2021 Annual Report:
Golden-cheeked Warbler *(Setophaga chrysoparia)*
Monitoring Program
Balcones Canyonlands Preserve



Golden-cheeked Warbler Fledgling, Jonny Scalise

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

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SUMMARY

This report summarizes the results of the golden-cheeked warbler (*Setophaga chrysoparia*) endangered species monitoring program on the Balcones Canyonlands Preserve (BCP) for the 2021 field season. We monitored 182 territories on 16 intensive monitoring plots, with an average estimated density of 0.15 males per hectare. The overall return rate of color-banded males was 50%, including a male banded as an SY on the Kent Butler plot in 2020 that was resighted multiple times on the Balcones Canyonlands National Wildlife Refuge (~19 km away). Average pairing and breeding success observed for all territories was 94% (range 75-100%) and 67% (range 20-100%), respectively. In addition, staff observed multiple successful double-broods and broods of second females paired with polygynous males. Of 147 active nests monitored, 84 nests fledged one or more young (57%) and 57 nests failed (39%). A warbler pair at Hamilton West was observed tending a brown-headed cowbird (*Molothrus ater*) fledgling, which was the only observation of parasitism in 2021, and the first since 2015.

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INTRODUCTION

Background

The golden-cheeked warbler (warbler) is a neotropical migrant passerine that breeds only in central Texas where mature Ashe juniper-oak (*Juniperus ashei–Quercus*) 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 expansion of development west of the City of Austin led to the creation of the Balcones Canyonlands Conservation Plan (a habitat conservation plan). The U.S. Fish and Wildlife Service issued a 10(a)(1)(B) permit in 1996 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 to be protected as a preserve (the BCP) for these species. The BCP is owned and managed by several 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% of the warbler's habitat in Travis County, protecting existing woodlands and promoting reforestation 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. 2016-2020). 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." A 5-year study (2011-2015) 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?

Reidy et al. (2015-2020) summarize findings from the 5-year study that have been published to date. The current long-term monitoring plan is intended to continue collecting demographic data to augment this study and meet the objectives of the Balcones Canyonlands Conservation Plan and the 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 uplands. 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 still 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 hampered natural succession to a closed canopy woodland. 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*), Mexican-buckeye (*Ungnadia speciosa*), Lindheimer silk-tassel (*Garrya ovata* var. *lindheimeri*), Texas mountain-laurel (*Dermatophyllum secundiflorum*), and elbowbush (*Forestiera pubescens*).

Study Sites

After the pandemic restrictions on field work in 2020, staff returned to the pre-pandemic regimen of tracking abundance and productivity on a set of 16 intensive monitoring plots in 2021 (Table 1, exhibits A, B). 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. BCP staff and volunteers also made a concerted effort to search for color-banded warblers outside of the intensive monitoring areas (see below) to gather data on site fidelity, dispersal, and return rates.

Intensive Monitoring Plots. The long-term monitoring plan includes 12 intensive monitoring plots (see City of Austin and Travis County [2019] for details) and additional plots contingent on staff and resource availability. In 2021, City of Austin staff were able to continue intensive monitoring on the Barton West, Emma Long Bike Park, and Emma Long Expansion plots. In addition, Travis County staff continued intensive monitoring on the Collins plot to study the impacts of tawny crazy ants (*Nylanderia fulva*).

Intensive monitoring plots were located within six of eight BCP macrosites (all but the Pedernales macrosite and the recently added Big Sandy Creek macrosite). Each of the 40.5-ha study plots includes a 100-m buffer around its perimeter (where access was permitted) to expand the search area for color-banded warblers and to obtain additional information on return rates, dispersal, territory size and configuration, and productivity.

The larger plots generally encompass habitat patches and do not include buffers. Intensive monitoring plots covered about 7% of the BCP. Including the 100-m buffers around each 40.5-ha plot, the Canyon Vista re-sighting plot, and additional areas surveyed by volunteers to search for color-banded warblers, surveys for this project covered about 19% of the BCP in 2021 (Table 1).

Re-sighting Plot. The previously established Canyon Vista plot was not intensively monitored in 2021, but was treated as a re-sighting plot (Table 1). This 40.5 ha. plot and its 100 meter buffer will be surveyed each breeding season until no banded birds are found. We discontinued re-sighting at the 3M/St. Edwards plot after finding no banded males in 2020. The absence of banded birds on the Baker Sanctuary, Vireo Ridge, Coldwater, Lake Perspectives/McGregor, and Gus Fruh/Sunset Valley plots led to a cessation of monitoring on those plots in previous years.

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 33 search areas totaling approximately 1,249 ha (Exhibit C).

Table 1. Intensive monitoring and re-sighting plots for macrosites within the Balcones Canyonlands Preserve, Travis County, Texas, field season 2021.

Plot Name, Ownership[1], and Size (ha)	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					
Barton West (COA)	47					
Forest Ridge (COA)		40.5				
Hamilton West (COA)		40.5				
Kent Butler (COA)		40.5				
Collins (TC)			40.5			
Vista Point (TC)			40.5			
Wheless (TC)			40.5			
Cortaña (COA)				62		
Emma Long (COA)				40.5		
Emma Long Bike Park (COA)				96		
Emma Long Expansion (COA)				34		
JJ&T (COA)					40.5	
Reicher (COA)					40.5	
Wild Basin/Vireo Preserve (COA, St. Edwards, TC)						180
Re-sighting Plots						
Canyon Vista (TC)		40.5				
Total BCP Hectares Owned (as of January 2019)[2]	2,481	2,027	3,925	2,299	1,643	188
% of macrosite surveyed[3]	6.8%	8.0%	3.1%	10.1%	4.9%	96%

[1]COA = City of Austin, TC = Travis County, TNC = The Nature Conservancy

[2]Does not include the Pedernales macrosite (106 ha) or Big Sandy Creek macrosite (386 ha).

[3]Does not include the 100-m buffers around the intensive monitoring/re-sighting plots (approx. 30 ha for each of the eleven 40.5-ha plots, where access was allowed, totaling about 285 ha), or the search areas beyond the buffers (about 1249 ha, see Exhibit C).

METHODS

Golden-cheeked Warbler Monitoring on Intensive Monitoring Plots

Color Banding. Color banding of adult warblers was conducted in conjunction with territory mapping on 16 intensive monitoring plots. We used target 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 numbered aluminum band and auxiliary color bands to allow identification of each individual. We used color-band combinations issued by the biological staff at Ft. Hood Military Reservation. 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], hatching-year [HY], 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 C lists the lead surveyors and survey hours for each intensive monitoring plot. Exhibit D provides details on the 2021 intensive study plot protocols.

To delineate territory size and configuration as accurately as possible, an effort was made to obtain at least 33 locations, separated by 30 meters or more, 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 21-day period. Exceptions to this rule were made during the 2021 field season for three males who had paired and nested but disappeared prior to the end of the 21-day period.

Warbler observations were recorded with Garmin global positioning units (GPS), which have an accuracy of 3 to 9 m. All observations were recorded on topographic maps, using a 100-m 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 Pro 2.5.2 (ESRI, Redlands, California) and displayed so that territories could be delineated. Territorial boundaries for each male were delineated using minimum convex polygons.

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) method (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 [1985] 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 2020 (including returns from previous years and those banded in 2020) that were observed again in 2021.

Pairing and Reproductive Success. Surveys to document productivity were conducted from March 15 through June 15. A second observer participated in the weekly surveys on medium-density plots (5-10 territories/40.5 ha) from April 20 through May 25, where needed to assist with fledgling counts. 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 percentage of males determined to have paired with a female for territories in which the pairing success is known. 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 percentage of territories, of known breeding success, determined to have produced at least one fledgling. 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 edge territories, divided by the plot size). Since documentation of successful second broods is opportunistic, the estimated number of fledglings and productivity is for first broods only. 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 for which reproductive success or failure is known, 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 four, 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 2021, a concerted effort was made to locate and monitor nests on Collins, Kent Butler, Emma Long Bike Park, and Emma Long Expansion plots. Nests were monitored on other intensive monitoring plots as staff and resources allowed. 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.

Golden-cheeked Warbler Monitoring on the Canyon Vista Re-sighting Plot

Because the territory density on the Canyon Vista plot was relatively high (<10 territories), at least two observers surveyed the plot each week for five consecutive weeks from March 24 through April 21. Single observers visited the plot weekly from April 30 to May 20. Staff surveyed the plot one more time late in the season to detect dispersing birds (May 27). Surveyors visually confirmed the banding status (banded or unbanded) and, if banded, the color combination of all warblers observed within the re-sighting plot (and buffer) and recorded their geographic positions.

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

Seventy-three volunteers conducted three 6-hour visits from March 20 through June 1 within the 33 search areas. The list of search areas where surveys were conducted, and the survey effort for each search area, are reported in Exhibit C.

Golden-cheeked Warbler DNA sampling

The City of Austin has been collaborating with Dr. Giri Athrey at Texas A&M University since 2018 to collect DNA samples across the warbler's breeding range. In 2021, we collected DNA samples from 97 warblers. These samples were collected from public and private lands: Camp Bullis, Fort Hood, Kickapoo Caverns State Park, Garner State Park, Hatfield Ranch, Love Creek Preserve, Marsh Ranch, Colorado Bend State Park, Meridian State Park, and Palo Pinto State Park. These samples have been extracted and are currently being sequenced to examine changes in genetic diversity and levels of dispersal across the range. These data will be used to assess gene flow, effective population size, and ultimately, population health.

RESULTS AND DISCUSSION

Territory Delineations

A total of 182 territories were identified in field season 2021, including 138 territories using Verner's (1985) method for all 16 intensive monitoring plots. This represents an average estimated density of 0.15 territories per hectare for the combined 905.5 ha of intensive monitoring plots, ranging from 0.01 to 0.42 territories/ha (Table 2). Territories that overlapped two of three plots (Emma Long, Emma Long Bike Park, and Emma Long Expansion) were counted as edge territories; to avoid double-counting across plots, these territories are noted in 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 (<3.35 m) canopy heights. A summary of the 2009-2021 territory data is provided in Exhibit E.

Table 2. Golden-cheeked warbler territory number and estimated territory density (per hectare) within 16 intensive study plots on the Balcones Canyonlands Preserve, Travis County, Texas, field season 2021.

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	2	5	3.5	0.09
Barton Creek Habitat Preserve	0	2	1	0.01
Barton West	2	4	3	0.06
Bull Creek Macrosite				
Forest Ridge	10	23	16.5	0.41
Kent Butler	8	23	15.5	0.38
Hamilton West	5	15	10	0.25
Cypress Creek Macrosite				
Collins	5	15	10	0.25
Vista Point	12	22	17	0.42
Wheless	2	7	4.5	0.11
North Lake Austin Macrosite				
Cortaña	4	4	4	0.06
Emma Long	7	13 (+1) [2]	10.5[2]	0.26
Emma Long Bike Park	13	19 (+4) [2]	18[2]	0.19
Emma Long Expansion	4	9[2]	6.5[2]	0.19
South Lake Austin Macrosite				
Double J&T	3	5	4	0.10
Reicher	3	7	5	0.12
West Austin Macrosite				
Wild Basin/Vireo Preserve	9	9	9	0.05
All Plots Combined	**89**	**182**	**138**	**0.15**

[1]Calculation based on Verner's counting method (see Methods section for calculations). Plots average 40.5 ha except for Barton Creek Habitat Preserve (81.5 ha), Barton West (47 ha), Emma Long Bike Park (96 ha), Emma Long Expansion (34 ha), Cortaña (62 ha), and Wild Basin/Vireo Preserve (180 ha).

[2]Emma Long, Emma Long Bike Park, and Emma Long Expansion are contiguous, so one or more territories may be on two plots. Numbers in parentheses represent territories that are primarily on a different plot; these territories are excluded from the total territories for the plot to ensure they are only counted once for all plots combined. They are included when calculating density per plot.

Color Banding

City of Austin and Travis County staff color banded a total of 143 adult warblers (124 males, 18 females) and one hatch-year on the BCP in 2021.

Age Structure

Of the 182 territorial males identified on the 16 intensive study plots in 2021, 134 were color-banded (74%; Table 3). Of these 134 males, 56% were ASY and 44% were SY. Reicher, JJ&T, Hamilton West, and Emma Long had the highest percentages of ASY males in 2021 (78-86%), while Vireo Preserve/Wild Basin, Cortaña, and Barton Creek had the highest percentage of SY males (80-100%). The different age structures observed among plots may be due to the influence of habitat characteristics on the recruitment of young territorial males, immigration of warblers displaced due to habitat loss outside of the preserves, 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 2009-2021 is presented in Exhibit F.

Table 3. Golden-cheeked warbler age structure data for color-banded territorial males observed within 16 intensive study plots on the Balcones Canyonlands Preserve, Travis County, Texas, field season 2021.

Plot Name	SY Males	ASY Males	AHY Males	Total Banded Males	Total Unbanded Males	% Banded Males
Barton Creek Macrosite						
Barton Creek	4	1	0	5	0	100
Barton Creek Habitat Preserve	1	1	0	2	0	100
Barton West	2	2	0	4	0	100
Bull Creek Macrosite						
Forest Ridge	8	9	0	17	6	74
Kent Butler	6	11	0	17	6	74
Hamilton West	2	7	0	9	6	60
Cypress Creek Macrosite						
Collins	7	4	0	11	4	73
Vista Point	5	7	0	12	10	55
Wheless	1	3	0	4	3	57
North Lake Austin Macrosite						
Cortaña	2	0	0	2	2	50
Emma Long	2	7 (+1)[1]	0	9 (+1)[1]	4	71
Emma Long Bike Park	8 (+2)[1]	8 (+1)[1]	0	16 (+3)[1]	3 (+1)[1]	83
Emma Long Expansion	2[1]	5[1]	0	7[1]	2[1]	78
South Lake Austin Macrosite						
Double J&T	1	4	0	5	0	100
Reicher	1	6	0	7	0	100
West Austin Macrosite						
Wild Basin/Vireo Preserve	7	0	0	7	2	78
All Plots Combined	**59**	**75**	**0**	**134**	**48**	**74**

[1]Emma Long, Emma Long Bike Park, and Emma Long Expansion are contiguous, so one or more territories may be on two plots. Numbers in parentheses indicate territories that are counted on a different plot.

Return Rates

The overall return rate of color-banded warbler males in 2021 was 50% (62/124), higher than the return rates observed in 2016 (37%) and 2015 (35%), but within the range of 2010-2014 and 2017-2019 return rates (41-56%). It was significantly higher than the return rate in 2020 (32%), which may have been an outlier resulting from limits imposed on field work by pandemic restrictions. Dispersals included a male banded on Emma Long in 2020 that returned to Emma Long Bike Park in 2021, a male banded on the former Vireo Ridge plot in 2016 that returned to Vista Point in 2021, and a male banded on the Kent Butler plot in 2020 that was resighted multiple times on the Balcones Canyonlands National Wildlife Refuge (~19 km away) in 2021.

Prior dispersals where males continued to return to the new site in 2021 included a male banded on Barton Creek in 2019 (returned to Reicher), and a male banded on Emma Long Bike Park in 2018 (returned to Emma Long).

Only two returning females were observed in 2021. One of the females had been banded on the Hamilton plot in 2019 and returned to a volunteer search area outside that plot for the second consecutive year. The other female, banded in 2020 on Forest Ridge, returned to the same area of the Forest Ridge plot, and paired with an ASY unbanded male that may have been same mate as in 2020..

Pairing and Reproductive Success

In 2021, a total of 182 territories were monitored for pairing and reproductive success on the 16 intensive study plots (Table 4). The average pairing and breeding success observed for all territories was 94% (range 75-100%) and 67% (range 20-100%), respectively. Breeding success was highest on the JJ&T and Barton Creek Habitat Preserve plots (100%) and lowest on the Barton Creek and Vireo Preserve/Wild Basin plots (20-33%).

Biologists detected 320 fledglings from first broods in 122 territories known to have been successful. Fledglings from second successful broods and second females of polygamous males are not included in this total. 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 four resulted in an adjusted total estimate of 440 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 density of fledglings, while the Barton Creek, Barton Creek Habitat Preserve, Barton West, and Wild Basin/Vireo Preserve plots had the lowest reproductive output. A summary of the 2009-2021 reproductive success data is presented in Exhibit G.

Biologists noted that at least 17 territories produced successful second broods, totaling 34 fledglings (observed), or a maximum of 65 fledglings if assuming 3.6 fledglings per successful nest. In addition, biologists found at least eight of the males were polygynous, and at least five of the broods tended by the second females were successful, fledging at least an additional nine young (or as many as 19). Including these additional successful broods would bring the total number of fledglings to 361 (observed) or a maximum of 517 (adjusted).

Table 4. Golden-cheeked warbler reproductive success on 16 intensive study plots on the Balcones Canyonlands Preserve, Travis County, Texas, field season 2021. Data are based on observations for both full and edge territories.

Plot Name	No. of Territories	No. of Territories w/ Female	Percent Pairing Success[1]	No. of Territories Producing ≥ 1 Young	Percent Breeding Success[1]	Observed and Adjusted[2] Productivity	Observed and Adjusted[2] Productivity Per Successful Territory	Total No. of Fledglings Observed and Adjusted[2] Fledglings	Density of Observed and Adjusted[2] Fledglings Per Hectare[3]
Barton Creek Macrosite									
Barton Creek	5	4	80	1	20	0.4 / 0.7	2.0 / 3.6	2 / 3.6	0.05 / 0.09
BCHP[4]	2	2	100	2	100	2.0 / 3.6	2.0 / 3.6	2 / 7.2	0.02 / 0.04
Barton West	4	3	75	2	50	0.5 / 1.8	1.0 / 3.6	2 / 7.2	0.03 / 0.11
Bull Creek Macrosite									
Forest Ridge	23	23	100	18	78	1.9 / 2.7	2.4 / 3.5	44 / 62.4	0.86 / 1.19
Kent Butler	23	21	91	18	78	2.3 / 2.9	2.9 / 3.7	53 / 65.8	0.85 / 1.08
Hamilton West	15	15	100	7	47	1.2 / 1.7	2.6 / 3.7	18 / 25.6	0.31 / 0.45
Cypress Creek Macrosite									
Collins	15	13	87	8	53	1.5 / 1.8	2.8 / 3.5	22 / 27.6	0.35 / 0.43
Vista Point	22	21	95	13	59	1.4 / 2.0	2.4 / 3.4	31 / 44.6	0..53 / 0.80
Wheless	7	7	100	6	86	2.9 / 3.3	3.3 / 3.9	20 / 23.2	0.32 / 0.38
North Lake Austin Macrosite									
Cortaña	4	3	75	2	50	1.5 / 1.8	3.0 / 3.6	6 / 7.2	0.10 / 0.12
Emma Long	13 (+1)[5]	12 (+1)[5]	92	9 (+1)[5]	71	1.9 / 2.7	2.6 / 3.7	26 / 37.2	0.40 / 0.59
Emma Long Bike Park	19 (+4)[5]	19 (+4)[5]	100	16 (+3)[5]	83	2.1 / 3.0	2.6 / 3.6	49 / 68.6	0.39 / 0.54
Emma Long Expansion	9	9	100	6	67	1.7 / 2.4	2.5 / 3.7	15 / 22.0	0.29 / 0.43
South Lake Austin Macrosite									
JJ&T	5	5	100	5	100	2.6 / 3.8	2.6 / 3.8	13 / 18.8	0.25 / 0.37
Reicher Ranch	7	7	100	6	86	2.1 / 3.1	2.5 / 3.7	15 / 22.0	0.28 / 0.41
West Austin Macrosite									
Wild Basin/Vireo Preserve	9	7	78	3	33	1.3 / 1.3	4.0 / 4.0	12 / 12.0	0.07 / 0.07
All Plots Combined	**182**	**171**	**94**	**122**	**67**	**1.7 / 2.4**	**2.6 / 3.6**	**320 / 440.2**	**0.26 / 0.36**

[1]Calculations do not include territories where mated and/or breeding status was unknown.
[2]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. See Methods section for calculations.
[3]Density based on number of fledglings produced per full + 0.5 territories divided by the plot size.
[4]BCHP = Barton Creek Habitat Preserve
[5]Emma Long, Emma Long Bike Park, and Emma Long Expansion are contiguous, so one or more territories may be on two plots. Numbers in parentheses refer to territories that are counted on a different plot.

Nest Data

BCP staff found and monitored a total of 147 active warbler nests within or around the intensive monitoring plots during the 2021 field season. Over 90% of the nests were in Ashe junipers, 6% were in cedar elm, and 3% were in oaks. The first nests were found on March 19, and fledging dates for observed nests ranged

from April 19 through June 12 for first broods. Biologists found successful second broods fledging at least to June 16. Of the 147 nests, 84 nests fledged one or more young (57%) and 57 nests failed (39%).

Other Observations

A warbler pair at Hamilton West was observed tending a brown-headed cowbird fledgling, which was the only observation of parasitism in 2021. This was the first observation of parasitism since 2015.

Biologists noted that three banded males disappeared after pairing and initiation of nesting, but before three weeks had passed. This was, to our recollection, an unusually high number of disappearances after nest initiation.

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Exhibit A. Distribution of Intensive Monitoring Plots within the Balcones Canyonlands Preserve, 2021.

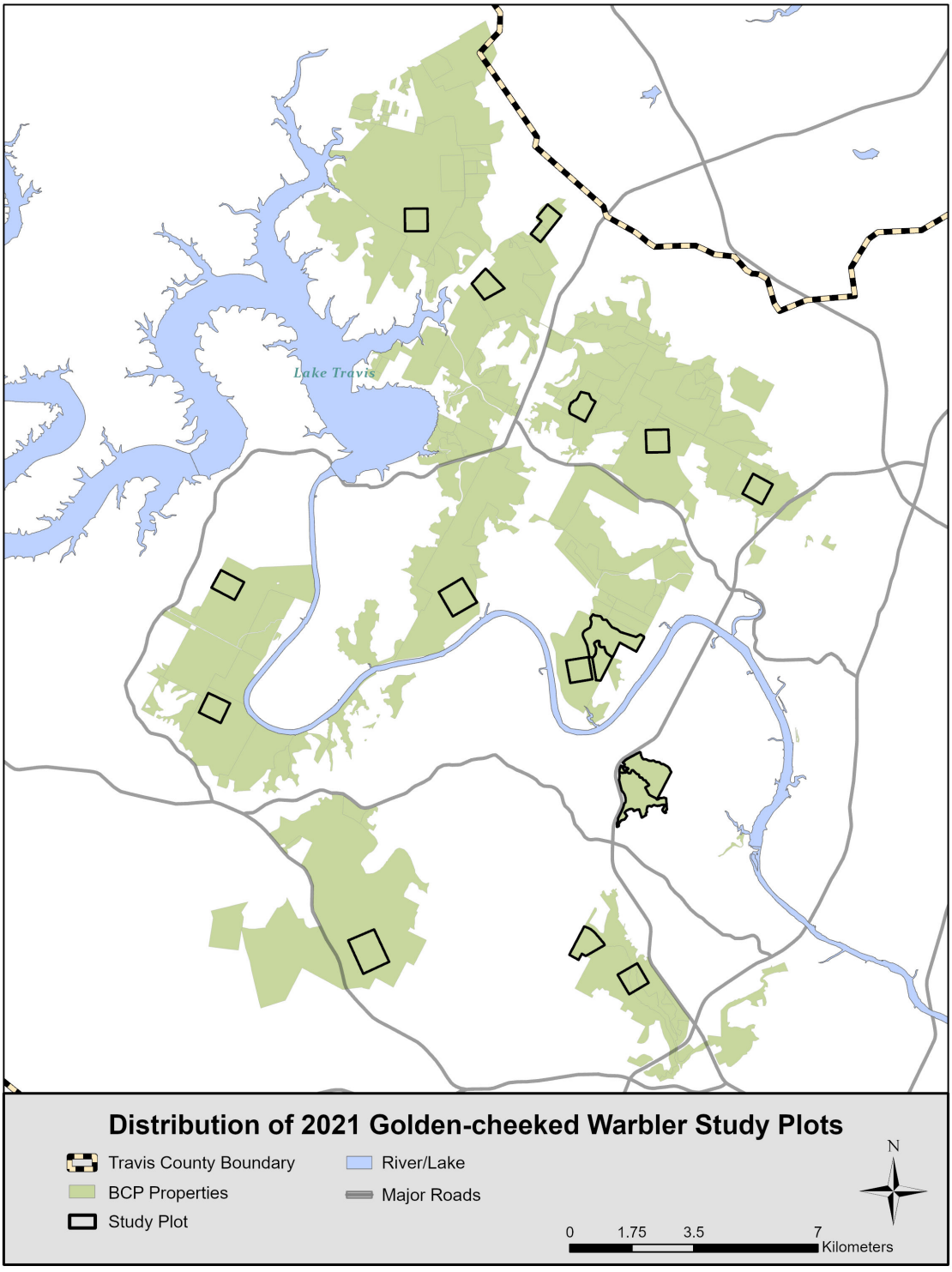

Figure 1

Exhibit B: Minimum Convex Polygons Representing Estimated Golden-cheeked Warbler Territory Boundaries for Intensive Monitoring Plots, (Figures 2-17), 2021. 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. Disclaimer: these products are for informational purposes and may not have been prepared for, or be suitable for, legal, engineering, or surveying purposes. They do not represent an on-the-ground survey and represent 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.

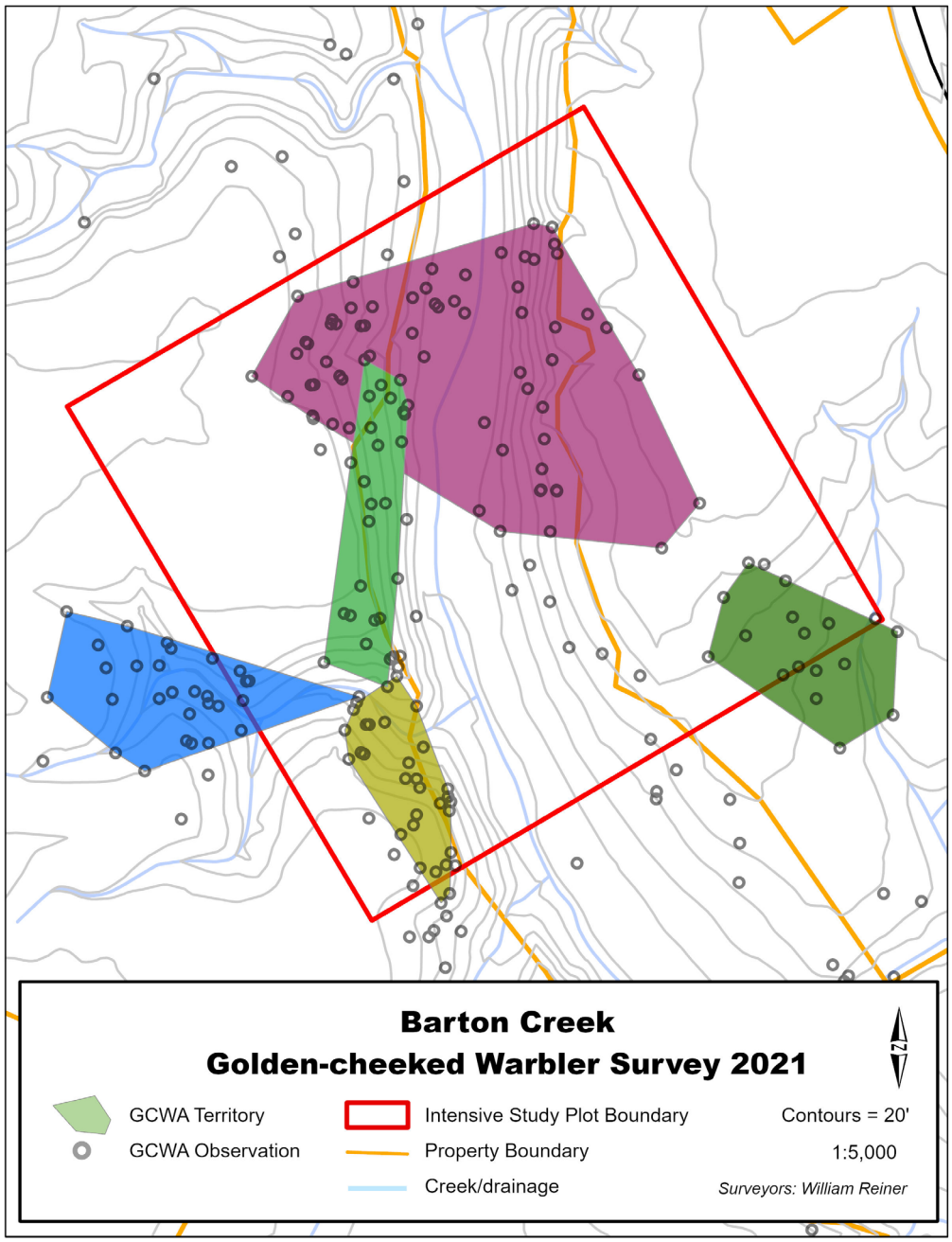

Figure 2

Exhibit B: Minimum Convex Polygons Representing Estimated Golden-cheeked Warbler Territory Boundaries for Intensive Monitoring Plots (Figures 2-17), 2021 (continued).

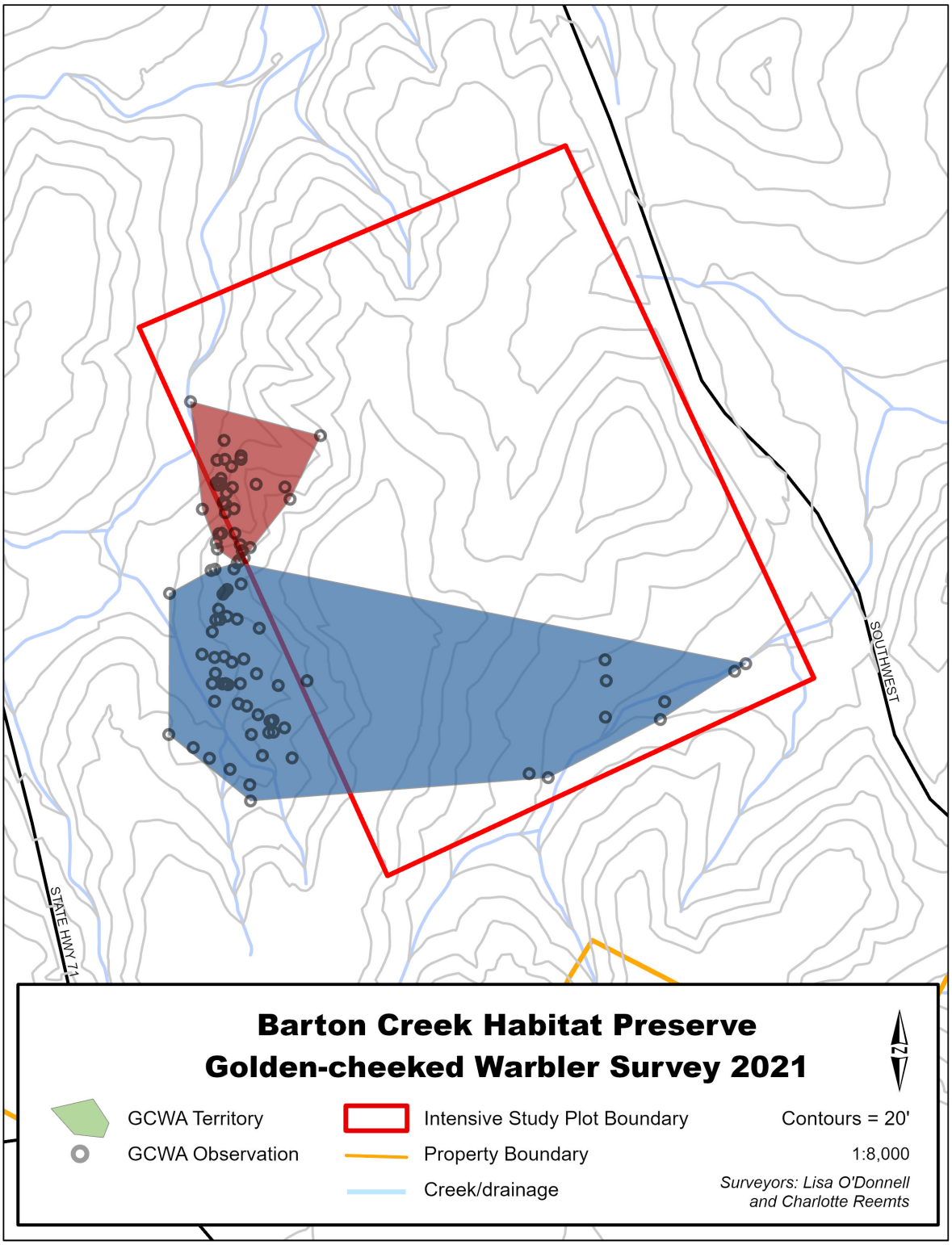

Figure 3

Exhibit B: Minimum Convex Polygons Representing Estimated Golden-cheeked Warbler Territory Boundaries for Intensive Monitoring Plots (Figures 2-17), 2021 (continued).

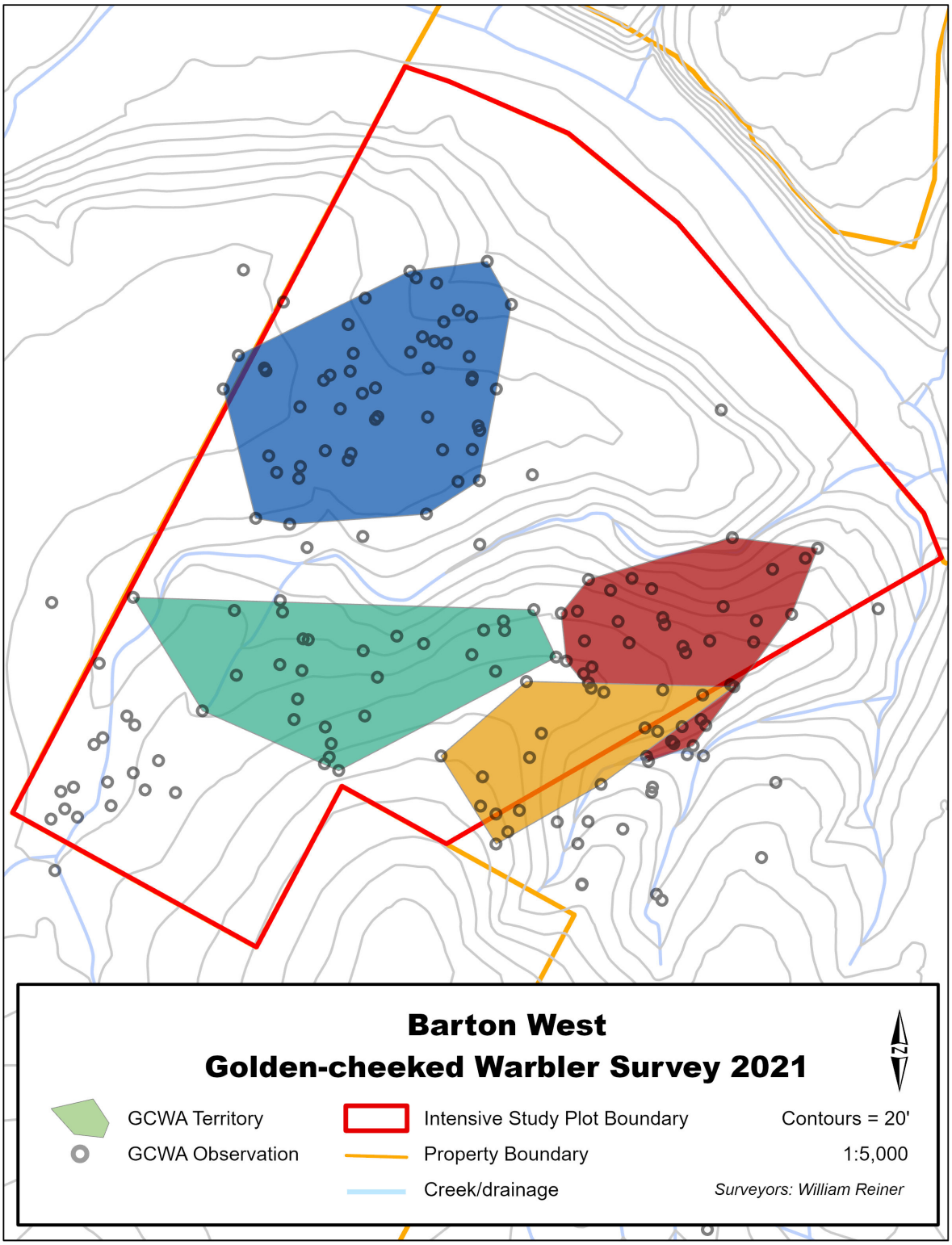

Figure 4

Exhibit B: Minimum Convex Polygons Representing Estimated Golden-cheeked Warbler Territory Boundaries for Intensive Monitoring Plots (Figures 2-17), 2021 (continued).

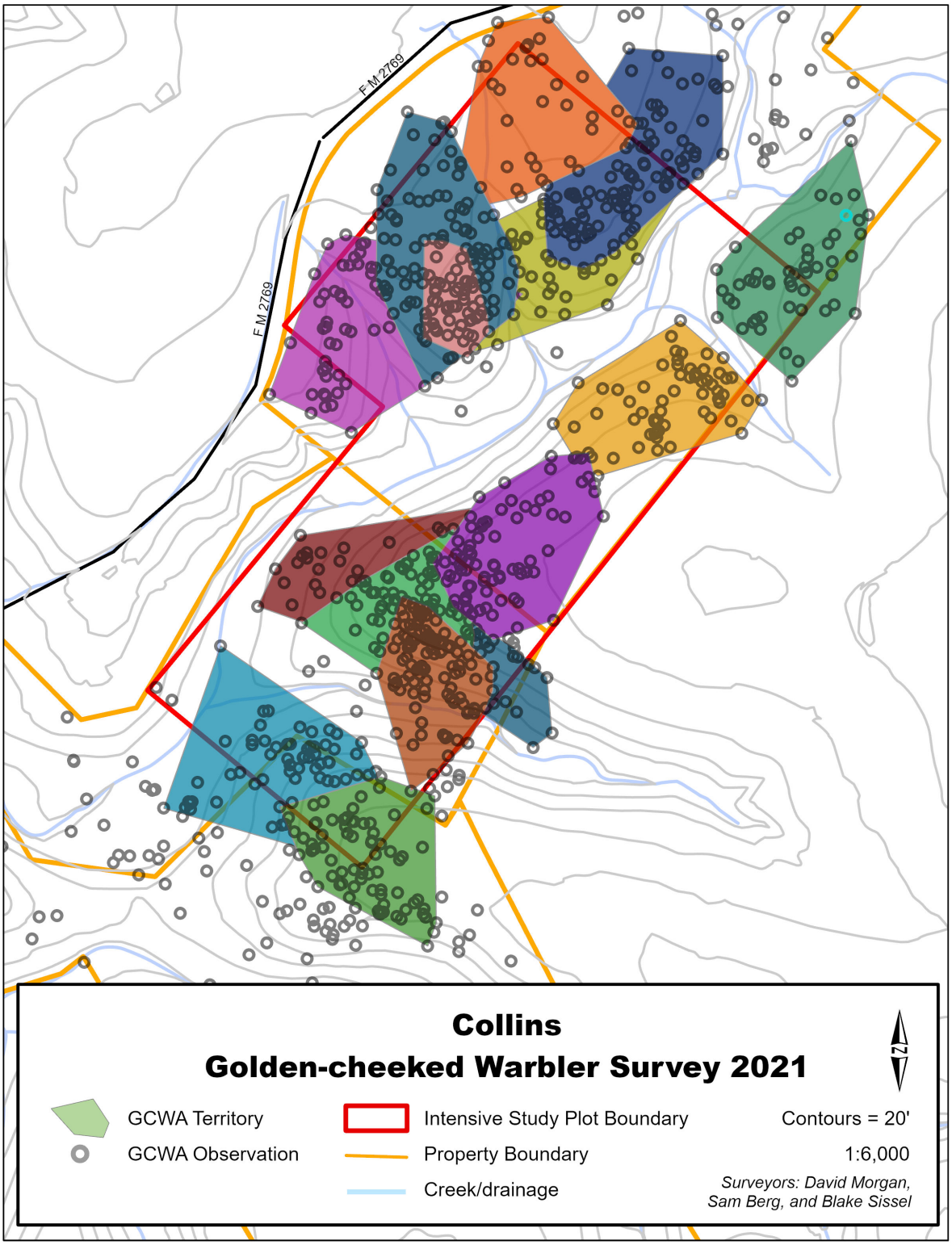

Figure 5

Exhibit B: Minimum Convex Polygons Representing Estimated Golden-cheeked Warbler Territory Boundaries for Intensive Monitoring Plots (Figures 2-17), 2021 (continued).

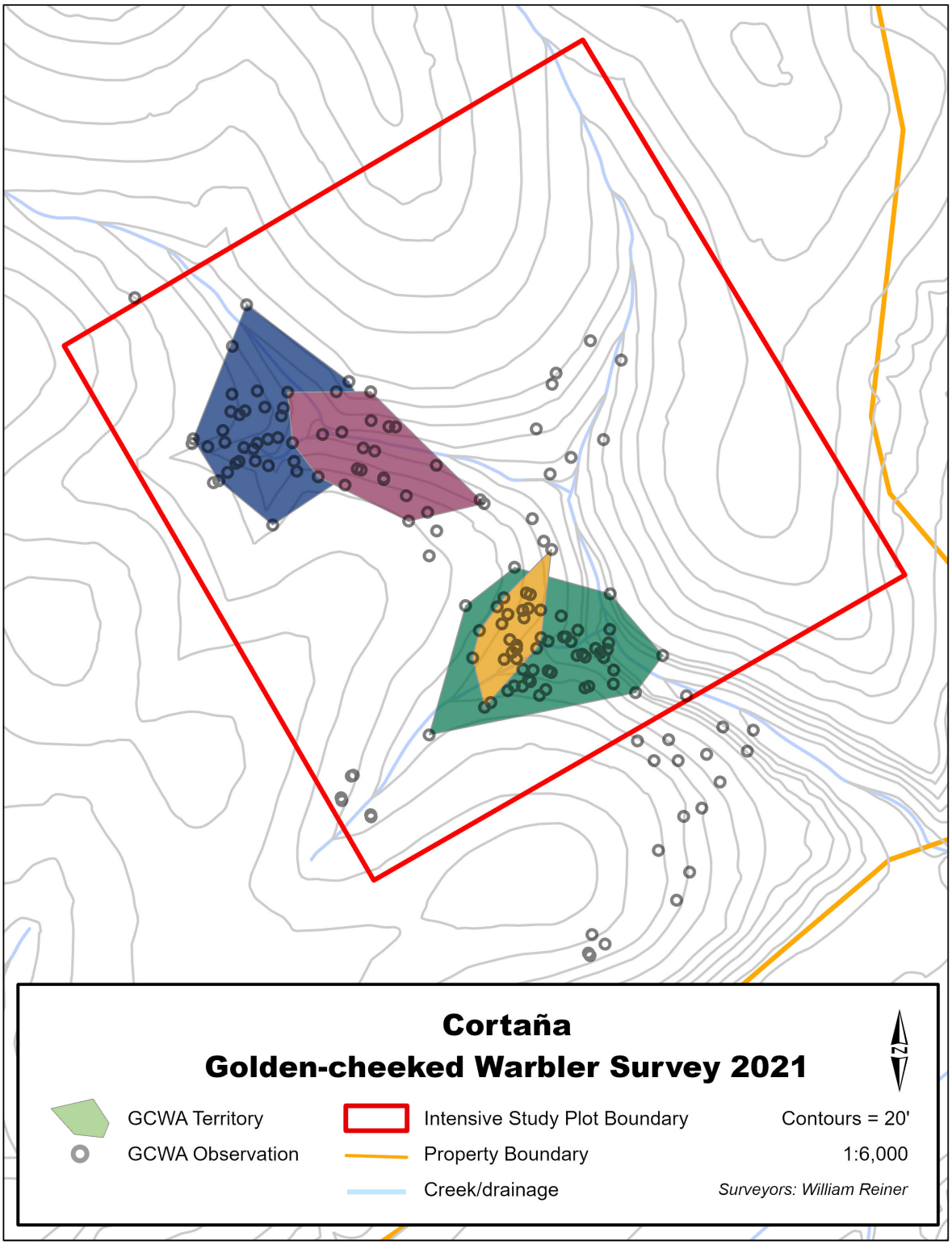

Figure 6

Exhibit B: Minimum Convex Polygons Representing Estimated Golden-cheeked Warbler Territory Boundaries for Intensive Monitoring Plots (Figures 2-17), 2021 (continued).

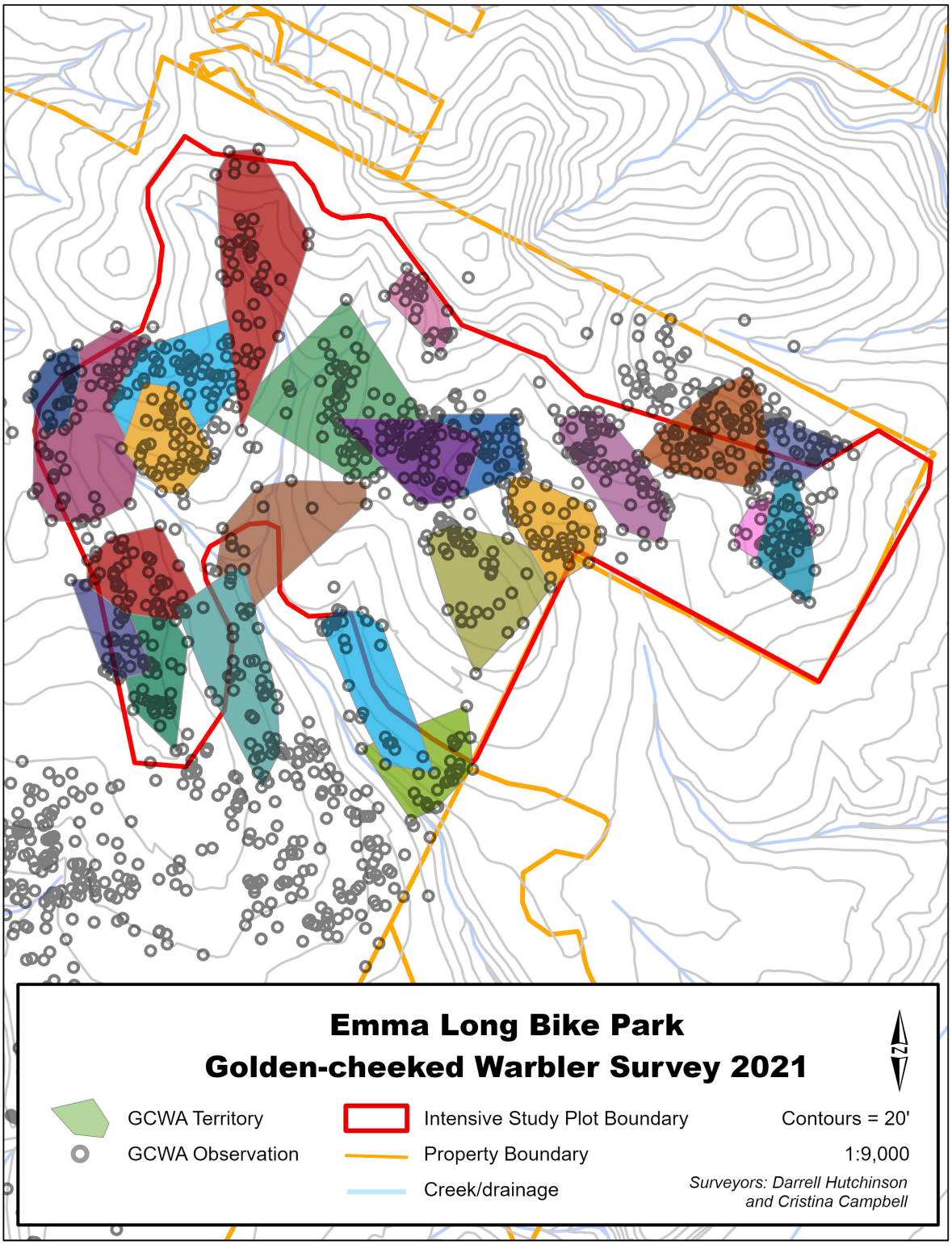

Figure 7

Exhibit B: Minimum Convex Polygons Representing Estimated Golden-cheeked Warbler Territory Boundaries for Intensive Monitoring Plots (Figures 2-17), 2021 (continued).

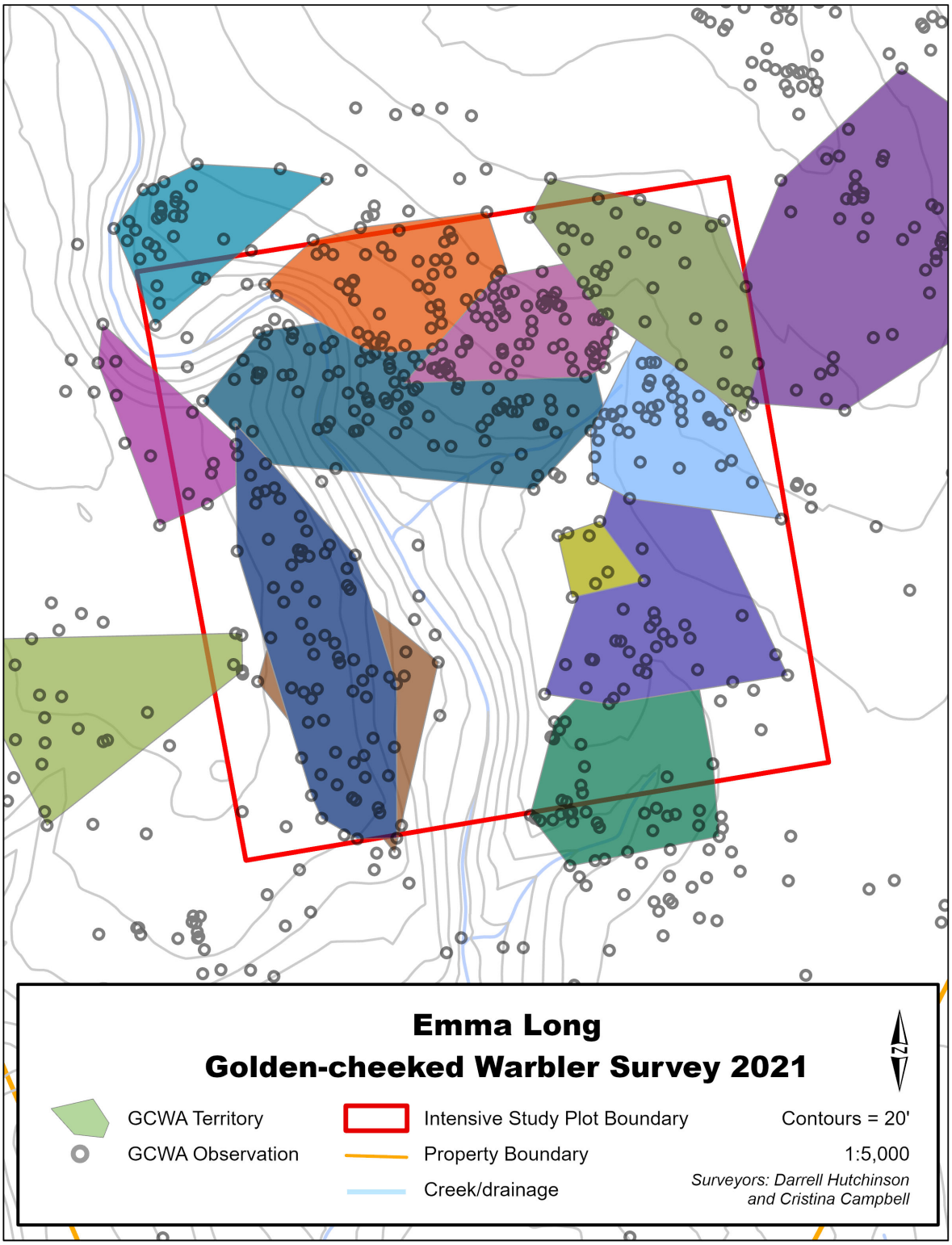

Figure 8

Exhibit B: Minimum Convex Polygons Representing Estimated Golden-cheeked Warbler Territory Boundaries for Intensive Monitoring Plots (Figures 2-17), 2021 (continued).

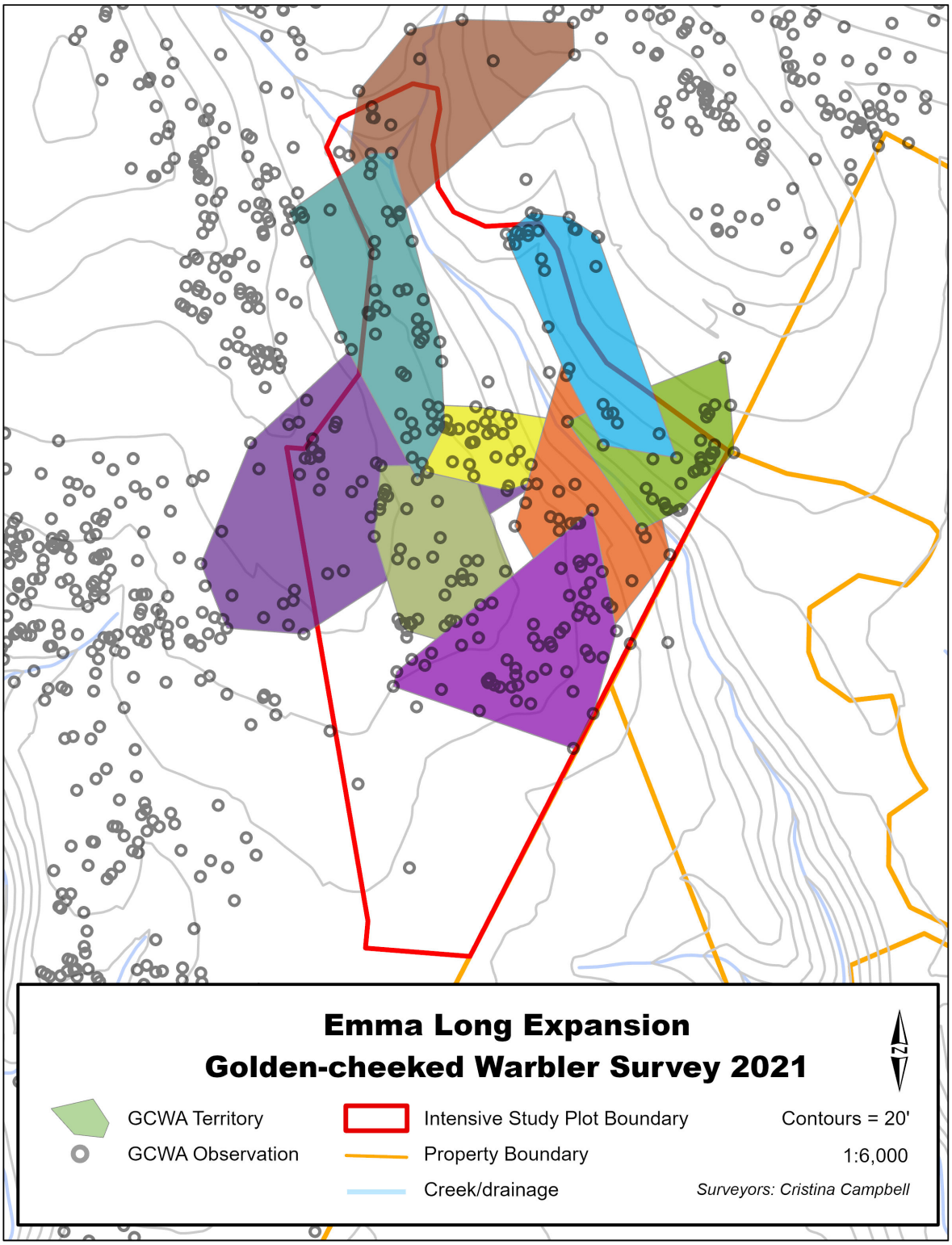

Figure 9

Exhibit B: Minimum Convex Polygons Representing Estimated Golden-cheeked Warbler Territory Boundaries for Intensive Monitoring Plots (Figures 2-17), 2021 (continued).

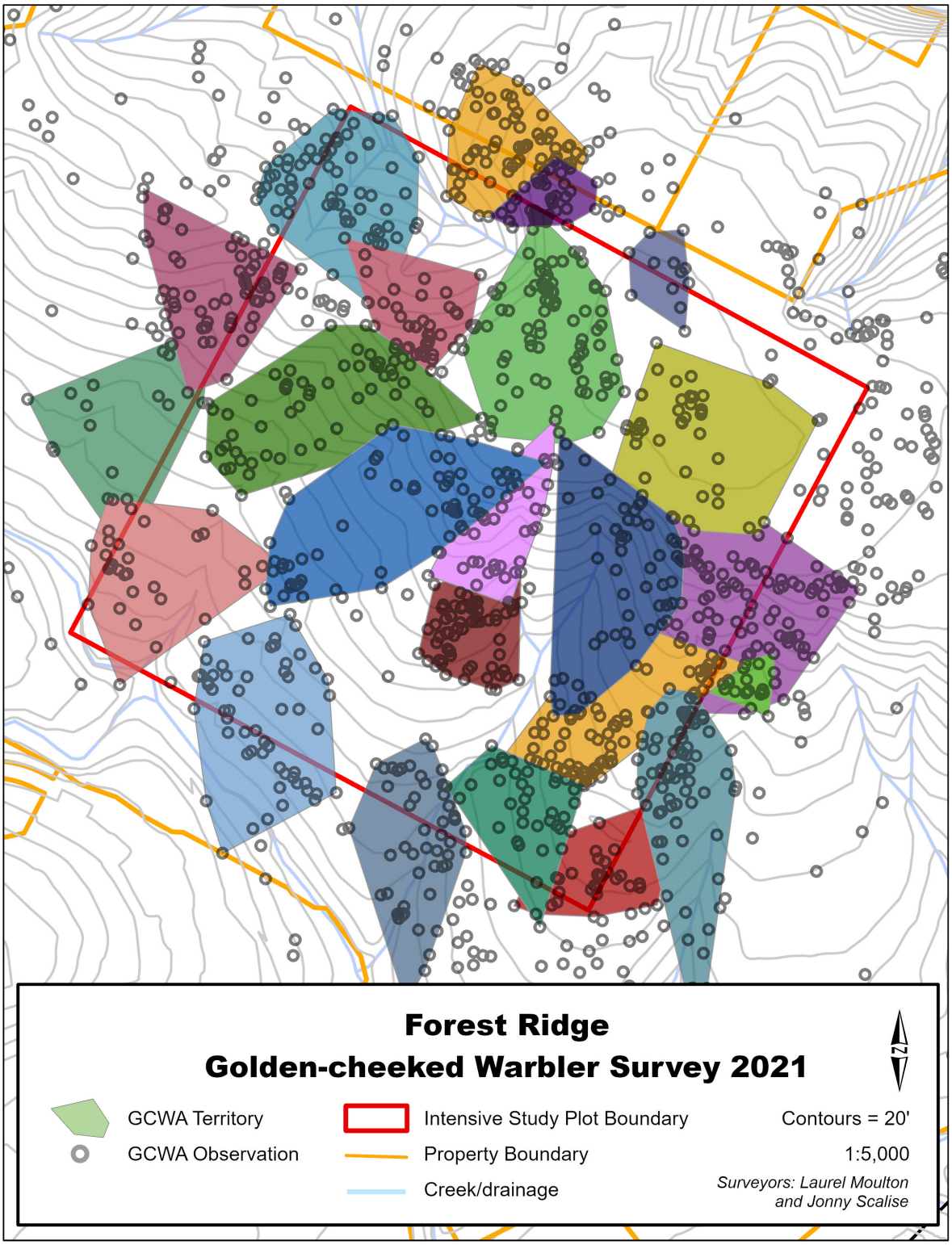

Figure 10

Exhibit B: Minimum Convex Polygons Representing Estimated Golden-cheeked Warbler Territory Boundaries for Intensive Monitoring Plots (Figures 2-17), 2021 (continued).

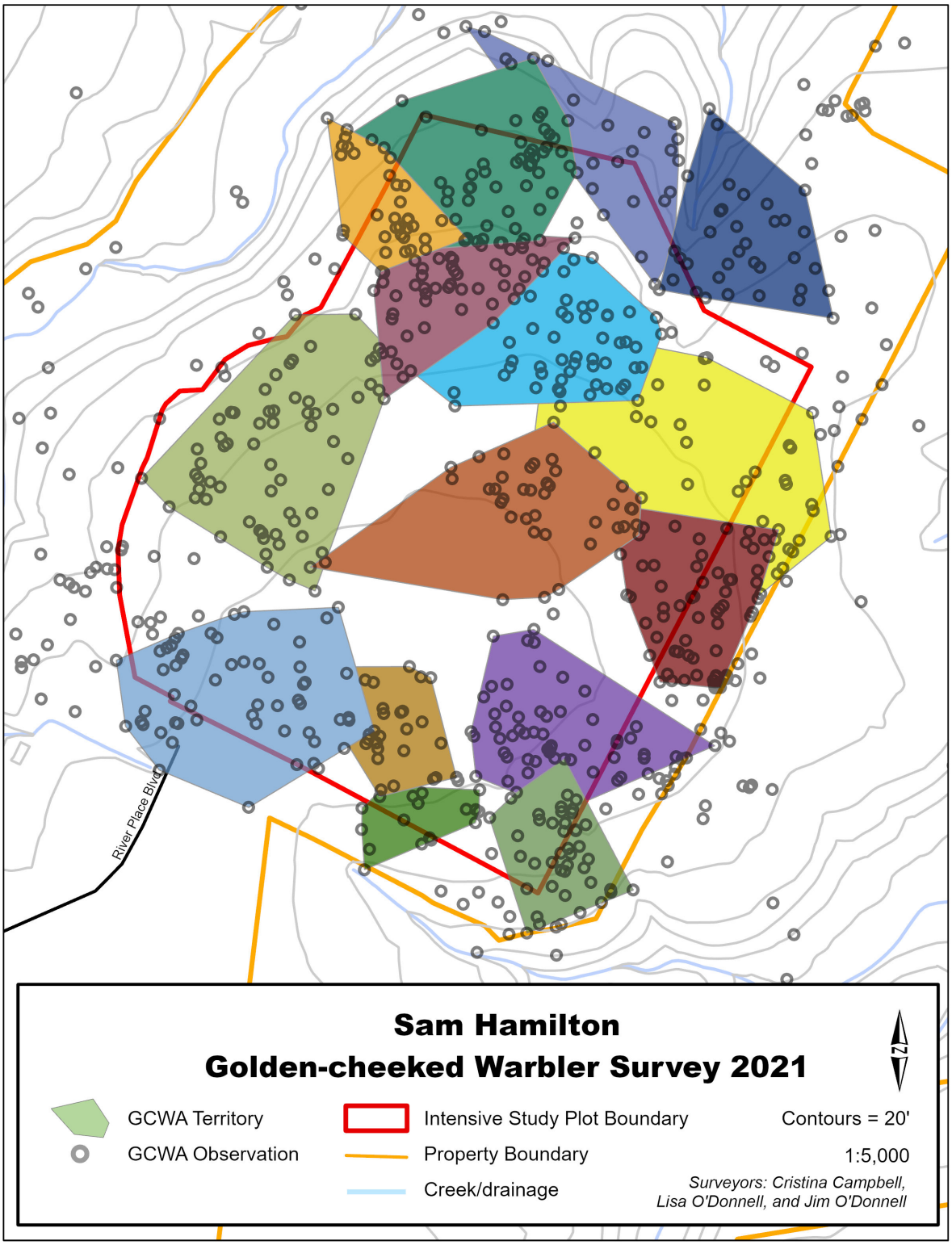

Figure 11

Exhibit B: Minimum Convex Polygons Representing Estimated Golden-cheeked Warbler Territory Boundaries for Intensive Monitoring Plots (Figures 2-17), 2021 (continued).

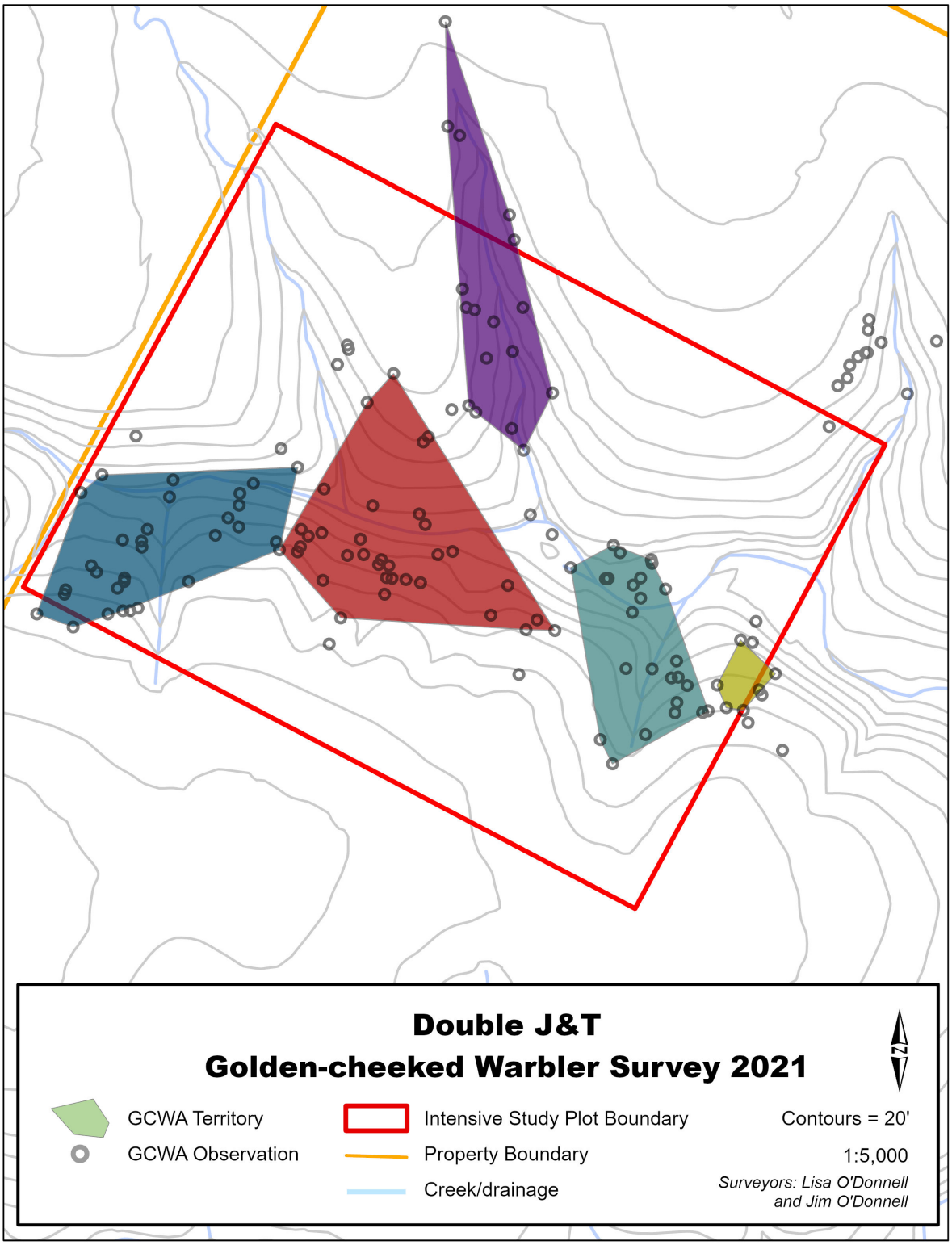

Figure 12

Exhibit B: Minimum Convex Polygons Representing Estimated Golden-cheeked Warbler Territory Boundaries for Intensive Monitoring Plots (Figures 2-17), 2021 (continued).

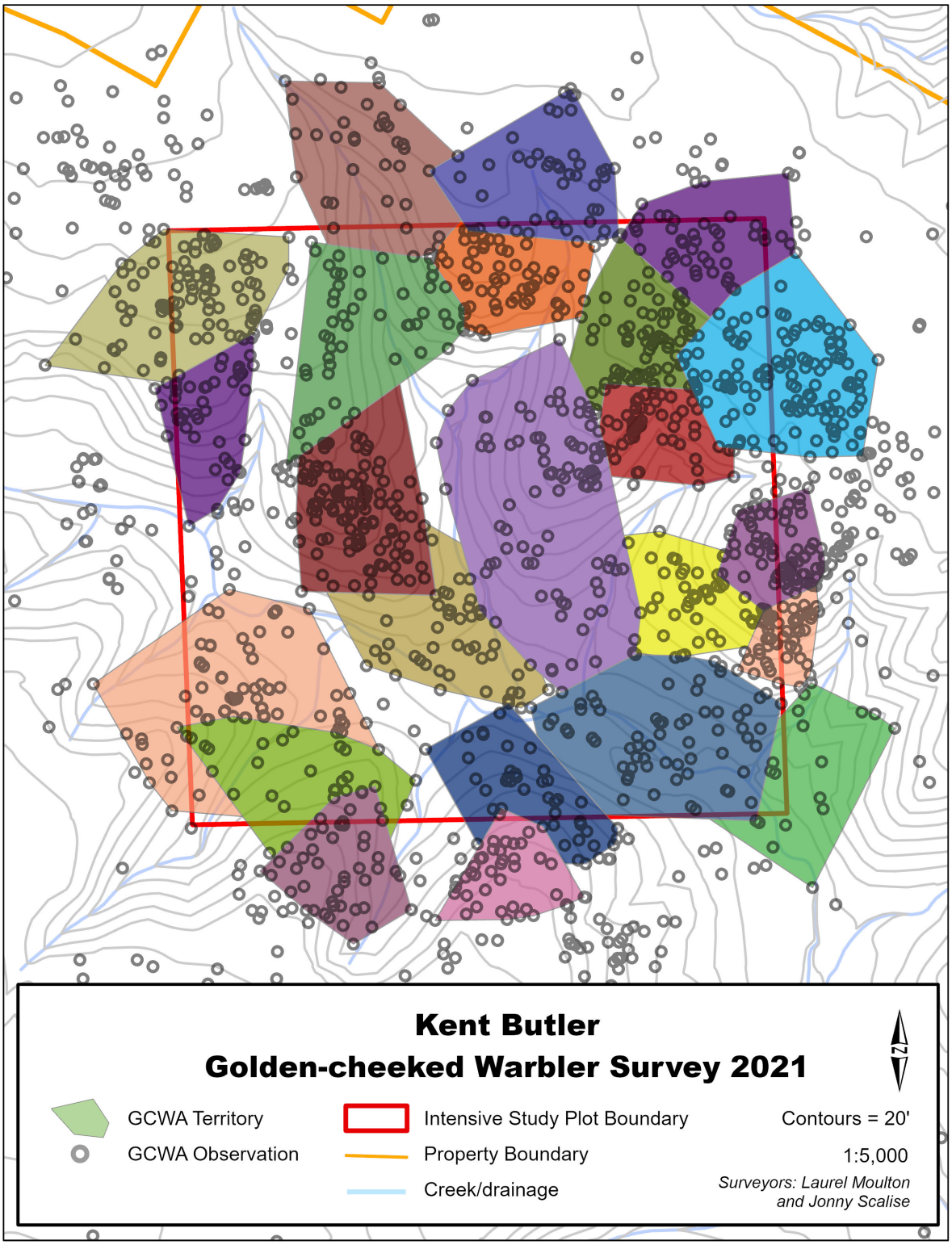

Figure 13

Exhibit B: Minimum Convex Polygons Representing Estimated Golden-cheeked Warbler Territory Boundaries for Intensive Monitoring Plots (Figures 2-17), 2021 (continued).

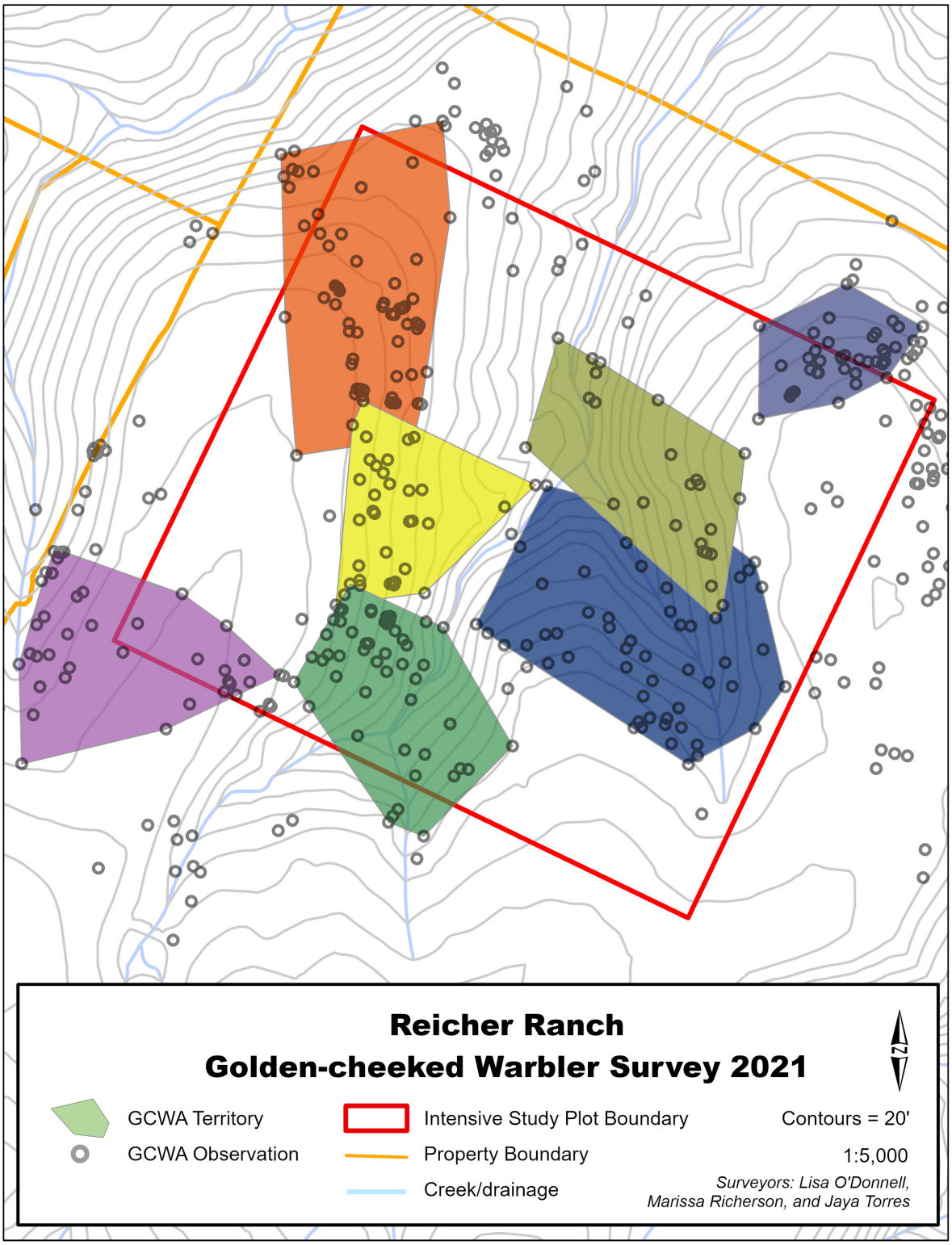

Figure 14

Exhibit B: Minimum Convex Polygons Representing Estimated Golden-cheeked Warbler Territory Boundaries for Intensive Monitoring Plots (Figures 2-17), 2021 (continued).

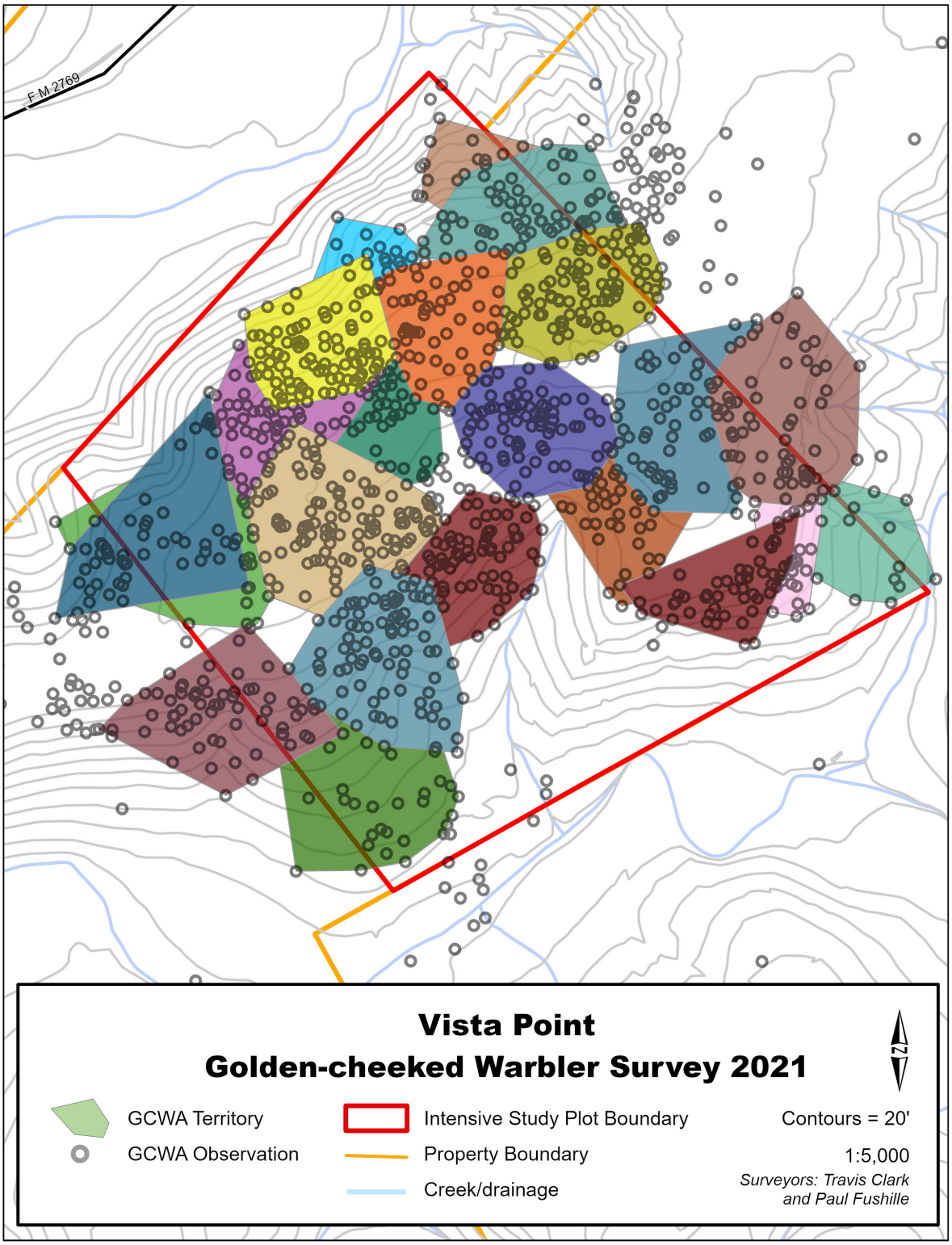

Figure 15

Exhibit B: Minimum Convex Polygons Representing Estimated Golden-cheeked Warbler Territory Boundaries for Intensive Monitoring Plots (Figures 2-17), 2021 (continued).

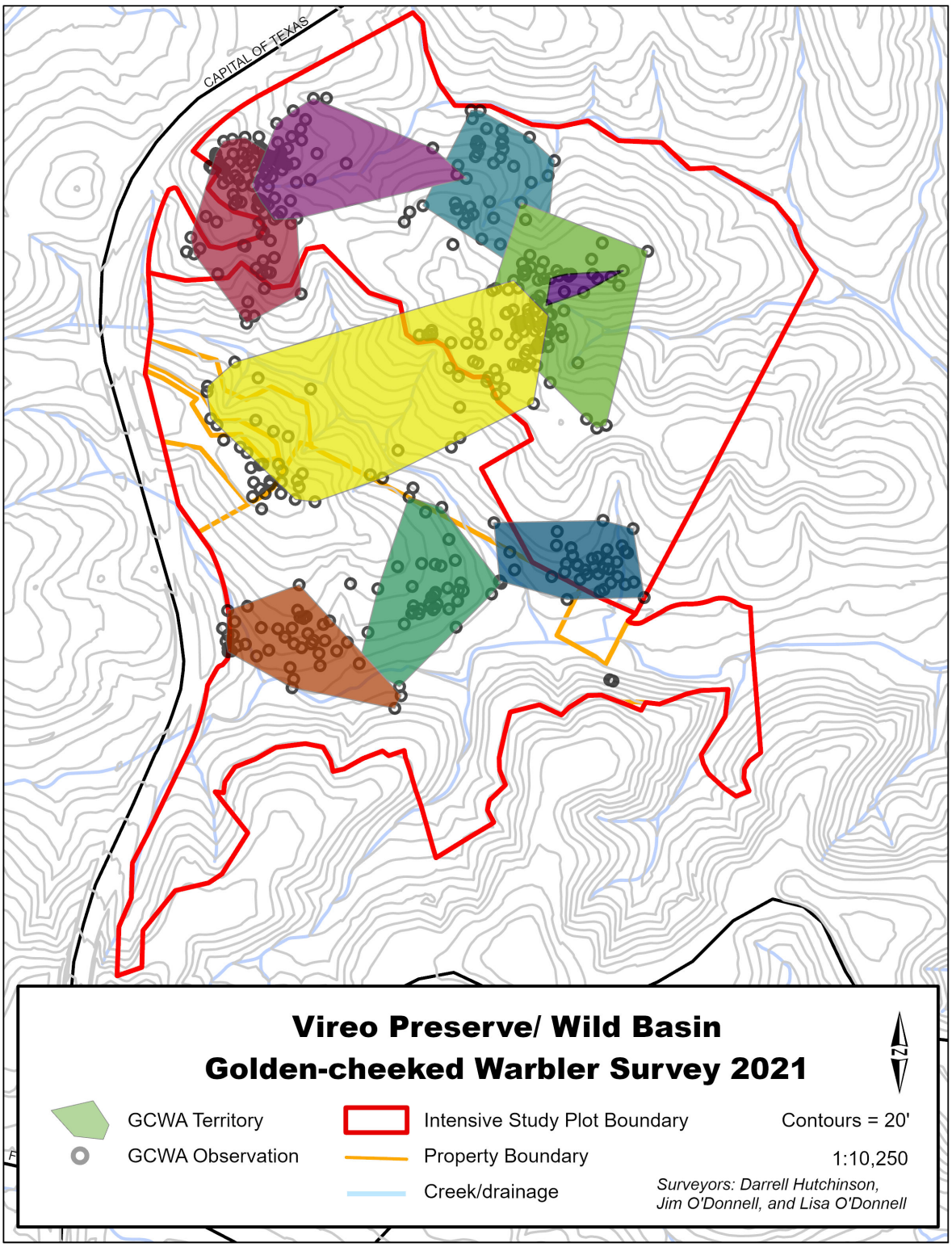

Figure 16

Exhibit B: Minimum Convex Polygons Representing Estimated Golden-cheeked Warbler Territory Boundaries for Intensive Monitoring Plots (Figures 2-17), 2021 (continued).

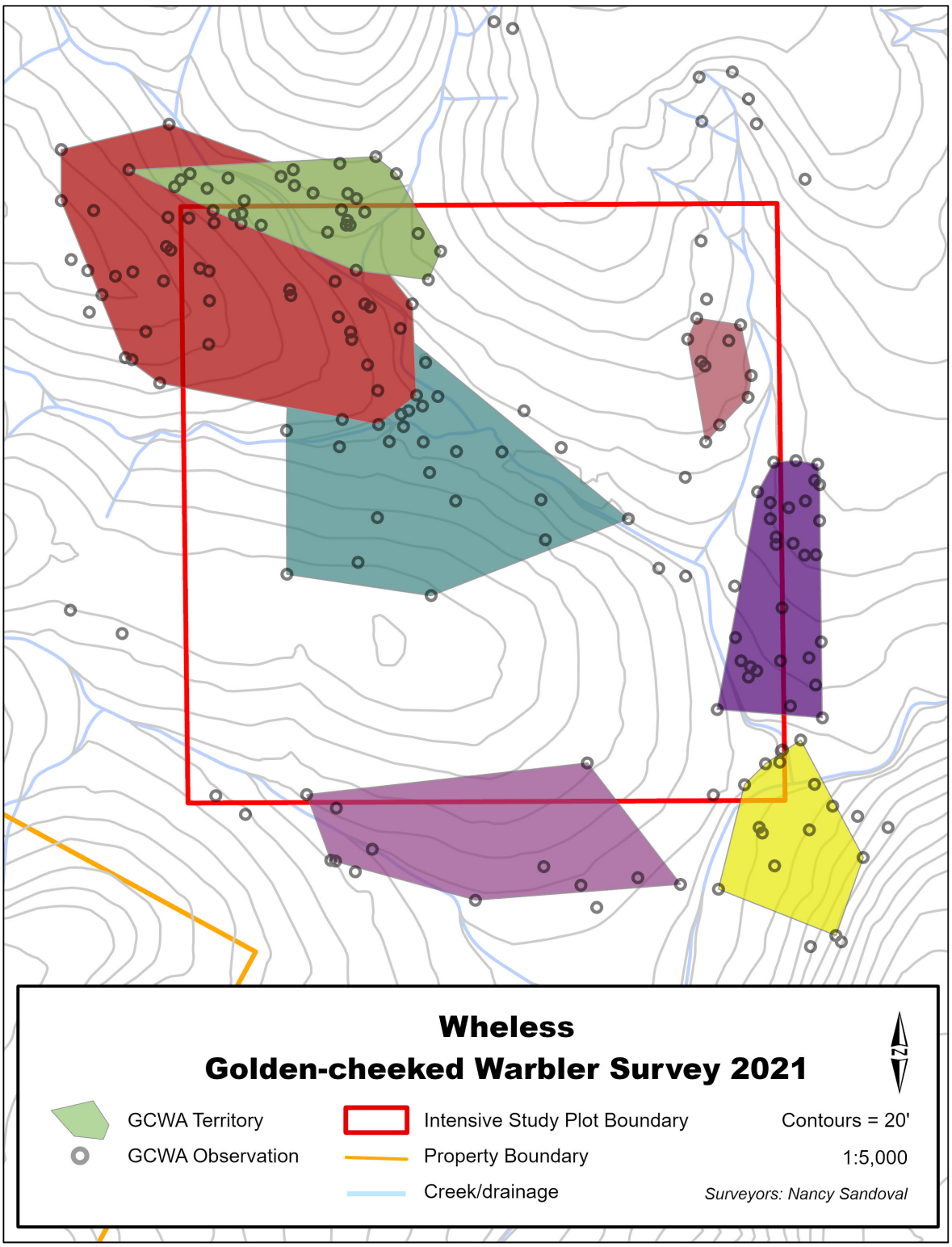

Figure 17

Exhibit C: Summary of Golden-cheeked Warbler Survey Effort on the Balcones Canyonlands Preserve, Travis County, Texas, 2021.

Intensive Monitoring Plots	Lead Surveyor(s)	Survey Hours	Area Surveyed (hectares)
Barton Creek Macrosite			
Barton Creek	William Reiner (COA)	104.25	40.5 + buffer
Barton Creek Habitat Preserve	Lisa O'Donnell, Jim O'Donnell (COA), Charlotte Reemts (TNC)	32.00	81.5
Barton West	William Reiner (COA)	91.25	47
Bull Creek Macrosite			
Forest Ridge	Jonny Scalise, Laurel Moulton (COA)	435.00	40.5 + buffer
Kent Butler	Laurel Moulton, Jonny Scalise (COA)	493.50	40.5 + buffer
Hamilton West	Cristina Campbell, Lisa O'Donnell, Jim O'Donnell, (COA)	212.00	40.5 + buffer
Cypress Creek Macrosite			
Vista Point	Travis Clark, Paul Fushille (TC)	168.5	40.5 + buffer
Wheless	Nancy Sandoval (TC)	70.00	40.5
Collins	Sam Berg, Kaitlin Lopez, David Morgan, Blake Sissel (TC)	261.00	40.5 + buffer
North Lake Austin Macrosite			
Emma Long	Darrell Hutchinson, Cristina Campbell (COA)	221.00	40.5 + buffer
Emma Long Bike Park	Darrell Hutchinson, Cristina Campbell (COA)	353.00	96
Emma Long Expansion	Cristina Campbell (COA)	117.50	34
Cortaña	William Reiner (COA)	72.50	62
South Lake Austin Macrosite			
Double J&T	Lisa O'Donnell, Jim O'Donnell (COA)	51.00	40.5 + buffer
Reicher	Lisa O'Donnell, Marissa Richerson, Jaya Torres (COA)	154.25	40.5 + buffer
West Austin Macrosite			
Vireo Preserve/Wild Basin	Darrell Hutchinson, Lisa O'Donnell, Jim O'Donnell (COA)	179.50	180
	Total	**3016.25**	**905.5 + buffers**

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

Exhibit C: Summary of Golden-cheeked Warbler Survey Effort on the Balcones Canyonlands Preserve, Travis County, Texas, 2021 (continued).

Re-sighting Plot	Surveyor(s)	Survey Hours	Area Surveyed (hectares)
Bull Creek Macrosite			
Canyon Vista	A. Lopez, K. Lopez, B. Woodward, A. Gray, J. Murray, S. Berg, J. Hull, D. Morgan, N. Sandoval, (TC)	124.50	40.5 + buffer
	Total	124.50	**40.5 + buffers**

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

Exhibit C: Summary of Golden-cheeked Warbler Survey Effort on the Balcones Canyonlands Preserve, Travis County, Texas, 2021 (continued).

Search Areas*	Survey Effort (hours)	Search Areas*	Survey Effort (hours)
3M South	46.25	Hamilton Northeast	18.00
3M Southeast	21.50	Hamilton Northwest	27.00
Barton Creek Northwest	18.50	Hamilton Southeast	40.00
Barton Creek Southeast (37.5 ha)	18.25	Interplot (33.4 ha) between Forest Ridge and former 3M plots	18.00
Barton Creek Southwest	24.50	Kent Butler East	23.50
Barton Creek Far Northwest	29.50	Kent Butler Northwest	30.25
Barton Creek Downstream	18.00	Kent Butler Southeast	12.25
Canyon Vista (25.3 ha)	45.75	Kent Butler Southwest	28.50
Carol Lee (18.4 ha)	19.00	Lime Creek North	15.50
Collins North (9.4 ha)	21.5	Lime Creek South	18.75
Collins South	18.00	Long Canyon – Leaning Rock	15.50
Emma Long South	58.00	Long Canyon – Standing Rock	15.75
Emma Long West	48.00	Reicher East (35.7 ha)	17.75
Forest Ridge Northeast	48.25	Vista Point North	21.00
Forest Ridge Northwest	18.00	Vista Point Southeast	14.00
Forest Ridge Southeast	45.25	Vista Point Southwest	13.50
Forest Ridge Southwest	18.00		

*All search areas were approximately 40.5 ha except where noted.

Exhibit D: Golden-cheeked Warbler Intensive Monitoring Plot Protocol, Balcones Canyonlands Preserve, 2021.

Objective: To provide the most accurate estimate of return rates, dispersal, and survival for the Golden-cheeked Warbler (GCWA) as possible. The most critical goals for resighting are:

1) to confirm visually the banding status (banded or unbanded) and color combination of all males within the resighting plot (and buffer, if any), and
2) to record the geographic position of all banded and unbanded GCWAs

Territory mapping is not necessary for the resighting effort. However, observers should attempt to see all of the GCWAs detected in the survey area on each visit to confirm whether each bird is banded.

Resighting Plots: These resighting protocols apply to any plot where birds have been banded but intensive territory monitoring has been terminated. Resighting surveys should continue each year until the birds banded on those plots are no longer found (estimated 3-5 years).

Survey Dates: A total of 5 weekly visits, with 4 weekly visits from approx. March 20 – April 15, and one late season visit to detect dispersing birds (approx. May 15-25).

Survey Effort: Observers should attempt to resight every male detected on a plot on each weekly visit to verify and record bands. Observers should strive to obtain at least one location for each banded/unbanded bird per visit.

Staffing: Two observers per plot averaging $\geq$10 territories. For plots with fewer territories, one observer is sufficient. Each observer will cover half (for plots averaging 10 or more territories) or the entire plot (for plots with <10 territories). 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 visit, each observer will rotate the area covered by 90° in a clockwise direction, where it is practical. This will ensure each observer covers the entire plot and begins at a different corner of the plot each week.

Survey documentation: Observers will obtain GPS locations for, and create hard copy maps of, all GCWA observations for every survey visit. 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.

Upon completion of each survey, enter each resighting that is recorded in your map/notes on the Resighting spreadsheet (accessed through Google Drive). (Observations recorded on field maps, on the Resighting spreadsheet, and in the avian database should be consistent).

Exhibit E: Summary of Golden-cheeked Warbler Territory Data for Intensive Study Plots on the Balcones Canyonlands Preserve, Travis County, Texas, Field Seasons 2009-2021. 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
	2018	2	4	3.0	0.07
	2019	3	3	3.0	0.07
	2020	2	2	2.0	0.05
	2021	2	5	3.5	0.09
Barton Creek Habitat Preserve	2017	0	2	1.0	0.01
	2018	1	2	1.5	0.02
	2019	0	2	1.0	0.01
	2020	--	--	--	--
	2021	0	2	1.0	0.01
Barton West	2019	4	7	5.5	0.12
	2020	0	2	1.0	0.02
	2021	2	4	3.0	0.06
Bull Creek Macrosite					
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
	2018	6	17	11.5	0.28
	2019	7	19	13.0	0.32
	2020	10	17	13.5	0.33
	2021	10	23	16.5	0.41
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
	2018	8	15	11.5	0.28
	2019	8	19	13.5	0.33
	2020	12	18	15.0	0.37
	2021	8	23	15.5	0.38

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

Plot Name	Survey Year	No. of Full Territories	Number of Full and Edge Territories	No. of Full Territories + 50% of Edge Territories	Territory Density per Hectare
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
	2018	4	10	7.0	0.17
	2019	3	12	7.5	0.19
	2020	6	12	9.0	0.22
	2021	5	15	10.0	0.25
Cypress Creek Macrosite					
Collins	2018	2	13	7.5	0.19
	2019	1	9	5.0	0.12
	2020	6	11	8.5	0.21
	2021	5	15	10	0.25
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
	2018	9	14	11.5	0.28
	2019	11	15	13.0	0.32
	2020	11	16	13.5	0.33
	2021	12	22	17.0	0.42
Wheless	2017	1	3	2.0	0.05
	2018	0	2	1.0	0.02
	2019	1	5	3.0	0.07
	2020	3	5	4.0	0.1
	2021	2	7	4.5	0.11
North Lake Austin Macrosite					
Cortaña	2017	4	5	4.5	0.07
	2018	2	2	2.0	0.03
	2019	4	6	5.0	0.08
	2020	3	3	3.0	0.04
	2021	4	4	4.0	0.06
Emma Long[1]	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	11	7	0.17
	2018	4	9	6.5	0.16
	2019	5	9	7.0	0.17
	2020	7	12	9.5	0.23
	2021	7	14	10.5	0.26

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

Plot Name	Survey Year	No. of Full Territories	Number of Full and Edge Territories	No. of Full Territories + 50% of Edge Territories	Territory Density per Hectare
Emma Long Bike Park	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	0.10
	2016	4	13	8.5	0.09
	2017	3	10	6.5	0.07
	2018	6	10	8.0	0.08
	2019	6	11	8.5	0.09
	2020	5	14	9.5	0.10
	2021	13	23	18.0	0.19
Emma Long Expansion[1]	2016	7	11	9.0	0.26
	2017	4	10	7.0	0.21
	2018	4	7	5.5	0.16
	2019	4	9	6.5	0.19
	2020	4	6	5.0	0.15
	2021	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
	2018	1	2	1.5	0.04
	2019	3	4	3.5	0.09
	2020	4	6	5.0	0.12
	2021	3	5	4.0	0.10
Reicher	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
	2018	2	6	4.0	0.10
	2019	3	8	5.5	0.14
	2020	3	8	5.5	0.14
	2021	3	7	5.0	0.12

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

Plot Name	Survey Year	No. of Full Territories	Number of Full and Edge Territories	No. of Full Territories + 50% of Edge Territories	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
	2018	4	4	4.0	0.02
	2019	5	5	5.0	0.03
	2020	6	6	6.0	0.03
	2021	9	9	9.0	0.05

Exhibit F: Summary of Golden-cheeked Warbler Age Structure Data for Territorial Males on Intensive Study Plots on the Balcones Canyonlands Preserve, Travis County, Texas, Field Seasons 2009-2021.

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
	2018	0	100	0	4	0	100
	2019	67	33	0	3	0	100
	2020	0	100	0	2	0	100
	2021	80	20	0	5	0	100
Barton Creek Habitat Preserve	2017	100	0	0	1	1	50
	2018	100	0	0	2	0	100
	2019	100	0	0	2	0	100
	2020	--	--	--	--	--	--
	2021	50	50	0	2	0	100
Barton West	2019	50	50	0	6	1	86
	2020	0	100	0	1	1	50
	2021	50	50	0	4	0	100
Bull Creek Macrosite							
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
	2018	14	86	0	14	3	82
	2019	50	50	0	16	3	84
	2020	43	57	0	14	3	82
	2021	47	53	0	17	6	74
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
	2018	70	30	0	10	5	67
	2019	50	50	0	14	5	74
	2020	86	14	0	14	4	78
	2021	35	65	0	17	6	74

Exhibit F: 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
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
	2018	0	100	0	6	4	60
	2019	17	83	0	6	6	50
	2020	67	33	0	6	6	50
	2021	22	78	0	9	6	60
Cypress Creek Macrosite							
Collins	2018	67	22	11	9	4	69
	2019	63	37	0	8	1	89
	2020	17	83	0	6	5	55
	2021	64	36	0	11	4	73
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
	2018	27	73	0	11	3	79
	2019	28	72	0	18	5	78
	2020	37	63	0	8	8	50
	2021	42	58	0	12	10	55
Wheless	2017	33	67	0	3	1	75
	2018	100	0	0	1	1	50
	2019	33	67	0	3	2	60
	2020	0	100	0	1	4	20
	2021	25	75	0	4	3	57
North Lake Austin Macrosite							
Cortaña	2017	20	80	0	5	0	100
	2018	0	100	0	2	0	100
	2019	67	33	0	6	0	100
	2020	67	33	0	3	0	100
	2021						100
Emma Long[1]	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	10	90	0	10	1	91
	2018	25	75	0	8	1	89
	2019	25	75	0	8	1	89
	2020	44	56	0	9	3	75
	2021	20	80	0	10	4	71

Exhibit F: 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
Emma Long Bike Park[1]	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
	2018	71	29	0	7	3	70
	2019	67	33	0	9	2	82
	2020	50	50	0	10	4	71
	2021	53	47	0	19	4	83
Emma Long Expansion[1]	2016	17	66	17	6	5	55
	2017	13	88	0	8	2	80
	2018	0	100	0	6	1	86
	2019	25	75	0	8	1	89
	2020	25	75	0	4	2	67
	2021	29	71	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
	2018	50	50	0	2	0	100
	2019	67	33	0	3	1	75
	2020	100	0	0	5	1	83
	2021	20	80	0	5	0	100
Reicher	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
	2018	20	80	0	5	1	83
	2019	43	57	0	7	1	88
	2020	0	100	0	6	2	75
	2021	14	86	0	7	0	100

Exhibit F: 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
	2018	67	33	0	3	1	75
	2019	60	40	0	5	0	100
	2020	0	100	0	1	5	17
	2021	100	0	0	7	2	78

Exhibit G: 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 2009-2021. 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
	2018	100	50	5 / 6.6	0.10 / 0.12
	2019	33	0	0	0
	2020	100	100	5 / 7.2	0.12 / 0.18
	2021	80	20	2 / 3.6	0.05 / 0.09
Barton Creek Habitat Preserve	2017	0	0	0	0
	2018	100	0	0	0
	2019	100	0	0	0
	2020	--	--	--	--
	2021	100	100	2 / 7.2	0.02 / 0.04
Barton West	2019	83	50	7.5 / 9	0.16 / 0.19
	2020	100	50	2 / 3.6	0.02 / 0.04
	2021	75	50	2 / 7.2	0.03 / 0.11
Bull Creek Macrosite					
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
	2018	100	71	29 / 41	0.54 / 0.73
	2019	100	68	28 / 44.6	0.52 / 0.82
	2020	100	100	33 / 47.6	0.68 / 0.95
	2021	100	78	44 / 62.4	0.86 / 1.19
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
	2018	100	67	26 / 37	0.51 / 0.73
	2019	84	47	22 / 33.6	0.37 / 0.55
	2020	100	88	35 / 45.8	0.73 / 0.91
	2021	91	78	53 / 65.8	0.85 / 1.08

Exhibit G: 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
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
	2018	100	80	25 / 27	0.44 / 0.48
	2019	100	45	12 / 16.4	0.21 / 0.29
	2020	90	67	20 / 28.8	0.35 / 0.49
	2021	100	47	18 / 25.6	0.31 / 0.45
Cypress Creek Macrosite					
Collins	2018	92	31	12 / 15	0.20 / 0.24
	2019	89	78	18 / 25.6	0.22 / 0.32
	2020	73	73	19 / 28.8	0.31 / 0.49
	2021	87	53	22 / 27.6	0.35 / 0.43
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
	2018	79	79	39 / 39	0.79 / 0.79
	2019	73	60	28 / 33.4	0.57 / 0.68
	2020	81	31	17 / 19.2	0.31 / 0.34
	2021	95	59	31 / 44.6	0.53 / 0.80
Wheless	2017	75	75	12 / 12	0.15 / 0.15
	2018	100	100	8 / 8	0.10 / 0.10
	2019	100	60	11 / 11	0.19 / 0.19
	2020	100	100	18 / 19.2	0.37 / 0.39
	2021	100	86	20 / 23.2	0.32 / 0.38
North Lake Austin Macrosite					
Cortaña	2017	80	40	5 / 7	0.08 / 0.11
	2018	100	100	5 / 7.6	0.08 / 0.12
	2019	50	33	7 / 7.6	0.11 / 0.12
	2020	100	100	6 / 10.8	0.10 / 0.17
	2021	75	50	6 / 7.2	0.10 / 0.12
Emma Long[1]	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	90	50	14 / 16.2	0.22 / 0.25
	2018	89	56	15 / 17	0.27 / 0.31
	2019	89	78	23 / 26.4	0.42 / 0.47
	2020	100	83	27 / 36.8	0.56 / 0.73
	2021	92	71	26 / 37.2	0.40 / 0.59

Exhibit G: 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
Emma Long Bike Park[1]	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
	2018	90	40	12 / 12	0.10 / 0.10
	2019	82	64	24 / 27.2	0.18 / 0.20
	2020	100	86	36 / 45.2	0.27 / 0.33
	2021	100	86	49 / 68.6	0.39 / 0.54
Emma Long Expansion[1]	2016	91	45	15 / 15.6	0.38 / 0.40
	2017	100	80	16 / 21.4	0.32 / 0.44
	2018	100	86	14 / 14	0.32 / 0.32
	2019	100	56	13 / 14.6	0.24 / 0.26
	2020	100	83	10 / 17.4	0.25 / 0.46
	2021	100	67	15 / 22.0	0.29 / 0.43
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
	2018	100	50	3 / 4	0.07 / 0.09
	2019	50	0	0	0
	2020	100	33	6 / 7.2	0.11 / 0.13
	2021	100	100	13 / 18.8	0.25 / 0.37
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
	2018	83	67	11 / 15	0.20 / 0.27
	2019	88	88	18 / 26	0.30 / 0.45
	2020	100	50	10 / 14.4	0.15 / 0.22
	2021	100	86	15 / 22.0	0.28 / 0.41

Exhibit G: 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	2011	73	45	9 / 18	0.05 / 0.10
	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
	2018	75	75	6 / 11	0.03 / 0.06
	2019	80	20	3 / 3.6	0.02 / 0.02
	2020	100	67	9 / 14.4	0.05 / 0.08
	2021	78	33	12 / 12.0	0.07 / 0.07