Census and Mapping of Chorro Creek bog thistle in Reservoir Canyon, San Luis Obispo, CA

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Abstract

Chorro Creek bog thistle (*Cirsium fontinale* var. *obispoense*) is a federally endangered variety of Fountain thistle endemic to western San Luis Obispo County. The U.S. Fish and Wildlife Service knows of nineteen populations, many with multiple colonies. A population was discovered in the Reservoir Canyon Natural Reserve in 2001, but has not been monitored or described since the time of its discovery. In fall of 2013, a census of the population was performed, the four colonies were mapped, and a floristic survey was conducted. A field experiment was initiated to determine if reducing the riparian canopy coverage can increase thistle colonization and establishment. Thistles in several populations exhibit close bunching behavior, making some individuals difficult to distinguish. A cluster of closely associated dead thistles in the Laguna Lake population was examined for subsurface connectivity. Physical connectivity of the thistles was observed, but the cause cannot be determined without further analysis.

Introduction

During a floristic survey of the Reservoir Canyon Open Space in 2001, Benjamin Carter (2002) discovered a population of Chorro Creek bog thistle and provided the first population size data. He described four distinct "clusters" of Chorro Creek bog thistle, hereafter referred to as CCBT, positioned along a serpentine seep - each accompanied by a single geocoordinate. The clusters, now recognized as colonies, were located along a steep densely vegetated tributary of Reservoir Canyon creek. In April 2013, the City of San Luis Obispo Natural Resources staff and I verified the location and persistence of the CCBT colonies since the 2001 discovery. Carter (2002) estimated (methods unknown) a total of 270 CCBT individuals among all four colonies.

In October and November of 2013, I conducted a census of the population, mapped the colony boundaries, and conducted a floristic survey of the drainage in which the colonies were located. A preliminary floristic survey was conducted in May 2013 and data from both surveys were combined. The purpose of this study was to provide U.S. Fish and Wildlife Service and the City of San Luis Obispo with current data about this occurrence that will contribute to the recovery of the species.

Initial observations of the Reservoir Canyon population in April 2013 were that the riparian corridor containing CCBT was thick with shade tree species, and CCBT colonies tended to exist where the canopy was most open. A small-scale canopy clearing experiment was initiated to see how opening the riparian canopy near CCBT colonies could affect seedling establishment in the cleared area.

Some populations of CCBT, including the population in Reservoir Canyon, exhibit very tight bunching of individuals. Chipping (1994) noted that counting individuals in one of the San

Simeon populations was difficult since they were bunched so closely together. While conducting the census at the Reservoir Canyon site, the same bunching behavior was encountered, and two closely associated plants were seen having tissue connection below the rosettes (Appendix B, photo 1). Subsurface connectivity had not previously been reported in this species. A field study was conducted at the Laguna Lake population – also exhibiting bunching - to examine dead plants for root connectivity (Appendix B, photo 2).

Background

Taxonomy

CCBT is a member of the family Asteraceae endemic to San Luis Obispo County and is listed as endangered by both the state and federal government. In California, there are 23 species in the genus *Cirsium*, 3 of which are non-native. *Cirsium fontinale* var. *obispoense* is one of three varieties of fountain thistle (Baldwin et al. 2012) and was first described by J.T. Howell in 1938 (Chipping 1994). CCBT also has the common name San Luis Obispo fountain thistle.

All three varieties of *Cirsium fontinale* have strict habitat requirements and localized distributions in California. The variety with the common name fountain thistle (*Cirsium fontinale* var. *fontinale*), is now found only in San Mateo County. Mount Hamilton fountain thistle (*Cirsium fontinale* var. *campylon*) is found in Santa Clara, Alemeda, and Stanislaus counties (Calflora 2013).

Characterization

CCBT is a conspicuous herbaceous plant with easily identifiable characteristics. It has somewhat succulent leaves that are densely pubescent, lobed, dentate, and spined. Its several basal leaves can be over 90 cm long and arise from a basal stem forming a rosette. Cauline leaves are well distributed on the flowering stalk and spined. A single flowering stalk is often formed in the second year and can grow to two meters tall (Baldwin et al. 2012). Chipping (1994) noted that secondary flowering stalks can occasionally form at the base of the primary stalk. Flowering heads form panicle-like clusters that branch from the primary stalk. The composite flower heads are distinguishable from other thistles by their nodding posture. Phyllaries are green to purple with the outermost being strongly recurved. The corolla is approximately 20 mm long and ranges from white to lavender. CCBT produces brown achenes that are between 3.4 mm and 5.0 mm. These achenes have an attached pappus for wind-dispersal (Baldwin et al. 2012).

Life History

CCBT plants are generally biennial; forming a rosette in their first year, flowering in their second year, and then dying. However, some plants may persist to a third year and flower a

second time (Chipping 1994). The plants tend to flower from May-July, but have been known to continue into November (Holland 2009). Seedlings are abundant in late summer and fall and grow rapidly during the first winter and spring if they survive (USFWS 2007).

Habitat

All three varieties of *Cirsium fontinale* are habitat specialists and have very strict requirements. They inhabit serpentine soils which provide an environment too harsh for many plant species. Serpentine rock is formed deep in the earth during the geologic process of subduction. Serpentine formations on the California coast are over 100 million years old. CCBT is found west of the Santa Lucia mountain range where million-year-old landslides of serpentinitic rock have formed the appropriate outcrop and spring habitats that the plants occupy (Chipping 1994). Serpentine soils have characteristically low calcium : magnesium ratios, high levels of nickel and chromium (Magney 2006), and are low in essential nutrients such as phosphorus and potassium. CCBT also requires very close proximity to a year-round water source. Some populations are found in boggy soils that are saturated with water. Others are found in wet areas of grasslands or on serpentine bedrock with access to water (Chipping 1994).

Chipping (1994) examined other factors of CCBT habitat including soil type, slope aspect, and local climatic conditions of populations known in 1994. Using Soil Conservation Service soil types he identified Diablo-Lodo Complex on 15-50% slopes and Obispo Rock outcrop complex on 15-75% slopes as the most common for CCBT occurrences known at that time. He did not observe a strong relationship between slope aspect and CCBT population locations. All CCBT populations are found west of the Santa Lucia mountain range. The local climate of this region experiences relatively mild summer temperatures, occasional summer fog, and humid nights.

Populations of CCBT generally consist of multiple colonies within a drainage or wetland habitat. The term colony, as it is used here, implies spatial separation of plant clusters within a population. Populations at Reservoir Canyon, Laguna Lake, Perfumo Canyon, Froom Ranch, Chorro Creek, and San Bernardo Creek all have multiple colonies (USFWS 2007). Sites at Pennington Creek and San Simeon consist of multiple populations, but colonies within these populations were not described (Chipping 1994). The distinction between a population and a colony is poorly defined and may in some cases be used interchangeably.

ESA Listing

Chorro Creek bog thistle (*Cirsium fontinale* var. *obispoense*) was placed on the California endangered species list in 1993 and on the federal endangered species list in 1994 (DFW 2013). Fountain thistle (*Cirsium fontinale* var. *fontinale*), is also on both state and federal endangered species lists (USFWS 1995). Mount Hamilton fountain thistle (*Cirsium fontinale* var. *campylon*) is not listed. However, the CNPS Inventory of Rare and Endangered Plants places it on list 1B.2 – rare in California and moderately threatened (CNPS 2010).

A recovery plan for *Cirsium fontinale* var. *obispoense* was published in 1998. At the time the recovery plan was written, CCBT was known from populations at eight different locations – four on private lands and four on public lands. Populations on private lands included San Simeon Creek, Froom Ranch, San Bernardo Creek, and Miossi Creek. Populations on government lands included Chorro Creek managed by Camp San Luis Obispo, Pennington Creek on Cal Poly property, and Laguna Lake and Perfumo Canyon which are both on San Luis Obispo City lands (USFWS 1998). Since the publishing of the recovery plan, additional populations of this species have been found and reported. USFWS currently knows of nineteen occurrences, ten of which are on private property (Kofron pers. comm. 2013). Two of these more recent discoveries include a population in the South Hills Open Space (USFWS 2007) and a population in the Reservoir Canyon Open Space managed by the City of San Luis Obispo (Carter 2002).

The recovery plan outlined several observed and anticipated threats to CCBT. Observed threats that have contributed to the species' decline include trampling by cattle, road right-of-way maintenance (a population had been mowed over), damage by the introduced Eurasian flower-head weevil, and possibly drought conditions. Anticipated threats include water diversions and prospective development. It is also likely that this species may never have been very abundant to begin with.

The Eurasian flower-head weevil (*Rhinocyllus conicus*) was introduced by San Luis Obispo County Department of Agriculture in 1980 in an effort to control exotic thistles (USFWS 1998). The weevils lay their eggs on the phyllaries of developing flower heads in spring. The larvae then tunnel through the flower heads to pupate where they eat the developing receptacles and florets. Galls form in response to damage by the weevils (Van Driesche 2002). The adults emerge in mid-summer. This species can cause significant damage to the seeds of infested flower heads. The Eurasian flower-head weevil has been observed feeding on CCBT in the San Simeon, Chorro Creek, and Laguna Lake populations. In one season, the Eurasian flower-head weevil was responsible for destroying 7.6% of the seed crop in the San Simeon population (Kofron pers. comm. 2013).

The downlisting strategy can be summarized by meeting four criteria. Downlisting requires (1) securing habitat and populations with multiple colonies at 6 sites from human threats, (2) providing population data for at least 3 sites regarding CCBT's response to varying precipitation cycles, (3) managing protected sites to promote population persistence and wetland habitat conservation, and (4) demonstrating that management is effective by accumulating at least 10 years of monitoring. More than six sites have been secured from human threats, several on San Luis Obispo City-owned open spaces. Secured sites include Laguna Lake Park, Perfumo Canyon, Froom Ranch, South Hills, Chorro Creek, and Pennington Creek. Population monitoring data is being collected regularly at Chorro Creek and in some city-owned open spaces (USFWS 2007). Many populations on city-owned land have inherent protection of the wetland habitats CCBT occupies and protection of populations by isolation or exclusion fencing (USFWS 2007).

Reservoir Canyon

The Reservoir Canyon Natural Reserve is owned by the City of San Luis Obispo and includes both Reservoir Canyon and Bowden Ranch opens spaces (Appendix A, map 1). RCNR is a 783 acre parcel of land with a rich biotic community and local history. In the 1800s, the San Luis Obispo Water Company purchased land in the canyon and created a system of water diversions, pipelines, and a reservoir for the city's water supply. Since the 1990s, use of this water supply has ceased, and much of it has been removed to restore the natural flow of the creeks. The north-east facing hills sustain a thick chaparral community while south-west facing hills are mainly covered with southern coastal scrub and grassland communities. Riparian trees shade many of the drainages, and Reservoir Canyon creek provides a well developed riparian habitat along the north-eastern boundary of the reserve (Havlik 2013). Reservoir Canyon burned in the Las Pilitas fire of 1985, but the vegetation has since recovered to support diverse plant and animal communities (Fire 2013).

To access the CCBT population, the trailhead on the north side of Reservoir Canyon should be used. Take Reservoir Canyon Road from Highway 101, and follow the road south to the unmaintained parking lot. Follow the trail along the creek and then most of the way up the hill. The closest colony to the trail lies a linear distance of about 150 meters off trail and about 65 meters downhill. The appropriate place to depart from the trail is approximately 175 meters further uphill from the trail easement on the Hasting's property (marked by a wooden sign). There, the trail offers a view of the upper part of the drainage to the north-west. Set a bearing for approximately 310° NW, and follow this to the top of Colony A (Appendix A, map 2).

Mapping

Mapping of the four colony boundaries occurred in October and November 2013 (Table 1). I used a Topcon GPS unit with ArcPad software (Appendix D) to collect points at locations around the perimeter of each colony. The North American Datum 1983 with a UTM 10N projection was used. Each point collected was set to take the average of 30 points at that site. Using the average of 30 points increased precision in rugged terrain where satellite reception was poor.

Positional dilution of precision (PDOP) values were recorded for each point as a measure of error. Low PDOP values indicate high precision. A high resolution base map image of Reservoir Canyon – collected by PG&E (2013) – was added as a base map on ArcPad for quick reference of point placement. Points with high PDOP values were closely examined against the basemap for visual inspection of accuracy. Any points that appeared obviously inaccurate were discarded and retaken.

To create colony boundaries, a total of 47 points were taken and later used to form polygons. PDOP values for the GPS points ranged from 2.7 to 13.0 with a mean of 5.0. The error of most points was likely within only a few meters. Generally, the distance between points was between three and eight meters, but occasionally distances were greater when point acquisition became a safety hazard due to steep terrain.

The population occupies a combined area of 227.7 m^2 with colonies stretching 131 meters along the drainage (Appendix A, map 3). Colony A occupies 80.1 m^2, and the colony's centroid is at 380 m elevation. Colony B occupies the greatest area at 106.4 m^2 and has its centroid at 375 m elevation. Both colonies C and D occupy just over 20 m^2. The elevation of colony C is at 326 m and colony D is at 318 m. Coverage of CCBT is not necessarily uniform within each colony perimeter; plants are more dense in some areas and occasionally there are small gaps where CCBT is absent within the colony. CCBT populations studied by Chipping (1994) are found at elevations between approximately 55 meters (at Laguna Lake Park) and 327 meters (at Pennington Creek). This means that the Reservoir Canyon population is among the highest in elevation.

A photo point location was established less than five meters downstream from each colony (Appendix B, photos 3-6). The locations chosen allow photos to capture the majority of plants in each colony. These points were marked by metal stakes hammered into the ground near the stream, but not directly in the stream channel. The stakes stick up at least 10 cm out of the ground and have been marked with orange flagging tape for increased visibility. GPS points were also taken at these photo point locations. PDOP values for the points ranged between 4.5 and 8.1. A photo of each colony was taken at a recorded height from the ground directly above the stake (from the lens to the ground), and the direction that the camera was facing was recorded. Compass bearings accounted for declination. Inclination of the slope of the drainage was also recorded from each photo point; values ranged between 24º and 40º (Table 2).

Census & Colony Descriptions

A census of each CCBT colony was conducted in October and November 2013 (Table 3). Each plant was inspected for its life stage, signs of damage, and weevil presence. Each colony was defined by the mapped boundaries – spatial separation of colonies was obvious – and each was walked through carefully in a zig-zag transect. To ensure that individuals were counted once and only once, orange flagging tape was loosely tied around a leaf of each individual at the time of inspection. The flagging tape was removed after each colony's census had been completed.

An individual CCBT plant was defined by a single rosette and its flowering stalk if present. In the event that a deteriorated flowering stalk without a rosette was encountered, the flowering stalk alone was considered an individual. The longest leaf of each individual was identified (usually among the oldest most basal leaves), and its length and width measurements

were taken. Dead individuals were counted as well, and leaf measurements were taken for the wilted leaves in their wilted state (not flattened or unfurled).

The criteria that David Magney Environmental Consulting (2006) used for life stage classification of the Chorro Creek population were used to classify the life stage of plants in Reservoir Canyon. The life stage of each plant was determined by two categories – each with subcategories – as follows:

1. Vegetative:
    - (VS) Seedlings: cotyledons present, leaves generally <7 cm, finely pubescent, mostly unlobed.
    - (VJ) Juveniles: cotyledons absent, leaves generally >6 cm and <15 cm, at least minimally lobed, largest without fine pubescence of seedling leaves.
    - (VE) Established: leaves >15 cm, lobed, without fine pubescence of seedling leaves; plant not bolting or flowering.
2. Reproductive:
    - (RB) Plants bolting, not yet in flower.
    - (RF) Plants flowering (no heads fruiting, heads fruiting, plants dying).
    - (D) Plants dead (heads fruiting, fruits dispersed, still rooted, not rooted, lying down on the ground, no longer reproductive).

As each individual was studied, they were searched for presence of and damage by the Eurasian flower-head weevil, *Rhinocyllus conicus*. Each leaf was examined to the extent practical for weevils. Each flower head was also examined for evidence of boring damage and weevil presence. The number of weevils on each plant was recorded as well as the number of flower heads with visually confirmed damage.

Great care was taken while walking among the plants to ensure that none were harmed. In some areas, plants could not be inspected or measured because approaching them was either a safety hazard or a threat to other CCBT individuals. In these cases, the best approximation for life stage was made by observing from a distance. Unapproachable areas were scanned visually for CCBT in an effort to count as many plants as possible.

A total of 802 CCBT individuals were counted in the census for the entire population (Table 3). There were 689 live individuals and 113 dead individuals. No individuals were in the bolting life stage, and only three were flowering. Nearly 50% of the population was established, 25% were seedlings, and 10% were juveniles. Photos were taken of each of the life stages (Appendix B, photos 7-10). This census was likely an underrepresentation of the true population size since some areas of colonies were inaccessible. Two hundred sixty-four plants (just under 33%) had at least one unmeasured feature due to inaccessibility.

The size of this population was larger than expected given the historical estimate from Carter (2002) of 270 plants. Carter's data for population size was taken in May of 2001 when seedlings were likely not yet abundant. Moreover, the high plant density and clustering of

rosettes gives the population a deceptively small appearance. With these factors in mind, it is possible that the population has not changed much since Carter's 2002 report.

There was no evidence for the presence of the Eurasian flower-head weevil in this population; however, two dead plants had flower heads with insect boring damage. The western spotted cucumber beetle (*Diabrotica undecimpunctata undecimpunctata*) was commonly found on CCBT (Appendix B, photo 8). The beetle was not observed causing damage to the thistles, but the species is regarded as an agricultural pest in the United States since it causes damage to cucumber, bean, and corn crops (Luna 2009).

Colony A is at the uppermost reach of the drainage where the spring begins to flow. The flow of water originates from underneath a large boulder and is a mere trickle at this point. The drainage banks are shallowly sloped to the west and steeply sloped to the east. California bay laurel (*Umbellularia californica)* and toyon (*Heteromeles arbutifolia*) trees shade the majority of this colony, but the canopy has openings to the north and to the south-east. The ground is covered in dense bay laurel leaf litter and a moderate amount of woody debris. Herbaceous plants that live among CCBT include giant wild rye (*Elymus condendatus*), melic grass (*Melica imperfecta*), and common monkey-flower (*Mimulus guttatus*), but none of these species are very abundant here. CCBT grows most densely near and directly in the stream below the boulder. Many plants, however, exist on the drier western bank with a few extending above the spring. Some plants in this colony could not be measured because they were either difficult to safely approach or could not be studied without stepping on others.

The count in colony A totaled 306 thistles constituting 38% of the total population. The majority of CCBT here were either established or dead. Only one individual remained in flower so late into the season. Many dead flowering stalks from the summer's blooming period were encountered. Most of the juveniles and seedlings in this colony were near the boulder and very close to the water. Several plants near the boulder showed signs of damage to the leaves (Appendix B, photo 7). Deer feces and hoof prints suggest that deer trample CCBT while coming to water or crossing the stream.

The colony B boundary begins about 12 meters downstream from colony A. The point of colony B furthest upstream is composed of only two CCBT individuals. These two plants have experienced some trampling as well; it appears that a game trail crosses the stream at their location. There is a gap of roughly 10 meters between these two plants and the bulk of colony B. The stream is a steady trickle on exposed bedrock. The banks are very steep on both sides and have loose dirt stabilized only by CCBT, Melic grass (*Melica imperfecta*), and hedge nettle (*Stachys* spp.). Small bay laurel trees shade the top half of this colony, but the lower half has little to no canopy cover. The bulk of CCBT in this colony occur where canopy is most open. *Stachys* species and *Mimulus guttatus* are moderately abundant among CCBT here. *Elymus condensatus* is less common, but still present. *Stachys* spp. and *Melica imperfecta* grow thick among CCBT on the steep western bank near the bottom of the colony.

Colony B, with 355 individuals, had the highest portion of the total CCBT population at 44%. There were more seedlings and juveniles than any other colony with 116 and 52, respectively. There were 169 established individuals, one flowering individual (Appendix B, photo 8), and 17 dead individuals. A high proportion of CCBT in this colony (55%) could not be measured or inspected for damage due to the steep erodible banks and high density of seedlings that could easily be stepped on. Thus, the majority of these plants were counted from a distance. It is likely that some CCBT were not counted because they could not be seen from a safe vantage point. One dead thistle had a flower head with evidence of insect boring through the phyllaries (Appendix B, photo 9). However, no evidence of the Eurasian flower-head weevil presented itself. No other insects were present on this individual.

Colony C begins 44 meters downstream from the bottom of colony B. The slope of the drainage flattens out near the bottom of this colony causing the stream to widen and the soil to become muddier. Short spike hedge nettle (*Stachys pycnantha*) and giant wild rye (*Elymus condensatus*) grow thickly among CCBT, particularly in the muddy areas. CCBT coverage is most dense at the center of the colony, and thistles are sparse where other herbaceous species grow tall. Common shade trees include bay laurel (*Umbellularia californica*), toyon (*Heteromeles arbutifolia*), and Brewer's willow (*Salix breweri*).

Colony C had the fewest number of thistles of the four colonies with 11 established, 35 seedlings, and 3 dead. Seedlings were clustered together in the portion of the stream with the least overhead canopy coverage. Some CCBT individuals were not measured or inspected since dense plant coverage restricted access to them.

Colony D begins only 5 meters downstream from colony C, but the two colonies are distinct because of the willow trees that separate them. Colony D lies just upstream from the confluence with the main tributary of Reservoir Canyon creek. The stream disappears and becomes subterranean at the confluence (about 7 meters below colony D). The flow of water is reduced through this colony, and several willow trees encroach on the CCBT that inhabit the stream. In fact, CCBT essentially form a ring around an "island" of willow trees. California coffeeberry (*Frangula californica*), toyon (*Heteromeles arbutifolia*), and bay laurel (*Umbellularia californica*) also form the canopy above CCBT. Herbaceous hedge nettle species are of moderate abundance in this colony.

There were 92 individuals in colony D, the majority of which were found directly in the stream. There were 43 established individuals, 25 seedlings, 4 juveniles, 1 flowering, and 19 dead. One dead thistle had a flower head with insect boring damage through the phyllaries. Upon close examination, a very small insect was briefly seen entering the hole. This unidentified insect was only 1-2 mm long, had a brown head and thorax, and a light brown abdomen. It did not appear to be the Eurasian flower-head weevil, but instead a different species with a smaller adult form. One established individual appeared to have lost a flowering stalk and is persisting to another season (Appendix B, photo 11).

Floristic Survey

A preliminary floristic survey of the drainage and the surrounding chaparral species was conducted on May 13, 2013 by myself and another Cal Poly biology undergraduate. A secondary floristic survey was performed as each colony was being censused. Three plant communities were described including chaparral (outside the drainage), riparian (in the drainage and on its banks), and south coastal scrub (just north of Colony D on the south-facing hill) (Appendix C).

A relatively linear transect was walked through the chaparral community from the Reservoir Canyon trail to the riparian corridor above colony A. Zig-zag transects were made through each CCBT colony and in the intervening spaces (Appendix A, map 4). Specimens of plant species that could not be identified in the field were collected and keyed using the Jepson Manual. The results of both floristic surveys were combined. Descriptions of abundance for the various plant species were based upon the season in which they were first discovered – either spring 2013 or fall 2013.

No new plants were encountered in fall 2013 that hadn't been encountered in spring. The herbaceous cover in the stream was reduced in fall for most species. Short spike hedge nettle (*Stachys pycnantha*), however, appeared to grow more vigorously in fall than in spring. Another sensitive plant species was seen growing near CCBT in spring: Hoffmann's Sanicle (*Sanicula hoffmannii*). This species is not listed, but the California Native Plant Society gives it a 4.3 rank indicating that it is of limited distribution (CNPS 2010).

Canopy Clearing

An area among the CCBT colonies was searched for an appropriate site for a preliminary canopy clearing field experiment. Requirements for the site included access to the perennial water source and a thick riparian canopy not supporting thistles in the undergrowth. Potential areas were searched for sensitive plants, nesting birds, and other possible wildlife conflicts.

A site immediately below Colony D was chosen to have the riparian canopy cleared. This relatively flat area was thick with Brewer's willow, California coffeeberry, and bay laurel, but contains no CCBT. The more open and sun-exposed area immediately upstream, however, does support CCBT. A 3.5 meter wide by 5 meter long rectangular plot was measured out in this area using a meter tape, compass, and metal stakes. The length extends from the bottom of colony D to the confluence of the main tributary of Reservoir Canyon creek where the water disappears. A width of 3.5 meters was chosen because it was wide enough to include the entire width of the stream but not so wide as to disturb a nearby woodrat midden. The clearing boundaries were mapped with the GPS unit. Four metal stakes with red flagging tape remain at the four corners of the plot for future reference (Appendix B, photo 12).

Branches and limbs of two Brewer's willows, a coffeeberry, a toyon, and a bay laurel tree that intersected the plot were trimmed with loppers to provide the canopy opening. Trimmings were dragged about 10 meters away and placed high on the bank of the drainage well below any CCBT. The cleared area has very little herbaceous growth - only a few *Stachys pycnantha* individuals.

The cleared area will be monitored by the City of San Luis Obispo Natural Resources staff in subsequent seasons to determine if CCBT seedling dispersal, establishment, and recruitment occurs there. Due to its proximity to colony D, it is likely that seeds have made it into the clearing site, but may not have succeeded due to low light conditions.

Plant Connectivity Field Study

Observations of CCBT in Reservoir Canyon challenged the traditional view that a thistle individual was defined by one rosette. A photograph of two thistles showing tissue connectivity below the rosettes was sent to Dr. David Keil, professor emeritus at Cal Poly San Luis Obispo and director of the Robert F. Hoover Herbarium, for analysis. His initial assessment was that the connection may either be branched caudex tissue or the result of terminal bud damage. The discovery of subsurface connectivity between closely associated rosettes warranted further investigation since it had not been previously recorded in this species. If the species is found to spread vegetatively, it would have major implications for how a genetic individual is defined.

Close bunching of thistles was seen in multiple populations including Reservoir Canyon and Laguna Lake. With permission from USFWS and the City of San Luis Obispo, a tightly bunched cluster of dead CCBT in the Laguna Lake population was inspected for root connectivity. Dr. David Keil assisted in observational analysis of the plant tissues. A cluster of multiple rosettes (possibly 3 or more) was chosen as a candidate specimen. The plants were dead; leaves were dry, wilted, and deteriorating (Appendix B, photo 2). The dead leaves were removed and the basal stems lifted out of the ground for visual examination.

Connectivity of the caudex tissue below the ground was confirmed in this dead cluster. However, Dr. Keil was not able to determine whether the connectivity was a result of a branched caudex from one individual, branching due to damage of the terminal bud, or natural grafting of multiple individuals. The dead plant tissues were deteriorating below the ground, and a common root connection could not be confirmed. (Appendix B, photo 13).

Although the cause of connectivity in the CCBT plants could not be determined by external examination, genetic analysis may be an effective alternative. Genetic analysis can be performed to compare the relatedness of rosettes in a cluster to those in the rest of the population. If bunched individuals are most similar to each other, they may be the same individual; if not, they are likely the product of natural grafting. Natural grafting can occur between individuals

that grow very closely together (Keil pers. comm. 2013). Given the strict habitat requirements of the species, it is likely that natural grafting could occur when seedlings establish themselves adjacent to other seedlings or established individuals.

Alternatively, observations on clusters of new seedlings can be taken on a frequent basis to see how they grow near each other over time, and determine if natural grafting takes place. Undoubtedly, if this species is confirmed to spread vegetatively via caudex branching or otherwise, it has population-level significance. For example, genetically effective population sizes may be smaller than previously thought if multiple rosettes and flowering stalks can belong to one individual.

Threat Assessment

The Reservoir Canyon population is secured from many of the common threats to the species. The Eurasian flower-head weevil was not found on any plants, but certainty of its absence cannot be reached since roughly 1/3 of plants could not be accessed for examination. Evidence of insect damage in the examined plants was very minimal. The western spotted cucumber beetle is not known to be a threat to the species.

The remoteness of the site and difficult access across tough terrain provide inherent protection from most people and cattle. Cattle from private properties adjacent to Reservoir Canyon use Reservoir Canyon Creek as a water source (Havlik 2013), but cannot travel up the steep tributary. Trampling damage by wildlife, however, is apparent in the top two colonies. Twenty-five plants appeared to have leaf damage attributed to trampling. Mule deer (*Odocoileus hemionus*) are the most likely culprit of the trampling since feral pigs (*Sus scrofa*) have not been documented in RCNR. Persistence of the water source for CCBT does not appear to be in jeopardy. The large extent of city-owned property provides protection for the water resources.

Extensive riparian canopy coverage above CCBT appears to affect the location of colonies and distribution of individuals within colonies. The most dense thistle coverage occurred in areas with the most open canopy. If the riparian trees continue to grow tall and expand along the drainage, CCBT may not receive enough light for optimal growth conditions. The canopy clearing experiment area should be monitored in subsequent seasons for CCBT establishment and expansion.

Evidence of an apparent small marijuana cultivation site was encountered in the tributary below the CCBT population. Chicken wire and irrigation tubing was seen near the stream, but the site appeared undisturbed for some time (Appendix B, photo 14). This location was mapped with a GPS point, and was found 320 meters downstream of colony D (Appendix A, map 2). No immediate threats to the population are attributed to this illegal activity.

Great care should be taken by researchers studying the Reservoir Canyon population so that they do not inadvertently damage plants or cause bank erosion. The drainage is very steep in places and researchers are forced to walk among CCBT for safe passage. Bank erosion can cause CCBT to be buried or the water flow to decrease.

Recommendations for Future Actions

The canopy clearing site will need to be surveyed to determine if CCBT has colonized the area. The San Luis Obispo Natural Resources Program has agreed to monitor the site in subsequent seasons. The first monitoring data should be collected in late summer of 2014 when many seedlings germinate. If the cleared site is colonized and established by CCBT, other areas of the drainage should be considered for canopy clearing to increase or improve available habitat.

This population, though difficult to access, may be a candidate for annual monitoring. Continuing to involve Cal Poly biology students in data collection should be considered by managers since many students may be interested in gaining field work experience.

Genetic analysis or seedling cluster monitoring should be performed to determine the cause of caudex tissue connection between individuals. Populations at Laguna Lake, San Simeon, Reservoir Canyon, and possibly others show close associations of rosettes and may all have individuals exhibiting connection. An easily accessible population should be chosen for analysis. If the number of genetic individuals is found to be fewer than expected, populations may be smaller than previously thought and deserving of greater protection.

Confirmation of the wildlife responsible for trampling CCBT in colonies A and B should be sought. Scat surveys may be performed to identify the mammal species that utilize the area. Perhaps a camera station can be deployed where trampling occurs to identify visitors to the site. Although herbivory of CCBT by deer has not been recorded, using a camera station could monitor for the possibility.

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Tables

Colony	Census & Mapping Date
A	November 3 & 7, 2013
B	October 27, 2013
C	October 16, 2013
D	October 13, 2013

Table 1. The date that each colony was censused and mapped.

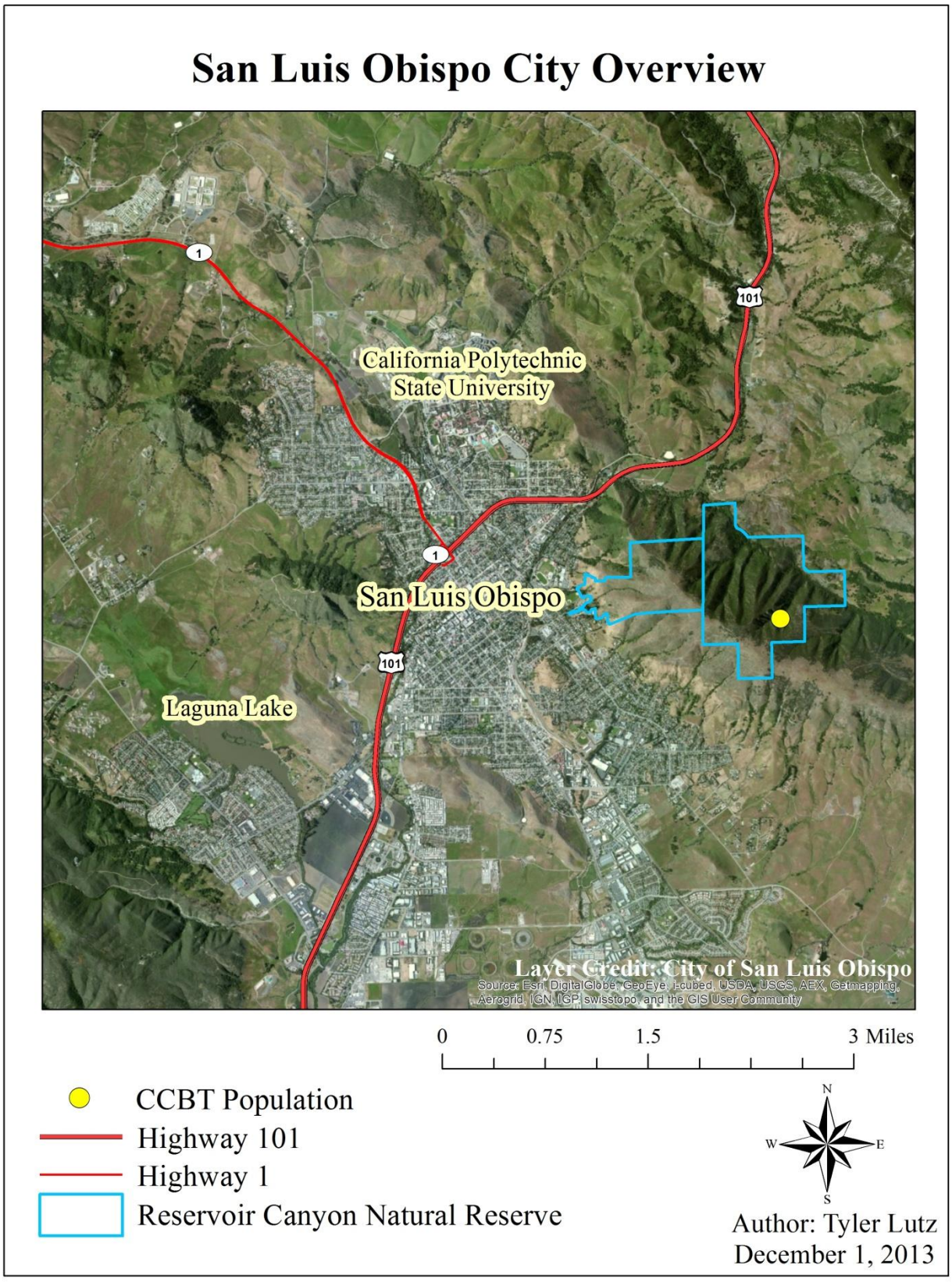
Colony	Camera Height (cm)	Point Accuracy (PDOP)	Bearing	Site Inclination	Photo Orientation
A	115	4.5	191°	39°	Portrait
B	134	6.0	154°	40°	Portrait
C	62	4.5	167°	24°	Landscape
D	124	8.1	201°	28°	Portrait

Table 2. Descriptive information for the photo point locations of each colony were recorded to allow replication during future monitoring. Camera height is the distance from the ground to the lens, PDOP is the level of accuracy for the GPS point acquired, bearing is the direction the camera was facing, and site inclination was the general inclination of the uphill slope at that point.

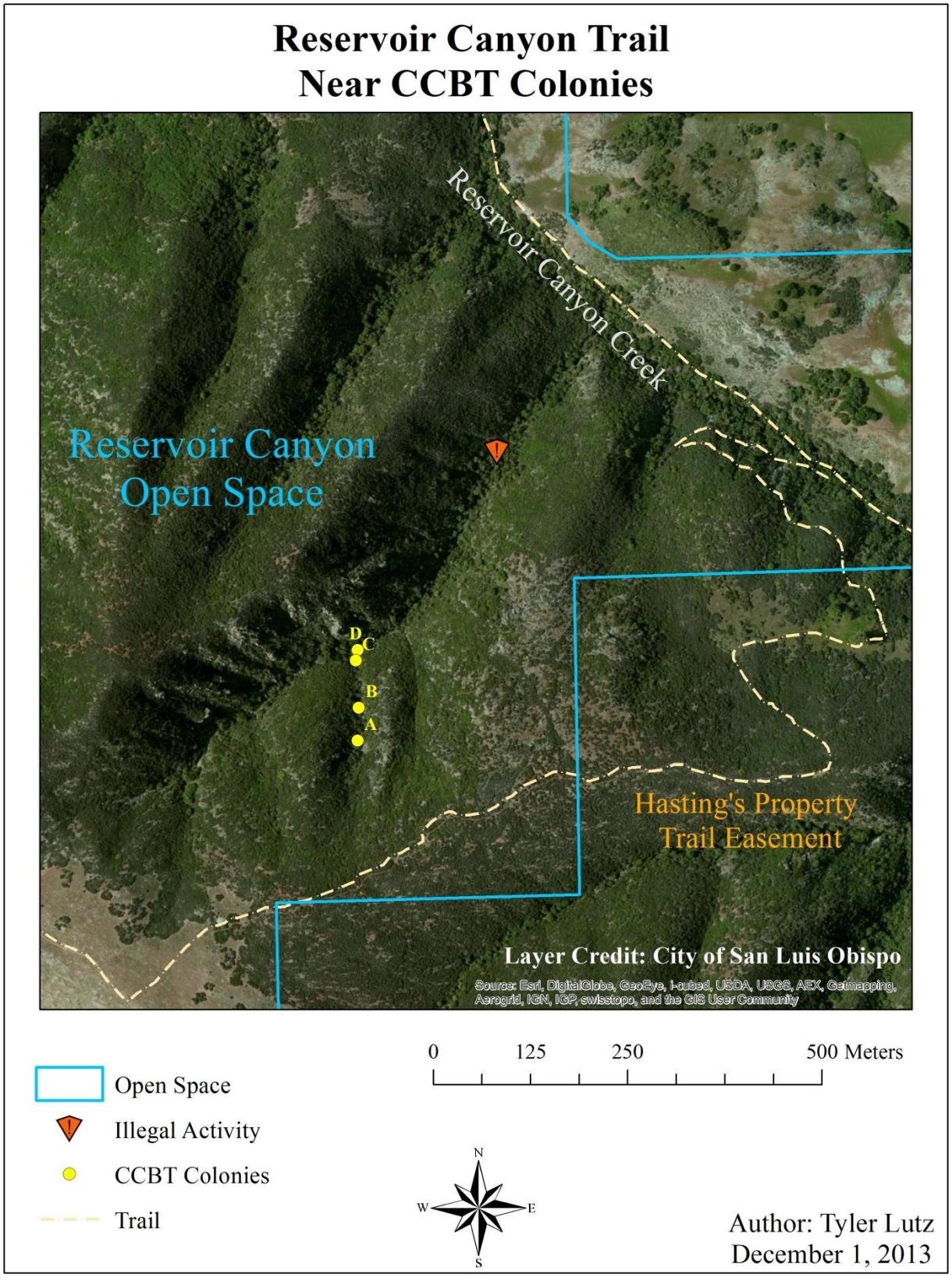
Colony	VS	VJ	VE	RB	RF	D	Colony Total	Proportion
A	32	23	176	0	1	74	306	38%
B	116	52	169	0	1	17	355	44%
C	35	0	11	0	0	3	49	6%
D	25	4	43	0	1	19	92	11%
Stage Total	208	79	399	0	3	113	**802**	
Proportion	26%	10%	50%	0%	0.4%	14%		

Table 3. A summary of the CCBT census for each colony. The proportion of the total population size in each colony is listed on the right. The proportion of each life stage in the total population is listed on the bottom.

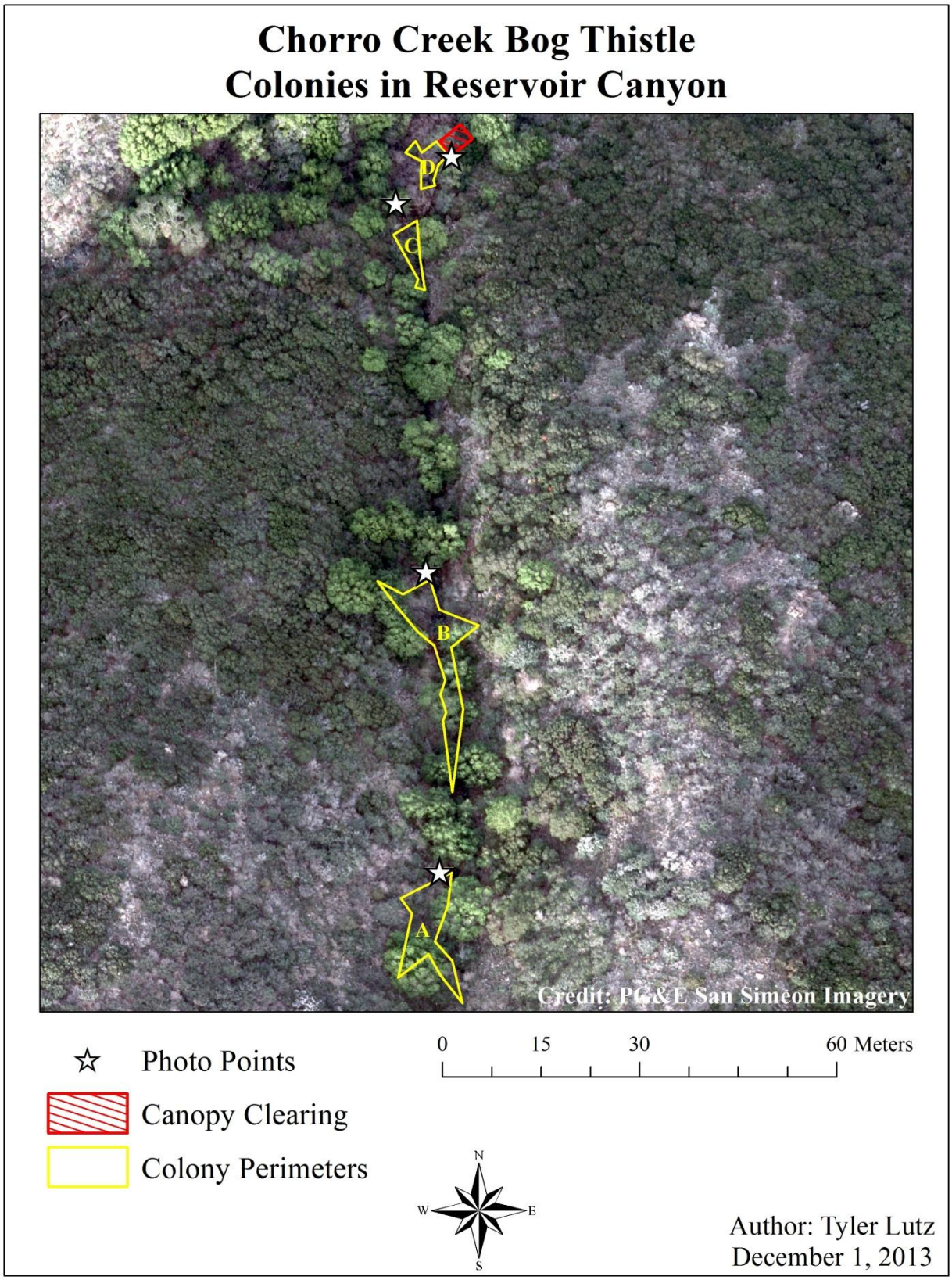
Appendix A - Maps



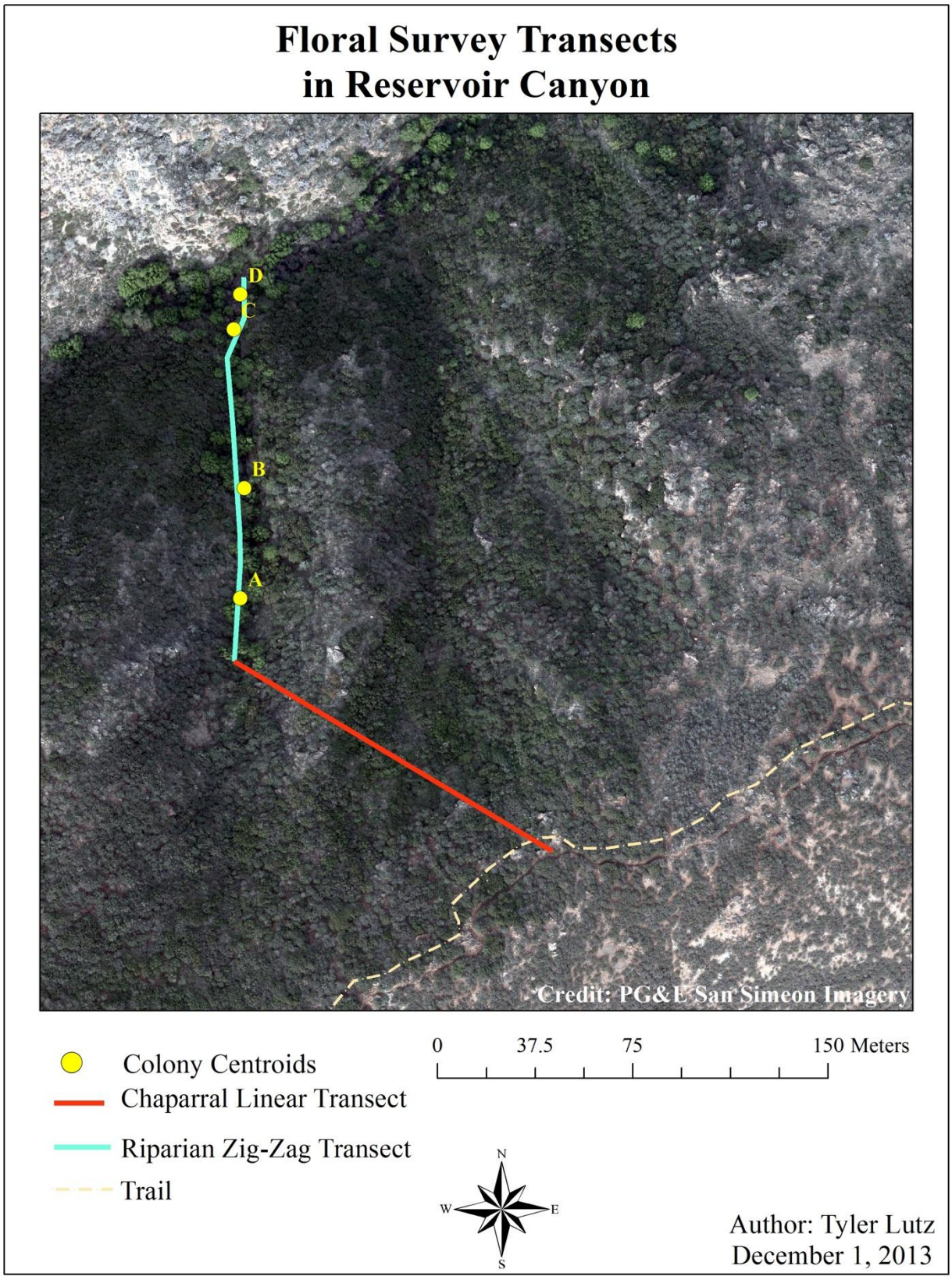
Map 1. An overview of San Luis Obispo city that shows the two open spaces comprising Reservoir Canyon Natural Reserve to the east.



Map 1. The Chorro Creek bog thistle colonies lay in a secondary tributary of Reservoir Canyon creek. The best way to access the site is to depart from the trail about 175 meters west of the Hasting's property.



Map 3. The four colonies of CCBT in a secondary tributary of Reservoir Canyon creek. The canopy clearing site is adjacent to colony D.



Map 4. Transects for the floristic survey were followed from the trail to the drainage (chaparral) and throughout the colonies in a zig-zag fashion (riparian).

Appendix B - Photos

Photo 1. Two closely growing thistles in colony D of the Reservoir Canyon population were seen having tissue connectivity below their rosettes. Many thistles in the population exhibit similar bunching behavior and may have similar connections that are unseen above ground.

Photo 2. A closely associated cluster of dead plants in the Laguna Lake population was chosen for examination of subsurface tissue connection. This cluster was representative of many thistles in the Reservoir Canyon population, but was much more accessible to researchers.

Photo 3. Colony A from the photo point.

Photo 4. Colony B from the photo point.

Photo 5. Colony C from the photo point.

Photo 6. Colony D from the photo point.

Photo 7. An established plant in colony A that has leaf damage likely due to trampling by wildlife.

Photo 8. A flowering plant in colony B with a spotted cucumber beetle present on the flower head.

Photo 9. A dead plant in colony B with a hole in the peduncle from insect boring. No insects were present.

Photo 10. A juvenile and seedlings in colony B.

Photo 11. An established plant in colony D that appears to have flowered, lost its stalk, and is persisting to another season.

Photo 12. The canopy clearing area below colony D delineated by four metal stakes with flagging tape.

Photo 13. A cluster of CCBT at Laguna Lake examined for connectivity. The subterranean caudex tissue of the rosettes were connected to each other. The cause of connectivity could not be determined by examination.

Photo 14. Black tubing and chicken wire 320 meters downstream from the CCBT population suggest a history of illegal activity (ie. possible marijuana cultivation).

Appendix C – Floristic Survey

Chaparral Community			
Scientific Name	**Common Name**	**Abundance**	**Discovery**
Adenostoma fasciculatum	Chamise	Medium	Spring 2013
Avena barbata	Slender Wild Oat	Medium	Spring 2013
Avena fatua	Common Wild Oat	Medium	Spring 2013
Briza minor	Little Quaking Grass	Medium	Spring 2013
Bromus diandrus	Ripgut Brome	Medium	Spring 2013
Calystegia macrostegia	Wild Morning Glory	High	Spring 2013
Ceanothus cuneatus	Buckbrush	High	Spring 2013
Chlorogallum pomeridianum	Soap Plant	Medium	Spring 2013
Dendromecon rigida	Bush Poppy	Medium	Spring 2013
Dudleya abramsii ssp. *murina*	San Luis Obispo Dudleya	Medium	Spring 2013
Eriophyllum confertiflorum	Golden Yarrow	Sparce	Spring 2013
Festuca microstachys	Annual Fescue	Medium	Spring 2013
Festuca perennis	Rye Grass	Medium	Spring 2013
Hesperoyucca whipplei	Chaparral Yucca	Medium	Spring 2013
Hordeum murinum	Foxtail Barley	Low	Spring 2013
Melica imperfecta	Melic Grass	Low	Spring 2013
Mimulus aurantiacus	Sticky Monkeyflower	Medium	Spring 2013
Pickeringia montana	Chaparral Pea	Sparce	Spring 2013
Quercus durata	Leather Oak	High	Spring 2013
Selaginella bigelovii	Spikemoss	Medium	Spring 2013
Stipa lepida	Purple Needlegrass	High	Spring 2013
Toxicodendron diversilobum	Poison-Oak	Medium	Spring 2013
Toxicoscordion fremontii	Death Camas	Low	Spring 2013

Southern Coastal Scrub Community			
Scientific Name	**Common Name**	**Abundance**	**Discovery**
Eriophyllum confertiflorum	Golden Yarrow	High	Spring 2013
Hesperoyucca whipplei	Chaparral Yucca	Medium	Spring 2013
Mimulus aurantiacus	Sticky Monkeyflower	High	Spring 2013
Quercus durata	Leather Oak	High	Spring 2013
Salvia mellifera	Black Sage	High	Spring 2013

Riparian Community			
Scientific Name	**Common Name**	**Abundance**	**Discovery**
Acmispon glaber	Deer Vetch	Medium	Spring 2013
Adiantum jordanii	California Maidenhair Fern	Medium	Spring 2013
Aquelegia eximia	VanHoutte's Columbine	Medium	Spring 2013
Calochortus albus	White Fairy Lantern	Low	Spring 2013
Ceanothus cuneatus	Buckbrush	Low	Spring 2013
Cirsium fontinale var. *obispense*	Chorro Creek Bog Thistle	High	Spring 2013
Dendromecon rigida	Bush Poppy	Medium	Spring 2013
Elymus condensatus	Giant Wild Rye	Low	Spring 2013
Frangula californica	California Coffeeberry	High	Spring 2013
Galium porrigens	Climbing Bedstraw	Medium	Spring 2013
Heteromeles arbutifolia	Toyon	High	Spring 2013
Lathyrus sp.	Vetch	Low	Spring 2013
Lonicera hispidula	Pink Honeysuckle	Low	Spring 2013
Melica imperfecta	Melic Grass	High	Spring 2013
Mimulus aurantiacus	Sticky Monkeyflower	High	Spring 2013
Mimulus guttatus	Common Monkeyflower	High	Spring 2013
Pentagramma triangularis	Gold Back Fern	Medium	Spring 2013
Polypodium californicum	California Polypody	Medium	Spring 2013
Salix breweri	Brewer's Willow	Low	Spring 2013
Sanicula hoffmanii	Hoffman's Sanicle	Sparce	Spring 2013
Scrophularia californica	Figwort	Low	Spring 2013
Stachys bullata	Common Hedgenettle	Medium	Spring 2013
Stachys pycnantha	Shortspike Hedgenettle	High	Spring 2013
Toxicodendron diversilobum	Poison-Oak	Low	Spring 2013
Umbellularia californica	California Bay Laurel	Medium	Spring 2013

Appendix D - Materials

Mapping:

- Topcon GMS2 handheld GPS unit
- Casio Exilim digital camera
- Metal stakes with flagging tape & hammer
- Silva Ranger compass

Census:

- 150 cm vinyl tape measure
- Casio Exilim digital camera
- Flagging tape
- Gloves
- Photos of *Rhinocyllus concinus* life stages and plant damage

Floristic Survey:

- Jepson Manual 2nd Edition
- Plastic bags
- Hand lens

Canopy Clearing:

- Loppers
- Metal stakes with flagging tape
- 30 meter tape measure
- Silva Ranger compass

Root Connectivity Field Study:

- Shovel
- Gloves