Post-Burn Restoration of Nesting Habitat for the Coastal Cactus Wren in the Orange County Central Reserve: Final Report

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INTRODUCTION

Background

The Coastal Cactus Wren (*Campylorhynchus brunneicapillus*) occurs in coastal southern California in a distinct sub-type of coastal sage scrub, southern cactus scrub, defined as having greater than 20% cover of cactus species *Opuntia littoralis* (coastal prickly pear), *Cylindropuntia prolifera* (coastal cholla), and *Opuntia oricola* (oracle cactus). For more than two decades, Coastal Cactus Wren populations have been declining rapidly, likely because of habitat loss and fragmentation due to urban and agricultural development and large-scale fire events (Mitrovitch and Hamilton 2006). The Coastal Cactus Wren is a California species of special concern and one of three target species in the Central-Coastal Orange County Natural Community Conservation Plan (Orange County NCCP).

The Orange County NCCP is divided into a Coastal Reserve (~17,000 acres) and a Central Reserve (~20,000 acres). The Nature Reserve of Orange County (NROC) is responsible for implementing the Orange County NCCP and coordinating management activities throughout the Reserve, while the Irvine Ranch Conservancy (IRC) is contracted to manage 11,220 acres in the Central Reserve and 3,146 acres in the Coastal Reserve. Within the Orange County NCCP, most of the Coastal Reserve burned in the 1993 Laguna fires. A study of the Coastal Reserve indicated approximately 1,473 acres of cactus scrub occupied by Coastal Cactus Wren in 1992, and only 187 acres occupied in 2006. In 2006, an estimated 58% of burned cactus scrub had not sufficiently recovered to be suitable for Coastal Cactus Wren occupancy (Mitrovitch and Hamilton 2006). In 2007, the Windy Ridge and Santiago Fires burned much of the Central Reserve, leaving little mature cactus scrub habitat for breeding Coastal Cactus Wrens. A study of the Central Reserve in 2008 estimated approximately 1,855 acres of cactus scrub prior to the 2007 fires, of which 1,059 were determined to have severe fire damage (Leatherman 2009).

Based on habitat suitability models, Mitrovitch and Hamilton (2006) found that high quality cactus scrub (relative to patch size), and the combination of high quality cactus scrub with the presence of *Sambucus nigra* were the strongest correlates of their highest ranking model for Coastal Cactus Wren occupancy. Their criteria for the highest quality habitat consisted of >20% cover of mature cactus in a contiguous acre, generally greater than 1 meter (m) tall. In 2009, consulting biologist Robert Hamilton, along with the Conservation Biology Institute and The Nature Conservancy summarized existing information on the Coastal Cactus Wren for a presentation on restoration guidelines to a Coastal Cactus Wren working group. Information presented on habitat characteristics suitable for Coastal Cactus Wren included: 1) spacing of suitable cactus scrub habitat no greater than 1.5 km to facilitate dispersal by juvenile Coastal Cactus Wren; 2) high quality cactus scrub 2-3 acres in size to support a nesting pair; 3) minimum cactus patch size of 15 m^2, with *O. littoralis/oricola* planted at approximately 2 pads/m^2 (more for *C. prolifera*); and, 4) the presence of some/all of the following plant species: *S. nigra, Artemisia californica,* and *Eriogonum fasiculatum* on the perimeters of cactus patches.

O. littoralis, O. oricola, and *C. prolifera* all occur in the Central Reserve; however, *O. littoralis* accounts for the large majority of the cactus populations (M. Lulow, personal observation; Roberts 2008). *O. littoralis* and *O. oricola* tend to be found on sandy and gravelly soils, on a variety of slopes, and in disturbed areas in grasslands or coastal sage scrub. They are not considered good competitors for light, becoming overgrown in shrub communities of taller stature (such as chaparral) and failing to establish well among undisturbed grasses. Therefore, their distribution in sandy or gravelly soil, southern aspects, and areas of disturbance may be an artifact of decreased competition from other plants, in addition to preferences for particular physical characteristics in these environments (Benson 1969; Edward Bobich, Cal Poly Pomona, personal comm.). Based on an overlay of cactus scrub mapped after the Santiago Fire in the Central Orange County Reserve (Leatherman et. al 2008) and the soil series digital map (Natural Resources Conservation Service 2008) for this area, cactus scrub occurs on a variety of soil types (Table 1).

In the Central Reserve, the majority of cactus populations occur along Lomas Ridge, all of which burned to some degree in the 2007 Santiago Fire (Leatherman et. al 2008). Due to the large-scale loss of habitat, the relatively slow growth of cactus, and current decline in Cactus Wren populations, restoration of remaining degraded cactus scrub patches is critical. The IRC and NROC have developed cactus restoration plans; one for the Central Reserve (Appendix 1), and one for the Coastal Reserve, respectively (Figure 1). NROC focused on initiating restoration of a linkage between southern and northern populations of Coastal Cactus Wren within the Coastal Reserve. These populations were isolated by the loss of cactus scrub in the 1993 Laguna Fire. IRC focused on restoring patches of cactus scrub in the recently burned areas of the Central Reserve, concentrating on augmenting habitat for remaining Coastal Cactus Wrens and providing linkages between extant populations (Figure 1).

Objectives

Our goal was to develop a restoration plan and implement restoration of burned cactus populations in strategic locations on the Central Reserve given the financial resources awarded by the California Department of Fish and Game and matching funds of the landowner. Specific objectives as outlined in the restoration plan were to:

1) Prioritize restoration sites within burned cactus scrub habitat using criteria that maximize benefit to Coastal Cactus Wrens.
2) Design a restoration approach utilizing techniques that: a) enhance the availability of nesting habitat for Coastal Cactus Wren; b) balance the benefits of abundant sites and rapid structure; and, c) create habitat that will be resilient in the face of future fires.
3) Develop a monitoring protocol including standardized techniques.

It was also a goal to implement the above objectives in a manner that would facilitate future restoration of cactus populations in the Central Reserve.

METHODS

The scope of work refers to a series of tasks that were to be performed in meeting the above objectives and these will be referred to in reporting our methodology (Table 2).

- **Task 1: Develop Restoration Plan**

Subtask 1.1 Determine Priority Areas for Cactus Scrub Restoration.
The Central Reserve Habitat Assessment and Survey (Leatherman et al. 2008) included data that categorized cactus populations by burn severity and recorded the distribution of Coastal Cactus Wrens in the Central Reserve. Utilizing the GIS data from this survey, the IRC developed criteria for priority restoration sites and developed a map of severely burned cactus populations of priority for restoration (Figure 2). The criteria were developed based on the desire to ensure areas of sufficient size to support Coastal Cactus Wren and to ensure opportunities for dispersal (see restoration recommendations from the Coastal Cactus Wren Working Group above). Polygons with severely burned populations of cactus were prioritized for potential restoration if they were located:

1) Within 200 m of cactus that was not considered severely burned in the Leatherman et al. (2008) survey, AND
2) Within 1,000 m of an existing Coastal Cactus Wren territory

In addition, polygons meeting these criteria that were in areas with multiple Coastal Cactus Wren pairs were preferred, with the following exceptions: 1) if the polygons had potential to serve as a linkage between Coastal Cactus Wren populations (Shoestring Canyon pair); or 2) if a single pair seemed threatened by a lack of suitable habitat in the larger area (e.g., Siphon Reservoir pair).

In May 2009, priority polygons were visited in each area to ground truth the status of cactus populations and assess conditions for restoration potential at the patch level, including surveys for sensitive plants. In addition, cactus and Coastal Cactus Wren surveys were conducted for the easement lands in the Shoestring Canyon area not covered in the Leatherman et al. (2008) survey.

While visiting potential cactus restoration polygons several factors appeared important in considering the potential of a site for restoration. First, a key objective was to have the restoration result in significant recovery of cactus in a given area. If sufficient cactus was already present and showing signs of vigorous regrowth, these areas were disqualified as it was reasonable to expect such areas would recover on their own. This applied to several polygons in Weir Canyon. A second consideration was that there be sufficient space to accommodate the minimum restoration patch size (15 m diameter, discussed below) and not result in either displacing an existing native community, or result in eventual displacement of the planted cactus as the pre-existing shrub community recovered from the fire. For most of the visited polygons, the majority of the area was composed of burned intact scrub. Therefore, while we wanted to cluster our restoration patches, our selected sites were somewhat dispersed, as opposed to occurring on only a few polygons. Sites also varied in the extent of weeds. As mentioned above, most polygons consisted of burned coastal sage

scrub with scattered individual cacti, although some areas consisted of annual grassland with scattered cacti. No candidate polygons consisted of large, contiguous stands of burned cactus. This may be because these areas are less common in the Lomas Ridge region and were less likely to have burned severely, and therefore did not come up as a qualifying polygon for restoration.

Subtask 1.2 & 1.3 Sensitive species and Coastal Cactus Wren surveys; Finalize Site Selection and Determine Restoration Implementation Specifications.

A total of 40 candidate sites were selected in five regions (Shoestring Canyon, Siphon Reservoir, Round Canyon, Limestone Ridge, and the Agua Chinon Orchard) (Figure 2). In June and July 2009, visits were made to verify the 2008 locations of Coastal Cactus Wren in each area by consulting biologist Rob Hamilton (Shoestring Canyon, Round Canyon, Limestone Ridge, and the Agua Chinon Orchard) and IRC staff member Susan Anon (Siphon Reservoir). Based on these visits, the minimum distance of restoration sites from moderately burned cactus was changed from 100 m to 200 m because some candidate sites in Round Canyon (4), Limestone Ridge (10), and Shoestring (4) were determined by Rob Hamilton to adequately support the existing Coastal Cactus Wren. We moved sites to nearby locations in greater need of supplemental cactus and with greater potential to support future fledglings from the core habitat area. Site assessments of these new areas were finalized in August 2009 and include information pertinent to restoration, such as extent of non-native species cover, burned and unburned cactus cover, slope, aspect, accessibility, and native species present (Table 3). In addition to the site assessments described above, all sites were overlaid with sensitive and rare plant GPS locations based on surveys in the Limestone and Lomas regions in the last 10 years (Roberts 1999, 2000, 2008). Sites (15 m diameter patch) where sensitive species were found, either through the site assessment or GIS data, were relocated.

<u>Restoration Specifications</u>

Although the exact cause for the recent rapid decline of Coastal Cactus Wren is not known, loss of cactus for nesting habitat is likely to have played a significant role (Mitrovitch and Hamilton 2006). For this reason, and because we are augmenting burned cactus scrub habitat, our restoration approach was to concentrate our resources on maximizing the amount of cactus planted. In the Central Reserve, *C. prolifera* is rare and therefore we did not attempt to restore this species. Among the prickly pear species, *O. oricola* is assumed to be preferable over *O. littoralis* because it has a taller stature and Coastal Cactus Wren tend to nest in cactus greater than 1 m in height. It proved to be very difficult to find sufficient numbers of individuals of this species growing in the wildlands in our region, however, and therefore the majority of the cactus used consisted of *O. littoralis.*

The fastest way to restore nesting habitat for Coastal Cactus Wren would be to transplant mature, multi-stemmed individuals and irrigate them; however, the availability of large, mature plants is limited and this would be the most costly approach to establishing cactus. Given a limited budget, we thought it would be preferable to cover more area planting cactus pads (also referred to as claddoes or joints), and include a few scattered larger transplants to provide some vertical structure.

Cactus Patch Design
In determining the basic design for a restoration patch, the following objectives were considered: a) Enhance the availability of nesting habitat for Coastal Cactus Wren; b) Balance the benefits of abundant sites and rapid structure; and c) Create habitat that will be resilient in the face of future fires.

We define a restoration patch (or site) as a 15 m diameter circular area where cactus was planted at 2-2.5 pads/m^2. We considered this size to be the minimum area where a fire burning through the ecosystem might be interrupted from burning the interior of the patch, ensuring some level of resiliency and continued function of the patch after the fire. Based on the density of planting, we estimate that it could take up to 10 years for the patch to fill in with cactus, yet this is within the range of a fairly frequent fire-return interval for the region, so we do not anticipate destruction of the patch as a result of fire. As mentioned above, restoration patches are clustered into regions and augment habitat, so the total area of available habitat in any region is greater than 1 acre (ac). Exceptions may be part of Round Canyon just below the Bowerman Landfill and Siphon Reservoir, but we selected these areas in part to provide connectivity.

Each 15 m diameter patch consisted of approximately 350 *O. littoralis* pads with approximately 175 square meters per patch. With the exception of patches with difficult access, four 3-year-old *O. littoralis* transplants in 5 gallon (gal) pots were planted in each patch to provide some immediate vertical structure. In addition, two 1 gal *Sambucus nigra* transplants were planted on the perimeter of each patch or in the nearest drainage or gully, as long as it occurred within about 60 m of the patch. Planting *S. nigra* within the interior can increase the risk of ignition within the interior. This basic design is depicted in Figure 3.

In addition to this basic design, we implemented an adaptive management approach and incorporated some variations to optimize available cactus materials and learn about best management practices (Table 4):

1) Access was too difficult at 17 of the 40 selected sites to transport the four, 5 ga, potted cactus transplants. To most effectively utilize these “left over” potted transplants, we selected two of the cactus patch locations that could be accessed with a tractor and tractor auger and instead of planting single pads, we planted 40 of these pots on 6-foot centers at each site (Figure 4).
2) In order to learn about the potential significance of patch size to Coastal Cactus Wren use, four patches were planted as double patches, essentially consisting of two of the standard patches fused together along an edge, hence measuring 15 m x 30 m (Figure 5). These sites were: Orchard 1 and 10; Orchard 2 and 9; Shoestring 1 and 2; and Shoestring 3 and 4 (Table 4).
3) The 3-year old potted cactus had grown quite large with branches extending outward. This made their transportation hazardous to workers carrying them with pot lifter hooks. We therefore had to trim portions of some branches off for most of the pots. In order to fully utilize this plant material, and because some of the sites were too difficult to transport potted plants to anyway, some of these sites were supplemented with additional cactus pads. At 11 of the 17 patches that proved too difficult to transport

potted cactus to, half of each patch was planted at double the standard density of cactus pads (Figure 6). The remaining 6 of the 17 patches received the standard number of cactus pads in the basic design (2 /m^2). This design provides additional information on the potential benefit of increasing the planting density of cactus with respect to overall growth rate.

4) The use of pruned pads to double the density of some sites fortuitously allowed a comparison of the establishment success of: 1) wildland harvested versus nursery harvested cactus pads, and 2) single versus multiple padded branches that had been pruned from pots.

Figure 7 depicts the location of each patch by planting design. Each patch in a double site is represented by its own dot, but in actuality, the dots are connected. One of the double patches in the Orchard area is obscured because the two double patches are close together.

Plant Materials

The IRC developed protocols on where and how to harvest cactus pads based on criteria that avoid significant harm to individual cactus plants and disturbance to Coastal Cactus Wrens. These criteria included:

1) Collection restricted to non-NCCP lands, preferably in development project areas.
2) Collection restricted to non-breeding periods of Coastal Cactus Wren.
3) Collection of pads not to exceed 5% of any given square meter of cactus (equals approximately 7 pads/m^2 based on several counts of total pads/m^2)
4) Collection restricted to sites with the lowest density of Coastal Cactus Wrens in the region (either no or a single pair in the larger collection area).
5) No plant < 1 m^2
6) No plant < 2/3 green
7) No pad < 14 x 7 cm
8) No pad off top of plant, preferably stray pads and branches protruding from bottom of plant.

These criteria were discussed with both Rob Hamilton, an ornithologist who has specialized in the study of Coastal Cactus Wren and with Edward Bobich with California State Polytechnic University Pomona, a plant biologist who has specialized in the study of cactus. Both experts felt that cactus collection in the manner detailed above would not cause significant detriment to the Coastal Cactus Wrens or the cactus.

Several areas were visited to survey their potential for adequate and accessible collection of cactus, as well as the presence of Coastal Cactus Wrens. For each area, estimates were made of the number of harvestable square meters (referring to both plant health and accessibility). The areas selected for collection were Portola Orchard, East Orange, and Gypsum Canyon. Pads were collected with barbeque tongs and placed in large plastic trash bins. These bins were then transported to a staging area with gravel and set out for 1-2 weeks (which was determined to be sufficient for callusing to occur). When it came time to plant, the cactus pads were again placed in the plastic bins and transported to the site for planting.

Maintenance
The cactus patches were weeded at least once per year, mid-late winter in 2010 and 2011. This timing is late enough in winter to allow sufficient germination of weeds, yet early enough to eliminate the weeds prior to significant competition for light. In most cases, weeds were pulled or hoed within a one foot radius of each pad. For very weedy patches, all weeds were cleared with a weed eater or weed wiper (sponge-like herbicide applicator). Results of a cactus restoration pilot study conducted by the IRC during the 2008-2009 growing season suggested that this level of weeding was sufficient for high survival rates among planted cactus pads.

Subtask 1.4 Draft and Final Restoration Plan Report.
A restoration plan titled: Post-Burn Restoration of Nesting Habitat for the Coastal Cactus Wren in the Orange County Central Reserve: Restoration Plan 2009 was submitted to the California Department of Fish and Game September 2009.

- **Task 2: Restoration Implementation**

Subtask 2.1& 2.2 Order *Sambucus nigra* transplants; Site Preparation
Sambucus nigra 1 gal pots were ordered from Tree of Life Nursery in May 2009 and received just prior to planting in late December.

During September and October, for sites with greater than 60% non-native cover, site preparation consisted of knocking back non-native thatch with weed eaters, and in some cases, raking. The non-native grasses and forbs (primarily *Brassica nigra*) comprising these groups had either dense or tall vegetation that would have made spot treating their seedlings more difficult, and planting cactus cumbersome.

Subtask 2.3 Collect *Opuntia littoralis*
Cactus pad collection was initiated in mid-October 2009 and concluded by the end of December. A total of 13,627 cactus pads were collected from designated areas in the following locations: Gypsum Canyon 9,862; Portola Orchard 2,096; East Orange 1,669. Volunteers spent 83 hours and paid labor spent 145 hours collecting . The collection rate for volunteers was 28 pads /hr, whereas the paid labor rate was 73 pads /hr. There were a total of 1,874 pads collected from the potted transplants, totaling 15,501 cactus pads among all sources.

Subtask 2.4 Restoration planting
Cactus pad planting was initiated in mid-November and completed in early December. While the cactus pads could be planted prior to rain saturating the soil, transplants could not, and therefore, the pads were planted first and we left room on the perimeter for the placement of the potted transplants. Cactus pads were planted on their sides to approximately one-third of their height. This was done by digging a trench with a framing hammer, tongs for handling the pad, and the hammer to tamp the soil around the pad. Blue chalk dust was used to guide planters with the spacing of the cactus pads. Volunteers spent 318 hours and paid labor

spent 258 hours planting cactus. Volunteers planted at a rate of 7pads/hr and paid labor 28 pads /hr. These rates included time to load up callused cactus pads from the staging area, but not transportation to field sites. Volunteers and paid labor worked together on volunteer planting days.

Two 1 gal *S. nigra* transplants were planted in late December across 39 patches. We did not plant *S. nigra* at one site because there were already four *S. nigra* trees near the edge of the cactus patch (Limestone 7). While the target number of *S. Nigra* trees for each patch was one, two plants were planted near each other, anticipating that one might not survive. For each set of *S. nigra* trees, a GPS point was taken and a tree tube staked over the tree to protect it from herbivory and create a beneficial microclimate (Figure 8). A total of 40 labor hours, approximately half of which were volunteer, were spent planting these trees.

From late December 2009 to mid-January 2010, all potted cactus were planted, including the two sites designed entirely with transplants. The 5 gal potted transplants were transported with long tree carrier hooks. A hand-held auger or shovel was used to dig holes. Once the pot was brought next to the hole, a knife was used to cut the bottom of the pot off and make a slit down the lower half of the side. The pot was then placed in the hole using the hooks, the remaining upper half of the cut along the side made to the top, and then the pot was removed from around the cactus. Only paid labor and a select highly trained volunteer planted the potted transplants. A total of 177 hours was spent planting 160 pots.

Figure 9 shows the relative proportion of labor hours conducting each activity. Collecting and planting cactus took just over three quarters of the total hours spent conducting the restoration planting. Man hours for weed maintenance were not documented, but the first round of weeding took about the same amount of time as planting the cactus pots.

- **Task 3: Maintenance**

The first round of weed maintenance occurred over a two-week period in mid-February 2010. The amount and nature of weeding at each patch depended on the abundance of weeds. Eight sites did not require any weeding (Limestone 1, 2, 5; Round Canyon 8&9, 10; Siphon 5, 6). At nine sites, the vegetation throughout the cactus patch consisted entirely of weeds, and therefore all emerging weeds throughout the patch were killed either using a hoe (Siphon 1, 2, 3; Round Canyon 4) or hand-held wick containing glyphosphate herbicide (Orchard 6, Shoestring 1&2; 3&4) (Figure 10). For all other areas (Limestone 6-10; Orchard 9&10, 2&9, 4, 5, 7, 8; Round 1-3, 5-7; Siphon 4), a 12-inch diameter area was weeded around each pad either by hand or with a hoe to avoid killing other native plants mixed with the weeds on site (Figure 11). In April 2010, sites were checked for the need for additional weed control and the same nine weediest sites were weeded (Siphon 1, 2, 3; Round Canyon 4; Orchard 6, Shoestring 1&2; 3&4). In October 2010, all sites were checked for weeds that may have come up during the summer. Russian thistle was growing and removed from a couple of patches at Siphon Reservoir. Early seasonal rain in the fall of 2010 caused prolific germination of annual grasses, so double patch 1&2 at Shoestring subsequently received low dose glyphosphate (1 qt/ac) treatment Patches were visited again in mid-January 2011, and the same method employed at each site as in mid-February 2010, with the following exception: we were unable to visit the Limestone sites, the Shoestring 3&4, and Orchard 4

and 6 due to inaccessibility from washed-out roads and other access complications. With the exception of the Limestone sites (due to continued access issues), these patches were weeded mid-March 2011, as they were in mid-February 2010.

RESULTS AND DISCUSSION

- **Task 4: Monitoring**

Short-term Results

Short-term monitoring of establishment success included survival per pad, growth per pad, and health. Data were collected on each transplant type (single wildland collected, single potted, branch potted, and whole potted transplants). The health index was based on a color and ranged from 0-4 based on the majority of the pad being brown, yellow, green, or combination yellow & green, respectively. All pads were green when harvested, although there was variable bruising to pads during their transportation, but this was consistent across all patches and transplant types, with the exception of the whole potted transplants, which suffered no bruising. Size classes of new pads were based on the number of new joints among different size classes: 1-5, 5-10, 10-15, >15 cm. All patches were visited for collection of data during May 2010. Ten individuals were randomly selected at each patch for each transplant type, with the following exceptions: 20 wildland collected cactus were sampled at each patch, and for the patches where four potted transplants were planted, all transplants were sampled.

Among regions (Limestone, Portola Orchard, Round Canyon, Shoestring, and Siphon Reservoir), survivorship among single wildland collected pads ranged from 94-97% (Figure 12). The mean number of new pads per wildland collected pad (i.e. growth of new pads branching off original collected pad) varied more among sites than survivorship, with Siphon Reservoir, Round Canyon, and Orchard having substantially more new pad growth compared to the Limestone Canyon and Shoestring sites (Figure 13). The Limestone Canyon and Shoestring sites tended to have greater relative cover of non-natives versus. natives based on the site assessment data (Table 3), but further analysis would be necessary in order to determine if this might be the cause of less new growth at these sites. While survivorship was high among all transplant types, the single wildland collected cactus appear to have significantly lower survivorship compared to all other transplant types (Figure 14). Health among transplant types followed a very similar pattern, but overall was excellent, with single wildland pad averaging green-yellow to green (~3.5) and all other transplant types averaging green (~3.9) (Figure 15). Based on the original number of cactus pads per transplant type, we calculated the proportion of new pads/original pad for two size classes among transplant types (<10 cm and >10 cm)(Figure 16). This data suggests that single pads collected from pots (potted pads) were the most productive.

Photos of some restoration patches for each main area were taken late March 2011 (Figure 17: Agua Chinon Orchard; Figure 18: Limestone Canyon; Figure 19: Shoestring Canyon; Figure 20: Round Canyon; and Figure 21: Siphon Reservoir).

Survivorship and health of *S. nigra* transplants was recorded mid-April 2010. The health index for elderberry was 0 (dead), 1 (fair - most leaves dried or yellow), 2 (good - green, no obvious new growth), and 3 (excellent - new growth evident). Mean survivorship among sites ranged from 33% at Siphon Reservoir to ~85% at Shoestring and Limestone Canyon (Figure 22). Health followed a very similar pattern among sites and ranged from 0.5 at Siphon Reservoir to 2.25 at Shoestring Canyon (Figure 23). Some preliminary analyses of the relationship between survivorship and environmental variables such as soil type, aspect, and slope position, indicated that slope position may be the most important for survivorship across sites; survivorship was greatest when planted in drainages (80%), followed by the top of slope (60%), and then the middle and bottom (each 40%).

Long-term Monitoring

Because both the NROC and the IRC are implementing cactus restoration projects in the Orange County NCCP, the two organizations have agreed to include standardized monitoring techniques to allow for comparisons across regions. Long-term vegetation monitoring will occur in May of any given year. The IRC will initiate measurement in 2011 (the end of the second growing season), and then in 2015 and 2020.

NROC and IRC have agreed to base our long-term monitoring measurements on methodologies discussed in Deutchman (2009). Due to the large number, but smaller size of the sites the IRC will be restoring, we chose to use half the transect length specified in Deutchman (2009). Changes in cactus growth will be measured by marking the origin of a patch center with rebar and PVC and running a 25 m transect centered on the origin. The 0 point will always start at the lower point on the slope and start and end points will be marked with 1 ft PVC. A total of 5 1x1 meter quadrats will be evenly spaced, on the right sides of the transect. For each quadrat, the following will be recorded: 1) Percent cover (estimated absolute) of cactus, native grass, native forb, shrubs, non-native grass, and non-native forb; 2) Cover of all native species; and, 3) List of non-native dominants (>20%). Point intercept data will be recorded every meter. Deutchman (2009) concludes that the point intercept method and quadrat method have similar results for cover estimates, with less time required for the point intercept method. The quadrats, however, better estimate uncommon species. Because our goal is primarily to track cover of the cactus, if we are limited on time and find the methods comparable after the first year, we may resort to using only the intercept method.

Post-planting surveys for Coastal Cactus Wren occurred in March 2011 (year 2 of cactus growth), and will be followed by surveys in 2015 and 2020. During these surveys, playbacks of Coastal Cactus Wren calls are not used, in order to minimize potential harassment and to ensure that estimates of site occupancy are not skewed by short-term movement to a restoration site in response to a call. A minimum of 1 morning visit over at least 1 hour is used to determine use. This protocol is also being used by NROC to monitor Coastal Cactus Wrens around their restoration sites.

The locations of Coastal Cactus Wren found during surveys in 2008, 2009, and 2011 are shown in Figure 24. Only the 2008 survey occurred over the entire Lomas Ridge region, the 2009 survey was conducted in the vicinity of each main site (Limestone Canyon ridge, Agua Chinon Orchard, Round Canyon, Siphon Reservoir, and Shoestring Canyon) and the 2011

survey was conducted around the vicinity of each cluster of restoration patches. The 2011 survey will be used as the baseline for long term monitoring of Coastal Cactus Wrens around the restoration sites.

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TABLES

Table 1. Soil series type and number of mapped polygons containing cactus scrub within. Data obtained from Leatherman et. al 2008 and NRCS 2008.

SOIL SERIES	NUMBER OF MAPPED CACTUS SCRUB POLYGONS
ALO CLAY	38
ANAHEIM CLAY LOAM	30
ANAHEIM LOAM	10
BALCOM CLAY LOAM	36
BOSANKO CLAY	22
CALLEGUAS CLAY LOAM	31
CAPISTRANO SANDY LOAM	25
CIENEBA SANDY LOAM	42
CIENEBA-ROCK OUTCROP COMPLEX	9
GABINO GRAVELLY CLAY LOAM	5
MYFORD SANDY LOAM	39
ROCK OUTCROP-CIENEBA COMPLEX	15
SOPER COBBLY LOAM	11
SOPER GRAVELLY LOAM	19
SOPER LOAM	16
YORBA GRAVELLY SANDY LOAM	4
BOSANKO-BALCOM COMPLEX	6

Table 2: Project tasks and schedule of completion dates as identified in LAG contract.

Activity	**Date**
Task 1: Develop Restoration Plan	March 2009-August 2009
Subtask 1.1: Determine Priority Areas for Scrub Restoration	March 2009
Subtask 1.2: Sensitive Species and Cactus Wren Surveys	June 2009
Subtask 1.3: Determine Restoration Implementation Specifications and Finalize Site Selection	June 2009
Subtask 1.4: Draft and Final Restoration Plan Report	July-August 2009
Task 2: Restoration Implementation	March 2009-January 2011
Subtask 2.1: Order *S. nigra* transplants	March 2009
Subtask 2.2: Site Preparation	September 2009
Subtask 2.3: Collect *O. littoralis* propagules	October 2009
Subtask 2.4: Restoration planting	November 2009-January 2010
Task 3: Maintenance	Winter-Spring 2010-Spring 2011
Task 4: Monitoring	Fall, Winter 2010-Spring 2011
Subtask 4.1 Restoration Monitoring	Fall**,** Winter 2010-Spring 2011
Subtask 4.2 Cactus Wren Monitoring	Spring 2009-2010;
Task 5: Interim, Draft and Final Report	March 2010; February-March 2011

Table 3. Estimated percent cover by plant functional group prior to cactus planting in May 2009 (sites are sorted by percent total non-native cover.

Patch #	Bareground	Burned Cactus	Green Cactus	Native Forb	Native Grass	Non-native Forb	Non-native Grass	Shrub	Total Non-native
Round 11	39	20	0	5	5	0	1	30	1
Round 5	15	35	2	22	5	0	1	20	1
Round 7	22	10	0	10	2	0	1	55	1
Round 6	2	25	3	5	2	1	1	61	2
Round 8	1	50	1		1	1	1	45	2
Round 9	15	20	1	5	1	2	1	55	3
Orchard 3	25	10	15	0	2	1	5	38	6
Orchard 1&10 double	20	25	2	0	0	5	2	47	7
Orchard 2&9 double	27	25	3	0	0	5	5	35	10
Round 1	3	8	1	62	1	2	8	15	10
Siphon 2	15	30	0	1	1	10	0	43	10
Orchard 8	35	20	2	1	1	20	1	20	21
Orchard 5	10	25	1	5	1	18	5	35	23
Round 10	10	30	10	0	5	3	20	22	23
Siphon 1	15	25	0	1	1	30	1	27	31
Orchard 4	15	20	0	5	0	30	5	25	35
Siphon 4	13	30	5	1	1	25	10	15	35
Siphon 5	8	10	0	20	0	10	27	25	37
Orchard 6	41	1	1	1	5	40	1	10	41
Orchard 7	28	5	0	5	1	40	1	20	41
Siphon 3	10	35	0	1	0	48	1	5	49
Limestone 7	5	5	1	35	1	15	35	3	50
Limestone 3	10	5	1	20	4	22	29	5	51
Limestone 4	2	5	2	20	8	26	32	5	58
Limestone 6	5	3	0	20	1	25	39	7	64
Limestone 8	2	3	7	10	3	32	32	8	64
Limestone 9	1	2	1	25	1	10	55	5	65
Limestone 10	0	1	0	25	3	40	26	5	66
Limestone 5	4	1	1	25	0	25	42	2	67
Siphon 6	<5	0	0	20	3	30	37	5	67
Round 2	7	4	1	5	1	7	70	5	77
Round 3	1	2	1	0	1	30	50	15	80
Limestone 1	0	1	1	10	5	7	75	1	82
Limestone 2	0	1	1	10	5	7	75	1	82
Round 4	0	2	5	0	0	46	46	1	92
Shoestring 1&2 double	0	0	0	0	0	40	60	0	100
Shoestring 3&4 double	0	0	1	0	0	40	60	1	100

Table 4. Summary of plantings in addition to initial planting of approximately 350 single cactus .

Patch #	Half site doubled pad # with potted	Potted Transplants	Only initial planting	# Sambucus trees
Limestone 1	Y	-	N	2
Limestone 2	Y	-	N	2
Limestone 3	Y	-	N	2
Limestone 4	Y	-	N	2
Limestone 5	N	4	N	2
Limestone 6	N	4	N	2
Limestone 7	N	3	N	0
Limestone 8	Y	-	N	2
Limestone 9	Y	-	N	2
Limestone 10	Y	-	N	2
Orchard 1 and 10*	N	8	N	4
Orchard 2 and 9*	N	5	N	4
Orchard 3	N	4	N	2
Orchard 4	N	-	Y	2
Orchard 5	N	-	Y	2
Orchard 6	N	-	Y	2
Orchard 7	N	4	N	2
Orchard 8	N	4	N	2
Round 1	N	4	N	2
Round 2	N	4	N	2
Round 3	N	4	N	2
Round 4	-	40	-	2
Round 5	N	-	Y	2
Round 6	Y	-	N	2
Round 7	Y	-	N	2
Round 8	Y	-	N	2
Round 9	N	-	Y	2
Round 10	Y	-	N	2
Shoestring 1 and 2*	N	8	N	4
Shoestring 3 and 4*	N	8	N	4
Siphon 1	N	4	N	2
Siphon 2	N	-	Y	2
Siphon 3	N	4	N	2
Siphon 4	-	40	-	2
Siphon 5	N	4	N	2
Siphon 6	N	4	N	2

*Two patches brought together as a single, large “double patch”, as shown in Figure 5.

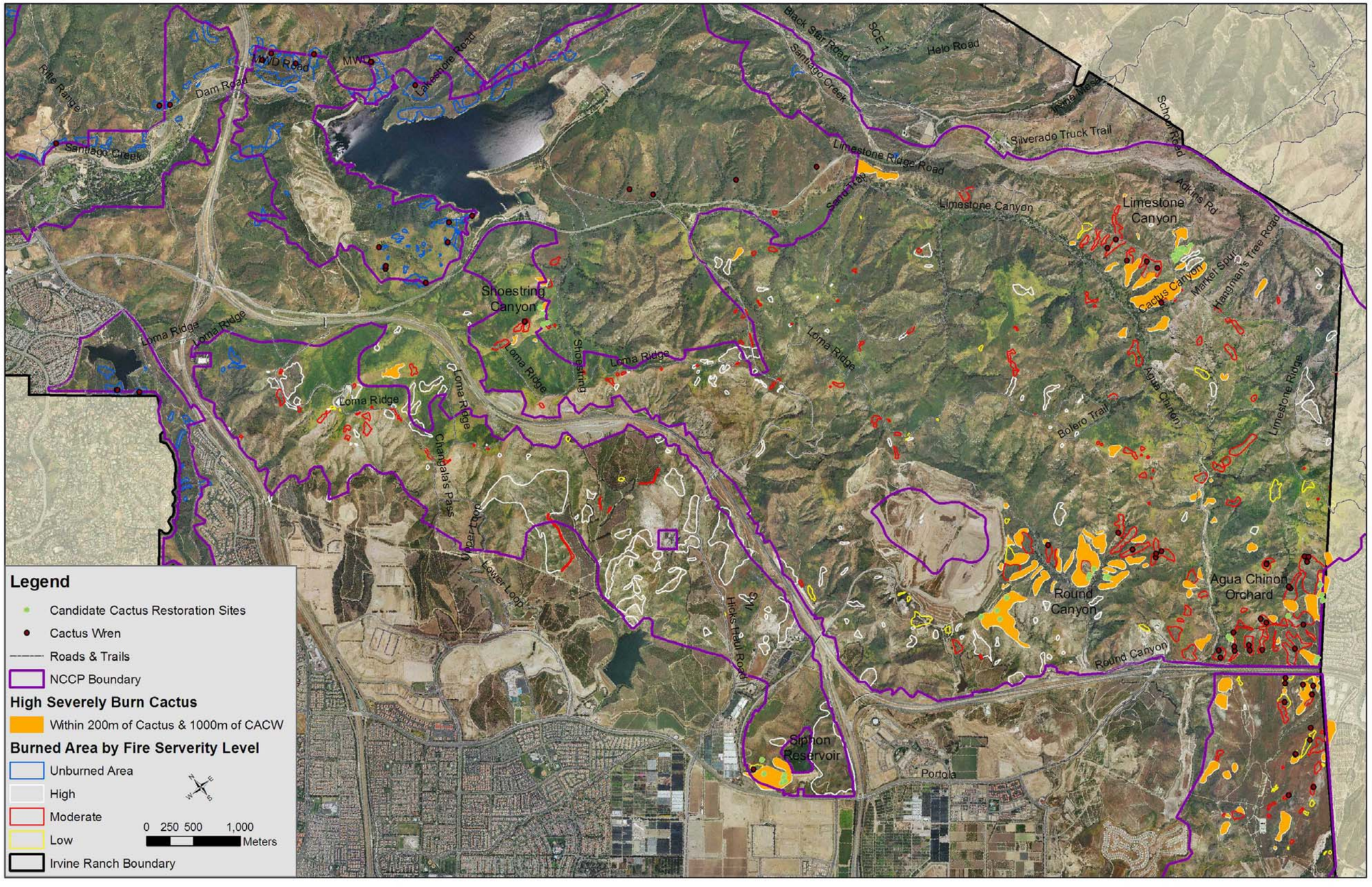
Black Star Road
SCE
Helo Road
Santiago Creek
Rattle Ranger
Dam Road
MWD Road
MWD
Lakestone Road
Santiago Creek
Limestone Ridge Road
Silverado Truck Trail
School Road
Sand Trail
Limestone Canyon
Limestone Canyon
Adkins Rd
Cactus Canyon
Market Spur
Hangman's Tree Road
Shoestring Canyon
Loma Ridge
Loma Ridge
Loma Ridge
Loma Ridge
Loma Ridge
Loma Ridge
Shoestring
Loma Ridge
Changala's Pass
Lower Loop
Lower Loop
Hicks Bull Road
Bolero Trail
Agua Chinon
Limestone Ridge
Round Canyon
Agua Chinon Orchard
Round Canyon
Siphon Reservoir
Portola
Legend
Candidate Cactus Restoration Sites
Cactus Wren
Roads & Trails
NCCP Boundary
High Severely Burn Cactus
Within 200m of Cactus & 1000m of CACW
Burned Area by Fire Serverity Level
Unburned Area
High
Moderate
Low
Irvine Ranch Boundary
0 250 500 1,000
Meters

Figure 2.

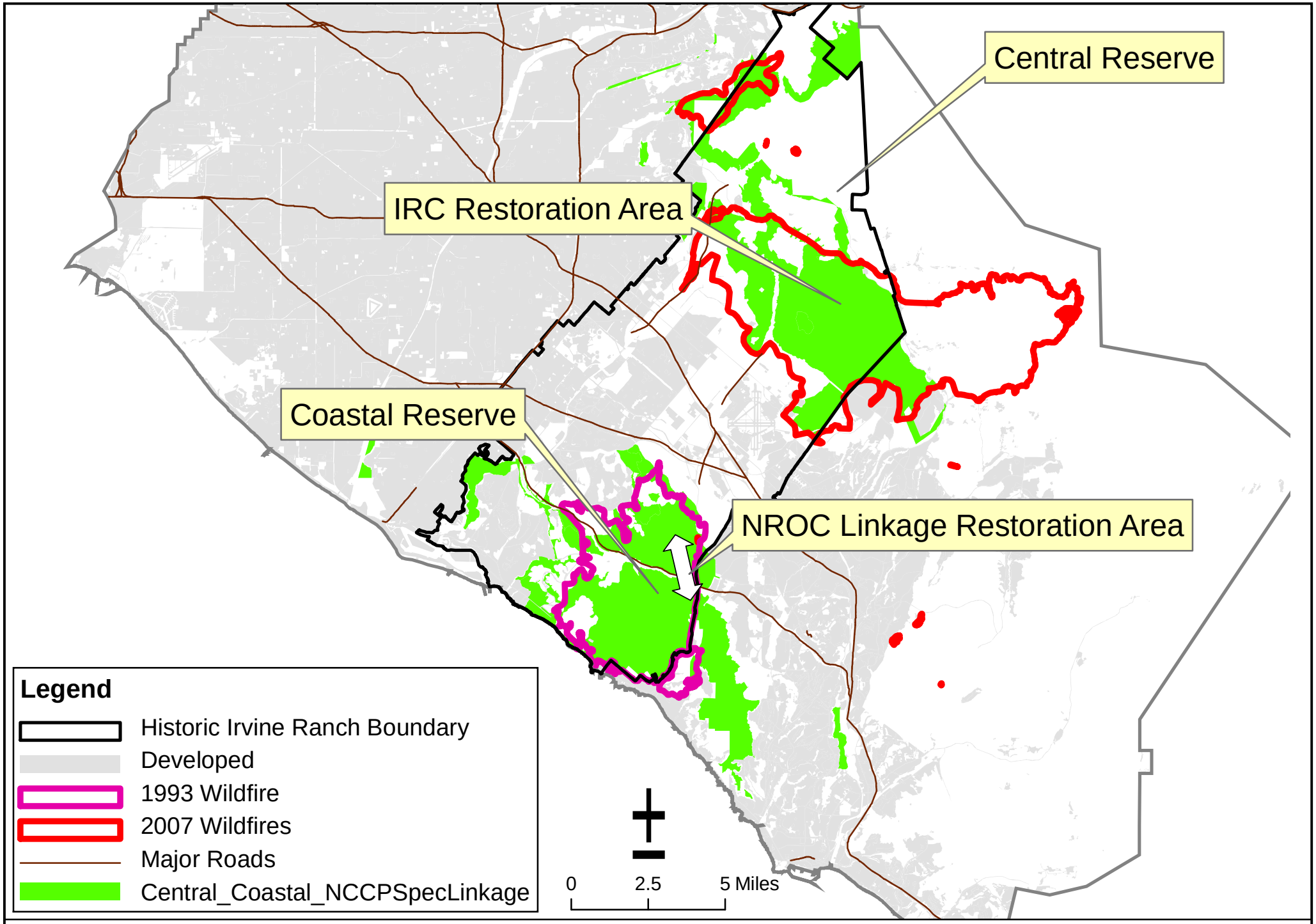

Figure 1. Cactus Scrub Restoration Project Areas and Wildfires in the Orange County Central-Coastal NCCP

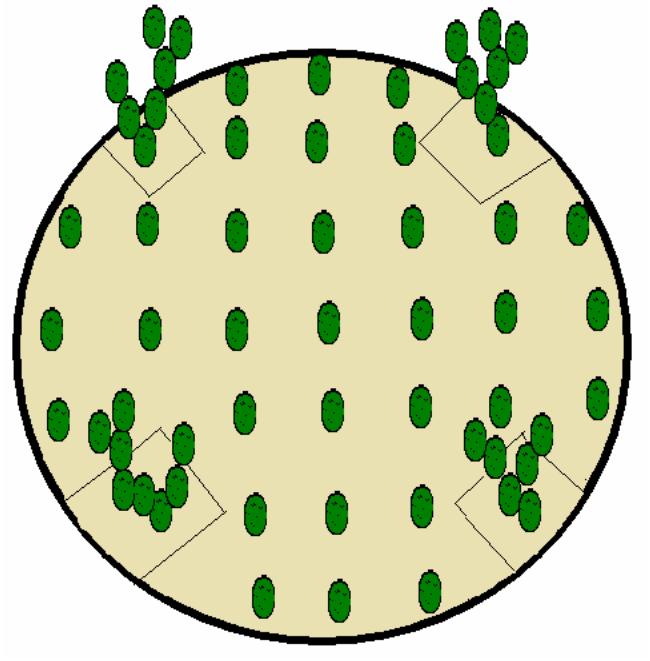

Figure 3: Basic site design: 15m diameter circle; 2 pads/ m^2 (~350 pads/site), 4 potted transplants.

Figure 4: Diagram of a site planted with 21 potted transplants (left), along with planting one of the pots in the field (right).

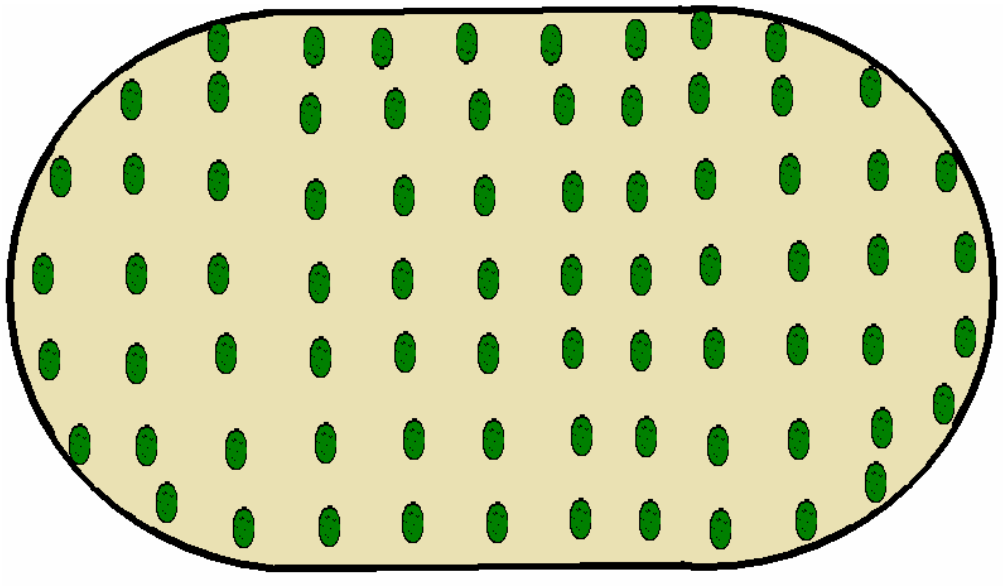

Figure 5: Diagram of a “double site”, exactly doubling the size of the patch and number of planted pads.

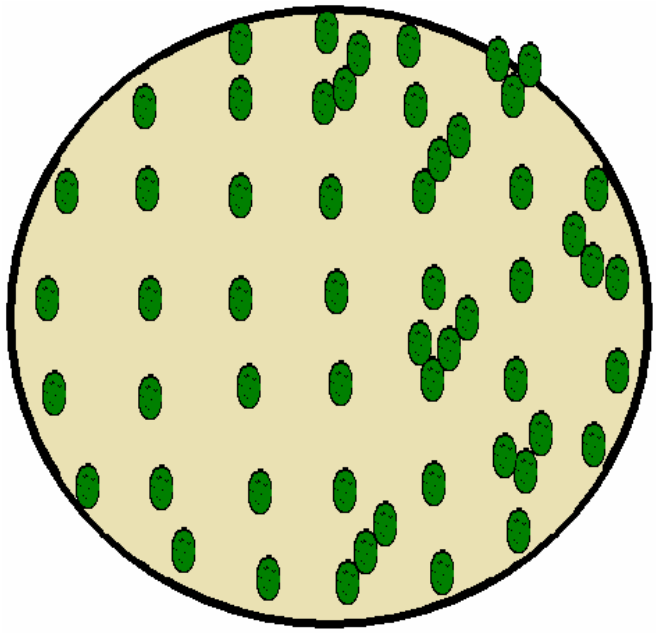

Figure 6: Diagram of a site inaccessible to transplants, but supplemented by additional cactus pads and branches.

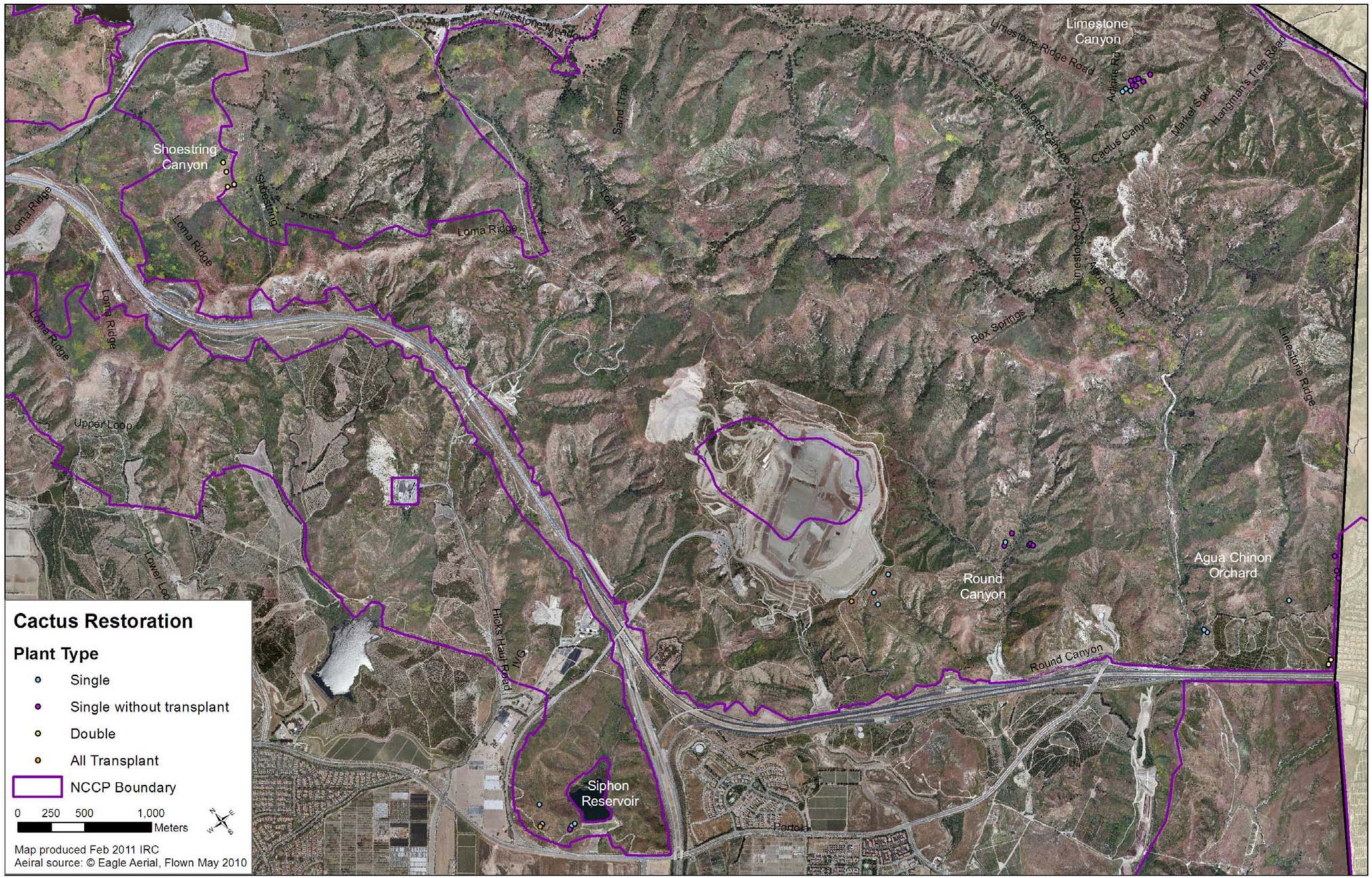
Limestone Canyon
Limestone Ridge Road
Adkins Rd
Hangman's Tree Road
Market Spur
Cactus Canyon
Limestone Canyon
Agua Chinon
Box Springs
Limestone Ridge
Limestone Meander
Sand Trap
Shoestring Canyon
Shoestring
Loma Ridge
Loma Ridge
Loma Ridge
Loma Ridge
Loma Ridge
Loma Ridge
Upper Loop
Lower Loop
Hicks Haul Road
Siphon Reservoir
Portola
Round Canyon
Round Canyon
Agua Chinon Orchard
Cactus Restoration
Plant Type
Single
Single without transplant
Double
All Transplant
NCCP Boundary
0 250 500 1,000
Meters
Map produced Feb 2011 IRC
Aeiral source: © Eagle Aerial, Flown May 2010

Figure 7.

Figure 8: Planting *Sambucus nigra* plants near each cactus patch.

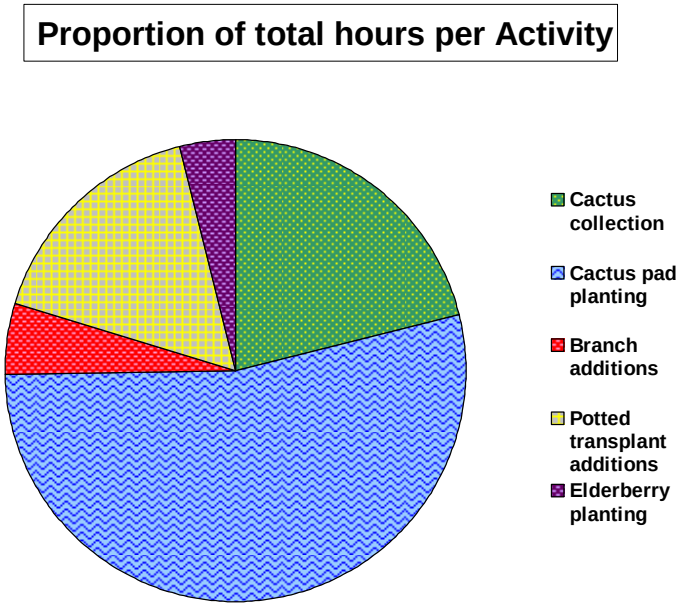

Figure 9.

Figure 10. Site maintenance at a transplant site in the Round Canyon area.

Figure 11. Weeding around the perimeter of each cactus pad.

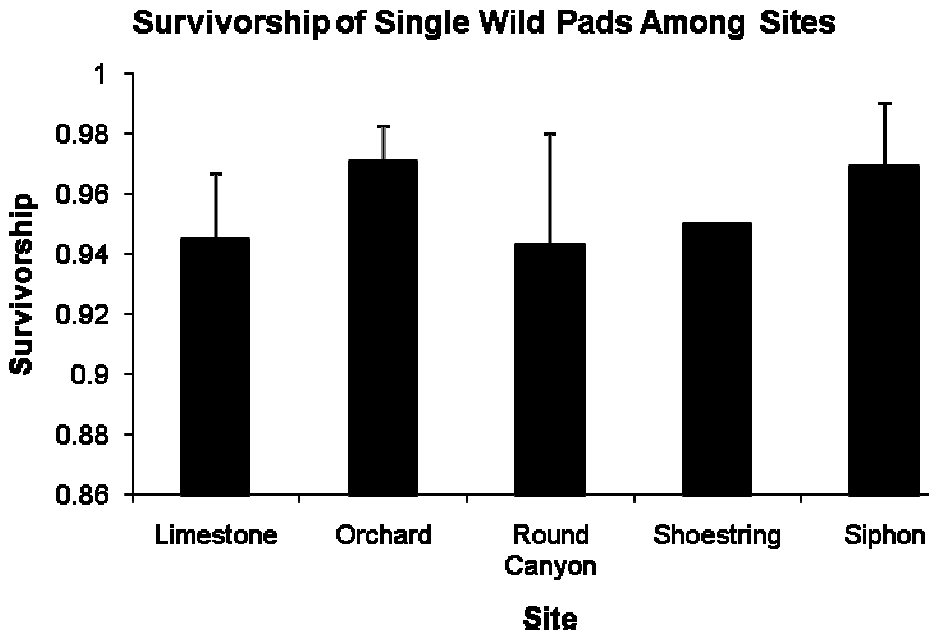

Figure 12.

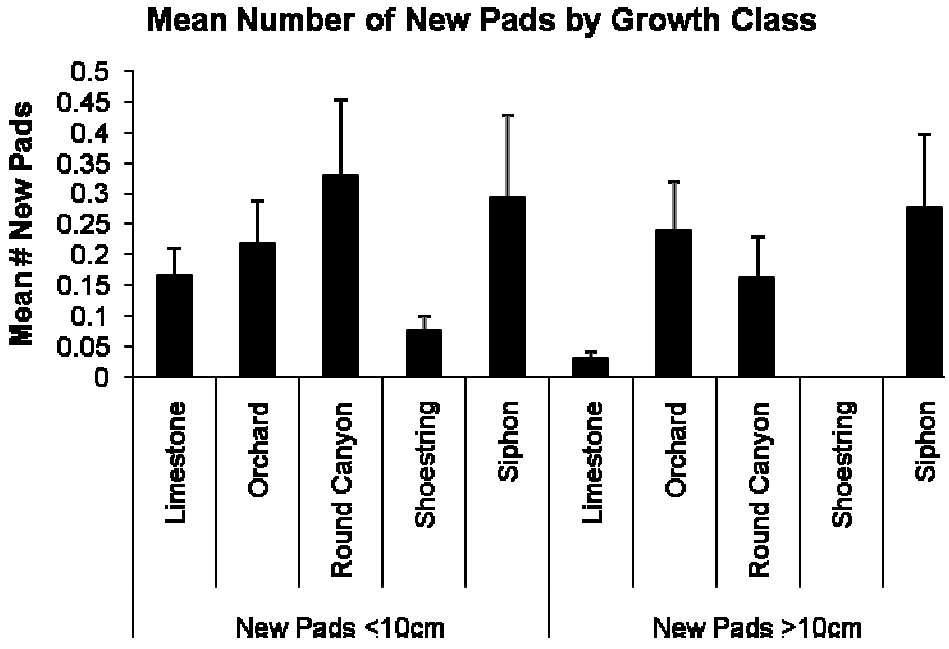

Figure 13.

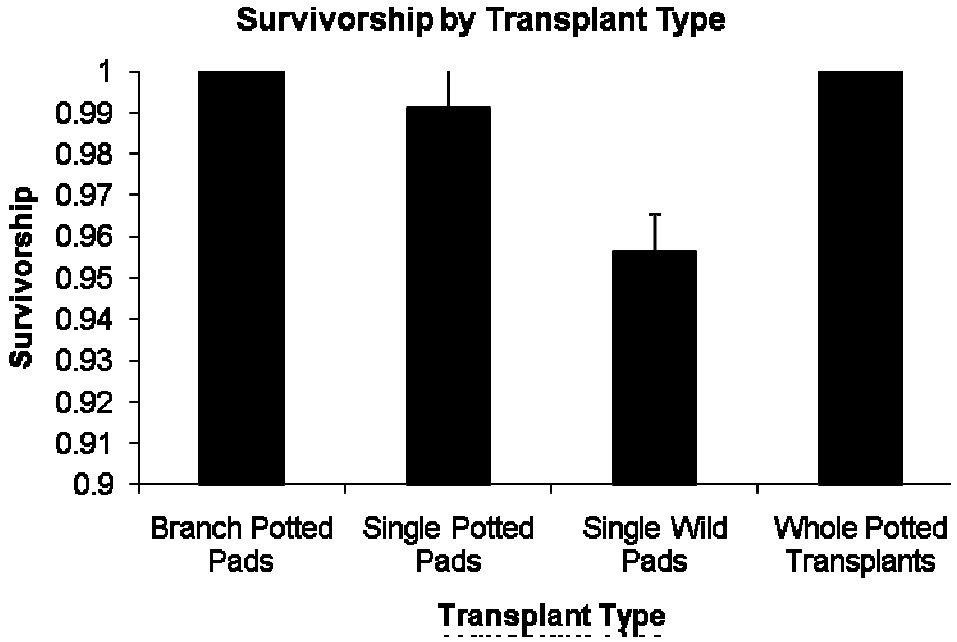

Figure 14.

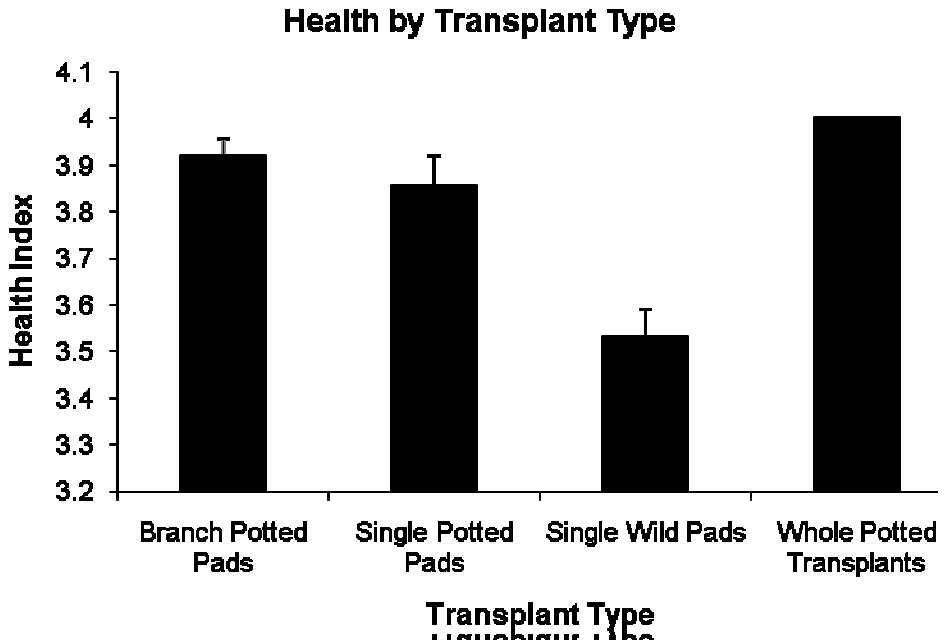

Figure 15.

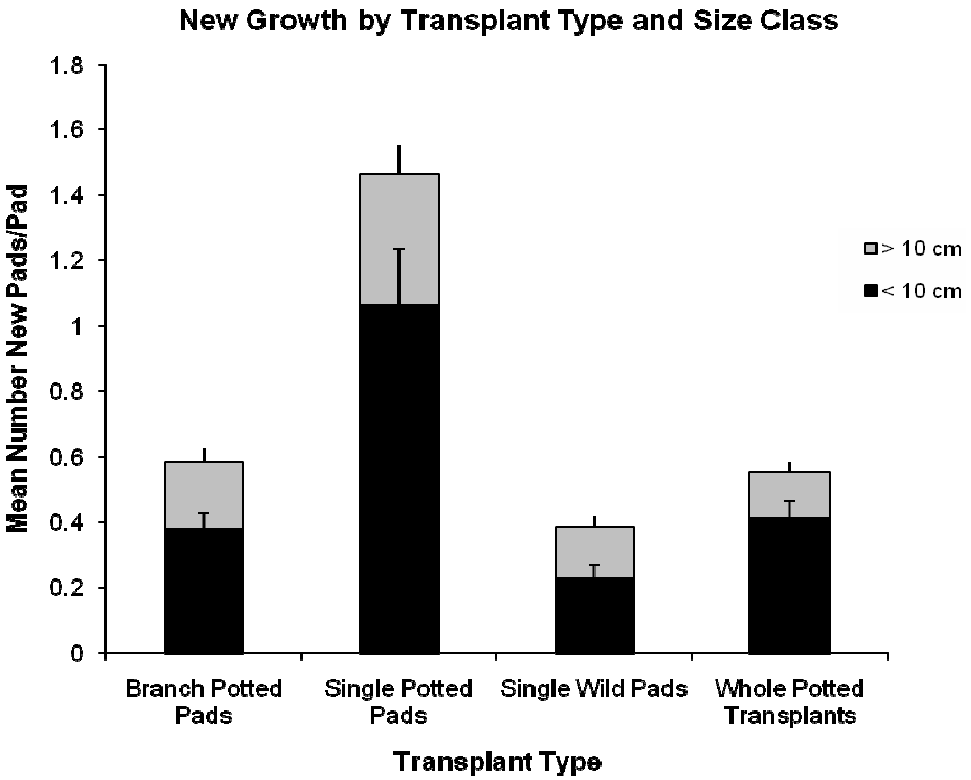
New Growth by Transplant Type and Size Class
Mean Number New Pads/Pad
1.8
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
> 10 cm
< 10 cm
Branch Potted Pads
Single Potted Pads
Single Wild Pads
Whole Potted Transplants
Transplant Type

Figure 16.

Figure 17. Planted cactus among Orchard restoration patches.

Figure 18. Planted cactus among Limestone restoration patches.

Figure 19. Planted cactus among Shoestring restoration patches.

Figure 20. Planted cactus among Round Canyon restoration patches.

Figure 21. Planted cactus among Siphon restoration patches.

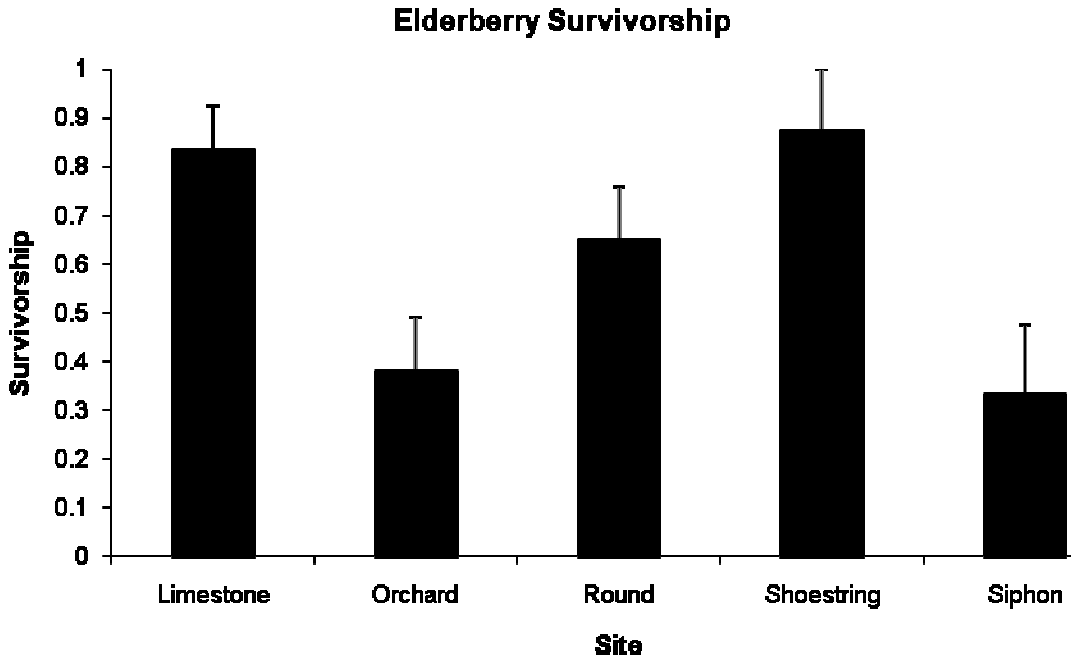

Figure 22.

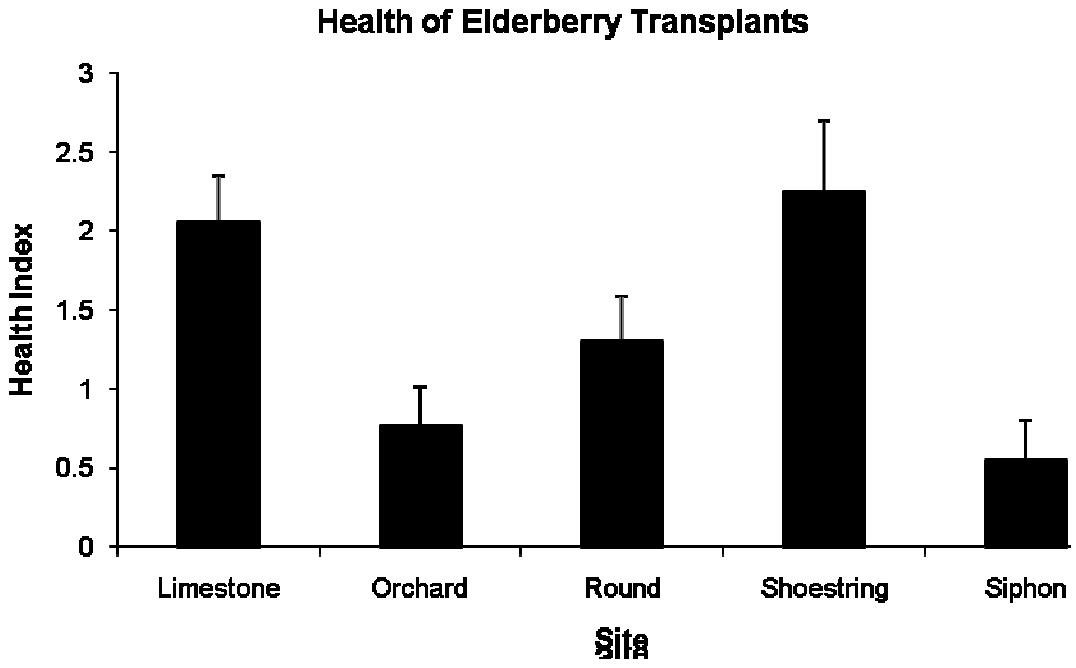

Figure 23.

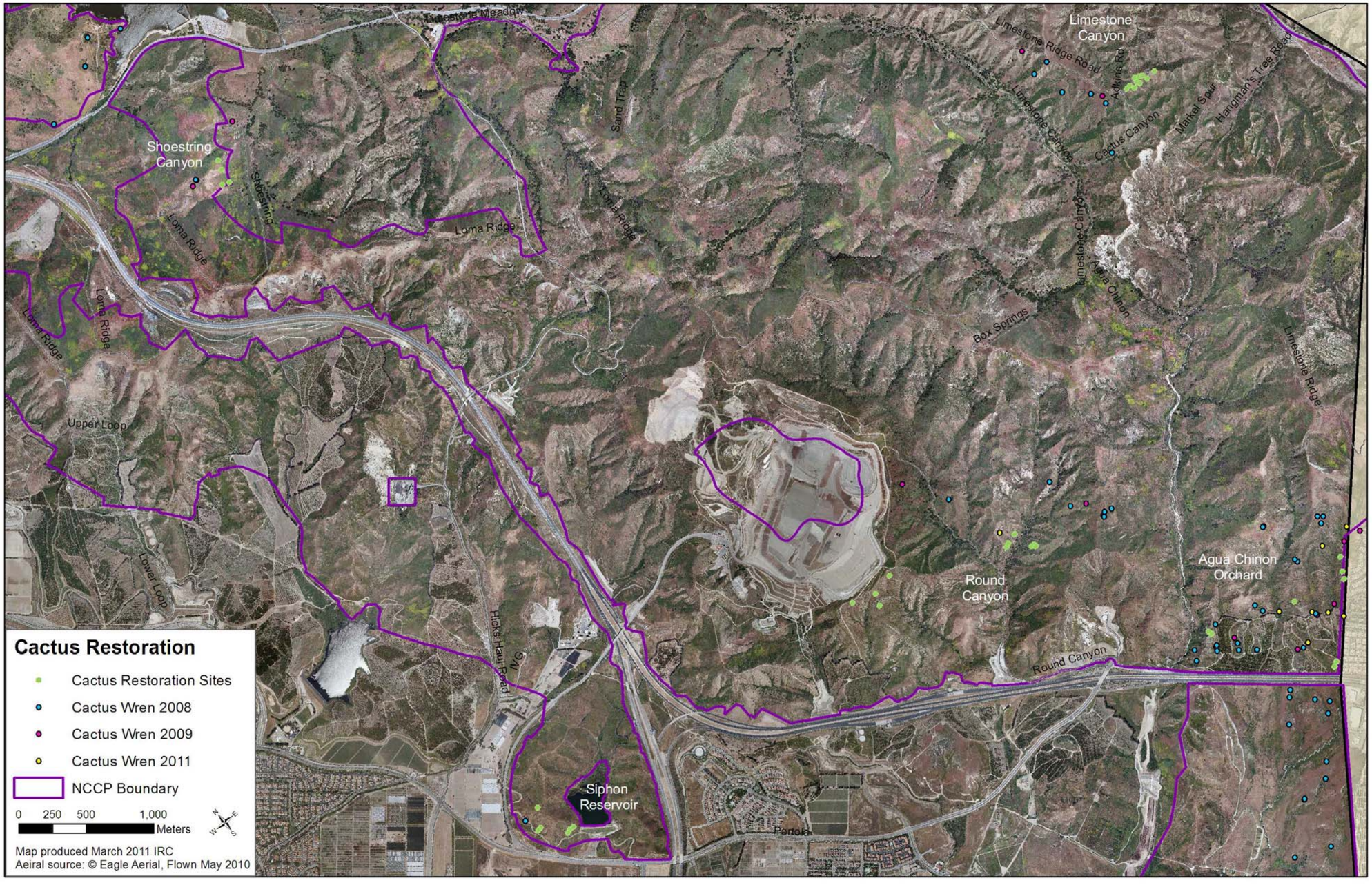
Limestone Meadow
Limestone Canyon
Limestone Ridge Road
Atkins Rd
Limestone Canyon
Cactus Canyon
Market Spur
Hangman's Tree Road
Sand Trap
Shoestring Canyon
Shoestring
Loma Ridge
Loma Ridge
Loma Ridge
Loma Ridge
Loma Ridge
Limestone Canyon
Agua Chinon
Box Spring
Limestone Ridge
Upper Loop
Lower Loop
Hicks Haul Road
SR-60
Siphon Reservoir
Portola
Round Canyon
Round Canyon
Agua Chinon Orchard
Cactus Restoration
Cactus Restoration Sites
Cactus Wren 2008
Cactus Wren 2009
Cactus Wren 2011
NCCP Boundary
0 250 500 1,000
Meters
Map produced March 2011 IRC
Aeiral source: © Eagle Aerial, Flown May 2010

Figure 24.

Post-Burn Restoration of Nesting Habitat for the Coastal Cactus Wren in the Orange County Central Reserve: Restoration Plan 2009

Prepared by:

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September 2009

TABLE OF CONTENTS

BACKGROUND

The coastal Cactus Wren (*Campylorhynchus brunneicapillus sandiegense/anothonyi*) occurs in coastal southern California in a distinct sub-type of coastal sage scrub, southern cactus scrub, defined as having greater than 20% cover of cactus species *Opuntia littoralis* (coastal prickly pear), *Cylindropuntia prolifera* (coastal cholla), and *Opuntia oricola* (oracle cactus). For more than two decades, coastal cactus wren populations have been declining rapidly, likely because of habitat loss and fragmentation due to urban and agricultural development and large-scale fire events (Mitrovitch and Hamilton 2006). The coastal Cactus Wren is a California species of special concern and one of three target species in the Central-Coastal Orange County Natural Community Conservation Plan (Orange County NCCP).

The Orange County NCCP is divided into a Coastal Reserve (~17,000 acres) and a Central Reserve (~20,000 acres). The Nature Reserve of Orange County (NROC) is responsible for implementing the Orange County NCCP and coordinating management activities throughout the Reserve, while the Irvine Ranch Conservancy (IRC) is responsible for managing 11,220 acres in the Central Reserve and 3,146 acres in the Coastal Reserve. Within the Orange County NCCP, most of the Coastal Reserve burned in the 1993 Laguna fires. A study of the Coastal Reserve indicated approximately 1,473 acres of cactus scrub occupied by Cactus Wren in 1992, and only 187 acres occupied in 2006. In 2006, an estimated 58% of burned cactus scrub had not sufficiently recovered to be suitable for Cactus Wren occupancy (Mitrovitch and Hamilton 2006). In 2007, the Windy Ridge and Santiago Fires burned much of the Central Reserve, leaving little mature cactus scrub habitat for breeding Cactus Wrens. A study of the Central Reserve in 2008 estimated approximately 1,855 acres of cactus scrub prior to the 2007 fires, of which 1,059 were determined to have severe fire damage (Leatherman 2009).

Based on habitat suitability models, Mitrovitch and Hamilton (2006) found that high quality cactus scrub (relative to patch size), and the combination of high quality cactus scrub with the presence of *Sambucus mexicana* were the strongest correlates of their highest ranking model for Cactus Wren occupancy. Their criteria for the highest quality habitat consisted of >20% cover of mature cactus in a contiguous acre, generally greater than 1 m tall. In 2009, consulting biologist Robert Hamilton, along with the Conservation Biology Institute and The Nature Conservancy summarized existing information on the coastal Cactus Wren for a presentation on restoration guidelines to a Cactus Wren working group. Information presented on habitat characteristics suitable for coastal Cactus Wren included: 1) spacing of suitable cactus scrub habitat no greater than 1.5 km to facilitate dispersal by juvenile Cactus Wren, 2) high quality cactus scrub 2-3 acres in size to support a nesting pair, 3) minimum cactus patch size of 15 m^2, with *O. littoralis/oricola* planted at approximately 2 cladodes/m^2 (more for *C. prolifera*), and 4) the presence of some/all of the following plant species: *S. mexicana, Artemisia californica,* and *Eriogonum fasiculatum* on the perimeters of cactus patches.

O. littoralis, O. oricola, and *C. prolifera* all occur in the Central Reserve, however, *O. littoralis* accounts for the large majority of the cactus populations (personal observation, Roberts 2008). *O. littoralis* and *O. oricola* tend to be found on sandy and gravelly soils, on a variety of slopes, and in disturbed areas in grasslands or coastal sage scrub. They are not considered good competitors for light, becoming overgrown in shrub communities of taller stature (such as chaparral) and failing to establish well among undisturbed grasses. Therefore, their distribution in sandy or gravelly soil, southern aspects, and areas of disturbance may be an artifact of decreased competition from other plants, in addition to preferences for particular physical characteristics in these environments (Benson 1969, Edward Bobich, Cal Poly Pomona, personnal comm.). Based on an overlay of cactus scrub mapped after the Santiago Fire in the Central Orange County Reserve (Leatherman et. al 2008) and the soil series digital map (Natural Resources Conservation Service 2008) for this area, cactus scrub occurs on a variety of soil types (Table 1).

In the Central Reserve, the majority of cactus populations occur along Lomas Ridge, all of which burned to some degree in the 2007 Santiago Fire (Leatherman et. al 2008). Due to the large-scale loss of habitat, the relatively slow growth of cactus, and current decline in Cactus Wren populations, restoration of remaining degraded cactus scrub patches is critical. The IRC and NROC are both developing cactus restoration plans; one for the Central Reserve, and one for the Coastal Reserve, respectively (Figure 1). NROC will focus on initiating restoration of a linkage between southern and northern populations of cactus wren within the Coastal Reserve. These populations were isolated by the loss of cactus scrub in the 1993 Laguna Fire. IRC will focus on restoring patches of cactus scrub in the recently burned areas of the Central Reserve, concentrating on augmenting habitat for remaining Cactus Wrens and providing linkages between extant populations (Figure 1). This restoration plan discusses and outlines restoration activities to be performed by the IRC in the Central Reserve, with the following objectives:

1) Prioritize restoration sites within burned cactus scrub habitat using criteria that maximize benefit to Cactus Wrens.
2) Design a restoration approach utilizing techniques that: a) enhance the availability of nesting habitat for Cactus Wren, b) balance the benefits of abundant sites and rapid structure, and c) create habitat that will be resilient in the face of future fires.
3) Develop a monitoring protocol including standardized techniques.

METHODS

Objective 1. Prioritize restoration sites within burned cactus scrub habitat using criteria that maximize benefit to Cactus Wrens.

The Central Reserve Habitat Assessment and Survey (Leatherman et al. 2008) included data that categorized cactus populations by burn severity and recorded the distribution of Cactus Wrens in the Central Reserve. Utilizing the GIS data from this survey, the IRC developed criteria for priority restoration sites and developed a map of severely burned cactus populations of priority for restoration (Figure 2). The criteria were developed based on the desire to ensure areas of sufficient size to support Cactus Wren and to ensure opportunities for dispersal (see restoration recommendations to the Cactus Wren working group above). Polygons with severely burned populations of cactus were prioritized for potential restoration if they were located:

1) Within 200 m of cactus that was not considered severely burned in the Leatherman et al. (2008) survey, AND
2) Within 1000 m of a Cactus Wren territory

In addition, polygons meeting these criteria that were in areas with multiple Cactus Wren pairs were preferred, with the following exceptions: 1) the polygons had potential to serve as a linkage between Cactus Wren populations (Shoestring Canyon pair), or 2) a single pair seemed threatened by a lack of suitable habitat in the larger area (Siphon Reservoir pair).

In May 2009, priority polygons were visited in each area to ground truth the status of cactus populations and assess conditions for restoration potential at the patch level, including surveys for sensitive plants. In addition, cactus and Cactus Wren surveys were conducted for the easement lands in the Shoestring Canyon area not covered in the Leatherman et al. (2008) survey.

While visiting potential cactus restoration polygons several factors appeared important in considering the potential of the site for restoration: 1) Based on the existing cactus in the polygon, would planting cactus significantly contribute to the recovery of cactus in the area? Polygons that had sufficient cactus that showed signs of vigorous regrowth were disqualified, for example, several polygons in Weir Canyon; and 2) Is there an area large enough given our minimum restoration patch size (see below) to accommodate cactus planting that would not either displace an existing native community, or result in eventual displacement of planted cactus as a result of shrub regrowth post-fire (Figure 3)? For most of the visited polygons, the majority of the area was composed of burned intact scrub. Therefore, while we wanted to cluster our restoration patches, our selected sites were somewhat dispersed, as opposed to occurring on only a few polygons. Sites also varied in the extent of weeds. As mentioned above, most polygons consisted of burned coastal sage scrub with scattered individual cacti, although some areas consisted of annual grassland with scattered cacti. No candidate polygons consisted of large, contiguous extents of burned cactus, perhaps because these areas are less common in the Lomas Ridge region and were less likely to have burned severely, and therefore did not come up as a qualifying polygon for restoration.

A total of 40 candidate sites were selected in five regions (Shoestring Canyon, Siphon Reservoir, Round Canyon, Limestone Ridge, and the Agua Chinon Orchard (Figure 4). In June and July 2009, visits were made to verify the 2008 locations of Cactus Wren in each area by consulting biologist Rob Hamilton (Shoestring Canyon, Round Canyon, Limestone Ridge, and the Agua Chinon Orchard) and IRC staff member Susan Anon (Siphon Reservoir). Based on these visits, the minimum distance of restoration sites from moderately-unburned cactus was changed from 100 m to 200 m (as stated above) because some candidate sites in Round Canyon (4), Limestone Ridge (10), and Shoestring (4) were determined by Rob Hamilton to adequately support the existing Cactus Wren. We moved sites to nearby locations in greater need of supplemental cactus and with greater potential to support future fledglings from the core habitat area. Site assessments of these new areas were finalized in August 2009 and include information pertinent to restoration, such as extent of non-native species cover, burned and unburned cactus cover, slope, aspect, accessibility, and native species present. In addition to the site assessments described above, all sites were overlaid with sensitive and rare plant GPS locations based on surveys in the Limestone and Lomas regions in the last 10 years (Roberts 1999, 2000; 2008). Sites where sensitive species were found either through the site assessment or GIS data were moved.

Objective 2: Design a restoration approach utilizing techniques that: a) enhance the availability of nesting habitat for Cactus Wren, b) balance the benefits of abundant sites and rapid structure, and c) create habitat that will be resilient in the face of future fires.

Site Design

Although the exact cause for the recent rapid decline of Cactus Wren is not known, loss of suitable nesting habitat is likely to have played a significant role (Mitrovitch and Hamilton 2006). For this reason, and because we are augmenting burned cactus scrub habitat, our restoration approach is to concentrate our resources on maximizing the amount of cactus planted vs. cactus scrub as a whole plant community. With respect to the composition among cactus species, *O. oricola* is the preferred species because it has a taller stature and Cactus Wren tend to nest in cactus greater than 1 m. It proved to be very difficult to find sufficient numbers of individuals of this species growing in the wildlands in our region, however, and therefore the majority of our plants will consist of *O. littoralis.* However many *O. oricola* pads we are able to collect will be planted at single sites to the most extent possible.

The fastest way to restore nesting habitat for Cactus Wren would be to transplant mature, multi-stemmed individuals and irrigate them, however, the availability of large, mature plants is limited and this would be the most costly approach to establishing cactus. Given a limited budget, we thought it would be preferable to cover more area planting cladodes (cactus pads, or joints), with a few scattered larger transplants for some vertical structure. In addition, the IRC has been developing artificial structures as alternative nesting sites to cactus for the Cactus Wrens. Structures constructed based on the second model design will be installed in approximately 10 of the 40 restoration sites (Figure 5).

We define a restoration site (or patch) as a 15 m diameter circular area where cactus will be planted at 2-2.5 cladodes/m^2 (see restoration guidelines cited above). We considered this size to be the minimum area where a fire burning through the ecosystem might be interrupted from burning the interior of the patch, ensuring some level of resiliency and continued function of the patch after the fire. Based on the density of planting, we approximate that it could take up to 10 years for the patch to fill in with cactus, yet this is within the range of a fairly frequent fire return interval for the region, so we don't anticipate destruction of the patch as a result of fire. As mentioned above, restoration patches are clustered into regions (Figure 4) and augment habitat, so the total area of available habitat in any region is greater than 1 ac. Exceptions may be part of Round Canyon just below the Bowerman Landfill and Siphon Reservoir, but we selected these areas in part to provide connectivity. We will also plant four double patches and several areas consist of patches less than 50 m apart.

Each 15 m diameter patch will require approximately 400 *Opuntia* cladodes with approximately 175 square meters per patch. Therefore, across 40 patches, we will be planting a total of approximately 16,000 cladodes. With the exception of patches with difficult access, four 2-year-old *O. littoralis* transplants in 5 ga pots will be planted in each patch to provide some immediate vertical structure. In addition, two 1 ga *Sambucus mexicana* transplants will be planted on the perimeter of each patch (planting them within the interior can increase the risk of ignition within the interior of a cactus patch in the event of a fire). Transplants left over from sites that were too difficult to access (approximately 15 sites, accounting for about 60 transplants) will be planted within a single site on 2 m centers that is easily accessible. A site from either the Round Canyon or Siphon Reservoir area (Figure 4) will be selected because these areas consist of more isolated Cactus Wren pairs and cactus habitat.

Implementation and Maintenance

During September and October, site preparation will consist of removing non-native thatch at sites with greater than 60% non-native cover because the non-native grasses and forbs (primarily *Brassica nigra*) comprising these groups have either dense or tall vegetation that will make spot treating their seedlings more difficult and planting cumbersome. Almost half of the selected sites fall into this category based on site assessment data. During November, cladodes will be planted across all sites, leaving sufficient room for cactus transplants to be planted. Cladodes that drop from transplants during planting will be used to fill in area around the transplant not meeting the prescribed density. Cladodes will be planted on their sides or vertically to a depth that secures the cladode in the ground (approximately 5 cm). Additionally, some cladodes may be planted in sets of 2 or 3 to see if this facilitates their survival or growth rate compared to single cladodes. At the time of planting, the immediate area around each cladode/plant (~30 cm) will be cleared across all sites. After sufficient rain to moisten the soil (likely January), transplants will be planted across sites, cactus transplants within the patch and *S. mexicana* transplants on the perimeter.

In January or February 2010, sites will be checked for weed growth. The timing of this check is scheduled to be early in the growing season when weed growth has not yet covered planted cladodes, facilitating the location and clearance around the vicinity of each cladode

with either hoes or weed wipers. An additional spot treatment of non-native species will be conducted during the same time of year in 2011. Based on monitoring results from June of 2010 (see monitoring methodology below), sites under 75% establishment success will be supplemented with cactus cladodes across sites during the fall and winter of 2010-2011.

Our weeding approach is based on the experience and results of a cactus restoration pilot study conducted by the IRC during the 2008-2009 growing season (Figure 6). Questions included a comparison of the growth and survival of planted cactus cladodes at two weed control levels (weed treatment) and between cactus scrub and non-native grassland post burn communities (position treatment). The results included an average 90% survival rate of planted *O. littoralis* cladodes, and no effect of weeding or position on survival or growth of cladodes.

Plant materials

The IRC has selected sites and developed protocols on where and how to harvest cactus cladodes based on criteria that avoid significant harm to individual cactus plants and disturbance to Cactus Wrens. These criteria include:

1) Collection restricted to non-NCCP lands, preferably in development project areas.
2) Collection restricted to non-breeding periods of Cactus Wren.
3) Collection of cladodes not to exceed 5% of any given square meter of cactus (equals approximately 7 cladodes/m^2 based on several counts of total cladodes/m^2)
4) Collection restricted to sites with the lowest density of Cactus Wrens in the region (either no or a single pair in the larger collection area).
5) No plant < 1 m^2
6) No plant < 2/3 green
7) No cladode < 14 x 7 cm
8) No cladode off top of plant, preferably stray cladodes and branches protruding from bottom of plant.

These criteria were discussed with both Rob Hamilton with Hamilton Biological, an ornithologist who has specialized in the study of Coastal Cactus Wren and with Edward Bobich with California State Polytechnic University Pomona, a plant biologist who has specialized in the study of cactus. Both experts felt that cactus collection in the manner detailed above would not cause significant detriment to the wrens or the cactus.

Several areas were visited to survey their potential for adequate and accessible collection of cactus, as well as the presence of Cactus Wrens. As mentioned earlier, most areas contained relatively few plants of the species *O. oricola*, but an effort will be made to collect cladodes of this species in the manner detailed above. Figure 7 shows selected areas for cactus collection. For each area, estimates were made of the number of harvestable square meters (referring to both plant health and accessibility). This number was multiplied by the estimated number of cladodes per square meter (see criteria above). The estimated number of cladodes for each area is as follows: Portola Orchard: 8000 cladodes; East Orange: 3000 cladodes; Gypsum Canyon: 5000 cladodes.

Objective 3: Develop a monitoring protocol including standardized techniques.

Because both the NROC and the IRC are implementing cactus restoration projects in the Orange County NCCP, we've agreed to include standardized monitoring techniques to allow for comparisons across regions.
Monitoring will include measurements that can track both short term establishment success as well as long term growth. Short term monitoring will occur in late spring (May or June) the first two years. Long term monitoring will occur in the late spring years 5, and 10.

Short term monitoring of establishment success will include: 1) survival per cladode based on random selection and marking of approximately 30 cladodes per patch, and 2) growth per cladode based on the number of new joints for the same randomly selected and marked cladodes.

NROC and IRC have agreed to base our long term monitoring measurements on methodologies discussed in Deutchman (2009). Due to the large number, but smaller size of the sites the IRC be restoring, we chose to use half the transect length specified in Deutchman (2009). Changes in cactus growth will be measured by marking the origin of a patch center with rebar and PVC and running a 25 m transect centered on the origin in a random direction. A total of 5 1x1 meter quadrats will be evenly spaced, on the right side of the transect. The 0 point will always start at the lower point on the slope and start and end points will be marked with 1 ft PVC. For each quadrat, the following will be recorded: 1) the percent cover of cactus, native grass, native forb, non-native grass, and non-native forb, 2) cover of all native species, and 3) list of non-native dominants (>20%). Point intercept data will be recorded every meter. Deutchman (2009) concludes that the point intercept method and quadrat method have similar results for cover estimates, with less time required for the point intercept method. The quadrats, however, better estimate uncommon species. Because our goal is primarily to track cover of the cactus, if we are limited on time and find the methods comparable after the first year, we may resort to using only the intercept method.

Post planting surveys for Cactus Wren will be February-March 2011 (year 2 of cactus growth), and years 5 and 10. During these surveys, playbacks of cactus wren calls will not be used, in order to minimize potential harassment of wrens and to ensure that estimates of site occupancy are not skewed by short-term movement to a restoration site in response to a call. A minimum of 1 morning visit over at least 1 hour will be used to determine use.

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TABLE AND FIGURES

Table 1. Soil series type and number of mapped polygons containing cactus scrub within. Data obtained from Leatherman et. al 2008 and NRCS 2008.

SOIL SERIES	NUMBER OF MAPPED CACTUS SCRUB POLYGONS
ALO CLAY	38
ANAHEIM CLAY LOAM	30
ANAHEIM LOAM	10
BALCOM CLAY LOAM	36
BOSANKO CLAY	22
CALLEGUAS CLAY LOAM	31
CAPISTRANO SANDY LOAM	25
CIENEBA SANDY LOAM	42
CIENEBA-ROCK OUTCROP COMPLEX	9
GABINO GRAVELLY CLAY LOAM	5
MYFORD SANDY LOAM	39
ROCK OUTCROP-CIENEBA COMPLEX	15
SOPER COBBLY LOAM	11
SOPER GRAVELLY LOAM	19
SOPER LOAM	16
YORBA GRAVELLY SANDY LOAM	4
BOSANKO-BALCOM COMPLEX	6

Figure 1. see attachment.

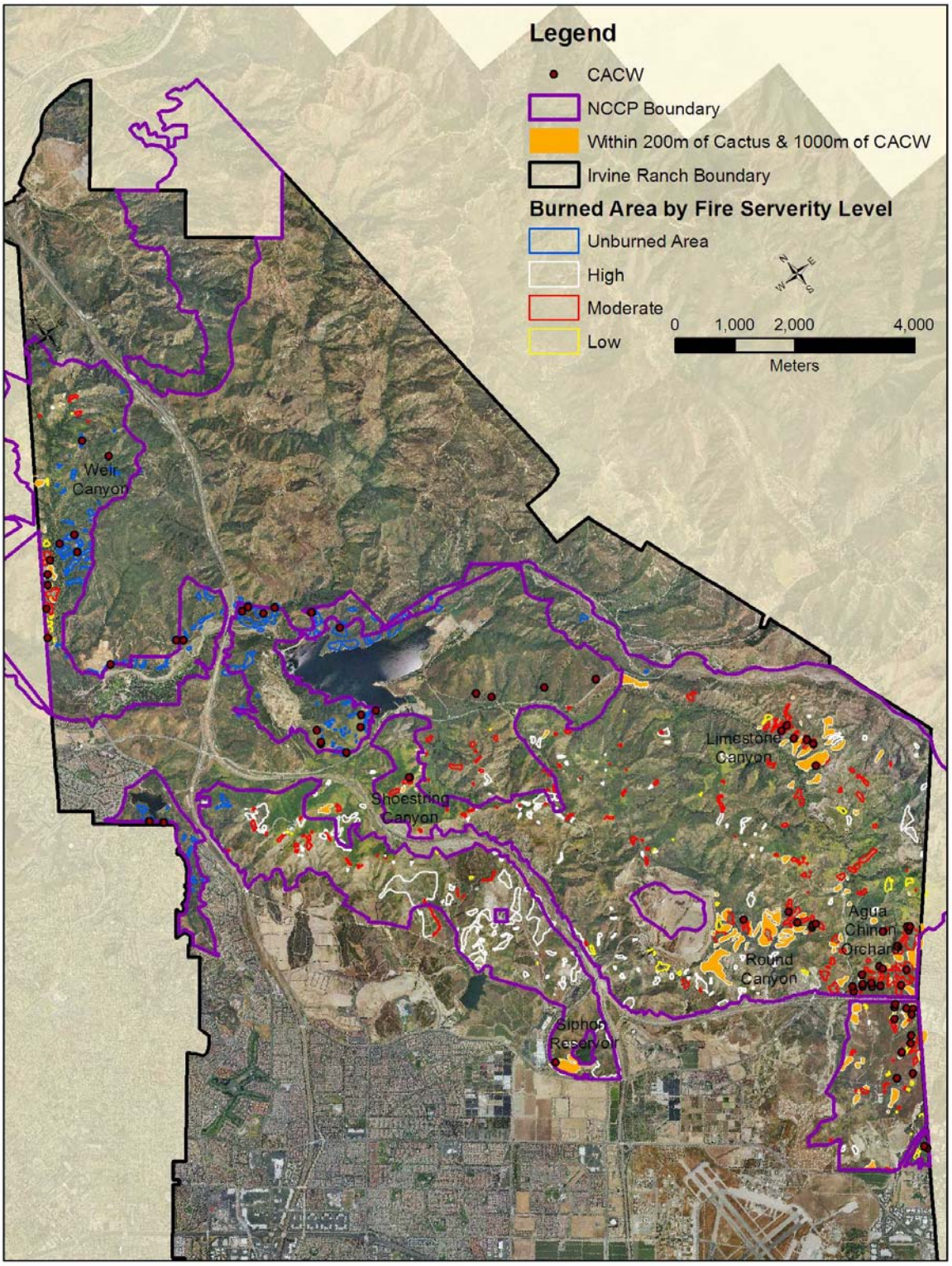


Figure 2. Priority cactus scrub polygons (orange) based on distance criteria from Cactus Wren locations and moderate, low, and unburned scrub polygons.

A.

B.

C.

Figure 3. Examples of the variety of cactus scrub environments encountered while ground truthing potential restoration polygons (Figure 2): A. Shrub cover too dense for cactus planting; B. Optimal hillside with nearby unburned cactus and native cover of early successional species with bareground; C. Burned cactus among weedy *Brassica nigra*.

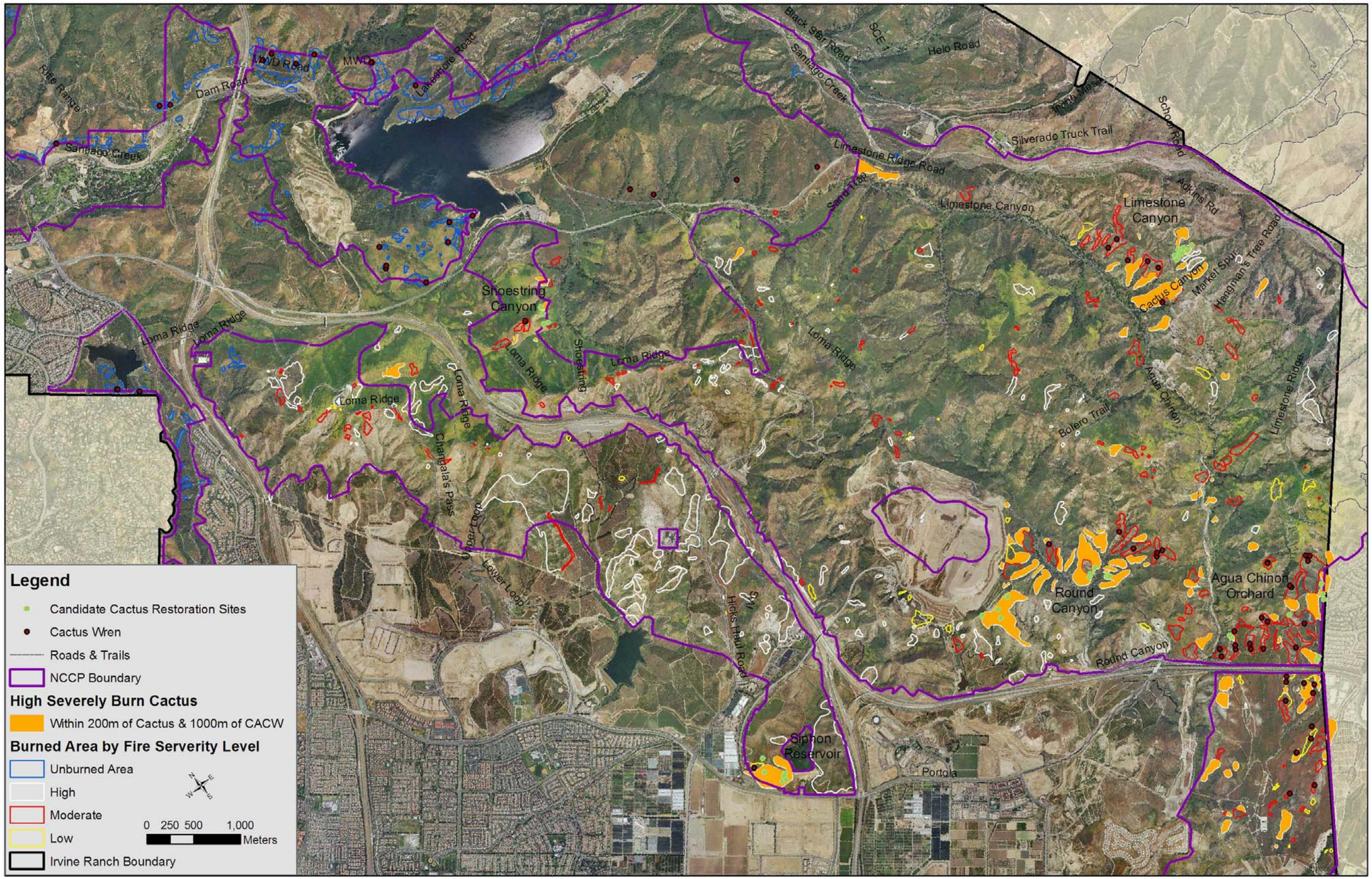
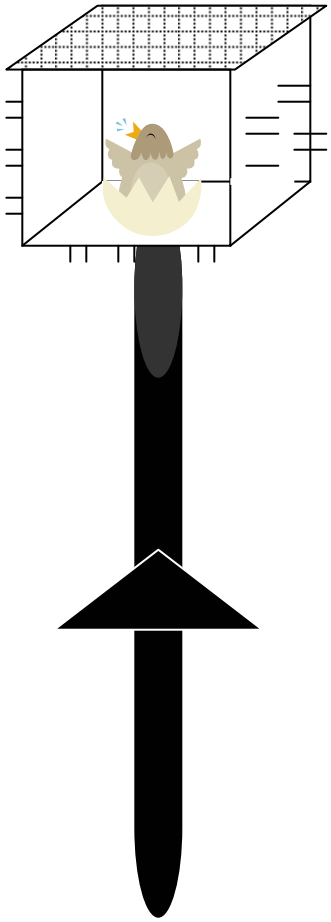


Figure 4. Selected restoration sites (green) determined by ground truthing priority polygons for plant environment and location of Cactus Wren in 2009.

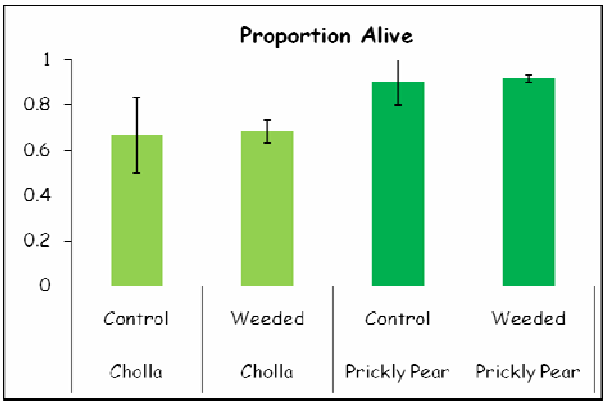


A.

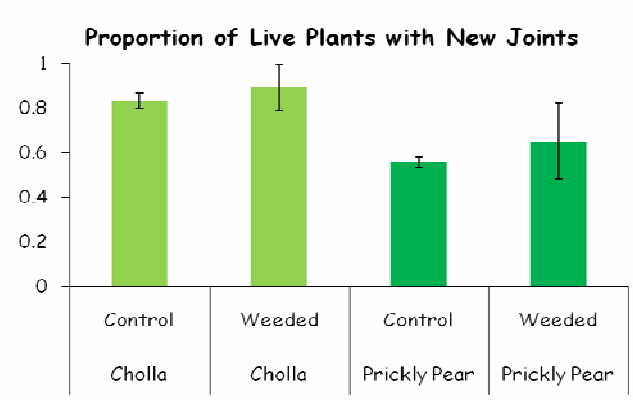
B.

C.

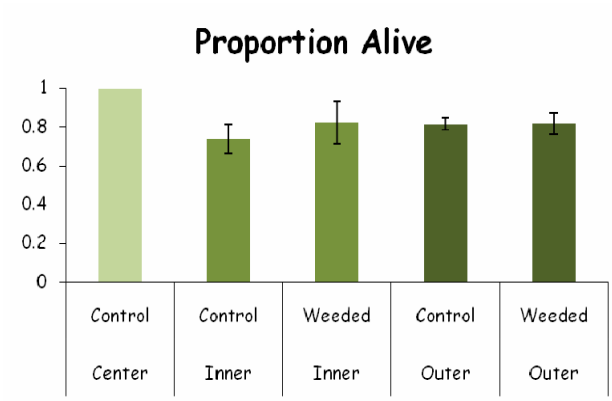
Figure 5. Basic diagram of modified artificial nest structure (A), cladode planting (B), and cactus transplants (C).



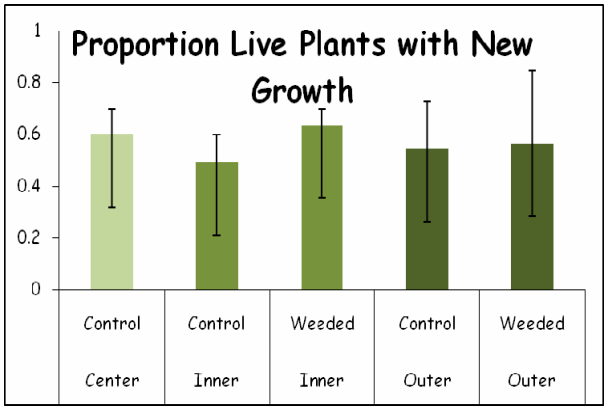
A.



B.



C.



D.

Figure 6. First year measurements of planted cladodes in IRC 2009 pilot studies in unburned (A and B) and one year post-burn (C and D) sites. For all sites, cladodes were cleared of weeds at the time of planting (January), yet half the cladodes received a second weeding in the early spring (Weeded), whereas the other half did not (Control). In addition, at the post-burn sites, cladodes were either planted inside intact cactus scrub habitat (Inner), outside intact habitat in weed patches (Outer), or within a burned cactus plant (Center).

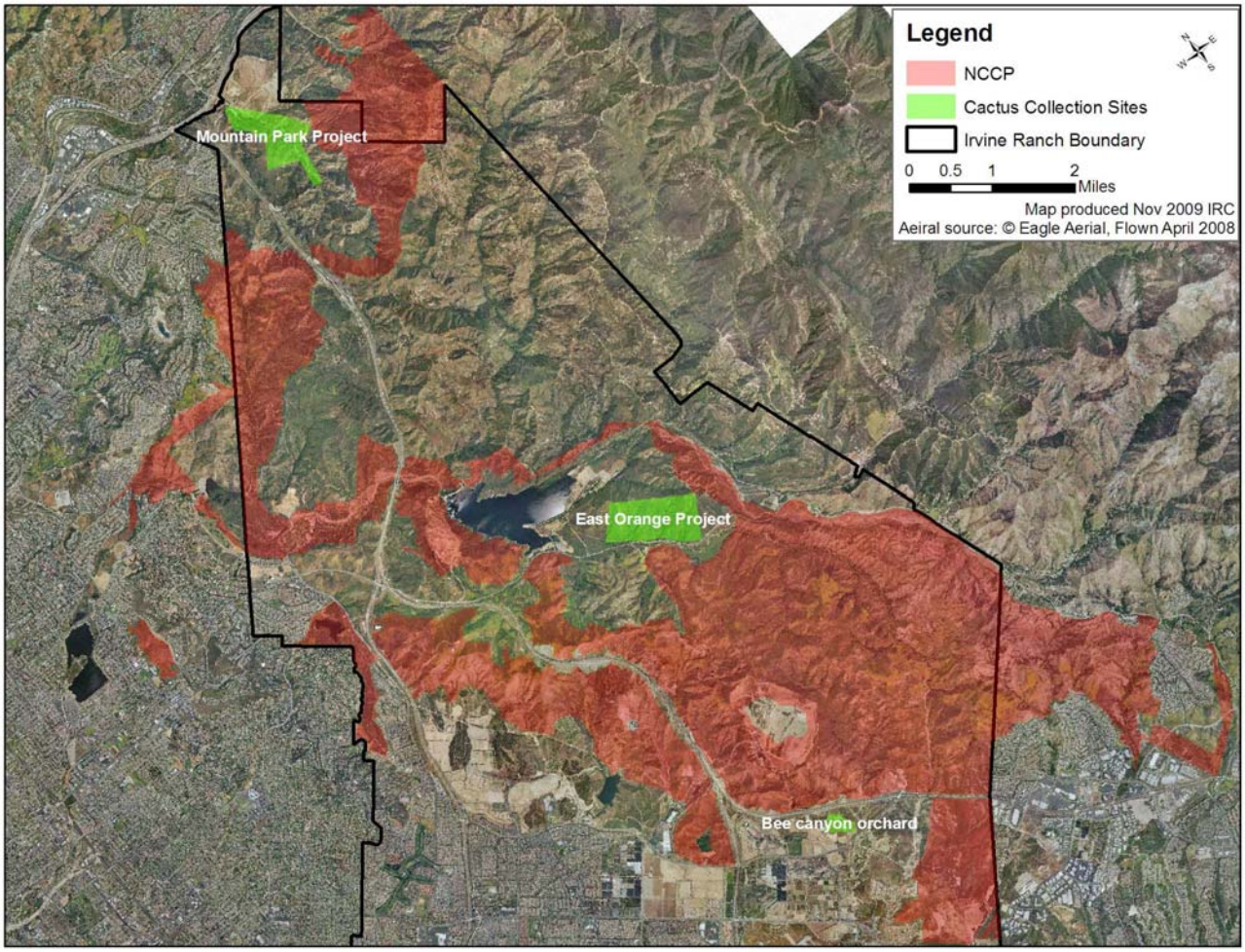


Figure 7. Areas including large populations of cactus selected for cladode collection.