2012 Balcones Canyonlands National Wildlife Refuge
Golden-cheeked Warbler (*Setophaga chrysoparia*)
And
Black-capped Vireo (*Vireo atricapilla*)
Annual Monitoring Report

Female golden-cheeked warbler

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INTRODUCTION

This report summarizes the results of the Balcones Canyonlands National Wildlife Refuge (BCNWR) 2012 golden-cheeked warbler (*Setophaga chrysoparia*) (GCWA) and black-capped vireo (*Vireo atricapilla*) (BCVI) endangered species monitoring program. This report only includes activities conducted by Refuge staff and volunteers. Additional monitoring and research activities for the BCVI were conducted by Michaela Murphy with Texas A&M University, and Lauren Seckel with Washington State University. Additionally, monitoring and research activities for the GCWA were conducted by Frank Thompson and Jennifer Reidy with the University of Missouri. These activities should be reported separately by the specific researcher and are not included in this report.

In 2012, the primary surveyors on staff were: Refuge Biologist Scott Rowin, Zone Biologist Jim Mueller, and Biological Technicians David Morgan, Roland Davis, and Emily Haeuser. Volunteers Frank and Connie Madia, Chris Weyenberg, Sandi Wickland, and John Harrington, along with BCNWR Staff including Deborah Holle, Megan Cooke, and Jeremy Edwardson assisted with enumeration surveys on several BCNWR tracts. All staff and volunteers mentioned above provided casual observations. All volunteers and staff received adequate training prior to surveying.

BACKGROUND

The GCWA is a neotropical migrant passerine that breeds only in central Texas where mature oak-juniper (*Quercus spp. - Juniperus ashei*) 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 BCVI is also an endangered, neotropical migrant that breeds in portions of Oklahoma, Texas, and Mexico (Grzybowski 1989). 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 National Wildlife Refuge was established in 1992 in part to promote the recovery of these species. The Refuge is located at the corners of Travis, Williamson, and Burnet Counties, Texas, and currently consists of approximately 25,480 acres (includes conservation easements and anticipated easements in the near future), with an anticipated future goal of having 46,000 acres. Of the acres currently, or soon to be included within the Refuge, approximately 18,728 acres have been identified in the Draft Refuge Habitat Management Plan as areas to be managed for the

warbler, some of which are currently not occupied, and approximately 1,861 acres are identified for the vireo, some of which are also not occupied. Additionally, approximately 142 acres within the Refuge have been identified as areas that could be managed for either or both species. The remaining acreage is typically identified and managed as grassland, savannah, riparian habitat, or facilities.

Since 1998 monitoring of the golden-cheeked warbler population on BCNWR has been part of a standardized, regional program between BCNWR and Balcones Canyonlands Preserve (BCP) in Travis County with objectives that tied into the Recovery Plan for the species. The protocol was to map male GCWA territories within several 100-acre plots over 10 weeks based on ≥60 hours of surveys (Balcones Canyonlands Preserve Land Management Plan, 2007, unpublished). Some plots were located in "prime" habitat, in which 75% of the plot had >70% canopy cover, and others in "transitional" habitats that were expected to mature into prime habitat. On BCNWR, 5 plots were established, 3 in prime and 2 in transitional habitats. Population and productivity trends were to be tracked on these 100-acre plots by collecting information on territory density, territory location, pairing success, breeding success, and productivity.

At the time of development it was believed population and productivity estimates for the BCNWR could be derived by extrapolating results from the five 100-acre plots and other short-term monitoring plots to similar habitats throughout the refuge. However, survey efforts on BCNWR over time have been sporadic and inconsistent due to lack of sufficient personnel, and as a result population and productivity data are limited. The latest population estimate for the refuge was at least 810 golden-cheeked warbler territories (Sexton 2009). This estimate was derived by utilizing these survey results and professional judgment, but may not be a valid estimate of the GCWA population on BCNWR for the reasons identified above. Past monitoring efforts also do not provide sufficient information for evaluating success of management activities. Because of this Refuge staff reevaluated its GCWA monitoring program for 2012. It was determined beginning in 2012 BCNWR would begin conducting occupancy surveys across the entire refuge (including conservation easements) every five years followed by productivity surveys in the interim four years. It is believed this would provide sufficient information to allow for needed management decisions and would allow for trends in occupancy to be monitored over time.

Due to the less extensive distribution of vireos throughout the Refuge, no formal monitoring plots for this species exist. Rather, discrete segments of the Refuge's vireo population are monitored on a regular basis by Refuge staff and/or outside researchers. Since 2009 considerable help in monitoring the Refuge's BCVI population has occurred through several Universities. With this help the Refuge has obtained good

data on BCVI populations and productivity, including the effects of the recent drought on this species. Additionally, the occupancy surveys mentioned above have been designed to include the BCVI.

OBJECTIVES

The objective of the occupancy survey is to determine the proportion of the refuge occupied by territorial (i.e., singing) male golden-cheeked warblers. It will also estimate area occupied by black-capped vireos and five other species. The other species and the rationale for selecting them were:

- black-capped vireo – one goal of the refuge is to increase abundance of this endangered species;
- brown-headed cowbird – the refuge conducts management activities to reduce the abundance of this nest parasite with a goal of reducing nest parasitism of black-capped vireo nests to ≤10%;
- western scrub-jay – this potential nest predator is associated with oak-juniper shrub habitat that may develop into higher quality warbler habitat with vegetative succession;
- blue jay – this potential nest predator increases with fragmentation of juniper-oak woodlands and urbanization ;
- northern bobwhite – this species of concern throughout the Oaks and Prairies Joint Venture is associated with savannas and is an indicator of grassland/savanna health, an ecosystem of concern for the Refuge;
- wild turkey – this species is hunted on the refuge; this species was added after the first round of surveys in 2012 to monitor its population to ensure we have a huntable population.

The occupancy surveys established the methodology for estimating the amount of area occupied by golden-cheeked warblers on the Refuge with a standard error ≤0.05. This survey will be repeated every five years to monitor trend in occupancy. If occupied golden-cheeked warbler habitat is found to be decreasing at any subsequent time, a thorough evaluation could be conducted to identify the cause of the decline (e.g., change in vegetative structure, increased nest parasitism, breeding season survival, productivity, migratory hazards, wintering ground habitat, etc.). If the vegetative composition and structure has degraded (e.g., loss of requisite canopy cover and/or declines in abundance of required tree species), management can then be implemented to correct the deficiency. Additional studies will be required to assess changes in demographics (e.g., productivity, survival). It is anticipated these surveys will be conducted in the interim four years between occupancy surveys. The methodology for these surveys has yet to be developed.

The objective for enumeration and casual observation surveys is to identify overall distribution and provide a rough estimate of the number of male GCWA and BCVI on Refuge tracts. Surveys in 2012 focused on tracts that have historically had very few, if any, surveys conducted on them.

METHODS

Occupancy surveys

The complete set of occupancy survey protocols is included as Attachment 1 of this report. The occupancy surveys followed the USFWS protocol for landbird monitoring (10-minute point count, Knutson et al. 2008) with a few exceptions. Surveys started between 15 minutes before sunrise (as opposed to 30 minutes) and 5 hours after sunrise (as opposed to 6 hours). Air temperature was ≥10°C (50°F) to match many protocols used for golden-cheeked warbler surveys. Surveys were allowed with a sky condition code of 5 (i.e., drizzle). The data sheet was tailored for this specific survey. The minute and second of the first detection of a song for golden-cheeked warbler or black-capped vireo or song/call for other species for each individual was recorded. The location of the bird was marked on the circular plot which was overlaid on recent imagery at a 1:2000 scale (1 mm = 2 m). Subsequent aural detections of each bird were tallied for each 2-minute period during the survey. Visual detections were recorded in the same manner, but separately, for each individual of the 7 species.

The survey design was based on a completely random sample of points from throughout the refuge (fee title and easement lands). For tracts owned in fee title and easements other than the Hickory Pass and potential future Hickory Ridge easement, a completely random set of 200 survey points was obtained using the ArcGIS Create Random Points data management tool. The Hickory Pass easement and potential future Hickory Ridge easement were incorporated into the overall sampling of the refuge as a distinct stratum with 50 sampling points. Points were given a minimum allowed distance to one another of 250 meters; a minimum distance of 300 m was attempted but would not work for the number of points required. Data for future analysis will likely be truncated at a distance of 100 m or less, so the distance between points is adequate to ensure no overlap between survey stations. No buffer between the refuge tract boundaries and the points was created. No other type of preference was given to any particular tracts or land cover types.

Surveys were conducted four times at each point beginning 2 April and repeating approximately every 2 weeks. To minimize observer bias, a minimum of three observers went to each point during the four surveys.

Enumeration and Casual Observation Surveys

Enumeration surveys were conducted this year at multiple sites on the Refuge to ascertain warbler and vireo distributions and to attempt to get a rough estimate of overall territory density. Volunteers contributed approximately 160 person-hours this year and helped survey all or portions of Cactus Rocks trail, Nagel, Barho, Greg, Payton, Circle 3-S, Mullen, Gainer, Shaw, Kennedy, and Victoria. Many of these tracts (or portions of them) have had few, if any, surveys conducted on them in the past. Protocols for Enumeration surveys are included as Attachment 2. Casual observations are just that, casual in nature, and as such no protocols exist for them.

RESULTS

Two geodatabases were developed this year to collect and maintain all observational data, one for archived endangered species data (1992 to 2011) and a second database that all 2012 and future endangered species data will be entered into. The new (2012 and future data) database will standardize the way in which all future data is entered, including data that is collected by outside researchers. Doing so will help tremendously in data management for the Refuge.

Figures 1-7 identify the 250 random points that were utilized during the occupancy surveys. Additionally, these Figures identify all GCWA and BCVI observations made during the occupancy, enumeration, and casual observation surveys during 2012.

Occupancy Survey

Data analysis is currently underway on the occupancy survey information. Refinement of the occupancy analysis to add covariates will be completed, as well as density estimates based on distance sampling. Additionally, habitat metrics are being developed with NAIP imagery (relative canopy cover by Ashe juniper and broadleaf trees) and LiDAR (canopy height) and will be used to evaluate correlations with occupancy and to guide management of juniper-oak woodlands for this species. Analysis of occupancy survey data has yet to be done for the remaining six species.

Preliminary analysis of the GCWA data is presented in Table 1. Because of the slightly higher density of points on Hickory Pass/Ridge than on the Refuge it is necessary to present the data separately. This also allows for separate reporting purposes, should there be a need to do so. It is likely future analysis will pool the data

as a single set for the entire Refuge (Refuge and Hickory Pass/Ridge) and will be used for management objectives. The data in table one identifies the probability of occupancy from 75, 100, and 150 meters from the 200 points on the Refuge and 50 points on Hickory Pass/Ridge. The standard error (SE) is slightly higher on Hickory Pass/Ridge due to the smaller sample size (200 points vs. 50 points).

Table 1: Summary results for 2012 occupancy surveys at 75, 100, and 150 meters (m) including the standard error (SE).

	75 m.	SE	100 m.	SE	150 m.	SE
200 pts. BCNWR	42.4%	4.7%	47.6%	4.1%	55.0%	3.9%
50 pts. Hickory Pass/Ridge	44.5%	8.7%	53.1%	8.8%	67.5%	8.4%

Enumeration and Casual Observation

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 but typically does not meet the minimum standards of a presence/absence survey (USFWS 2010). Incidental sightings of females, fledglings, and nests are also recorded, as are observations of parasitism and potential predators during these surveys. This type of survey effort allows staff and/or volunteers to cover larger areas, but the results are less accurate than those obtained with other methods. Surveyors attempted to sort out individual GCWAs and BCVIs to increase the accuracy of the count. However, significantly less time is spent on enumeration surveys per acre than presence/absence surveys and therefore only provides a rough estimate of distribution, and 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. Observations after May 25 are recorded, but not used to delineate territory boundaries as fledging is well underway and territories boundaries have begun to breakdown. Warbler observations were recorded with a GPS datalogger (Garmin GPSMap 62st) and were later transcribed on field maps and entered into ArcGIS. Enumeration survey results are summarized in Table 1 and are included on Figures 1-7.

Table 2: Summary data for 2012 Enumeration Surveys.

Location	**Area Surveyed**	**Minimum # GCWA Territories**	**Minimum # BCVI Territories**	**# of Survey Visits**
Victoria	Entire tract limited survey	27		6
Shaw	Entire tract	4	1	5
Warbler Vista trail	Trail area	9		3
Nagel	Western canyon limited survey	4		2
Mullen	Northern portion	5	1	5
Kennedy	Entire Tract	8		3
Gainer	Pre-treatment unit south of road	7	3	6
Barho	Entire tract limited survey	3		2
Greg	Entire tract limited survey	1		1
Payton	Entire tract	1		1
Circle 3-S	Entire tract	6		3

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Figure 1. 2012 GCWA/BCVI Surveys in Mullen, Russell and Eckhardt Area

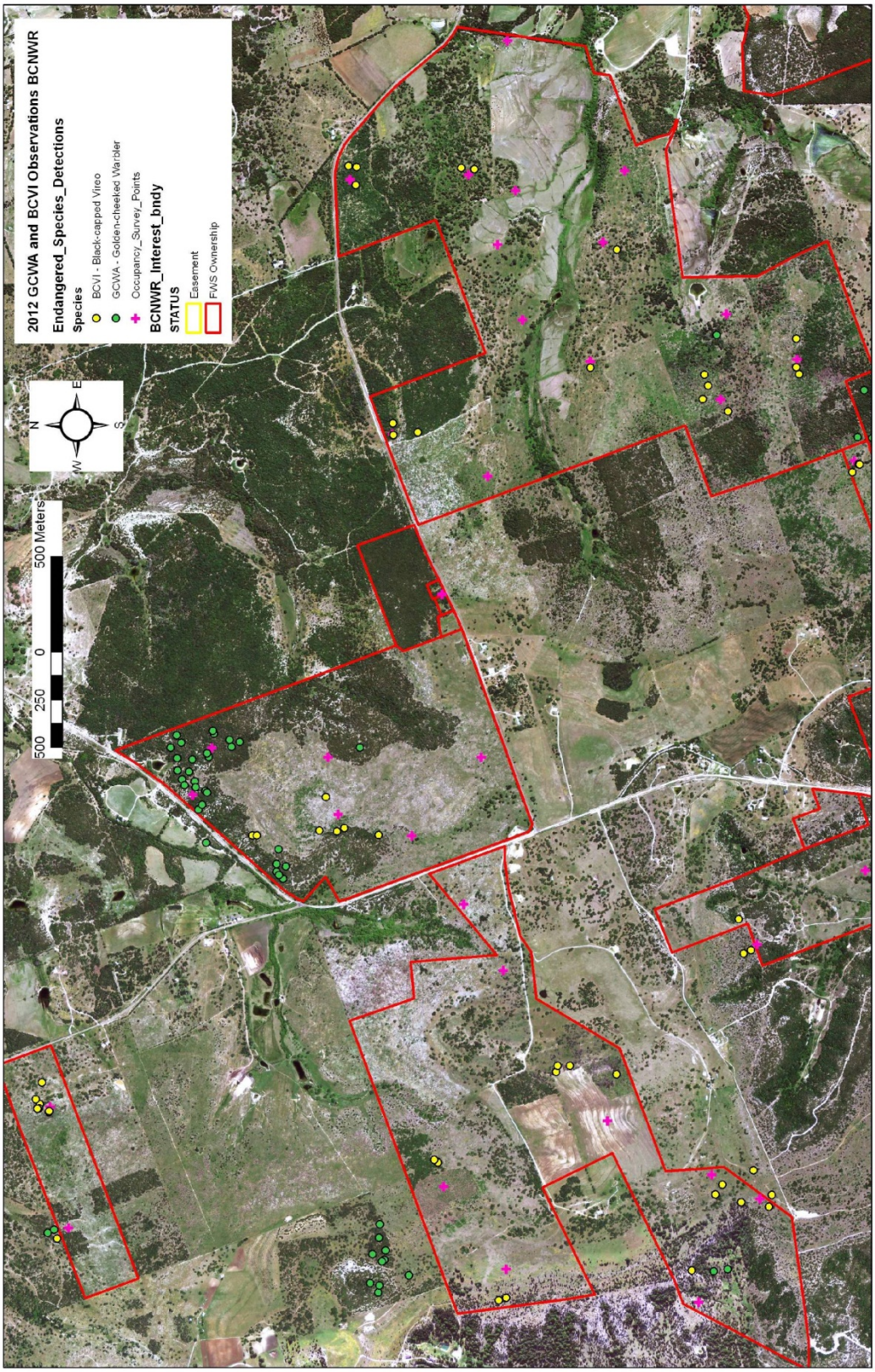


Figure 2. 2012 GCWA/BCVI Surveys in Flying X and Doeskin Area

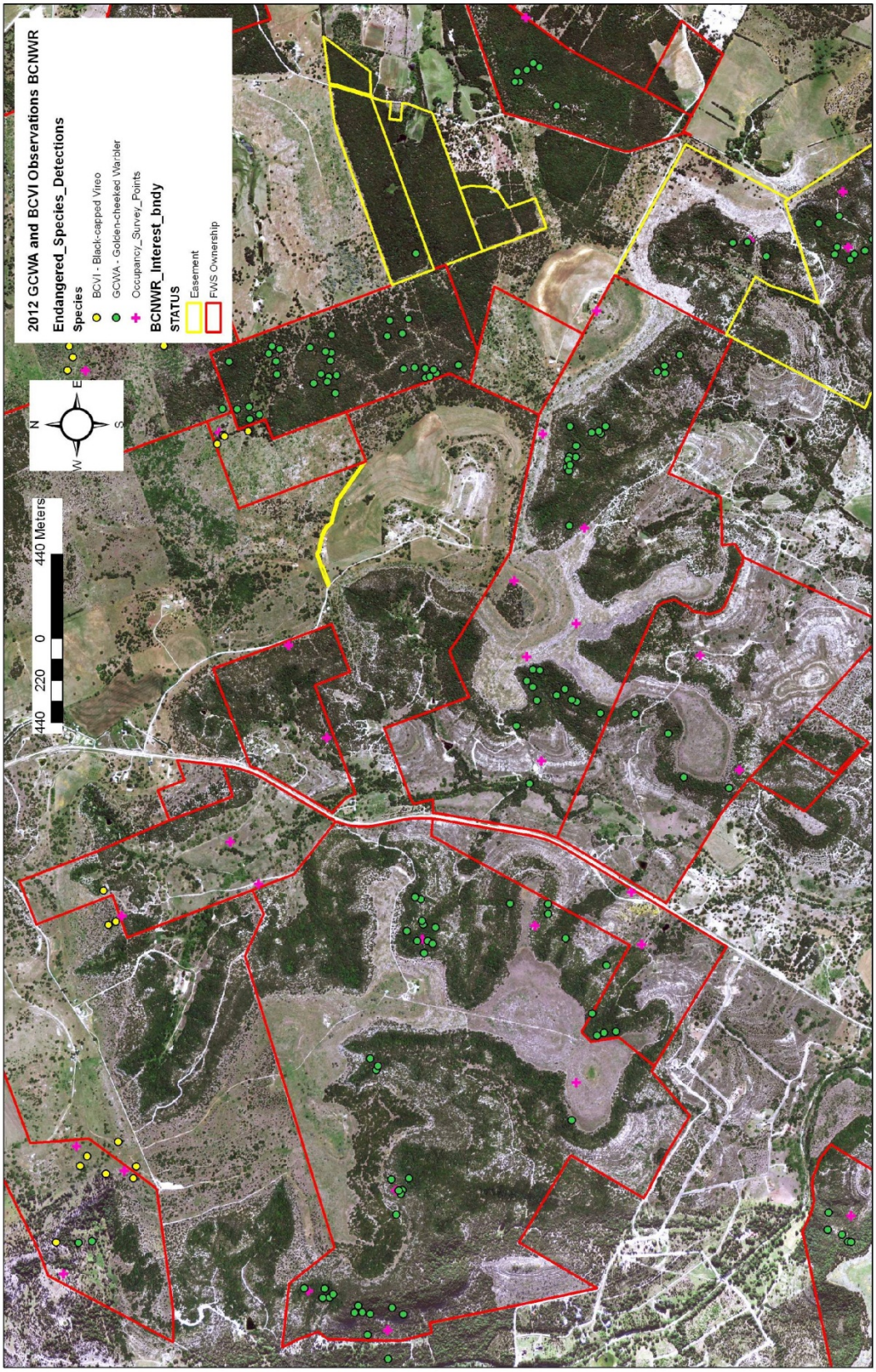


Figure 3. 2012 GCWA/BCVI Surveys in Johnson and Gainer Area

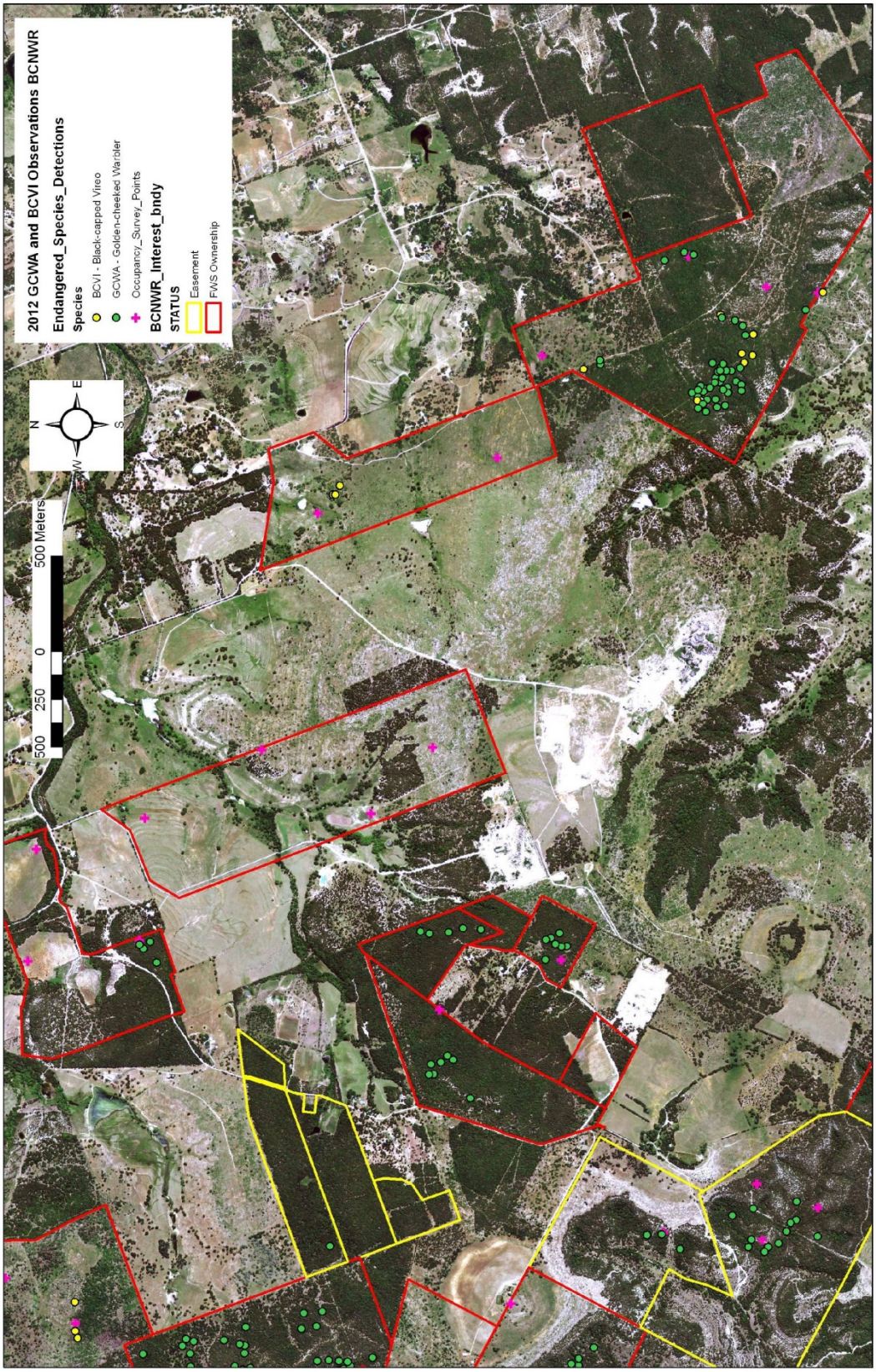


Figure 4. 2012 GCWA/BCVI Surveys in Three Creeks Area.

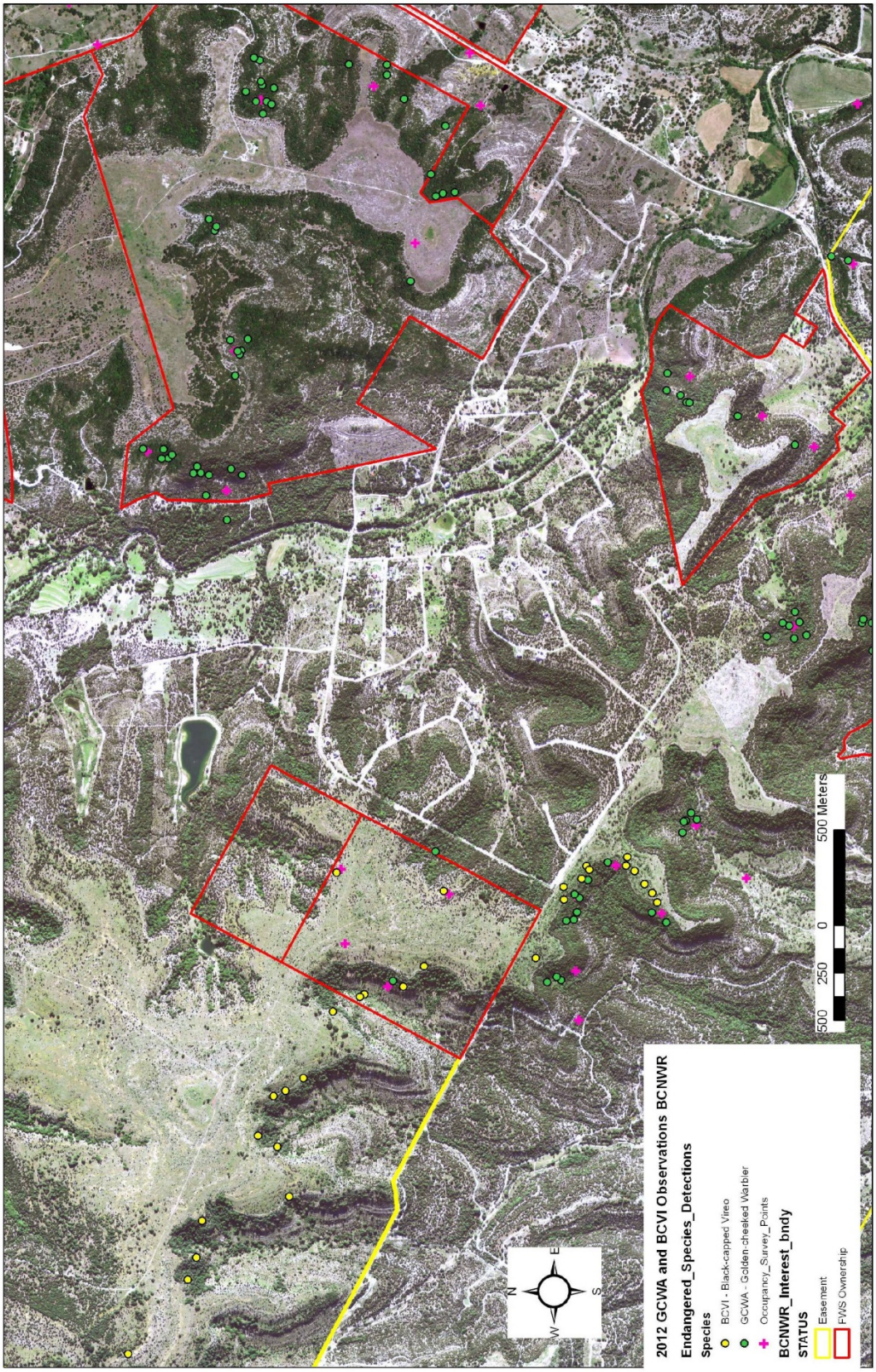


Figure 5. 2012 GCWA/BCVI Surveys in Hickory Pass/Ridge and Cloud Canyon Area.

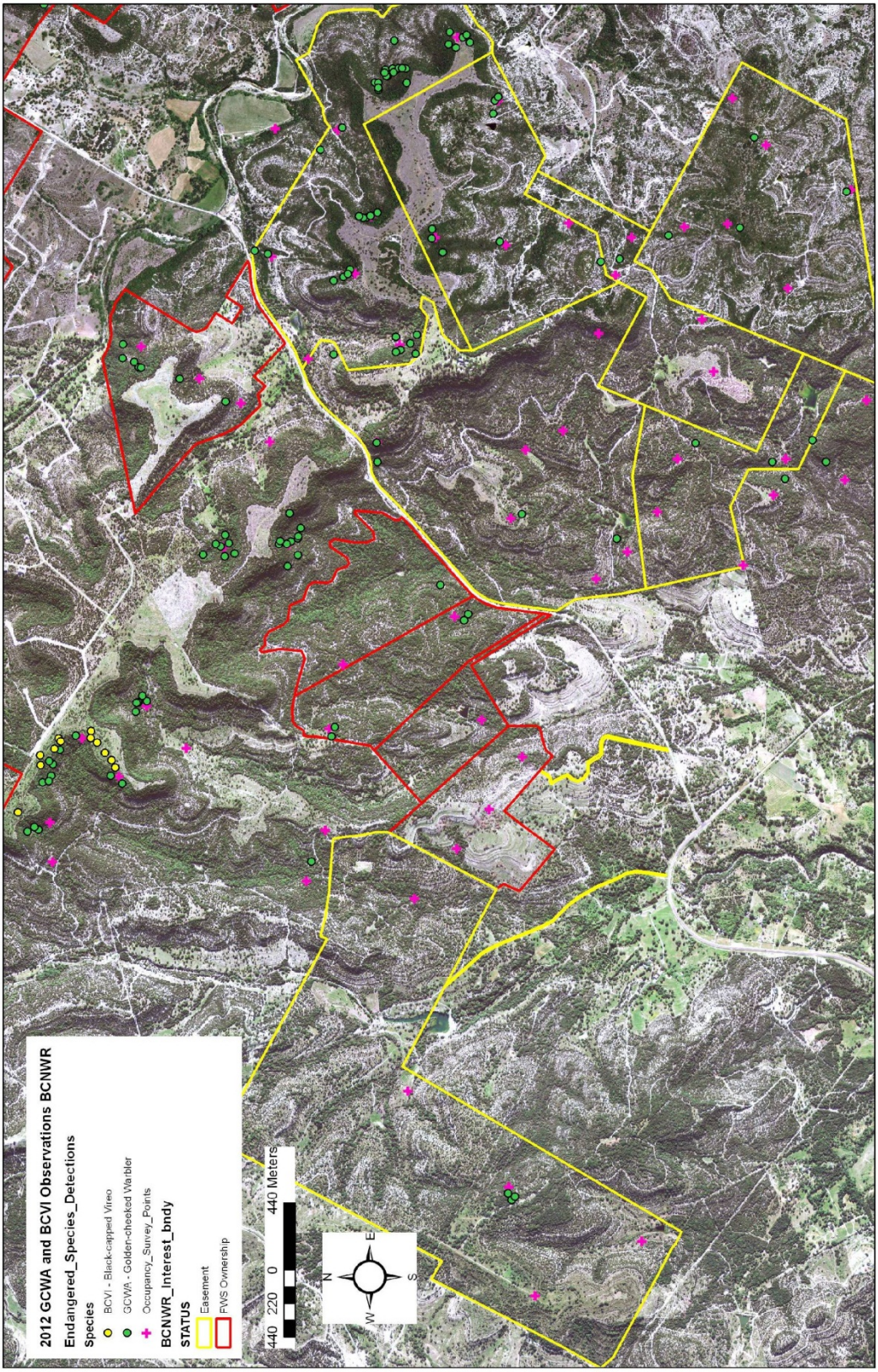


Figure 6. 2012 GCWA/BCVI Surveys in Rodgers Area.

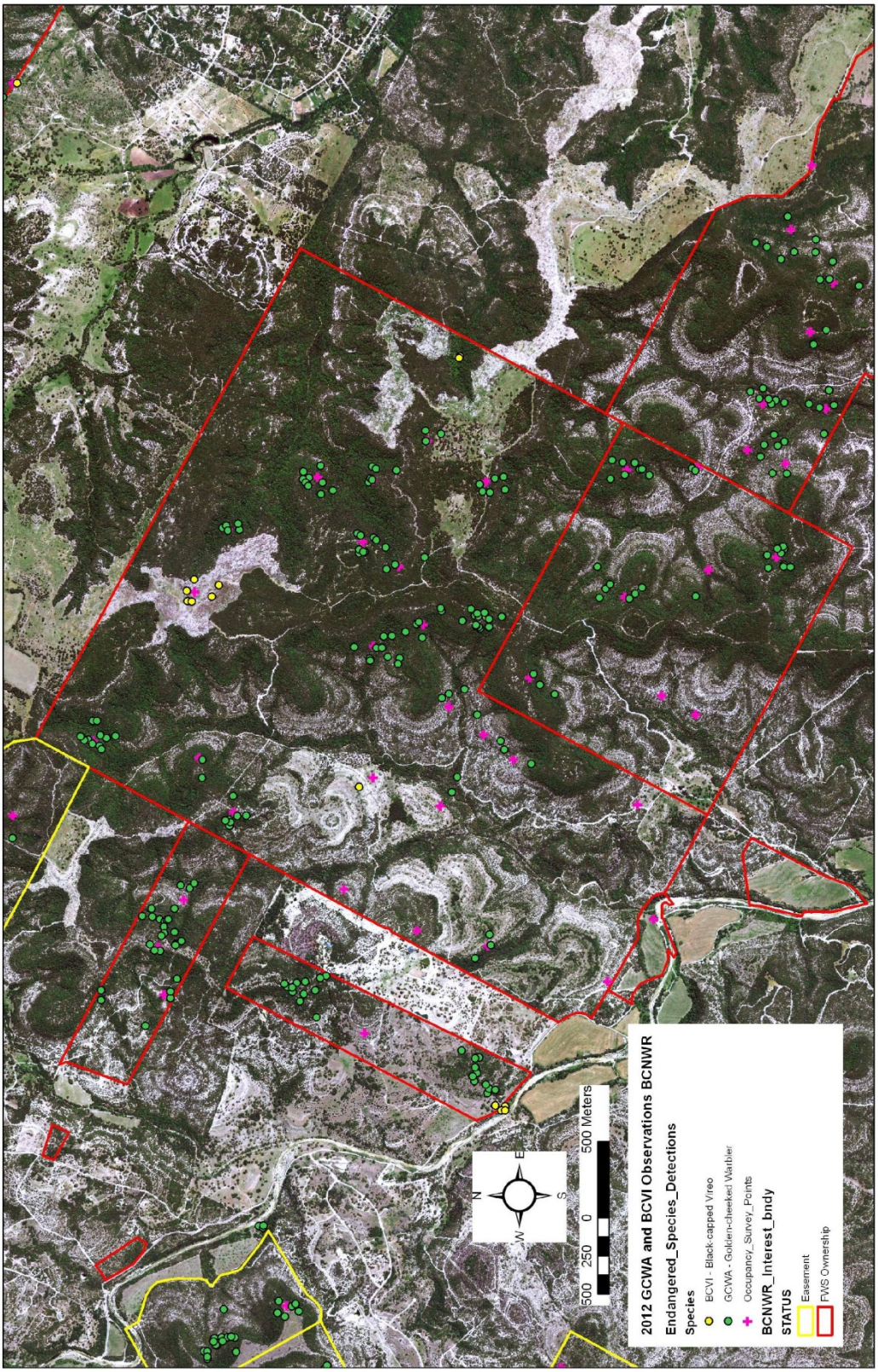
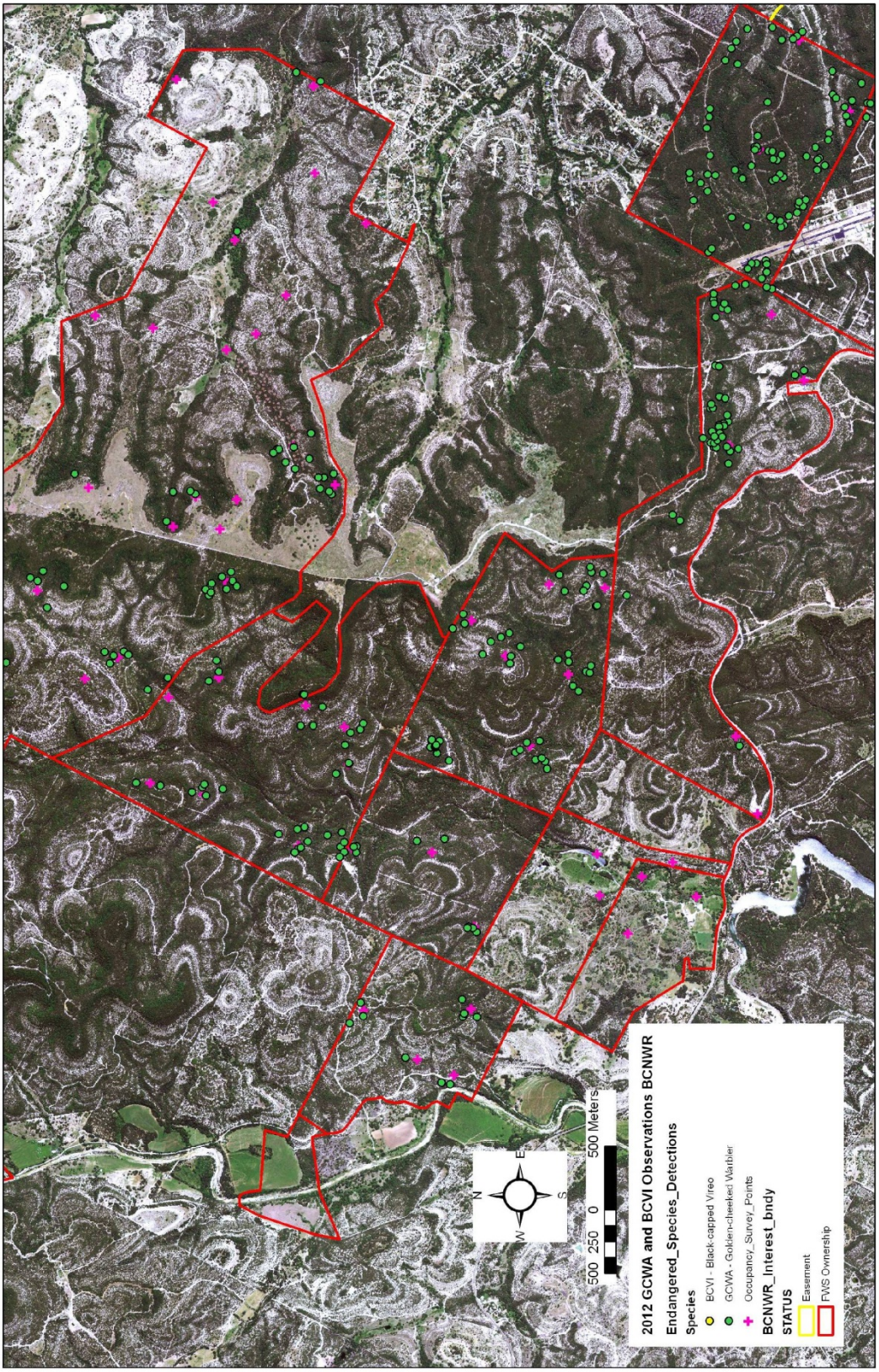


Figure 7. 2012 GCWA/BCVI Surveys in Front Range and Webster Area.



Attachment 1

Balcones Canyonlands National Wildlife Refuge Golden-cheeked Warbler Monitoring Survey Protocol (version 3/22/2012)

I. Justification and Objectives

Balcones Canyonlands National Wildlife Refuge (BCNWR) was established in 1992 primarily to protect habitat for the golden-cheeked warbler (*Setophaga chrysoparia*) and black-capped vireo (*Vireo atricapilla*). One goal of the refuge is to restore and enhance threatened and endangered species habitat (BCNWR Comprehensive Conservation Plan, 2001). The management objective for the golden-cheeked warbler is to protect existing habitat and enhance additional areas where appropriate. The Draft BCNWR Habitat Management Plan (2010) identified approximately 15,000 acres of the 23,822-acre Refuge that are managed for the golden-cheeked warbler. Management activities identified in the Comprehensive Conservation Plan included encouraging maturation of young woodlands, maintaining low white-tailed deer and feral hog densities (less than 1 deer per 20 acres, as few feral hogs as feasible) to maximize recruitment of hardwood trees, protecting warbler habitat from wildfire, monitoring brown-headed cowbird (*Molothrus ater*) nest parasitism and implementing cowbird control if it exceeds 10%, and monitoring and controlling oak wilt outbreaks. The historical monitoring of golden-cheeked warblers on the refuge is described in Appendix A.

This plan establishes the methodology for estimating the amount of area occupied by golden-cheeked warblers on the Refuge with a standard error ≤0.05. It will also estimate area occupied by black-capped vireos and four other species. When feasible, appropriate data will be collected to facilitate incorporation into work being conducted on the Balcones Canyonlands Preserve by Thompson and Reidy. This survey will be repeated every five years to monitor trend in occupancy. If occupied golden-cheeked warbler habitat is found to be decreasing at any subsequent time, a thorough evaluation will be conducted to identify the cause of the decline (e.g., change in vegetative structure, increased nest parasitism, breeding season survival, productivity, migratory hazards, wintering ground habitat, etc.). If the vegetative composition and structure has degraded (e.g., loss of requisite canopy cover and/or declines in abundance of required tree species), management will be implemented to correct the deficiency. Additional studies will be required to assess changes in demographics that are unrelated to vegetation (e.g., productivity, survival).

II. Peer-reviewed Protocol

This survey will follow the USFWS protocol for landbird monitoring (Knutson et al. 2008) with clarifications and exceptions described below. In the following sections, a 1-paragraph summary is given for each Standard Operating Procedure (SOP) from Knutson et al. (2008) for which there is a deviation. Additional detailed explanations of factors that explain the rationale for the methods selected are included as appendices.

SOP #1 – Sampling Designs
The objective for the survey is to estimate occupancy of golden-cheeked warblers across the refuge and subsequently to estimate trend every five years. Design and analysis will follow the framework of occupancy modeling (MacKenzie et al. 2006). The survey should estimate occupancy with a standard error of 0.05 (95% confidence interval of approximately ± 10%). The survey design is based on a completely random sample of points. However, the Hickory Pass easement is under a unique management agreement in which a contractor will be hired to monitor warblers; per agreement, that area will be incorporated into the overall sampling of the refuge as a distinct stratum with 50 sampling points. Thus, for tracts owned in fee title and easements other than the Hickory Pass easement, a completely random set of 200 survey points was obtained using the ArcGIS Create Random Points data management tool. Points were given a minimum allowed distance to one another of 250 meters (Butcher et al. 2010); a minimum distance of 300 m was attempted but would not work for the number of points required. Data will likely be truncated at a distance of 100 m or less, so the distance between points is adequate to ensure no overlap between survey stations. No buffer between the refuge tract boundaries and the points was created. No other type of preference was given to any particular tracts or land cover types. Another set of 50 random points was selected in the same manner for the Hickory Pass conservation easement. Rationale for this sampling design and methodology is described in Appendix B.

SOP #3 – Hiring and Training Observers
Because hearing loss that exceeds 20dB is expected to compromise survey ability, hearing tests for surveyors is mandatory. Golden-cheeked warbler type A and B songs are primarily between 4 and 7 kHz, with greatest intensity at 5 kHz (Bolsinger 2000). Thus, the median threshold sound intensity from the audiogram for frequencies from 4 to 7 kHz will be used as a covariate in the analysis.

SOP #4 – Using GPS to Mark and Locate Sampling Points
Survey points will be marked temporarily with flagging for identification on subsequent surveys that year. No long term marking is required for the bird survey point because GPS units with 3-5 m accuracy will be used to find the point in the future. A plethora of stakes identifying a bewildering array of studies already exists on the refuge, and many of these serve primarily as sources of flat tires or head scratching. However, a permanent marker will be placed for this survey when the vegetation is sampled using a GPS with sub-meter accuracy; the vegetation data will be used for classification of vegetation from NAIP imagery and LiDAR data, and thus the greater accuracy is required. The permanent marker will be resistant to loss from fire and weather (e.g., a rebar stake with an engraved aluminum tag attached to the stake with aluminum wire).

SOP #5 – Conducting the Bird Point Count
Weather and Time Considerations - Surveys will start between 15 minutes before sunrise (as opposed to 30 minutes) and 5 hours after sunrise (as opposed to 6 hours). Air temperature must be ≥10°C (50°F) to match many protocols used for golden-cheeked warbler surveys. Surveys may be conducted with a sky condition code of 5 (i.e., drizzle).

Rationale: Bolsinger (2000) found that nearly all male golden-cheeked warblers begin singing between 15 and 30 minutes before sunrise and continue singing at relatively high rates up to 5 hours after sunrise. He also found that late in the breeding season singing declined in the first 2 hours after sunrise. Peak (2011) surveyed from 30 minutes after sunrise to 4 hours after sunrise. Reidy (unpublished protocol for surveys at Balcones Canyonlands Preserve in 2011 and 2012) surveyed from 10-15 minutes after sunrise to 1100 h. These later survey times are apparently due to the report by Pulich (1976) that this species does not sing before sunrise, and the subsequent adoption of this by USFWS for presence-

absence surveys for this species. To be consistent with the amount of time surveys are conducted each day, the ending time will be based on hours after sunrise rather than a specific time. The temperature guidelines and allowing surveying during drizzle are to match these other protocols. One unpublished reference states that singing decreases at temperatures below 55°F.

Species to be recorded – The following species will be recorded when detected on the survey: golden-cheeked warbler, black-capped vireo, brown-headed cowbird, western scrub-jay (*Aphelocoma californica*), blue jay (*Cyanocitta cristata*), and northern bobwhite (*Colinus virginianus*).

Rationale: The primary objective of the occupancy survey is to estimate occupancy of the golden-cheeked warbler. Five additional species were selected for recording:

- black-capped vireo – one goal of the refuge is to increase abundance of this endangered species
- brown-headed cowbird – the refuge conducts management activities to reduce the abundance of this nest parasite with a goal of reducing nest parasitism of black-capped vireo nests to ≤10%
- western scrub-jay – this potential nest predator is associated with oak-juniper shrub habitat that may develop into higher quality warbler habitat with vegetative succession
- blue jay – this potential nest predator increases with fragmentation of juniper-oak woodlands and urbanization
- northern bobwhite – this species of concern throughout the Oaks and Prairies Joint Venture is associated with savannas

Data to record – A revised data sheet will be used (Appendix C). The minute and second of the first detection of a song for golden-cheeked warbler or black-capped vireo or song/call for other species for each individual will be recorded. The location of the bird will be marked on the circular plot which is overlaid on recent imagery at a 1:2000 scale (1 mm = 2 m). Subsequent aural detections of each bird will be tallied for each 2-minute period during the survey. Visual detections will be recorded in the same manner, but separately, for each individual of the 6 species. Codes will not deviate from the established protocol and are listed in Appendix D. National Land Cover Database (NLCD) class, slope, and aspect will be recorded on the last visit to each point when vegetation is measured.

Rationale: The data sheet has been consolidated so that it all fits on one page. The survey measures the probability of occupancy of singing males and is based on calculation of detection probabilities of singing birds. Visual detections are ancillary data. Dividing the survey into 2-minute blocks allows calculation of *availability*, or the rate of singing by males (Stanislav et al. 2010).

SOP #5 – Vegetation

This optional protocol will not be used. National Agricultural Inventory Program (NAIP) imagery and LiDAR will be used to obtain vegetation metrics such as canopy cover and canopy height. A separate protocol will be developed to gather species composition data suitable for training and testing classification of the remotely sensed data. These data will be collected in the 2-month period following the bird survey. At that time, a permanent survey point will be established using a sub-meter GPS unit. In addition to the vegetation data necessary for the remotely sensed data, NLCD class, slope, and aspect will be recorded.

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Appendix A. Historic Monitoring of Golden-cheeked Warblers on Balcones Canyonlands NWR

Monitoring of the golden-cheeked warbler population on BCNWR has been part of a standardized, regional program begun in 1998 with objectives that tied into the Recovery Plan for the species. The protocol was to map male golden-cheeked warbler territories within 100-acre plots over 10 weeks based on ≥60 hours of surveys (Balcones Canyonlands Preserve Land Management Plan, 2007, unpublished). Some plots were located in "prime" habitat, in which 75% of the plot had >70% canopy cover, and others in "transitional" habitats that were expected to mature into prime habitat. On BCNWR, 5 plots were established, 3 in prime and 2 in transitional habitats. However, survey effort was sporadic due to lack of sufficient personnel. Population and productivity trends were tracked on a series of 100-acre plots located on BCNWR and the Balcones Canyonlands Preserve (BCP) in Travis County. The BCP and BCNWR collected data on territory density, territory location, pairing success, breeding success, and productivity. Population estimates of golden-cheeked warblers for the BCNWR were derived by extrapolating results from the five 100-acre plots and other short-term monitoring plots to similar habitats throughout the refuge. The latest population estimate for the refuge was at least 810 golden-cheeked warbler territories (Sexton memo to file, A new estimate of the golden-cheeked warbler population on the Balcones Canyonlands NWR, 5 March 2009). This monitoring protocol is not sufficient for valid estimates of the golden-cheeked warbler population on the BCNWR and does not provide sufficient information for evaluating success of management activities.

Appendix B. Rationale for Sampling Design and Methodology for Golden-cheeked Warbler Survey at BCNWR

Golden-cheeked warbler population parameters have been estimated using different approaches. Laake et al. (2011) described a point based mark-recapture distance sampling technique in which two observers are used at each point; birds detected by the first observer are counted as "marked" and those detected by the second observer are counted as either "recaptures" if also detected by the first observer or as a new detection. This work was part of a larger project by Morrison et al. (2010) which used point counts first for estimating occupancy of patches of various sizes and then using those estimates to identify a population of potential locations for estimating density. Thompson (2011) is surveying the Balcones Canyonlands Preserve in Austin using point counts, focal bird monitoring, and banding to estimate demographic parameters for a population viability assessment. Peak (2011) compared estimates of the golden-cheeked warbler population size at Fort Hood derived from point based distance sampling and intensive territory mapping; point counts overestimated population size and the overestimate increased with duration of survey.

Estimates of population size are dependent upon the probability that the organism is detected. Detectability of golden-cheeked warblers may vary due to species density (e.g., higher densities may result in greater rates of singing), observer biases (e.g., hearing abilities and experience), vegetative characteristics (e.g., density of vegetative structure, height of canopy and associated perches), environmental acoustics (e.g., temperature, humidity), and other factors. Thus, count data from surveys are often not a reliable index of population size without estimates of detectability. For example, an upward trend in count data could be due to increased observer experience with a site and with the species.

MacKenzie et al. (2006) suggested that monitoring programs ought to give greater consideration to estimation of occupancy (i.e., species presence) because in many cases it may be of greater value for the objective and it is often less expensive. Occupancy is the best variable to use when estimating distribution and range. For BCNWR, occupancy is the primary variable of interest in assessments of restoration success. Methods for estimating occupancy and probability of detection are readily available through Program PRESENCE and associated literature.

A standard occupancy sampling design involves a fixed number of visits to a site (e.g., 4 visits to each site). A removal design involves repeated visits to a site until a detection is made, up to some fixed number that allows calculation of the probability of occurrence given no detection. When occupancy is greater than 30%, a removal design is more efficient, but this design restricts robust analysis of covariates. Collier et al. (2010) estimated that approximately 100 sites were required for a standard error of 0.05 with a removal design that allowed at least 4 surveys or a standard design that allowed at least 3 surveys per site. Based on experience of other biologists, a standard design will be implemented with 4 surveys per point.

In 2009, Sexton estimated that there were 810 territorial males on the 22,860 acre refuge (unpublished report, A new estimate of the golden-cheeked warbler population on the Balcones Canyonlands NWR, 5 March 2009). If average territory size is 4.3 acres (Pulich 1976), then the refuge contains 3483 acres of occupied warbler territories. If the entire refuge is surveyed without regard to woodland cover, then *a priori* occupancy is 0.15.

Probability of detection of golden-cheeked warblers during a 5-minute point count survey with a single observer was approximately 0.5 at 50-m and 0.15 at 100 m (Laake et al. 2011: Figure 2, p. 401). The probability of detection within a 100-m circle at a distance of 70 m (a radius that represents one-half of the area sampled) was approximately 0.3. Detection probability should increase with a 10-minute count.

Based on these estimates, it was estimated that 92 sites would be required for a standard error of 0.05. If the refuge was divided into strata based on the Diamond Model C (revised) high quality habitat versus remainder of refuge, it was estimated that 199 sites would be required in the high quality habitat and 33 in the remainder of the refuge. Following this analysis, it was decided to survey 200 sites selected completely at random throughout the refuge. This will allow for a more powerful analysis of covariates, comparison of multiple habitat models to evaluate which best predicts occupancy, and does not rely on assumptions regarding where the species is found. This last factor will become more important in the future when these surveys will be repeated and the habitat will have changed, hopefully resulting in more habitat and greater occupancy.

Sampling every 5 years to monitor trend is based on the time expected for a change in occupancy that could be detected to occur. The species inhabits a climax community (juniper-oak woodland) and is not expected to exhibit large annual population swings. However, if a catastrophic event occurred such as a large-scale loss of habitat due to a wild fire, surveys may be implemented annually for a time to understand the response of the species.

Method for calculation - Following MacKenzie et al. (2006), Ψ (psi) is the probability a site is occupied, p_j is the probability of detecting the species in the *j*th survey. For a series of surveys in which the species is never detected, the probability of occurrence is the sum of two probabilities: (1) the probability of not detecting the species in any survey when present and, (2) the probability that the species does not occupy the site (1 - Ψ). By calculating these probabilities for all points, detectability and occurrence can be calculated using maximum likelihood estimates. Program PRESENCE (http://www.mbr-pwrc.usgs.gov/software/doc/presence/presence.html#install, free of charge) estimates these variables following the input of the capture history for points at each site.

Size of sites to be surveyed – Point counts are used frequently for golden-cheeked warbler surveys. If a site size is selected that is approximately equivalent to the species territory size, than the estimated number of occupied sites should be equivalent to the number of territorial animals (Mackenzie et al. 2006:42). Golden-cheeked warbler territory size was estimated by Pulich (1976) to average 4.3 acres (1.74 ha) which is equivalent to the area of a circle with a 74-m radius. To facilitate comparison with other studies, it is recommended that all detections be recorded, and data be truncated appropriately during analysis. In addition, the time of detection and distance to location of initial detection will be recorded. Thus, site size can be adjusted to estimate number of territories (sensu MacKenzie et al. 2006) or used in other regional analyses.

Season of surveys: Detectability of golden-cheeked warblers is highest when warblers arrive to establish territories and declines during the breeding season (Collier et al. 2010). Predicted detectability after 10 weeks is approximately one-half that at the beginning of the season. The recommended period for surveys is 15 March – 1 May during the period of peak detectability (Collier et al. 2010).

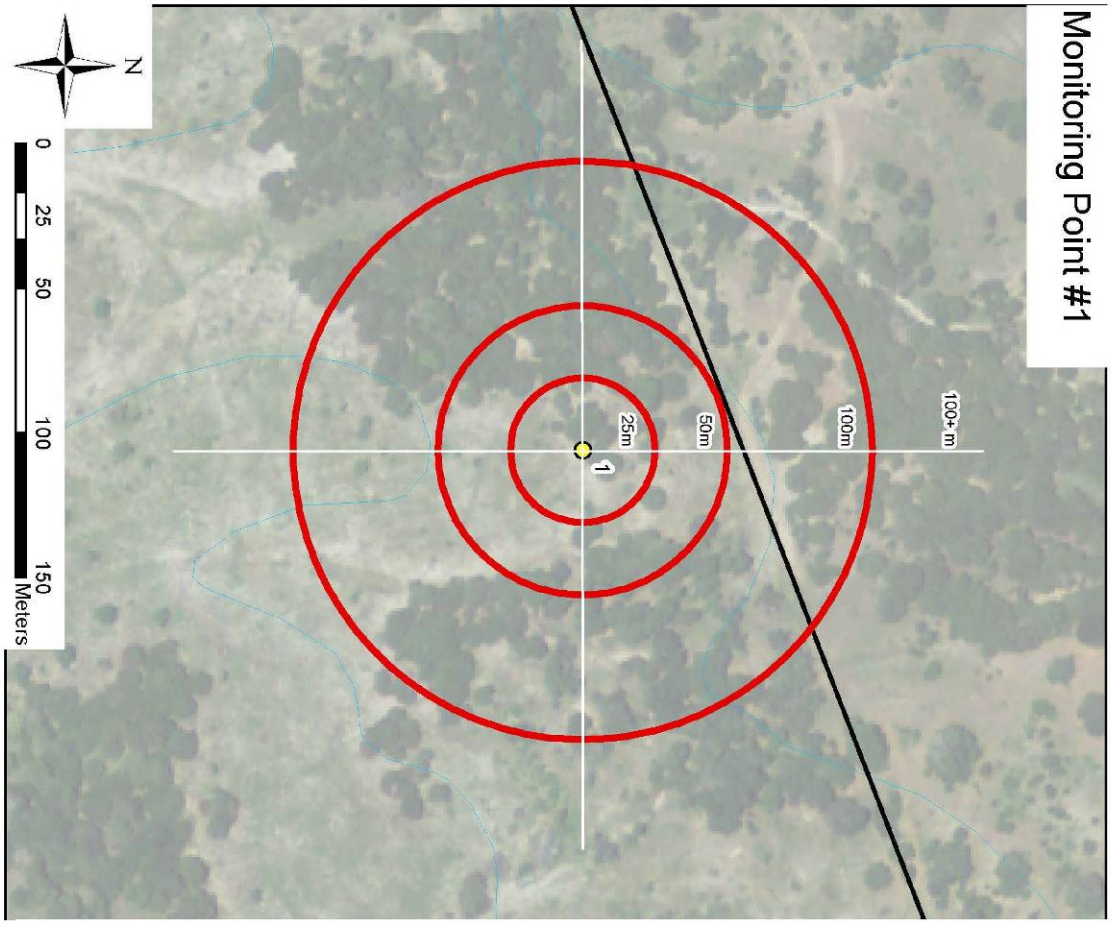
Covariates that vary among sites: DeBoer and Diamond (2006) found the following variables to be important in their model of golden-cheeked warbler habitat: steep slopes, forest interior, Ashe juniper canopy cover (>2 m), height of canopy (tallest tree), and proximity to protected lands. Emrick et al.

(2010) assessed features of occupied golden-cheeked warbler habitat at Fort Hood and found that the ratio of Ashe juniper to other woody species, specifically, a 4:1 ratio in the mid- to upper canopy, was strongly related to golden-cheeked warbler occurrence.

Covariates that vary among surveys: Observer, Julian day.

Covariates that vary among observers: Surveyors will have hearing tests conducted to determine the detection thresholds at frequencies associated with golden-cheeked warbler songs (Emlen and DeJong 1992).

Appendix C. Data sheet for Occupancy Survey of Birds at Balcones Canyonlands NWR



FIELD DATA FORM—CIRCULAR PLOT

Field Conditions

Date:	Grid: BCNWR	Start time:	Visit #:
Easting:		Northing:	
Tract:		Observer:	
Wind Direction:		Temp (C):	
Wind Speed Code:		Sky Code:	
Precipitation:		Noise Code:	

Aural Detections

Obs	Species	Distance	Minute 0-1	Minute 2-3	Minute 4-5	Minute 6-7	Minute 8-9
1							
2							
3							
4							
5							
6							
7							
8							
9							
10							

Visual Detections

Obs	Species	Distance	Minute 0-1	Minute 2-3	Minute 4-5	Minute 6-7	Minute 8-9
1							
2							
3							
4							
5							

Comments:

Appendix D. Codes for Occupancy Survey Data Sheet

Field Condition Codes for Occupancy Survey

Date: MM/DD/YYYY; for data form, do not record leading zeroes and century; Example = 4/2/12
Start Time: HHMM in 24-hour time; for data form, do not record leading zeroes; Example 735
Visit #: Record 1, 2, 3, or 4 corresponding to the survey period; each survey period lasts 2 weeks
Easting/Northing: Record the easting and northing displayed by your GPS
Tract: Record the tract name. This can be found on the list of coordinates for points.
Observer: Record the first and last name of the observer.
Wind direction: Record the direction from which the wind is blowing (N, S, E, W, NE, NW, SE, SW, VRB=variable) during the 10-minute point count. Wind direction may be considered variable if, during the 2-minute evaluation period, Beaufort code ≤2. In addition, the wind direction shall be considered variable if, during the 2-minute evaluation period, it varies by 60 degrees or more when the average wind speed is greater than 7 mph (Beaufort code >2).
Temperature: Record ambient air temperature in degrees Celsius at chest height.
Wind Speed Code: Record average using the following estimators. Conduct surveys only when code ≤3.

Wind Speed Code	Wind Speed (miles/hr)	Description
0	< 1	Calm; smoke rises vertically
1	1-3	Light air; wind direction shown by smoke drift
2	4-7	Light breeze; wind felt on face
3	8-12	Gentle breeze; leaves in constant motion, light flag extended
4	13-18	Moderate breeze; raises dust; small branches move
5	19-24	Fresh breeze; small trees sway, crested wavelets on inland waters
6	25 or more	Strong breeze; large branches in motion

Sky Code: Record using the following descriptions. Conduct surveys only when code is 0, 1, 2, or 5.

Sky Code	Description
0	Clear or a few clouds
1	Partly cloudy (scattered)
2	Cloudy (broken) or overcast
4	Fog or Smoke
5	Drizzle
7	Snow
8	Showers

Precipitation: Leave blank.
Noise Code: Record using the following descriptions. Conduct surveys when code is ≤2.

NOISE CODE	DESCRIPTION
0	No background noise (BN) during most of the survey (< 40 decibels [dB])
1	Faint BN during at least half of the survey (~40-45 dB)
2	Moderate BN; difficulty hearing birds > 100 m away (~45-50 dB)
3	Loud BN; difficulty hearing birds > 50 m away (~50-60 dB)
4	Intense BN; difficulty hearing birds > 25 m away (>60 dB)

Bird Species Codes:

Species	Code
Golden-cheeked Warbler	GCWA
Black-capped Vireo	BCVI
Brown-headed Cowbird	BHCO
Western Scrub-Jay	WESJ
Blue Jay	BLJA
Northern Bobwhite	NOBO

Appendix D. Continued.

Conducting the Survey (Adapted from LMVJV SOP)

1. Prior to the day of the counts, determine which points will be sampled and the order they are to be counted. Also, determine and upload the x,y coordinates for each point into a GPS.

2. Sampling will occur in the morning, from 15 minutes before sunrise to 5 hours after sunrise.

3. Do not conduct the count during high winds or heavy rains. Counts should not be conducted if it is raining hard (sky code 8) or if wind strength on the Beaufort Scale is a sustained 4 or greater. If these conditions are encountered, either wait until the weather improves or cancel the sampling for the day and reschedule.

4. Approach the location, noting in the comments any target birds within 100 m of the counting station that are flushed, fly away, or retreat.

5. Orient the bull's-eye data sheet to a fixed direction, record the data under field conditions except coordinates.

6. Position a GPS unit and start it recording.

7. As soon as possible, start the count. Use a pocket timer or watch to keep track of time.

8. When a target species is detected by song, plot the location on the map using the observation number. Record the species code, time (minute:second), and distance of the initial detection within the proper 2-minute survey interval. Record subsequent singing of that bird within each 2-minute interval with a checkmark. Count family groups of juveniles with a single adult as a single bird.

9. Record visual detections of target species that are unaccompanied by song in the same manner. Record other detections that are unaccompanied by song, for example *chips*, under comments.

10. Holding the sheet in a fixed position, spend part of the time facing in each of the cardinal directions in order to better detect birds.

11. Mark each bird once, using the mapped locations to judge whether subsequent songs are from new or already recorded individuals. All birds greater than 100 m from point center are recorded outside of the 100 m band. The recorded distance should be the horizontal distance between the location a bird was first detected and the plot center.

12. At the end of 10 minutes, stop recording bird observations. Do not record any new birds seen or heard after the 10 minutes have passed.

13. Record the Easting and Northing from the GPS unit and mark the location.

14. After the survey, estimate the distance to the nearest golden-cheeked warbler or black-capped vireo, or if neither species is present, other target species. Mark your location with the GPS. Then, measure the distance to that bird by walking to it and determining distance with the GPS. Adjust your estimated distances on your data form if appropriate.

Attachment 2

Golden-cheeked Warbler Monitoring
Balcones Canyonlands National Wildlife Refuge
2012 Volunteer Protocols for Enumeration Surveys

As a volunteer conducting golden-cheeked warbler (GCWA) surveys you will help us gain a better understanding of the overall distribution of this endangered species on the Refuge. The tracts that have been identified for enumeration surveys are tracts that have had very few, if any, surveys conducted on them. Your information will therefore help fill in critical knowledge gaps. Please note participating in this program requires a considerable amount of time on everyone's part. You should only participate if you have the time and interest to make it worth everyone's effort.

Training: Unless you have recent (past two years) field experience meeting the minimum survey requirements identified in the website below, you must attend training and provide the Refuge a copy of your certification form. One of the reasons for this training is that the Refuge has an endangered species permit that authorized impacts associated with conducting surveys for GCWAs. This permit specifies minimum criteria that must be met by all persons conducting these surveys. Such qualifications and data standardization also help maintain scientific credibility for the Refuge and helps ensure your safety. Information on minimum experience requirements for conducting enumeration surveys, as well as a recommended format and example for reporting an individual's minimum experience requirements may be found at the following web site: http://www.fws.gov/R2ESArlington/recoverypermits.htm." Please review this website to determine which category you are in. Most volunteers will need a minimum of five days of training. In order to meet these minimum criteria, the Refuge will be providing training the last two weeks of March (Monday – Saturday). During this training we assign keys, vehicle placards and any other equipment, and will discuss logistics, orienteering, reading a map, GPS use, safety, filling out datasheets, GCWA auditory and visual detections, etc.

Safety: Your safety is of utmost importance. It is likely you will be in the field in remote locations by yourself and you should be prepared for any incident. The following is provided to help you be prepared.

1. Be sure to bring a cell phone with you into the field. Cell phone reception is spotty on the Refuge. Remember, you are more likely to get reception from a high point. Important telephone numbers:
   - Main Refuge number (512)339-9432. Common number for all Refuge employees.
   - Scott Rowin cell phone number (512)800-5046
   - Jim Mueller cell phone number (512)810-9763
   - John Harrington cell phone number (512)971-3931
   - David Maple home phone number (512) 355-2826 (after hours on-refuge contact)
2. Preferably there will be a second person surveying the tract with you. You can coordinate with the GCWA survey volunteer coordinator, John Harrington, on other volunteer's schedules.
3. Be sure to let John Harrington know when you are surveying and let him know when you are done surveying for the day.
4. Snake Chaps are available at the Refuge. Contact John Harrington if you are interested.
5. You should carry a first aid kit with you at all times. Kits are available to check out at the Refuge. Contact David Maple regarding this. You should also include any necessary medication you need.
6. Bring plenty of water.
7. Wear sturdy shoes, pants, and long sleeved shirts.
8. Some people prefer to wear sun/safety glasses to protect their eyes from low branches.
9. Insect repellent.

Enumeration: The goal of an enumeration survey is to gain a general idea of the number and locations of GCWA territories across a broad area, with minimal effort.

1) As a general rule, devote about 1 hour for each 25 acres of the site covered on each visit. Sites of less than 25 acres should be monitored for at least one hour per visit.
2) Each site should receive a minimum of 5 visits during the season. If a tract is large (for instance, over 200 acres), you will need more than a day to visit the whole site.
3) Ideally, no two visits should be less than 5 days apart.
4) It is acceptable to survey multiple sites in one day, but surveys should be complete by approximately 1:00 p.m. CST. Each site should be surveyed early in the day on at least two visits. Starting surveys within 30 minutes of sunrise is best.
5) At 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.
6) 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.
7) Try to obtain a visual of every GCWA encountered and look for color bands on its legs. Should color bands be seen, record to the best of your abilities, the color combination and notify Scott Rowin as soon as possible. Color combinations are read upper left leg/lower left leg then upper right leg/lower right leg.
8) 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". See example field map for a reference.
9) 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.
10) Record any other relevant information on the back of the survey form.
11) The monitoring season this year will run from March 15 through May 25.
12) Do not census GCWAs in steady rain or thunderstorms (light drizzle is okay).
13) Do not conduct a GCWA census if sustained wind is stronger than 12 miles/hour (> Beaufort 3). Oftentimes you can adjust the location of where you are surveying to minimize the amount of wind (i.e. survey on the side of a canyon)
14) Do not use playback of songs or calls to elicit a response.
15) 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.
16) 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.
17) Materials to bring with you for monitoring visits:

- **field maps (aerial and topographic)**
- **pens/pencils**
- **binoculars**
- **GPS unit and extra batteries**
- **compass**
- **Thermometer**
- **cell phone**
- **water**
- **first aid kit**