City of Austin 2009
Golden-cheeked Warbler *(Dendroica chrysoparia)* and Black-capped Vireo *(Vireo atricapilla)* Monitoring Program

Balcones Canyonlands Preserve Annual Report
Fiscal Year 2008-09



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City of Austin Water Utility
Wildland Conservation Division
Balcones Canyonlands Preserve Program

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City of Austin

2009 Golden-cheeked Warbler and Black-capped Vireo Monitoring Program

Balcones Canyonlands Preserve Annual Report

FY 2008-09

This report summarizes the results of the City of Austin's 2009 golden-cheeked warbler (*Dendroica chrysoparia*) and black-capped vireo (*Vireo atricapilla*) endangered species monitoring program. The 2009 field season was the twelfth year of endangered species monitoring on the City of Austin's Balcones Canyonlands Preserve tracts. Highlights of the 2009 field season included initiating color banding of golden-cheeked warblers in conjunction with the 100-acre study plots. Results of the banding study and comparison with previous years is presented in the results and discussion section. 2009 was also the final year of a three-year color banding study by Texas State University to analyze natal and breeding dispersal of black-capped vireos.

I. GOLDEN-CHEEKED WARBLER MONITORING

INTRODUCTION

Background

The golden-cheeked warbler (hereafter, 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 continuing loss of warbler breeding habitat in western Travis County and to aid in the species' local recovery (BCP 1998). The BCP is managed by a number of private and public entities, including the City of Austin. The City of Austin manages approximately 13,600 acres of the BCP.

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 identifies the following goals and objectives: "The GCWA 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. Occupancy, survivorship, and productivity data are critical to assess population viability." Since the inception of the City of Austin's warbler monitoring program in 1998, the primary focus has been to estimate population size, territory density and trends, productivity, and distribution. To ensure the accuracy of the 100-acre plot methodology and allow for a more comprehensive examination of the warbler's demography within the BCP, the City of Austin initiated a pilot color banding study during the 2009 field season (City of Austin 2008a). The banding program is intended to provide information needed to understand underlying trends in abundance, including age structure/recruitment and return rates/survival, and more reliable estimates of densities and reproductive success.

METHODS

The warbler populations on the BCP and on the Balcones Canyonlands National Wildlife Refuge (BCNWR) are monitored in accordance with the Tier IIA-7 land management plan guidelines using a standardized, region-wide program (BCP 2007). Population and productivity trends are tracked on a series of 100-acre plots located on the BCP and BCNWR. The City of Austin collects data on territory density, territory location, pairing success, breeding success, and productivity for each 100-acre plot. The City of Austin also conducts territory enumerations over a larger area of the BCP to ascertain warbler distribution and to attempt to get a rough estimate of overall territory density. Territory enumerations were limited during the 2009 field season so that staff could focus on the pilot color banding study.

Study Sites

In field season 2009, warbler territories were mapped on five 100-acre "prime" study plots and three "transitional" study plots. Prime plots are defined as those with a minimum of 75 percent excellent warbler habitat (mature juniper-oak woodlands), and at least 70 percent canopy cover (BCP 2007). Prime plots are located on five different BCP tracts: Emma Long Metropolitan Park, Barton Creek Wilderness Preserve and Greenbelt, Ivanhoe, Forest Ridge, and 3M/St. Edwards (Appendix A). Staff biologists monitor these plots annually.

Transitional plots are located on three different BCP tracts: Bohls, Canyon Creek, and Double J&T (Appendix A). These plots comprise areas containing zero to a few warbler territories and may improve as warbler habitat within the next 30 years (BCP 1998). With the exception of the Bohls plot, transitional plots have been monitored every other year and were monitored in 2007, so data were collected again in 2009. Since the Bohls plot was changed from a prime plot to transitional in 2008 (City of Austin 2008b), it was monitored every year at the same level of effort as the prime plots until the 2009 field season.

In addition to the 100-acre plot surveys, enumeration surveys were conducted on the Barton Creek Wilderness Preserve and Greenbelt and Friesenhahn tract, Coldwater/Vaught Ranch, and the former Water Treatment Plant 4 site, comprising a total of 1575 acres.

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 savannas. 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.

It is thought that woodlands in western Travis County were logged in the late 1800s and early 1900s and are currently in various stages of recovery (Keddy-Hector 1996). After clearing, much of the topsoil was lost due to chaining and subsequent goat and cattle overgrazing. 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. 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 elbow bush (*Forestiera pubescens*). Descriptions of individual prime plots can be found in Abbruzzese and Koehler (2003), as well as in Tier III Land Management Plans for each property.

Region-wide Monitoring Program: 100-acre Study Plots

Color Banding

Color banding was conducted in conjunction with territory mapping (BCP 2007) on all of the eight permanent 100-acre study plots, from March 15 through May 13. Methods consisted of mist netting within a male warbler's territory and playback of a tape-recorded male warbler's song. 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 color band combinations were issued by The Nature Conservancy (TNC) staff at Ft. Hood Military Reservation. Other data collected during banding included date, time, GPS coordinates of the banding location, temperature, weather conditions, weight, and wing chord length. 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 TNC staff. Each warbler was photographed just prior to release to document band combinations and plumage characteristics.

Surveys on each of the prime plots were conducted once 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). 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, each prime plot was surveyed by two biologists. The three transitional plots were monitored every other week from March 15 through May 25. Due to the lower densities of warblers, the transitional plots were surveyed by one biologist. Because of the reduced level of effort, productivity data are typically not collected for transitional plots.

Warbler observations were primarily recorded with Garmin global positioning units (GPS), which have an accuracy of 9 to 20 feet. Other sightings were recorded on topographic maps at a scale of 1:3,600, using a 100-meter Universal Transverse Mercator (UTM) grid. For each observation, date, color combination (for observations of banded birds), UTM coordinates, and presence of female, nest, and/or fledglings were recorded. The data were then entered into ArcGIS and displayed so that territories could be delineated.

The monitoring program and data collection protocol are described in detail in 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 B 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. Appendix C lists surveyors and survey hours per plot.

Analysis of Age Structure (Recruitment). To estimate recruitment for each 100-acre plot, the number of territorial SY males was divided by the total number of territorial males with a known age. The percent of ASY and AHY males was also estimated for each plot.

Analysis of Territory Density on 100-Acre Plots. Territory size and configuration were based on observations during ten visits between March 15 and 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 and those locations were separated by 30 meters or more. Territorial

boundaries for each male were entered into ArcGIS and delineated using minimum convex polygons.

In 2009, the number of territories on 100-acre plots was calculated two ways: 1) full territories (territories contained entirely within the plot) and 2) 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). Finally, territory density is given as the number of territories (using Verner's counting method) per 100 hectares. These calculations were also applied during the previous eleven survey years for the 100-acre plots (Appendix D).

Analysis of Pairing and Productivity on Prime Plots. Productivity and mated status were estimated for full territories only. 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. The pairing success is the number of males determined to have paired divided by the number of full 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 full territories determined to have produced at least one fledgling divided by the total number of full territories. Productivity is the sum of the number of fledglings observed for all full territories. Average productivity is presented in two ways: 1) as the sum of all fledglings divided by the number of pairs that successfully bred (as defined above), and 2) as the sum of all fledglings divided by the total number of full territories.

Fecundity was derived by multiplying the total number of fledglings observed for all full territories within each prime plot by 0.5 [based on studies indicating a 1:1 ratio of male and female offspring for this species (Anders 2000)] and then dividing by the number of full territories with females. To allow for comparison with previous years, an estimate of the number of male offspring per territorial male was also calculated.

A summary of reproductive success data for each survey year since 1998 is provided in Appendix E.

Nest monitoring. Biologists located nests from mid-March through mid-June while working within and near the 100-acre 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 time limitations prevented frequent follow-up monitoring required to determine nest fate and number of fledglings produced for most nests. If nest fate was not

observed directly, a nest within a banded male's territory was assumed to have been successful only if young were being tended by that male 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, and nest tree height and diameter at breast height (dbh). 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. Other nest site and nest patch data, including distance of the nest to the main trunk, average height of junipers and oaks, canopy cover, nest cover, percent shrub cover, slope, stem density and basal area were collected but will be analyzed by Jennifer Reidy as part of a separate study.

Enumerations

An enumeration is a survey of all male warblers in a given area. This methodology provides information on distribution of the species over a large area. Enumerations typically require a minimum of three visits per survey area during good weather conditions (USFWS 1994). Incidental sightings of females and fledglings are also recorded, as are observations of parasitism and potential predators. Surveys were carried out by staff biologists and trained volunteers.

Enumeration surveys were conducted this year on all or portions of the Barton Creek Wilderness Preserve and Greenbelt and the Friesenhahn tract, former Water Treatment Plant 4 tract, and Coldwater/Vaught Ranch, comprising 1575 acres. For each survey in 2009, observers were directed to allow roughly one hour for each 25 acres of habitat for each of the 5 visits. This survey effort allows staff to cover a large portion of the preserve, but the results are less accurate than those obtained on the 100-acre prime plots. Surveyors attempted to sort out individual warblers to increase the accuracy of the count. However, significantly less time was spent on enumeration surveys per acre than on 100-acre prime plots (Appendix C). Therefore, enumerations provide only rough estimates of territory number and size due to a limited number of sightings. Because enumeration survey effort varies among tracts and among years, results are not comparable.

A complete list of properties on which enumerations were conducted, acres surveyed, surveyors, and survey effort for each tract are reported (Appendix C). Acreages listed are for

the areas that were surveyed within each tract (minus any 100-acre plot within the tract), not for the warbler habitat within the tract.

RESULTS AND DISCUSSION

100-acre Study Plots

Territory Densities and Locations. In field season 2009, average warbler territory density (based on the full + 0.5 edge calculation) for all eight plots was 11 territories/100 acres (27 territories/100 ha). Average territory density for the five prime plots was 14 territories/100 acres (35 territories/100 ha). Average density for the transitional plots was 5 territories/100 acres (13 territories/100 ha). Data on territory density are presented in Table 1.

Territory densities were highest in the largest habitat patches, the Bull Creek and North Lake Austin macrosites. The two prime plots near the center of the Bull Creek macrosite, 3M/St. Edwards and Ivanhoe, had the highest densities (18 territories/100 acres each), followed by Forest Ridge and Emma Long (14 territories/100 acres each), and the Canyon Creek transitional plot (10 territories/100 acres). Barton Creek had the lowest density of the prime plots (5 territories/100 acres) and half of the density estimate for the Canyon Creek plot in Bull Creek. The Bohls and Double J&T transitional plots had 3.5 and 2.5 territories/100 acres, respectively.

Figures 1-8 (Appendix F) depict warbler territory locations for the five prime plots and three transitional plots in field season 2009. 100-acre plot maps depict territories relative to topographic features and to other warbler territories. Territories are represented by minimum convex polygons drawn to connect the outermost observations of each territorial male. An "X" symbol on the figures represents an observation of a male warbler that does not have enough sightings or other information, such as identification of color band combinations or contemporaneous vocalizations, to assign it to an existing territory or to estimate territory boundaries. The "X" symbol on the figures is also used to represent floater males. Floaters are typically young males observed later in the season only on one or two occasions. Female and fledgling observations are summarized and depicted by estimated numbers for a territory.

Table 1. Golden-cheeked warbler territory number (per 100 acres) and estimated territory density (per 100 hectares) for each of the five 100-acre prime study plots on the City of Austin Balcones Canyonlands Preserve, Travis County, Texas, field season 2009. 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)	Territory Density 100 ha[1]
Barton Creek	2	8	5	12
Emma Long	9	19	14	35
Forest Ridge	10	18	14	35
Ivanhoe	11	25	18	44
3M/St. Edwards	9	27	18	44
Average	8		14	34
Double J&T	2	3	2.5	6
Bohls	2	5	3.5	9
Canyon Creek	3	17	10	25
Average	2		5	13

[1]Calculation based on Verner's counting method.

Color Banding. A total of 104 warblers were banded in 2009, including 97 males and 3 females on the eight 100-acre plots. In addition, 4 males were banded on former WTP4 site as part of an education and outreach event. Seventy-two percent (88) of the territorial males found on the 100-acre plots were banded (Table 2). Nine banded males were either observed outside of the 100-acre plots or were not observed again. The highest numbers of banded birds were on 3M/St. Edwards and Ivanhoe (20 and 17, respectively), followed by Forest Ridge (15), Canyon Creek (15), and Emma Long (13). One to five birds were banded on the Barton Creek (5), Bohls (2), and Double J&T (1) plots.

Age Structure (Recruitment). Of the 88 territorial males banded within the plots, 27 percent were SY, 66 percent were ASY, and 7 percent were AHY. All 13 males banded at Emma Long were ASY males (100%), while Ivanhoe had the highest percentage of SY males (53%). Barton Creek, Canyon Creek, Forest Ridge, and 3M/St. Edwards plots had 20 to 30 percent SY males. The different age structures observed among plots suggest habitat

characteristics may be influencing recruitment, but additional data are needed to understand the significance and potential underlying mechanisms.

Table 2. Golden-cheeked warbler age structure data for full and edge territories within each 100-acre plot.

Plot Name	% SY Males	%ASY Males	%AHY Males	Total # Banded	Total # Unbanded	% Banded
Barton Creek	20	60	20	5	3	63
Emma Long	0	100	0	13	6	68
Forest Ridge	20	73	7	15	3	83
Ivanhoe	53	29	18	17	8	68
3M/St. Edwards	30	70	0	20	7	74
Double J&T	100	0	0	1	2	33
Bohls	0	100	0	2	3	40
Canyon Creek	27	67	7	15	2	88
Overall Average	27	66	7			72

Comparison of Territory Density Estimates from Color Banding Data with Previous Years. Compared to long-term averages from the 11-year dataset (1998-2008; Appendix D) prior to the color banding study, the 2009 estimates differed by 0.5 to 2 territories for the five prime plots combined (long-term average = 13 territories/100 ac; 2009 = 14 territories/100 ac), the three transitional plots combined (long-term average = 4 territories/100 ac; 2009 = 5 territories/100 ac), four of the prime plots (Barton Creek, Emma Long, Ivanhoe, and Forest Ridge), and two of the transitional plots (Bohls, Double J&T). The 3M/St. Edwards and Canyon Creek plots increased by 7 and 5 territories, a factor of 1.6 and 2, respectively.

Compared to territory densities from 2008 (prime plots, Bohls) and 2007 (Canyon Creek, Double J&T), the 2009 estimates differed by 0.5 to 1 territory for the five prime plots combined, the three transitional plots combined, two of the prime plots (Barton Creek, Emma Long), and two of the transitional plots (Bohls, Double J&T). Ivanhoe, Forest Ridge, and Canyon Creek differed by 3.5 territories. The most significant difference in territory density estimates was an increase of 5 territories at 3M/St. Edwards.

The differences observed between 2009 and previous years are attributed to increased level of effort and accuracy, particularly for the prime plots, which were surveyed more frequently and more intensively than the transitional plots. The addition of color banding allows for accurate identification of multiple individuals, whereas territory mapping without color banded birds requires simultaneous countersinging to distinguish individuals. Further, having two surveyors and no time constraints for each prime plot allowed for more thorough coverage of these areas than in previous years. Continuation of color banding will help validate observed spatial and temporal changes in territory densities and provide additional data (return rates/survival, age structure/recruitment) needed to understand underlying causes of observed changes.

Pairing Success, Breeding Success, and Productivity. In 2009, a total of 41 full territories were monitored for pairing and productivity data. Average pairing rate for full territories on the five prime plots was 93 percent (Table 3). Barton Creek, Emma Long, and Ivanhoe had 100 percent pairing, and 3M/St. Edwards had 89 percent. Forest Ridge had two territories with unknown pairing success, so the pairing success may have been higher than the observed 80 percent. The increased pairing and reproductive success observed for the combined prime plots and for the Ivanhoe plot is most likely due to increased level of survey effort. In contrast, the Bohls transitional plot, which had 100 percent pairing success in 2008 when it was surveyed every week, had a pairing success of 50 percent in 2009 when it was surveyed every other week. The Double J&T and Canyon Creek transitional plots had an observed 0 and 67 percent pairing success, respectively.

Average breeding success for full territories on the five prime plots was 78 percent (Table 3). The two full territories on the Barton Creek tract had 100 percent breeding success, followed by Ivanhoe (82 percent), Forest Ridge (80 percent), Emma Long (78 percent), and 3M/St. Edwards (67 percent). No breeding was observed on any of the transitional plots. Again, this may be due in part to greater level of survey effort on the prime plots, particularly Barton Creek, which had 2 full territories compared to 9 to 11 on the other four prime plots.

A total of 69 fledglings were observed in the full territories on the five prime plots in 2009. Ivanhoe produced the greatest number of fledglings (20 fledglings observed; 9 territories producing young), while Barton Creek had the lowest number (6 observed, 2 territories producing young). For those territories that did produce offspring, the average productivity for all five plots was 2.16 fledglings. Average productivity for all full territories on the five prime plots was 1.68 fledglings. Number of male offspring per territorial male in the prime plots averaged 0.84. Fecundity (number of female offspring per full territory with a female) averaged 0.91.

Because nests and fledglings are difficult to locate, breeding success, productivity, and fecundity represent minimum estimates only. Females and males often split their broods and can travel long distances from nests shortly after their young have fledged. Also, young are often difficult to detect unless they are vocalizing. For example, camera surveillance recorded 4 fledglings from each of three nests, while only 2 to 3 fledglings were observed during subsequent field observations. Reidy et al. (2008) documented a mean number of 3.6 young fledged per successful nest in the BCP. Applying this estimate to the number of full territories producing one or more young on each of the five prime plots gives an adjusted total of 115 young fledged and an average productivity per full territory of 2.81, which is 1.7 times the observed value. These differences highlight the importance of locating and monitoring nests to determine the actual number of young fledged and estimate productivity more accurately.

Table 3. Golden-cheeked warbler reproductive success on 100-acre study plots on the City of Austin's Balcones Canyonlands Preserve, Travis County, Texas, field season 2009. Data are based on observations of full territories only. See Methods section for calculations.

Plot Name	No. of Full Territories	No. of Full Territories w/ Female	Pairing Success	No. of Full Territories Producing ≥ 1 Young	Breeding Success	Total No. of Fledglings Observed	Product. per Successful Territory	Product. per Full Territory	Adjusted Product. per Full Territory*
Prime Plots									
Barton Creek	2	2	1.00	2	1.00	6	3.00	3.00	3.60
Emma Long	9	9	1.00	7	0.78	13	1.86	1.44	2.80
Forest Ridge	10	8	0.80	8	0.80	15	1.88	1.50	2.88
Ivanhoe	11	11	1.00	9	0.82	20	2.22	1.82	2.95
3M/St. Edwards	9	8	0.89	6	0.67	15	2.50	1.67	2.40
Average			0.93		0.78		2.16	1.68	2.81
Transitional Plots									
Double J&T	2	0	0	0	0	0	0	0	--
Bohls	2	1	0.50	0	0	0	0	0	--
Canyon Creek	3	2	0.67	0	0	0	0	0	--
Average			0.43		0		0	0	--

*Based on mean number of 3.6 young per successful nest (Reidy et al. 2008).

Enumerations

The enumeration effort in 2009 totaled over 167 hours, covering three BCP tracts and 1575 acres (Appendix C). For each hour spent conducting enumerations in 2009, an average of 9.4 acres were covered. In contrast, for each hour spent conducting territory mapping on 100-acre prime plots in 2009, approximately 0.87 acres were covered. Because enumerations represent a lesser survey effort than territory mapping on 100-acre plots, results of enumerations should be considered rough estimates of distribution and territory numbers. It is expected that some territories are missed and some territories are represented as smaller than what they actually are due to being based on a limited number of sightings. In addition, some of the warbler observations that were outside of the enumeration survey areas were approximate locations based on auditory rather than visual cues.

Figures 9-11 (Appendix F) display the distribution of estimated territories, given the limitations described above. Polygons displayed on the maps represent best approximations of individual bird territories. A single dot on the figures represents what were believed to be a territorial warbler, but there were not enough observations recorded to create a minimum convex polygon. An "X" symbol on the figures represents an observation of a male warbler that did not have enough sightings or other information, such as identification of color band combinations or contemporaneous vocalizations, to assign it to a territory or to estimate territory boundaries. Boundaries for the 100-acre plots are depicted on their tract's respective enumeration map. See Figures 1-8 for 100-acre plot data.

Nest Data

City of Austin staff and volunteers found a total of 37 warbler nests during the 2009 field season (Table 4). The first nest was found March 28, and the last nest was found June 2 while the young were fledging. Thirty-one nests were found in Ashe juniper (84%), four were in live oak (11%), and two were in cedar elms (5%). Nest tree height for all tree species averaged 7.31 meters (range 3.75-17.25 m), and dbh averaged 29 centimeters (range 11.5-69 cm). Nest height averaged 4.84 meters (range 2.3-13.92 m).

Twenty-four nests (65%) fledged one or more young, five nests (14%) failed, 1 nest (3%) was abandoned during construction, and seven nests (19%) had an unknown fate.

Ten of the 37 nests were monitored with cameras until the nest failed or produced young. Of the ten nests, seven fledged young, two nests were depredated by Texas rat snakes (***Elaphe obsoleta lindheimeri***), and one nest was depredated by a western scrub jay (*Aphelocoma californica*). For one of these nests, a Texas rat snake consumed the entire contents, including the incubating female warbler.

Table 4. Summary of data collected for 37 Golden-cheeked warbler nests found on the City of Austin's Balcones Canyonlands Preserve, Travis County, Texas, field season 2009.

COA Tract	Date Found	Tree Species	Tree Height (m)	Tree DBH (cm)	Nest Height (m)	Camera Monitored ?	Fate	Comments
3M/St. Edwards	4/4/09	Ashe juniper	6.28	36	3.84	Y	Fledged	4 fledglings
3M/St. Edwards	4/7/09	Ashe juniper	8.25	33	3.60		Unknown	
3M/St. Edwards	5/5/09	Ashe juniper	3.75	18	3.35		Fledged	
3M/St. Edwards	4/18/09	Ashe juniper	6.44	24	4.97	Y	Depredated	Female warbler and nestlings depredated by Texas rat snake
3M/St. Edwards	4/18/09	Ashe juniper	10.24	35	7.90		Fledged	
3M/St. Edwards	4/18/09	Ashe juniper	7.25	23	6.35		Fledged	
3M/St. Edwards	4/18/09	Ashe juniper	4.85	23	4.30	Y	Fledged	4 fledglings
3M/St. Edwards	5/2/09	Ashe juniper	9.66	45	4.98		Fledged	
3M/St. Edwards	4/28/09	Ashe juniper	4.71	40	3.33		Fledged	
3M/St. Edwards	5/1/09	Ashe juniper	--	--	--		Abandoned	Abandoned during construction
3M/St. Edwards	4/20/09	Ashe juniper	9.12	44	5.82		Fledged	
3M/St. Edwards	9/18/09	Ashe juniper	6.18	12.5	3.72		Unknown	Found after breeding season
Barton Creek	5/12/09	Ashe juniper	4.56	11.5	4.08		Fledged	
Canyon Creek	4/28/09	Live oak	9.73	30	6.70		Failed	
Emma Long	4/22/09	Ashe juniper	14.86	40	--		Fledged	Unable to relocate nest for nest height
Emma Long	5/1/09	Ashe juniper	9.73	24.5	5.52		Unknown	Off plot
Forest Ridge	3/28/09	Ashe juniper	8.96	47	5.95	Y	Depredated	Depredated by Texas rat snake
Forest Ridge	5/4/09	Ashe juniper	6.10	21	4.20		Fledged	
Forest Ridge	4/12/09	Ashe juniper	9.06	68.75	4.98		Fledged	Inactive when found; fledglings seen nearby
Forest Ridge	6/2/09	Live oak	5.95	40	4.62		Fledged	
Forest Ridge	4/15/09	Ashe juniper	6.60	23	5.55	Y	Fledged	4 fledglings
Forest Ridge	4/20/09	Ashe juniper	4.50	12	4.05		Fledged	
Forest Ridge	4/20/09	Ashe juniper	5.28	52	4.40		Fledged	

Table 4 (continued). Summary of data collected for 37 Golden-cheeked warbler nests found on the City of Austin's Balcones Canyonlands Preserve, Travis County, Texas, field season 2009.

COA Tract	Date Found	Tree Species	Tree Height (m)	Tree DBH (cm)	Nest Height (m)	Camera Monitored ?	Fate	Comments
Forest Ridge	4/20/09	Ashe juniper	6.60	22	2.88	Y	Fledged	>1 fledgling
Forest Ridge	4/25/09	Ashe juniper	4.80	20	2.30	Y	Fledged	4 fledglings; off plot
Ivanhoe	4/13/09	Ashe juniper	10.14	24	7.10		Fledged	Fledglings seen nearby
Ivanhoe	4/27/09	Cedar elm	17.25	23	13.92		Unknown	
Ivanhoe	4/27/09	Ashe juniper	6.05	15	4.75	Y	Fledged	Camera removed before fledged, but fledglings seen nearby
Ivanhoe	4/28/09	Ashe juniper	4.36	20	3.08		Depredated	
Ivanhoe	4/15/09	Cedar elm	9.64	19	--		Fledged	Fledglings seen nearby. Unable to relocate nest for nest height
Ivanhoe	4/15/09	Ashe juniper	5.10	40	3.20	Y	Depredated	Depredated by scrub jay
Ivanhoe	4/27/09	Ashe juniper	5.94	37	4.74	Y	Fledged	4 fledglings
Ivanhoe	4/27/09	Ashe juniper	5.45	30	4.55		Fledged	Fledglings seen nearby
Ivanhoe	5/6/09	Ashe juniper	4.20	14	2.88		Fledged	
Former WTP4	5/17/09	Live oak	7.04	23	3.36		Unknown	
Former WTP4	4/3/09	Live oak	--	--	--		Unknown	
Former WTP4	4/23/09	Ashe juniper	--	--	--		Unknown	
Average			**7.31**	**29**	**4.84**			

Other Observations

As in 2008 and previous years, field staff observed female warblers 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 the ground. On one occasion, an adult male was seen picking up tiny pieces of white snail shells off the ground. Warblers were also occasionally seen bathing in springs, and one male was observed singing while bathing. These behaviors underscore the importance of ground habitat and water to this species in addition to the tree canopy and mid-story vegetation.

Consistent with Beardmore (1994), staff noticed a shift of adult warblers foraging primarily in oaks and other hardwoods early in the season to foraging primarily in Ashe juniper later in the season. This shift appeared to correspond with timing of young fledging from nests, around late April. During 2009, staff also noticed a large number of katydids (family: Tettigoniidae) and walking-sticks (family: Phasmatidae) being fed to young. In one case, a fledgling refused to eat the katydid.

Evidence of polygamous mating systems may become more apparent with a color banded population. For example, on the 3M/St. Edwards 100-acre plot, a banded SY male was observed actively defending a full territory near the center of the plot. Although this male was never observed singing outside of this area, he was seen feeding a female on a nest that was off the plot in what was believed to be another male's territory. Becky Peak (TNC, Fort Hood) has observed two different banded males feeding the same female on a nest (personal communication, 2009). It is possible, then, that the banded SY male on the 3M/St. Edwards plot may have been feeding a female that was mated with another male.

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 as well. Warblers displayed this injury-feigning behavior when field biologists were near newly fledged young.

A behavior that staff biologists noted for the first time this year was warblers bathing in oak leaves during and shortly after rain events. On at least three separate occasions, an adult warbler was seen in the tree canopy diving into a cluster of wet oak leaves, shaking the water off, and preening. Each individual repeated this bathing activity several times.

Staff biologists observed a hatch year warbler foraging in a Texas red oak at Emma Long on August 20, which is one of the latest observations on record, including for the BCP.

Habitat Mapping

In September 2009, the City of Austin contracted with Baylor University to estimate woodland stand age and changes in composition over time, using a decadal series of aerial photographs from 1940 to present. This mapping project will be used to assess habitat quality for the warbler, estimate the amount of habitat within each macrosite, and estimate the number of warbler pairs within the BCP.

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II. BLACK-CAPPED VIREO MONITORING

INTRODUCTION

Background

The black-capped vireo (hereafter, vireo) is an endangered, neotropical migrant that breeds in portions of Oklahoma, Texas, and Mexico (Grzybowski 1995). This species was listed by the U.S. Fish and Wildlife Service in 1987. Major threats to the species' survival are habitat loss, habitat fragmentation, and parasitism by brown-headed cowbirds.

The Balcones Canyonlands Preserve was established in 1996 to mitigate for loss of vireo habitat in western Travis County due to exurban sprawl, and to aid vireo recovery. The vireo has been documented on several BCP tracts managed by the City of Austin. The best-studied colony existed at the Black-capped Vireo Research Area. That colony declined steadily from 32 territories in 1987 to one territory in 1997 (Grzybowski 1989, Steed 1988, Abbruzzese 1998) and an intermittent sighting of a male in 2004 (Becker and Koehler 2004).

A small breeding colony of vireos (three to five territories) has occupied habitat on the Cortaña tract every year since 2000. A part of this colony spills onto the adjacent River Place mitigation tract to the northeast. Other records for vireos on the City of Austin's BCP tracts for the past decade include sightings of males on Forest Ridge, Ivanhoe, Parke West, and the former WTP4. Last year, for the first time since the BCP was established, biologists documented on the Ivanhoe tract a pair of vireos that successfully raised at least one young; a vireo pair again established a territory on Ivanhoe this year. In addition, vireos set up three territories on the Forest Ridge tract in 2009. Vireos have previously been sighted intermittently on the Forest Ridge tract, but this year marks the first documented territory establishment and nesting attempt.

Objectives

The City of Austin's vireo monitoring program focuses on estimating population size, trends, and productivity. To monitor population trends, surveys for vireos are conducted every year. Data are collected on abundance, pairing, nesting, and productivity. Survey effort on the established Cortaña colony is roughly equivalent to effort on golden-cheeked warbler 100-acre prime plots. When vireos establish territories elsewhere on the Preserve, BCP staff make a concerted effort to determine the extent of territories and nesting success.

Because of the threat posed by the brown-headed cowbird, monitoring for direct and indirect signs of cowbird parasitism during field surveys is a high priority. BCP staff are committed

to intensive management of cowbirds at all vireo colonies. BCP staff and volunteers have managed cowbirds at the Cortaña colony every year since vireos were first observed there in 2000, and have also maintained a cowbird trap on the Ivanhoe tract, near the vireo territory there.

Vireos occupy shrublands of mixed deciduous and evergreen species with irregular height and distribution, open spaces between the woody vegetation, and vegetation cover to ground level. Because this is an early successional stage habitat that must continually be manipulated to remain viable, restoration projects are typically undertaken every year on various City of Austin tracts. During early February 2009, City of Austin BCP staff partnered with the Lower Colorado River Authority to manipulate an area of about 4.5 acres along a transmission line right-of-way near the Ivanhoe territory. Preparations are still underway for restoration efforts planned at the Vireo Research Area (see Black-capped Vireo Habitat Restoration, Section III, below). Additional restoration work is also planned for the Cortaña tract.

METHODS

Sites and Survey Effort

In field season 2009, vireos were censused on a 39-acre section of the Cortaña tract (total acreage: 1,752). Combined with an 18-acre section of the adjacent River Place Mitigation tract, this parcel makes up the 57-acre vireo habitat study area that was originally restored in 1996. Vireos detected during other endangered species surveys were also recorded and mapped, and attempts were made to determine their breeding status.

From the Cortaña colony, City of Austin staff biologists collected the following data: number of territories, territory location, pairing success, breeding success, parasitism, and productivity. Staff biologists used territory mapping (IBCC 1970, Bibbey 1992) methods to determine numbers and locations of territories, conducting surveys from 22 April to 29 June 2009 for a total of 37.75 hours.

Data Collection and Analysis

Locations of vireos were primarily recorded with a GPS datalogger (Garmin E-trex), which has an accuracy of 9 to 20 feet. Other sightings were recorded on topographic maps at a scale of 1:3,600, using a 100-meter UTM grid. Pairing status, breeding success, and number of fledglings produced per pair were determined for each territory. For methodology and calculations, see Data Collection and Analysis in Part I: Golden-cheeked Warbler. No playback tapes of vireo songs or calls were used during this season's monitoring.

Natal Dispersal Study

2009 was the third year of a three-year Texas State University study spatially analyzing natal and breeding dispersal of vireos. The research focused on known vireo colonies while also investigating unoccupied but potential habitat at Balcones Canyonlands National Wildlife Refuge and the BCP (Travis County and City of Austin tracts). Field work continued this year as William Simper, the primary field biologist, and his team, attempted to mist net and band as many vireos as possible in the disparate colonies, and to relocate birds banded in the previous two years. This information is presented in a separate report.

Staff coordinated monitoring efforts with the TSU team, and shared information. The banders did judiciously use playback tapes of vireo song for short periods in order to draw vireos into a mist net for banding.

RESULTS AND DISCUSSION

In 2009, staff found vireos on three City-owned BCP tracts: Cortaña, Ivanhoe, and Forest Ridge.

Territory Mapping on the Cortaña Study Site

Four male vireos defended territories on the restored portions of Cortaña and the adjacent River Place mitigation tract, an increase of one territory from 2007. Figure 12 (Appendix F) depicts territory locations for the Cortaña tract during 2009.

All three of the males banded by TSU researchers in 2008 returned to establish territories in 2009. The three males first appeared, early in the season, in approximately the same locations that they had occupied in 2008, but by May two of the territories had shifted. The oldest male, banded Red/White:Black/Silver (RD/WH:BK/SI, more than 3 years old) remained near the gate into the northwest part of the tract. Male Blue/Silver:Yellow/Black (BL/SI:YE/BK) moved to an area mostly off the Cortaña tract and onto the adjacent River Place MUD tract. The male banded Dark Blue/Silver:Dark Blue/Green (DB/SI:DB/GR) shifted westward into the space vacated by BL/SI:YE/BK. The fourth territory was held by a second-year male, based upon plumage characteristics described in Pyle (1997), and was situated entirely on the River Place MUD property.

Pairing, Breeding Success, and Productivity on the Cortaña Study Site

Pairing success was 50 percent. Half of the territorial males were observed associating with a female, or tending a nest or fledglings. Male DB/SI:DB/GR also followed a female as she tended fledglings from the brood she raised with RD/WH:BK/SI, but the interaction between the two suggested that they were not mated.

City biologists were able to confirm offspring from only one vireo pair (male RD/WH:BK/SI), which fledged 4 young in one brood. However, Simper reported finding

male BL/SI:YE/BK carrying food, and heard the sound of a juvenile begging. Including his data, breeding success was at least 50 percent. Productivity was at least 5 fledglings for the two successful territories, and 1.25 fledglings/territory for all territories. As demonstrated by these findings, vireo fledglings can be difficult to detect, so productivity results represent minimum numbers.

Natal Dispersal Study

One of the vireos that appeared this year on the Forest Ridge tract was a second-year (SY) female that had been banded by TSU researchers in 2008 as a nestling on Travis County's Nootsie tract. William Simper of TSU attempted unsuccessfully to recapture this female to switch the generic band combination given to all nestlings of that nest (NB/SI:BL/RD) to a unique combination. He did, however, manage to mist net and band her mate, which was also an SY bird, and a second territorial SY male on the Forest Ridge tract. The locations of the vireo territories on Forest Ridge are shown in Figure 13 (Appendix F).

Simper successfully mist netted and banded the one male vireo that had not been banded in 2008 on the Cortaña tract. This SY male was assigned the band combination Orange/Silver: Red/Red (OR/SI:RD/RD). Simper also mist netted and banded the male vireo that established a territory on the Ivanhoe tract. It was also a SY male (so was not the same male that successfully nested on Ivanhoe in 2008), and was banded Dark Green/Yellow:Black/Silver (DG/YE:BK/SI). Figure 14 (Appendix F) shows the location of this territory.

Vireos on Other Tracts

Again this year, BCP staff found a vireo singing on the Ivanhoe tract (Figure 14, Appendix F), along a utility line corridor near the northwest corner of the GCWA 100-acre study plot. Simper banded this male (see above), who then attracted a mate. BCP staff located a nest in a yaupon (*Ilex vomitoria*) with at least three eggs on June 3. By June 11, there were three nestlings, but a return visit on June 13 found them all dead. A strong storm on the evening of June 11 may have killed them.

Three territorial males were observed on and near the 100-acre plot on Forest Ridge in May and June 2009 (Figure 13, Appendix F). The first vireo was heard singing on the 100-acre plot on May 1 and was present on each subsequent survey through mid-June. This SY male was banded Green/Silver:Yellow/Yellow (GR/SI:YE/YE). Two other males were observed for the first time on May 11. These males established territories adjacent to each other and were along and just east of the 100-acre plot boundary. One of these males was an SY male that was banded Orange/Silver:Blue/Green (OR/SI:BL/GR). He was mated to the SY female that had been banded as a fledgling on Travis County's Nootsie tract in 2008 (see Natal Dispersal Study, above). This pair had one nest found by William Simper on May 23 with

nestlings estimated to be about 4 days old. Simper checked the nest again on May 31 and reported the nest was still active and appeared to be beginning to fledge. The nestlings would have been about 12 days old, which is consistent with the timing of fledging. While no fledglings were observed on subsequent visits, surveys were conducted too infrequently to verify the fate of this nest.

2009 is the first year vireo territories were established on the Forest Ridge tract. In 2007, a male vireo, which appeared to be SY, sang persistently in the northeast corner of the plot on May 2, but was not relocated on later visits (O'Donnell et al., 2007). In 2001, a male vireo was observed on one occasion along the eastern edge of the 100-acre plot, near where the two territories were established this year (Abbruzzese 2001). DLS Associates (1990) also documented a vireo in this area. While the habitat is more mature than what is typically used by vireos, it does have a shrub component along narrow edges within the mature juniper-oak woodland. Common deciduous shrubs along these habitat edges include Evergreen Sumac (*Rhus virens*), Texas Mountain Laurel (*Sophora secundiflora*), Shin Oak, Elbow Bush, Wafer-Ash (*Ptelea trifoliata*), and Agarita (*Mahonia trifoliolata*). The vireo nest found in 2009 was in a Mountain Laurel under a mature juniper-oak canopy.

Parasitism

Brown-headed cowbirds were seen on the Cortaña site only in the immediate vicinity of the cowbird trap, though they were occasionally observed flying overhead. No vireos were observed tending cowbird fledglings. A total of 12 cowbirds were caught in the metal trap located in the Cortaña study area; six of these were female brown-headed cowbirds and one was a female bronzed cowbird. A trap on the Ivanhoe tract caught 5 male and 2 female brown-headed cowbirds.

In 2004, common grackles (*Quiscalus quiscula*) and northern mockingbirds (*Mimus polyglottos*) were observed harassing vireos in the Cortaña study area on several occasions, but no harassment by other avian species has been observed since then (Becker and Koehler, 2004). On one occasion this year a female black-capped vireo appeared to join other passerines in mobbing a greater roadrunner (*Geococcyx californianus*). Roadrunners will eat nestlings of other birds (Terres 1991, Sibley 2001). Although depredation of nests was not observed in 2009, potential predators include several snake species, ringtails (*Bassariscus astutus*), raccoons (*Procyon lotor*), foxes, squirrels, roadrunners, western scrub-jays (*Aphelocoma coerulescens*), American crows (*Corvus brachyrhynchos*), various raptor species, and red imported fire ants (*Solenopsis invicta*).

Golden-cheeked Warblers in Black-capped Vireo Habitat

In some areas, vireo habitat may progress to golden-cheeked warbler habitat through natural succession. Likewise, natural or anthropogenic disturbance patterns may convert warbler

habitat to the early successional stage preferred by the vireo. These habitat types often overlap. During 2009 within the City of Austin BCP, warblers and vireos were observed in the same or neighboring areas on the Cortaña, Ivanhoe, and Forest Ridge tracts.

Golden-cheeked warblers were incidentally mapped during vireo surveys around the 39-acre vireo habitat area on the Cortaña tract (Figure 12, Appendix F). Male warblers were usually detected singing near the perimeter of the vireo habitat area; the canyons surrounding the upland study site are excellent golden-cheeked warbler habitat. A warbler pair appeared once at the south end of the study area, along the main road. Unlike in previous years (see Becker and Koehler 2004, Becker and Koehler 2005, O'Donnell et. al. 2007), no golden-cheeked warblers were observed in the interior of the study site this year.

The black-capped vireo habitat on the Ivanhoe tract is situated under and between two parallel utility lines, near the northwest corner of the 100-acre study plot for golden-cheeked warblers. The utility corridors are flanked by mature juniper-oak woodland on either side. This woodland is densely populated by golden-cheeked warblers, which were frequently seen in the shrubby habitat under the utility lines where we normally encountered the vireos.

On the Forest Ridge tract, the vireos established territories along narrow edges within prime golden-cheeked warbler habitat on and near the 100-acre study plot. Warbler territories observed on the Forest Ridge 100-acre plot are shown in Figure 4 (Appendix F).

III. BLACK-CAPPED VIREO HABITAT RESTORATION

Background. The BCCP Land Management Plan (BCP 1998) requires maintaining or creating 2000 acres of black-capped vireo (vireo) habitat within the BCP. The plan originally identified specific acreages as potential vireo habitat. Much of this acreage is currently mature juniper-oak woodland that is prime habitat for the warbler. Additionally, a number of properties containing potential or occupied vireo habitat that were originally included within the proposed BCP boundaries have been lost to development since 1996.

Currently Occupied Habitat. The Cortaña tract (1,752 acres) in the North Lake Austin Macrosite is the only City of Austin BCP property under active management that is currently occupied by vireos. In 1996, about 57 acres of juniper-oak woodlands were manipulated on upper Cortaña and the adjacent, privately managed, River Place Mitigation tract. Approximately 39 acres were manipulated on Cortaña and 18 acres on River Place. Both hand-clearing and hydro-axing methods were applied. In each year since 2000, three to five males have established territories in this area.

Identifying Sites. Travis County and City of Austin BCP staff are currently working on a comprehensive plan to identify sites for vireo habitat restoration or creation. A GIS database is being developed to assess site characteristics and to locate potential sites. Data layers include soils, topography, geology, vireo territories, and warbler observations. To identify priority woodlands for the warbler and potential management areas for the vireo, the City of Austin has a contract with Baylor University to estimate woodland stand age and changes in composition throughout the BCP using historical aerial photography. These data layers should be available by summer 2010. Other variables that will be considered in identifying sites for vireo management include size of the potential restoration area, history of occupation by vireos, proximity to the nearest vireo colony, proximity to urban development, and feasibility of management (for example, prescribed burns). Focal areas for vireo habitat management on City of Austin BCP lands currently include Cortaña, Vireo Research Area, Bohls, and infrastructure corridors (Ivanhoe).

Habitat Restoration Efforts – Vireo Research Area. During the fall of 2008, City of Austin staff and American Youth Works prepared staging areas and 12- to 15-foot firelines along existing 2-tracks to accommodate a prescribed burn project on the Vireo Research Area. The prescribed burn is planned as a pilot project for a seven-acre area on a knoll near the center of the tract. This area has historically been the epicenter of the Vireo Research Area colony and is the location of the most recent sightings in 2004 (Becker and Koehler 2004) and 1997 (Abbruzzese 1998). The burn was originally scheduled for February 2009, but due to unfavorable weather conditions, is now scheduled for winter 2009-2010. Mechanical manipulation along the uplands between the two knolls and around the perimeter of the proposed burn area is planned for early 2011. A long-term mechanical manipulation and burn plan is also being developed for this site.

The Vireo Research Area, although once home to 32 vireo territories during the mid-1980s, is no longer occupied habitat. The last territory was detected there in 1997 (Abbruzzese 1998). This site was once part of a larger ranch that burned in April 1961 and has not been burned since. City of Austin staff hand-cleared Ashe juniper (*Juniperus ashei*) and topped some of the oaks from portions of the Vireo Research Area during the mid-1990s. However, much of the broad-leaved component of the habitat, which has grown out of suitability as nesting substrate, was not manipulated. In particular, the predominant nesting shrub, the evergreen sumac (*Rhus virens*), appears to be too tall, with thick trunks and stems and sparse foliage, to be suitable for concealing vireo nests from potential predators. Encouraging resprouting of evergreen sumac and other deciduous species, protecting regenerating plants from browse, creating a more open habitat, and maintaining a diverse height structure will be the focus of future management efforts.

Habitat Restoration Efforts – Ivanhoe. After a vireo pair nested successfully along the Ivanhoe transmission line corridors in 2008, BCP staff re-considered a Lower Colorado River Authority warbler-habitat restoration project that had been underway since 2006. To complete the final phase of this project would have required a large commitment of resources by BCP staff for little net benefit to warblers. In lieu of completing the project, BCP and LCRA staff negotiated an experimental vireo habitat improvement plan.

The new project entailed removing trunks of most or all woody plants in three small areas beneath the transmission lines, not including the area that had been used by vireos the previous year. Most of these areas had a preponderance of Ashe juniper crowding broad-leaved shrub-forming species such as shin oak (*Quercus sinuata*). By removing the juniper, we expect the other species to re-sprout from the roots to form a more suitable open, low shrubland. The combination of the relatively narrow infrastructure corridor and the adjacent juniper-oak woodlands should provide the diversity of vegetation heights preferred by the vireo as well as juniper bark for nests.

Using flail mowers, LCRA staff completed the woody trunk removal in three days in early February 2009. The three affected areas totaled approximately 4.5 acres. All oak stems susceptible to oak wilt were coated with wound sealant after they were cut. Slash was ground into mulch and distributed thinly over the sites so it would not impede re-sprouting. Areas where broad-leaved shrubs of suitable height predominated were left alone. BCP staff planted a small quantity of broad-leaved shrub seeds in the cut areas to supplement the existing vegetation.

By September 2009 several broad-leaved shrubs had begun to resprout, despite an extraordinarily hot, droughty summer. Further plantings of seeds may help to accelerate the growth into suitable vireo habitat, especially if central Texas has an anticipated wet winter.

Habitat Restoration Efforts – Cortaña and Bohls. No significant habitat restoration took place on either of these tracts this year. Staff are planning a prescribed burn to enhance habitat on approximately 12 acres of the Cortaña tract in winter 2009-10. A five-year prescribed burn plan for all BCP tracts is being drafted to assist staff with prioritizing these projects. It includes plans for a prescribed burn on a portion of the Bohls tract, near the established shinnery, as early as summer 2010.

Habitat Monitoring. During the fall of 2009, BCP staff and a volunteer monitored restoration efforts on the Cortaña and Bohls tracts, and recorded baseline data for the Vireo Research Area. On Cortaña and Bohls, monitoring consisted of taking photographs from established photo points, and collecting data along vegetation transects (point-intercept and line-transect methods). At Vireo Research Area, staff established and collected data from five new vegetation transects on the knoll where the prescribed burn was planned.

IV. LITERATURE CITED

Abbruzzese, C. 1998. 1998 Golden-cheeked warbler and black-capped vireo monitoring program, Balcones Canyonlands Preserve. City of Austin Parks and Recreation Department, Natural Resources Division. Austin, Texas.

——. 2001. 2001 Golden-cheeked warbler and black-capped vireo monitoring program, Balcones Canyonlands Preserve. City of Austin Parks and Recreation Department, Natural Resources Division. Austin, Texas.

——, and D.L. Koehler. 2003. City of Austin 2003 Golden-cheeked warbler and black-capped vireo monitoring program: Balcones Canyonlands Preserve annual report FY2002-03. City of Austin, Water Utility, Wildland Conservation Division, Balcones Canyonlands Preserve program. Austin, Texas.

Anders, A. D. 2000. Demography of golden-cheeked warblers on Fort Hood, Texas in 2000: productivity, age structure, territory density, and adult return rates. *In* Endangered species monitoring and management at Fort Hood, Texas: 2000 annual report. Fort Hood Project, The Nature Conservancy of Texas, Fort Hood, Texas.

Balcones Canyonlands Preserve. 2007. Land management plan, Tier IIA-7, golden-cheeked warbler management. City of Austin and Travis County, Austin, Texas.

Balcones Canyonlands Preserve. 1998. Management of the golden-cheeked warbler. *In* Balcones Canyonlands Preserve Land Management Plan, Tier IIA. Austin, Texas.

Becker, H. and D. Koehler. 2004. City of Austin 2004 golden-cheeked warbler *Dendroica chrysoparia* and black-capped vireo *Vireo atricapilla* monitoring program: Balcones Canyonlands Preserve annual report FY2003-04. City of Austin Water, Utility Wildland Conservation Division, Balcones Canyonlands Preserve program. Austin, Texas.

——. 2005. City of Austin 2005 golden-cheeked warbler *Dendroica chrysoparia* and black-capped vireo *Vireo atricapilla* monitoring program: Balcones Canyonlands Preserve annual report FY2004-05. City of Austin Water, Utility Wildland Conservation Division, Balcones Canyonlands Preserve program. Austin, Texas.

Bibbey, C. J., N.D. Burges, and D.A. Hill. 1992. Bird Census Techniques. Academic Press. San Diego, California. 257pp.

City of Austin. 2008a. Assessment of golden-cheeked warbler monitoring program: City of Austin Balcones Canyonlands Preserve. City of Austin Water Utility Wildland Conservation Division. Balcones Canyonlands Preserve. Austin, Texas.

——. 2008b. City of Austin 2009 golden-cheeked warbler *(Dendroica chrysoparia)* and

black-capped vireo *(Vireo atricapilla)* monitoring program: Balcones Canyonlands Preserve annual report FY 2008-09. City of Austin Water Utility Wildland Conservation Division. Balcones Canyonlands Preserve. Austin, Texas.

DLS Associates. 1990. Black-capped vireo monitoring program, Travis County, Texas, 1990. Final report submitted to The Nature Conservancy of Texas, Inc. Austin, Texas.

Grzybowski, J.A. 1989. Interim report: black-capped vireo investigations: population and nesting ecology. U.S. Fish and Wildlife Service, Albuquerque, New Mexico.

——. 1995. Black-capped Vireo (Vireo atricapillus). *In* The Birds of North America, No. 181 (A. Poole and F. Gill, eds). The Academy of Natural Sciences, Philadelphia, and The American Ornithologists' Union, Washington, D. C.

International Bird Census Committee. 1970. An international standard for a mapping method in bird census work. Audubon Field Notes 24(6):722-726.

Keddy-Hector, D.P. 1996. Conservation of the golden-cheeked warbler at the Barton Creek Habitat Preserve: 1996 field season. Austin, Texas.

Ladd, C., and L. Gass. 1999. Golden-cheeked warbler (Dendroica chrysoparia). *In* The Birds of North America, No. 181 (A. Poole and F. Gill, eds). The Academy of Natural Sciences, Philadelphia, and The American Ornithologists' Union, Washington, D. C.

O'Donnell, L., K. Nesvacil, and W. Reiner. 2007. City of Austin 2007 golden-cheeked warbler *Dendroica chrysoparia* and black-capped vireo *Vireo atricapilla* monitoring program: annual report FY2006-07. City of Austin Water Utility Wildland Conservation Division. Balcones Canyonlands Preserve. Austin, Texas.

Pyle, P. 1997. Identification guide to North American Birds, Part I. Slate Creek Press, Bolinas, California, USA.

Reidy, J. 2007. Golden-cheeked warbler nest success and nest predators in urban and rural landscapes. M.S. thesis, University of Missouri, Columbia, MO.

Reidy, J., M. Stake, and F. Thompson. 2008. Golden-cheeked warbler nest mortality and predators in urban and rural landscapes. The Condor 110(3):458-466.

Sibley, D. 2001. The Sibley guide to bird life and behavior. Chanticleer Press, Inc., New York, New York.

Steed, D.L. 1988. Black-capped vireo in Travis County, Texas. Technical Brief. July 1987. Revised 1988. DLS Associates. Austin, Texas.

Terres, John K. 1991. The Audubon Society Encyclopedia of North American Birds. Wings Books, New York, NY.

U.S. Fish and Wildlife Service. 1990. Endangered and threatened wildlife and plants; emergency rule to list the golden-cheeked warbler as endangered. Federal Register 55(87):18844-18845.

——. 1994. Minimum procedures for determining the presence/absence of golden-cheeked warblers and black-capped vireos. Albuquerque, New Mexico.

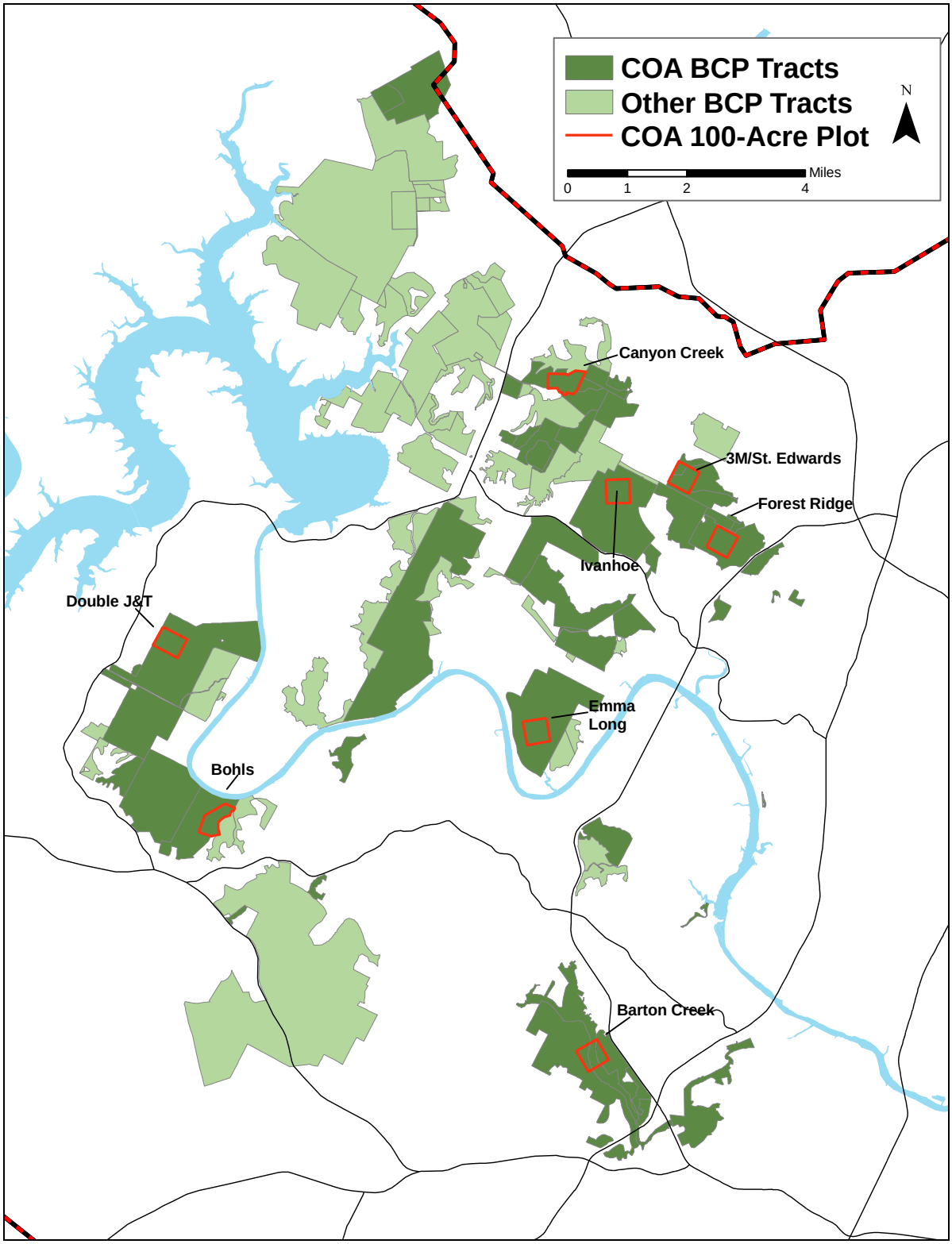
——. 1996. Final environmental impact statement/habitat conservation plan for proposed issuance of a permit to allow incidental take of the golden-cheeked warbler, black-capped vireo, and six karst invertebrates in Travis County, Texas. Prepared by Regional Environmental Consultants (RECON) and U.S. Fish and Wildlife Service. Albuquerque, New Mexico.

Verner, J. 1985. Assessment of counting techniques. Current Ornithology. 2:247-302.

Weckerly, F. and J. Ott. 2008. Statistical trends of golden-cheeked warblers on Balcones Canyonlands Preserve, City of Austin, Texas. Texas State University, San Marcos, Texas.

V. APPENDICES

Appendix A: Distribution of City of Austin 100-acre Study Plots



Appendix B: 100-acre Study Plot Protocol

Golden-cheeked Warbler Monitoring
Balcones Canyonlands Preserve, City of Austin
100-Acre Plot Protocol, 2009

The primary goals of the Golden-cheeked warbler (GCWA) monitoring program are to map the location and extent of territories as accurately as possible and to determine pairing success, breeding success, and productivity to estimate long-term trends in these parameters. This field season will increase 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 people will split the 100-acre prime plots to help allow adequate time to resight banded birds and to address potential observer bias issues.

Prime Study Plots are located in excellent GCWA habitat with greater than 70% canopy cover.
Transitional Study Plots are situated in areas that have zero to a few warbler territories but have the potential to improve as GCWA habitat.

Survey Dates: March 15 - May 25, with 10 visits (one visit/week) for prime plots and 5 visits (one visit/every other week) for transitional plots.

Survey effort: 6 hours per 100 acres *minimum*. There will be no maximum time constraints. The level of effort will be based on territory densities, terrain, surveyor's physical condition, etc. Surveyors will take as much time as is needed to collect data for each territory (estimate about 45 minutes per territory). Additionally, a minimum of 5 locations separated by >30 meters (use your judgment), up to 10 locations, should be collected for each territory during every survey. This additional criteria fits within the 45+ minute time allotment/territory.

Staffing: Two people per prime plot, with a *minimum* 3 hours/50 acres/person (*minimum* 6 hours total/100 acres).

Training: All staff scheduled for the 2009 field season will have prior experience conducting 100-acre plot surveys.

1) Each observer will cover half (for prime plots) or the entire plot (for transitional plots) on each visit. For prime 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^{o} in a clockwise direction. This will ensure each observer covers the entire plot and begins at a different corner of the plot on each visit.
2) At the start and end of each site visit, record on the field map the time, date, and weather conditions – temperature, wind speed, cloud cover, and any precipitation. Starting and ending times are important so we can report how many hours we devoted to each site this year.
3) Record each observation of a GCWA on a field map, using the symbols on the attached sheet. Observations should include birds seen or heard, and nests. Standardized notation, especially symbols showing where a bird moved and counter-singing males, will be especially important when we group observations into territories.
4) For each observation, use a different number or letter, unless you are certain the bird is the same as an earlier one. For a female GCWA, use the female symbol: "♀". (Do not use the male symbol "♂" for a male GCWA, because it could be confused for a singing bird that has moved to the upper right.) For a fledgling GCWA, use a lowercase "f".
5) Write any details of the observation (plumage characteristics of the bird, song type, behavior, etc.) on the reverse side of the field map or on the survey form. These details can help distinguish individual birds, especially females. This year, it will be particularly important to look for leg bands, and to record the color combinations of any seen.
6) Record other information requested on the survey form. You may either use a copy of the form or record the data on the back of the field map.
7) Do not survey GCWAs in steady rain or thunderstorms (light drizzle is okay).

8) Do not conduct a GCWA survey if sustained wind is stronger than 12 miles/hour (> Beaufort 3).
9) Do not use playback of songs or calls to elicit a response.
10) If you see a warbler carrying nesting material or food, try to follow it, unobtrusively. Locations of GCWA nests are important information, but do not warrant disturbance of the nesting pair. If the parents appear agitated, move away to watch from a respectful distance. If you locate a GCWA nest, mark its location as a waypoint in your GPS (and write it down in your notebook in case something should happen to the waypoint). Flag the location at least 3 meters from the nest. Nests should be monitored ideally ~3-4 days after activity is confirmed (more often close to fledging). Monitor the nest long enough to determine status (inactive, active) and stage. At a minimum, monitor after each survey and stay up to 30 mins to confirm status (active nests will almost always be visited within this time frame).
11) Record numbers of potential predators observed, such as Blue Jays, Western Scrub-Jays, American Crows, Common Ravens, grackles, hawks, owls, Texas Rat Snakes, and Eastern Fox Squirrels. Numbers of Brown-headed Cowbirds, and sightings of GCWAs feeding fledgling cowbirds are especially important.
12) If you are surveying in an area where GCWAs encounter the public, please note any interactions and the warblers' response.
13) Materials to bring with you for monitoring visits:
    Field maps
    Survey form
    Pens/pencils
    Binoculars
    Compass and/or GPS
    Thermometer
    Flagging (pink)

Appendix C. Summary of Golden-cheeked Warbler Enumeration Surveys on the City of Austin's Balcones Canyonlands Preserve, Travis County, Texas, Field Season 2009.

Tract Name	Surveyor(s)	Survey Hours (March 15-May 25)	Acres Surveyed
100-acre prime plots			
Barton Creek	J. Chenoweth W. Reiner	105	100
Emma Long	K. Nesvacil C. Sperry	107	100
Ivanhoe	W. Reiner M. Sanders	133	100
3M/St. Edwards	L. O'Donnell C. Sperry	119	100
Forest Ridge	K. Nesvacil L. O'Donnell	109	100
Prime Plot Totals		**573**	**500**
100-acre transitional plots			
Bohls	J. Chenoweth W. Reiner	39	100
Canyon Creek	M. Sanders	33	100
Double J&T	C. Sperry	26	100
Transition Plot Totals		**98**	**300**
Enumerations			
Barton Creek Wilderness Preserve	J. Beach J. Chenoweth S. Hargis L. Foss W. Reiner	104	1272
Coldwater/Vaught Ranch	K. Nesvacil	15	65
Former WTP4	J. Mundy J. Weber L. Weber	48	238
Enumeration Totals		**167**	**1575**

Appendix D: Golden-cheeked Warbler 100-Acre Study Plot Territory Data

A summary of Golden-cheeked warbler territory number per 100 acres and per 100 hectares for five 100-acre prime study plots and three 100-acre transitional study plots on the City of Austin's BCP, Travis County, Texas, field seasons 1998-2009. 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**	**12**
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**	**35**
Ivanhoe	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**	**44**

Appendix D: Golden-cheeked Warbler 100-Acre 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**	**44**
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**	**35**
Average, All Prime Plots	1998	6	9.0	22
	1999	8	11.0	27
	2000	8	12.0	30
	2001	6	10.0	25
	2002	10	13.0	32
	2003	9	14.0	35
	2004	9	14.5	36
	2005	10	15.0	37
	2006	14	18.0	44
	2007	7	12.0	30
	2008	9	13.0	32
	Average	9	13.0	32
	Initiation of Color Banding			
	2009	**8**	**14**	**35**

Appendix D: Golden-cheeked Warbler 100-Acre 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	7
	Average	4	5.0	13
	Initiation of Color Banding			
	2009	**2**	**3.5**	**9**
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**	**25**
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**
Average, All Transitional Plots	1998	2	3.5	7
	1999	1	3.0	7
	2000	0	2.5	6
	2001	3	5.5	14
	2003	2	4.5	11
	2005	5	7.5	19
	2007	2	4.5	12
	Average	2	4.0	11
	Initiation of Color Banding			
	2009	**2**	**5**	**13**

Appendix E: Golden-cheeked Warbler 100-Acre Study Plot Reproductive Success Data

A summary of Golden-cheeked warbler reproductive success data for five 100-acre prime study plots on the City of Austin's BCP, Travis County, Texas, field seasons 1998-2009. 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**
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**
Ivanhoe	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**

Appendix E: Golden-cheeked Warbler 100-Acre Study Plot Reproductive Success Data (continued)

Plot Name	Survey Year	Pairing Success	Breeding Success	Productivity per Successful Territory	Productivity per Full Territory
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**
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**
Average, All Prime Plots	1998	0.67	0.54	2.36	0.97
	1999	0.74	0.67	2.34	1.30
	2000	0.53	0.34	2.36	0.81
	2001	0.70	0.55	1.96	1.56
	2002	0.68	0.40	2.06	0.93
	2003	0.71	0.67	2.08	1.30
	2004	0.72	0.50	2.42	1.16
	2005	0.80	0.63	2.20	1.40
	2006	0.89	0.70	2.31	1.62
	2007	0.84	0.82	2.49	2.03
	2008	0.88	0.69	2.40	1.68
	Average	0.74	0.59	2.27	1.34
	Initiation of Color Banding				
	2009	**0.93**	**0.78**	**2.16**	**1.68**

Appendix F: Survey Maps (figures 1-14)

100-acre Study Plots

Figures 1–8 depict estimated territories from 100-acre plot surveys. 100-acre plot maps depict territories relative to topographic features and to other warbler territories. Territories are represented by minimum convex polygons drawn to connect the outermost observations of each territorial male. An "X" symbol on the figures represents an observation of a male warbler that does not have enough sightings or other information, such as identification of color band combinations or contemporaneous vocalizations, to assign it to an existing territory or to estimate territory boundaries. The "X" symbol on the figures is also used to represent floater males. Floaters are typically young males observed later in the season only on one or two occasions. Female and fledgling observations are summarized and depicted by estimated numbers for a territory.

Figure 1: 3M/St. Edwards

Figure 2: Barton Creek

Figure 3: Emma Long

Figure 4: Forest Ridge

Figure 5: Ivanhoe

Figure 6: Bohls

Figure 7: Canyon Creek

Figure 8: Double J&T

Enumerations

Figures 9-11 display the distribution of estimated territories. Polygons displayed on the maps represent best approximations of individual bird territories. A single dot on the figures represents what were believed to be a territorial warbler, but there were not enough observations recorded to create a minimum convex polygon. An "X" symbol on the figures represents an observation of a male warbler that did not have enough sightings or other information, such as identification of color band combinations or contemporaneous vocalizations, to assign it to a territory or to estimate territory boundaries. Boundaries for the 100-acre plots are depicted on their tract's respective enumeration map.

Figure 9: Barton Creek Wilderness Preserve

Figure 10: Coldwater/Vaught Ranch/Long Canyon

Figure 11: Former WTP4

Black-capped Vireo Surveys

Figures 12-14 depict estimated vireo territories. Territories were mapped using the same methodology as the 100-acre study plots (see above).

Figure 12: Cortaña

Figure 13: Forest Ridge

Figure 14: Ivanhoe

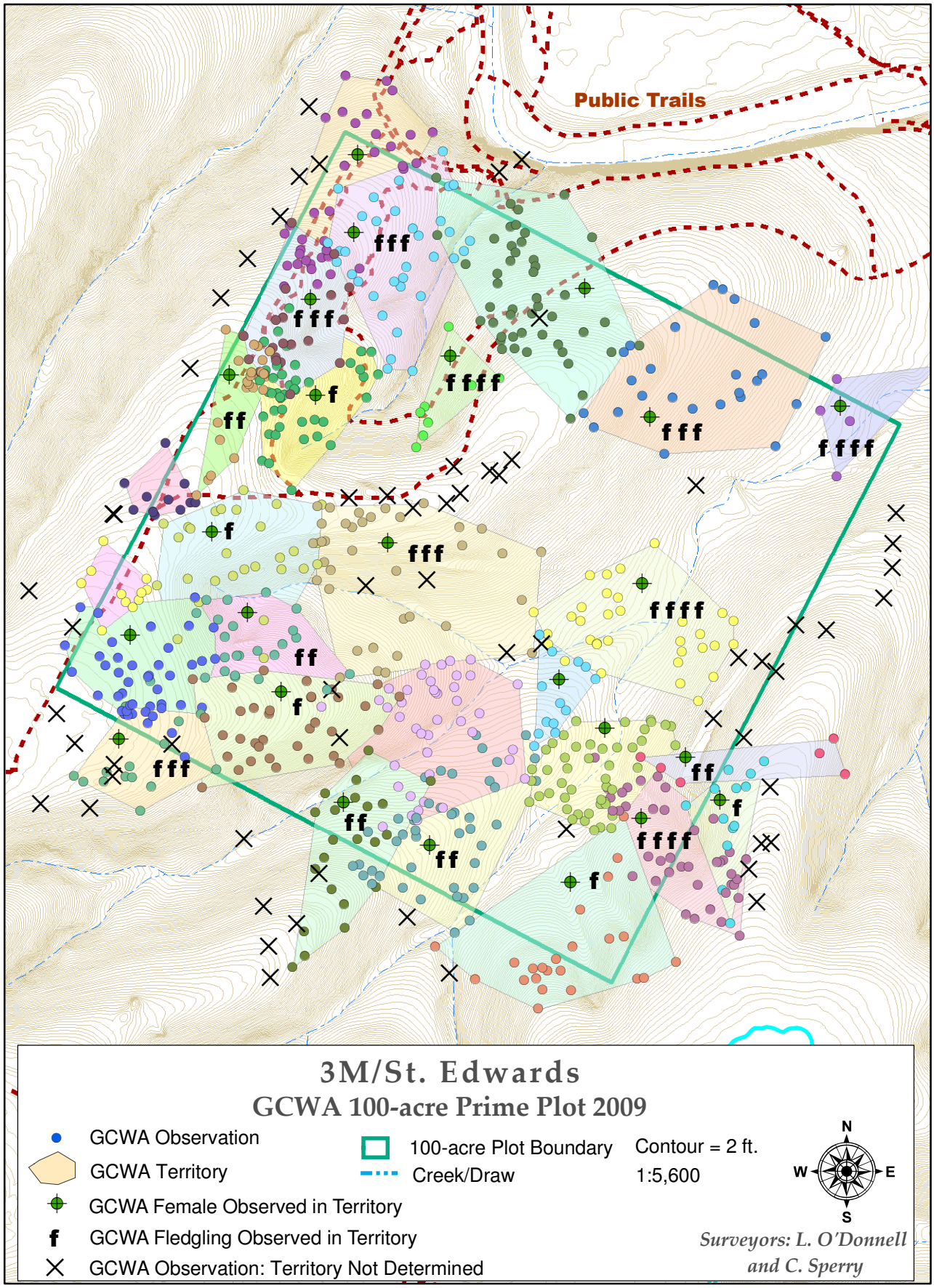

Public Trails
3M/St. Edwards
GCWA 100-acre Prime Plot 2009
GCWA Observation
GCWA Territory
GCWA Female Observed in Territory
f GCWA Fledgling Observed in Territory
GCWA Observation: Territory Not Determined
100-acre Plot Boundary
Creek/Draw
Contour = 2 ft.
1:5,600
N
W
E
S
Surveyors: L. O'Donnell and C. Sperry

Figure 1

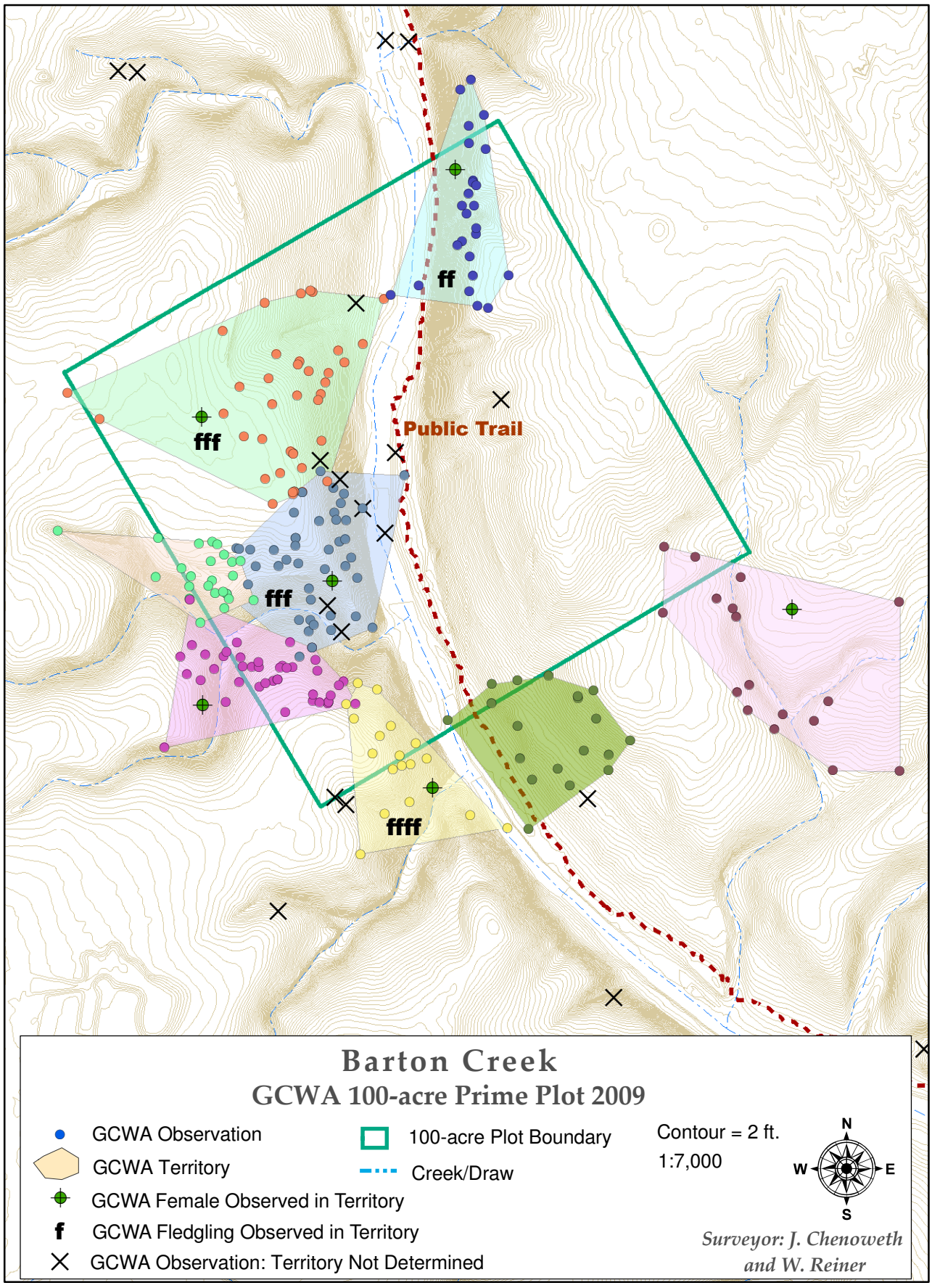

Barton Creek
GCWA 100-acre Prime Plot 2009
GCWA Observation
GCWA Territory
GCWA Female Observed in Territory
f GCWA Fledgling Observed in Territory
GCWA Observation: Territory Not Determined
100-acre Plot Boundary
Creek/Draw
Contour = 2 ft.
1:7,000
N
W
E
S
Surveyor: J. Chenoweth
and W. Reiner
Public Trail
ff
fff
fff
ffff

Figure 2

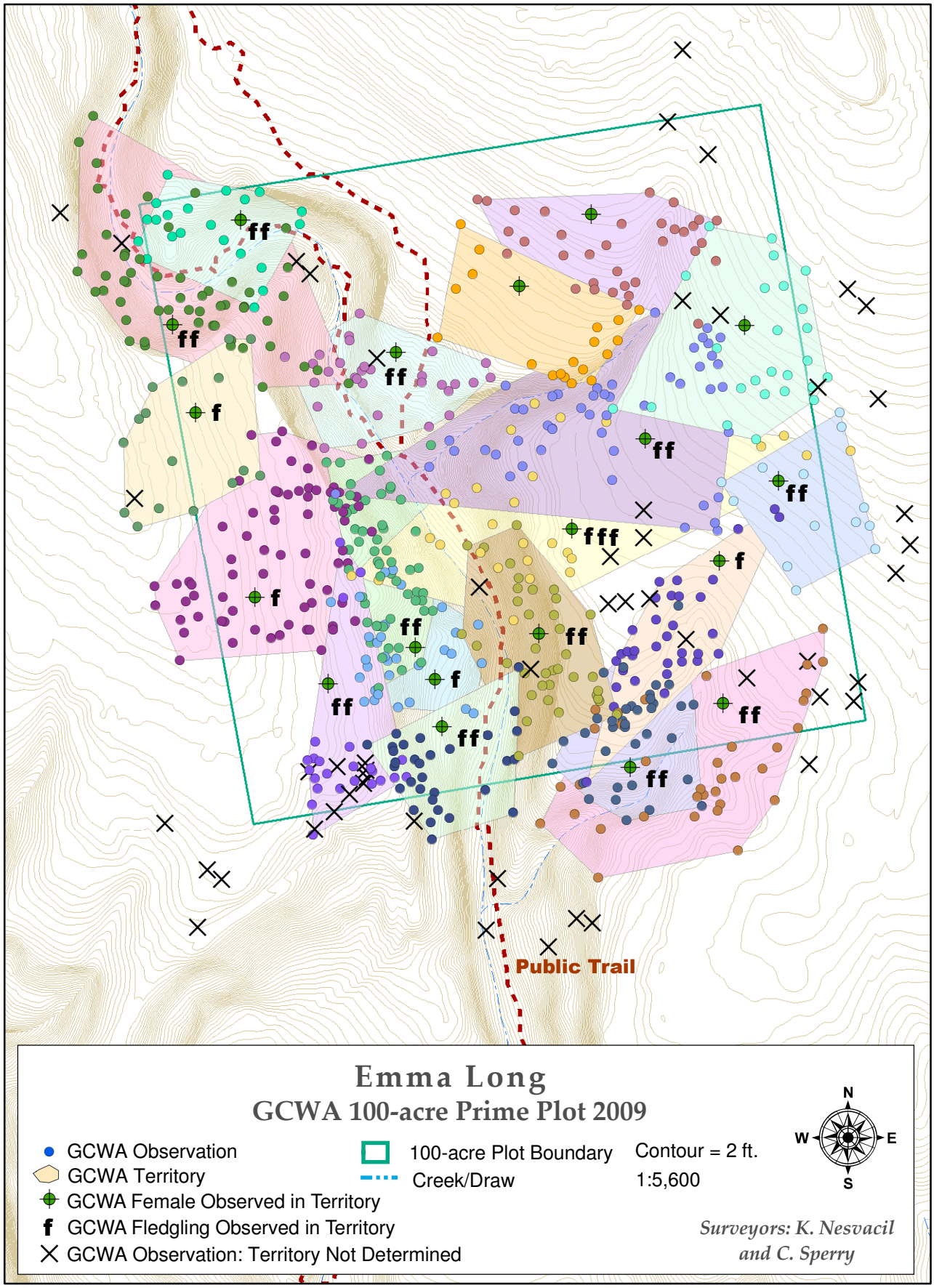

Public Trail
Emma Long
GCWA 100-acre Prime Plot 2009
GCWA Observation
GCWA Territory
GCWA Female Observed in Territory
f GCWA Fledgling Observed in Territory
GCWA Observation: Territory Not Determined
100-acre Plot Boundary
Creek/Draw
Contour = 2 ft.
1:5,600
N
W
E
S
Surveyors: K. Nesvacil and C. Sperry

Figure 3

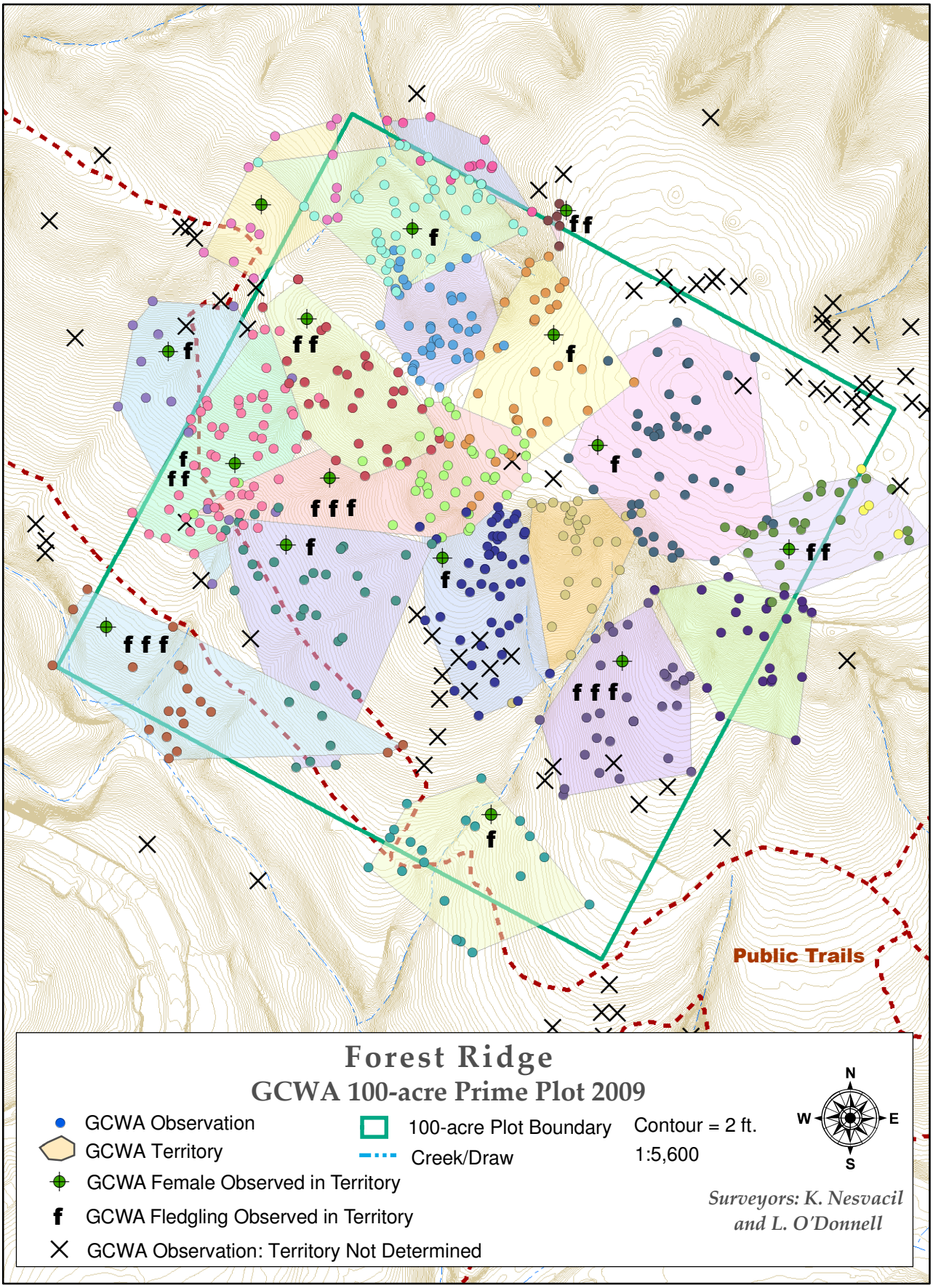

Forest Ridge
GCWA 100-acre Prime Plot 2009
GCWA Observation
GCWA Territory
GCWA Female Observed in Territory
f GCWA Fledgling Observed in Territory
GCWA Observation: Territory Not Determined
100-acre Plot Boundary
Creek/Draw
Contour = 2 ft.
1:5,600
N
W
E
S
Surveyors: K. Nesvacil and L. O'Donnell
Public Trails

Figure 4

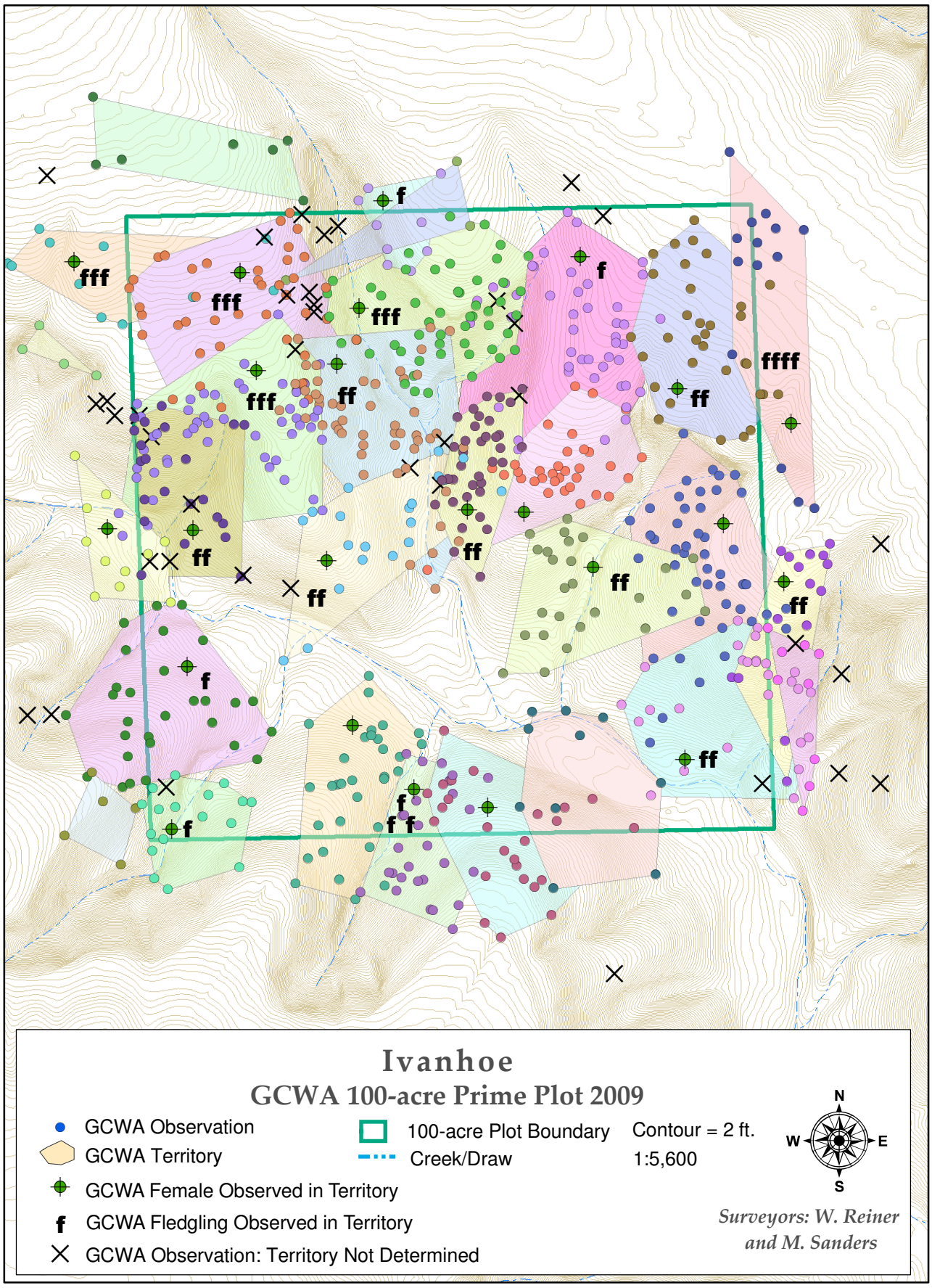

Ivanhoe
GCWA 100-acre Prime Plot 2009
GCWA Observation
GCWA Territory
GCWA Female Observed in Territory
f GCWA Fledgling Observed in Territory
GCWA Observation: Territory Not Determined
100-acre Plot Boundary
Creek/Draw
Contour = 2 ft.
1:5,600
N
W
E
S
Surveyors: W. Reiner and M. Sanders

Figure 5

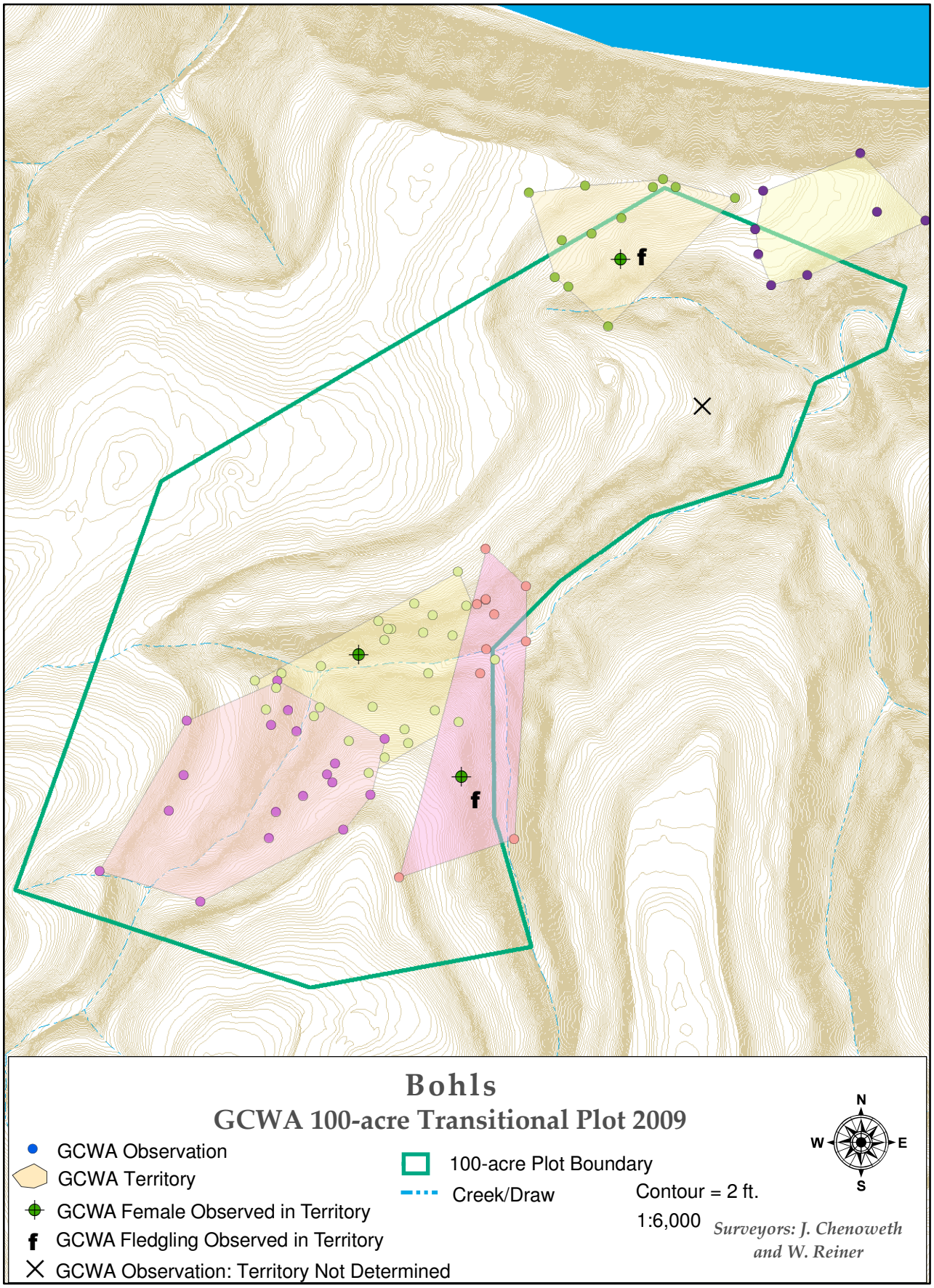

Bohls
GCWA 100-acre Transitional Plot 2009
GCWA Observation
GCWA Territory
GCWA Female Observed in Territory
f GCWA Fledgling Observed in Territory
GCWA Observation: Territory Not Determined
100-acre Plot Boundary
Creek/Draw
Contour = 2 ft.
1:6,000
Surveyors: J. Chenoweth and W. Reiner
N
W
E
S
f
f

Figure 6

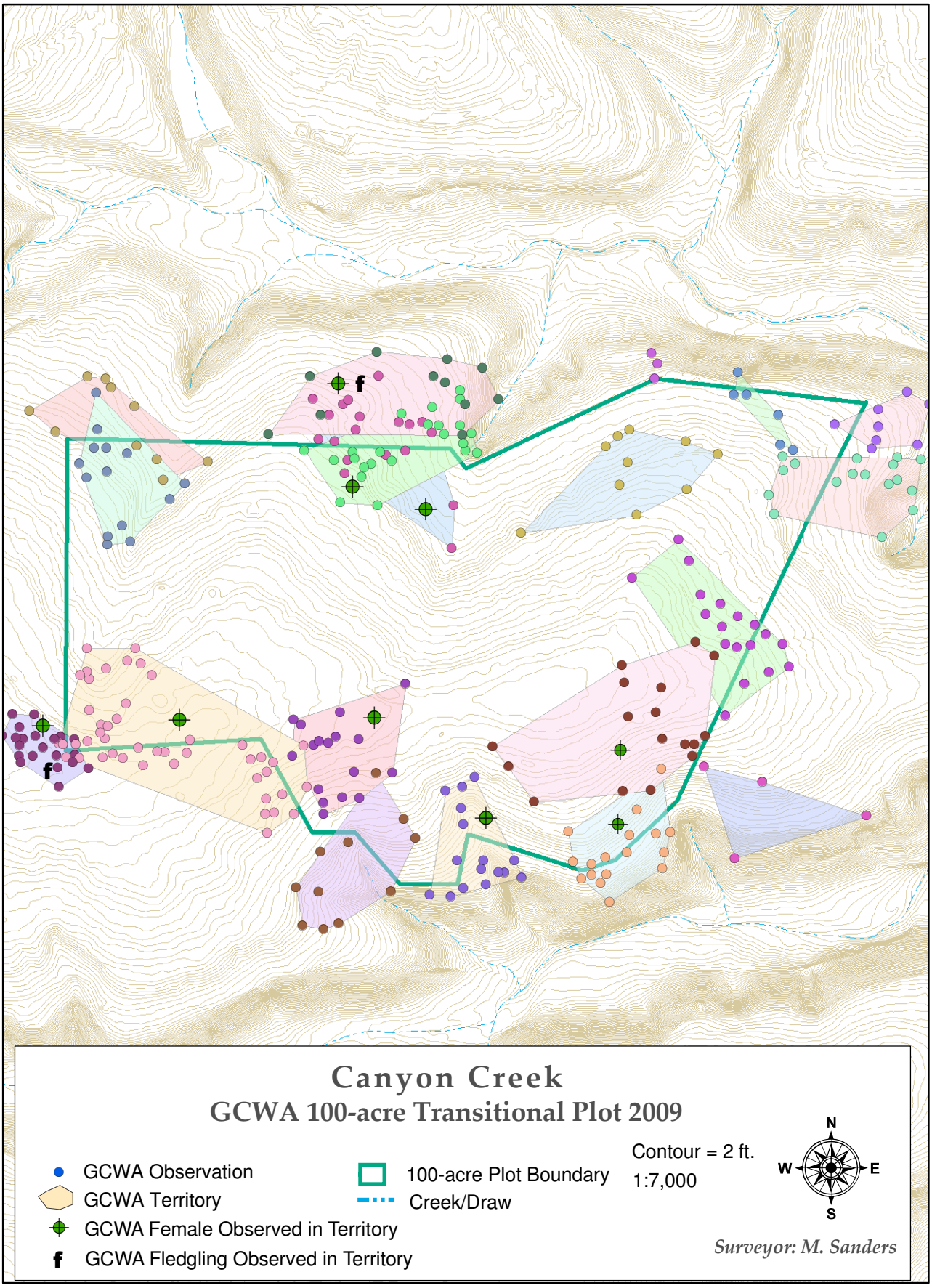

Canyon Creek
GCWA 100-acre Transitional Plot 2009
GCWA Observation
GCWA Territory
GCWA Female Observed in Territory
GCWA Fledgling Observed in Territory
100-acre Plot Boundary
Creek/Draw
Contour = 2 ft.
1:7,000
N
W
E
S
Surveyor: M. Sanders

Figure 7

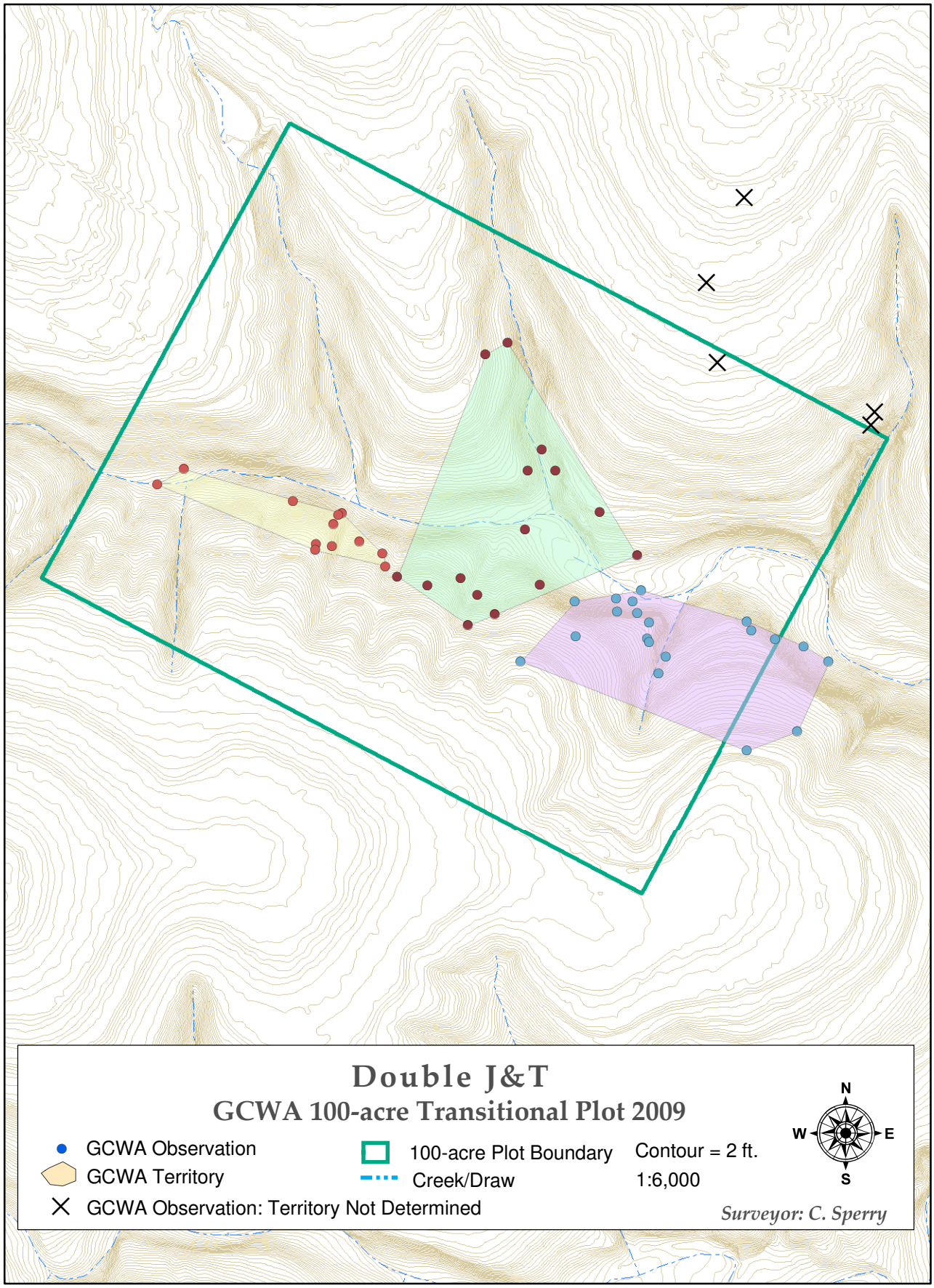

Double J&T
GCWA 100-acre Transitional Plot 2009
GCWA Observation
GCWA Territory
GCWA Observation: Territory Not Determined
100-acre Plot Boundary
Creek/Draw
Contour = 2 ft.
1:6,000
N
W
E
S
Surveyor: C. Sperry

Figure 8

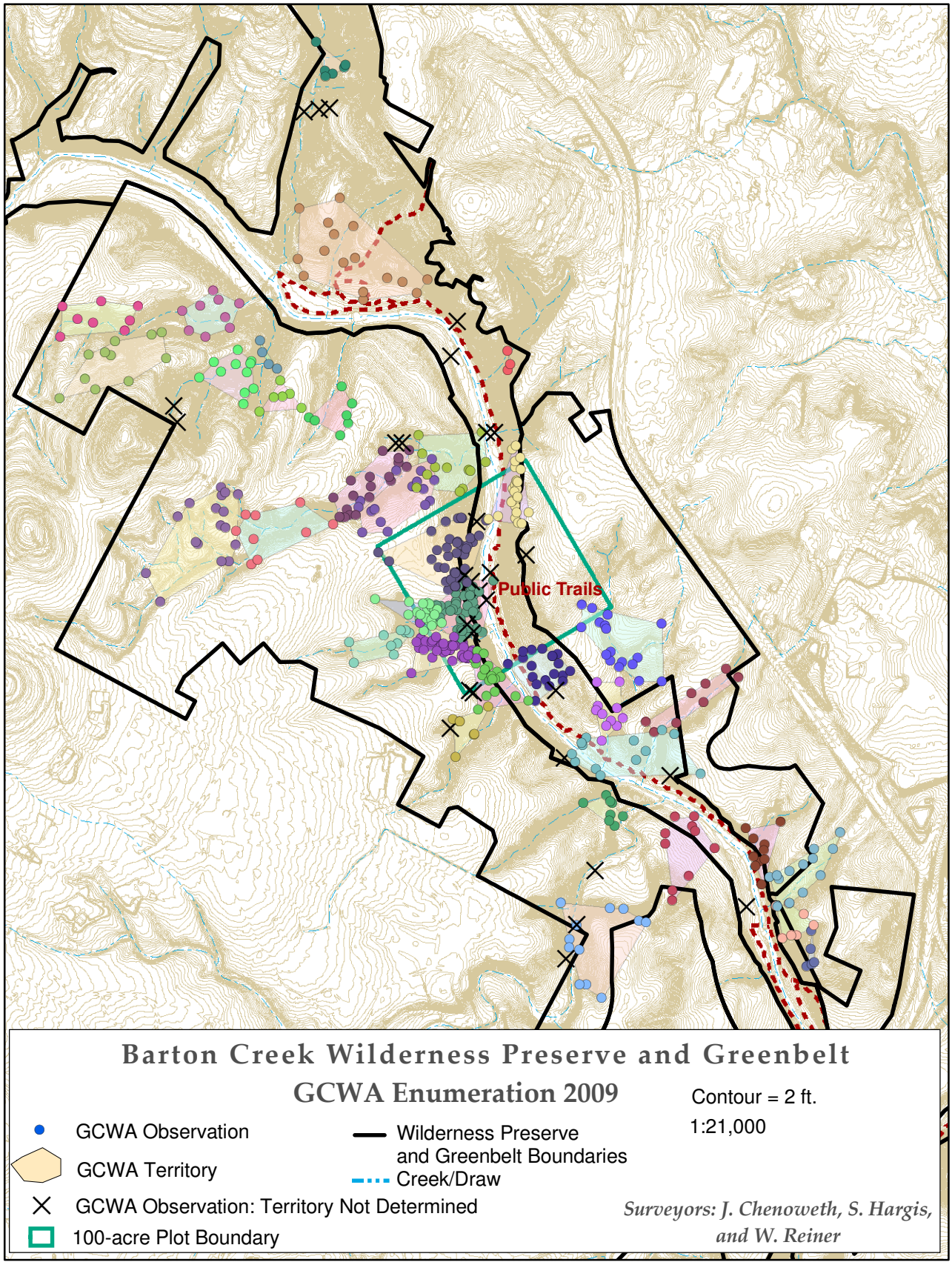

Public Trails
Barton Creek Wilderness Preserve and Greenbelt
GCWA Enumeration 2009
Contour = 2 ft.
1:21,000
GCWA Observation
GCWA Territory
GCWA Observation: Territory Not Determined
100-acre Plot Boundary
Wilderness Preserve and Greenbelt Boundaries
Creek/Draw
Surveyors: J. Chenoweth, S. Hargis, and W. Reiner

Figure 9

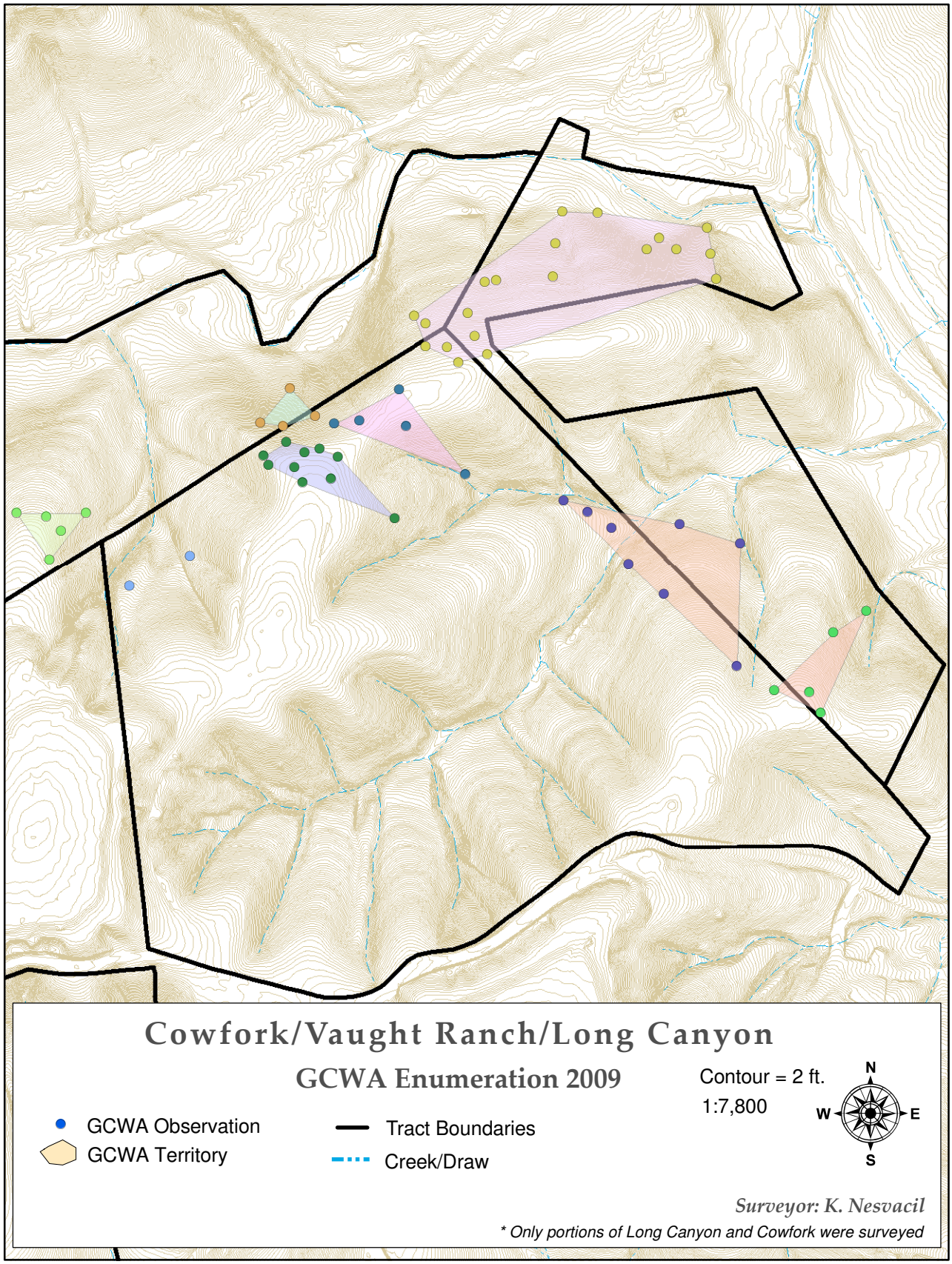

Cowfork/Vaught Ranch/Long Canyon
GCWA Enumeration 2009
Contour = 2 ft.
1:7,800
N
W
E
S
GCWA Observation
GCWA Territory
Tract Boundaries
Creek/Draw
Surveyor: K. Nesvacil
* Only portions of Long Canyon and Cowfork were surveyed

Figure 10

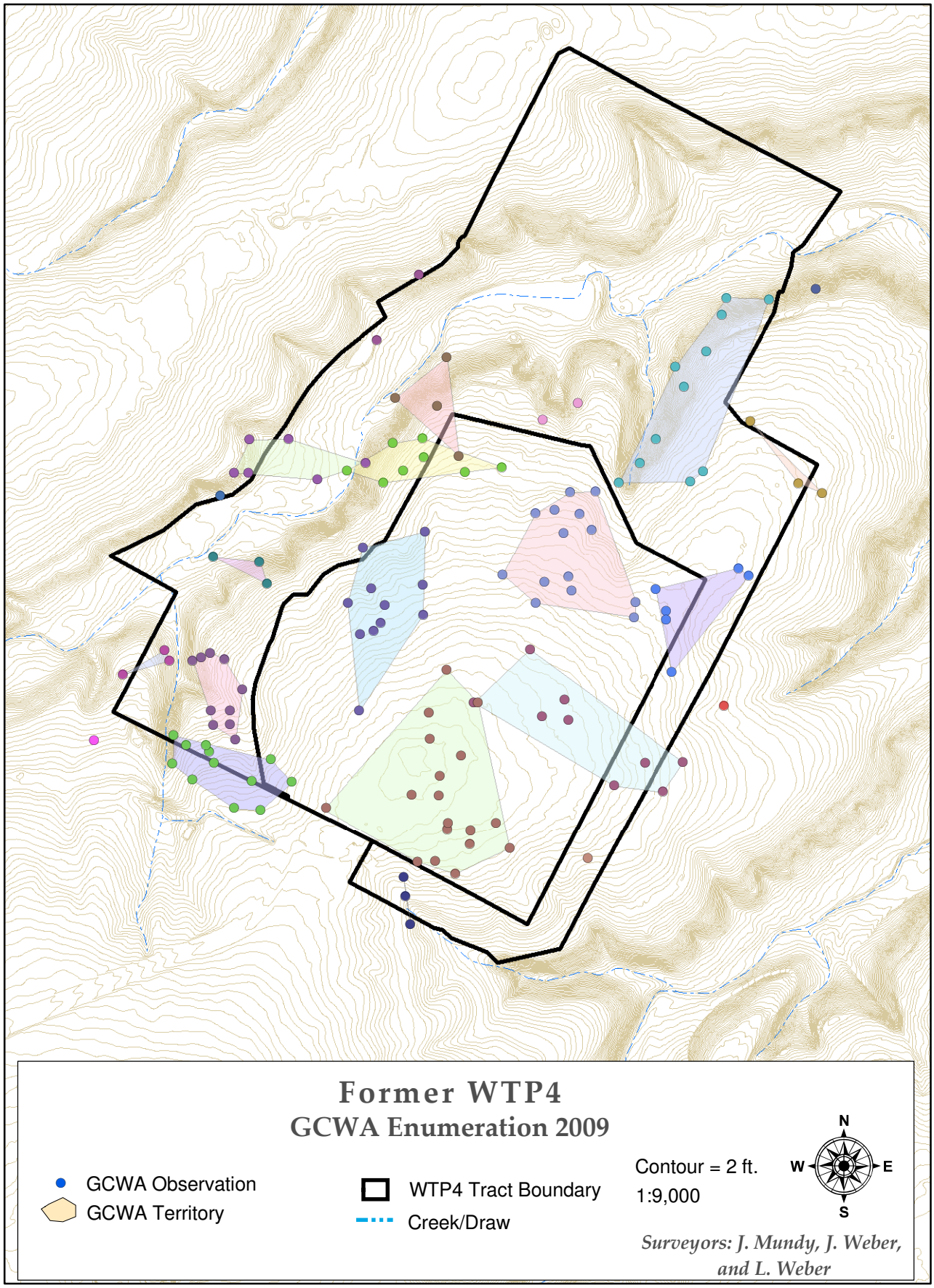

Former WTP4
GCWA Enumeration 2009
GCWA Observation
GCWA Territory
WTP4 Tract Boundary
Creek/Draw
Contour = 2 ft.
1:9,000
N
W
E
S
Surveyors: J. Mundy, J. Weber, and L. Weber

Figure 11

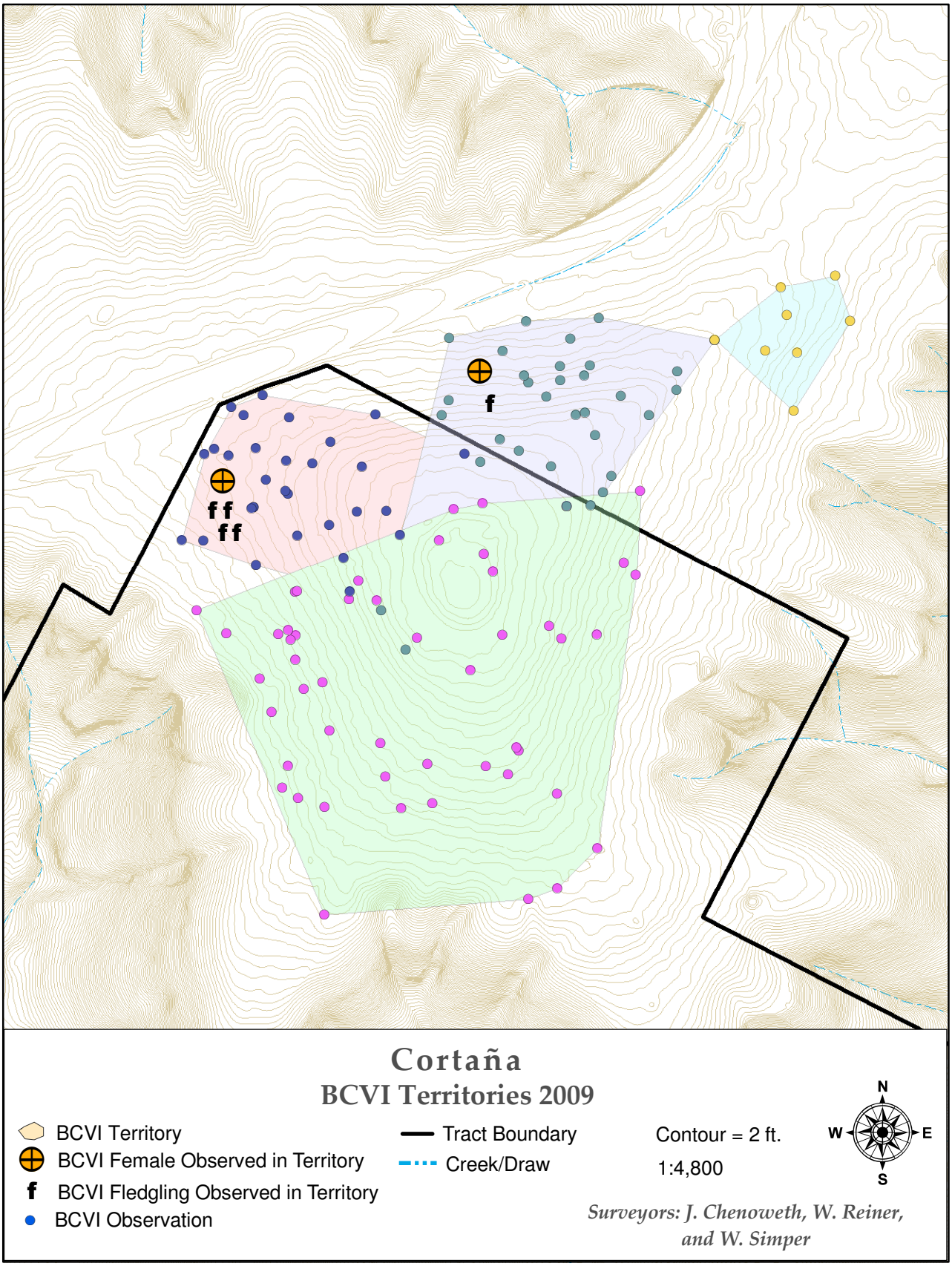

f
f f
f f
Cortaña
BCVI Territories 2009
BCVI Territory
BCVI Female Observed in Territory
f BCVI Fledgling Observed in Territory
BCVI Observation
Tract Boundary
Creek/Draw
Contour = 2 ft.
1:4,800
N
W
E
S
Surveyors: J. Chenoweth, W. Reiner, and W. Simper

Figure 12

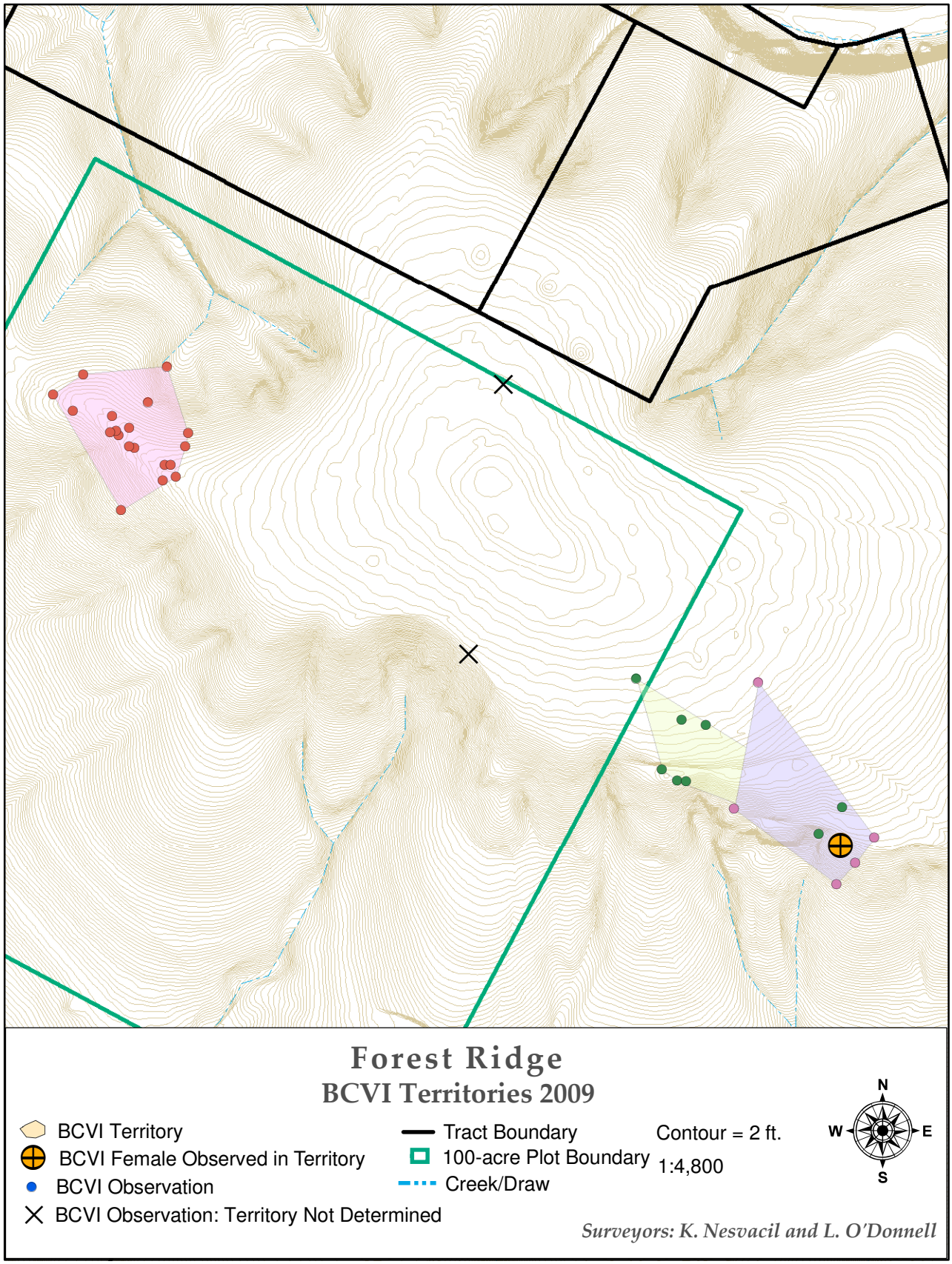

Forest Ridge
BCVI Territories 2009
BCVI Territory
BCVI Female Observed in Territory
BCVI Observation
BCVI Observation: Territory Not Determined
Tract Boundary
100-acre Plot Boundary
Creek/Draw
Contour = 2 ft.
1:4,800
N
W
E
S
Surveyors: K. Nesvacil and L. O'Donnell

Figure 13

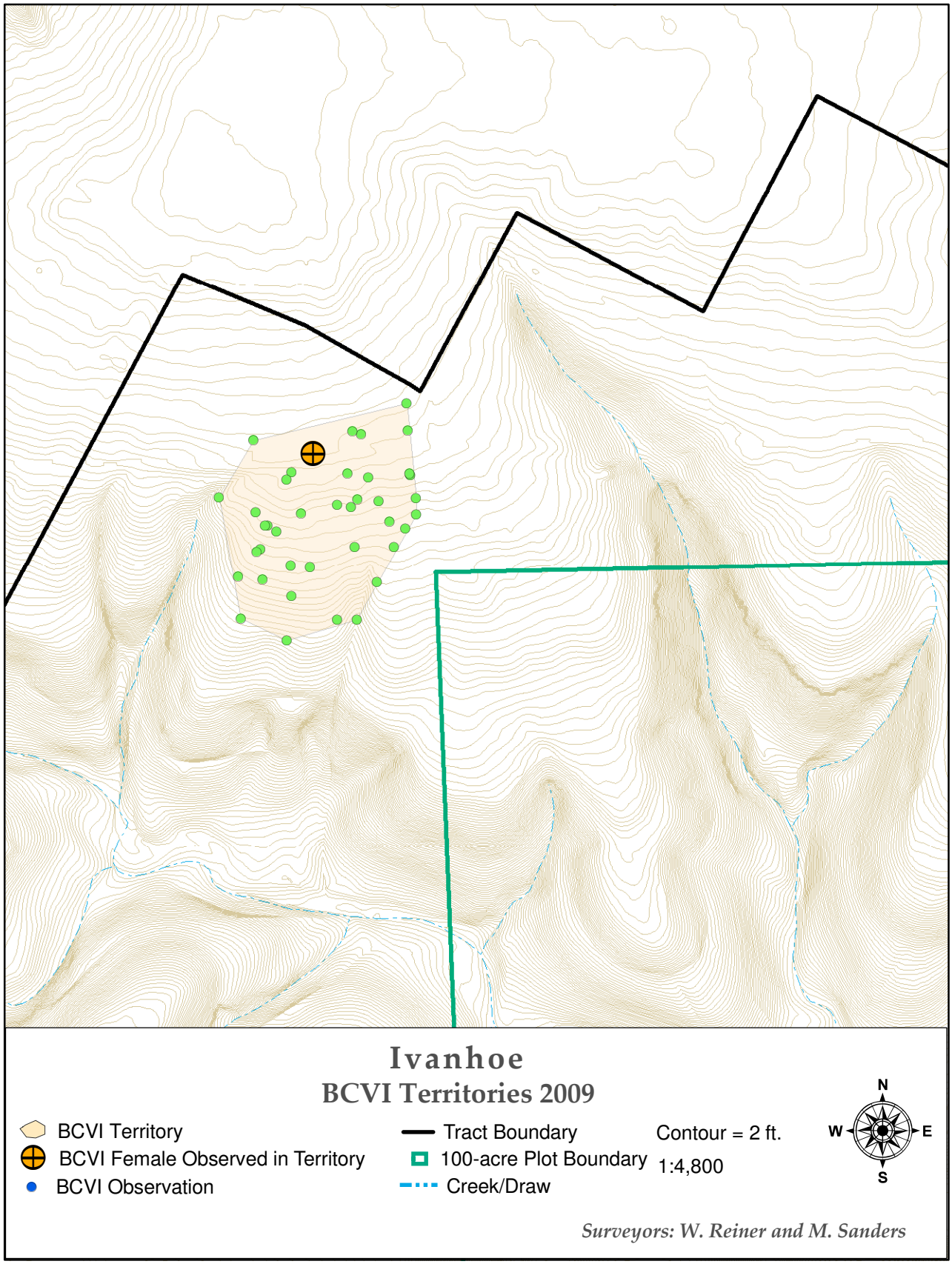

Ivanhoe
BCVI Territories 2009
BCVI Territory
BCVI Female Observed in Territory
BCVI Observation
Tract Boundary
100-acre Plot Boundary
Creek/Draw
Contour = 2 ft.
1:4,800
N
W
E
S
Surveyors: W. Reiner and M. Sanders

Figure 14