2012 Annual Report:
Golden-cheeked Warbler *(Setophaga chrysoparia)*
Monitoring Program
Balcones Canyonlands Preserve



After Second-Year Golden-cheeked Warbler Male



Newly Fledged Golden-cheeked Warbler

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2012 Golden-cheeked Warbler Monitoring Program
Balcones Canyonlands Preserve Annual Report

This report summarizes the results of the golden-cheeked warbler (*Setophaga chrysoparia*) endangered species monitoring program for the 2012 field season. This was the fifteenth year of golden-cheeked warbler monitoring on the City of Austin's Balcones Canyonlands Preserve tracts, and the second year of a five-year agreement with the U.S. Forest Service (USFS) to develop models to better understand factors influencing the long-term viability of the warbler and its habitat and to predict the fate of both under various management scenarios within the BCP. This collaborative project includes the USFS, University of Missouri, City of Austin, Travis County, BCP managing partners (Lower Colorado River Authority, St. Edwards University/Wild Basin, Travis Audubon Society, The Nature Conservancy), Baylor University, and a team of volunteers all playing key roles and contributing data. Further, this project will build on existing monitoring and research, including previous warbler survey data and work being conducted by Baylor University to estimate woodland stand age, successional pathways, and fire histories within the BCP. This research will provide a foundation for the models and will be used to evaluate how land use changes have affected habitat quality. Preliminary findings to date are consistent with other research that golden-cheeked warblers depend on large blocks of closed canopy Ashe juniper-oak woodlands with a healthy understory. Development of the population and habitat suitability models will commence following the third year of the USFS project (2013 field season).

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INTRODUCTION

Background

The golden-cheeked warbler (warbler) is a neotropical migrant passerine that breeds only in central Texas where mature Ashe juniper-oak (*Juniperus ashei* - *Quercus* spp.) habitat occurs (Ladd and Gass 1999). Due to accelerating loss of breeding habitat over the past several decades, this species was listed as federally endangered by the U.S. Fish and Wildlife Service in 1990 (USFWS 1990). The Balcones Canyonlands Preserve (BCP) was established in 1996 in part to mitigate for continual loss of warbler breeding habitat in western Travis County and to aid in the species' local recovery (USFWS 1996). The BCP consists of over 12,300 hectares that are 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.

The primary goal of the BCP is to protect and enhance the habitat of endangered and rare species as mitigation for development in western Travis County (USFWS 1996). The BCP is critical to the survival and recovery of the warbler; warbler habitat in western Travis County is widely considered to be the highest quality and least fragmented of any county within this species' limited breeding range. The BCP protects about 25 to 30 percent of the warbler's habitat in Travis County. To mitigate for the loss of the remaining habitat, management of the BCP must promote habitat sustainability, regeneration, and restoration to support a viable breeding population.

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

Objectives

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

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

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

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

2012 field season continued the collaborative effort initiated in 2011 to collect data on fecundity, recruitment, dispersal, abundance, and survival on both previously established 40.5-hectare monitoring plots and newly created intensive study areas that span the range of canopy cover and woodland stand age in which the warbler breeds on the BCP. BCP staff, managing partners, and volunteers also worked to refine and implement monitoring protocols to ensure the information collected can be utilized in the modeling project. Additionally, USFS are continuing efforts to refine a point count methodology to provide reliable estimates of warbler density and abundance across the BCP. Existing species and habitat monitoring protocols will continue to be evaluated and revised as necessary to ensure data collection is adequate for development of the viability models.

METHODS

A detailed description of the demographic methods used during the 2012 field season is described in Reidy and Thompson (2010). The methods closely followed the protocols outlined in the Tier IIA-7 land management plan guidelines (BCP 2007), but required intensive territory monitoring, including more frequent surveys for territory delineations, and nest searching and monitoring. Population and productivity trends of color-banded individuals were tracked on a series of intensive study plots (including 40.5-hectare plots and larger study areas). BCP partners collected data on territory density, territory size and location, age structure, pairing success, breeding success, and productivity for each intensive study plot. BCP staff and volunteers also made a concerted effort to search for color-banded warblers outside of the intensive study areas to gather data on site fidelity and dispersal. Nests were located and monitored throughout the field season, and vegetation measurements were collected at each nest site at the end of the field season.

Point Counts

To estimate warbler density and abundance across the BCP, USFS staff conducted a second year of point count surveys and vegetation surveys at each point on a 250-meter grid of points. Surveys were conducted from mid-April through mid-May in favorable weather (>50°, <12 mph winds, no or light precipitation) from sunrise to 1100. A preliminary report of the 2011 survey results is provided in Appendix H.

Intensive Study Plots

During field season 2012, an effort was made to intensively monitor as much of the BCP as possible given staff and resource limitations, to include previously established study sites, and to capture a diversity of habitats across the BCP. Warbler territories were mapped on 18 intensive study plots, including 12 40.5 hectare plots and six plots ranging from 64 to 180 hectares in size (Table 1, Appendix A), and totaling about 1,080 hectares. Intensive study plots were located within six of the seven BCP macrosites (all but the Pedernales macrosite). The Motocross Park (Bike Park) in Emma Long Metropolitan Park and the Coldwater tract in the North Lake Austin macrosite were included in the intensive monitoring sites to continue the pilot study initiated in 2010 to further evaluate the effects of recreation. In addition, a 100-meter buffer was established around each of the 40.5-hectare study plots (where access was permitted) to expand the search area for color-banded warblers and obtain additional

information on return rates, dispersal, and territory size and configuration. While staff limitations prevented inclusion of the Bohls, Canyon Creek, and Ribelin plots in the intensive monitoring effort, BCP staff and volunteers conducted cursory surveys to resight color-banded warblers on Bohls and Canyon Creek, and Travis County staff continued to monitor the Ribelin plot. In addition, volunteers surveyed areas outside the intensive study plots and 100-meter buffers to obtain additional information on return rates and dispersal.

The intensive monitoring plots covered about nine percent of the existing BCP. Including the 100-meter buffers around each 40.5-ha plot (where access was allowed) and additional areas surveyed by volunteers to search for color-banded warblers, surveys for this project covered about 20 percent of the BCP in 2012.

Table 1. Intensive study plots for each macrosite within the Balcones Canyonlands Preserve, Travis County, Texas, field season 2012.

Plot Name, Ownership, and Size (hectares)*	Barton Creek Macrosite	Bull Creek Macrosite	Cypress Creek Macrosite	No. Lake Austin Macrosite	So. Lake Austin Macrosite	West Austin Macrosite
Barton Creek (COA)	40.5					
Gus Fruh (COA)	85					
Sunset Valley (COA)	63.5					
3M/St. Edwards (COA)		40.5				
Canyon Vista (TC)		40.5				
Forest Ridge (COA)		40.5				
Butler (COA)		40.5				
Hamilton West (COA)		40.5				
Baker Sanctuary (Travis Audubon)			40.5			
Lake Perspectives/ McGregor (LCRA, TC)			40.5			
Vireo Ridge (TC)			59.0			
Vista Point (TC)			40.5			
Bike Park (COA)				99		
Coldwater (COA)				107		
Emma Long (COA)				40.5		
JJ&T COA)					40.5	
Reicher (COA)					40.5	
Wild Basin/Vireo Preserve (COA, Wild Basin, St. Edwards, TC)						180
Total Acreage Owned (as of 6/30/2011)	2,470	2,033	3,511	2,177	1,643	193
% of macrosite intensively surveyed*	~8%	~10%	~5%	~11%	~5%	~93%

* Does not include the 100-m buffers around the study plots (approx. 30 ha for each of the 12 40.5-ha plots, where access was allowed, totaling about 360 ha), resighting on the Canyon Creek, Bohls, and Ribelin 40.5-ha plots (121.5 ha), or the resighting areas beyond the buffers (about 1013 ha, see Appendix B).

Site Description

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

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

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

In selecting the intensive study plot locations, an effort was made to represent a diversity of habitat types across the BCP, including vegetation types (i.e., evergreen, deciduous, and mixed evergreen-deciduous forests), stand ages, slope and aspect, habitat patch sizes, proximity to urban development, and land management activities. Resources used included aerial photos, preliminary stand age maps produced by Baylor University, and mapped vegetation types from Phase 1 of the Texas Ecological Systems Classification (http://morap.missouri.edu/Projects.aspx?ProjectId=57).

Golden-cheeked Warbler Monitoring on Intensive Study Plots

Color Banding

Color banding was conducted in conjunction with territory mapping on all of the 18 intensive study plots, from March 12 through May 19. 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, GPS coordinates of the banding location, temperature, and weather

conditions. Individuals were sexed and aged (second-year (SY), after second-year (ASY), after hatch-year (AHY)) according to Pyle (1997)), using data sheets developed by Ft. Hood staff. Each warbler was photographed just prior to release to document band combinations.

Territory Delineation and Density. Surveys on each intensive plot were conducted at least twice a week from mid-March through mid-June to delineate territories (dates used: March 15-May 25) and gather data on reproductive success (entire season, from March 15-June 15). 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. Due to the low densities of warblers, Barton Creek, Gus Fruh, and Sunset Valley plots were surveyed by one biologist. Appendix B lists the number of lead surveyors and survey hours for each intensive study plot.

To delineate territory size and configuration as accurately as possible, an effort was made to obtain at least 33 locations for each male from March 15 through May 25. Observations after May 25 were recorded, but were used to determine productivity and not to delineate territory boundaries. Males were considered territorial if they were observed in the same area on three different days spread at least a week apart 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 9 to 30 feet. Other sightings were recorded on topographic maps, using a 100-meter Universal Transverse Mercator (UTM) grid. Date, color combination (for observations of banded birds), UTM coordinates, and presence of female, nest, and/or fledglings were recorded for each observation. The data were then entered into ArcGIS and displayed so that territories could be delineated. Territorial boundaries for each male were delineated using minimum convex polygons in ArcGIS.

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

Territory density is given as the number of territories (using Verner's counting method) per hectare. These calculations have previously been applied to the original City of Austin 40.5-ha plots. To allow for

comparison with previous years, a summary of these data for the original 40.5-ha plots are provided in Appendix D.

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

Age Structure. To calculate age structure for each study plot, the number of territorial SY males was divided by the total number of territorial males with a known age. The percentage of ASY and AHY males was also estimated for each plot. A summary of the 2009-2012 age structure data for the original City of Austin 40.5-ha plots is provided in Appendix E.

Return Rate. Return rates were based on the number of males color-banded in 2009 through 2011 that were observed again in 2012, divided by the total number banded within and near the plots from 2009 through 2011. Return rates were derived for the entire banding and resighting dataset and for each study plot. Summary data for the original City of Austin 40.5-ha plots are presented in Appendix F.

Pairing and Reproductive Success. For field season 2012, mated status and reproductive success are reported for both full and edge territories. However, to allow for comparison with previous years, a summary of the data for full territories only is presented for the original City of Austin 40.5-ha plots in Appendix G. Territories for which mated status and reproductive success were undetermined are not included in the analyses for these parameters.

A male was determined to be paired if he was observed associating with a female, observed tending young, or a nest was located for that male. Pairing success is the number of males determined to have paired with a female divided by the total number of territories. A territory was considered to have had breeding success if the male or female was observed tending one or more fledglings. Breeding success is the number of territories determined to have produced at least one fledgling divided by the total number of territories. Reproductive success is presented as the observed and adjusted number of fledglings (described below) for each plot and per hectare. To allow for comparison with previous years, productivity is also presented as the sum of all fledglings divided by the total number of territories. Appendix G presents productivity for full territories in the original City of Austin 40.5-hectare plots as the sum of all fledglings divided by the number of pairs that successfully bred (as defined above), and as the sum of all fledglings divided by the total number of territories.

Breeding success, productivity, and fecundity are generally believed to represent minimum estimates only because nests and fledglings are difficult to locate. Females and males often split their broods and can travel long distances from nests shortly after their young have fledged. In addition, young are often difficult to detect unless they are vocalizing. Reidy *et al.* (2008) has documented a mean number of 3.6

young fledged per successful nest in the Bull Creek and North Lake Austin macrosites. This estimate was applied to those territories where the number of fledglings was uncertain to obtain adjusted estimates of the number of young produced and productivity estimates. Since the estimate of 3.6 young fledged per nest may be high for some habitat patches, the actual number of fledglings is likely somewhere between the observed and adjusted values.

Nest monitoring. Biologists located nests from mid-March through mid-June while working within and near the study plots. UTM coordinates were recorded for each nest location using Garmin GPS units, and flagging was placed at least three meters from the nest to mark its location. Staff monitored each nest every few days to determine its fate and number of fledglings produced. If nest fate was not observed directly, a nest within a banded male's territory was assumed to have been successful only if that male was observed tending young shortly after the anticipated fledging date. Otherwise, the fate of the nest was recorded as unknown.

As part of a separate and ongoing study of nest success and nest predation within the BCP, Jennifer Reidy placed miniature video cameras on a subset of active nests found. Methodology for the camera monitoring is described in Reidy (2007) and Reidy *et al.* (2008).

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

Surveys for Banded Warblers Outside Intensive Study Plots

Surveys were conducted to search for and identify color-banded warblers in areas outside of the intensive study areas (plots plus buffers). Twenty-two teams of 31 volunteers conducted surveys on approximately 1,013 hectares. For each survey, observers were directed to allow approximately six hours per visit for each 40.5 hectares of habitat for a minimum of three visits. The list of properties where surveys were conducted, total area surveyed, and the survey effort for each tract are reported in Appendix B.

Pilot Study to Further Examine Effects of Recreation

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

warblers, direct observations of warbler encounters with mountain bikers documented a flushing response of over 20 meters.

To document both temporal and spatial changes in warbler demographics, a follow-up study was initiated at the Bike Park in 2010 and continued through 2012. The control site in the Davis *et al.* study included the Forest Ridge 40.5-ha plot. The Coldwater tract was added as another control site in 2010. The Bike Park has a high trail density, is composed of open and closed-canopy trails, and allows the use of both mountain bikes and motorized dirt bikes during the warbler breeding season. The Bike Park is on the east side of City Park Road, northeast of the Emma Long intensive study plot. The Coldwater tract lies to the north of Emma Long Metropolitan Park. It contains Ashe juniper-oak woodlands as well as open areas with bare ground and shrubby growth that are currently not suitable warbler habitat. While there is no public access to the Coldwater tract, some closed-canopy trails and abandoned open-canopy ranch roads exist.

Warblers were color banded to determine territory size and configuration, pairing success, breeding success, and nest success, consistent with the Davis *et al.* 2010 study and following the methods employed on other intensive monitoring plots. Additionally, point counts surveys were conducted across the Bike Park and Coldwater for all bird species in both years to help evaluate survey methods and provide comparative data on the bird community on each tract. These data will be incorporated into the models to assess warbler population viability and habitat suitability across the BCP. Preliminary results for the Bike Park and Coldwater (2010, 2011) are presented in Appendix H. Major limitations of the pilot study include small sample sizes (low numbers of warblers) and lack of quantitative data on recreational activities (including number of recreational users per day, type(s) of activities, pathways taken through the BCP tracts, etc.).

RESULTS AND DISCUSSION

Intensive Study Plots

Territory Densities and Locations. A total of 235 territories were identified in field season 2012, including 183 full + 0.5 edge territories for all 18 intensive study plots (an average estimated density of 0.17 territories per hectare for the combined 1,080-ha study plots, ranging from 0 to 0.51 territories/ha). Territory densities were highest in closed canopy woodlands of the largest habitat parches (Bull Creek and Cypress Creek macrosites), and lowest in the small habitat patches surrounded by urban development, including the Gus Fruh and Sunset Valley portions of Barton Creek, and in the West Austin macrosite. Data on territory numbers and densities are presented in Table 2 for field season 2012 (summary data for the original City of Austin 40.5-ha plots for field seasons 1998-2012 are presented in Appendix D).

Table 2. Golden-cheeked warbler territory number and estimated territory density (per hectare) for each of the 18 intensive study plots on the Balcones Canyonlands Preserve, Travis County, Texas, field season 2012. See Methods section for calculations.

Plot Name	No. of Full Territories	No. of Full and Edge Territories	No. of Full Territories + (0.5 x Edge Territories)[1]	Territory Density Per Hectare[1]
Barton Creek Macrosite				
Barton Creek	2	7	4.5	0.11
Gus Fruh	0	0	0	0
Sunset Valley	0	0	0	0
Bull Creek Macrosite				
3M/St. Edwards	14	27	20.5	0.51
Canyon Vista	6	23	14.5	0.36
Forest Ridge	13	23	18	0.44
Butler	11	24	17.5	0.43
Hamilton West	6	10	8	0.20
Cypress Creek Macrosite				
Baker Sanctuary	8	12	10	0.25
Lake Perspectives/McGregor	4	10	7	0.17
Vireo Ridge	12	16	14	0.24
Vista Point	13	20	16.5	0.41
North Lake Austin Macrosite				
Coldwater	7	12	9.5	0.09
Bike Park	12	17	14.5	0.15
Emma Long	11	18	14.5	0.36
South Lake Austin Macrosite				
Double J&T	4	4	4	0.10
Reicher	2	6	4	0.10
West Austin Macrosite				
Wild Basin/Vireo Preserve	6	6	6	0.03
Total/Average	**131**	**235**	**183**	**0.17**

[1]Calculation based on Verner's counting method. All plots average 40.5 ha except for Gus Fruh (85 ha), Sunset Valley (64 ha), Bike Park (99 ha), Coldwater (107 ha), Vireo Ridge (59 ha), and Wild Basin/Vireo Preserve (180 ha).

Color Banding. A total of 104 warblers were banded in 2012, including 94 males and 10 females (Table 3). Of the 94 males, 48 percent were ASY, 48 percent were SY, and 4 percent were AHY. Of the 10 females, 50 percent were ASY, 30 percent were SY, and 20 percent were AHY.

Table 3. Number of golden-cheeked warblers banded within the Balcones Canyonlands Preserve, Travis County, Texas, field season 2012.

Plot Name	No. Males Banded in 2012			No. Females Banded in 2012			Total No. Banded, 2012
	SY	ASY	AHY	SY	ASY	AHY	
Barton Creek Macrosite							
Barton Creek	0	7	0	0	0	0	7
Gus Fruh/ Sunset Valley	--	--	--	--	--	--	--
Bull Creek Macrosite							
3M/St. Edwards	7	5	0	1	0	0	13
Canyon Vista	4	6	0	0	0	0	10
Forest Ridge	0	4	0	1	2	1	8
Butler	10	1	2	1	0	1	15
Hamilton West	3	0	1	0	0	0	4
Cypress Creek Macrosite							
Baker Sanctuary	6	3	0	0	1	0	10
Lake Perspectives/ McGregor	2	3	0	0	0	0	5
Vireo Ridge	2	5	0	0	0	0	7
Vista Point	2	4	0	0	0	0	6
North Lake Austin Macrosite							
Coldwater	0	1	1	1	0	0	3
Bike Park	5	3	0	0	0	0	8
Emma Long	1	2	0	0	0	0	3
South Lake Austin Macrosite							
Double J&T	1	1	0	0	0	0	2
Reicher	1	0	0	0	0	0	1
West Austin Macrosite							
Wild Basin/ Vireo Preserve	1	0	0	1	0	0	2
Total	**45**	**45**	**4**	**5**	**3**	**2**	**104**

Age Structure. We identified 235 territories on the 18 study plots in 2012, including 176 territorial males (75%) that were banded in 2009 through 2012, and 59 unbanded males (25%) (Table 4). Of the 176 banded males within the 18 study plots, 75 percent were ASY, 23 percent were SY, and 2 percent were AHY. Barton Creek, Forest Ridge, Emma Long, Coldwater, and Vista Point had the highest percentages of ASY males (88-100%), while Kent Butler, Baker Sanctuary, Double J&T, and Reicher had the highest percentages of SY males (50-100%). The different age structures observed among plots suggest habitat characteristics may be influencing recruitment of young territorial males, but additional data and analyses are needed to understand the significance and potential underlying mechanisms.

Table 4. Golden-cheeked warbler age structure data for all banded territorial males observed within 18 intensive study plots on the Balcones Canyonlands Preserve, Travis County, Texas, field season 2012.

Plot Name	SY Males	ASY Males	AHY Males	Total Banded Males	Total Unbanded Males	% Banded Males
Barton Creek Macrosite						
Barton Creek	0	5 (100%)	0	5	2	71
Gus Fruh/Sunset Valley	--	--	--	--	--	0
Bull Creek Macrosite						
3M/St. Edwards	6 (29%)	15 (71%)	0	21	6	78
Canyon Vista	3 (18%)	14 (82%)	0	17	6	74
Forest Ridge	0	16 (100%)	0	16	7	67
Butler	10 (53%)	8 (42%)	1 (5%)	19	5	79
Hamilton West	2 (29%)	4 (57%)	1 (14%)	7	3	70
Cypress Creek Macrosite						
Baker Sanctuary	5 (50%)	5 (50%)	0	10	2	83
Lake Perspectives/McGregor	2 (20%)	8 (80%)	0	10	0	100
Vireo Ridge	2 (15%)	11 (85%)	0	13	3	81
Vista Point	2 (12%)	15 (88%)	0	17	3	85
North Lake Austin Macrosite						
Coldwater	0	8 (89%)	1 (11%)	9	3	75
Bike Park	4 (29%)	10 (71%)	0	14	3	82
Emma Long	1 (10%)	9 (90%)	0	10	8	56
South Lake Austin Macrosite						
Double J&T	1 (100%)	0	0	1	3	25
Reicher	1 (50%)	1 (50%)	0	2	4	33
West Austin Macrosite						
Wild Basin/Vireo Preserve	1 (20%)	4 (80%)	0	5	1	83
Total	**40 (23%)**	**133 (75%)**	**3 (2%)**	**176**	**59**	**74%**

Male Return Rates. At least 57% percent of the warbler males banded in 2011 returned in 2012. The return rate for males banded in 2010 was 24 percent, and 7 percent for males banded in 2009 (Table 5). The highest return rates (70-78%) were for males banded at Wild Basin/Vireo Preserve, 3M/St. Edwards, Lake Perspectives/McGregor, and Emma Long in 2011. However, some of these males moved to other sites in 2012. The Double J&T, Reicher, Barton Creek, Hamilton West, and Baker Sanctuary plots had the lowest return rates for males banded in 2011 (0-36%), but sample sizes were small. Over 93 percent of all 122 male returns were observed on or near the same plot as in previous years. Only seven were observed more than one kilometer off plot (Table 7).

Table 5. Return rates for male golden-cheeked warblers banded in 2009-2011 within the Balcones Canyonlands Preserve, Travis County, Texas, field season 2012.

Plot Name	Males Banded 2009	2009 Male Returns in 2012	Males Banded 2010	2010 Male Returns in 2012	Males Banded 2011	2011 Male Returns in 2012	Total Male Returns in 2012
Barton Creek Macrosite							
Barton Creek	6	1 (17%)	7	1 (14%)	3	1 (33%)	3 (19%)
Gus Fruh/ Sunset Valley	--	--	--	--	--	--	--
Bull Creek Macrosite							
3M/St. Edwards	22	2 (9%)	11	1 (9%)[1]	16	12 (75%)[2]	15 (31%)
Canyon Vista	--	--	--	--	15	9 (60%)[3]	9 (60%)
Forest Ridge	16	1 (6%)	6	3 (50%)	18	10 (56%)	14 (35%)
Butler	21	3 (14%)	11	2 (18%)	10	5 (50%)	10 (24%)
Hamilton West	4	0	11	1 (9%)	11	4 (36%)	5 (19%)
Canyon Creek*	15	0	8	5 (63%)	--	--	5 (22%)
Ribelin*	--	--	6	0	--	--	0
Cypress Creek Macrosite							
Baker Sanctuary	--	--	--	--	11	4 (36%)	4 (36%)
Lake Perspectives/ McGregor	--	--	--	--	7	5 (71%)	5 (71%)
Vireo Ridge	--	--	--	--	10	5 (50%)	5 (50%)
Vista Point	--		--	--	17	11 (65%)	11 (65%)
North Lake Austin Macrosite							
Coldwater	--	--	13	4 (31%)	8	4 (50%)[4]	8 (38%)
Bike Park	--	--	8	2 (13%)[5]	12	8 (67%)[6]	10 (50%)
Emma Long	14	0	3	2 (67%)	10	7 (70%)	9 (33%)
South Lake 3Austin Macrosite							
Double J&T	1	0	3	0	2	0	0
Reicher	--	--	--	--	3	1 (33%)	1 (33%)
Bohls*	2	0	4	1 (25%)	--	--	1 (17%)
West Austin Macrosite							
Wild Basin/ Vireo Preserve	--	--	--	--	9	7 (78%)[7]	7 (78%)
Total	**101**	**7 (7%)**	**91**	**22 (24%)**	**162**	**93 (57%)**	**122 (34%)**

*Not one of the intensive study plots in 2012, but cursory surveys conducted to resight color-banded individuals. The following males returned to a different location from where they were banded: [1]one male resighted at Canyon Vista; [2]one male resighted at Reicher; [3]one male resighted at Vireo Ridge; [4]one male resighted at Ribelin; [5]one male resighted south of the Bike Park (<1 km); [6]one male resighted at Coldwater; and [7]two males resighted at Vista Point and west of Forest Ridge (see Table 7).

Female Return Rates. Females are typically more challenging to capture and observe, so the number banded each year and return rates observed in subsequent years is much lower than for males. The return rate for females banded in 2011 was 38 percent. None of the six females banded in 2009 or 2010 were observed in 2012 (Table 6).

Table 6. Return rates for female golden-cheeked warblers banded in 2009-2011 within the Balcones Canyonlands Preserve, Travis County, Texas, field season 2012.

Plot Name	Females Banded 2009	2009 Female Returns in 2012	Females Banded 2010	2010 Female Returns in 2012	Females Banded 2011	2011 Female Returns in 2012	Total Female Returns in 2012
Barton Creek Macrosite							
Barton Creek	0	0	1	0	0	0	0
Gus Fruh/ Sunset Valley	--	--	--	--	--	--	--
Bull Creek Macrosite							
3M/St. Edwards	1	0	1	0	1	1 (100%)	1 (33%)
Canyon Vista	--	--	--	--	0	0	0
Forest Ridge	0	0	1	0	1	0	0
Butler	1	0	0	0	0	0	0
Hamilton West	0	0	0	0	0	0	0
Canyon Creek*	1	0	0	0	--	--	
Ribelin*	--	--	0	0	--	--	0
Cypress Creek Macrosite							
Baker Sanctuary	--	--	--	--	2	0	0
Lake Perspectives/ McGregor	--	--	--	--	1	0	0
Vireo Ridge	--	--	--	--	0	0	0
Vista Point	--	--	--	--	1	1 (100%)	1 (100%)
North Lake Austin Macrosite							
Coldwater	--	--	0	0	0	0	0
Bike Park	--	--	0	0	0	0	0
Emma Long	0	0	0	0	2	1 (50%)	1 (50%)
South Lake Austin Macrosite							
Double J&T	0	0	0	0	0	0	0
Reicher	--	--	--	--	0	0	0
Bohls*	0	0	0	0	--	--	0
West Austin Macrosite							
Wild Basin/Vireo Preserve	--	--	--	--	0	0	0
Total	**3**	**0**	**3**	**0**	**8**	**3 (38%)**	**3 (21%)**

*Not one of the intensive study plots in 2012, but cursory surveys conducted to resight color-banded individuals.

Dispersal. Of the 125 male and female warblers banded in 2009 through 2011 and observed in 2011 (tables 5 and 6), BCP staff and volunteers documented seven dispersal events (6%) both within and among habitat patches (Table 7). Six dispersal events were of males that were aged SY in 2011 and returned to new sites in 2012, the other was a male that was aged ASY in 2011. Dispersal distances ranged from 1.2 to 16 kilometers and occurred within macrosites (2 of 7 dispersal events, ranging from 1.2 to 1.9 km) and between macrosites (5 of 7, ranging from 4.6 to 16 km). The remaining 117 color-banded warblers returning in 2012 (94%) returned to or remained within or near the same study plot, suggesting high site fidelity and low dispersal rates among adult warblers.

BCP staff surveyed both the intensive study plots and the 100-meter buffer around each study plot (where access was available). In addition, 21 teams of 31 volunteers devoted over 570 hours and covered over 1,013 hectares (Appendix B) searching for banded warblers outside of the intensive study areas. Documenting the location of returning warblers is critical to understanding survival, dispersal, and site fidelity, all of which influence the viability of the warbler populations.

Table 7. Observed dispersal events for golden-cheeked warblers banded in 2009-2011 within the Balcones Canyonlands Preserve, Travis County, Texas, field season 2012.

Plot Where Banded	Date Banded	Age When Banded	Sex	Resighting Location(s)	Approx. Dispersal Distance
3M/St. Ed	4/13/10	SY	M	Canyon Vista, 3M/St. Ed	1.9 km
3M/St. Ed	3/23/11	SY	M	Reicher	16 km
Bike Park	4/7/11	SY	M	Coldwater	1.2 km
Canyon Vista	3/24/11	SY	M	Vireo Ridge	7.7 km
Coldwater	4/27/11	SY	M	Ribelin	4.6 km
Wild Basin	4/5/11	SY	M	west of Forest Ridge plot	9.6 km
Wild Basin	3/22/11	SY	M	Vista Point	15.6 km

Pairing and Reproductive Success. In 2012, a total of 235 territories were monitored for pairing and reproductive success on the 18 intensive study plots (Table 8). The average pairing and breeding success observed for all territories with known pairing and reproductive success was 97 percent (range 83-100%) and 74 percent (range 0-100%), respectively. No females or fledglings were observed on the Gus Fruh or Sunset Valley plots, and no fledglings were observed on the Double J&T plot. For the plots where reproduction was observed, Coldwater, 3M/St. Edwards, and Canyon Vista had the lowest observed breeding success (50-57%), and Barton Creek and the Bike Park has the highest observed breeding success (100%).

At least 477 fledglings were observed in 213 territories with known reproductive success (estimates exclude 22 territories where reproduction was unknown). Applying the Reidy *et al.* (2008) estimate of 3.6 young fledged per successful nest in the Bull Creek and North Lake Austin macrosites to the number of territories where the number of fledglings was uncertain gives an adjusted total estimate of 565 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 (Butler, Forest Ridge, 3M/St. Edwards), Cypress Creek (Vista Point), and North Lake Austin (Emma Long) macrosites produced the greatest number of fledglings (1.01-1.48 observed fledglings/ha; 1.01-1.75 adjusted fledglings/ha), while study plots in smaller habitat patches (Gus Fruh, Sunset Valley, Wild Basin/Vireo Preserve) and young or more open woodlands (Double J&T) had the lowest reproductive output (0-0.04 observed fledgling/ha; 0-0.06 adjusted fledglings/ha).

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

Table 8. Golden-cheeked warbler reproductive success on 18 intensive study plots on the Balcones Canyonlands Preserve, Travis County, Texas, field season 2012. Data are based on observations for both full and edge territories. See Methods section for calculations. Territories for which pairing and reproductive success were unknown are not included in the calculations (actual sample sizes are indicated in parentheses). Data for full territories are presented in Appendix G.

Plot Name	No. of Territories	No. of Territories w/ Female	Pairing Success	No. of Territories Producing ≥ 1 Young	Breeding Success	Total No. of Fledglings Observed and Adjusted* Fledglings	Density of Observed and Adjusted* Fledglings Per Hectare	Observed and Adjusted* Productivity
Barton Creek Macrosite								
Barton Creek	7	7 (7)	100	7 (7)	100	24 / 27	0.59 / 0.67	3.4 / 3.9
Gus Fruh	0	0	0	0	0	0	0	0
Sunset Valley	0	0	0	0	0	0	0	0
Bull Creek Macrosite								
3M/St. Edwards	27	22 (22)	100	15 (27)	56	48 / 58	1.19 / 1.43	1.8 / 2.1
Canyon Vista	23	18 (18)	100	13 (23)	57	30 / 44	0.74 / 1.09	1.3 / 1.9
Forest Ridge	23	19 (23)	83	17 (23)	74	55 / 65	1.36 / 1.60	2.4 / 2.8
Butler	24	22 (23)	96	19 (24)	79	60 / 71	1.48 / 1.75	2.5 / 3.0
Hamilton West	10	9 (10)	90	7 (9)	78	18 / 23	0.44 / 0.57	2.0 / 2.5
Cypress Creek Macrosite								
Baker Sanctuary	12	12 (12)	100	10 (12)	83	28 / 28	0.69 / 0.69	2.3 / 2.3
Lake Perspectives/ McGregor	10	10 (10)	100	6 (10)	60	18 / 21	0.44 / 0.52	1.8 / 2.1
Vireo Ridge	16	16 (16)	100	14 (15)	93	37 / 48	0.63 / 0.81	2.5 / 3.2
Vista Point	20	20 (20)	100	12 (19)	63	41 / 42	1.01 / 1.04	2.2 / 2.2
North Lake Austin Macrosite								
Coldwater	12	9 (9)	100	3 (6)	50	10 / 12	0.09 / 0.11	1.7 / 1.9
Bike Park	17	15 (15)	100	10 (10)	100	33 / 38	0.33 / 0.38	3.3 / 3.8
Emma Long	18	17 (17)	100	17 (18)	94	54 / 62	1.33 / 1.53	3.0 / 3.4
South Lake Austin Macrosite								
Double J&T	4	1 (1)	100	0	0	0	0	0
Reicher	6	5 (6)	83	4 (6)	67	14 / 16	0.35 / 0.40	2.3 / 2.6
West Austin Macrosite								
Wild Basin/Vireo Preserve	6	5 (5)	100	3 (4)	75	7 / 10	0.04 / 0.06	1.8 / 2.6
Total/Avg.	**235**	**207 (214)**	**97%**	**157 (213)**	**74%**	**477 / 565**	**0.44 / 0.52**	**2.2 / 2.6**

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

Nest Data

BCP staff found and monitored a total of 151 active warbler nests during the 2012 field season (Table 9). The first nests were found on March 16, the last nest was found on June1, and the final fledging date of the observed nests was June 5. Ninety nests fledged one or more young (60 %), 56 nest failed (37%), and 5 had an unknown fate (3%).

Table 9. Fates of monitored golden-cheeked warblers nests within the Balcones Canyonlands Preserve, Travis County, Texas, field season 2012. Successful nests include any nest that fledged ≥1 young.

Plot Name	Total No. Nests	Failed Nests	No. Successful Nests	No. Nests Unknown Fate
Barton Creek Macrosite				
Barton Creek	5	0	5 (100%)	0
Gus Fruh/Sunset Valley	0	--	--	--
Bull Creek Macrosite				
3M/St. Edwards	13	6 (46%)	7 (54%)	0
Canyon Vista	3	1 (33%)	2 (67%)	0
Forest Ridge	6	1 (17%)	5 (83%)	0
Butler	9	1 (11%)	8 (89%)	0
Hamilton West	8	4 (50%)	4 (50%)	0
Canyon Creek*	1	1 (100%)	0	0
Cypress Creek Macrosite				
Baker Sanctuary	17	6 (35%)	11 (65%)	0
Lake Perspectives/McGregor	6	4 (67%)	2 (33%)	0
Vireo Ridge	16	3 (19%)	12 (75%)	1 (6%)
Vista Point	26	15 (58%)	10 (38%)	1 (4%)
North Lake Austin Macrosite				
Coldwater	9	6 (67%)	2 (22%)	1 (11%)
Bike Park	14	4 (29%)	8 (57%)	2 (14%)
Emma Long	9	1 (11%)	8 (89%)	0
Cortaña	1	0	1 (100%)	0
South Lake Austin Macrosite				
Double J&T	0	--	--	--
Reicher	3	1 (33%)	2 (67%)	0
Bohls*	1	0	1 (100%)	0
West Austin Macrosite				
Wild Basin/Vireo Preserve	4	2 (50%)	2 (50%)	0
Total	**151**	**56 (37%)**	**90 (60%)**	**5 (3%)**

*Not one of the intensive study plots in 2012.

Seven of the 151 nests were monitored with cameras until the nest failed or produced young: three on Vista Point, three on Vireo Ridge, and one on the Bike Park. The Bike Park nest fledged four young. One of the Vista Point nests fledged four young, one fledged three (one egg did not hatch), and the other was depredated, but the camera battery died before the predation occurred so the predator could not be identified. The Vireo Ridge nests all fledged three to four young; an unhatched egg remained in one nest, and the number fledged (3-4) from another nest was difficult to determine due to the placement of the camera.

The majority of nests were found in Ashe juniper (71%), followed by live oak (17%) and cedar elm (9%). Three nests were also found in shin oak (2%), one in an American elm (1%), and one in an Arizona walnut (1%) (Table 10). Nest tree height for all tree species averaged 8.8 meters, and DBH averaged 24 centimeters. Nest height averaged 6.9 meters. Canopy cover averaged 87 percent.

The nest data are part of a growing dataset of nests monitored on the BCP. These data are being used to analyze the relationships between habitat characteristics and nest success. Analyses include effects of landscape metrics (i.e., land use, stand age, habitat composition, amount of edge) and more localized effects. Results of the first year of data (2011) are presented in Appendix H.

Table 10. Summary of vegetation data collected for 149 golden-cheeked warbler nests found within the Balcones Canyonlands Preserve, Travis County, Texas, field season 2012

Tree Species	Total Nests	Tree Height Avg, Range (m)	Tree DBH Avg, Range (cm)	Nest Height Avg, Range (m)	% Canopy Cover Avg, Range	Successful Nests
Juniperus ashei (Ashe Juniper)	106 (71%)	8.2 (4.1 - 13.5)	23.0 (9 – 57)	6.4 (2.7 – 10.3)	88.4 (52.6 – 99.7)	64 (60%)
Quercus fusiformis (Live Oak)	25 (17%)	9.6 (6.5 – 13.9)	25.3 (12 – 48)	7.5 (4.5 – 11.6)	84.5 (47.7 – 99.2)	15 (60%)
Ulmus crassifolia (Cedar Elm)	13 (9%)	10.3 (6.7 – 18.3)	26.5 (17 – 38)	8.3 (3.3 – 15.4)	82.0 (64.8 – 98.7)	8 (62%)
Quercus sinuate var. *breviloba* (Shin Oak)	3 (2%)	11.2 (8.1 – 16.7)	26.8 (16.5 – 41)	7.4 (6.6 – 8.3)	91.6 (86.9 – 94.8)	1 (33%)
Ulmus americana (American elm)	1 (1%)	23.8	28.5	21.4	93.8	1 (100%)
Juglans major (Arizona walnut)	1 (1%)	9.8	29	7.8	97.9	1 (100%)
Totals	**149**	**8.8 (4.1 – 23.8)**	**23.8 (9 - 57)**	**6.9 (2.7 – 21.4)**	**87.3 (47.7 – 99.7)**	

Parasitism

No observations of Brown-headed Cowbird (*Molothrus ater*) parasitism of warbler nests or of adult warblers feeding cowbird chicks were reported in 2012.

Avian Pox

A few individual warblers and a northern mockingbird exhibiting symptoms of avian pox were observed during the 2012 field season. The first report was in early May of an unbanded SY warbler male in the Bull Creek macrosite (3M/St. Edwards plot) with what appeared to be swollen, bleeding legs and feet. The male was captured, photographed, and released on May 9, confirming lesions on the entirety of both legs and feet (the mist net used to capture this male was discarded). Three banded ASY males on 3M/St.

Edwards and an unbanded fledgling on Barton Creek were also observed during the month of May with various degrees of swelling near the color bands, but typically on only one leg and not as extensive as the unbanded SY male. Several fledglings on and near the Kent Butler plot were reported with what appeared to be lesions on the face between the eye and bill; typically only one affected fledgling was noted in a given family group.

Travis County BCP staff found a juvenile female northern mockingbird in early June in the Cypress Creek macrosite with lesions on all eight toes, right eyelid, and lower beak. The U.S. Geological Survey's National Wildlife Health Center examined this individual and diagnosed infection with avian pox.

Avian pox is an infectious viral disease characterized by wart-like nodules or lesions on featherless areas of the body. The typical route of transmission is through a vector such as mosquitoes, but the disease can also be mechanically transmitted by contact with surfaces contaminated by the pox virus. There is no known effective treatment for wild birds, although birds can recover if the pox lesion(s) does not impair their ability to obtain food and water, seek shelter, or evade predators. BCP staff are developing preventative measures for the 2013 and future field seasons to avoid contamination of banding equipment.

In addition to the pox-like symptoms, several unbanded fledglings were observed with what appeared to be swellings on the wing, particularly near the carpal joint. Based on an evaluation of a photograph submitted by Travis County BCP staff , the National Wildlife Health Center believed these anomalies were the result of acute trauma with hemorrhage or ulcer and not avian pox.

Other Observations

With the increased nest monitoring in 2012, BCP staff and partners had an opportunity to more closely observe nest-building and nesting behaviors. Of interest include a male landing on an early stage nest platform after the female flew off of it. He proceeded to wiggle in the nest (females typically do this to shape the nest) and sang an A song before flying off. Another biologist observed a female gathering large strips of Ashe juniper bark, taking them to the ground, and beating them on a rock to break them into smaller pieces. While the nest is constructed with strips of Ashe juniper bark, females are more opportunistic when gathering material to line their nests, typically selecting fine grasses, feathers, and other downy material. A dead Virginia opossum (*Didelphis virginiana*) at Wild Basin presented such an opportunity, and two different females were seen gathering fur from the carcass for their nests.

Warblers are frequently seen drinking and bathing in springs and shallow pools that are shaded by overhanging vegetation. During field season 2012, banded warblers were occasionally found at sites with water a good distance from their territories. No territorial disputes were apparent during these observations; the birds kept low to the ground and did not sing.

As in previous years, field staff observed female warblers mid-story in Ashe junipers and on the ground collecting nesting material. Both males and females were observed collecting food on the ground, and fledglings were often seen in dense mid-story vegetation and near or on the ground. Each field season,

BCP staff videotape and/or photograph adults tending newly-fledged young that are unable to fly well, highlighting the vulnerability of newly fledged young and the importance of ground habitat to the warbler, in addition to the tree canopy and mid-story vegetation.

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

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



Male Golden-cheeked Warbler Searching for Food on Ground. © Jennifer Reidy

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V. APPENDICES

Appendix A: Distribution of Intensive Study Areas (Figure 1) and Minimum Convex Polygons Representing Estimated Golden-cheeked Warbler Territory Boundaries for Intensive Study Areas (Figures 2-17), 2012.

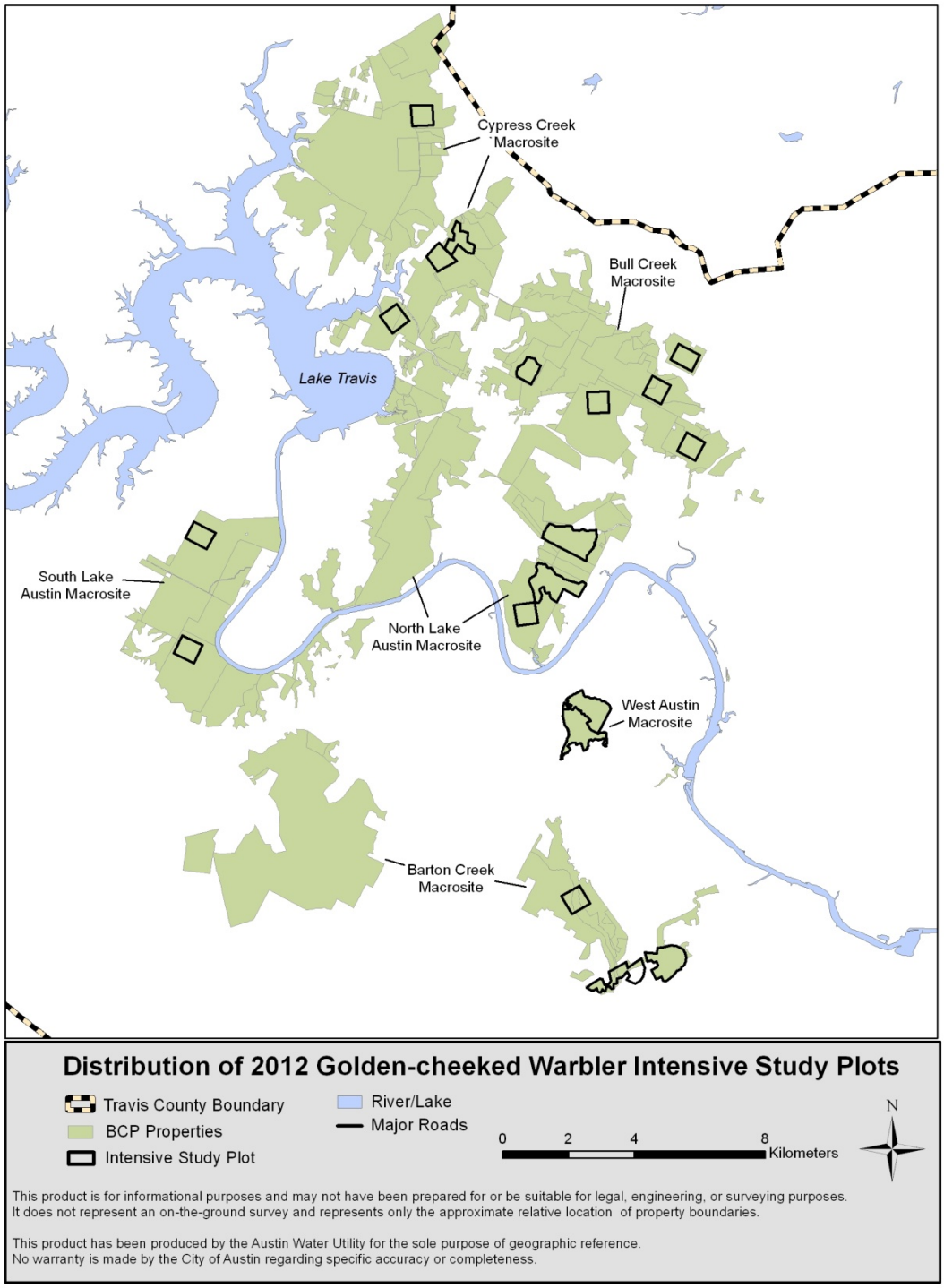


Figure 1

Appendix A: Minimum Convex Polygons Representing Estimated Golden-cheeked Warbler Territory Boundaries for Intensive Study Areas (Figures 2-17), 2012 (continued).

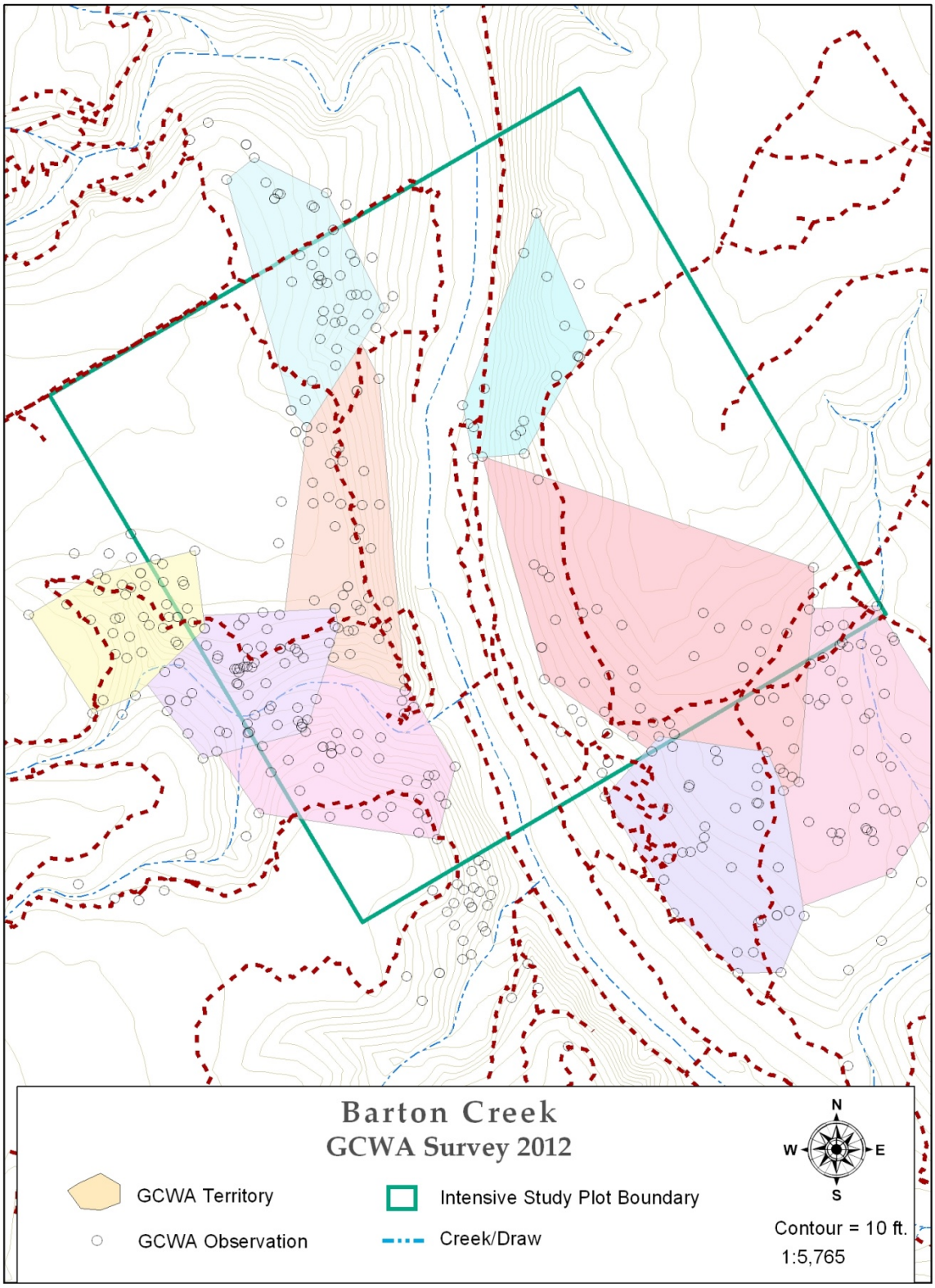


Figure 2

Appendix A: Minimum Convex Polygons Representing Estimated Golden-cheeked Warbler Territory Boundaries for Intensive Study Areas (Figures 2-17), 2012 (continued).

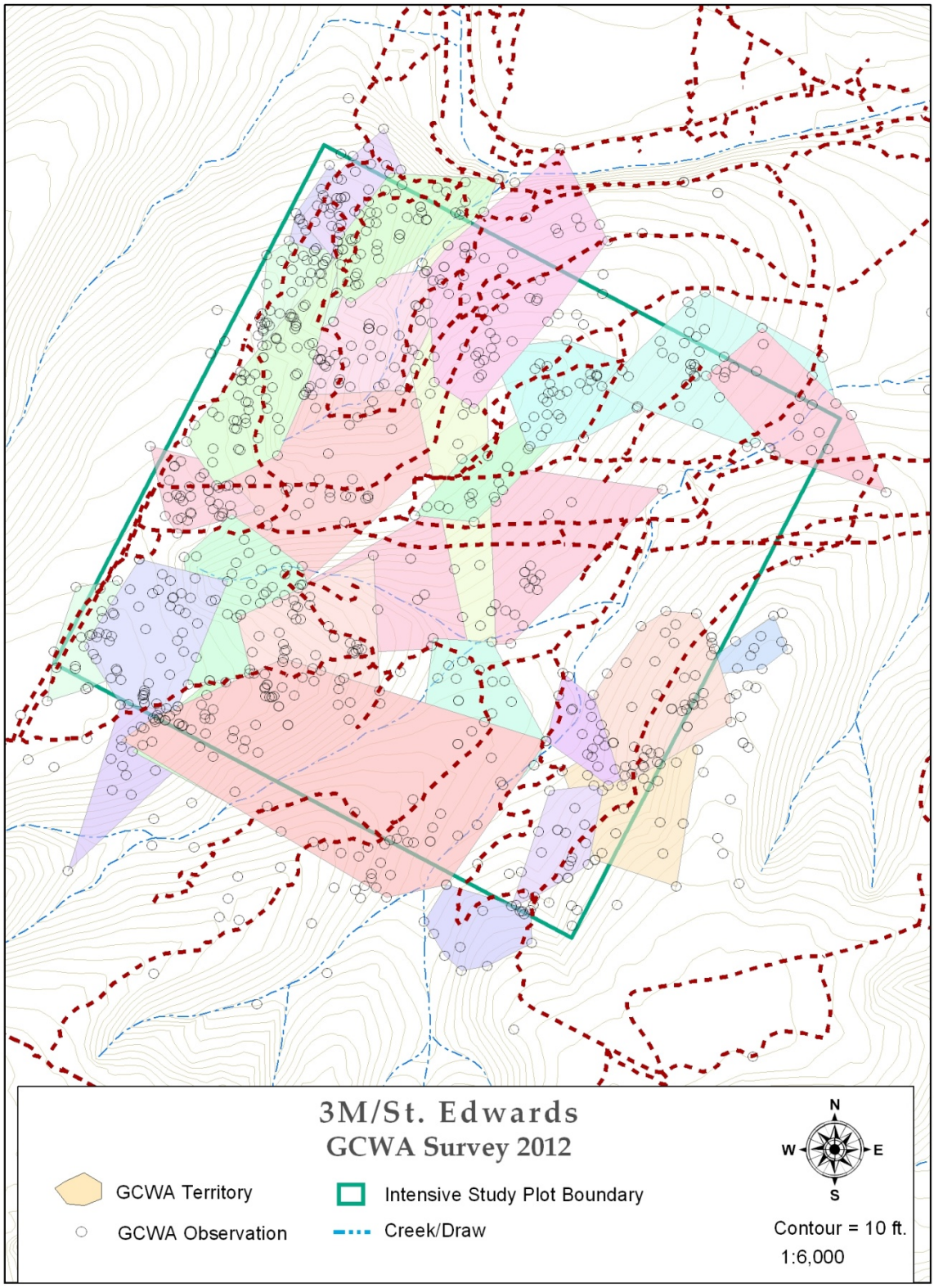


Figure 3

Appendix A: Minimum Convex Polygons Representing Estimated Golden-cheeked Warbler Territory Boundaries for Intensive Study Areas (Figures 2-17), 2012 (continued).

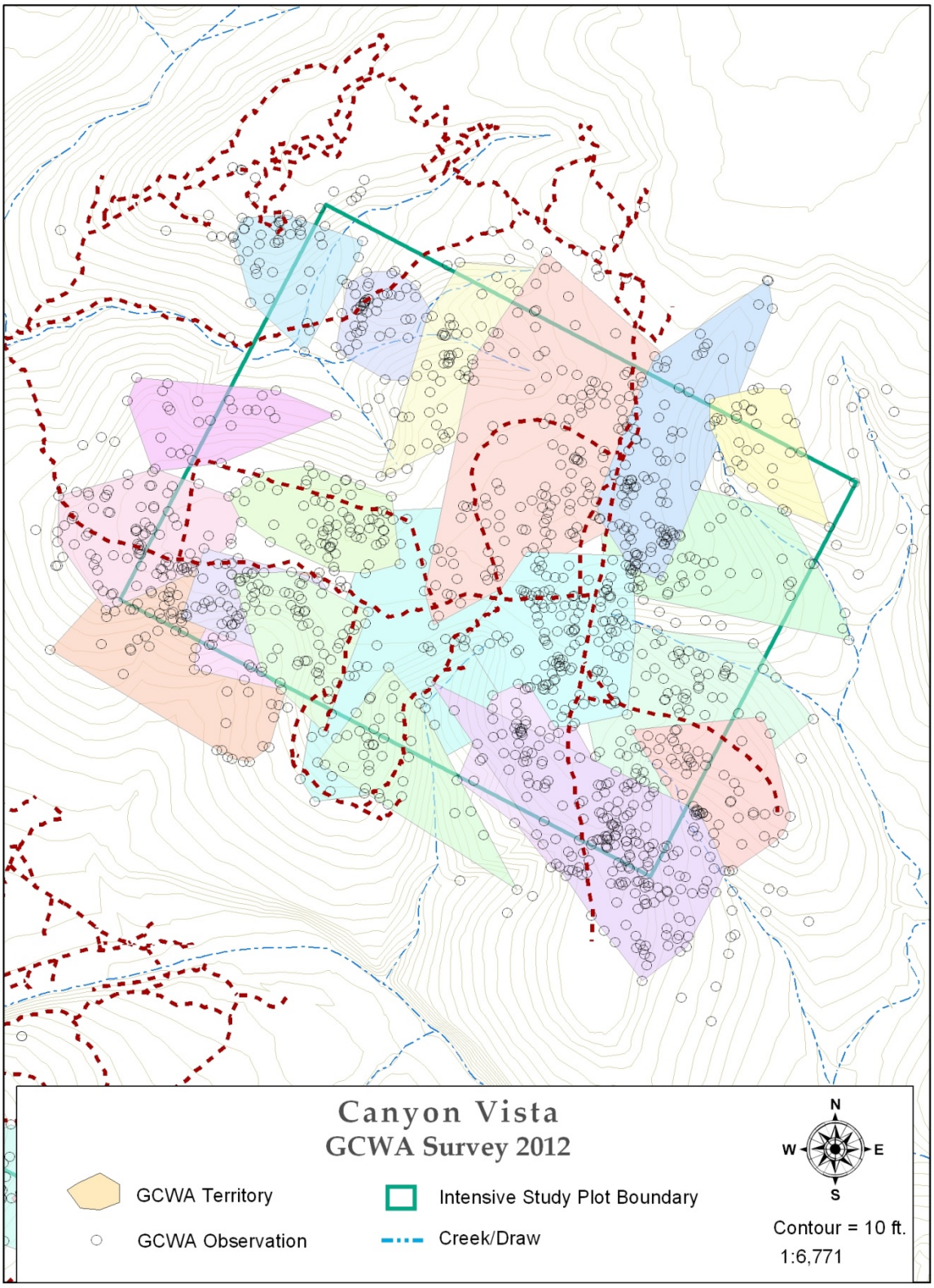


Figure 4

Appendix A: Minimum Convex Polygons Representing Estimated Golden-cheeked Warbler Territory Boundaries for Intensive Study Areas (Figures 2-17), 2012 (continued).

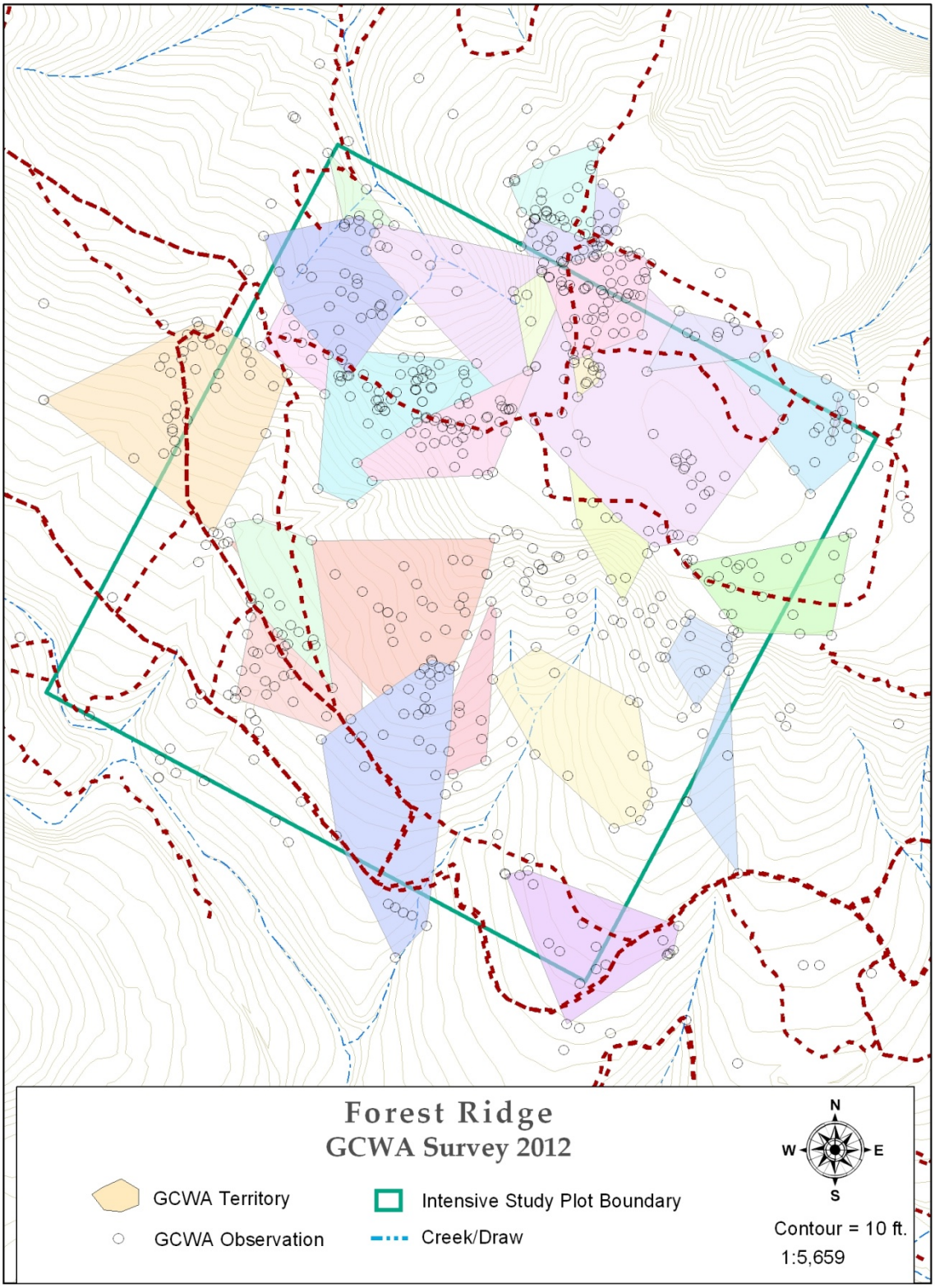


Figure 5

Appendix A: Minimum Convex Polygons Representing Estimated Golden-cheeked Warbler Territory Boundaries for Intensive Study Areas (Figures 2-17), 2012 (continued).

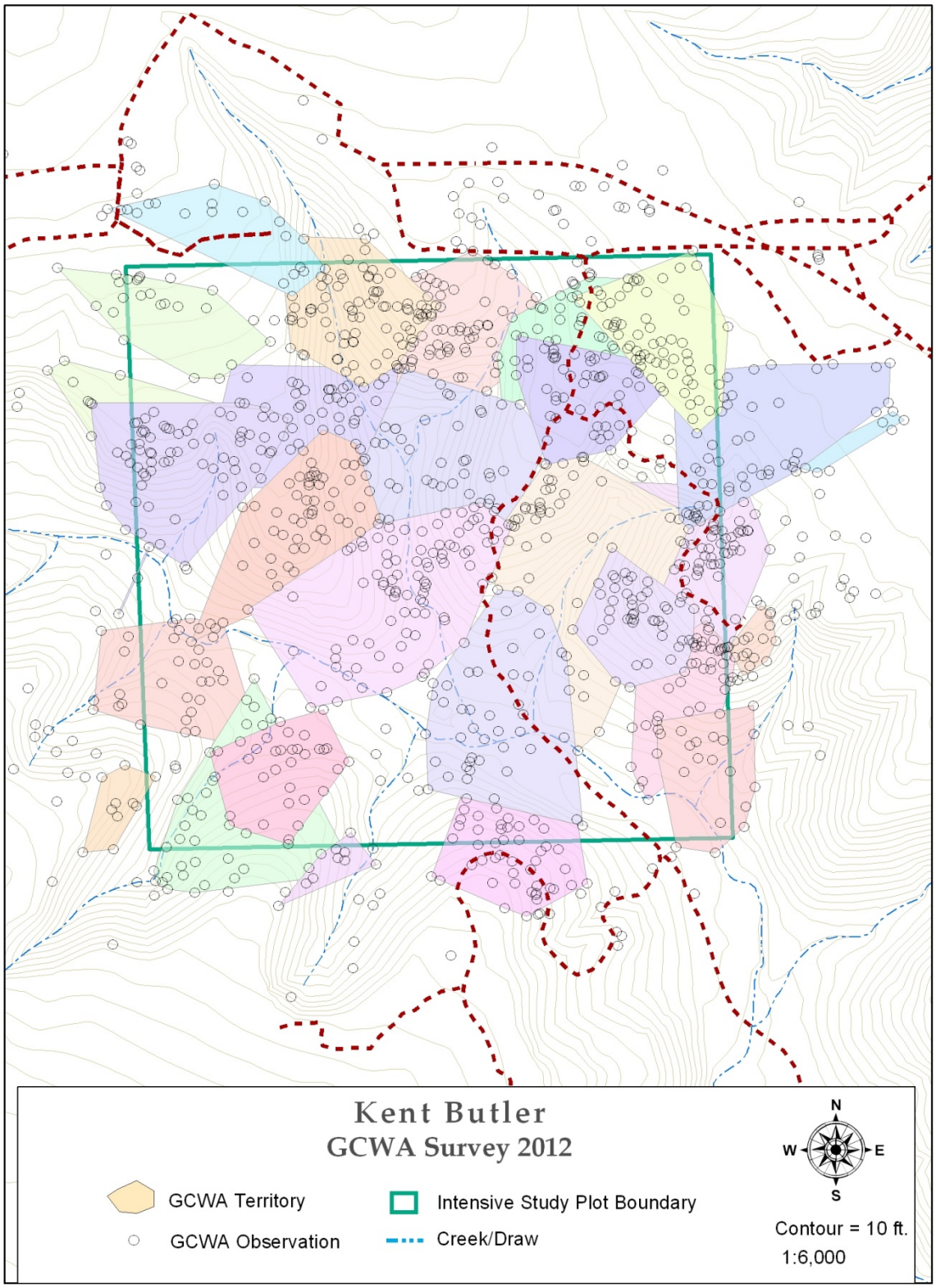


Figure 6

Appendix A: Minimum Convex Polygons Representing Estimated Golden-cheeked Warbler Territory Boundaries for Intensive Study Areas (Figures 2-17), 2012 (continued).

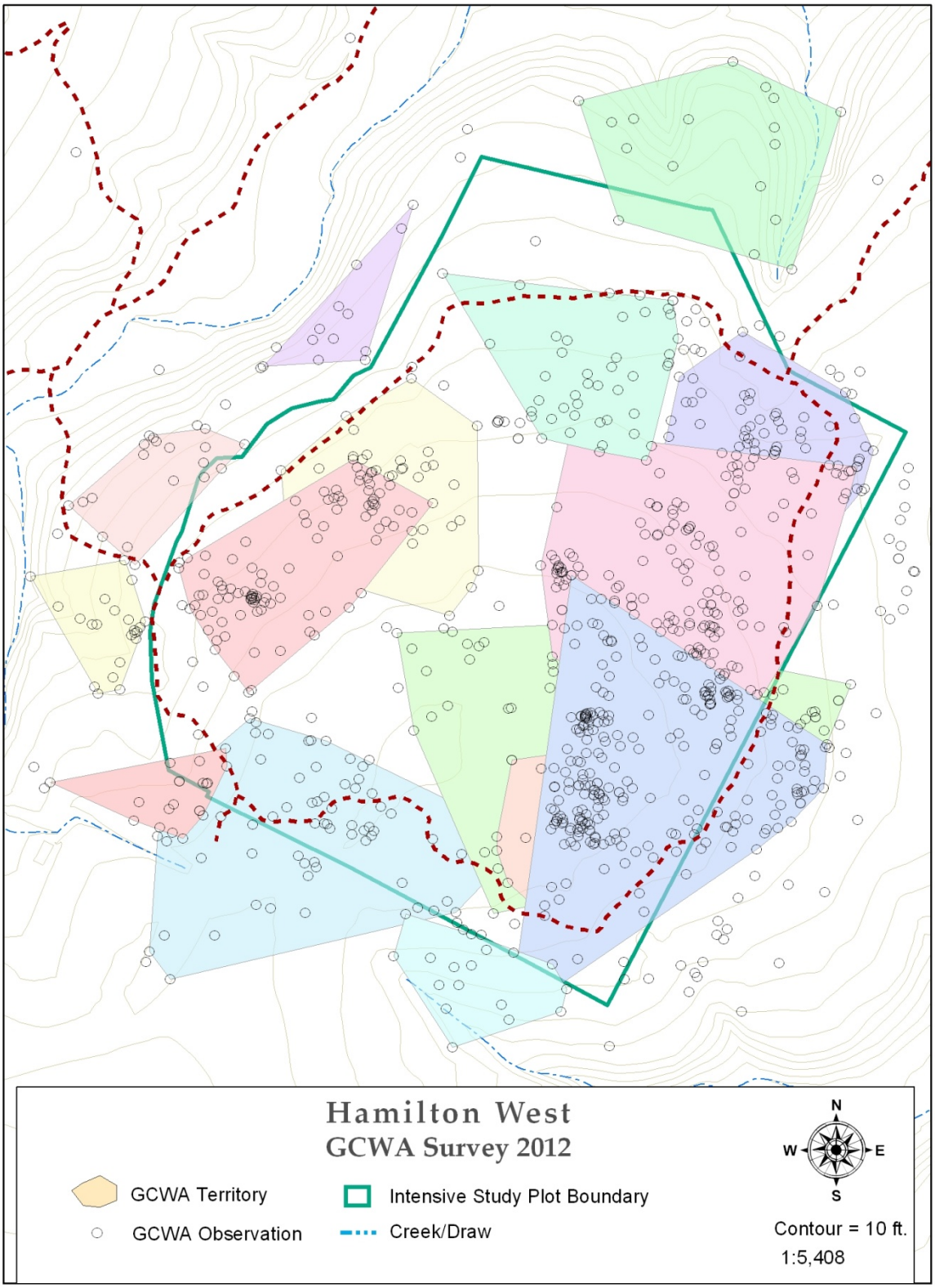


Figure 7

Appendix A: Minimum Convex Polygons Representing Estimated Golden-cheeked Warbler Territory Boundaries for Intensive Study Areas (Figures 2-17), 2012 (continued).

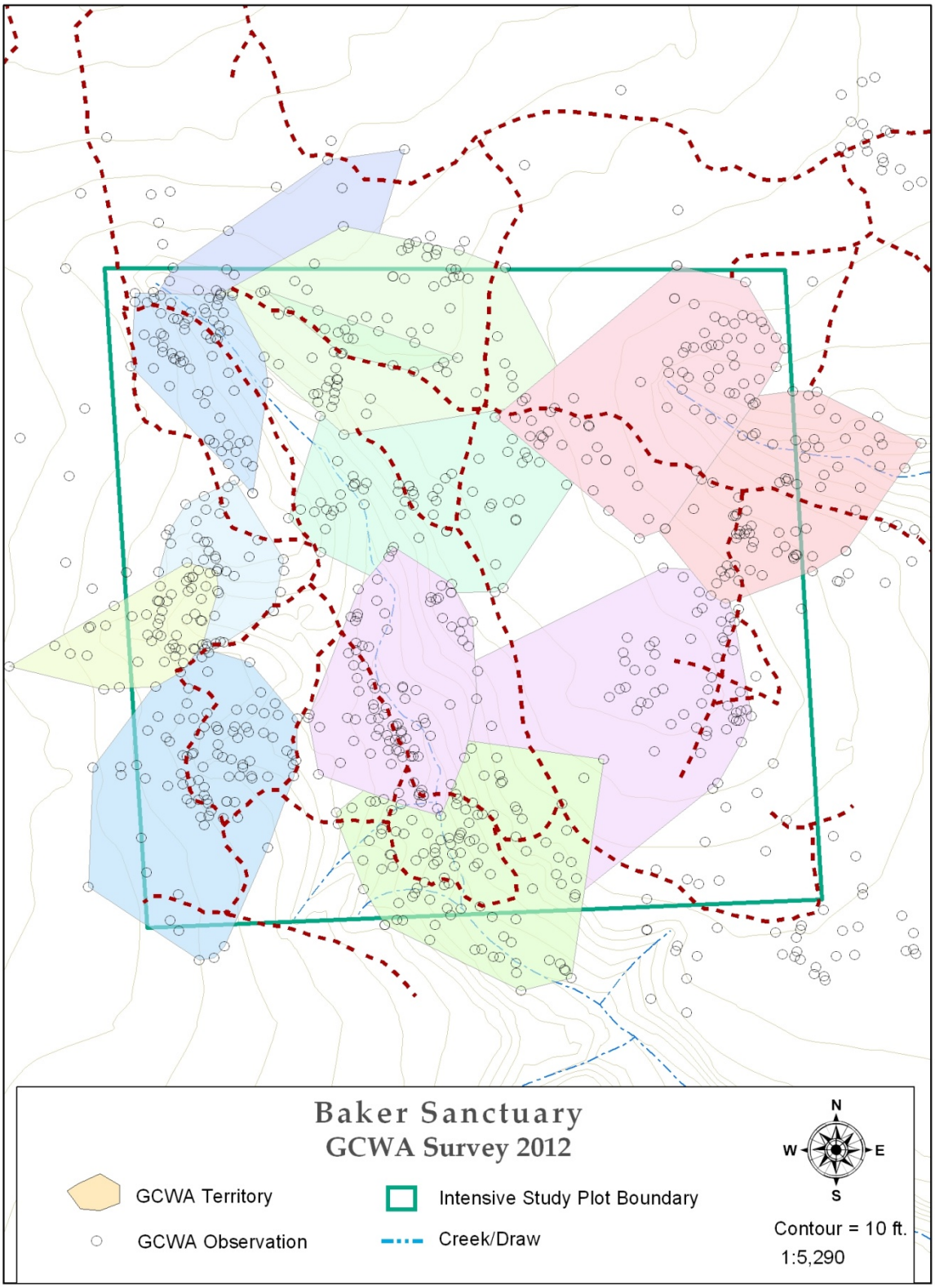


Figure 8

Appendix A: Minimum Convex Polygons Representing Estimated Golden-cheeked Warbler Territory Boundaries for Intensive Study Areas (Figures 2-17), 2012 (continued).

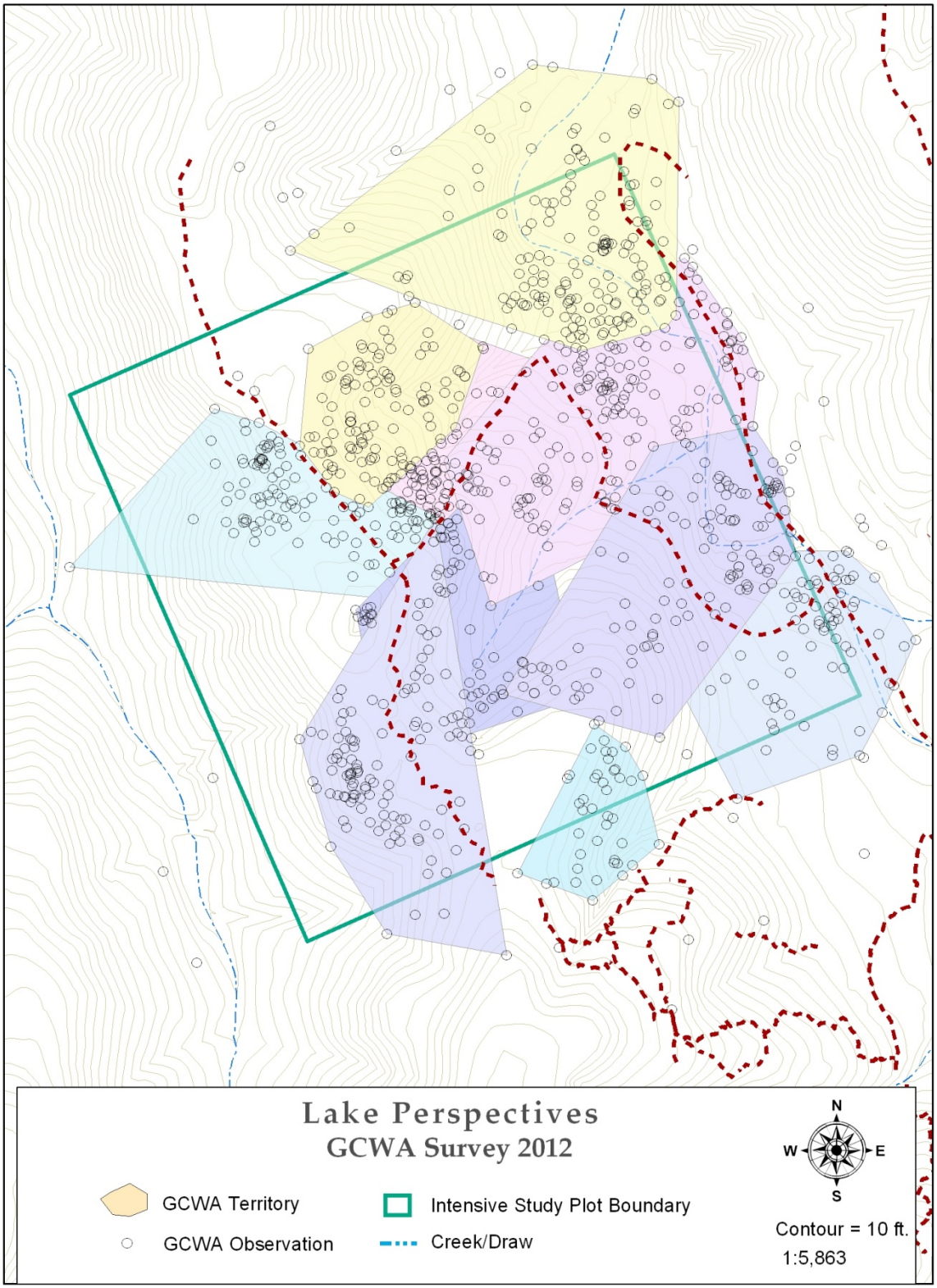


Figure 9

Appendix A: Minimum Convex Polygons Representing Estimated Golden-cheeked Warbler Territory Boundaries for Intensive Study Areas (Figures 2-17), 2012 (continued).

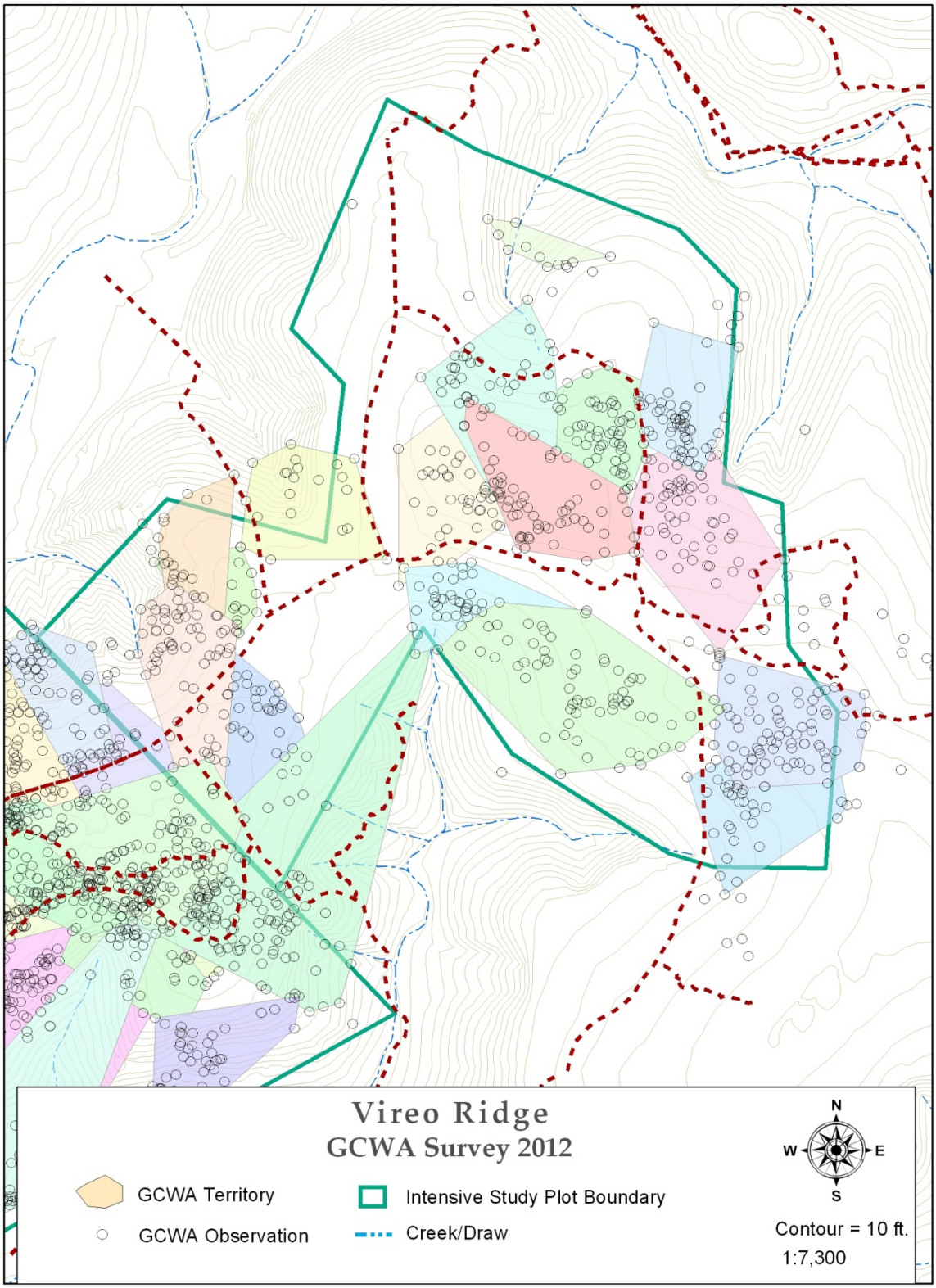


Figure 10

Appendix A: Minimum Convex Polygons Representing Estimated Golden-cheeked Warbler Territory Boundaries for Intensive Study Areas (Figures 2-17), 2012 (continued).

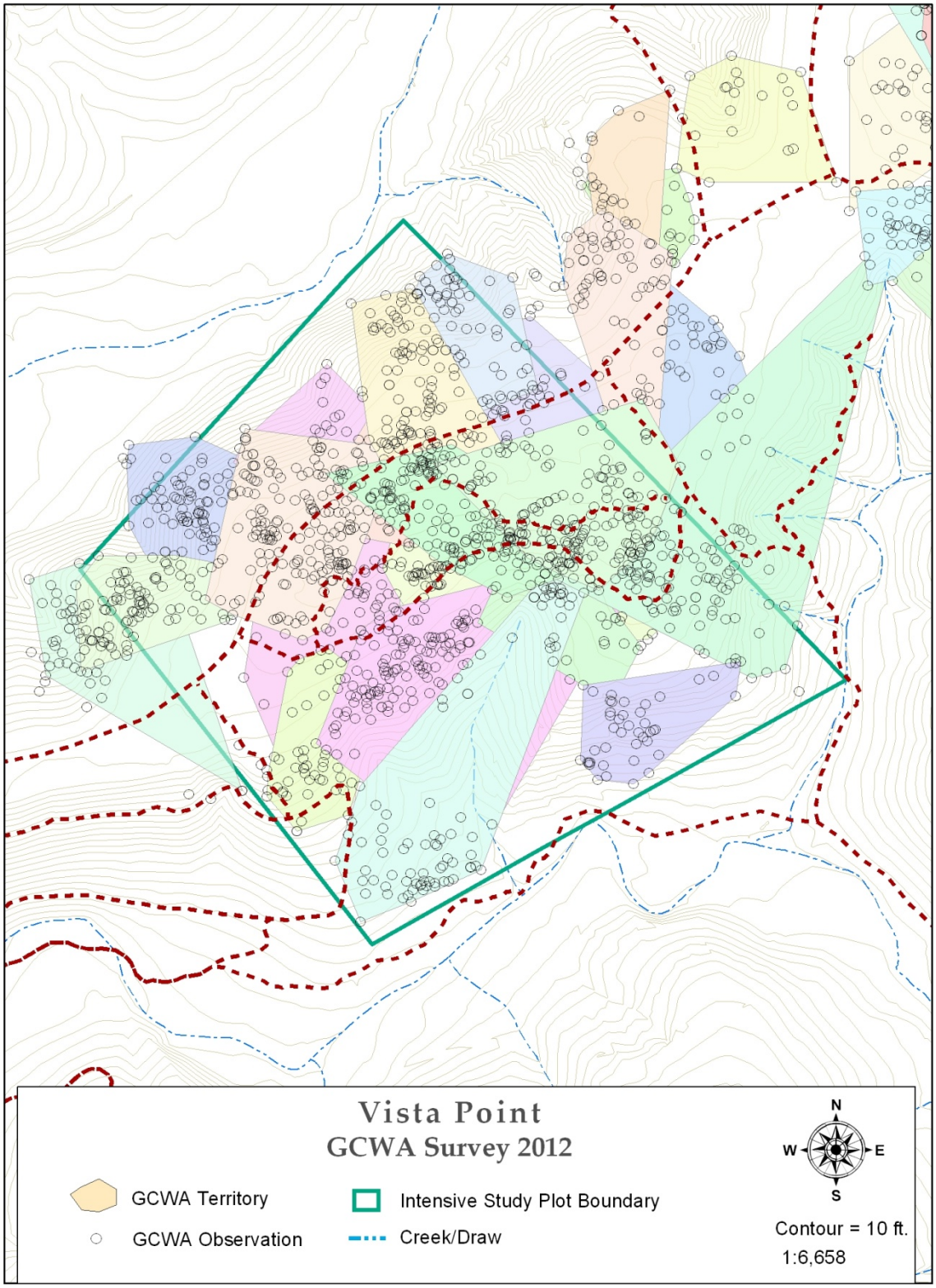


Figure 11

Appendix A: Minimum Convex Polygons Representing Estimated Golden-cheeked Warbler Territory Boundaries for Intensive Study Areas (Figures 2-17), 2012 (continued).

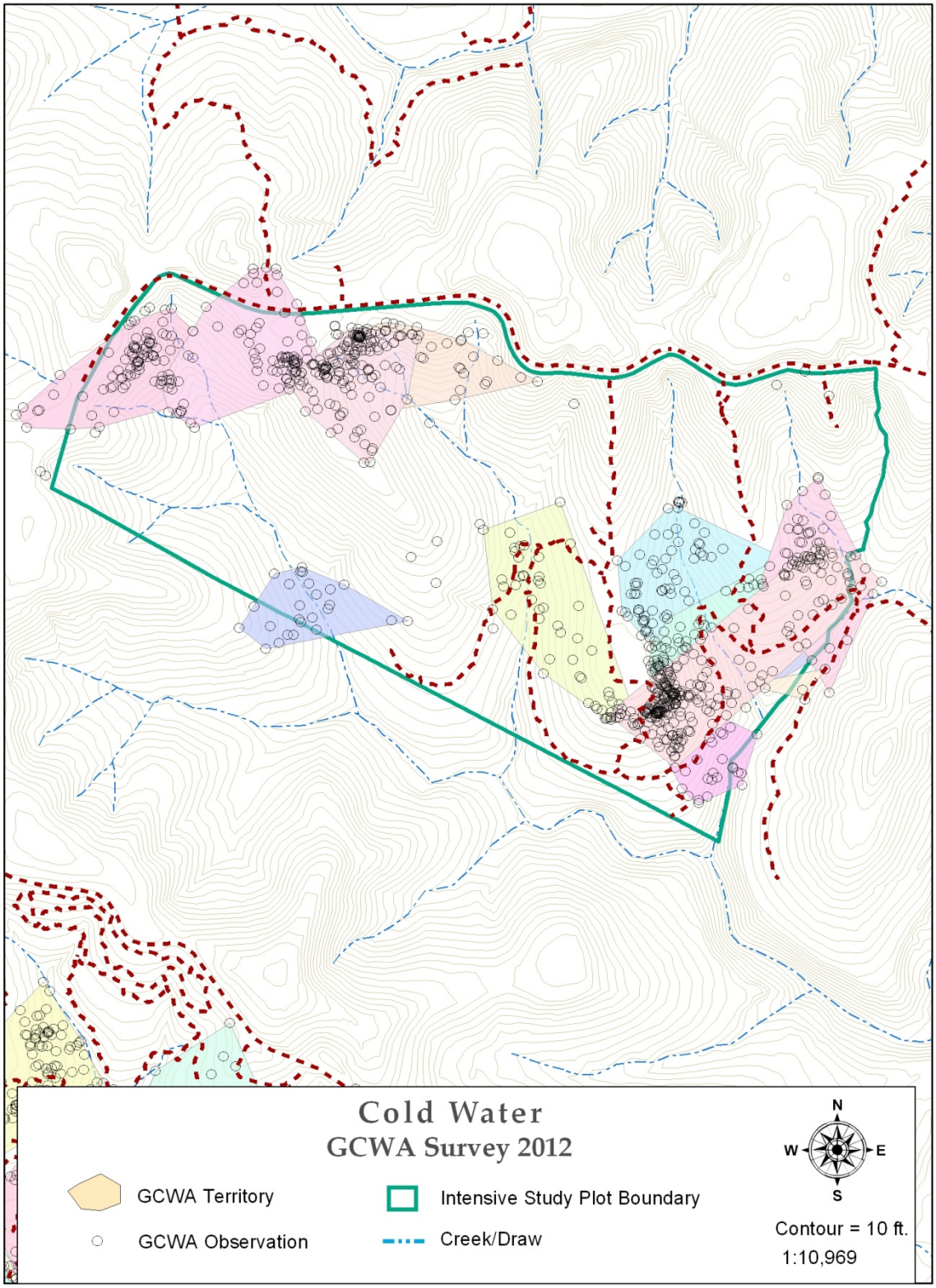


Figure 12

Appendix A: Minimum Convex Polygons Representing Estimated Golden-cheeked Warbler Territory Boundaries for Intensive Study Areas (Figures 2-17), 2012 (continued).

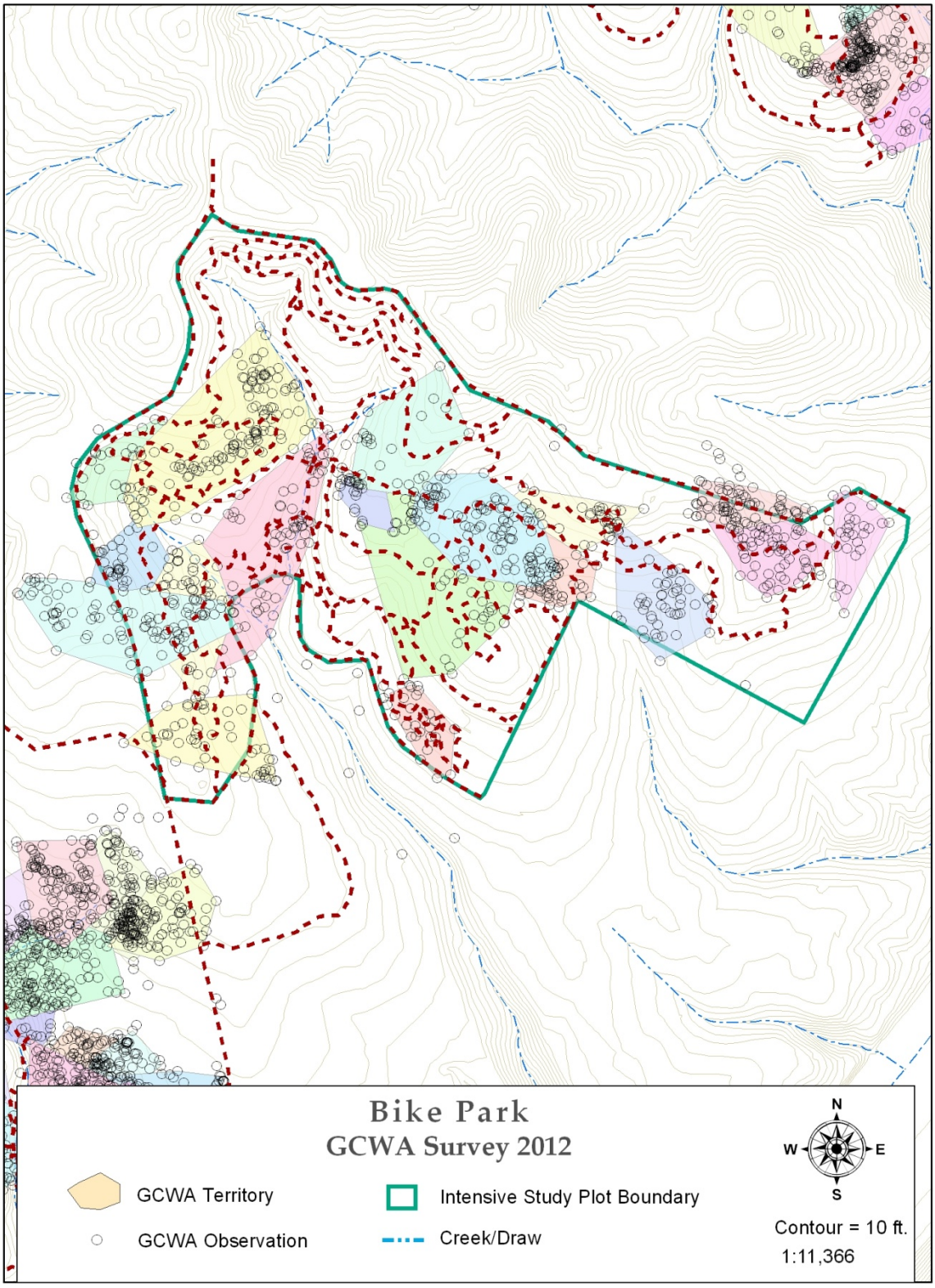


Figure 13

Appendix A: Minimum Convex Polygons Representing Estimated Golden-cheeked Warbler Territory Boundaries for Intensive Study Areas (Figures 2-17), 2012 (continued).

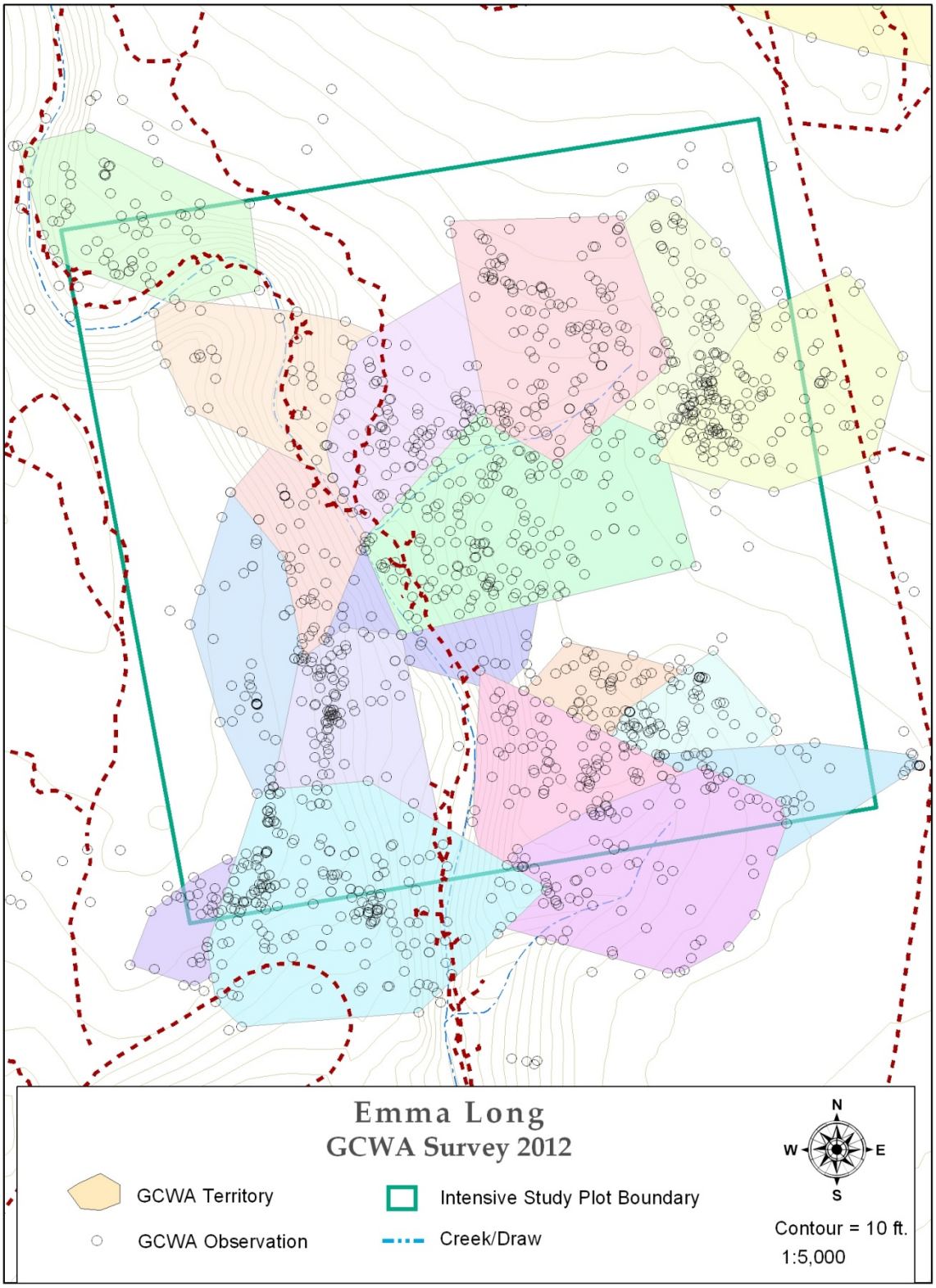


Figure 14

Appendix A: Minimum Convex Polygons Representing Estimated Golden-cheeked Warbler Territory Boundaries for Intensive Study Areas (Figures 2-17), 2012 (continued).

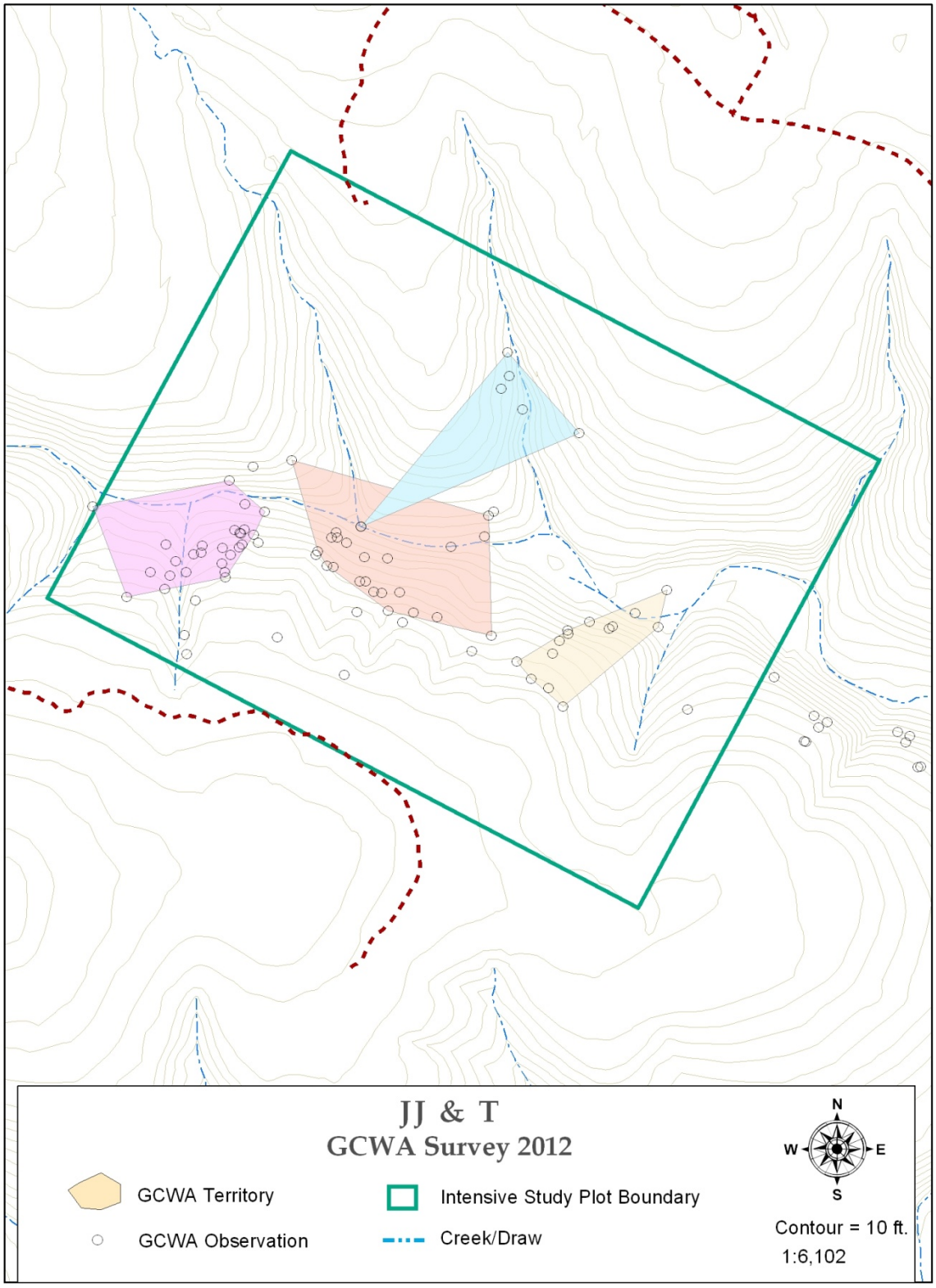


Figure 15

Appendix A: Minimum Convex Polygons Representing Estimated Golden-cheeked Warbler Territory Boundaries for Intensive Study Areas (Figures 2-17), 2012 (continued).

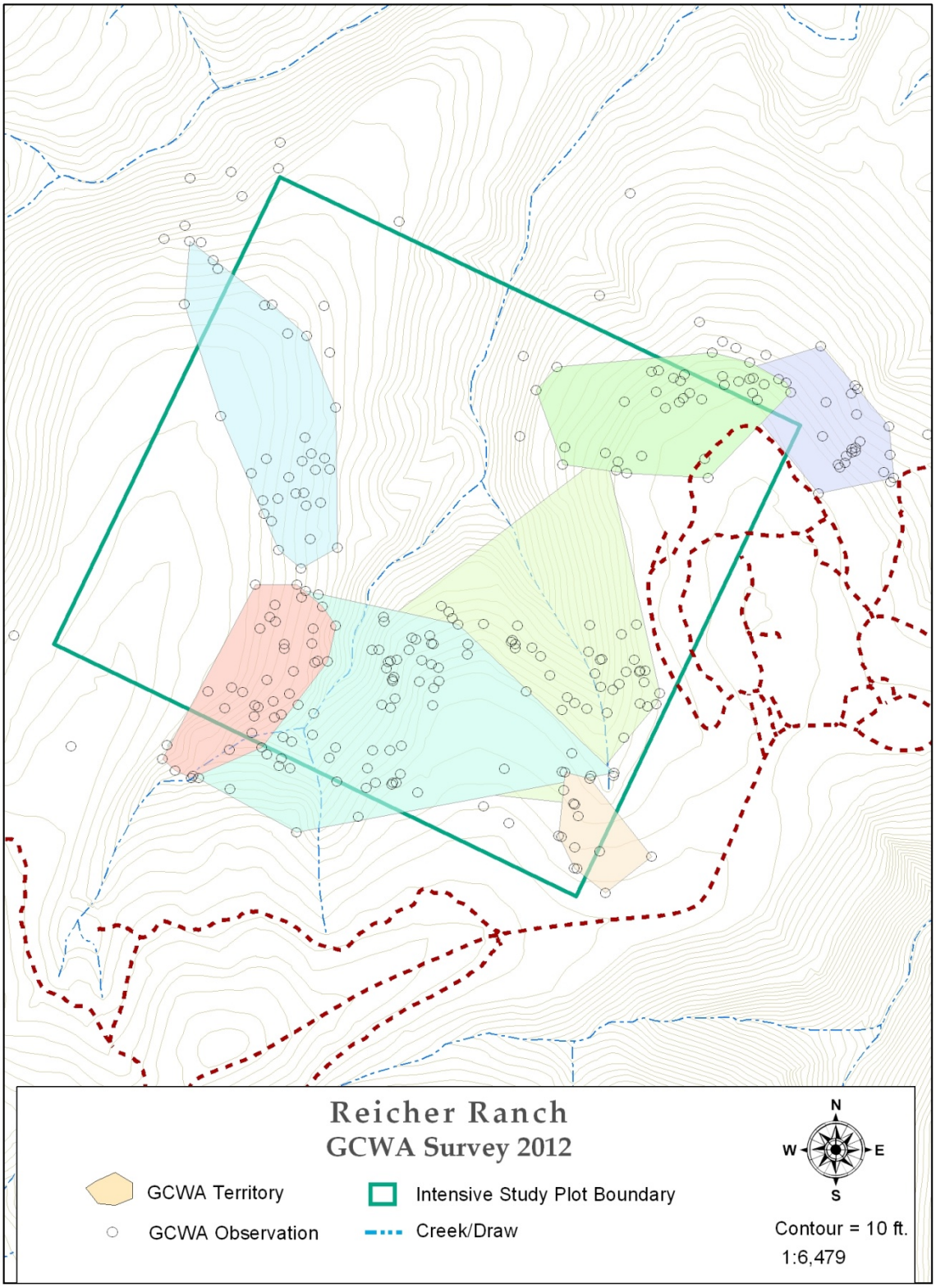


Figure 16

Appendix A: Minimum Convex Polygons Representing Estimated Golden-cheeked Warbler Territory Boundaries for Intensive Study Areas (Figures 2-17), 2012 (continued).

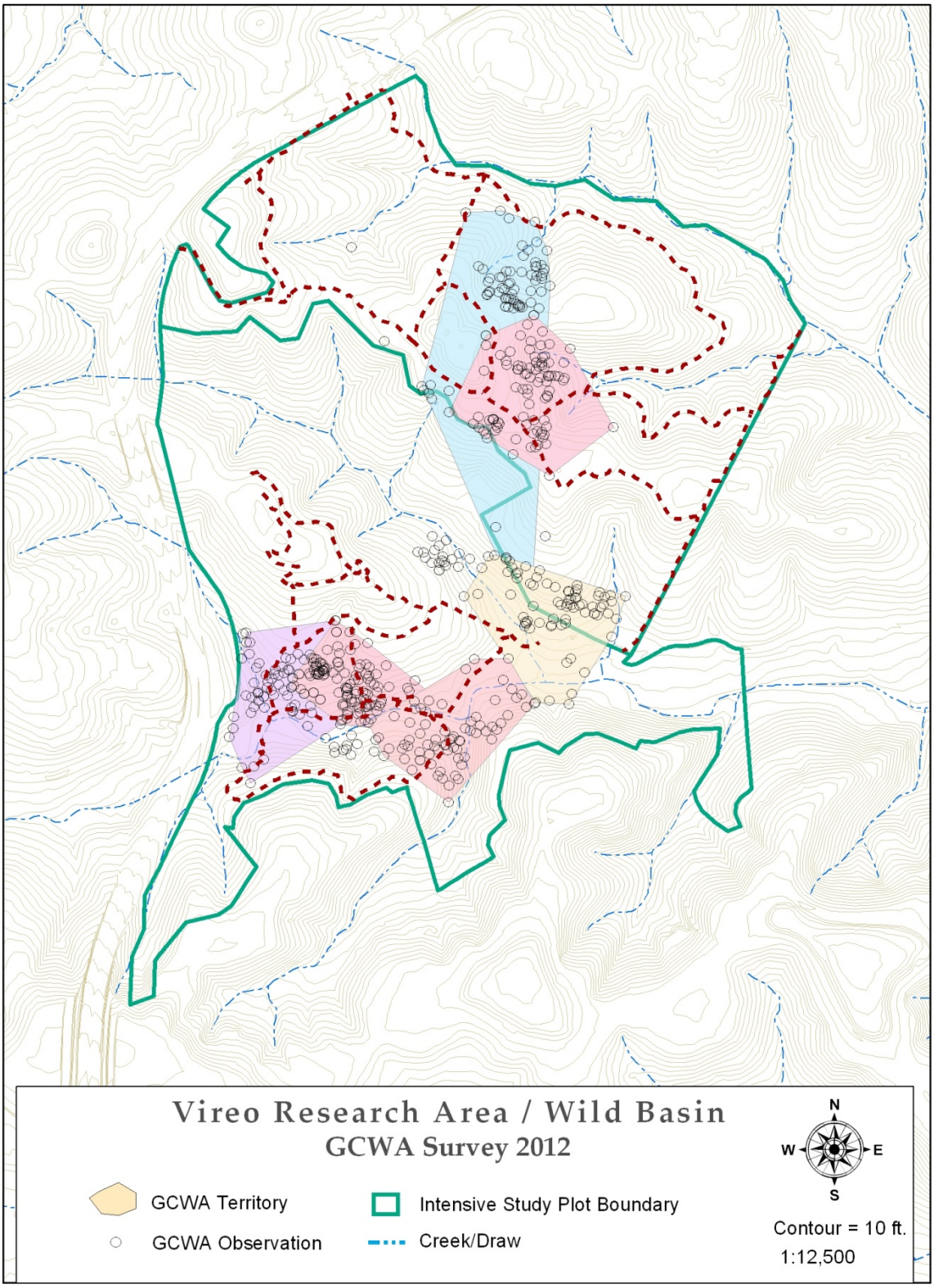


Figure 17

Appendix B: Summary of Golden-cheeked Warbler Survey Effort on the Balcones Canyonlands Preserve, Travis County, Texas, Field Season 2012.

Intensive Study Plots	Lead Surveyor(s)	Survey Hours (March 8-June 15)	Area Surveyed (hectares)
Barton Creek Macrosite			
Barton Creek	Chris Warren, COA	91.0	40.5 + buffer
Gus Fruh	Chris Warren, COA	15.5	85
Sunset Valley	Chris Warren, COA	16.75	64
Bull Creek Macrosite			
3M/St. Edwards	Jason Hunt, Chris Warren, COA	227.50	40.5 + buffer
Canyon Vista	Todd Bayless, Renee Fields, TC Cindy Sperry, COA	300.5	40.5 + buffer
Forest Ridge	Jason Hunt, Jim O'Donnell, COA	373.5	40.5 + buffer
Butler	William Reiner, Mark Sanders, COA	291.75	40.5 + buffer
Hamilton West	John Chenoweth, Lisa O'Donnell, COA	238.75	40.5 + buffer
Cypress Creek Macrosite			
Baker Sanctuary	Caitlin Winters, USFS Chris Murray, Travis Audubon	326.5	40.5 + buffer
Lake Perspectives/McGregor	Paul Fushille, William Simper, TC Lisa O'Donnell, COA	222.75	40.5 + buffer
Vireo Ridge	Jennifer Reidy, Caitlin Winters, Cara Whalen USFS	247.00	59
Vista Point	Jennifer Reidy, Caitlin Winters, USFS	385.00	40.5 + buffer
North Lake Austin Macrosite			
Bike Park	Cara Whalen, Jennifer Reidy, Chris Gurgis, USFS	448.00	99
Coldwater	Chris Gurgis Jennifer Reidy, Cara Whalen, Caitlin Winters, USFS	378	107
Emma Long	Darrell Hutchinson, COA Cindy Sperry, COA	324.3	40.5 + buffer
South Lake Austin Macrosite			
Double J&T	Chris Gurgis, Cara Whalen, Jennifer Reidy, USFS	92.5	40.5 + buffer
Reicher	John Chenoweth, William Reiner, COA	146.25	40.5 + buffer
West Austin Macrosite			
Vireo Preserve/Wild Basin	Darrell Hutchinson, Jim O'Donnell, Lisa O'Donnell, COA	200.00	180
	Total	**4,325.50**	**1,079.5 + buffers**

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

Appendix B: Summary of Golden-cheeked Warbler Survey Effort on the Balcones Canyonlands Preserve, Travis County, Texas, Field Season 2012 (continued).

Resighting Plots	Surveyor(s)	Survey Hours (March 15-May 25)	Area Surveyed (Hectares)
Barton Creek Macrosite			
Barton Creek Northwest	Shelia Hargis Laurie Foss	18.00	40.5
Barton Creek Southwest	Stephen Ramirez	10.00	40.5
Barton Creek Southeast	Jacquie Ferrato Ellie Loggins	13.50	40.5
Bull Creek Macrosite			
Butler East Butler Northwest	Amanda Aurora Christina Williams	46.00	81
3M Northeast Hamilton West	Paul Brick Tere Sariol	32.00	81
Butler Southeast Butler Southwest	Jeff Mundy	36.50	81
3M South	Susanne Shipper Travis Clark	18.00	40.5
3M Southeast	Joseph Hunt Mike Rogan	16.50	40.5
Hamilton Northeast	Jake McCumber Adrian Johnson	12.50	40.5
Forest Ridge Northeast	Kensley Greuter	18.50	
Forest Ridge Southwest Forest Ridge Northwest	Jim Weber Lynne Weber	36.50	81
Forest Ridge Southeast	Celeste Brancel	74.00	40.5
Canyon Vista	Elena Pinto-Torres Bruce Calder	15.00	40.5
Canyon Creek 40.5-Hectare plot	Mark Sanders, COA	39.00	40.5
Ribelin 40.5-Hectare plot	Travis County staff	--	40.5
North Lake Austin Macrosite			
Emma Long East	Elena Pinto-Torres Bruce Calder Travis Clark	16.00	40.5
Emma Long West	Nancy Norman	21.50	40.5
Emma Long South	Amy Tsay	18.50	40.5
South Lake Austin Macrosite			
Bohls 40.5-Hectare plot	Jason Hunt, COA	31.50	40.5
Cypress Creek Macrosite			
Baker Sanctuary 1	Christina Campbell	15.50	40.5
Baker Sanctuary 2	Allan Pringle	18.50	40.5
Baker Sanctuary – LCRA 3	Christina Campbell Elena Pinto Torres	17.00	40.5
Lake Perspectives 1	Shaw McMahon	17.50	40.5
Vista Point Southeast	Nevin Durish	16.50	40.5
Vireo Ridge	Harris Frampton Dustin Jones	11.50	40.5
Total		**570**	**1134**

COA = City of Austin.

Appendix C: Intensive Study Plot Protocol, 2012.

Golden-cheeked Warbler Monitoring
Intensive Study Plot Protocol, 2012

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. Additionally, two observers will split intensive study plots that average 5 or more territories to ensure comprehensive coverage and help address potential observer bias issues.

Study Sites: Within each intensive study plot, observers will focus on re-sighting color-banded GCWAs, mapping the location and extent of territories, searching for and monitoring nests, and looking for females and fledglings. In addition, the observers responsible for each study plot 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. This re-sighting data is of paramount importance in learning about dispersal and differentiating survival from return rates.

Survey Dates: March 15 - May 25 for standard territory mapping visits (one visit/week with at least 5 days separation between visits). Each observer will visit the plot 1-2 additional days per week for the purposes of banding all territorial male GCWAs, finding and monitoring nests and fledglings, and re-sighting birds not re-sighted during the mapping visit. Productivity visits will continue into June.

Survey effort for territory mapping: *Minimum* 6 hours per 40.5 hectares per visit. 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 ≥30 meters, up to 10 locations, for birds in each territory during each survey. Males are considered territorial if they are observed in the same area on three different days spread at least a week apart and those locations were separated by ≥30 meters. A full territory is one in which the male is observed singing outside the plot no more than once (could be multiple positions on one visit) between March 15-May 25. A territory is considered outside the plot if the singing male is found on the plot no more than once (could be multiple positions on one visit). An edge territory is one in which singing male is observed both inside and outside the plot on more than one visit each.

Staffing: Two observers per plot averaging ≥5 territories, with a *minimum* 3 hours/50 acres/person (*minimum* 6 hours total) per territory mapping visit.

Training: All staff scheduled for the 2012 field season will have prior experience conducting Golden-cheeked Warbler surveys or be trained by experienced personnel prior to the field season.

Survey Procedures: Observers are to follow the **Standards for Conducting and Documenting Golden-cheeked Warbler Surveys (COA 2012)** during all field visits.

The following additional procedures are specific to surveying intensive study plots:

1. Surveys of intensive study plots should start within 30 minutes of sunrise (before or after).
2. Each observer will cover half (for plots averaging 5 or more territories) or the entire plot (for plots with <5 territories) on each territory mapping visit. 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 this is practical. This will ensure each observer covers the entire plot and begins at a different corner of the plot on each visit.
3. Volunteers will be recruited to conduct searches for banded GCWAs outside the 100-m buffers surrounding each plot. These surveys will be conducted at least three times within the season, ≥ 2 weeks apart. The observers responsible for each study plot may need to assist with these re-sighting surveys. Observers and volunteers conducting these searches will follow the **Standards for Conducting and Documenting Golden-cheeked Warbler Surveys (COA 2012)**.

Appendix D: Golden-cheeked Warbler 40.5-hectare Study Plot Territory Data. A summary of golden-cheeked warbler territory number per 40.5 hectare and per 100 hectares for five prime study plots, three transitional study plots, and the Hamilton West transitional plot on the City of Austin's BCP, Travis County, Texas, field seasons 1998-2012. See Methods section for calculations.

Plot Name	Survey Year	No. of Full Territories	No. of Full Territories + 50% of Edge Territories	No. of Territories per 100 ha
Prime Plots				
Barton Creek	1998	2	5.0	12
	1999	6	9.0	22
	2000	5	7.0	17
	2001	3	5.0	12
	2002	2	5.0	12
	2003	2	5.5	14
	2004	3	6.5	16
	2005	4	7.0	17
	2006	6	9.0	22
	2007	6	7.5	17
	2008	4	6.5	16
	Average	4	7.0	17
	Initiation of Color Banding			
	2009	2	5.0	12
	2010	2	6.0	15
	2011	4	6.5	16
	2012	2	4.5	11
Emma Long	1998	6	8.5	21
	1999	7	9.5	23
	2000	12	16.5	41
	2001	14	18.5	46
	2002	18	20.0	49
	2003	14	16.5	41
	2004	11	16.5	41
	2005	14	18.0	44
	2006	19	24.5	61
	2007	5	10.5	26
	2008	9	13.5	33
	Average	12	16.0	39
	Initiation of Color Banding			
	2009	9	14.0	35
	2010	10	13.0	32
	2011	10	13.0	33
	2012	11	14.5	36
Butler	1998	7	10.0	25
	1999	8	12.5	31
	2000	7	13.0	32
	2001	2	8.0	20
	2002	9	15.5	38
	2003	13	21.5	53
	2004	12	21.0	52
	2005	15	20.5	51
	2006	20	24.0	59
	2007	16	20.0	49
	2008	16	21.5	53
	Average	11	17.0	42
	Initiation of Color Banding			
	2009	11	18.0	44
	2010	11	15.5	38
	2011	12	17.0	43
	2012	11	17.5	43

Appendix D: Golden-cheeked Warbler 40.5-Hectare Study Plot Territory Data (continued).

Plot Name	Survey Year	No. of Full Territories	No. of Full Territories + 50% of Edge Territories	No. of Territories per 100 ha
3M/St. Edwards	1998	6	9.0	23
	1999	7	11.0	28
	2000	7	12.0	30
	2001	3	6.0	15
	2002	9	12.5	31
	2003	8	12.5	31
	2004	6	11.5	28
	2005	7	13.0	32
	2006	8	11.5	28
	2007	6	11.5	28
	2008	7	13.0	32
	Average	7	11.0	28
	Initiation of Color Banding			
	2009	9	18.0	44
	2010	13	19.5	48
	2011	12	18.5	46
	2012	14	20.5	51
Forest Ridge	1998	7	10.5	26
	1999	11	14.0	35
	2000	7	10.5	26
	2001	9	12.5	31
	2002	11	13.0	32
	2003	9	12.5	31
	2004	13	17.5	43
	2005	11	15.0	37
	2006	16	21.0	52
	2007	4	9.0	22
	2008	7	10.5	26
	Average	10	13.0	32
	Initiation of Color Banding			
	2009	10	14.0	35
	2010	10	15.0	37
	2011	13	16.5	41
	2012	13	18	44

Appendix D: Golden-cheeked Warbler 40.5-Hectare Study Plot Territory Data (continued).

Plot Name	Survey Year	No. of Full Territories	No. of Full Territories + 50% of Edge Territories	No. of Territories per 100 ha
Transitional Plots				
Bohls	1998	3	4.0	10
	1999	1	4.0	10
	2000	1	3.0	7
	2001	5	6.5	16
	2002	4	5.5	14
	2003	4	6.5	16
	2004	5	8.0	20
	2005	6	8.0	20
	2006	3	6.5	16
	2007	1	4.0	10
	2008	1	3.0	7
	Average	4	5.0	13
	Initiation of Color Banding			
	2009	2	3.5	9
	2010	3	3.0	7
	2011, 2012	--	--	--
Canyon Creek	1998	0	4.0	10
	1999	2	4.5	11
	2000	0	4.0	10
	2001	3	7.5	19
	2003	0	3.5	9
	2005	3	8.0	20
	2007	3	6.5	16
	Average	2	5.0	13
	Initiation of Color Banding			
	2009	3	10.0	25
	2010	6	10.0	25
	2011	--	--	--
	2012	6	11.0	27
Double J&T	1998	2	2.5	6
	1999	0	0.5	1
	2000	0	0.5	1
	2001	2	3.0	7
	2003	3	3.5	9
	2005	6	6.5	16
	2007	3	3.5	9
	Average	2	3.0	6
	Initiation of Color Banding			
	2009	2	2.5	6
	2010	3	3.0	7
	2011	3	3.5	9
	2012	4	4.0	10
Transitional Plot (Added in 2010)				
Hamilton West	2010	2	8	20
	2011	8	14	35
	2012	6	8	20

Appendix E: Golden-cheeked Warbler 40.5-Hectare Study Plot Age Structure Data for All Territorial Males. A summary of golden-cheeked warbler male age structure data for five prime study plots, three transitional study plots, and the Hamilton West transitional plot on the City of Austin's BCP, Travis County, Texas, field seasons 2009-2012. See Methods section for calculations.

Plot	Survey Year	% SY Males	%AHY Males	%ASY Males	Total No. Banded Males	Total No. Unbanded Males	% Banded Males
Prime Plots							
Barton Creek	2009	20	20	60	5	3	63
	2010	22	0	78	9	1	90
	2011	0	0	100	6	3	67
	2012	0	0	100	5	2	71
Emma Long	2009	0	0	100	13	6	68
	2010	11	0	89	9	7	56
	2011	27	0	73	11	5	69
	2012	10	0	90	10	8	56
Forest Ridge	2009	20	7	73	15	3	83
	2010	21	0	79	14	6	70
	2011	35	0	65	17	3	85
	2012	0	0	100	16	7	67
Butler	2009	53	18	29	17	8	68
	2010	33	0	67	15	5	75
	2011	62	0	37	16	6	73
	2012	53	5	42	19	5	79
3M/St. Edwards	2009	30	0	70	20	7	74
	2010	38	0	63	16	10	62
	2011	56	0	44	18	7	72
	2012	29	0	71	21	6	78
Transitional Plots							
Double J&T	2009	100	0	0	1	2	33
	2010	67	0	33	3	0	100
	2011	100	0	0	2	2	50
	2012	100	0	0	1	3	25
Bohls	2009	0	0	100	2	3	40
	2010	67	0	33	3	0	100
	2011, 2012	--	--	--	--	--	--
Canyon Creek	2009	27	7	67	15	2	88
	2010	36	0	64	11	3	79
	2011, 2012	--	--	--	--	--	--
Hamilton West	2010	40	0	60	10	4	71
	2011	60	13	27	15	5	75
	2012	29	14	57	7	3	70

Appendix F: Golden-cheeked Warbler 40.5-Hectare Study Plot Return Rates for All Banded Males. A summary of golden-cheeked warbler banding and resighting data for five prime study plots, three transitional study plots, and the Hamilton West transitional plot on the City of Austin's BCP, Travis County, Texas, field seasons 2009-2012. See Methods section for calculations.

Plot Name	Survey Year	Males Banded	2009 Returning Males	2010 Returning Males	No. 2011 Returning Males	Total Returning Males
Prime Plots						
Barton Creek	2009	6	--	--	--	--
	2010	7	4 (67%)	--	--	--
	2011	3	1 (17%)	2 (29%)	--	3 (23%)
	2012	7	1 (17%)	1 (14%)	1 (33%)	3 (19%)
Emma Long	2009	14	--	--	--	--
	2010	3	9 (64%)	--	--	--
	2011	10	3 (21%)	2 (67%)	--	5 (29%)
	2012	3	0	2 (67%)	7 (70%)	9 (33%)
Forest Ridge	2009	16	--	--	--	--
	2010	6	7 (44%)	--	--	--
	2011	18	3 (19%)	2 (33%)	--	5 (23%)
	2012	4	1 (6%)	3 (50%)	10 (56%)	14 (35%)
Butler	2009	21	--	--	--	--
	2010	11	10 (48%)	--	--	--
	2011	10	7 (33%)	5 (45%)	--	12 (36%)
	2012	13	3 (14%)	2 (18%)	5 (50%)	10 (24%)
3M/St. Edwards	2009	22	--	--	--	--
	2010	11	12 (57%)	--	--	--
	2011	16	4 (18%)	3 (27%)	--	7 (21%)
	2012	12	2 (9%)	1 (9%)	12 (75%)	15 (31%)
Transitional Plots						
Double J&T	2009	1	--	--	--	--
	2010	3	0	--	--	--
	2011	2	0	0	--	0
	2012	2	0	0	0	0
Bohls	2009	2	--	--	--	--
	2010	4	0	--	--	--
	2011	--	0	1 (25%)	--	1 (17%)
	2012	--	0	1 (25%)	--	1 (17%)
Canyon Creek	2009	15	--	--	--	--
	2010	8	2 (13%)	--	--	--
	2011	--	0	4 (50%)	--	4 (17%)
	2012	--	0	5 (63%)	--	5 (22%)
Hamilton West	2009	4	--	--	--	--
	2010	11	2 (50%)	--	--	--
	2011	11	1 (25%)	7 (64%)	--	8 (53%)
	2012	4	0	1 (9%)	4 (36%)	5 (19%)

Appendix G: Golden-cheeked Warbler 40.5-Hectare Study Plot Reproductive Success Data. A summary of golden-cheeked warbler reproductive success data for full territories within five prime study plots and the Hamilton West transitional plot on the City of Austin's BCP, Travis County, Texas, field seasons 1998-2012. See Methods section for calculations.

Plot Name	Survey Year	Pairing Success	Breeding Success	Productivity per Successful Territory	Productivity per Full Territory
Prime Plots					
Barton Creek	1998	0.50	0.50	2.00	1.30
	1999	1.00	1.00	2.20	2.20
	2000	0.80	0.40	1.50	0.60
	2001	1.00	0.67	2.50	1.67
	2002	1.00	0.50	2.00	1.00
	2003	1.00	1.00	1.50	1.50
	2004	1.00	0.67	1.50	1.00
	2005	1.00	1.00	3.00	3.00
	2006	0.83	0.67	2.25	1.50
	2007	0.83	0.83	2.60	2.17
	2008	1.00	1.00	2.75	2.75
	Average	0.91	0.75	2.16	1.70
	Initiation of Color Banding				
	2009	1.00	1.00	3.00	3.00
	2010	1.00	1.00	4.00	4.00
	2011	1.00	0.75	3.33	2.50
	2012	1.00	1.00	3.00	3.00
Emma Long	1998	1.00	1.00	2.30	1.30
	1999	0.86	0.86	2.30	2.00
	2000	0.42	0.17	2.00	0.33
	2001	0.71	0.64	1.78	1.06
	2002	0.67	0.39	1.70	0.66
	2003	0.71	0.50	2.40	1.21
	2004	0.82	0.45	2.60	1.18
	2005	0.86	0.43	2.17	0.93
	2006	0.90	0.71	2.27	1.62
	2007	0.80	0.80	2.25	1.80
	2008	0.89	0.78	2.43	1.89
	Average	0.79	0.61	2.20	1.27
	Initiation of Color Banding				
	2009	1.00	0.78	1.86	1.44
	2010	0.90	0.50	1.60	0.80
	2011	1.00	1.00	3.08	3.70
	2012	1.00	0.91	3.10	2.80

Appendix G: Golden-cheeked Warbler 40.5-Hectare Study Plot Reproductive Success Data (continued).

Plot Name	Survey Year	Pairing Success	Breeding Success	Productivity per Successful Territory	Productivity per Full Territory
Butler	1998	0.43	0.43	2.70	1.30
	1999	0.50	0.50	2.80	1.30
	2000	0.14	0.14	3.00	0.43
	2001	1.00	1.00	3.00	3.00
	2002	0.67	0.56	3.00	1.70
	2003	0.69	0.69	2.70	1.80
	2004	0.58	0.33	3.00	1.00
	2005	0.53	0.27	2.50	0.67
	2006	0.70	0.30	2.17	0.65
	2007	0.75	0.63	2.40	1.50
	2008	0.63	0.38	2.33	0.88
	Average	0.60	0.48	2.69	1.29
	Initiation of Color Banding				
	2009	1.00	0.82	2.22	1.82
	2010	1.00	0.82	2.22	1.82
	2011	1.00	0.58	3.00	1.75
	2012	0.91	0.73	3.25	2.40
3M/St. Edwards	1998	0.83	0.33	2.50	0.80
	1999	0.71	0.43	1.70	0.70
	2000	0.43	0.29	2.50	0.71
	2001	0	0	0	0
	2002	0.22	0.11	1.00	0.10
	2003	0.38	0.50	1.50	0.43
	2004	0.67	0.50	2.00	1.00
	2005	0.71	0.71	1.60	1.14
	2006	1.00	1.00	2.38	2.38
	2007	0.83	0.83	3.20	2.67
	2008	0.86	0.71	2.00	1.43
	Average	0.60	0.49	1.85	1.03
	Initiation of Color Banding				
	2009	0.89	0.67	2.50	1.67
	2010	1.00	1.00	2.54	2.54
	2011	1.00	0.50	2.17	1.08
	2012	1.00	0.71	3.30	2.40
Forest Ridge	1998	0.57	0.43	2.30	1.10
	1999	0.67	0.55	2.70	1.50
	2000	0.86	0.71	2.80	2.00
	2001	0.78	0.44	2.50	1.30
	2002	0.82	0.45	2.60	1.20
	2003	0.78	0.67	2.30	1.60
	2004	0.54	0.54	3.00	1.62
	2005	0.91	0.73	1.75	1.27
	2006	1.00	0.78	2.50	1.94
	2007	1.00	1.00	2.00	2.00
	2008	1.00	0.57	2.50	1.43
	Average	0.81	0.62	2.45	1.54
	Initiation of Color Banding				
	2009	0.80	0.80	1.88	1.50
	2010	0.70	0.70	1.86	1.30
	2011	1.00	0.77	1.90	1.46
	2012	0.85	0.77	3.40	2.60
Transitional Plot (Added 2010)					
Hamilton West	2010	1.00	1.00	2.50	2.50
	2011	0.90	0.50	2.80	1.75
	2012	0.83	0.67	2.25	1.50

Appendix H: Golden-cheeked Warbler Population Viability and Habitat Suitability within the BCP and Pilot Recreation Study, Progress Report for Year 1 (2011).

GOLDEN-CHEEKED WARBLER POPULATION VIABILITY AND HABITAT SUITABILITY WITHIN THE BALCONES CANYONLANDS PRESERVE AND PILOT RECREATION STUDY TO EXAMINE IMPACTS OF TRAILS: YEAR 1 PROGRESS REPORT, 2012

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Background

In 2011, the City of Austin entered into a 5-year agreement with the U.S. Forest Service to conduct a population viability and habitat suitability analysis for golden-cheeked warblers on the Balcones Canyonlands Preserve (BCP). During year 1, we focused on a collaborative effort between all cooperating partners to implement more rigorous field methods to collect the necessary data and identified additional focal areas to ensure adequate sampling across available and occupied habitat. We collected demographic data on a series of existing and new intensive monitoring plots. Additionally, we conducted point count and vegetation surveys across the BCP. We present preliminary results from the point count and vegetation surveys, nest monitoring, productivity, and pilot recreation study and provide recommendations for improved monitoring in subsequent years.

Methods – Population Viability and Habitat Suitability Study

Point Counts - We created a point grid with 250-m spacing and overlaid it on BCP in ArcMap 9.3, resulting in random-systematic coverage of the entire study area (Fig. 1). We removed points that were <50 m from major roads because the plot would be partly composed of roadway and decreased ability to hear over road noise. This results in a total of 1,820 points within the BCP. We built point transects consisting of 8-12 points based on topography and access. To ensure even coverage each year, we defined 9 patches of interest, based on patch connectiveness, and divided the final transects in each patch by 3, such that at the end of three years, all points would be surveyed. We selected every third transect to be surveyed in year 1 (Fig. 2).

We conducted 10-minute, unlimited radius point counts from 10 minutes post-sunrise until approximately 11:00am from April 7 through May 7, 2011. Counts were surveyed in good weather conditions (>50°, <12 mph winds, no or light precipitation). At each point, we recorded time of, distance to, and type of (song, call, visual) initial detections of individuals of 10 species, including golden-cheeked warblers and

black-capped vireos. Additionally, we recorded weather information and UTM coordinates. Distances were measured with a laser range-finder or estimated directly. Observers had prior experience working with the focal species.

We estimated detection probability and density based on distance-sampling using program Distance 6.0. This method estimates a portion of the detection probability, detectability (the probability that a bird giving a detectable cue is detected by the observer). We evaluated the fit of the data and decided based on differences with the observers to model each observer separately. We calculated the effective detection radius (EDR) and detection probability (p) for each observer. The EDR defines the radius beyond which as many animals are detected as are missed within the EDR; therefore the true density can be estimated as the count divided by the area defined by the EDR.

We measured vegetation composition and structure at each point. We averaged canopy cover measured with a densiometer in the four cardinal directions at the point. We counted small stems (woody stems >10 cm high and <2.5 cm at dbh) of junipers, live oaks, other oaks, other deciduous (shrub species) and exotics in a 5-m radius around the point and converted the sums to density per ha. We averaged ground cover estimated in each quadrant for four categories (shrub, grass/forb, bare/rock/debris, and litter) in a 5-m radius around the point. We averaged juniper and oak/hardwood tree height in each quadrant in an 11.3-m radius. We recorded dbh of all live oaks, Texas red oaks, shin oaks, and other trees >2.5 cm with a Biltmore stick in an 11.3-m radius from the point and converted the sums to stand basal area per ha. We also classified live oaks and deciduous trees as large (≥15 cm) and small (<15 cm) and summed the counts per ha as an alternative to stand basal area. Due to dbh measurement errors for multi-trunked trees (each trunk was treated as independent rather than grouped by tree), dbh of Ashe junipers are not included in the 2011 results. The field measurements have been corrected and will be used in future years of this study.

We calculated landscape metrics in ArcMap and Fragstats using the Texas Ecological Systems phase 1 vegetation classification. We calculated the proportion of total forest and 3 forest types (juniper-dominated, mixed, hardwood-dominated [deciduous and live oak]) at two spatial scales - within a 1-km radius and within 100-m radius of each point. We also calculated edge density (the interface between forest and non-forest) in a 100-m radius from each point.

We modeled the effect of our vegetation and landscape variables on golden-cheeked warbler density using generalized linear models that adjusted counts with an offset term that was the observer-specific EDR. We lumped non-junipers for small stem density and basal area and examined variables for correlation. Correlated variables were not included within individual models. We evaluated support for 10 vegetation models and 5 landscape models using an information-theoretic approach by ranking the ΔAIC_c and corresponding Akaike's weights (w_i). We used the most supported models to predict golden-cheeked warbler density for different values of the habitat and landscape covariates. We used a parametric bootstrap procedure based on 1000 iterations to incorporate uncertainty in the EDR estimates

into the confidence limits around the density estimates. We used the most supported landscape model (because we were able to predict across the entire BCP) to create a density map of the BCP in a GIS based on a 10-m pixel resolution.

Intensive Study Plots - We searched for nests and fledglings of golden-cheeked warblers on 19 intensive monitoring plots (21-107 ha) situated on 7 of the 9 patches (or 5 of 6 macrosites). Nests were monitored every 1-4 days until the nest fledged young or failed. At the end of the field season, we collected vegetation measurements at each nest. Measurements included all those measured at points and described above, and several unique to nests. We calculated the nest height and the nest tree height and measured the dbh of the nest tree. The dbh of multi-trunked nest trees was measured as the sum of the largest trunk plus one-half of each of the smaller trunks. We estimated the distance between the nest and the main trunk along the branch it extended out on. We recorded the distance as zero if the nest was positioned against a main vertical trunk or branch. We visually estimated nest cover 1 m above, below and in each cardinal direction (as 100% minus the percent of the nest visible) and averaged these to arrive at a single estimate. We also calculated the same landscape metrics used in the abundance analysis and described above.

We used an information-theoretic approach to evaluate candidate models representing our *a priori* predictions about factors affecting golden-cheeked warbler nest survival. We developed 7 models and ranked model support by Akaike's weights (w_i). We included day of year and nest stage in every model because they are known to affect golden-cheeked warbler nest survival (Reidy et al. 2009) and we wanted to control for their effect. We assessed whether any of our variables were correlated; correlated variables did not appear in the same model. We considered only active nests and excluded intervals in the building stage for the analysis. We estimated daily survival using the logistic exposure method with a binomial response for each monitoring interval (success=1, failure=0). We predicted nest survival as a function of the variables in the most supported model by varying the variable across the observed range of values while holding other variables at their mean.

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

Methods – Recreation Study

Study Sites – This progress report presents results only for the Bike Park and Coldwater tracts and does not include the original control site (Forest Ridge) in the Davis et al. (2010) study. The Bike Park has a high trail density (at least 143 m/ha), is composed of open and closed-canopy trails, and allows the use of both mountain bikes and motorized dirt bikes during the golden-cheeked warbler breeding season. There is no public access on Coldwater, but some closed-canopy trails and abandoned open-canopy ranch roads

exist (at least 40 m/ha). Both sites have similar habitat composition, with 96% and 92% classified as juniper woodland for the Bike Park and Coldwater, respectively.

Age structure/return rates- To calculate age structure, the number of territorial SY males was divided by the total number of territorial males with a known age. All males were aged as SY or ASY. The percentage of males banded on each site in 2010 that returned to the site in 2011 is also reported.

Territory size and density – We delineated territories using the same methods as City of Austin (2011), with the exception that we did not include observations of males with young >2 days out of the nest because movement patterns may shift at this point. To determine territory size, we calculated minimum convex polygons (MCP) for territorial males using the Hawth's Tools extension in ArcMap 9.3. We calculated Verner's territory density by dividing the number of full territories and ½ of edge territories by the site area. We calculated the trail density within each MCP and total trail density within each site (reported above under study site) by dividing the total trail length by territory and plot size. We used a generalized linear model (GLM) to compare territory size, territory density, and trail density within each MCP.

Reproductive success – Reproductive success was based on the same methods as City of Austin (2011). In addition, we monitored as many nests as possible with video cameras following protocols developed by Stake et al. (2004) and Reidy et al. (2008). Nests that we could not monitor with cameras were monitored by standing at the nest flag >5 m from the nest tree and watching the nest for adult activity for up to 30 minutes. We categorized nest fate as successful if we verified that at least one host young fledged. If no fledglings were verified, we categorized the nest as failed. We calculated apparent nest success as the number of successful nests divided by the number of active monitored nests. For territories in which we were unable to locate a nest, we continued to actively search for fledglings until early June. We considered a territory successful if we monitored a successful nest or confirmed at least one host juvenile being tended to by the territorial adults. In 2011, we increased our effort to locate all fledglings produced for territories. We calculated productivity as the total number of young divided by the total number of territories with a known territory success status and as the number of young divided by successful territories. We used a GLM to compare pairing, apparent nest success, and territory success between sites.

Nest survival - We used an information-theoretic approach to evaluate 8 models representing *a priori* predictions about factors affecting golden-cheeked nest survival. Day of monitoring was included in all models because it is known to affect golden-cheeked nest survival (Reidy et al. 2009) and because we considered it a nuisance parameter that we wanted to control for. Due to few observations in the egg stage and overall low numbers of nests, we chose not to evaluate effects of nest stage and year. Additionally, because we attempted to control for habitat composition, we did not further evaluate landscape features. Therefore the focus of the 2011 analysis was on nest site and nest patch variables. We included only active nests and excluded observations from the building stage for this analysis.

Because site and trail density were correlated, they were not included in the same model. We evaluated support using Akaike's information criterion (AIC_c) and ranked the models by the ΔAIC_c (difference in model AIC_c from top model, top model AIC_c=0) and Akaike's weight (w_i). We used the logistic exposure method to model variables of interest and estimate nest survival rates. We estimated daily survival as a function of the variables of interest, and calculated period survival by exponentiating daily survival by 25 (the number of days in the nest cycle). We varied the value of continuous variables by the range of observed values while holding other variables at their mean, whereas we used the observed proportion for categorical variables.

Vegetation surveys - We collected vegetation measurements around all active nests using methods described in City of Austin (2011) and in the point count methods in this report. Dbh measurement errors preclude using the 2011 data for Ashe junipers except for the nest trees, where dbh was re-measured. We calculated the following landscape metrics using Fragstats: edge (interface between forest and non-forest) density in 100-m radius around nests, and proportion of 3 forest types (juniper-dominated, mixed, and hardwood [live oak and deciduous]) within 1-km radius of nests. We calculated the trail density in a 100-m radius around nests in ArcMap 9.3. We compared site means for vegetation measurements with a t-test.

Results – Population Viability and Habitat Suitability Study

Point Counts - Two observers completed 44 transects comprised of 390 points (Fig. 2) and detected a total of 289 golden-cheeked warblers. Forty percent of the detections occurred in minute 1 of the survey with the remainder split between the next 9 mins. Approximately 70% of detections occurred within the first 5 mins. The distribution of distances to detected individuals varied greatly by observer suggesting observer-related detection issues. Therefore we modeled detection probability separately for each observer. Detection probability was 0.074 and 0.39 for observer 1 and observer 2, respectively. Effective detection radius was 54.25 m and 124.91 m for observer 1 and observer 2, respectively. Distance models produced an average density estimate of 0.39 (0.26-0.59) for the points surveyed. Incorporating the EDR as an offset in a generalized linear mixed model, our top landscape model included the variables edge density and the 3 forest types in a 1-km radius, and when used to predict density across the entire BCP (Fig. 3) produced an average density of 0.19 (0.17-0.21). Predicted density decreased with increased edge density (Fig. 4), and increased with increasing proportion of the 3 forest types (Fig. 5-7). Predicted warbler density increased with more non-grass ground cover (Fig. 8) and more shrub cover (Fig. 9).

We calculated the predicted abundance of golden-cheeked warbler males across the 19 intensive monitoring plots and compared the predicted abundance to abundance estimates produced from territory mapping (City of Austin 2011). For plots within large, contiguous patches the predicted abundance and mapped abundance were similar, but the model overestimated density for isolated, smaller patches (Table 1).

Intensive Study Plots - We located 107 nests in 2011, of which 14 had an unknown fate (10 failed between building and confirming incubation, 4 were last active in the nestling stage and nest fate was not able to be assigned due to inadequate monitoring). We deleted the 10 nests that failed prior to confirmed post-building activity and right-censored final observations for the other 4 nests with unknown fates. Daily nest survival based on 347 monitoring intervals was 0.972 (0.953-0.983) and period survival for the 25-day nesting cycle was 0.486 (0.306-0.645). The most supported model included nest height and nest cover in addition to the temporal variables. Nest survival declined throughout the season (Fig. 10) and was lower in the egg stage than nestling stage (0.962, CI: 0.914-0.984 versus 0.975, CI: 0.956-0.986), however only 25% of observations occurred in the egg stage.

The majority of nests were found in Ashe juniper (n=76, 71%), with the remainder in a variety of other dominant canopy trees, including cedar elms (n=9, 8%), live oak (n=18, 17%), red oak (n=1, 1%) and shin oak (n=3, 3%). Tree dbh averaged 25 cm, but the minimum recorded was 7 cm, suggesting even small diameter trees provide usable nesting substrates.

We monitored a total of 242 territories, of which we assigned a territory success fate to 221. We documented 402 fledglings on the intensive monitoring plots. Productivity was 1.82 young per territory and 2.70 young per successful territory. Successful territories with a nest monitored documented 3.15 fledglings whereas successful territories without a nest monitored documented 2.45 fledglings.

Results – Recreation Study

Territory size and density - During the 2010 field season, we were unable to gather >30 locations for the majority of territorial males so we created MCPs for males with >20 locations (Fig. 11). We increased survey effort in 2011 so we created MCPs for males with >30 locations (Fig. 12), which we believe more accurately reflects territory boundaries. Territory size and density did not differ by site (Table 2).

Age structure/return rates - We banded a high proportion of territorial males on the Coldwater and Bike Park sites in 2010 and 2011 (87%-100%) resulting in 0-2 unmarked males. The Bike Park supported an almost significantly larger percentage of young males in both 2010 and 2011 (Wald $\chi^2 = 3.39$, $P = 0.07$). The Bike Park had a lower return rate (25%, 2 of 8) in 2011 than Coldwater (42%, 5 of 12). In 2011, one male on the Bike Park returned to the same general area, while another moved ~300 m away (territory center). All males on Coldwater returned to the same general area. Older males had a higher return rate than younger males on both sites (33% vs 20% on the Bike Park and 50% vs 25% on Coldwater). There was an increase of territorial males on the both sites in 2011. These totals include full and edge territories and exclude one male on the Bike Park in 2010 that shifted to outside the study site shortly after arrival and in 2011 one male that could not be considered territorial.

Reproductive success - Pairing success overall was high, and did not differ between sites either year (Table 2). Apparent nest success was high, but due to small sample sizes, it was inappropriate to compare between sites and years. Territory success was marginally higher on Coldwater during 2011 than during

2010 or either year at the Bike Park (Table 2). Overall productivity for 2011 was slightly higher on Coldwater than the Bike Park (Table 2), but lower per successful territory.

Nest survival - Average daily nest survival was 0.977 (0.906-0.995). The most supported model included nest site attributes (nest height, nest cover, nest tree dbh); however there was substantial model selection uncertainty. There was some support for the model with trail density; survival decreased marginally with increased trail density (Fig 13). Odds of success were 14% greater for nests on Coldwater than the Bike Park, although confidence intervals were wide and overlapped one.

Nest vegetation- Eighteen nests were in Ashe juniper, 2 in cedar elm, and 1 in a live oak. We detected differences between sites for the following vegetation and landscape measurements: nest tree dbh, canopy cover, non-juniper and total small stem density, and edge density. Coldwater nests were in larger trees, had more canopy cover, more total and deciduous small stems, and higher edge density.

Conclusions and Recommendations

We successfully implemented the first year of the population viability and habitat suitability study. With the caveats noted in the methods and below, field methods and analyses were executed and performed as proposed. While the analyses summarized in this report indicate promising and insightful results, we caution against drawing strong inferences from these results because they represent preliminary analyses of the first years' data. We believe proceeding with the project as proposed will achieve its objectives and reiterate some important aspects of field methods below for achieving reliable estimates.

Most previous research has focused on predicting occupancy rather than abundance and much of that work has relied on remotely-sensed landscape features and no or a few field-based vegetation measurements (DeBoer and Diamond 2006, Watson et al. 2008, Collier et al. 2012). This study is the first to our knowledge to develop a spatially-explicit abundance distribution map built on sampling across multiple habitat types, not just within juniper-oak woodlands or within a generic forest classification, and utilizing field-based and remotely-sensed habitat measurements. We were able to predict density across the entire BCP from the results of the avian surveys using the relationship we found between abundance and landscape metrics. The final abundance distribution map will be based on field-based vegetation measurements, stand age maps, and GIS-derived metrics. Based on the number of transects completed in 2011, it will take >3 years to survey abundance across the entire BCP. However, at the conclusion, we will have amassed the most comprehensive abundance-habitat dataset available for golden-cheeked warblers. We provide evidence that the landscape-scale metrics we used were adequate for predicting abundance at large, contiguous patches, based on the comparison between territory mapping and predicted abundance, but are not adequate to predict abundance at smaller, more fragmented patches. This highlights two important issues: 1) we need to develop additional landscape scale metrics to represent patch isolation and fragmentation, and 2) habitat and landscape attributes that can successfully predict abundance at large patches may not work for small patches. We will investigate additional landscape indices such as patch cohesion and shape index in future years.

Thus far, most studies investigating reproductive success of golden-cheeked warblers have relied on reproductive indices such as the Vickery index (Lackey et al. 2011) or documenting host young being tended by adults (City of Austin 2010). However, tests of the Vickery method have proven it is unreliable and the ultimate rank does not correlate with actual reproductive success (Morgan et al. 2010). Using video monitoring at nests, Reidy et al. (2008) documented a fledgling rate of 3.6 young per successful nest in large, contiguous patches. Yet productivity for successful territories was reported as 2.70 (City of Austin 2011) and 2.68 young (City of Austin 2010). To increase the reliability of productivity estimates, we increased survey efforts in 2011 to locate and monitor nests and to locate all fledglings produced for each monitored territory. Despite the increased effort, productivity estimates for 2010 and 2011 are similar. However, fledgling counts for successful territories were higher from territories with a monitored nest versus those without, providing evidence that increased effort to locate nests provides more accurate data for estimating productivity. The nest survival analysis highlighted the need to locate nests earlier in the cycle, preferably in the building stage, and for better monitoring. Nest monitoring needs to be consistent and occur ~3 days, and more frequently near the predicted hatch and fledge days to increase accuracy of assigning nest stage, nest fate, and ultimately to locate all fledglings produced from a successful nest. Additionally, we identified a need to increase sampling in areas of lower canopy cover, increased slopes, more non-juniper forest, and more fragmentation.

While we did not detect significant effects of trail density on territory size or density or reproductive measures in 2010 and 2011, sample sizes for the Bike Park and Coldwater sites are small. However, the Bike Park did support a higher proportion of young males in both years and had a lower return rate, suggesting it may be serving as lower quality habitat. Additionally, point count surveys detected similar number of golden-cheeked warblers as territory mapping for both years at Coldwater, but far fewer at the Bike Park (Table 3). This suggests that detectability or availability or both was different between sites, but due to small sample size, we were unable to examine site-level detectability, and distance models assume availability is one. These results could result from behavioral effects on birds nesting at the Bike Park or could be spurious. Distance models overestimated actual abundance by about 4 times based on territory mapping. We recommend continued monitoring at these sites and sampling at additional sites to increase power to detect effects. These data will also be evaluated as part of the broader population viability and habitat suitability analyses. To effectively evaluate effects of recreation, current trail density maps and data on recreational activities during the nesting season (i.e., number of users per day, pathways taken for each user, etc.) are needed for these and other sites throughout the BCP.

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Figure 1. Point count survey locations (yellow dots) generated from random point grid with 250-meter spacing within 9 patches (color-coded) on Balcones Canyonlands Preserve. Removed points <50 m from major road because of reduced observer detectability.

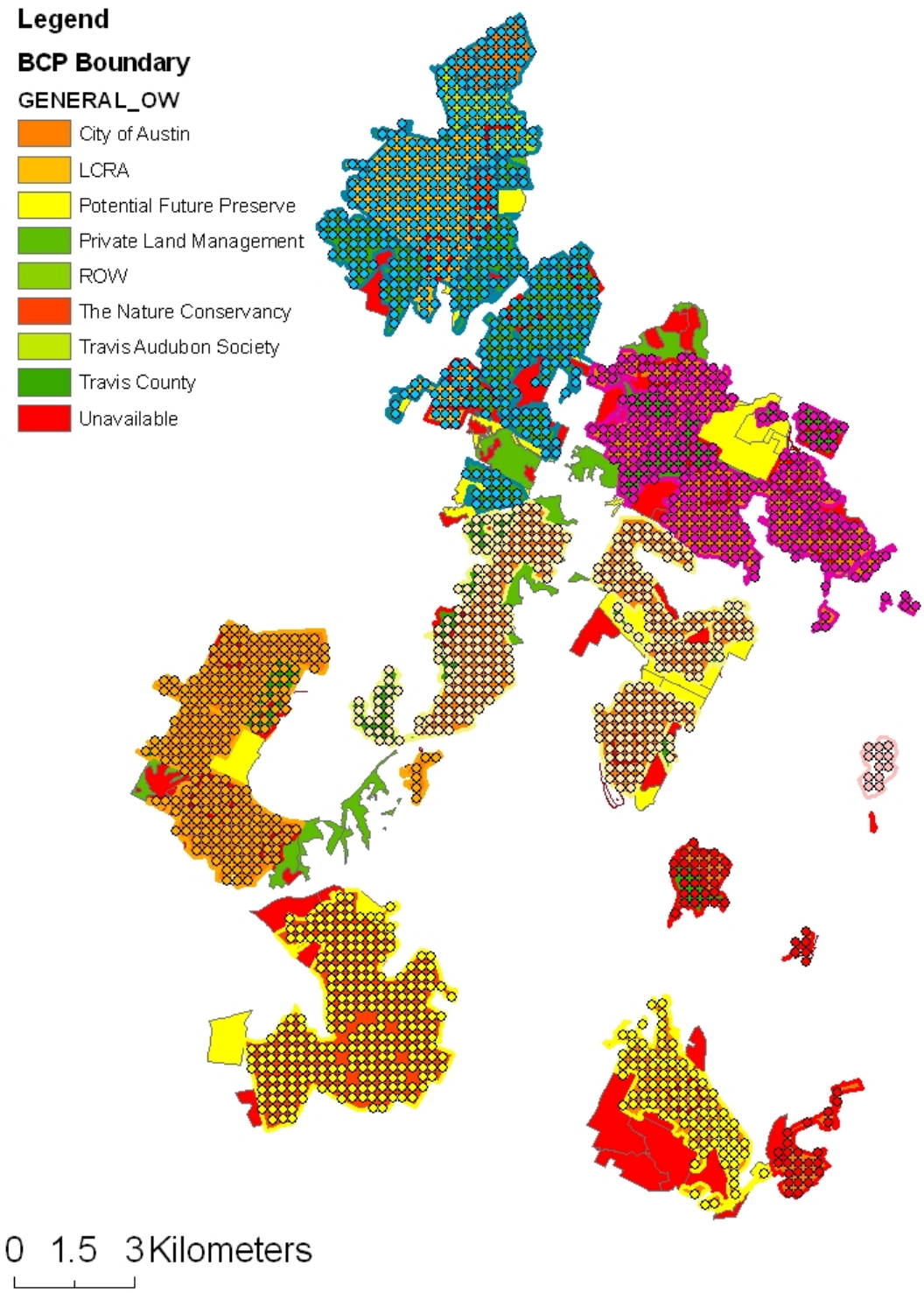


Figure 2. Locations of point count surveys (yellow dots) completed within 9 patches (color-coded) on Balcones Canyonlands Preserve in 2011.

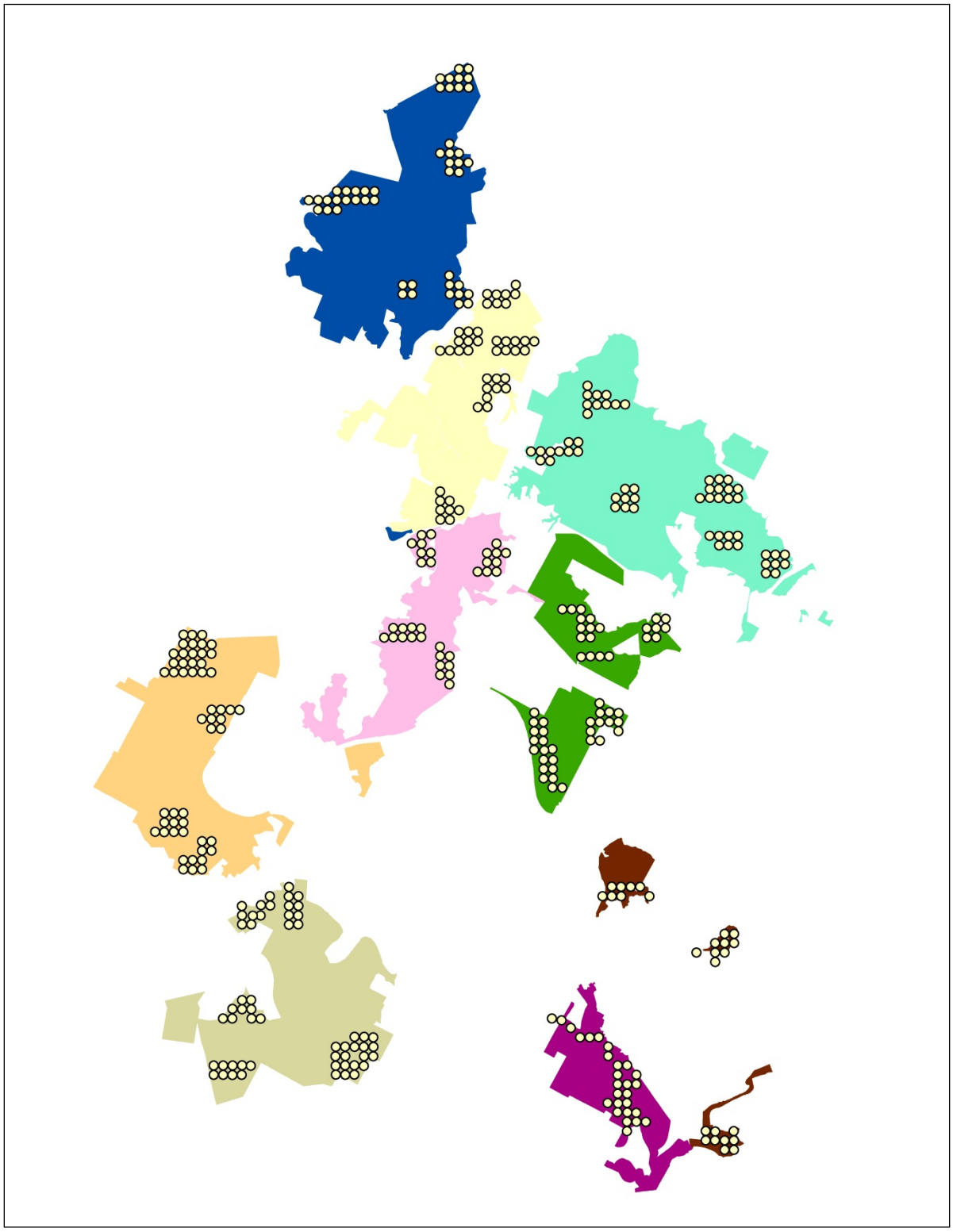


Figure 3. Density distribution map of golden-cheeked warblers (males/hectare) on Balcones Canyonlands Preserve, 2011.

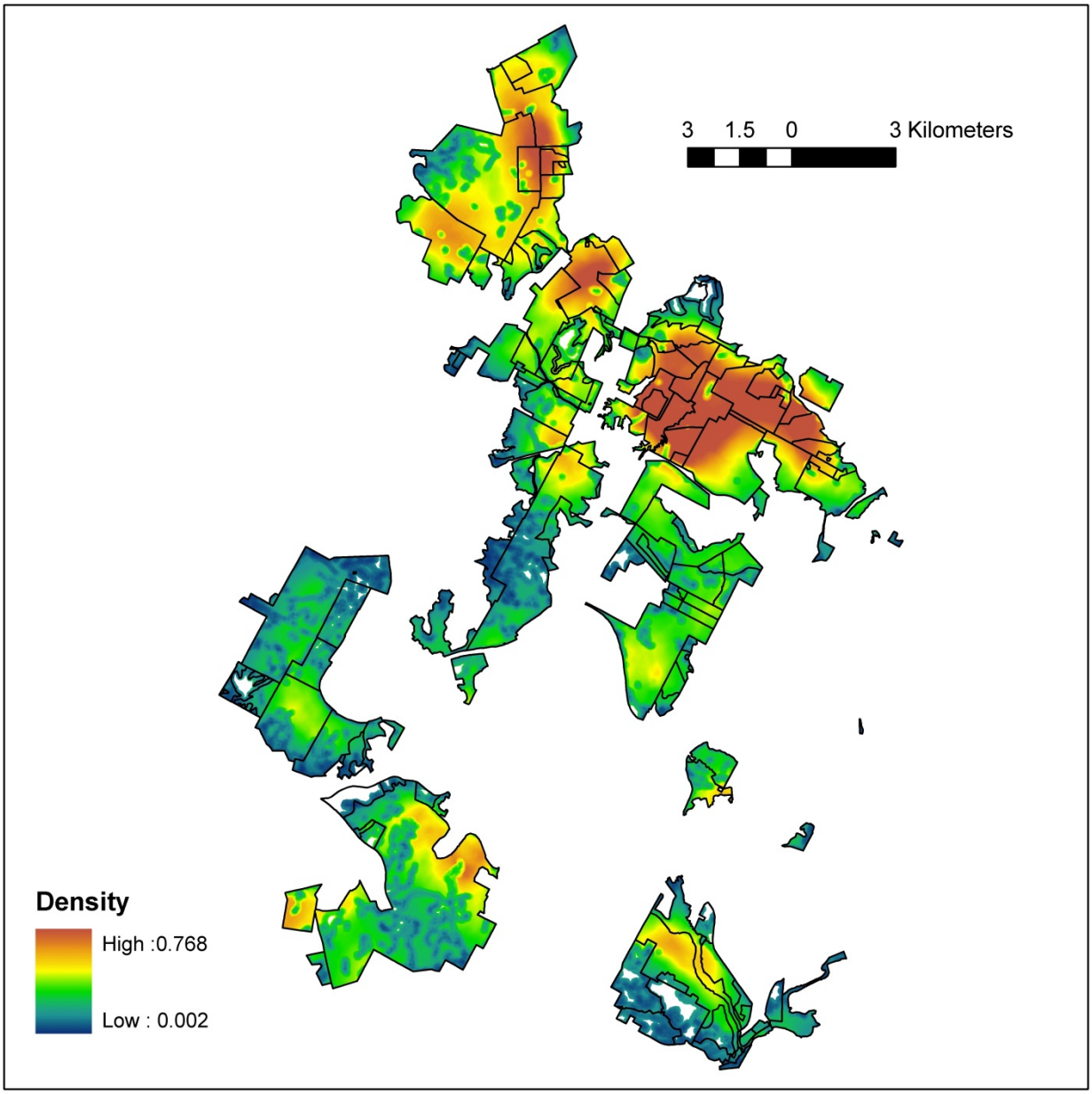


Figure 4. Predicted density of golden-cheeked warblers (males/hectare) on Balcones Canyonlands Preserve as a function of edge density, 2011.

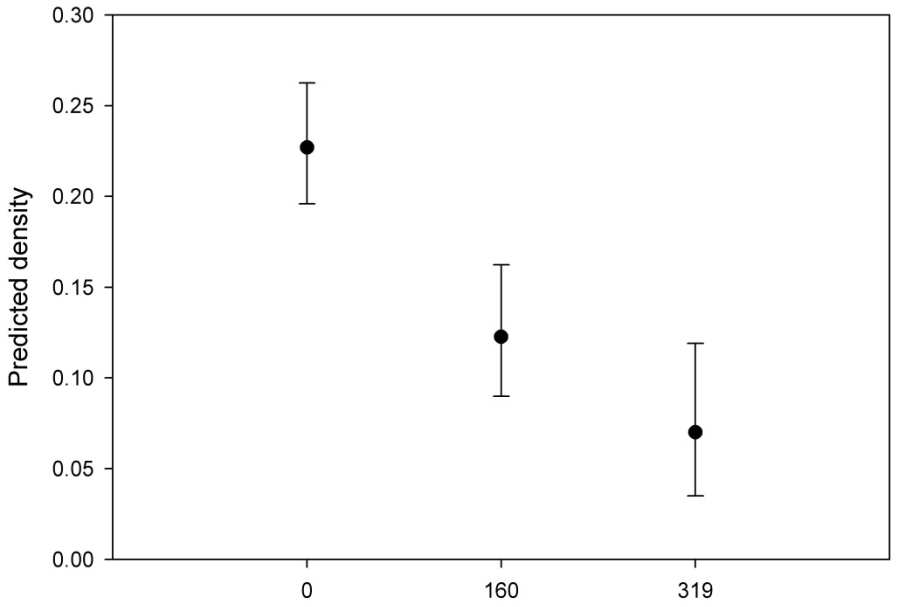


Figure 5. Predicted density of golden-cheeked warblers (males/hectare) on Balcones Canyonlands Preserve as a function of proportion of juniper forest in 1-km radius around points, 2011.

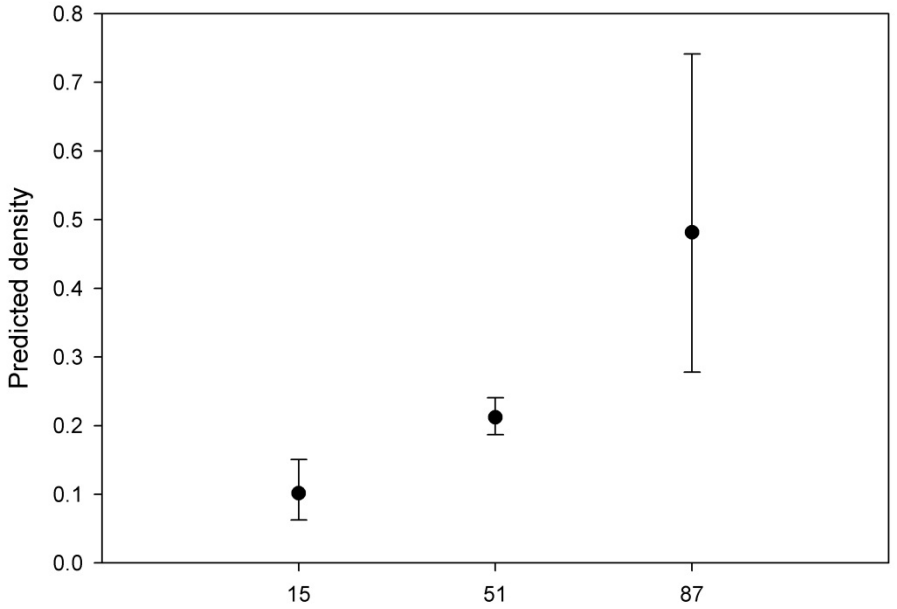


Figure 6. Predicted density of golden-cheeked warblers (males/hectare) on Balcones Canyonlands Preserve as a function of proportion of hardwood forest in 1-km radius around points, 2011.

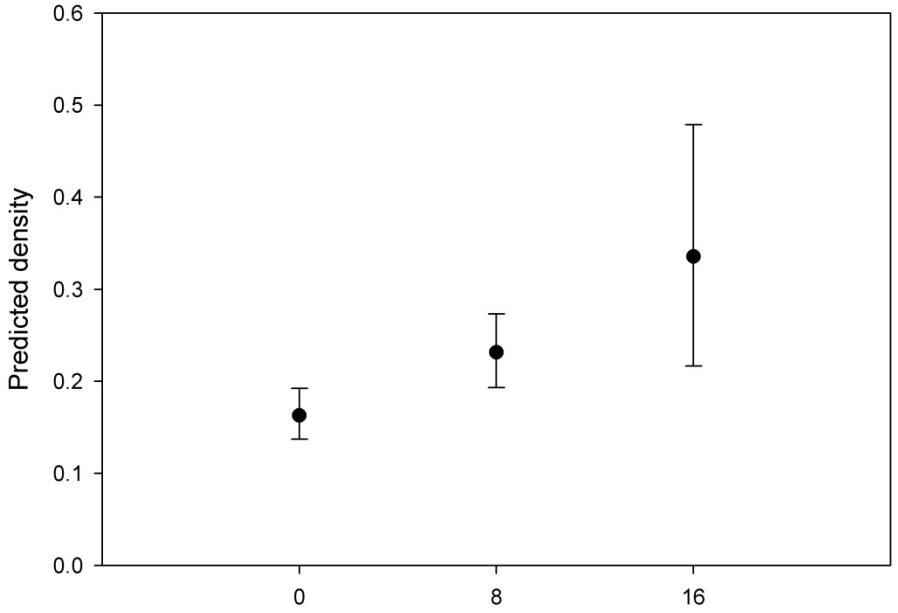


Figure 7. Predicted density of golden-cheeked warblers (males/hectare) on Balcones Canyonlands Preserve as a function of proportion of mixed forest in 1-km radius around points, 2011.

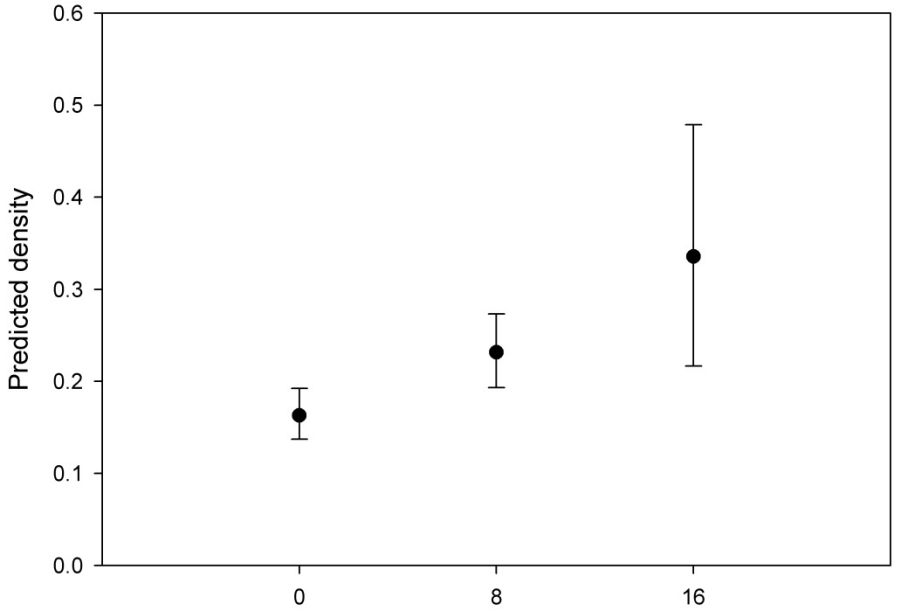


Figure 8. Predicted density of golden-cheeked warblers warblers (males/hectare) on Balcones Canyonlands Preserve as a function of proportion of non-grass (bare and litter) ground cover, 2011.

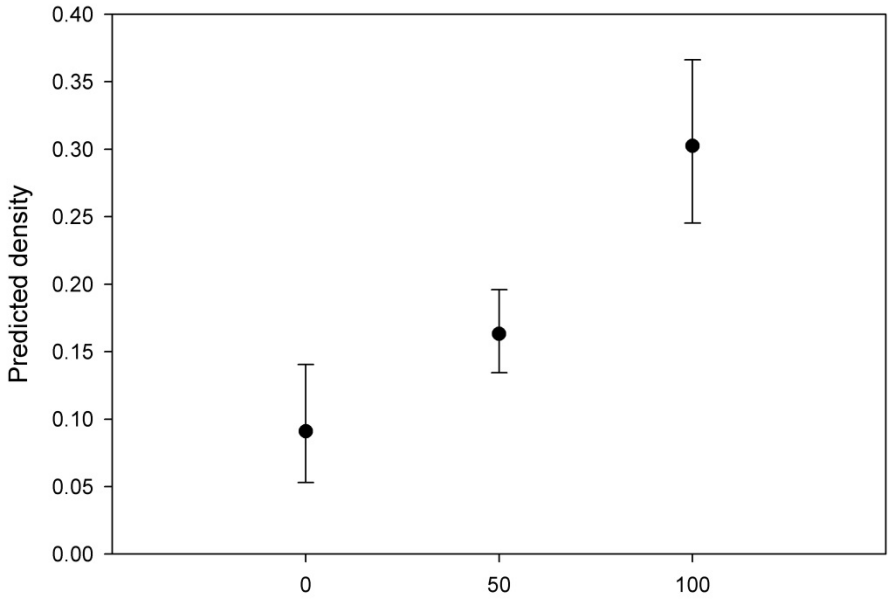


Figure 9. Predicted density of golden-cheeked warblers warblers (males/hectare) on Balcones Canyonlands Preserve as a function of proportion of shrubs, 2011.

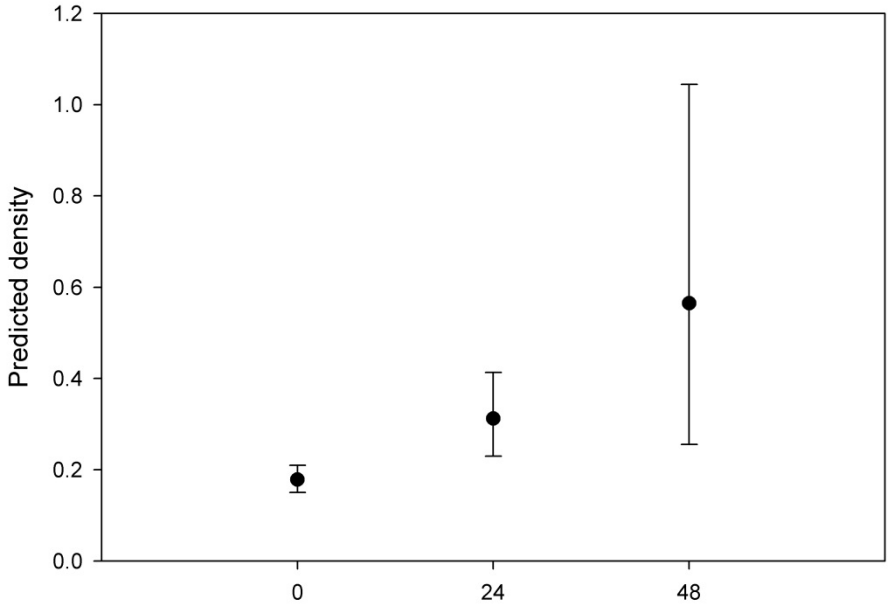


Figure 10. Daily nest survival of golden-cheeked warblers as a function of day of year on Balcones Canyonlands Preserve, 2011.

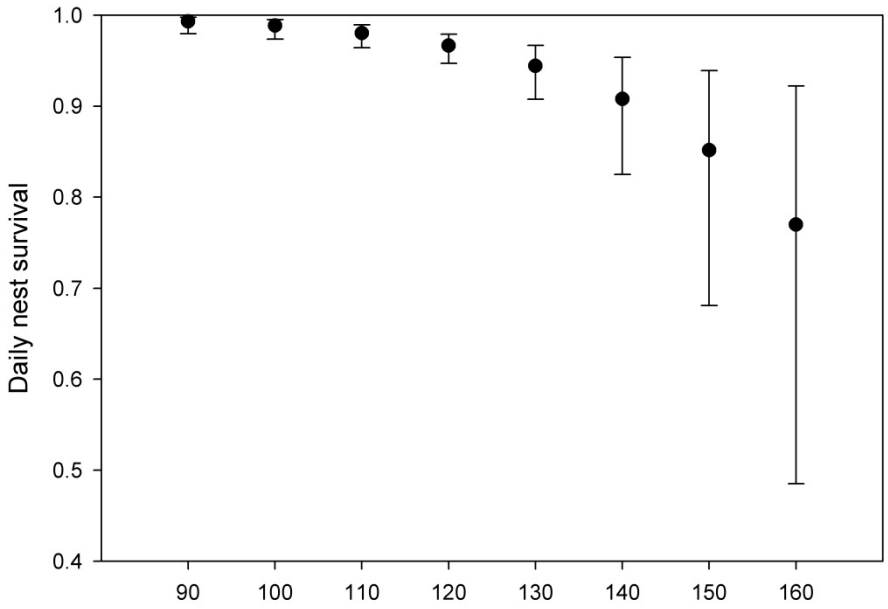


Figure 11. Minimum convex polygons (MCP) representing golden-cheeked warbler territories and trails (yellow lines) on Coldwater (orange outline) and the Bike Park (red outline) during 2010.



Figure 12. Minimum convex polygons (MCP) representing golden-cheeked warbler territories and trails (yellow lines) on Coldwater (orange outline) and the Bike Park (red outline) during 2011.



Figure 13. Period nest survival as a function of trail density (m/ha) in a 100-m radius around golden-cheeked nests monitored on Coldwater and the Bike Park during 2010 and 2011.

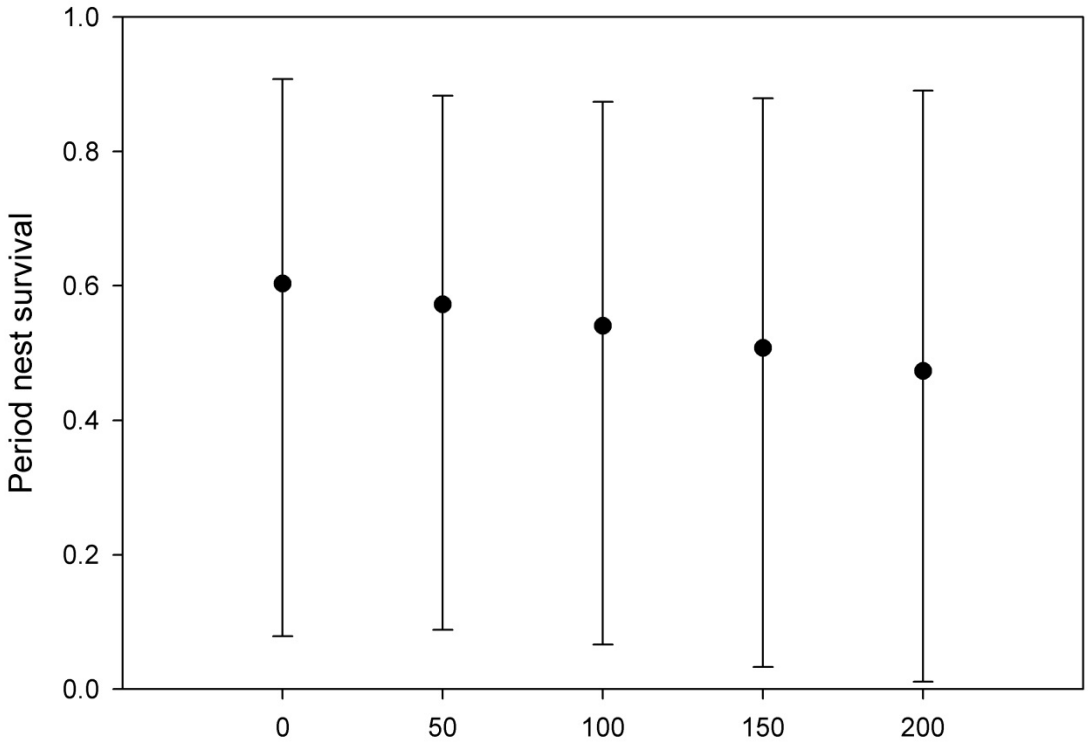


Table 1. Comparison of predicted plot abundance from point counts and abundance from territory mapping (full territories plus 0.5 edge territories) reported in City of Austin (2011).

Macrosite	Plot	Predicted abundance	Full +0.5 edge territories
Barton Creek	Barton Creek	14	6.5
Barton Creek	Gus Fruh	11	0.5
Barton Creek	Sunset Valley	8	1
Bull Creek	3M/St Eds	22.5	18.5
Bull Creek	Canyon Vista	12	16
Bull Creek	Forest Ridge	11	16.5
Bull Creek	Hamilton	20	14
Bull Creek	Ivanhoe	16	17
Cypress Creek	Baker	19	10.5
Cypress Creek	Lake Perspectives	10	7.5
Cypress Creek	Vireo Ridge	19	10
Cypress Creek	Vista Point	17	16
North Lake Austin	Bike Park	21.5	13.5
North Lake Austin	Coldwater	21	13.5
North Lake Austin	Emma Long	11.5	13
South Lake Austin	Double J&T	5	3.5
South Lake Austin	Reicher Ranch	11	3.5
West Austin	Ulrich	3	0
West Austin	Vireo Research Area/Wild Basin	35.5	9.5

Table 2. Total number of monitored territories, percentage of SY males, territory size (ha), site abundance (males per site calculated as the Verner's territory density divided by site area), trail density (m/ha), pairing, apparent nest, and territory success, and productivity on Coldwater and the Bike park during 2010 and 2011. Sample sizes are same as total number unless otherwise noted.

	Coldwater		Bike Park		*F*	*P*
	2010	2011	2010	2011		
Total number	12	15	8	14		
% SY males	33%	54%	63%	79%		
Territory size	4.2 ± 2.9	4.6 ± 2.1	3.3 ± 2.2	4.6 ± 2.0	0.08	0.78
Verner's territory density	0.88 ± 0.23	0.83 ± 0.24	0.81 ± 0.26	0.82 ± 0.25	3.05	0.22
Site abundance	9.8	11.7	6.6	11.6	0.38	0.61
Trail density	40.6 ± 50.1	32.1 ± 32.5	132.0 ± 54.7	115.1 ± 47.4	36.18	<0.0001
Pairing success	92% ± 29%	100% (n=14)	100%	92% ± 29% (n=12)	0.03	0.87
Apparent nest success	67 % ± 52% (n=6)	73 % ± 44% (n=13)	100% (n=3)	86% ± 69% (n=7)	--	--
Territory success	58% ± 51%	83% ± 39% (n=12)	63% ± 52%	64% ± 50% (n=11)	0.31	0.58
Productivity	--	3.00 (n=12)	--	2.45 (n=11)	--	--

Table 3. Total number of golden-cheeked warblers detected, estimated density and site abundance (truncated to max detection distance of 100 m), and distance-based density and abundance (truncated to max detection distance of 100 m).

	Coldwater (n=28)		Bike Park (n=21)	
Total detected	14	15	5	6
Density	0.16 (0.07-0.25)	0.17 (0.08-0.26)	0.08 (0.00-0.15)	0.09 (0.02-0.16)
Site abundance	17	7.5	18	9
Distance-based density	0.66 (0.39-1.13)	0.71 (0.41-1.22)	0.32 (0.18-0.54)	0.38 (0.22-0.65)
Distance-based abundance	71 (41-121)	76 (44-130)	31 (18-54)	37 (22-64)