2016 Annual Report:
Golden-cheeked Warbler *(Setophaga chrysoparia)*
Monitoring Program
Balcones Canyonlands Preserve



Photo of Golden-Cheeked Warbler fledgling by Jonny Scalise

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

2016 Golden-cheeked Warbler Monitoring Program

Balcones Canyonlands Preserve Annual Report

SUMMARY

This was the nineteenth year of Golden-cheeked Warbler monitoring on the Balcones Canyonlands Preserve (BCP). It was also the first year following the five-year agreement with the U.S. Forest Service (USFS) and University of Missouri to develop models to better understand factors influencing the long-term viability of the Golden-cheeked Warbler. Findings from the 5-year study are consistent with research on Fort Hood (Peak and Thompson 2013, 2014) that large blocks of tall, closed-canopy Ashe juniper (*Juniperus ashei*) and oak (*Quercus* spp.) woodlands support highest densities of Golden-cheeked Warblers (Reidy et al. 2016), and these adults are more productive and more site-faithful than adults in more fragmented woodlands. The 5-year study also found that nest survival is highest on level terrain and with understory vegetation below the nest (Reidy et al. in press). Population viability analyses and manuscript preparations are underway; one manuscript has been accepted for publication, and two more are expected to be submitted to peer-reviewed journals in early 2017. BCP staff and partners are working on a long-term monitoring plan for the Golden-cheeked Warbler based on permit requirements, the 2007 land management plan, and recommendations from the 5-year study.

ACKNOWLEDGEMENTS

We would like to thank all of the BCP partners and staff for their collaboration in the 2016 survey efforts: Lower Colorado River Authority, Travis Audubon Society, The Nature Conservancy, and St. Edwards/Wild Basin. We would also like to thank the many volunteers who assisted with the 2016 survey effort. Without their support and perseverance, it would not have been possible to obtain these critical data: David Brady, Jim Branch, Kathleen Branch, Laura Brennand, Paul Brick, Alan Carlin, Heidi Carlin, Marli Claytor, Paul Clements, Kathleen Collins, Crystal Datri, Leslyn Dillow, Nevin Durish, Angela England, Mary Gilroy, Natalie Goldsworthy, Shelia Hargis, Amanda Hargrave, Matthew Haverland, Ranleigh Hirsch, Joseph Hunt, Leigh Jandle, Adrian Johnson, Robin Laine, Eric Mansker, Stacy Marcus, Cheryl McGrath, Brian Miller, Jacob Owen, Elena Pinto-Torres, Janet Reed, Kathrine Ross, Jenny Samford, Misa Soliz, Gloria Stevens, Kerry Stevens, Dale Thompson, Will Thompson, Tam Tran, Sara Weaver, Jim Weber, Lynne Weber, Kerri Welch, Tracy White, Gloria Wilson, Laurie Winnette, and Laura Zebehazy.

INTRODUCTION

Background

The Golden-cheeked Warbler (Warbler) is a Neotropical migrant passerine that breeds only in central Texas where mature Ashe juniper-oak woodlands occur (Ladd and Gass 1999). Due to accelerating loss of breeding habitat over the past several decades, the Warbler was listed as federally endangered by the U.S. Fish and Wildlife Service in 1990 (USFWS 1990). Warbler habitat in western Travis County is widely considered to be some of the highest quality and least fragmented of any county within this species' limited breeding range (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 sustainability, regeneration, and restoration of the remaining habitat 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, Reidy et al. 2008, Peak and Thompson 2014). Active habitat management requires minimizing threats to this species, including disturbance from human activities; declining oak regeneration from white-tailed deer (*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."

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 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 2016 field season continued to gather data in accordance with the objectives of the 2007 land management plan and the four questions listed above, but at a reduced level from the 5-year study. BCP staff and partners are currently working with the USFS to develop a long-term monitoring plan for the

Warbler based on permit requirements, the 2007 land management plan, and recommendations from the 5-year study.

SITE DESCRIPTION

The topography and vegetation of the BCP are typical of the eastern edge of the Edwards Plateau. Steep, wooded canyons and riparian corridors dissect drier upland vegetation. Most streams are intermittent, though a few have a permanent water source, such as a perennial spring. The predominant vegetation association is mature Ashe juniper-oak woodlands, except at Hamilton West, Vireo Ridge, and Wild Basin/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 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*). Descriptions of individual plots can be found in Abbruzzese and Koehler (2003) and the Tier III Land Management Plans for each property.

STUDY SITES

Staff continued to track population and productivity trends on a series of intensive monitoring plots (City of Austin et al. 2015). Intensive territory monitoring includes data collection for color-banded Warblers to estimate territory density, territory size and location, age structure, pairing success, breeding success, productivity, and nest survival. Previously established plots that were not intensively monitored in 2016 were treated as resighting 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 resighting plots to gather data on site fidelity, dispersal, and return rates. BCP staff are currently developing a long-term monitoring plan, with the goal of distributing intensive monitoring plots evenly across the BCP, in proportion to the representative canopy heights and vegetation types (i.e., evergreen, deciduous, and mixed evergreen-deciduous forests) within the BCP, and across a variety of habitat patch sizes, slope and aspect, proximity to urban development, and land management activities.

Intensive Monitoring Plots

An effort was made to intensively monitor as much of the BCP as possible given staff and resource limitations. Warblers were banded and their territories were mapped on 12 intensive monitoring plots, including six 40.5-hectare plots and six plots ranging from 27 to 180 hectares in size (Table 1, Exhibit A), totaling about 718 hectares. Intensive monitoring plots were located within six of eight BCP macrosites (all but the Pedernales macrosite and recently added Big Sandy Creek macrosite). In addition, 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, and territory size and configuration.

Resighting Plots

Previously established plots that were not intensively monitored in 2016, including the 100-m buffers around the 40.5-ha plots, were treated as resighting plots. Resighting was discontinued on the Bohls and Canyon Creek plots in 2016, since no color-banded Warblers were observed during the 2015 surveys (Warblers were banded on these plots in 2009 and 2010). Travis County staff made a final visit to the Ribelin plot in 2016 to search for the last one of four males (banded in 2010) that returned in 2015, so resighting on this site has been discontinued as well.

Search Efforts for Banded Warblers Outside of Intensive Monitoring/Resighting Plots

To obtain additional information on return rates and dispersal outside of the intensive monitoring and resighting plots, volunteers searched for color-banded Warblers on 31 search areas totaling approximately 1,245 hectares (Exhibit B).

Additional Monitoring Sites

To help assess the Warbler's use of marginal habitat and areas with active recreation, BCP staff monitored a few additional areas beyond the intensive monitoring plots in the Barton Creek and North Lake Austin macrosites during the 2016 field season. This included intensive territory monitoring on about 41 ha in Emma Long Metropolitan Park ("Emma Long Expansion") and nest searches beyond the Barton Creek plot ("Barton Creek Expansion") and within the Emma Long plot.

Table 1. Intensive monitoring and resighting plots for each macrosite within the Balcones Canyonlands Preserve, Travis County, Texas, field season 2016.

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
Intensive Monitoring Plots						
Barton Creek (COA)	40.5					
Gus Fruh (COA)[1]	85					
Sunset Valley (COA)[1]	27					
Canyon Vista (TC)		40.5				
Forest Ridge (COA)		40.5				
Butler (COA)		40.5				
Hamilton West (COA)		40.5				
Vireo Ridge (TC)[2]			51[2]			
Emma Long Bike Park (COA)				96		
Emma Long Expansion (COA)				41		
JJ&T (COA)					40.5	
Wild Basin/Vireo Preserve (COA, Wild Basin, St. Edwards, TC)						180
Resighting Plots						
3M/St. Edwards (COA)		40.5				
Baker Sanctuary (Travis Audubon)			40.5			
Emma Long (COA)[3]				40.5		
Lake Perspectives/ McGregor (TC/LCRA)			40.5			
Vista Point (TC)			40.5			
Coldwater (COA)				107		
Emma Long (COA)				40.5		
Reicher (COA)					40.5	
Nest Monitoring						
Barton Creek Expansion (COA)	~60					
Total # BCP Hectares Owned (as of November 2016)[4]	2,479	2,025	3,780	2,265	1,643	188
% of macrosite intensively surveyed[5]	6.2%	8%	1.4%	6%	2.5%	96%

[1]Data for the Gus Fruh and Sunset Valley plots are combined into one plot in the results section.
[2]Plot boundaries vary slightly from year to year, and plot size has increased from 41.7 to 51 hectares since the plot was initially established in 2011; results for each year are based on the plot dimensions for that year.
[3]Surveys for the Emma Long resighting plot also included nest monitoring in 2016.
[4]Does not include the 100-m buffers around the intensive monitoring/resighting plots (approx. 30 ha for each of the twelve 40.5-ha plots, where access was allowed, totaling about 360 ha), Travis County's 40.5-ha Ribelin plot (one visit in 2016), or the search areas beyond the buffers (about 1,245 ha, see Exhibit B).
[5]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 GCWAs was conducted in conjunction with territory mapping on 12 intensive monitoring plots, from March 16 through May 18, 2016. Methods consisted of mist netting within a male Warbler's territory using playback of a tape-recorded male Warbler's song to attract the bird to the net. Although a few females were caught using this method, most of the Warblers captured were males. All Warblers captured in mist nets were marked with a unique combination of a U.S. Geological Survey (USGS) numbered aluminum band and auxiliary color bands to allow identification of each individual. The biological staff at Ft. Hood Military Reservation issued the color-band combinations. Other data collected during banding included date, time, banding location, temperature, and weather conditions. Individuals were sexed and aged (second-year (SY), after second-year (ASY), or after hatch-year (AHY) according to Pyle (1997) and Peak and Lusk (2009)), using data sheets developed by Ft. Hood staff. Each Warbler was photographed just prior to release to document band combinations.

In addition, Jennifer Reidy (USFS/University of Missouri) attempted to band nestlings to collect data on hatch-year (HY) Warblers to determine length of dependence on adults, dispersal distances from the natal area within the season, and potentially to gather critical data about dispersal distances and survival over multiple seasons. Nestlings were banded approximately 7 to 9 days after hatching. They were removed from the nest while the adults were absent, placed in a small pliable box with air holes and then in a soft cloth bag, and carried down to the banding site, where they were banded with a standard color combination (2-3 colors and 1 USGS numbered aluminum band). Nestlings were returned to the nest immediately after banding. The nest was monitored from a safe distance to verify adults resumed normal feeding behavior.

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

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

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

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.

Nest monitoring. Biologists located nests from mid-March through mid-June while working within and near the study plots. UTM coordinates were recorded for each nest location using Garmin GPS units, and flagging was placed at least five meters from the nest to mark its location. Staff monitored each nest every few days to confirm activity and nest stage, and 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), and searched for fledglings for any nest that was no longer active until fledglings were confirmed, 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, we recorded the nest fate as failed. If nesting activity ceased around the time of anticipated fledging, and the pair was not detected or rarely detected for the remainder of the breeding season, we recorded nest fate as unknown. Nest tree species and nest coordinates were collected at each nest at the end of the field season.

Golden-cheeked Warbler Monitoring on Resighting Plots

To determine the arrival weeks and detectability of banded Warblers each week, BCP staff and volunteers conducted weekly visits to each resighting plot between March 15 and May 25, for a total of 10 visits. Surveyors visually confirmed the banding status (banded or unbanded) and color combination of all Warblers observed within the resighting plot (and buffer, if any) and recorded their geographic positions. Surveyors also attempted to obtain a minimum of five locations for each banded Warbler per visit (only one location for unbanded birds) to provide additional data for dispersal models. For future years, BCP staff are evaluating the 2016 data to determine whether fewer visits (e.g., $\leq$ 5 visits) are sufficient to resight all of the banded birds on a plot.

Search for Banded Warblers Outside of Intensive Monitoring/Resighting Plots

Forty-seven volunteers conducted three 6-hour visits from March 15-May 25 on the 31 search areas. The list of resighting plots where surveys were conducted and the survey effort for each plot are reported in Exhibit B.

RESULTS

Territory Delineations

A total of 126 territories were identified in field season 2016, including 93 territories using Verner's (1985) method for the 12 intensive monitoring plots (an average estimated density of 0.13 territories per hectare for the combined 718-ha intensive monitoring plots). Territory densities were highest in tall, 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. Territory maps for each intensive monitoring plot are presented in Exhibit A (note: in Figure 11, the male designated by the pink polygon on Wild Basin was later resighted in the buffer outside of the Forest Ridge plot, and these observations were excluded from the territory delineations).

Color Banding

A total of 88 adult Warblers (76 males, 12 females) and 3 nestlings were banded in 2016.

Return Rates

The overall return rate of color-banded Warbler males (males banded in 2015 plus banded male returns from previous years) in 2016 was 37 percent, consistent with the 35 percent return rate observed in 2015, but lower than the 2010-2014 return rates (41-56%).

Nest Data

USFS, BCP staff, and BCP partners found and monitored a total of 125 active Warbler nests within the intensive monitoring plots during the 2016 field season. The first nests were found on March 22, and fledging dates for observed nests ranged from April 22 through June 13. Of the 125 nests, 64 fledged one or more young (51.2%), 55 nests failed (44%), and 6 had an unknown fate (4.8%).

Parasitism

There were no observations of Brown-headed Cowbird (*Molothrus ater*) parasitism at warbler nests in 2016.

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Exhibit A: Distribution of Intensive Monitoring Areas (Figure 1) and Minimum Convex Polygons Representing Estimated Golden-cheeked Warbler Territory Boundaries for Intensive Monitoring Plots (Figures 2-12), 2016. Disclaimer: these products are for informational purposes and may not have been prepared for or be suitable for legal, engineering, or surveying purposes. It does not represent an on-the-ground survey and represents only the approximate relative location of property boundaries. These products have been produced by the Wildland Conservation Division for the sole purpose of geographic reference. No warranty is made by the City of Austin regarding specific accuracy or completeness.

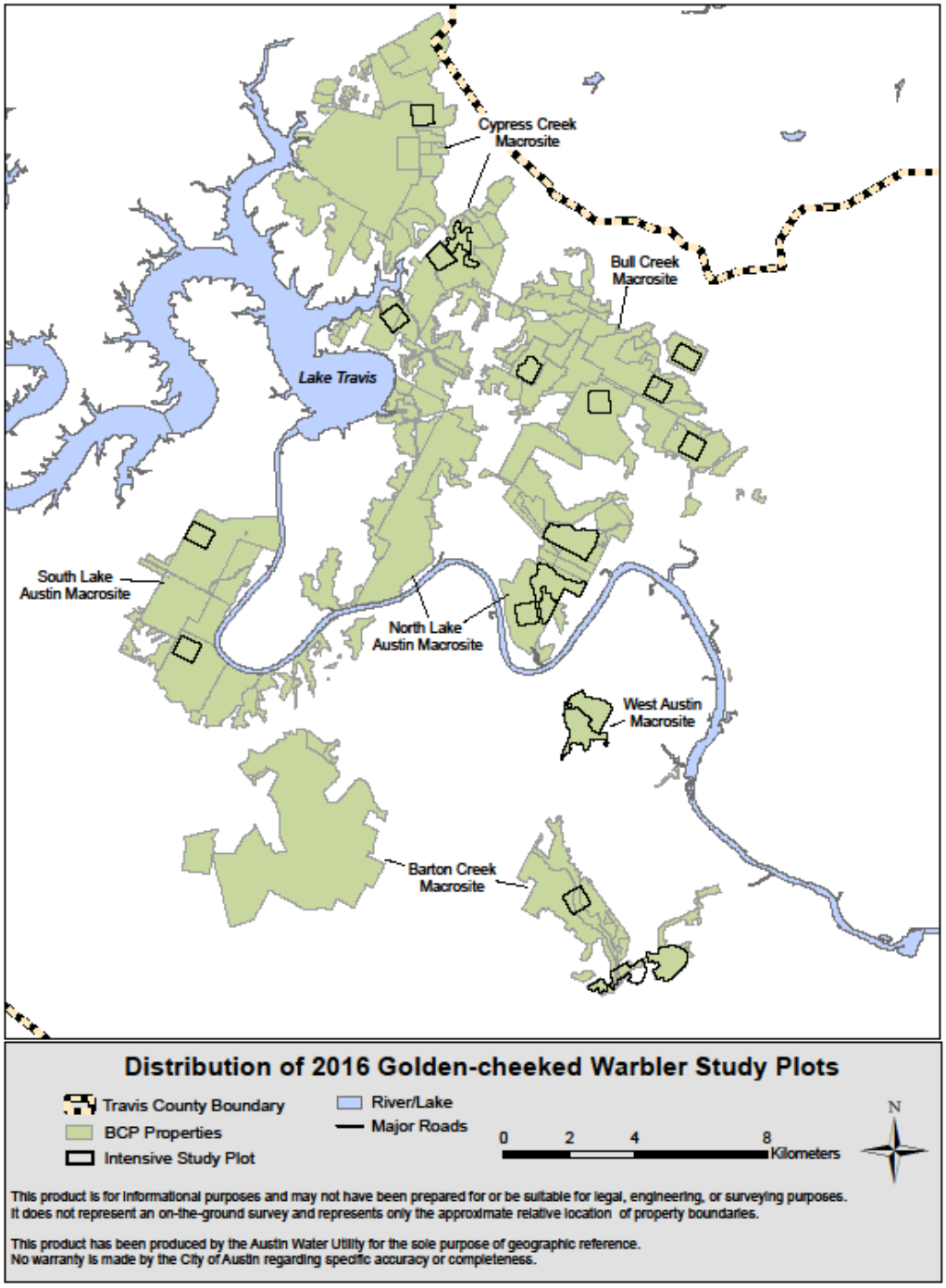


Figure 1

Exhibit A: Minimum Convex Polygons Representing Estimated Golden-cheeked Warbler Territory Boundaries for Intensive Monitoring Plots (Figures 2-12), 2016 (continued).

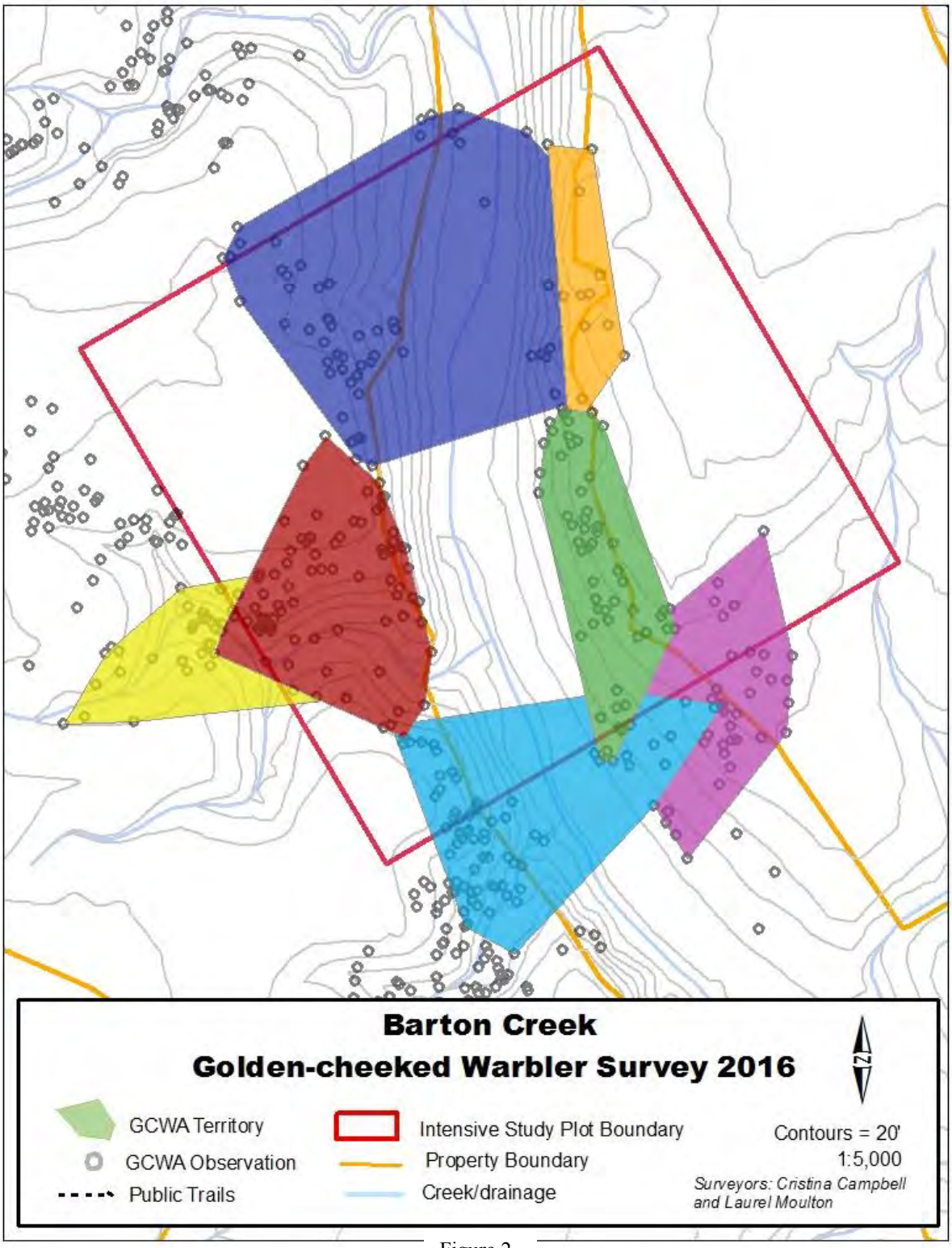


Figure 2

Exhibit A: Minimum Convex Polygons Representing Estimated Golden-cheeked Warbler Territory Boundaries for Intensive Monitoring Plots (Figures 2-12), 2016 (continued).

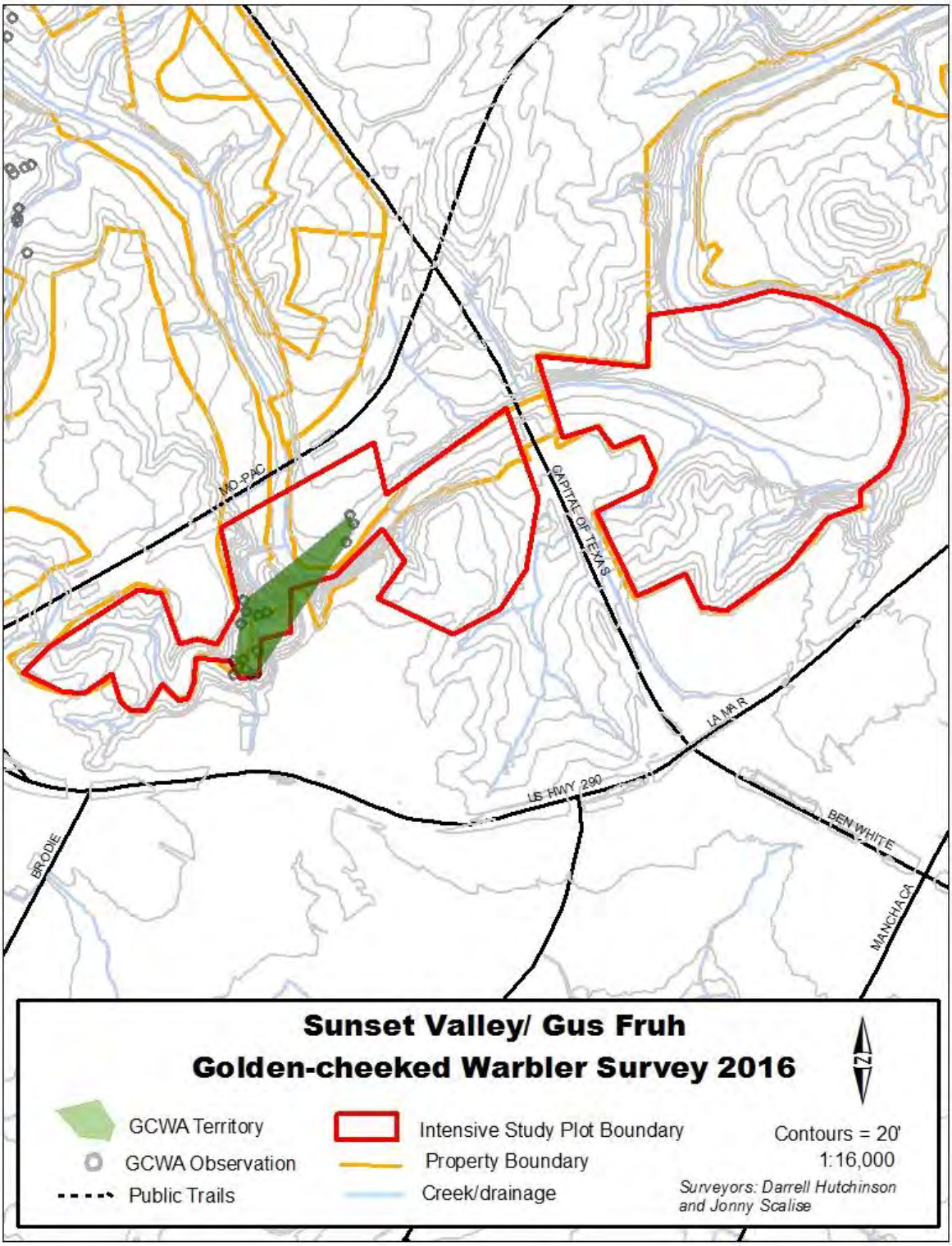


Figure 3

Exhibit A: Minimum Convex Polygons Representing Estimated Golden-cheeked Warbler Territory Boundaries for Intensive Monitoring Plots (Figures 2-12), 2016 (continued).

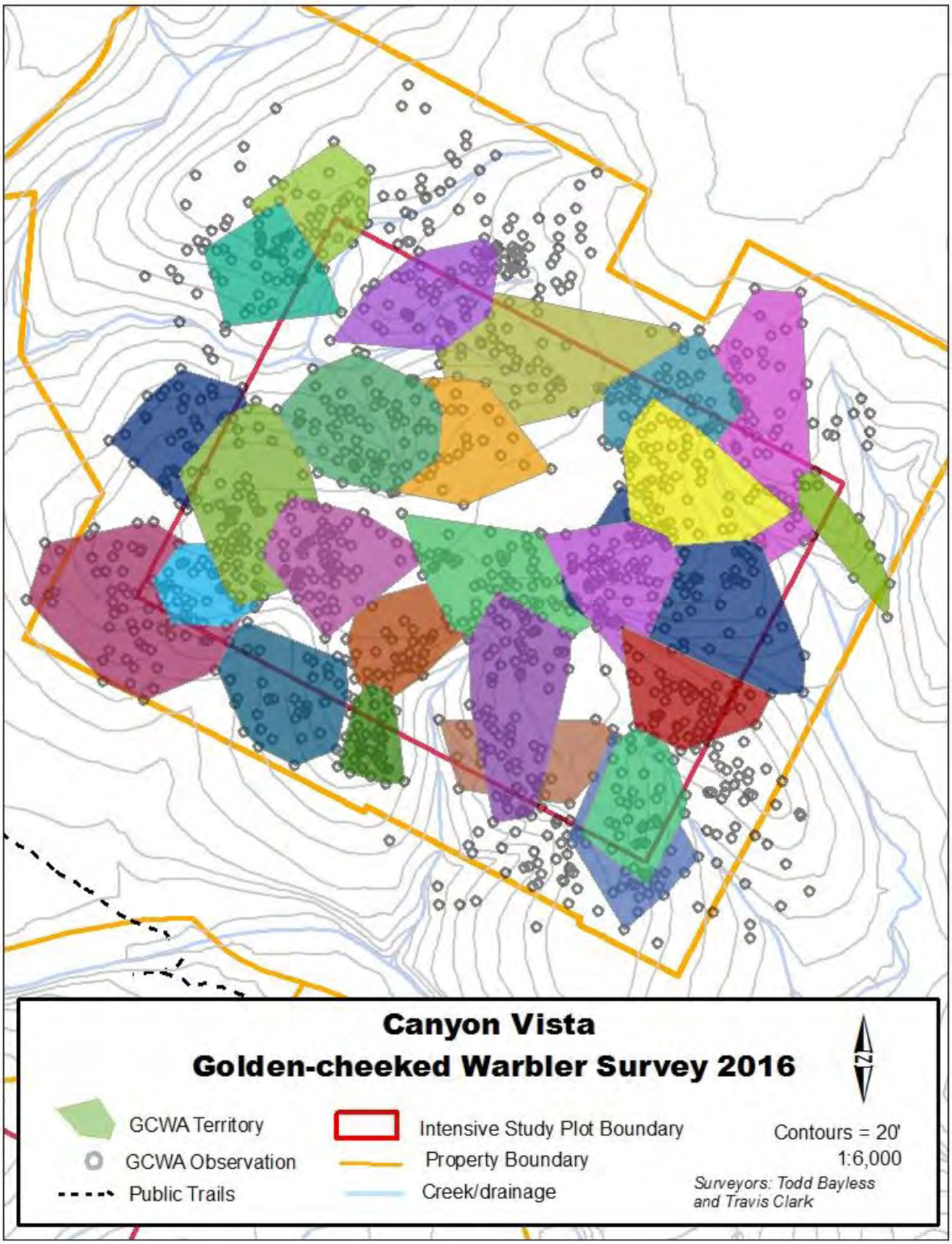


Figure 4

Exhibit A: Minimum Convex Polygons Representing Estimated Golden-cheeked Warbler Territory Boundaries for Intensive Monitoring Plots (Figures 2-12), 2016 (continued).

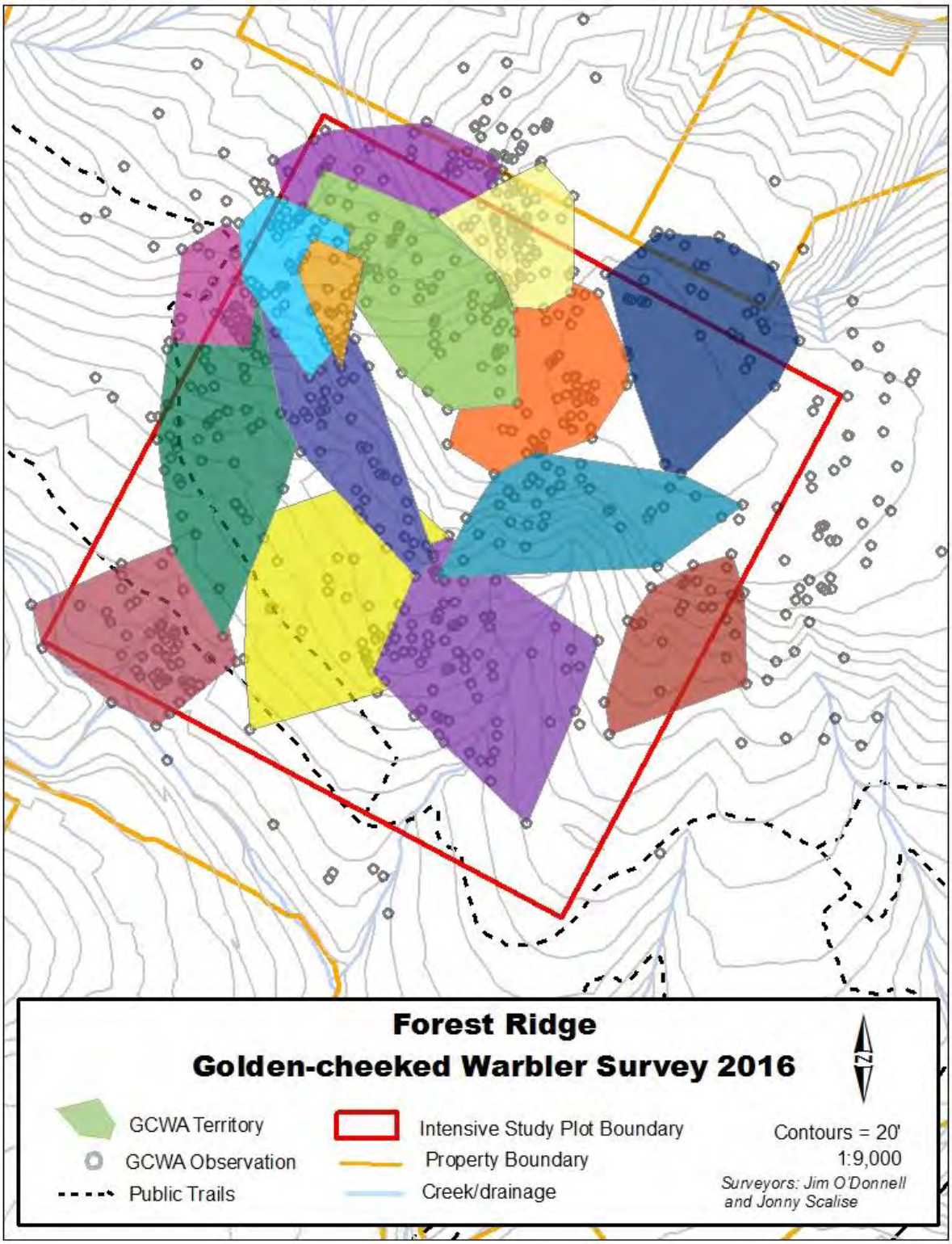


Figure 5

Exhibit A: Minimum Convex Polygons Representing Estimated Golden-cheeked Warbler Territory Boundaries for Intensive Monitoring Plots (Figures 2-12), 2016 (continued).

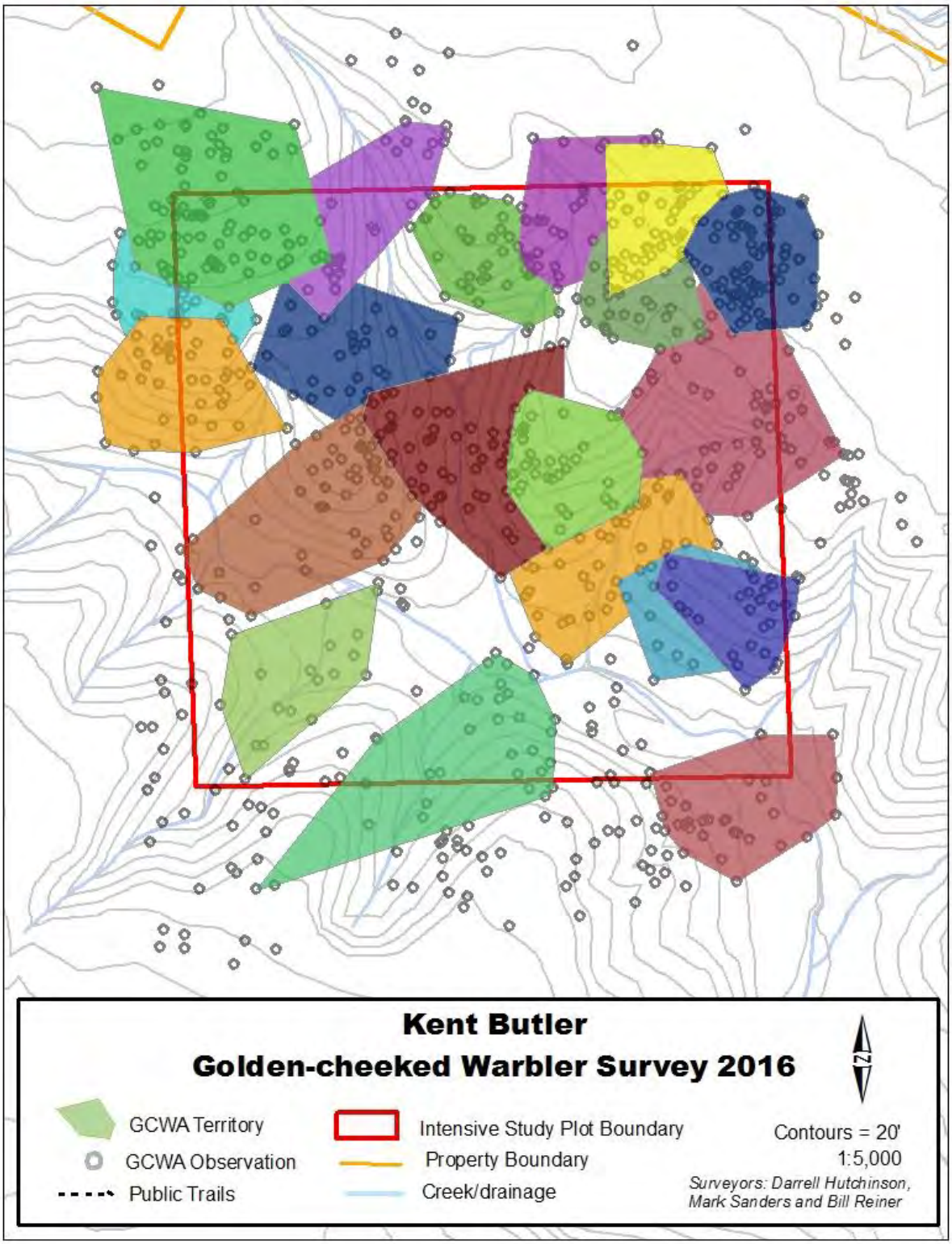


Figure 6

Exhibit A: Minimum Convex Polygons Representing Estimated Golden-cheeked Warbler Territory Boundaries for Intensive Monitoring Plots (Figures 2-12), 2016 (continued).

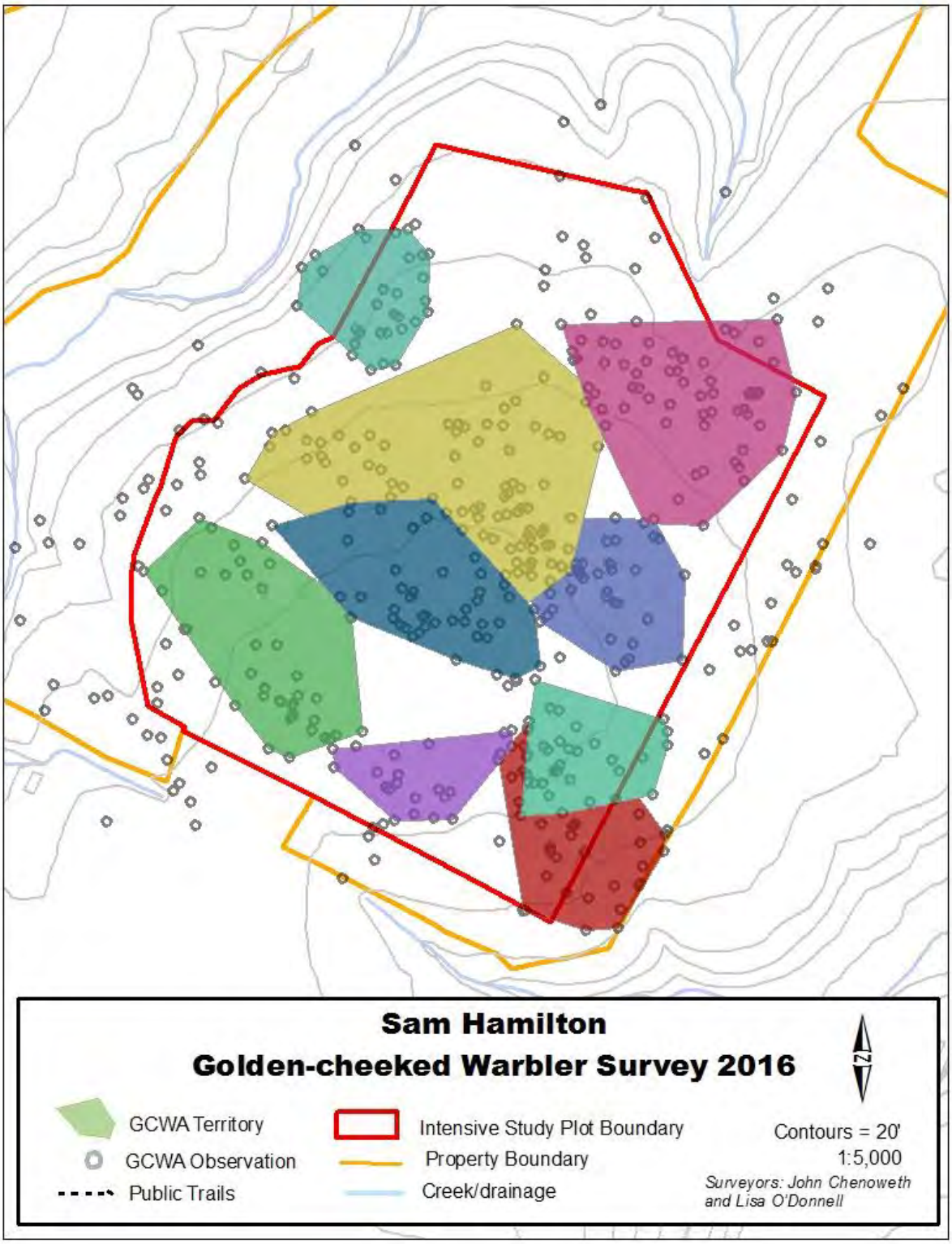


Figure 7

Exhibit A: Minimum Convex Polygons Representing Estimated Golden-cheeked Warbler Territory Boundaries for Intensive Monitoring Plots (Figures 2-12), 2016 (continued).

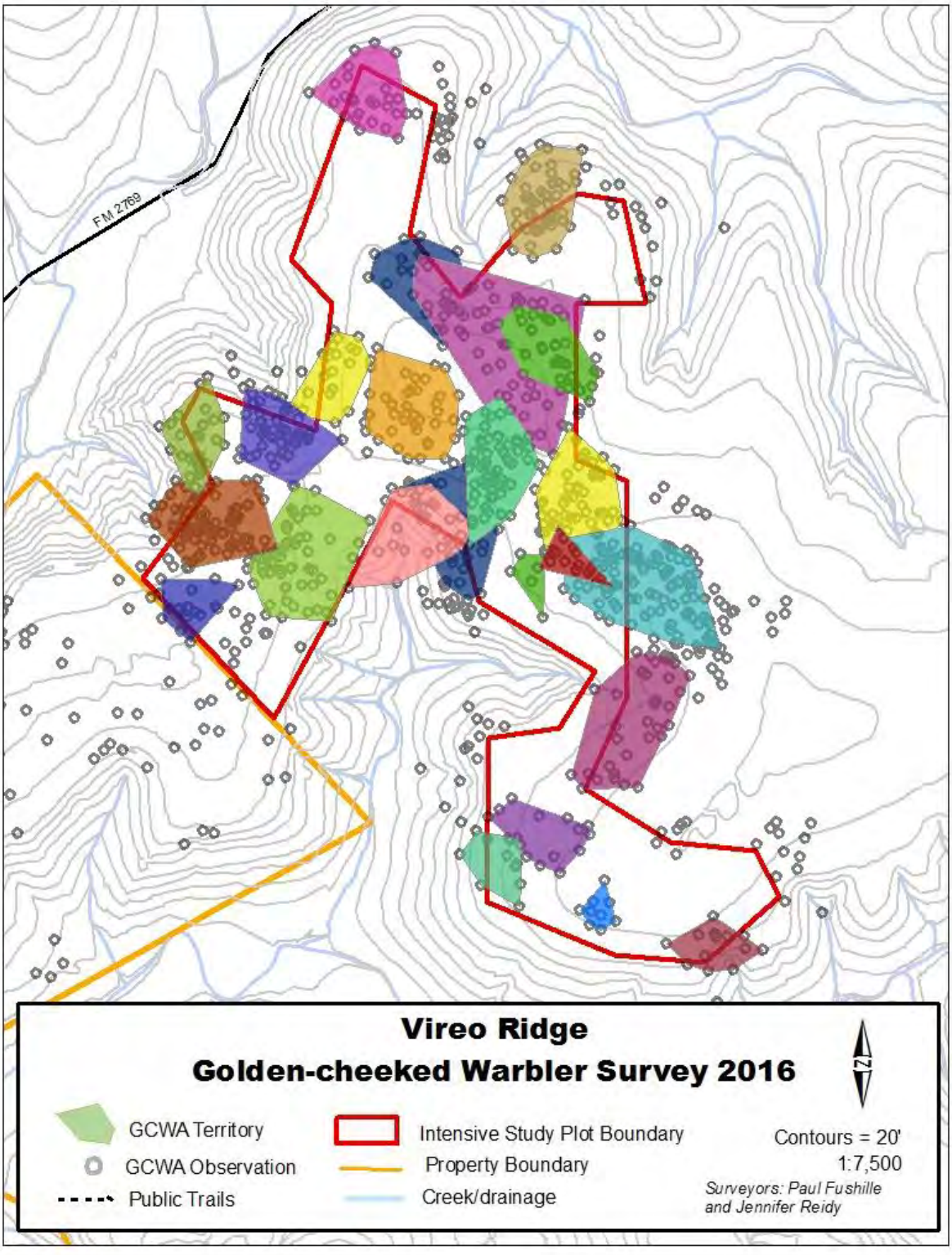


Figure 8

Exhibit A: Minimum Convex Polygons Representing Estimated Golden-cheeked Warbler Territory Boundaries for Intensive Monitoring Plots (Figures 2-12), 2016 (continued).

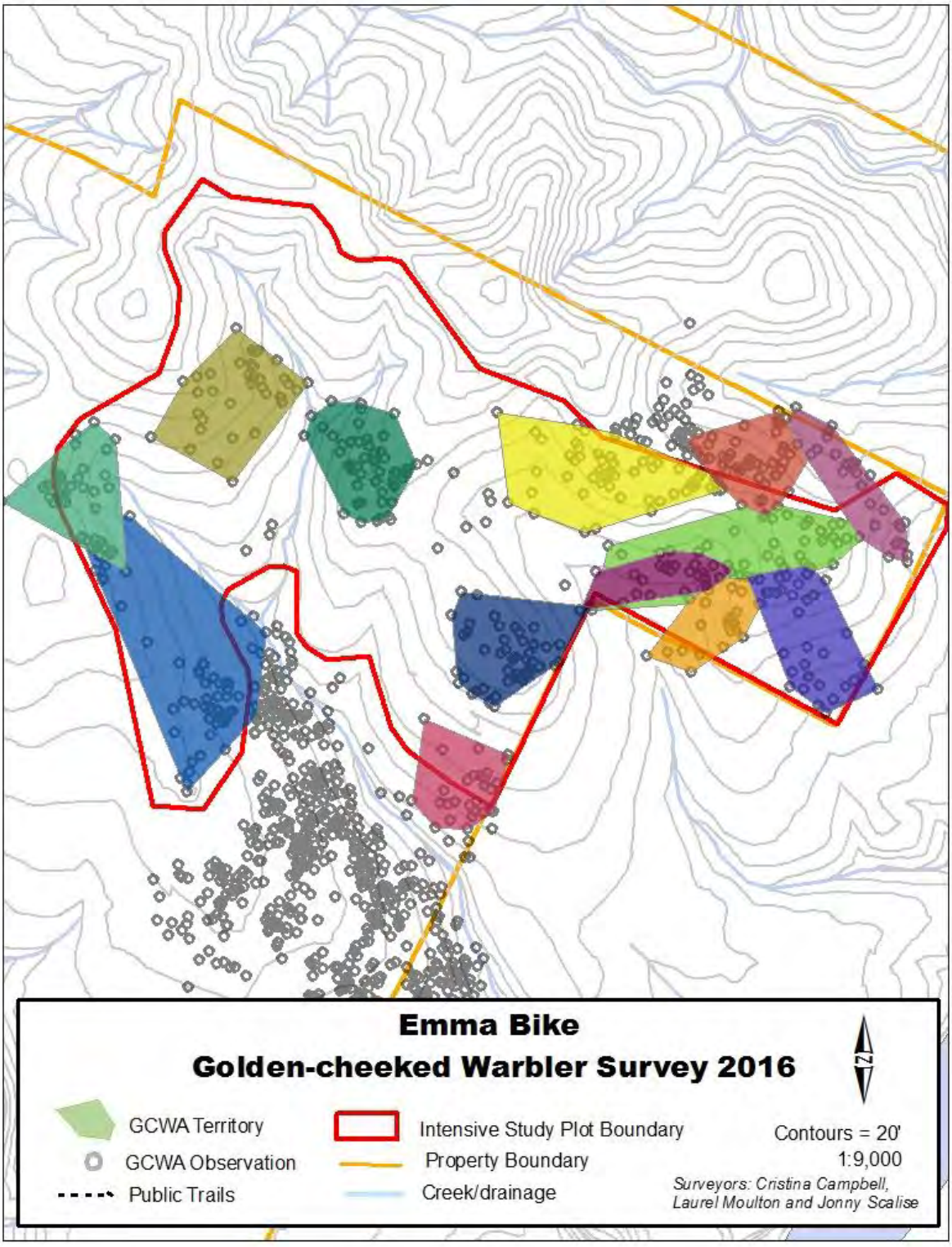


Figure 9

Exhibit A: Minimum Convex Polygons Representing Estimated Golden-cheeked Warbler Territory Boundaries for Intensive Monitoring Plots (Figures 2-12), 2016 (continued).

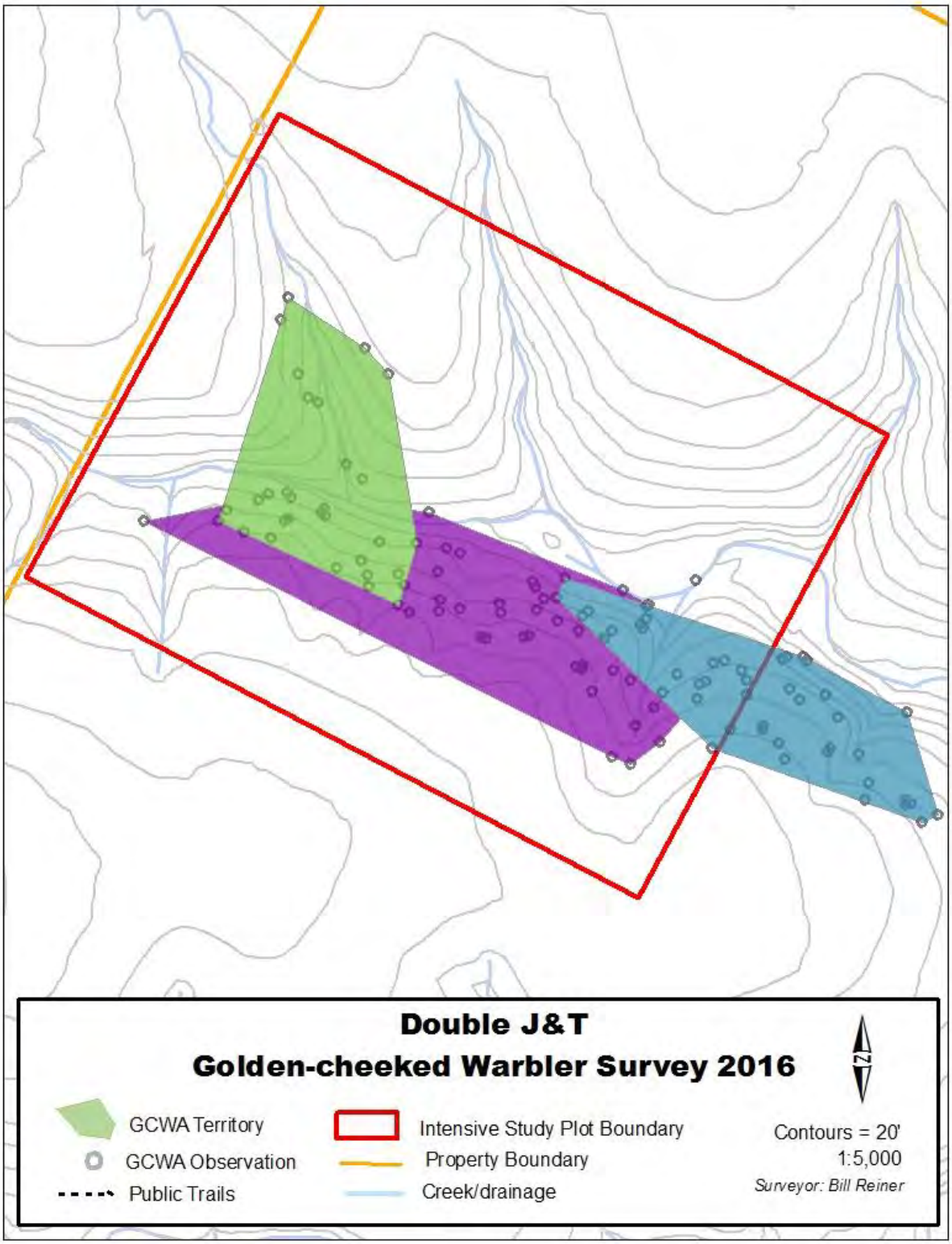


Figure 10

Exhibit A: Minimum Convex Polygons Representing Estimated Golden-cheeked Warbler Territory Boundaries for Intensive Monitoring Plots (Figures 2-12), 2016 (continued).

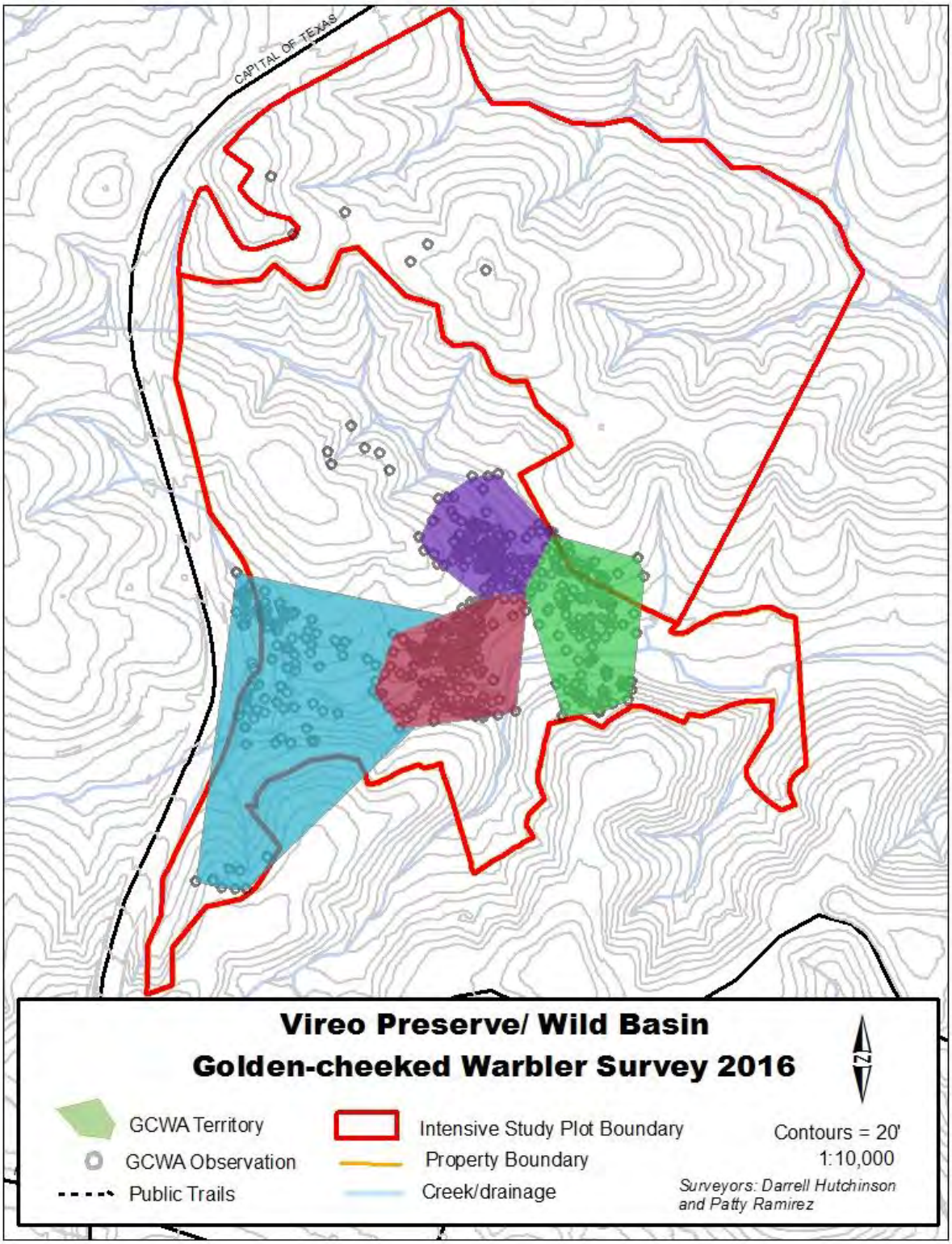


Figure 11

Exhibit A: Minimum Convex Polygons Representing Estimated Golden-cheeked Warbler Territory Boundaries for Intensive Monitoring Plots (Figures 2-12), 2016.

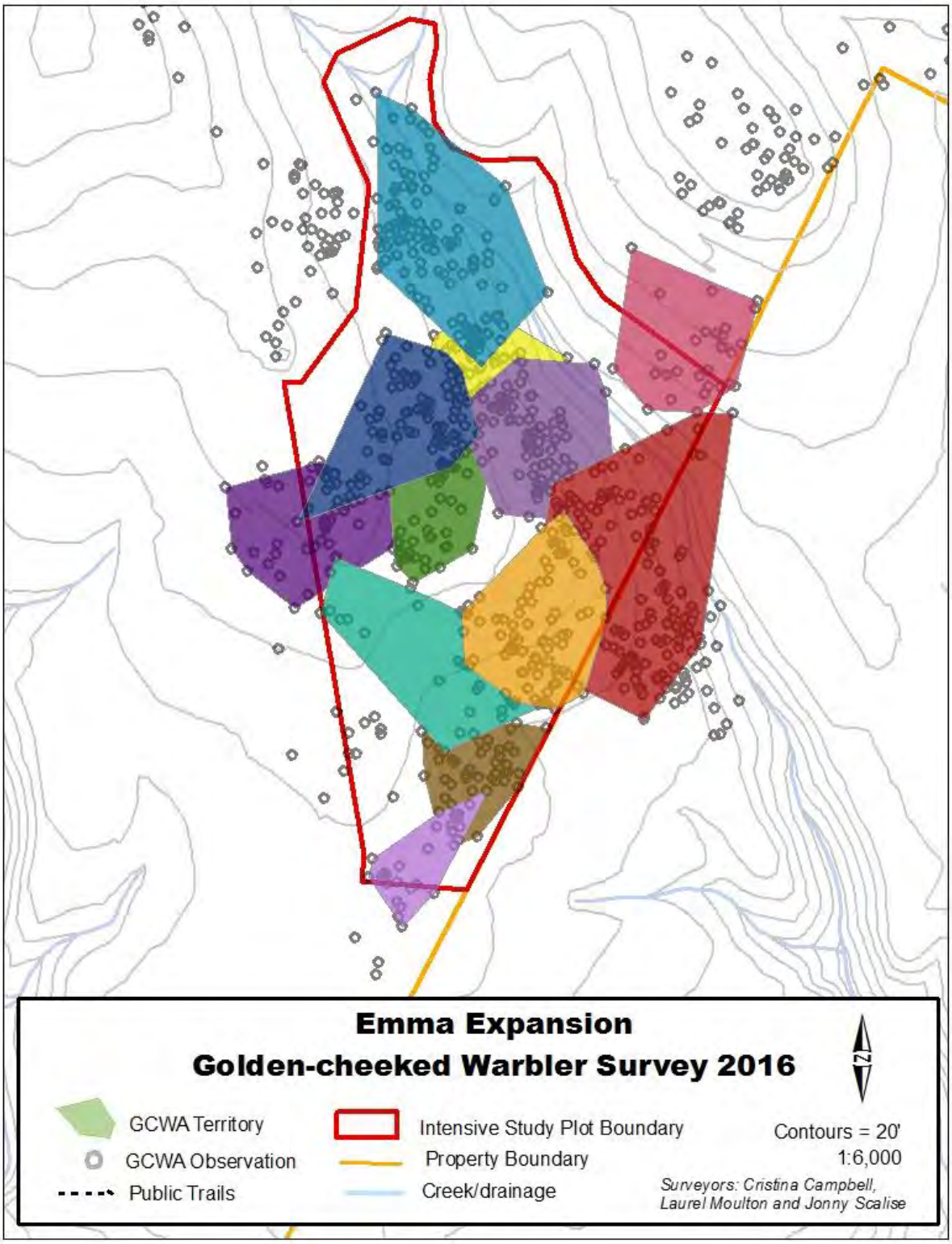


Figure 12

Exhibit B: Summary of Golden-cheeked Warbler Survey Effort on the Balcones Canyonlands Preserve, Travis County, Texas, Field Season 2016.

Intensive Monitoring Plots	Lead Surveyor(s)	Survey Hours (March 11-June 18)	Area Surveyed (hectares)
Barton Creek Macrosite			
Barton Creek	Cristina Campbell, COA; Laurel Moulton, COA	337	40.5 + buffer
Gus Fruh/ Sunset Valley	Darrell Hutchinson, Jonny Scalise, COA	57	85 + 27
Bull Creek Macrosite			
Canyon Vista	Todd Bayless, Travis Clark, TC	303	40.5 + buffer
Forest Ridge	Jonny Scalise, Jim O'Donnell, COA	377	40.5 + buffer
Kent Butler	William Reiner, Mark Sanders, Darrell Hutchinson, COA	360	40.5 + buffer
Hamilton West	John Chenoweth, Lisa O'Donnell, COA	197	40.5 + buffer
Cypress Creek Macrosite			
Vireo Ridge	Paul Fushille, TC; Jennifer Reidy, USFS	264	46
North Lake Austin Macrosite			
Emma Long Bike Park	Jonny Scalise, Cristina Campbell, Laurel Moulton, COA	466	96
Emma Long Expansion	Jonny Scalise, Cristina Campbell, Laurel Moulton, COA		41
South Lake Austin Macrosite			
Double J&T	William Reiner, COA	92	40.5 + buffer
West Austin Macrosite			
Vireo Preserve/Wild Basin	Darrell Hutchinson, COA; Patty Ramirez, WB	223	180
	Total		**718 + buffers**

COA = City of Austin, TC = Travis County, USFS = United States Forest Service/University of Missouri, WB = Wild Basin. Buffers = approx. 30 hectares for each 40.5-ha plot, where access was allowed.

Resighting Plots	Surveyor(s)	Survey Hours (March 15-May 25)	Area Surveyed (hectares)
Bull Creek Macrosite			
3M/St. Edwards	Paul Clements Ranleigh Hirsh Lisa O'Donnell (COA) Jim O'Donnell (COA)	94	40.5 + buffer
Cypress Creek Macrosite			
Baker Sanctuary	Chris Murray, Beth Samuelson, Travis Audubon	94	40.5 + buffer
Lake Perspectives	Travis Clark (TC) Todd Bayless (TC) Jim Weber Lynn Weber	26.5	40.5 + buffer
Vista Point	Julie Murray (TC) Jennifer Reidy (USFS)	59	40.5 + buffer
North Lake Austin Macrosite			
Coldwater	Laurel Moulton (COA) Jim O'Donnell (COA)	76	107
Emma Long*	Cristina Campbell (COA) Nevin Durish Darrell Hutchinson (COA)	143.5	40.5 + buffer
South Lake Austin Macrosite			
Reicher	Alan and Heidi Carlin John Chenoweth (COA) William Reiner (COA)	67.5	40.5 + buffer
	Total		**350 + buffers**

COA = City of Austin, TC = Travis County, USFS = United States Forest Service/University of Missouri,, WB = Wild Basin Buffers = approx. 30 hectares for each 40.5-ha plot, where access was allowed.
*Surveys on the Emma Long plot also included nest monitoring in 2016.

Exhibit B: Summary of Golden-cheeked Warbler Survey Effort on the Balcones Canyonlands Preserve, Travis County, Texas, 2016 Field Season (continued).

Search Areas*	Surveyor(s)	Survey Hours (March 15-May 25)
3M Northeast	Laura Brennand Laurie Winnette Cheryl McGrath	24.25
3M South	Dale Thompson	12
3M Southeast	Laura Zebehazy	16
Baker Sanctuary North	Kathrine Ross	23.5
Baker Sanctuary Southeast	Tam Tran	18
Baker Sanctuary Northwest	Gloria Stevens Kerry Stevens	16.5
Baker Sanctuary Southwest	Leigh Jandle	18
Barton Creek Northwest	Shelia Hargis	19
Barton Creek Southeast	Misa Soliz Amanda Hargrave	23.75
Barton Creek Southwest	Stacy Marcus	11.75
Barton Creek downstream	David Brady	18.25
Canyon Vista	Paul Clements Ranleigh Hirsh	19.5
Emma Long West	Jim Branch Kathleen Thies Leslyn Dillow	20.25
Emma Long South	Joseph Hunt Eric Mansker	15
Forest Ridge Northeast	Natalie Goldsworthy David Brady Crystal Datri	14.5
Forest Ridge Northwest	Jim and Lynne Weber	18
Forest Ridge Southeast	Jenny Samford Kerri Welch	18.5
Forest Ridge Southwest	Jim and Lynne Weber	18
Hamilton Northeast	Adrian Johnson	19.75
Hamilton West	Paul Brick	13.5
Hamilton Southeast	Angela England Will Thompson	20.5
Interplot (33.4 ha) (between 3M and Forest Ridge plots)	Kathleen Collins Mary Gilroy	21.75
Kent Butler East	Brian Miller Gloria Wilson	38.25
Kent Butler Northwest	Lauren Dill Janet Reed Tracy White	55
Kent Butler Southeast	Matthew Haverland	18
Kent Butler Southwest	Alan and Heidi Carlin	21.25
Lake Perspectives Northwest	Sara Weaver	17.25
Lake Perspectives South	Leigh Jandle	18

Search Areas*	Surveyor(s)	Survey Hours (March 15-May 25)
Vireo Ridge	Elena Pinto-Torres	18.5
Vista Point Southeast	Robin Laine	18.75
Vista Point Southwest	Marli Claytor	12.75

*All search areas were approximately 40.4 ha except where noted.
COA = City of Austin, TC = Travis County, USFS = United States Forest Service

Exhibit C: Golden-cheeked Warbler Intensive Monitoring Plot Protocol, Balcones Canyonlands Preserve, 2016.

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

Study Sites: Within each intensive monitoring 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 resighting birds. Separate visits may be required to band territorial males but GCWA observations made during banding attempts are not to be reported as territory observations. Productivity visits will continue at least once a week from May 25-June 15.

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

Mapping: Observers will obtain GPS locations for, and create hard copy maps of, all GCWA observations for every survey visit, following the Standards for Conducting and Documenting Golden-cheeked Warbler Surveys (COA 2015). 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 >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 2015 field season will have prior experience conducting Warbler surveys or be trained by experienced personnel prior to the field season.

Survey Procedures: Observers are to follow the Standards for Conducting and Documenting Golden-cheeked Warbler Surveys (COA 2015) 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 monitoring 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 2015).