Habitat Suitability Model for Evaluating City of San Antonio Land Donation for Golden-cheeked Warblers

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The Golden-cheeked warbler (*Dendroica chrysoparia*; hereafter GCWA or warbler) is a federally and state listed endangered species that nests and rears its young exclusively in the Edwards Plateau ecoregion of central Texas. The species is listed in the Texas Wildlife Action Plan as a high priority species that is critically imperiled.

The City of San Antonio (COSA) passed bond measures in 2000 and 2005 to protect land over the Edwards Aquifer, the city's primary source for drinking water. They purchased or obtained conservation easements on approximately 85,260 acres within Bexar and surrounding counties. Some of those parcels were adjacent to Government Canyon State Natural Area, an 8,624 acre property owned and operated by Texas Parks & Wildlife Department (TPWD; See Figure 1).

In the summer of 2008, COSA initiated discussions with TPWD to transfer 2,980 acres to TPWD to provide public access and to increase endangered species protection, management, and monitoring. COSA had not surveyed the property for GCWA, and no comprehensive vegetation surveys had been conducted on the properties. Prior to the acceptance of these parcels, TPWD conducted an assessment of the properties for potential golden-cheeked warbler habitat. This study attempted to create a GIS model 1) describe vegetative characteristics of the study area, 2) Evaluate the study area for potential golden-cheeked warbler habitat, and 3) collect incidental locations of Golden-cheeked warblers on the property.

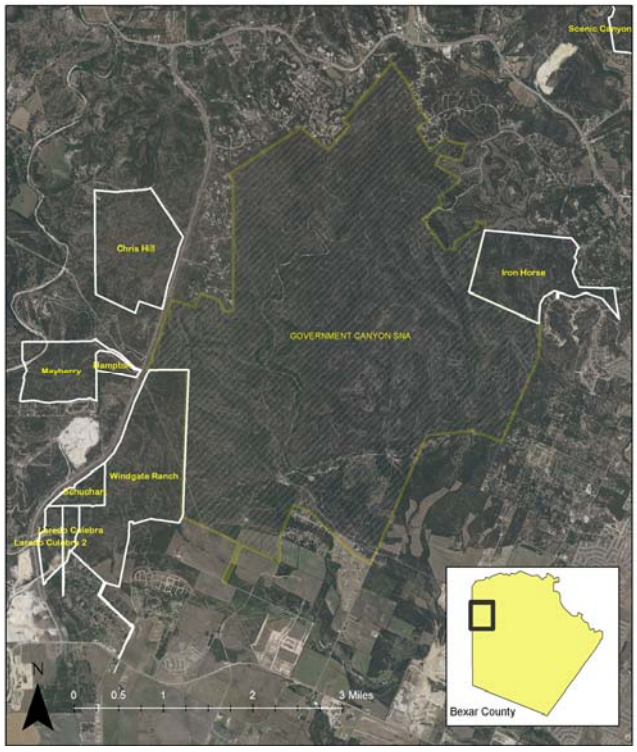

Figure 1. Study Area (white outline) of Spring 2009 Habitat Assessment

METHODS

Vegetation surveys

We generated a 200m grid system over the study area (Watson et al. 2008) and established survey points at the intersections of the gridlines and in the center of each grid square. We thus generated 608 survey points (corners and centers combined) over all 6 parcels (Figure 2). Corners and centers were surveyed independently of each other, and at least 5 days apart. This arrangement enabled us to more completely survey the vegetation of the study area.

A considerable effort was made to conduct vegetation surveys within the parameters of a GCWA Protocol Survey (USFWS 2006) to maximize the opportunity for detecting warblers. Due to time and personnel constraints and an emphasis on evaluation of vegetation rather than on avian populations, surveys were allowed to continue outside of GCWA Survey Protocol conditions. Surveys were scheduled in March and April, between sunrise and 1:00pm, in temperatures between 40°F –85°F and when winds were <12 mph, and outside of detectable precipitation.

Observers navigated to survey points using handheld GPS units. Upon arriving at a site, observers recorded GPS unit accuracy, % Canopy cover with a densiometer, and visually estimated % Ashe Juniper (*Juniperus* ashei; hereafter juniper) in canopy, and approximate canopy height (in ft; See Table 1). Additionally, observers identified woody plant species present within the canopy and classified junipers by age category (Table 2) within a 1 acre area around the survey point (radius = 39m). While juniper age classifications were subjective, we were asked to collect data that are comparable to those collected at Camp Bullis (L. Cooksey, pers. Comm. 2008). For this project, canopy was defined as the upper third of vegetation, and canopy height was measured from the ground to the top of the canopy layer (measured in ft).

GCWA surveys

When vegetation surveys were completed, observers remained within 1 acre (39m radius) of the survey point and listened for GCWA up to 10 minutes of total survey time. Detection probabilities decline rapidly beyond 100m, so this was considered the maximum distance of detection (Alldredge et al. 2007). If a GCWA was observed, observers estimated relative distance (See Table 3) and direction to the GCWA relative to the survey point. Upon detection of a GCWA, observers were allowed to immediately proceed to their next point or stay for the remainder of the 10-minute period. Observations of GCWA between survey points were also documented relative to the nearest survey point.

Figure 2. (a) Two sets of survey points were generated on a 200-m grid. Each set was surveyed independently and at least 5 days apart. (b) Survey points provided comprehensive coverage of the study area.

Training

Observers were selected based on their familiarity with vegetation sampling techniques, ability to collect high-quality scientific data, and pre-existing knowledge of central Texas plant species. Volunteers were mostly professional biologists or Texas Master Naturalists© familiar with scientific techniques and plant identification. All observers received an orientation on sampling procedures, plant identification, and GCWA song identification, and were supervised by experienced biologists until their skills and techniques were approved.

Figure 2. (a) Two sets of survey points were generated on a 200-m grid. Each set was surveyed independently and at least 5 days apart. (b) Survey points provided comprehensive coverage of the study area.

	Method	Breadth of measurement
% Canopy Cover	Spherical Densiometer	At point
GPS Error	Handheld GPS Unit	At point
% Juniper in Canopy	Visual estimation	Within 1 acre (39 m) of point
Canopy Height	Visual estimation	Within 1 acre (39 m) of point
Age of Junipers present (J1, J2, J3, J4)	Visual estimation	Within 1 acre (39 m) of point
Inventory of woody plants within canopy	Visual estimation	Within 1 acre (39 m) of point
Presence of GCWA	Visual and auditory observation	Distance and direction relative to nearest survey point

Table 1. Vegetation measurements collected during Spring 2009 Habitat Assessment on COSA lands adjacent to Government Canyon SNA.

Age Category	Ashe Juniper Description
J-1	<6 ft tall, trunk <3" DBH
J-2	Nearly full height, many branchlets, white fungus on bark, trunk 3-8" DBH
J-3	Branchlets beginning to thin and tree opening up inside, bark beginning to darken and strip, no white fungus, trunk >8" dbh
J-4	Relatively open inside, dark bark w/ considerable stripping, branchlets reduced, often 'un-huggable' trunk

Table 2. Age categories and descriptions of Ashe Juniper used in Spring 2009 habitat assessment on COSA lands adjacent to GCSNA

Description	Distance (m)
Very Close	10
Close	25
Medium	50
Far	75
Very far	100

Table 3. Relative Distances used to describe auditory detections of GCWA. Observers were encouraged to use hybrid descriptions when applicable.

Model Development

We created a GIS model using ArcGIS Desktop 9.2 and Spatial Analyst to delineate "Potential habitat" vs "Unlikely habitat" within the study area. Campbell's (1995) habitat definitions were incorporated into the model parameters. These included canopy closure, presence of live oak and/or deciduous trees within the canopy, presence of mature Juniper, and canopy height. Vegetation data collected within 1 acre around each point were averaged between points using Spatial Analyst Natural Neighbor interpolation.

Percent Canopy Cover.— TPWD Habitat Definitions define potential habitat as areas with 35%-100% canopy closure (Campbell 1995). We included all areas with ≥35% canopy closure.

Presence of deciduous hardwoods and appropriate Juniper density.—Campbell (1995) described non-habitat as having Juniper in excess of 90% or as having less than 10% hardwoods. We included all areas in which Juniper made up 10-90% of the canopy, inclusively.

Presence of mature Ashe Juniper. — In an analysis of averaged point data, mature Juniper was available within 200m of any place within the study area, excepting a 58 acre open field in the southern corner of the Windgate Complex. GCWA could easily travel 200m to obtain nest material, and we felt the inclusion of this layer would unduly exclude potential habitat patches. We determined that mature Junipers were not a limiting factor for nesting GCWA on our study area so we excluded this layer from the model.

Canopy height. — Campbell (1995) described GCWA habitat as having an average canopy height ≥ 20 ft with mature junipers ≥15 ft. While canopy height is useful as a general guideline to land managers throughout the range of the species, and is helpful in aging disturbed or cleared sites, COSA (2009 unpubl. data) documented GCWA in areas with canopy height <20 ft. In Bexar County, canopy height is likely not as useful in small-scale habitat delineation as other vegetation characteristics in predicting habitat suitability. Because of local observations and the scale at which we performed these analyses, we excluded this layer from the model.

Vegetation characteristics used to create the model are summarized in Table 4.

	Not Habitat	Potential Habitat
Canopy Height	No restrictions	
Percent Canopy Cover	<35%	>= 35%
Percent Juniper within canopy	<10% or >90%	10–90%, inclusive
Presence of shredding bark Juniper nearby	Required, but not included in model	

Table 4. Vegetation characteristics used to model potential GCWA habitat on public lands in NW Bexar County

RESULTS AND DISCUSSION

We conducted surveys between March 23, 2009 and April 17, 2009 between sunrise and 13:25. Start temperature averaged 58.23° F (range 41– 71) and ending temperature averaged 70.7° F (range 54–83). All surveys were begun within Protocol wind speeds, but were not always terminated when wind speed exceeded 12mph. Approximately 79% of surveys concluded before wind speed exceeded 15mph.

Six survey points were outside the property boundary and 1 point was inadvertently omitted. We thus surveyed 601 points with an average satellite accuracy of 3.57 m.

Vegetation surveys

Vegetation on the study area consisted of Juniper-Oak woodlands of various canopy closure. Predominant canopy species in upland areas included Plateau Live Oak (*Quercus fusiformis*), Mountain Laurel (*Sophora secundiflori*), and Persimmon (*Diospyros texana*). Dry creekbeds throughout the areas provided a mixed deciduous component and included Spanish Oak (*Quercus buckleyi*), Shin Oak (*Quercus sinuate* var. *breviloba*), Cedar Elm (*Ulumus crassifolia*), Hackberry (*Celtis laevigata*), Lacey Oak (Quercus laceyi), and were complemented by woody plants that often extended into the canopy layer or comprised a lower canopy component. These "miscellaneous canopy species" included *Foristiera reticulata*, Southwest Bernardia (*Bernardia myricifolia)*, Condalia (*Condalia viridis*), and Roemer Acacia (*Acacia roemeriana*)..

Other woody plant species observed in the canopy included Huisache (*Acacia farnesiana*), Mesquite (*Prosopis glandulosa*), Post Oak (*Quercus stellata*), Evergreen sumac (*Rhus virens*), Gum Bumelia (*Bumelia lanuginosa*), Baccharis (*Baccharis neglecta*), Bois D'arc (*Maclura pomifera*), Guajillo (*Acacia berlandieri*), Black Cherry (*Prunus serotina* var. *eximia*), Sycamore (*Platanus occidentalis*), Vitex (*Vitex agnus-castus*), and Texas Ash (*Fraxinus texensis*).

Average vegetation measurements for each parcel are listed in Table 5. The Iron Horse tract had steeper terrain and was characterized by steep-sided canyons with relatively small ridgetop or hill-top areas.

	Size (acres)	# Points	% Canopy	Canopy Ht (ft)	Greatest Juniper	Canopy Sp. Richness (excl A. juniper)	% Juniper in canopy
Chris Hill	710	135	62.89	21.16	2.75	2.49	59.56
Iron Horse	594	115	60.86	20.03	2.77	2.67	53.32
Mayberry-Hampton	395	87	75.75	22.89	2.84	2.40	65.17
Windgate Complex	1281	264	64.31	22.88	2.76	2.38	64.61
Total or Average	2980	601	64.98	21.95	2.77	2.46	61.41

Table 5. Average results for vegetation measurements by parcel. Collected Spring 2009 in northwest Bexar Co.

Vegetation layers are presented in Figures 3-7 and the composite habitat map is presented in Figure 8. Our model indicated an abundance of potential habitat for the Golden-cheeked warbler. The suitability model delineated 2,289.9 acres of potential habitat and 640.99 acres of land that is not likely habitat. The model could not evaluate some land between survey points and the parcel boundaries. This "model edge" totaled 48.71 acres.

The City of San Antonio had previously granted 2 conservation easements on the study area for other mitigation projects. The 2 easements totaling 90 acres should be considered when evaluating the number of mitigation credits available to the city.

GCWA surveys

We recorded 157 observations of Golden-cheeked warblers during the study. Of these observations, 150 were within the study area boundaries. GCWA detections are approximate locations because observers were not instructed to obtain visual confirmation and a corresponding GPS location. Auditory detections were measured with approximate distances and direction relative to the nearest survey point, and thus the projected locations represent approximate locations. Figure 9 displays the projected GCWA detections.

While GCWA territory size in the Southern Edwards Plateau is unknown, and territories are unlikely to be circular, we replicated Camp Bullis's method of approximating territories in the absence of territorial data. Golden-cheeked warbler observations were buffered 10 acres (Ft. Sam Houston, 2009) to estimate occupied habitat. The resulting estimate of occupied lands within the study area boundaries is 985.8 acres (Figure 10).

Model Predictability

Vegetation characteristics of GCWA observations should be interpreted with caution. Due to the small scale of our model, the vegetation averaging between points, and the approximate locations of GCWA observations, such micro-scale analysis could lead to incorrect conclusions regarding habitat selection in Bexar County. However, GCWA observations and their associated vegetation measurements might be useful in evaluating the model's large-scale ability to predict habitat suitability. It might also be useful in comparing habitat preferences across the breeding range of the species.

We analyzed GCWA locations by vegetation characteristics (Table 6) to test the model. Approximately 79% of GCWA Observations were within the spatial boundaries of our predictive model. 81% of GCWA observations were found where canopy closure ≥35%. 93% of observations were made where Juniper comprised 10-90% of the canopy, and 83% of observations were in canopy ≥20 ft.

Percent Canopy Closure Distribution		Proportion	
Class	# GCWA Observations		
0-35	29	19.3%	
35-50	14	9.3%	
50-75	36	24.0%	80.67%
75-100	71	47.3%	
Total	150		

% Juniper in Canopy Distribution			
Class	# GCWA Observations		
0-10	8	5.3%	
10-50	45	30.0%	
50-75	52	34.7%	92.00%
75-90	41	27.3%	
90-100	4	2.7%	
Total	150		

Canopy Height Distribution		
Class (ft)	# GCWA Observations	
0-10	18	12.0%
10-15	8	5.3%
15-20	32	21.3%
20+	92	61.3%
Total	150	

Table 6. Vegetation characteristics of projected GCWA observations during Spring 2009 surveys.

There is a paucity of data available on GCWA habitat preference in Bexar and surrounding counties. Camp Bullis has conducted vegetation and GCWA surveys since 1991. Approximately 87% of their GCWA observations (Camp Bullis, unpubl, data) were found where canopy closure was ≥50%, compared to 71% of our observations. Approximately 94% of Camp Bullis GCWA sightings occurred where Canopy closure was ≥30%, compared to 84% in our study.

Management Implications and Future Research

This approach was useful in evaluating habitat for GCWA while simultaneously performing presence/absence surveys. When project timelines do not facilitate multi-year Protocol surveys, this approach will be useful in delineating potential habitat for Golden-cheeked warblers. While our methods are labor intensive, they can be completed within 1 breeding season, and provides useful data on habitat selection within Bexar County. With this vegetation data, this approach will allow us to formulate standardized habitat definitions for Bexar County, which will be useful in regional land planning, landowner education and outreach, and long term recovery of this endangered species. Additional data would also help refine and test our model parameters.

We recommend that GCWA Protocol surveys be conducted on this study area in future years to assess and refine model strength. We also recommend that this method be used to evaluate new properties to simultaneously collect more data on localized habitat selection and perform presence/absence surveys.

We recommend small modifications to survey methods, which should strengthen the model. Field crews should record 4 canopy closure readings at each survey point, 1 in each cardinal direction. The age classification of junipers was useful in comparing this study area to Camp Bullis data, but we recommend additional sub-categories denoting when Junipers are >15ft, >5" dbh, and whether they have stripping bark. Additionally, our time requirements and survey methods did not facilitate the development of a complete floristic inventory. We recommend these data to be collected as additional species are encountered between points.

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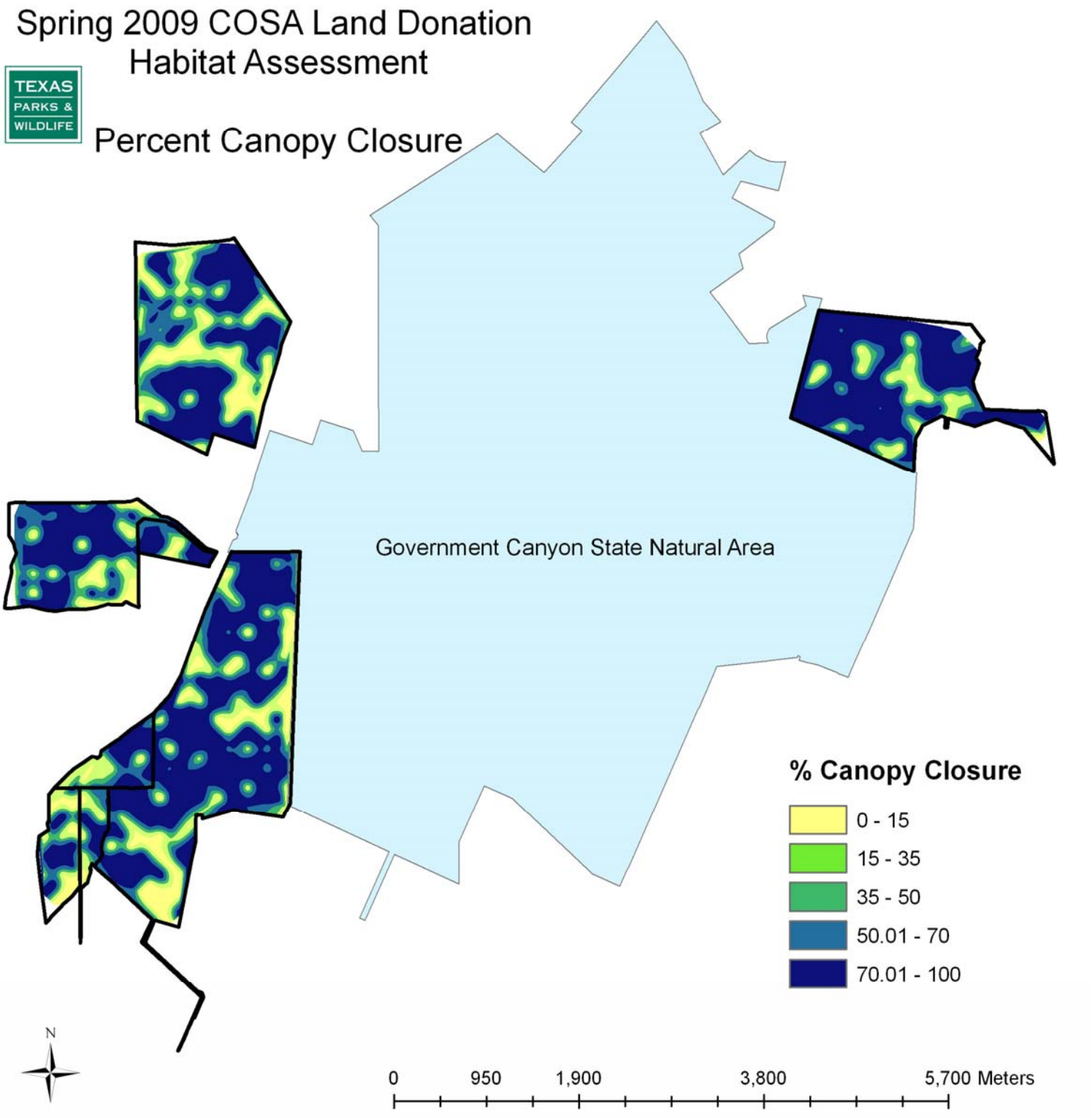

Figure 3. Average percent canopy closure of study area, natural neighbor interpolation

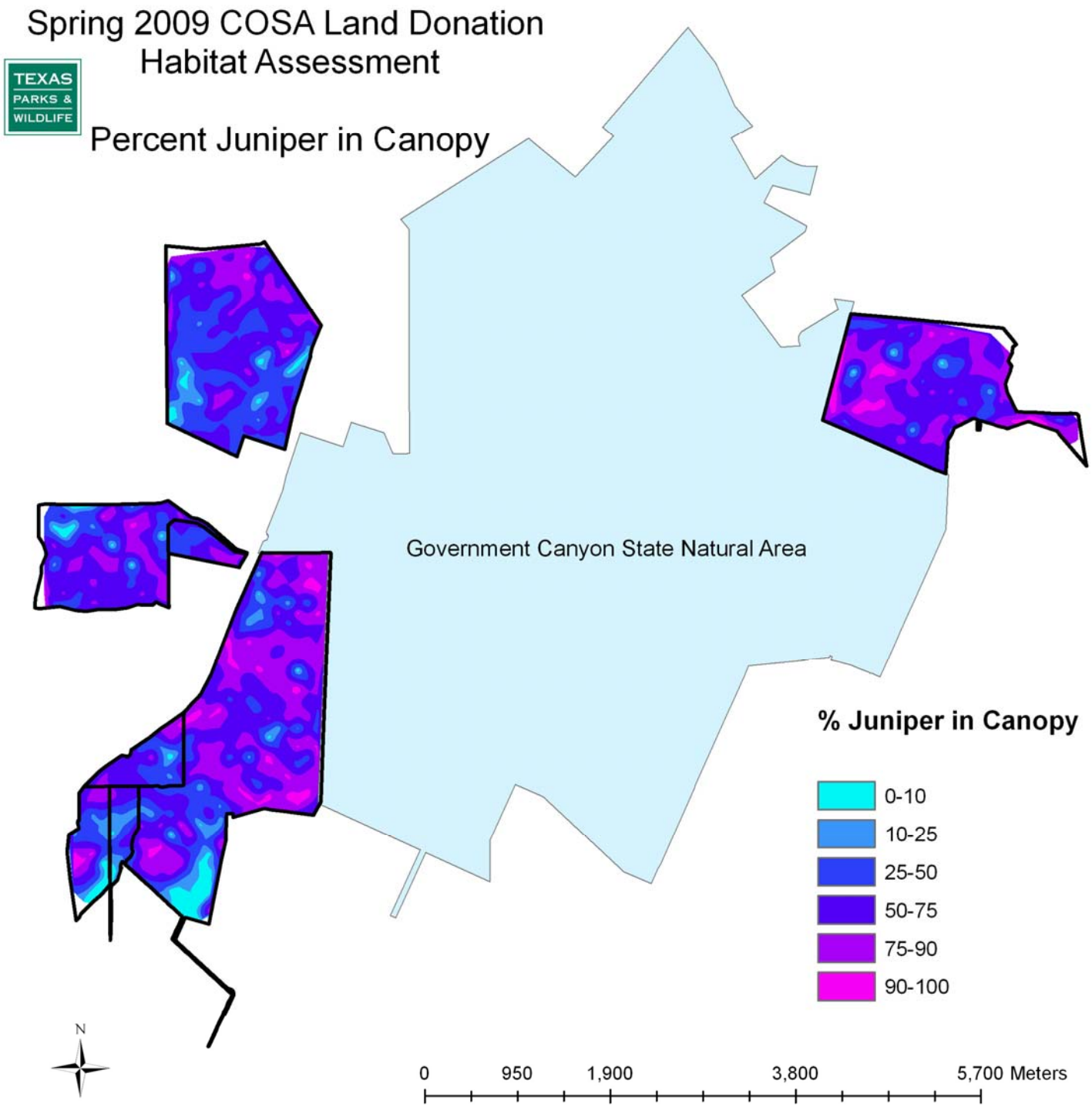

Figure 4. Average percent juniper composition in the canopy; natural neighbor interpolation.

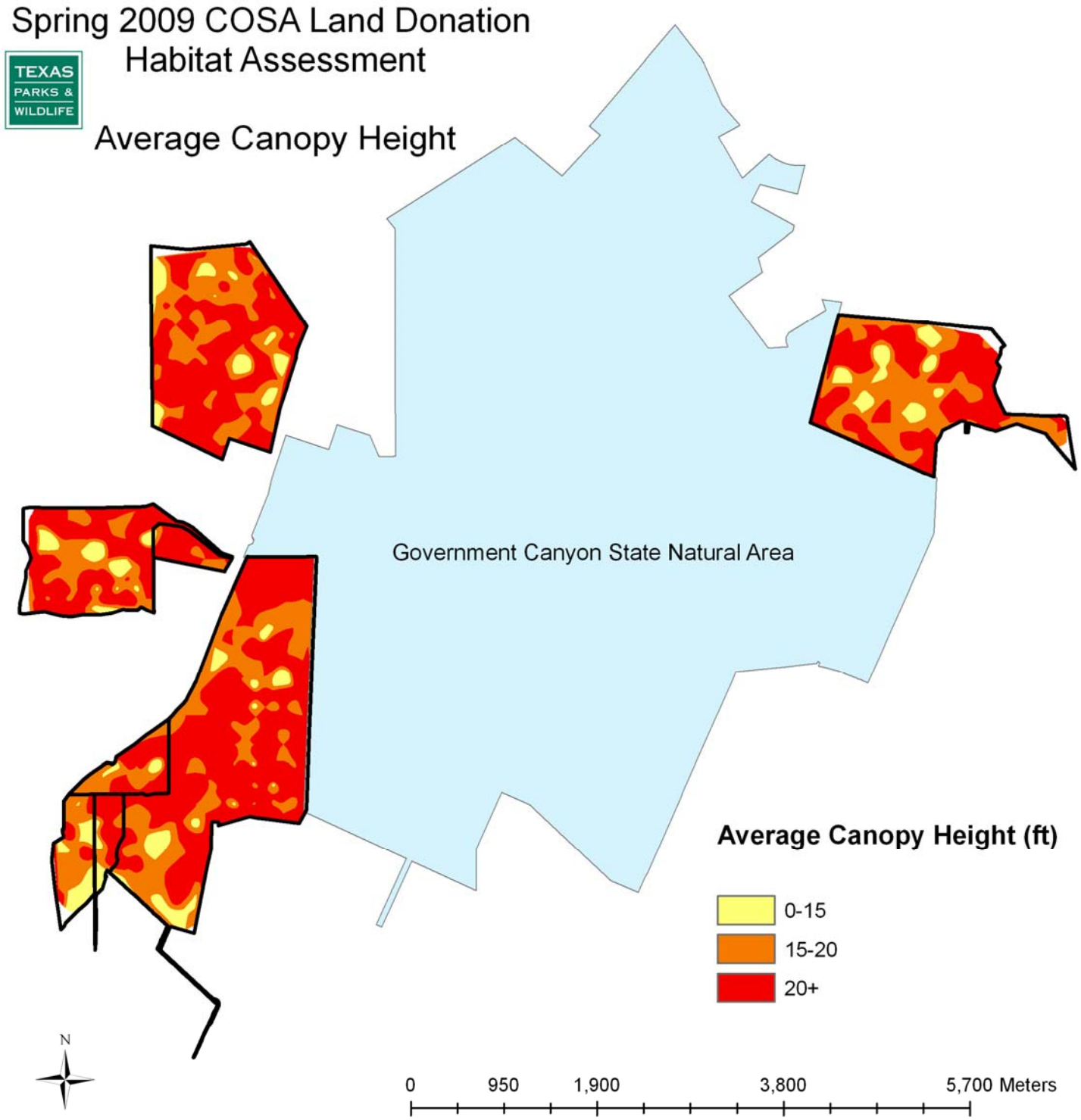

Figure 5. Average canopy height of study area; natural neighbor interpolation.

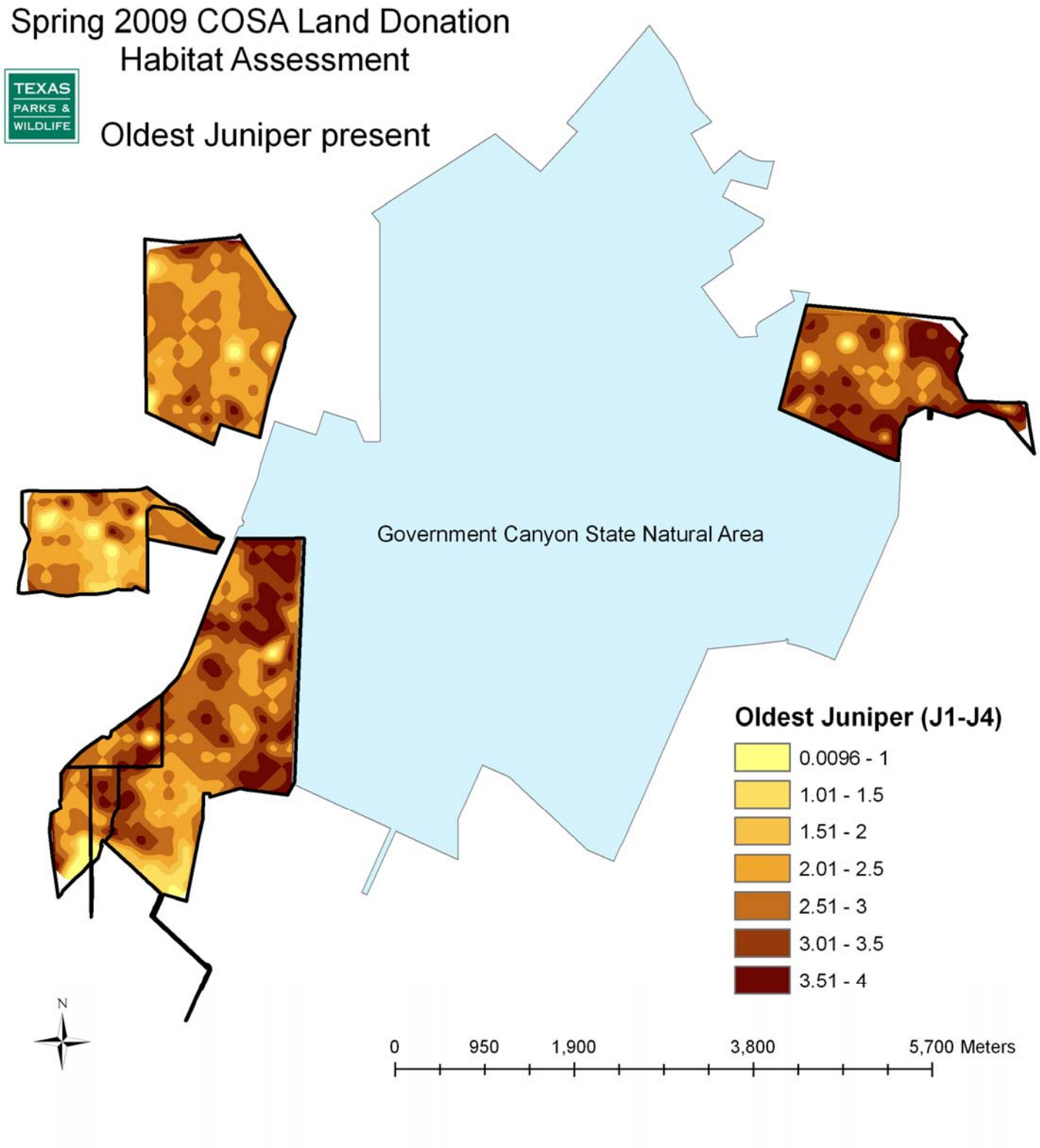

Figure 6. Oldest Ashe Juniper found near survey point; natural neighbor interpolation.

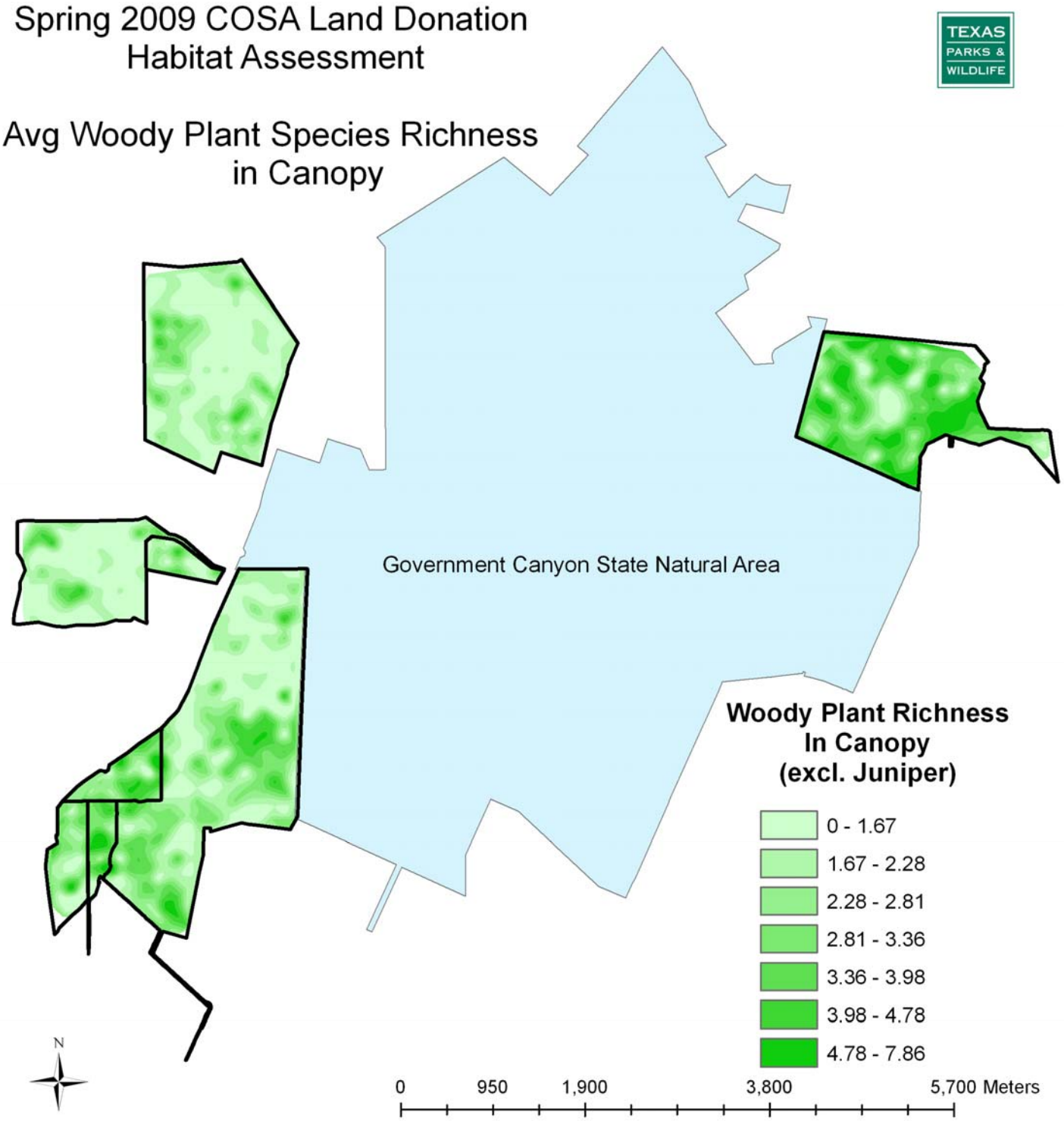

Figure 7. Average species richness of woody plants in the canopy excluding Ashe Juniper; natural neighbor interpolation.

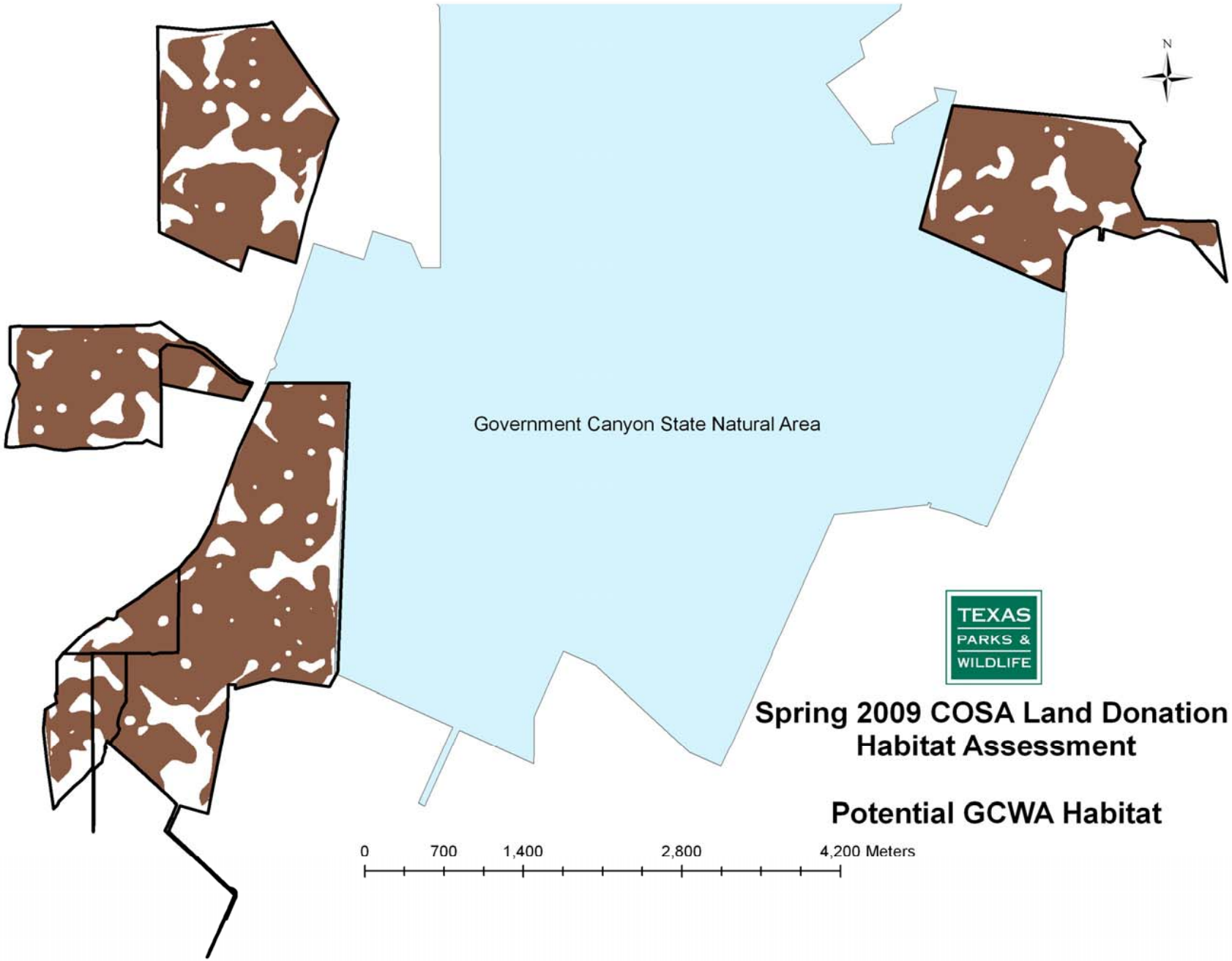

Figure 8. Suitable habitat delineation for the Golden-cheeked Warbler.

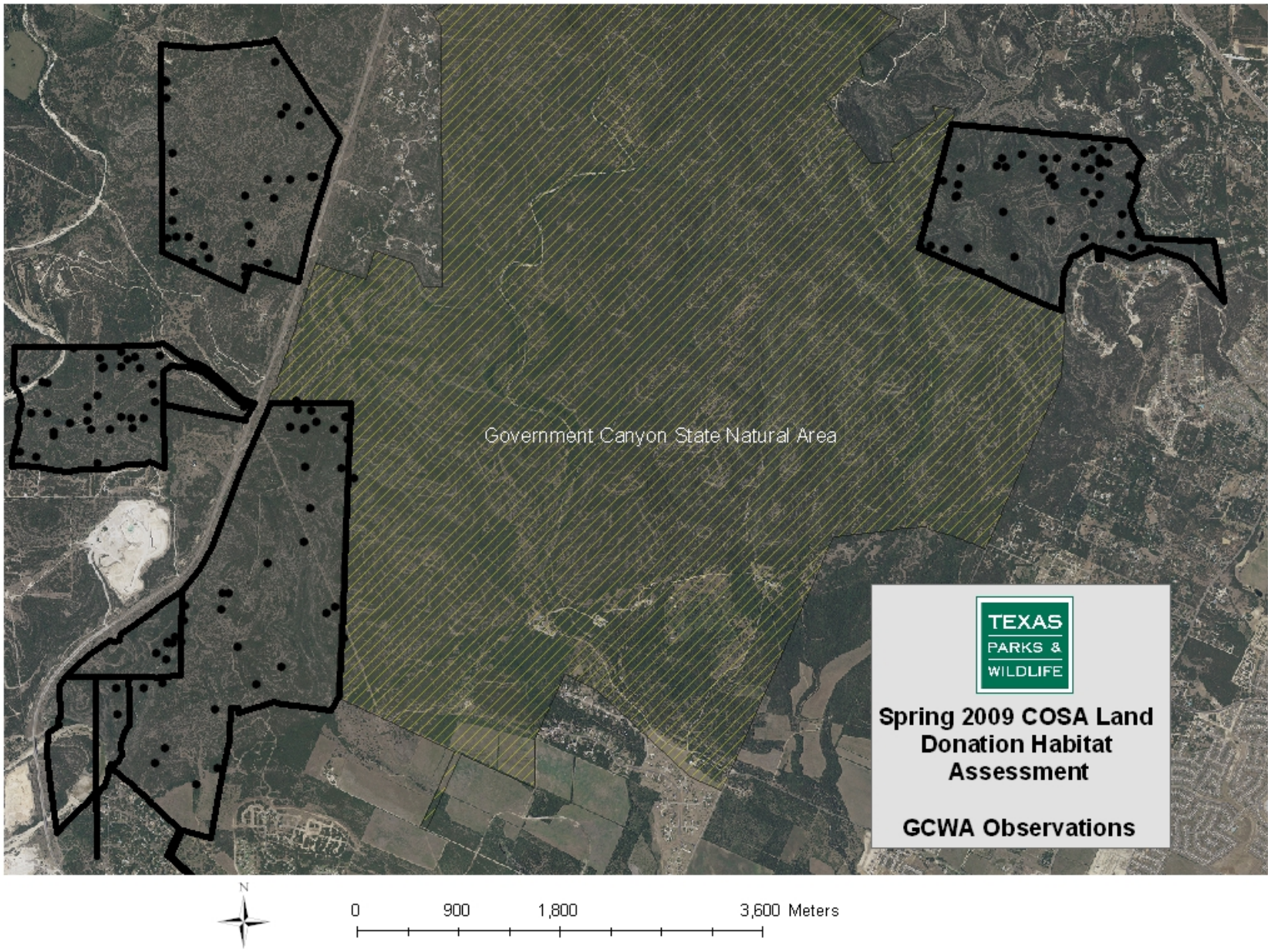

Figure 9. Detections of Golden-cheeked warblers 23 March – 17 April 2009

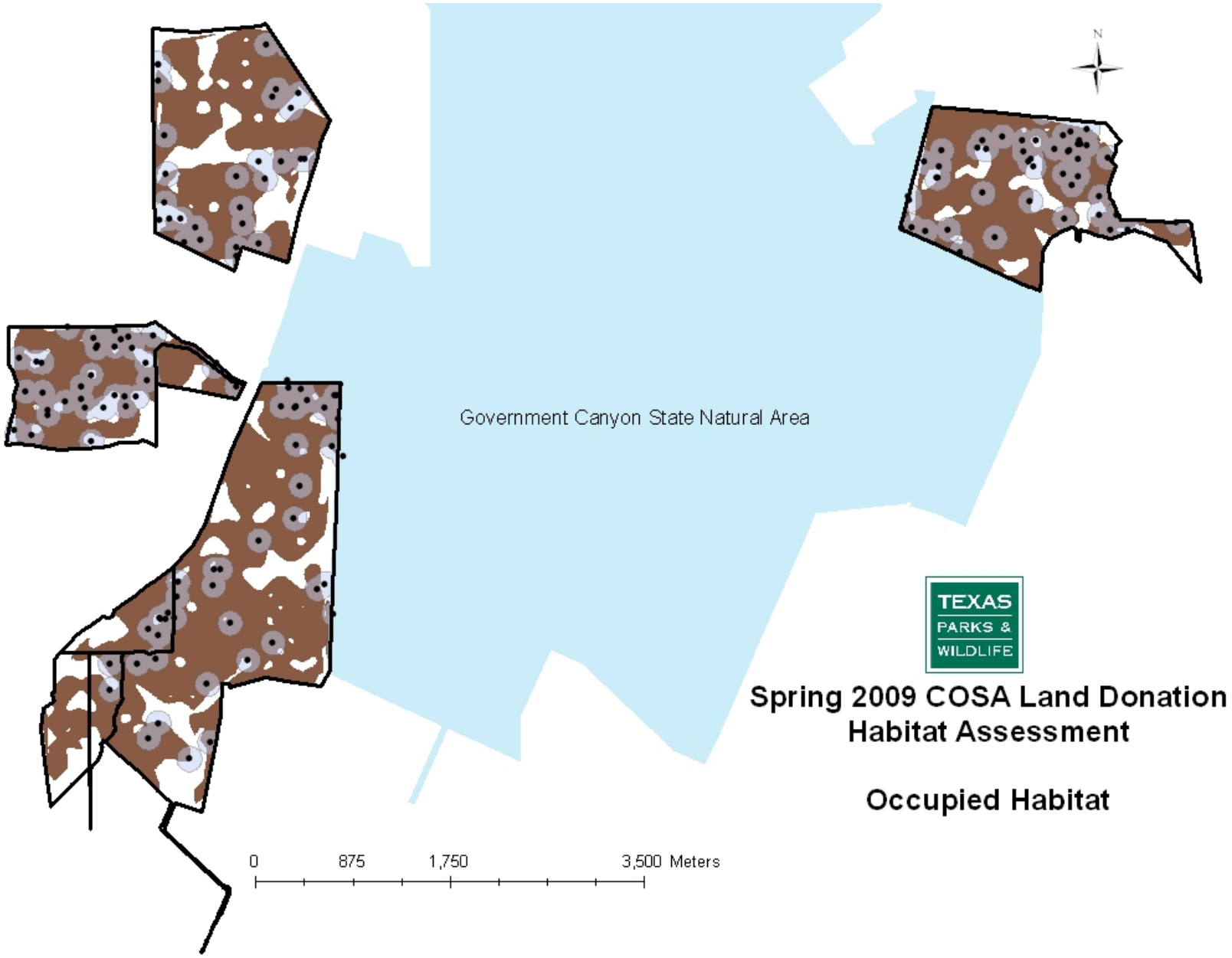

Figure 10. Estimated occupied habitat based on GCWA detections.