, a second observer will assist with the weekly surveys from April 20-May 25 (see procedures for shared plots, below).
- For high density plots (>10 territories/100 acres): two observers will survey the plot/buffer once a week from March 15-May 25 (see procedures for shared plots, below), and one observer will survey the plot/buffer from May 25-June 15.
- For plots that include a focus on nest monitoring and fledgling counts (see Objective, above): two observers will survey the plot/buffer twice a week from March 15-May 25 (see procedures for shared plots, below), and one observer will survey the plot/buffer from May 25-June 15.

Training: All field staff 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 2017)** during all field visits. For shared plots with two observers (see Staffing, above), each observer will cover half of the plot/buffer during each survey, and 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.

Exhibit D: Summary of Golden-cheeked Warbler Territory Data for Intensive Study Plots on the Balcones Canyonlands Preserve, Travis County, Texas, Field Seasons 2009-2017. 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 Macrosite					
Barton Creek	2009	2	8	5.0	0.12
	2010	2	10	6.0	0.15
	2011	4	9	6.5	0.16
	2012	2	7	4.5	0.11
	2013	4	10	7.0	0.17
	2014	5	12	8.5	0.21
	2015	6	9	7.5	0.19
	2016	3	6	4.5	0.11
	2017	3	6	4.5	0.11
Barton Creek Habitat Preserve	2017	0	2	1.0	0.01
Gus Fruh/ Sunset Valley	2009	--	--	--	--
	2010	--	--	--	--
	2011	1	2	1.0	0.01
	2012	0	0	0	0
	2013	1	1	1.0	0.01
	2014	2	4	3.0	0.03
	2015	1	2	1.5	0.01
	2016	1	1	1.0	0.01
	2017	--	--	--	--
Bull Creek Macrosite					
3M/ St. Edwards	2009	9	27	18.0	0.44
	2010	13	26	19.5	0.48
	2011	12	25	18.5	0.46
	2012	14	27	20.5	0.51
	2013	13	26	19.5	0.48
	2014	12	28	20.0	0.49
	2015	16	25	20.5	0.51
	2016	--	--	--	--
	2017	--	--	--	--
Canyon Vista	2009	--	--	--	--
	2010	--	--	--	--
	2011	10	22	16.0	0.40
	2012	6	23	14.5	0.36
	2013	7	22	14.5	0.36
	2014	8	23	15.5	0.38
	2015	12	24	18.0	0.44
	2016	8	26	17.0	0.42
	2017	--	--	--	--
Forest Ridge	2009	10	18	14.0	0.35
	2010	10	20	15.0	0.37
	2011	13	20	16.5	0.41
	2012	13	23	18.0	0.44
	2013	8	14	11.0	0.27
	2014	9	19	14.0	0.35
	2015	14	20	17.0	0.42
	2016	8	15	11.5	0.28
	2017	11	20	15.5	0.38

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
Kent Butler	2009	11	25	18.0	0.44
	2010	11	20	15.5	0.38
	2011	12	22	17.0	0.43
	2012	11	24	17.5	0.43
	2013	18	32	25.0	0.62
	2014	15	20	17.5	0.43
	2015	13	25	19.0	0.47
	2016	11	20	15.5	0.38
	2017	7	19	13.0	0.32
Hamilton West	2009	--	--	--	--
	2010	2	14	8.0	0.20
	2011	8	20	14.0	0.35
	2012	6	10	8.0	0.20
	2013	5	11	8.0	0.20
	2014	5	12	8.5	0.21
	2015	6	10	8.0	0.20
	2016	5	9	7.0	0.17
	2017	5	9	7.0	0.17
Cypress Creek Macrosite					
Baker Sanctuary	2009	--	--	--	--
	2010	--	--	--	--
	2011	5	16	10.5	0.26
	2012	8	12	10.0	0.25
	2013	6	14	10.0	0.25
	2014	5	12	8.5	0.21
	2015	7	14	10.5	0.26
	2016	--	--	--	--
	2017	--	--	--	--
Lake Perspectives/ McGregor	2009	--	--	--	--
	2010	--	--	--	--
	2011	5	10	7.5	0.19
	2012	4	10	7.0	0.17
	2013	6	11	8.5	0.21
	2014	4	10	7.0	0.17
	2015	5	11	8.0	0.20
	2016	--	--	--	--
	2017	--	--	--	--
Vireo Ridge	2009	--	--	--	--
	2010	--	--	--	--
	2011	7	13	10.0	0.25
	2012	12	16	14.0	0.24
	2013	9	11	10.0	0.24
	2014	12	13	12.5	0.27
	2015	15	16	15.5	0.34
	2016	8	23	15.5	0.30
	2017	--	--	--	--
Vista Point	2009	--	--	--	--
	2010	--	--	--	--
	2011	15	17	16.0	0.40
	2012	13	20	14.0	0.34
	2013	10	17	13.5	0.33
	2014	9	19	14.0	0.35
	2015	17	24	20.5	0.51
	2016	--	--	--	--
	2017	8	14	11.0	0.27
Wheless	2017	1	3	4.0	0.06

Exhibit D: 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
North Lake Austin Macrosite					
Coldwater	2009	--	--	--	--
	2010	12	12	12.0	0.11
	2011	11	16	13.5	0.14
	2012	7	12	9.5	0.09
	2013	10	13	11.5	0.11
	2014	7	13	10.0	0.09
	2015	6	17	11.5	0.11
	2016	--	--	--	--
	2017	--	--	--	--
Cortaña	2017	4	5	4.5	0.07
Emma Long	2009	9	19	14.0	0.35
	2010	10	16	13.0	0.32
	2011	10	16	13.0	0.33
	2012	11	18	14.5	0.36
	2013	11	20	15.5	0.38
	2014	9	17	13.0	0.32
	2015	10	17	13.5	0.33
	2016	--	--	--	--
	2017	3	10	6.5	0.16
Emma Long Bike Park	2009	--	--	--	--
	2010	9	9	9.0	0.09
	2011	12	15	13.5	0.14
	2012	12	17	14.5	0.15
	2013	5	13	9.0	0.09
	2014	12	19	15.5	0.16
	2015	6	14	10	0.10
	2016	4	13	8.5	0.09
	2017	3	10	6.5	0.07
Emma Long Expansion	2016	7	10	8.5	0.25
	2017	4	9	6.5	0.19
South Lake Austin Macrosite					
Double J&T	2009	2	3	2.5	0.06
	2010	3	3	3.0	0.07
	2011	3	4	3.5	0.09
	2012	4	4	4.0	0.10
	2013	2	4	3.0	0.07
	2014	3	5	4.0	0.10
	2015	2	2	2.0	0.05
	2016	2	3	2.5	0.06
	2017	2	3	2.5	0.06
Reicher	2009	--	--	--	--
	2010	--	--	--	--
	2011	3	4	3.5	0.09
	2012	2	6	4.0	0.10
	2013	3	6	6.0	0.11
	2014	5	11	8.0	0.20
	2015	3	8	5.5	0.14
	2016	--	--	--	--
	2017	3	6	4.5	0.11

Exhibit D: 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	Territory Density per Hectare
West Austin Macrosite					
Wild Basin/ Vireo Preserve	2009	--	--	--	--
	2010	--	--	--	--
	2011	8	11	9.5	0.05
	2012	6	6	6.0	0.03
	2013	8	8	8.0	0.04
	2014	9	10	9.5	0.05
	2015	7	7	7.0	0.04
	2016	4	4	4.0	0.02
	2017	4	4	4.0	0.02

Exhibit E: 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 2009-2017.

Plot	Survey Year	% SY Males	%ASY Males	%AHY Males	Total No. Banded Males	Total No. Unbanded Males	% Banded Males
Barton Creek Macrosite							
Barton Creek	2009	20	60	20	5	3	63
	2010	22	78	0	9	1	90
	2011	0	100	0	6	3	67
	2012	0	100	0	5	2	71
	2013	40	60	0	5	5	50
	2014	25	75	0	8	4	67
	2015	0	100	0	3	6	33
	2016	17	83	0	6	0	100
	2017	20	80	0	5	1	83
Barton Creek Habitat Preserve	2017	100	0	0	1	1	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
	2014	100	0	0	4	0	100
	2015	100	0	0	2	0	100
	2016	0	0	0	0	1	0
	2017	--	--	--	--	--	--
Bull Creek Macrosite							
3M/St. Edwards	2009	30	70	0	20	7	74
	2010	38	63	0	16	10	62
	2011	56	44	0	18	7	72
	2012	29	71	0	21	6	78
	2013	39	61	0	18	8	69
	2014	55	45	0	20	8	71
	2015	35	65	0	17	8	68
	2016	--	--	--	--	--	--
	2017	--	--	--	--	--	--
Canyon Vista	2009	--	--	--	--	--	--
	2010	--	--	--	--	--	--
	2011	29	71	0	14	8	64
	2012	18	82	0	17	6	74
	2013	31	69	0	16	6	73
	2014	25	75	0	12	11	52
	2015	50	38	12	16	8	67
	2016	21	79	0	14	12	54
	2017	--	--	--	--	--	--
Forest Ridge	2009	20	73	7	15	3	83
	2010	21	79	0	14	6	70
	2011	35	65	0	17	3	85
	2012	0	100	0	16	7	67
	2013	11	89	0	9	5	64
	2014	27	73	0	11	8	58
	2015	30	70	0	10	10	50
	2016	25	75	0	12	3	80
	2017	8	92	0	13	7	65

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

Plot	Survey Year	% SY Males	%ASY Males	%AHY Males	Total No. Banded Males	Total No. Unbanded Males	% Banded Males
Kent Butler	2009	53	29	18	17	8	68
	2010	33	67	0	15	5	75
	2011	62	37	0	16	6	73
	2012	53	42	5	19	5	79
	2013	36	59	5	22	10	69
	2014	19	81	0	16	4	80
	2015	41	53	6	17	8	68
	2016	36	64	0	14	6	70
	2017	38	62	0	13	6	68
Hamilton West	--	--	--	--	--	--	--
	2010	40	60	0	10	4	71
	2011	60	27	13	15	5	75
	2012	29	57	14	7	3	70
	2013	63	38	0	8	3	73
	2014	50	50	0	8	4	67
	2015	62	38	0	8	2	80
	2016	57	43	0	7	2	78
	2017	38	62	0	8	1	89
Cypress Creek Macrosite							
Baker Sanctuary	2009	--	--	--	--	--	--
	2010	--	--	--	--	--	--
	2011	50	50	0	8	8	50
	2012	50	50	0	10	2	83
	2013	25	75	0	8	6	57
	2014	0	100	0	9	3	75
	2015	38	62	0	8	6	57
	2016	--	--	--	--	--	--
	2017	--	--	--	--	--	--
Lake Perspectives/ McGregor	2009	--	--	--	--	--	--
	2010	--	--	--	--	--	--
	2011	43	57	0	7	3	70
	2012	20	80	0	10	0	100
	2013	33	67	0	9	2	82
	2014	29	71	0	7	3	70
	2015	50	50	0	10	1	91
	2016	--	--	--	--	--	--
	2017	--	--	--	--	--	--
Vireo Ridge	2009	--	--	--	--	--	--
	2010	--	--	--	--	--	--
	2011	37	62	0	8	5	62
	2012	15	85	0	13	3	81
	2013	22	78	0	9	2	82
	2014	43	57	0	7	6	54
	2015	75	25	0	8	8	50
	2016	50	50	0	12	11	52
	2017	--	--	--	--	--	--
Vista Point	2009	--	--	--	--	--	--
	2010	--	--	--	--	--	--
	2011	24	76	0	17	0	100
	2012	12	88	0	17	3	81
	2013	29	71	0	14	3	82
	2014	9	91	0	11	8	59
	2015	67	33	0	12	12	50
	2016	--	--	--	--	--	--
	2017	9	91	0	11	3	79
Wheless	2017	33	67	0	3	1	75

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

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Plot	Survey Year	% SY Males	%ASY Males	%AHY Males	Total No. Banded Males	Total No. Unbanded Males	% Banded Males
North Lake Austin Macrosite							
Coldwater	2009	--	--	--	--	--	--
	2010	42	58	0	12	0	100
	2011	54	46	0	13	3	81
	2012	0	89	11	9	3	75
	2013	50	50	0	8	5	62
	2014	60	40	0	10	3	77
	2015	85	15	0	13	4	17
	2016	--	--	--	--	--	--
	2017	--	--	--	--	--	--
Cortaña	2017	20	80	0	5	0	100
Emma Long	2009	0	100	0	13	6	68
	2010	11	89	0	9	7	56
	2011	27	73	0	11	5	69
	2012	10	90	0	10	8	56
	2013	0	100	0	10	10	50
	2014	33	67	0	9	8	53
	2015	25	75	0	12	5	71
	2016	--	--	--	--	--	--
	2017	22	78	0	9	1	90
Emma Long Bike Park	2009	--	--	--	--	--	--
	2010	63	38	0	8	1	89
	2011	79	21	0	14	1	93
	2012	29	71	0	14	3	82
	2013	71	29	0	7	6	54
	2014	69	31	0	13	6	68
	2015	56	44	0	9	5	64
	2016	33	56	11	9	4	69
	2017	57	33	0	7	3	70
Emma Long Expansion	2016	33	50	17	6	4	60
	2017	14	86	0	7	2	78
South Lake Austin Macrosite							
Double J&T	2009	100	0	0	1	2	33
	2010	67	33	0	3	0	100
	2011	100	0	0	2	2	50
	2012	100	0	0	1	3	25
	2013	100	0	0	4	0	100
	2014	0	100	0	3	2	60
	2015	0	100	0	1	1	50
	2016	33	67	0	3	0	100
	2017	33	67	0	3	0	100
Reicher	2009	--	--	--	--	--	--
	2010	--	--	--	--	--	--
	2011	33	67	0	3	1	75
	2012	50	50	0	2	4	33
	2013	25	75	0	4	2	67
	2014	38	50	12	8	3	73
	2015	20	80	0	5	3	63
	2016	--	--	--	--	--	--
	2017	25	75	0	4	2	67

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

Plot	Survey Year	% SY Males	%ASY Males	%AHY Males	Total No. Banded Males	Total No. Unbanded Males	% Banded Males
West Austin Macrosite							
Wild Basin/ Vireo Preserve	2009	--	--	--	--	--	--
	2010	--	--	--	--	--	--
	2011	78	22	0	9	2	82
	2012	20	80	0	5	1	83
	2013	33	67	0	6	2	75
	2014	50	50	0	8	2	80
	2015	67	33	0	6	1	86
	2016	50	50	0	4	0	100
	2017	25	75	0	4	0	100

Exhibit F: 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 2009-2017. 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 Macrosite					
Barton Creek	2009	75	63	12 / 14	0.22 / 0.27
	2010	100	80	24 / 29	0.40 / 0.44
	2011	100	67	17 / 21	0.33 / 0.40
	2012	100	100	24/ 27	0.37 / 0.44
	2013	90	70	24 / 27	0.43 / 0.48
	2014	100	58	17 / 21	0.36 / 0.41
	2015	100	78	22 / 25	0.51 / 0 58
	2016	83	50	7 / 7	0.12 / 0.12
	2017	100	17	4 / 4	0.10 / 0.10
Barton Creek Habitat Preserve	2017	0	0	0	0
Gus Fruh/ Sunset Valley	2009	--	--	--	--
	2010	--	--	--	--
	2011	0	0	0	0
	2012	0	0	0	0
	2013	100	0	0	0
	2014	0	0	0	0
	2015	50	0	0	0
	2016	0	0	0	0
	2017	--	--	--	--
Bull Creek Macrosite					
3M/ St. Edwards	2009	89	70	46 / 68	0.75 / 1.11
	2010	96	77	49 / 72	1.01 / 1.47
	2011	96	65	35 / 55	0.59 / 0.94
	2012	100	56	48 / 58	0.93 / 1.19
	2013	65	65	38 / 44	0.62 / 0.72
	2014	100	64	54 / 68	0.89 / 1.12
	2015	96	63	39 / 54	0.77 / 1.01
	2016	--	--	--	--
	2017	--	--	--	--
Canyon Vista	2009	--	--	--	--
	2010	--	--	--	--
	2011	73	55	27 / 44	0.52 / 0.81
	2012	100	57	30 / 44	0.43 / 0.63
	2013	100	65	39 / 39	0.63 / 0.63
	2014	91	74	56 / 56	0.91 / 0.91
	2015	100	73	43 / 52	0.77 / 0.90
	2016	100	77	55 / 69	0.93 / 1.14
	2017	--	--	--	--
Forest Ridge	2009	83	78	25 / 50	0.49 / 0.98
	2010	80	65	30 / 47	0.53 / 0.89
	2011	100	74	29 / 47	0.59 / 0.99
	2012	83	74	55 / 65	1.10 / 1.28
	2013	86	71	28 / 37	0.62 / 0.77
	2014	100	89	49 / 57	0.89 / 1.02
	2015	100	88	33 / 47	0 68 / 1.00
	2016	93	73	30 / 41	0.53 / 0.73
	2017	100	70	37 / 51	0.73 / 0.99

Exhibit F: 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
Kent Butler	2009	92	72	39 / 65	0.73 / 1.20
	2010	95	70	35 / 50	0.68 / 1.02
	2011	95	67	40 / 50	0.75 / 0.94
	2012	96	79	60 / 71	1.06 / 1.23
	2013	90	58	50 / 61	1.00 / 1.16
	2014	95	85	47 / 64	0.98 / 1.33
	2015	88	63	46 / 54	1.01 / 1.13
	2016	95	70	40 / 50	0.77 / 0.94
	2017	95	74	35 / 48	0.60 / 0.80
Hamilton West	2009	--	--	--	--
	2010	64	57	18 / 29	0.28 / 0.44
	2011	90	50	24 / 24	0.47 / 0/47
	2012	90	78	18 / 23	0.33 / 0.43
	2013	100	82	20 / 29	0.38 / 0.53
	2014	100	73	27 / 27	0.53 / 0.53
	2015	100	90	23 / 33	0.40/ 0.62
	2016	100	56	14 / 14	0.26 / 0.26
	2017	100	78	21 / 27	0.42 / 0.52
Cypress Creek Macrosite					
Baker Sanctuary	2009	--	--	--	--
	2010	--	--	--	--
	2011	81	63	22 / 36	0.31 / 0.54
	2012	100	83	28 / 28	0.57 / 0.57
	2013	93	50	16 / 23	0.28 / 0.38
	2014	100	83	22 / 34	0.42 / 0.61
	2015	92	62	20 / 23	0.44 / 0.49
	2016	--	--	--	--
	2017	--	--	--	--
Lake Perspectives/ McGregor	2009	--	--	--	--
	2010	--	--	--	--
	2011	100	70	21 / 22	0.37 / 0.40
	2012	100	60	18 / 21	0.37 / 0.40
	2013	91	64	20 / 24	0.37 / 0.42
	2014	100	89	25 / 27	0.46 / 0.50
	2015	89	60	21/ 21	0.43 / 0.43
	2016	--	--	--	--
	2017	--	--	--	--
Vireo Ridge	2009	--	--	--	--
	2010	--	--	--	--
	2011	100	89	22 / 29	0.51 / 0.63
	2012	100	93	37 / 48	0.55 / 0.68
	2013	100	89	25 / 29	0.56 / 0.64
	2014	100	55	17 / 22	0.40 / 0.53
	2015	88	75	38 / 45	0.78 / 0.94
	2016	95	55	41 / 45	0.58 / 0.62
	2017	--	--	--	--
Vista Point	2009	--	--	--	--
	2010	--	--	--	--
	2011	94	75	42 / 45	1.01 / 1.08
	2012	100	63	41 / 42	0.83 / 0.85
	2013	100	53	27 / 27	0.52 / 0.52
	2014	89	68	49 / 50	0.86 / 0.88
	2015	100	52	30 / 37	0.65 / 0.82
	2016	--	--	--	--
	2017	86	64	31 / 31	0.49 / 0.49
Wheless	2017	75	75	12 / 12	0.15 / 0.15

Exhibit F: 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
North Lake Austin Macrosite					
Coldwater	2009	--	--	--	--
	2010	92	58	7 / 25	0.07 / 0.24
	2011	100	83	36 / 37	0.31 / 0.31
	2012	100	50	10 / 12	0.07 / 0.09
	2013	58	50	19 / 19	0.18 / 0.18
	2014	85	54	24 / 27	0.18 / 0.19
	2015	92	80	10 /13	0.07 / 0.09
	2016	--	--	--	--
	2017	--	--	--	--
Cortaña	2017	80	40	5 / 7	0.08 / 0.11
Emma Long	2009	100	84	29 / 58	0.52 / 1.02
	2010	94	63	19 / 36	0.33 / 0.67
	2011	100	100	41 / 52	0.96 / 1.19
	2012	100	94	54 / 62	1.05 / 1.20
	2013	89	59	34 / 36	0.63 / 0.68
	2014	88	81	47 / 50	0.94 / 1.01
	2015	94	41	21 / 22	0.38 / 0.40
	2016	--	--	--	--
	2017	89	44	12 / 13	0.20 / 0.20
Emma Long Bike Park	2009	--	--	--	--
	2010	89	56	8 / 18	0.08 / 0.19
	2011	92	58	24 / 27	0.23 / 0.26
	2012	100	100	33 / 38	0.29 / 0.34
	2013	92	69	26 / 32	0.17 / 0.21
	2014	84	59	28 / 32	0.24 / 0.26
	2015	100	79	26 / 32	0.21 / 0.26
	2016	85	38	13 / 16	0.11 / 0.12
	2017	90	70	19 / 21	0.14 / 0.15
Emma Long Expansion	2016	90	40	14 / 15	0.37 / 0.39
	2017	100	78	15 / 19	0.31 / 0.40
South Lake Austin Macrosite					
Double J&T	2009	0	0	0	0
	2010	67	0	0	0
	2011	75	50	2 / 7	0.04 / 0.13
	2012	100	0	0	0
	2013	50	50	6 / 6	0.12 / 0.12
	2014	100	60	9 / 9	0.20 / 0.20
	2015	50	0	0	0
	2016	67	67	6 / 7	0.11 / 0.12
	2017	67	67	5 / 7	0.09 / 0.13
Reicher	2009	--	--	--	--
	2010	--	--	--	--
	2011	100	100	11 / 12	0.22 / 0.24
	2012	83	67	14 / 16	0.25 / 0.29
	2013	100	83	13 / 19	0.20 / 0.32
	2014	82	73	25 / 30	0.43 / 0.52
	2015	88	50	9 / 10	0.12 / 0.14
	2016	--	--	--	--
	2017	100	67	8 / 13	0.16 / 0.26

Exhibit F: 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
West Austin Macrosite					
Wild Basin/ Vireo Preserve	2009	--	--	--	--
	2010	--	--	--	--
	2011	73	45	9 / 18	0.08 / 0.15
	2012	100	75	7 / 10	0.04 / 0.06
	2013	86	43	9 / 11	0.05 / 0.06
	2014	56	11	3 / 3	0.02 / 0.02
	2015	86	14	4 / 4	0.02 / 0.02
	2016	75	25	4 / 4	0.02 / 0.02
	2017	50	0	0	0