

Nature Reserve of Orange County Cactus Wren Habitat Linkage Restoration Project

Final Report prepared for:

Ms. Cara Allen
California Department of Fish and Game
Natural Community Conservation Plan Program
4949 Viewridge Avenue
San Diego, CA 92123
Local Assistant Grant #PO8500010



Prepared by:

Kristine Preston, PhD
Nature Reserve of Orange County
15600 Sand Canyon Avenue
Irvine, CA 92618
&
Margot Griswold, PhD
& Travis Brooks
NewFields AER, LLC
2116 Arlington Ave. Ste 301
Los Angeles, CA 90018

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1.0 INTRODUCTION

1.1 Background

Cactus Wren (*Campylorhynchus brunneicapillus*) are found primarily in cactus and desert scrub throughout their range in the arid and semi-arid deserts of the southwestern United States (Proudfoot et al. 2000). The Coastal Cactus Wren occurs in coastal southern California and inhabits cactus scrub, which is patchily distributed across the region. Cactus scrub occupied by these wrens consists of coastal sage scrub vegetation supporting dense thickets of cactus, such as prickly pear (*Opuntia littoralis* and *O. oricola*) and coastal cholla (*Cylindropuntia prolifera*) (Rea and Weaver 1990; Proudfoot et al. 2000; Mitrovich and Hamilton 2007).

Over the last several decades, the Coastal Cactus Wren has significantly declined in abundance in southern California as a result of habitat loss and fragmentation from urban and agricultural development. Natural Community Conservation Plans (NCCPs) have been established to protect Coastal Cactus Wrens and other sensitive plant and animal species in the region. Beginning in the early 1990's large blocks of habitat were set aside and designated for conservation. The Coastal Cactus Wren is currently listed as a California State Species of Special Concern and Cleveland National Forest Federal Sensitive Species, is a covered species under several NCCPs, and is a surrogate for conservation of coastal sage scrub habitat (Proudfoot et al. 2000).

Despite efforts to conserve their habitat, the Coastal Cactus Wren has continued to decline, mainly as a result of recent large and catastrophic wildfires that have burned large expanses of cactus scrub and impacted wren populations. In addition to wildfire induced mortality, wrens are also affected by the temporary and even permanent loss of cactus scrub habitat. Following a wildfire, it can take many years for cactus to grow back to a size sufficient to support breeding Cactus Wrens (Proudfoot et al. 2000; Solek and Szijj 2004). Wildfire and the extensive urban development in coastal southern California has not only led to habitat loss and fragmentation, it has also resulted in small, isolated Cactus Wren populations. Dispersal between populations may be constrained, increasing the potential for local extinction and limited recolonization.

1.1.1 Population Status of Cactus Wrens in Orange County's Central and Coastal NCCP/HCP

The Nature Reserve of Orange County (NROC) is responsible for implementing Orange County's Central and Coastal Natural Community Conservation Plan/Habitat Conservation Plan (NCCP/HCP). The NCCP/HCP conserves over 37,000 acres in a Reserve System with multiple land owners and managers (Figure 1). The Coastal Reserve contains approximately 17,000 acres and the Central Reserve the remaining 20,000 acres. When the NCCP/HCP was established in 1996, 67.5% of 994 Cactus Wren locations documented during 1992 surveys were conserved in a multiple Owner and land manager Reserve System (County of Orange 1996). Another 10.4% of

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Figure 1. Orange County's Central and Coastal NCCP/HCP, showing Coastal and Central Reserves in dark green, Other Conserved Open Space in light green and special linkages in orange.

locations were potentially conserved in special linkages and existing use areas. Since the NCCP/HCP was established, NROC has been monitoring Cactus Wren populations in the Reserve System. Although the original Cactus Wren locations within the Reserve System were conserved, wrens have disappeared from many of these areas over the last two decades.

Annual surveys conducted by NROC in the NCCP/HCP from 1999 to 2004, and 2006 to 2008 documented a significant decline in Cactus Wren populations (Mitrovich and Hamilton 2007, Leatherman 2009). A major cause for this decline is large wildfires that have burned cactus scrub and impacted wren populations in the Coastal and Central Reserves. In 1993, the Laguna Fire burned 75% of the 17,000 acre Coastal Reserve and 58% of the cactus scrub has still not recovered sufficiently to provide suitable habitat for wrens (Mitrovich and Hamilton 2007). Within the Coastal Reserve, in areas primarily impacted by the 1993 Laguna Fire burn area, only about 42% (987 acres) of the cactus containing scrub habitat mapped in 2006 was considered suitably developed for colonization by breeding Cactus Wren pairs (Mitrovich and Hamilton 2007). In 2007, the Santiago Canyon fire burned over 75% of the 20,000 acre Central Reserve (Leatherman BioConsulting 2009). This fire burned 75% of the 1,855 acres of cactus scrub, and 75% of this fire damaged cactus scrub was so severely burned that it is currently unsuitable for wrens. Cactus Wrens typically do not re-colonize burned habitat until the cactus is at least 1-meter tall, and cactus recovery is slow following fire (Bontrager *et al.* 1995, Mitrovich and Hamilton 2007).

While the Laguna Fire substantially impacted Cactus Wren populations in the Coastal Reserve, there have also been considerable decreases in local wren populations inhabiting unburned areas. Annual surveys conducted from 1999 to 2004 documented larger proportional reductions in Cactus Wren populations in unburned portions of the Coastal Reserve than in the ~20,000 acre Central Reserve (Hamilton 2004). These declines could be due to reduced annual productivity and survivorship and increased population isolation resulting from urban development, new road construction, and wildfire destruction of habitat. In addition to fire, there are other potential reasons for declining Cactus Wren populations. These include low productivity corresponding with food limitation during multiple years of below average rainfall between 1998 and 2007, impacts of edge effects from development, high predation rates, and mortality from West Nile Virus.

Of particular concern is the increasing fragmentation and isolation of Cactus Wren populations due to urbanization and wildfire caused loss of cactus scrub habitat. Dispersal between populations is further limited by the sedentary nature of the Cactus Wren. Cactus Wrens do not migrate or make long distance seasonal movements (Solek and Szijj 2004). Cactus Wrens in the Coastal Reserve have been reported to typically disperse up to 2km, while individuals have been observed to move up to 7km (Atwood *et al.* 2002), although it is not documented whether these longer dispersal events result in viable breeding populations. As Cactus Wren populations become smaller and more isolated, they are more vulnerable to extinction from annual fluctuations in mortality and reproduction. If individual Cactus Wrens, particularly juveniles, are unable to disperse

between populations, then these small isolated populations will not be augmented by immigrants or re-established following a local extinction event.

1.2 Project Goals and Objectives

Restoring cactus scrub to increase suitable habitat for Cactus Wren nesting and dispersal between isolated populations is likely to enhance persistence of Cactus Wren populations in the NCCP/HCP. For this reason, NROC and the Irvine Ranch Conservancy (IRC), a land manager in the NCCP/HCP, have undertaken two cactus scrub restoration projects. This report describes NROC's project to restore a linkage between isolated populations in the Coastal Reserve (Figures 2 and 3). This linkage was destroyed in the 1993 Laguna Fire and is important for connecting two large blocks of cactus scrub habitat recently occupied by Cactus Wrens. IRC will focus restoration efforts in the Central Reserve to augment breeding habitat and enhance connectivity in areas affected by the 2007 Santiago Canyon Fire (Figure 3). IRC will begin restoring patches of cactus scrub in recently burned areas of the Central Reserve, concentrating on augmenting habitat for remaining Cactus Wrens and providing linkage between populations. While NROC and IRC will independently implement their restoration projects, they will ensure that activities are coordinated and that comparable restoration and monitoring methods are employed.

The purpose of NROC's restoration project is to improve the movement of individuals between isolated breeding populations, with a secondary goal of increasing suitable habitat for breeding pairs of Cactus Wrens. Cactus Wren habitat in James Dilly Reserve will be linked to wren habitat and populations in Aliso and Wood Canyons Wilderness Park to the southeast and in the City of Irvine Open Space Preserve South to the northwest (Figure 2). NROC planned to restore the linkage in two phases, depending on the availability of funding. Phase I is detailed in this report and focuses on initiating restoration of cactus scrub in the southern and middle portions of the alignment within the Laguna Coast Wilderness Park. Phase II involves expanding our restoration area in Laguna Coast Wilderness Park and restoring the northern portion of the alignment in the City of Irvine Open Space South. In 2010 IRC initiated restoration at this northern end when some cactus became available for salvaging for restoration purposes.

1.2.1 Specific Objectives of NROC's Cactus Wren Habitat Linkage Restoration Project

Objective 1. Collaborate with IRC to implement cactus scrub restoration projects in the NCCP/HCP

Objective 2. Prepare a site specific restoration plan for the NROC Coastal Reserve Cactus Wren habitat linkage

Objective 3. Implement restoration, maintenance and monitoring of the NROC Coastal Reserve Cactus Wren habitat linkage

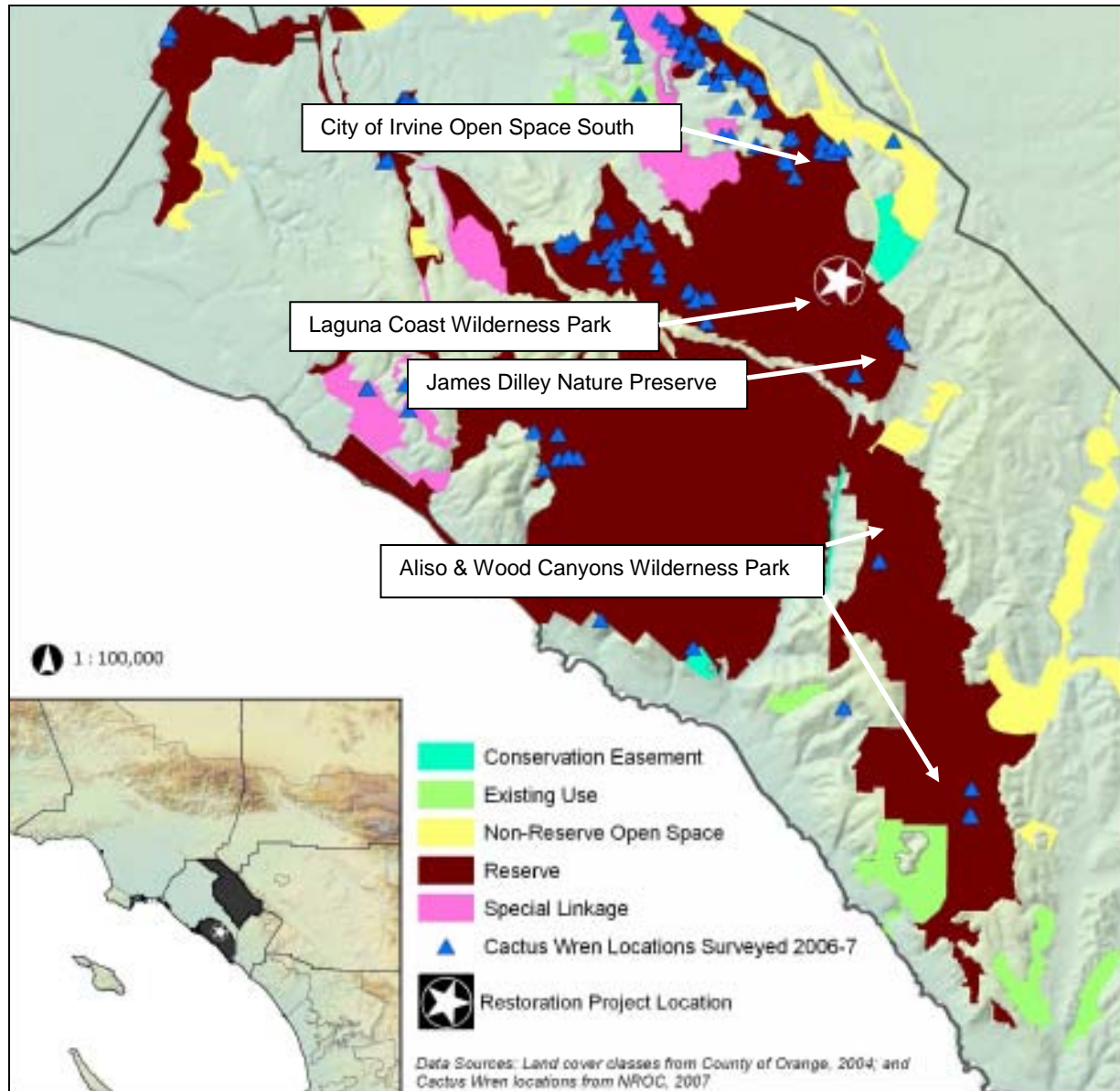


Figure 2. Regional location of NROC's Cactus Wren Habitat Linkage Restoration Project in relation to land owners with Cactus Wren populations in 2006-2007 that are intended to be connected by the restored linkage.

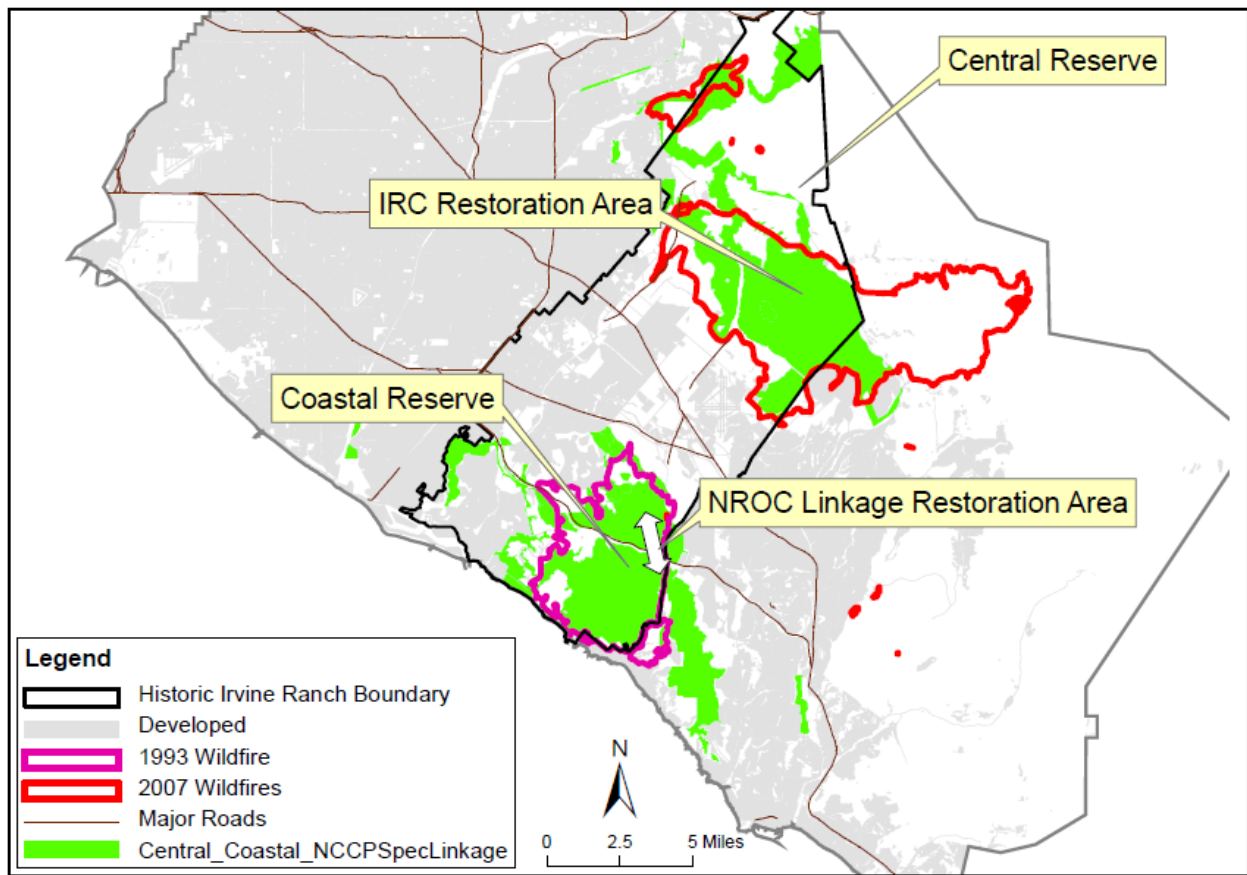


Figure 3. Cactus scrub restoration project areas for NROC and IRC in relation to wildfires within Orange County's Central and Coastal NCCP.

2.0 METHODS

The “Cactus Wren Habitat Linkage Restoration Plan: Coastal Reserve Nature Reserve of Orange County” (Restoration Plan) describes the methods used in this project (NewFields 2009). The following sections summarize these methods and the Restoration Plan should be referred to for additional detail and information.

2.1 Restoration Site Selection

2.1.1 Restoration Site Locations

Figure 4 shows the location of potential restoration sites in the NROC Coastal Reserve Cactus Wren habitat linkage in relation to the existing cactus scrub and location of recent and current Cactus Wren populations. Phase I is detailed in this report and restores cactus scrub in the southern and middle portions of the alignment and includes the numbered patches shown in Figure 4. This area is within the Laguna Coast Wilderness Park, which is owned and managed by Orange County Parks Department. These areas were prioritized for restoration in 2009 and 2010 due to the large amount of disturbed habitat, lack of mature cactus patches, and favorable topography for channeling dispersal through the linkage. The general location of Phase II consisting of IRC’s current site and future restoration sites is indicated by stars in Figure 4.

2.1.2 Restoration Site Descriptions

Potential cactus scrub restoration sites were assessed based upon a review of existing information, field surveys, meetings and site visits by NewField restoration ecologists with Orange County Park rangers, NROC staff and ecologists from The Nature Conservancy (NewFields 2009). Areas selected for restoration would be those dominated by non-native annual grasses and forbs and with appropriate soils. Focused site surveys were conducted in spring 2009 to search for rare plants, to document the vegetation community, including the dominance of native and non-native plant species, and to assess soil characteristics relevant to restoration.

An important factor in the selection of restoration sites included a Geographic Information Systems (GIS) viewshed analysis to identify the line of sight of restoration sites in relation to each other and existing cactus scrub habitat (NewFields 2009). This analysis was based upon the assumption that dispersing birds would scan the landscape and move toward patches of cactus that provide suitable habitat for potentially establishing a territory and finding a mate.

After evaluating all available information, restoration sites were selected for planting of cactus, seeding of native plants, and planting of container shrubs.

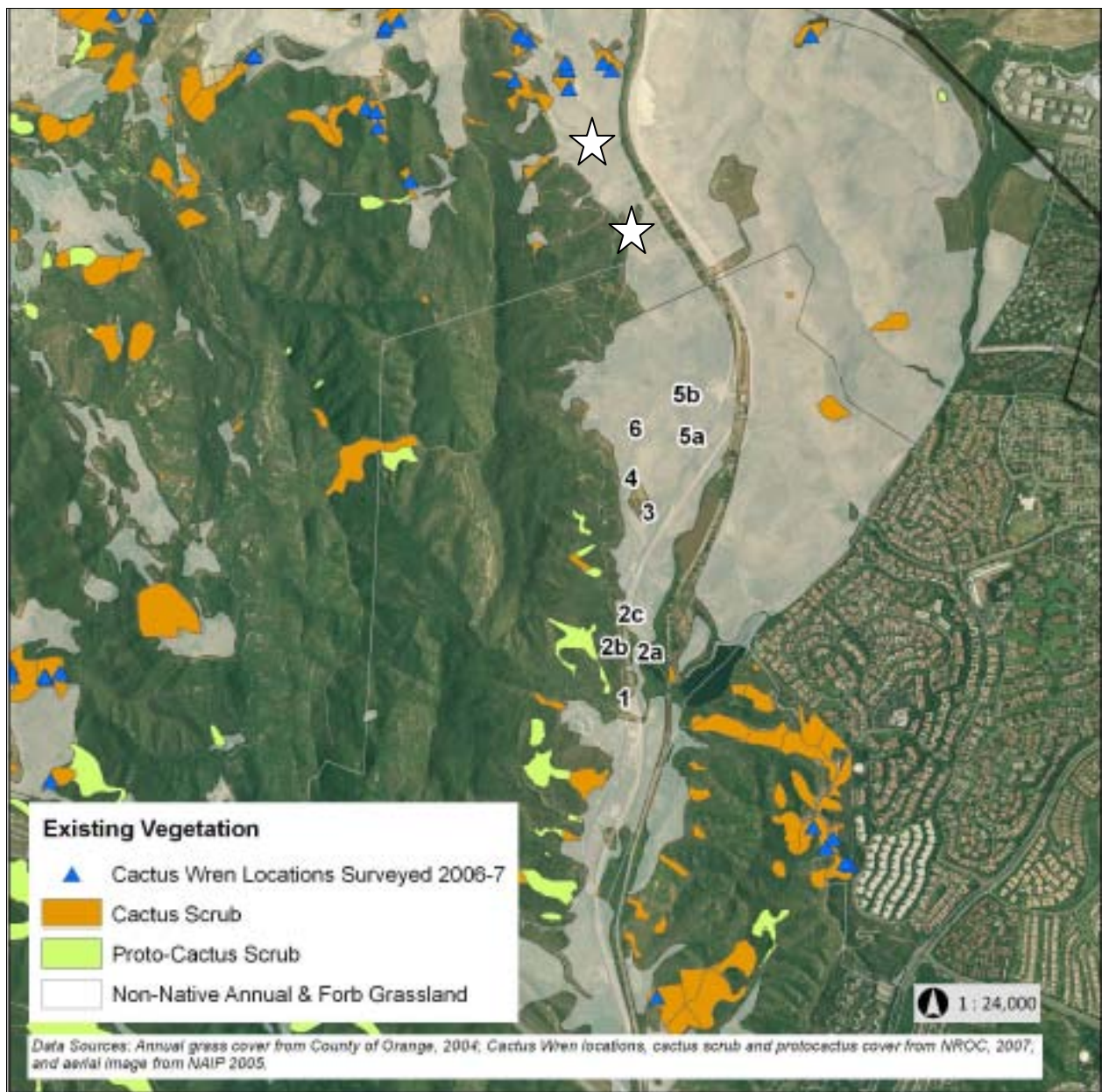


Figure 4. Regional location of NROC's Cactus Wren Habitat Linkage Restoration Project potential cactus scrub restoration sites in relation to existing cactus scrub habitat. Numbered locations refer to locations for NROC Phase I implementation and white stars to IRC's Phase II implementation.

2.2 Restoration Site Preparation

Restoration of cactus scrub habitat requires site preparation to control exotic plant species. The intensity of site preparation varies depending on the density of exotic and native species at each site. For this project, site preparation consisted of physical removal of weeds in winter 2009-2010 (NewFields 2009). This was done by weed whipping and raking and removal of weed biomass from the restoration sites. In order to reduce competition with native plants, the spot application of herbicide was used to kill weeds emerging after the first rains following weed removal and prior to planting and seeding native plants. The contractor was required to have a qualified applicant's license and herbicides used at the restoration sites were registered for use in California for natural areas. All herbicides were applied under appropriate weather conditions.

2.3 Plant Sources and Species

Because of funding limitations, the decision was made to prioritize planting of cactus in the first year (NewFields 2009). In the second year, native plants were seeded and in one area 1 gallon elderberry (*Sambucus Mexicana*) were planted. The cactus scrub planting palette is shown in Table 1. The species selected for the restoration occur in native cactus scrub in the region. Some species were included in the seed mix as a nurse crop until the native cactus scrub species establish. The Mexican 1 gallon container plants were purchased from commercial sources within Orange County. Elderberry was selected as it is a tall shrub that Cactus Wren have been observed flying to from relatively long distances. In addition, elderberry appears to be an important component of Cactus Wren habitat, providing food, cover and perches to sing from. Elderberry have been identified with the occurrence of Cactus Wren within the NCCP/HCP (Mitrovich and Hamilton 2007).

Some prickly pear cactus pads were available from a salvage operation (NewField 2009). There were also prickly pear cactus pads available for collection from cactus located along the edge of dirt roads in Laguna Coast Wilderness Park. These cacti are trimmed each year as part of routine road maintenance and collection of these pads did not result in an additional loss of cactus within the Reserve System. In addition, within each patch of cactus, there were 1 gallon prickly pear and 1 gallon cholla planted that were purchased from commercial sources within Orange County.

2.4 Seeding and Plant Specifications

2.4.1 Planting

The restoration plan focuses on planting cactus in the first year. Patches were approximately 200 m², although in some cases they were smaller if the site was of a more linear nature (NewFields 2009). The number of patches at each site depended on the size of the site. Each patch was planted with approximately 205 pads/plants. An estimated 3,000 cactus pads were used in the restoration. Pads of prickly

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Table 1. Cactus scrub plant palette.

| Scientific Name | Common Name | Cactus Pad and Container Plant ¹ Spacing | Total Number of Plants | Bulk Pounds of Seed Per Acre ² |
|--|---------------------------|--|---------------------------|--|
| <i>Artemisia californica</i> | California sagebrush | | | 0.5 |
| <i>Deinandra fasciculata</i> | fascicled tarweed | | | 1.5 |
| <i>Eriogonum fasciculatum</i> | California buckwheat | | | 1.5 |
| <i>Isocoma menziesii</i> | coast goldenbush | | | 0.1 |
| <i>Lotus scoparius</i> | deerweed | | | 1.0 |
| <i>Lupinus purshianus</i> | Spanish lupine | | | 1.5 |
| <i>Nassella lepida</i> | foothill needlegrass | | | 1.5 |
| <i>Opuntia littoralis</i> | coast prickly pear cactus | 3.5' o.c. | 200 1-gal 2970 pads | - |
| <i>Cylindropuntia prolifera</i> | coastal cholla | 3.5' o.c. | 60 1-gal | - |
| <i>Phacelia ramosissima</i> | branching phacelia | | | 0.2 |
| <i>Plantago insularis</i> | wooly plantain | | | 10.0 |
| <i>Rhus integrifolia</i> ³ | lemonadeberry | 25' o.c. | | - |
| <i>Sambucus mexicana</i> ³ | Mexican elderberry | 25' o.c. | | - |
| ¹ Cactus will be salvaged pads and 1-gallon container plants. Lemonadeberry will be 1-gallon containers; Mexican elderberry will be rose pot or 1 gallon containers.. ² Bulk seed rate may be adjusted depending on results of tests for germination. ³ Lemonadeberry and Mexican elderberry will be planted in year 2 of the project. Plants will be concentrated at site 6, but one or two of these species may be added at each site as necessary. o.c. = On center | | | | |

pear were arranged around 1-gallon planted prickly pear and cholla. The 1 gallon plants provided some initial height.

2.4.2 Seeding

Seeding was done with a hand spreader (NewFields 2009). The seeds were lightly raked into the soil and soil disturbance minimized. Seeding was done after the first flush of weeds was killed with herbicide in the process of site preparation.

2.5 Restoration Implementation

Site preparation was conducted in winter 2009-2010 with cactus planting following weed removal and the first application of herbicide (NewFields 2009). Cactus was salvaged 3-4 weeks prior to planting and the pads allowed to harden. 1 gallon prickly pear and cholla were planted at the same time as the cactus pads.

Native plants were seeded in winter 2010-2011 (NewFields 2009). The delay between planting cactus and seeding shrubs allowed for a full year of weed control to reduce non-native plants at the weedy restoration sites. Elderberry seedlings were planted in the second year during winter/spring of 2010-2011.

2.6 Restoration Site Maintenance

Maintenance of the site was necessary initially to establish self-sustaining cactus scrub habitat (NewFields 2009). Weed control reduces competition between native plants and non-native weeds and allows the native plants to establish. Competition for light can have a great impact on cactus growth. Maintenance consisted of weed control for target invasive species and replacement seeding in areas where target seed germination failed.

Typically it takes three years of maintenance for restoration plants to establish (NewFields 2009). The most intense maintenance is in the first and second years and depends on weather conditions and how the site develops. The total maintenance period may last for five years, depending on the progress at each restoration site. Mustard and annual grasses will need to be controlled during the maintenance period to limit competition with the cactus and native seed mix. During the active maintenance period, the cover of target weed species should be 10% or less. Weeds may be controlled from late winter through early summer as determined by monitoring observations. Weed control will typically consist of hand weeding as it is the least disruptive to the establishing native cover and soil. Hand weeding will be conducted by experienced staff familiar with identification of common weeds in the area. Mowing will be employed in buffer areas where there has been no seeding or planting.

Cactus pad replacement is not anticipated as it is unlikely that survivorship will fall below 95% during the establishment period (Williams 2009). If there is significant mortality, then cactus pads will be replaced as funding allows and after the cause of mortality is determined.

2.7 Restoration Monitoring

Uncertainty is an inherent part of the restoration process as there is variability in many factors influencing the recovery of native vegetation, including annual variation in weather patterns, introduction of new exotic plant species, and different land management practices surrounding the restoration area (Ecological Restoration Institute 2009). Adaptive management allows for the adjustment of restoration plans to future uncertainties by incorporating flexibility into management. Monitoring the various stages of the restoration process is an important component of adaptive management as it facilitates adjustments to the plan as necessary. Monitoring over time allows tracking of changes within the site and comparison of outcomes between sites. In this project, periodic monitoring will be undertaken to assess recovery of the native plant community and to document use of restored cactus scrub by Cactus Wrens.

2.7.1 Vegetation Monitoring

Qualitative and quantitative vegetation monitoring will be used to assess recovery of the native plant community and to guide management actions during the five year restoration period (NewFields 2009). Cactus restoration sites were monitored quarterly in the first year after installation to assess weeds and the necessity for weed management.

Quantitative monitoring will document performance over time and be implemented annually for five years following the restoration installation. An annual monitoring report will provide a quantitative description of the vegetation community, include photo documentation at permanent photo points, describe any maintenance activities during the year, and make recommendations for future maintenance. A final monitoring report will be prepared in the fifth year and will assess how well the restoration project met restoration performance criteria (see below). The annual performance reports will be prepared by NROC and submitted to CDFG by December 31st of each year. Upon completion of the five year restoration monitoring, the restoration sites will be included in NROC's long-term vegetation monitoring program to be sampled periodically after the five year project period is completed.

The annual vegetation performance monitoring will take place in mid-spring each year to capture the majority of native annual as well as native perennial species within the restoration sites. The exact timing will be dependent on weather conditions. Performance monitoring will be overseen by a qualified ecologist and may include teams of interested volunteers and interns.

2.7.1.1. Restoration Performance Criteria

Restoration criteria are used to assess the functions and values of the cactus restoration and to evaluate whether the goals for the restoration have been met. Restoration sites will be monitored to assess whether there are trends in cactus survivorship and growth and in native plant cover. The restoration project will be evaluated to see how it meets the following criteria developed in the project's Restoration Plan (NewFields 2009):

- The site does not require significant maintenance measures during the last two years of the establishment period as documented by the annual monitoring report.
- The restored habitat resists invasion by exotic plant species as documented by less than 25% cover of annual invasive plant and exotic forb species. There shall be no target invasive species, such as false brome. In addition to false brome, there shall be no Cal-IPC List 1-A species within the restoration sites.
- At least 95% of the planted cactus demonstrates establishment and growth based upon sampling estimates.

2.7.1.2 Quantitative Vegetation Monitoring Methods

The selection of vegetation variables to measure in order to assess annual site performance is based upon the goals of the restoration project, cactus development characteristics, and performance standards outlined in the restoration criteria (NewFields 2009). Measured variables will include cactus cover and height, cover of other native plant species, cover of exotic plant species, percent bare ground, and litter.

A total of 50-meters of point intercept transects with ten 1 meter² quadrats on alternating sides of the transect will be used to measure vegetation cover at restoration sites (NewFields 2009). To fit within smaller restoration sites, the 50-meter transect may be divided up into smaller segments aligned at intervals within the restoration polygon and associated with a total of 10 quadrats. The combination of a 50-meter transect with ten staggered 1 m² quadrats is the method used in NROC's vegetation monitoring program and has been evaluated for accuracy and efficiency (Deutschman and Strahm 2009).

Transects (or segments of transects) will be centered within each restoration with the orientation of the initial transect randomly determined (NewFields 2009).. Each transect will be permanently established using sub-meter Geographic Positioning System (GPS) units and rebar stakes capped with PV pipe to mark the start and end of the transect. Vegetation will be measured at points spaced 1 meter apart along the transect. At each point every plant species and the ground cover type (bare earth versus litter) that intersects the transect tape and the vertical plane under the tape will be recorded. For cactus, the height will also be recorded. Cover data will be reported as absolute cover corresponding to the number of points a species or ground cover type occurred divided by the total number of points on the transect.

Ten 1-meter² quadrats will be permanently located every five meters on alternate sides of the transect (NewFields 2009). All species within these quadrats will be recorded. The quadrats are used to capture rare species that may be missed in the point intercept transects. Species diversity will be calculated based upon the number of species measured at each site using the point intercept transects and quadrats.

Cactus growth will be measured using at least 30 planted cactus per restoration patch (NewFields 2009). The cactus will be randomly selected from cactus encountered along the permanent transect lines and quadrats. A map will be developed in the first year of monitoring that shows the position of cactus to be measured for growth each year. Measurements will include the growth of new joints and survival of the cactus.

2.7.2 Cactus Wren Monitoring

Annual spring surveys for Cactus Wrens will be conducted by NROC biologists for the five years following initial planting of the cactus (NewFields 2009). At the end of the five year monitoring program, the restoration sites will be included within NROC's long term Cactus Wren monitoring program and will be periodically surveyed.

NROC will follow protocol surveys so that data will be comparable with standard surveys throughout the Central and Coastal Reserves (Mitrovich and Hamilton 2007, Leatherman BioConsulting 2009). Restoration sites will be surveyed during the morning hours under suitable weather conditions. Surveys will be conducted from a single vantage point that allows unobstructed views of the restoration site(s). Each survey will last six minutes with Cactus Wren vocalizations played for one minute after two minutes with no wren detected. Once a wren is detected, the use of taped vocalizations will be discontinued for that survey. Every Cactus Wren detected during the survey will be mapped and any observations of Cactus Wrens outside the survey period will be noted as incidental and also mapped. Movements of Cactus Wren between restoration sites will also be recorded.

2.8 Coordination of Methods with IRC

Coordination between NROC and IRC will facilitate comparison of methods and results from the two projects. This coordination includes meeting during development of restoration plans to work out restoration specifications, determine timelines for restoration and monitoring activities and to decide upon monitoring methods. NROC and IRC will provide copies of their restoration plans for review and comment. Prior to annual monitoring, NROC and IRC staff will communicate to facilitate similar scheduling of activities. Because the specific goals of each project differ, there are differences in overall design and specific methodologies. However, the timing of restoration activities and overall monitoring methodologies are similar so that results obtained by each project can be compared.

3.0 RESULTS

3.1 Restoration Site Selection

Potential cactus scrub restoration sites were evaluated in detail and comprehensive results are presented in the Restoration Plan (NewFields 2009).

3.1.1 Restoration Site Locations

Five sites were selected for cactus restoration based on an analysis of existing vegetation, line of sight analysis, and soil characterization (Figure 5). Site 6 will not be planted with cacti, instead a portion will be planted with Mexican elderberry. The intent is to provide tall shrubs that will facilitate dispersal by providing cover, high perches from which to scan the landscape and food resources during dispersal.

3.1.2 Restoration Site Descriptions

Site 1. Restoration site 1 is located at the southern end of the linkage and consists of a low slope facing northeast to southeast (NewFields 2009 and Figure 5, Appendix Figure 2). There is some existing coastal sage scrub at the southwest end of the site. The restoration area is dominated by non-native annual grasses and red-stemmed filaree (*Erodium cicutarium*). A total of four cactus patches comprising 0.31 acres were planted with cactus and seeded with native plants (Table 2).

Site 2. This site is composed of three separate subunits based upon soil characteristics, topography and vegetation (NewFields 2009, Figure 5 and Appendix Figure 3). The site consists of a north to east facing slope and a large flat area, and depending on the subunit these areas are dominated by ripgut brome (*Bromus diandrus*), shortpod mustard (*Hirschfeldia incana*), black mustard (*Brassica nigra*). Only subunit 2a was restored at this time as it had a lower weed load and more suitable soils for successful restoration. Three cactus patches were planted and the area seeded for a total of 0.30 acres of cactus scrub (Table 2).

Site 3. Site 3 is on a southwest facing slope with good line of site to Sites 1 and 2 (NewFields 2009, Figure 5 and Appendix Figure 4). The site is dominated by non-native wild oats (*Avena fatua*) and native cover includes ragweed (*Ambrosia Psilostachya*) and bush mallow (*Malacothamnus fasciculatus*). Remnants of burned prickly pear can be seen at the site which is also surrounded by land with significant cover of both native and non-native plants. Site 3 was restored with three patches of cactus scrub encompassing 0.21 acres (Table 2).

Site 4. This site is below a rock outcrop running north to south and is mid-way up a west facing slope (NewFields 2009, Figure 5 and Appendix Figure 5). Site 3 is located further south along the same slope and the intervening area has coastal sage scrub with one large prickly pear. Site 4 is dominated by non-native annual grasses but has some native plant cover.

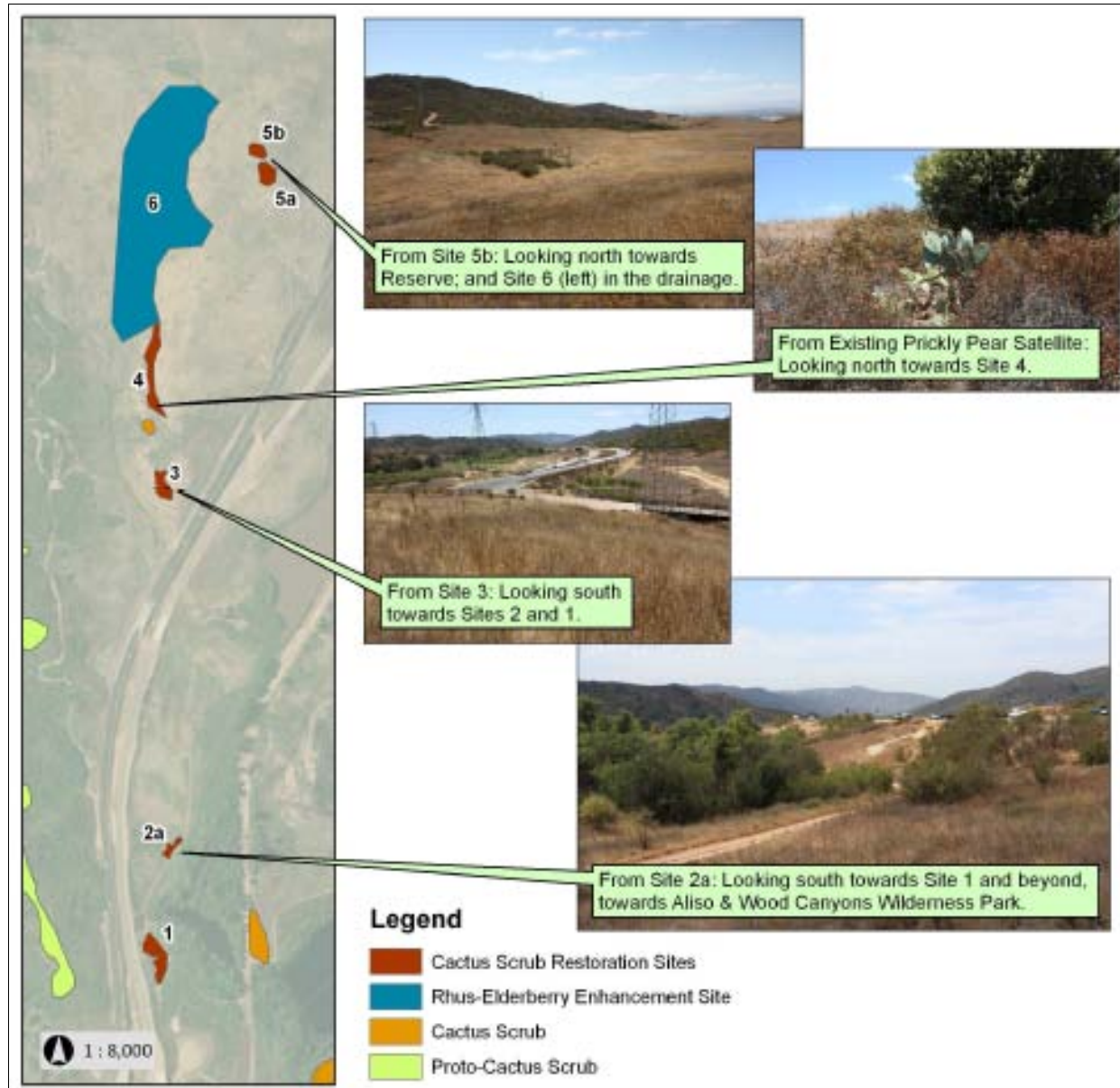


Figure 5. Final sites for NROC's Cactus Wren Habitat Linkage Restoration Project cactus restoration within the Laguna Coast Wilderness Park in the Coastal Reserve of Orange County. Five sites will be restored with cactus and seeded with native plants and one site (in blue) will be planted with Mexican elderberry and lemonadeberry container plants.

Table 2. Summary of restoration acreages, restoration patches, and number of cactus and shrubs planted at sites in NROC's Cactus Wren Habitat Linkage Restoration project.

| Restoration Site | Acreage | Number of Cactus Patches ¹ | Total Number of Cactus |
|--|---------------------|---------------------------------------|------------------------|
| 1 | 0.31 | 4 | 820 |
| 2a | 0.30 | 3 | 615 |
| 3 | 0.20 | 3 | 615 |
| 4 | 0.41 | 6 ² | 360 |
| 5a | 0.18 | 2 | 410 |
| 5b | 0.11 | 2 | 410 |
| 6 | 2.5 (7.9 in future) | N/A ³ | N/A ³ |
| ¹ Cactus patches will be approximately 200 m ² ² Site 4 patches will be smaller at approximately 30 – 60 cactus pads per patch. ³ Lemonade berry and elderberry will be planted in year 2 of the project at site 6, which will not be planted with cactus. Only 2.5 acres will be planted at this time based upon available funding. | | | |

This site was planted with six smaller patches of cactus and seeded with native plants to restore a total of 0.41 acres (Table 2).

Sites 5a and 5b. These two sites are on the top of a ridge with a gentle slope and provides a good line of site to the other restoration sites (NewFields 2009, Figure 5 and Appendix Figure 6). It also has less abundant invasive plants. The restoration subunits 5a and 5b were selected as they had soils most conducive to restoration of cactus scrub. A weed control buffer was also delineated around the two patches to reduce invasion of exotic plants into the restored cactus scrub. Two patches of cactus scrub were planted in each of the subunits for a total of 0.29 acres (Table 2).

Site 6. Site 6 was located on lower slopes along the drainage between restoration sites 4 and 5 and showed strong potential for enhancement with large native shrubs such as Mexican elderberry (NewFields 2009 and Figure 5). Elderberry is an important component of Cactus Wren habitat and would improve habitat quality for the nearby cactus patches. Elderberry provides resources for dispersing birds including high perches from which to scan the landscape, dense cover for roosting in the absence of a roost nest in cactus, and a visible target for birds to aim at when making dispersal

flights. Site 6 is dominated by non-native annual grasses and is a large area of 7.0 acres. This site was selected for enhancement with elderberry and lemonadeberry planting but was not intended for cactus scrub restoration. The size of the enhancement area was dependent on available funding and approximately 2.5 acres were planted during Phase I. The intention is to complete enhancement should additional funding become available.

Phase 2 Sites. There was insufficient funding for NROC to restore patches identified at the north end of the alignment (Figure 4). It was intended that these sites would be restored as Phase II as additional funding could be obtained. However, IRC was the beneficiary of cactus for salvaging and was able to begin restoration of the northern most patch (IRC 2010). IRC and NROC conducted a site visit in March 2009 and identified two restoration sites. The northern site showed good line of sight to cactus supporting Cactus Wren to the north. The southern most of the two sites was located on a hill top and visible to the northern restoration patch and to NROC's cactus scrub restoration sites to the south. Cactus branches and pads were planted by IRC in April 2010 in the northern most of these two sites.

3.2 Restoration Site Preparation

Site preparation for cactus planting was completed in the winter of 2009-2010. The boundaries of restoration sites 1, 2a, 3, 4, 5a and 5b were marked on December 29, 2009. The existing weeds and thatch were cut down and removed from the site by a combination of mowing, weed-whipping and hand tools during the period of January 19-29, 2010. On February 2-5, 2010, a few weeks prior to planting the cactus, limited spot application of herbicide was applied using a backpack sprayer.

There was early season rainfall in October 2010¹, prior to seeding the cactus scrub palette, and this led to germination of non-native annual grasses. These grasses were controlled with herbicide on November 9, 2010 a week and a half prior to seeding the native plants.

Weeds were weed-whipped prior to planting Mexican elderberry at Site 6 in early March 2011.

Appendix A provides photos showing the different restoration sites and stages of the restoration process.

¹ The seasonal total to date (July 1 – November 19, 2010), as reported by the Newport Beach Station was 2.69-inches of rainfall, which is 212% of normal rainfall totals (as defined by the years 1971-2000). Further, most of this rainfall (2.08-inches) was recorded in October, when the normal total is 0.31-inches (NWS 2010).

3.3 Plant Sources and Species

Prickly pear cactus pads were harvested January 25-29, 2010 from the edge of dirt roads at Laguna Coast Wilderness Park. These cactus are trimmed back annually as part of road maintenance activities. A total of 2,970 cactus pads were harvested. The pads were allowed to harden for three weeks prior to planting. Some pads were also available from cactus that was cut down by vandals and was salvaged at James Dilley Nature Preserve. Two hundred 1 gallon prickly pear cactus and 60 1 gallon cholla were purchased from a commercial nursery for planting. A total of 1,300 lbs of native plant seed mix (see Table 1 for planting palette) were purchased for restoring restoration sites 1-5. For Site 6, 382 Mexican elderberry seedlings were purchased in early March 2011 for restoration of 2.5 acres.

3.4 Restoration Implementation

Pads of prickly pear cactus (*O. littoralis*) and 1-gallon container nursery grown cholla and prickly pear were planted in Cactus Patches at sites 1-5 on February 15-19, 2010. These restoration sites were seeded the following fall, on November 19, 2010. The seeding was prior to the arrival of two winter storm systems on November 20-21, 2010 that brought a total of 0.81 inches of rainfall. The seeds were spread by hand and lightly raked into the soil.

Mexican elderberry seedlings were planted March 4, 2011 at Site 6 over 2.5 acres to total 4.0 acres of restoration and enhancement. This project was not fully funded, so it was not possible to complete all of Phase I or to initiate Phase II without additional funding. To completely finish installation of the Restoration Plan will require enhancing 5.4 acres of Site 6 with planted elderberry and lemonadeberry and to plant cactus scrub at the southern most of the two City of Irvine Open Space South sites identified as Phase II of the project.

3.5 Restoration Site Maintenance

Maintenance of Sites 1-5 planted in cactus in February 2010, consisted of three weed control events between summer 2010 and winter 2010-2011. Following the installation of cactus pads and container cactus, the restoration sites were hand weeded on June 29-30, 2010. This included mowing of the buffer area around sites 5a and 5b. The weeds controlled included shortpod mustard (*Hirschfeldia incana*), bristly ox-tongue (*Picris echioides*) and tocalote (*Centaurea melitensis*). New non-native annual grass biomass was low, reflecting the effectiveness of the winter weeding effort prior to planting and low rainfall totals from March to July, 2010. There was little new growth of weeds following the summer weeding effort; however, following the October 2010 rainfall, non-native annual grass germination was observed, which was subsequently controlled with herbicide prior to seeding in fall 2010. Restoration sites were hand

weeded and buffers mowed again on February 17, 2011. The hand weeding was conducted by experienced staff familiar with identification of common weeds at the site.

3.6 Restoration Monitoring

3.6.1 Qualitative Monitoring

A NewFields ecologist qualitatively monitored restoration activities on the following dates (photos are available for the restoration sites on dates that are noted):

- July 17, 2009 (*photos*) – Restoration site selection
- December 29, 2009 – Layout of restoration site boundaries
- February 1, 2010 (*photos*) – After weed and thatch removal
- February 18, 2010 (*photos*) – After planting of cactus pads and containers
- April 8, 2010 – Walk-over to monitor cactus survival and weed growth
- September 23, 2010 – Walk-over to monitor cactus survival and weed growth
- November 19, 2010 (*photos*) – After spot herbicide and seeding

The restoration ecologist relied upon these observations to help guide the timing of restoration activities, as outlined in the Restoration Plan (NewFields 2009). There was no significant mortality of cactus pads nor were any problems with the restoration noted.

3.6.2 Quantitative Monitoring

The first year of quantitative restoration monitoring, including vegetation measurements and avian sampling, is scheduled for spring 2011, as described in the Restoration Plan (2009). Avian surveys will be conducted from mid-March to mid-June and vegetation sampling in May.

3.7 Coordination of Methods with IRC

NROC and IRC communicated via meetings, site visits, emails and phone calls to develop the project scopes and cactus restoration plans. There were a couple of meetings between NROC and IRC staff in 2008 and 2009 to coordinate and develop initial approaches. On June 24, 2009, the teams for both projects met to describe their projects and coordinate development of restoration plans. In fall 2009, there was a site visit to view potential cactus restoration and salvage sites for the IRC project in the Central Reserve. In early spring 2010, NROC and IRC staff visited the northern portion of NROC's proposed habitat linkage to evaluate sites identified for restoration in Phase II and which IRC was able to obtain salvaged cactus to begin the restoration ahead of schedule. Restoration ecologists for IRC and NROC along with NROC staff reviewed and commented on both restoration plans. The purpose of these communications and

reviews was to develop compatible projects, share information and encourage collaboration. It is important to note that the specific goals of each project differ to some extent, resulting in somewhat different approaches to restoration design and specific planting and maintenance methodologies.

Ways in which NROC and IRC collaborated to improve consistency between their projects:

- Sharing data and information such as the GIS layers for NROC's 2008 cactus mapping and surveys in the Central Reserve
- Jointly developing criteria for prioritizing restoration sites in the Central Reserve
- Conducting site visits to the Central and Coastal Reserves to evaluate restoration sites and cactus salvaging sites
- Using point intercept transects with staggered quadrats to measure vegetation and randomly selecting 30 cactus per match to monitor survival and growth
- Coordinating timing of quantitative vegetation and Cactus Wren monitoring so that data are collected in a similar time frame each year

4.0 DISCUSSION

4.1 Future Tasks

NROC is committed to five years of quantitative vegetation monitoring and Cactus Wren surveys. Cactus was planted in February 2010, so quantitative monitoring is to begin in spring 2011 after one growing season. This is one year later than estimated in the Restoration Plan, meaning that monitoring will continue until spring 2015. NROC will also conduct invasive plant control at least once annually if determined to be necessary during this time period.

After the completion of five years of quantitative monitoring, the restoration sites will be included in NROC's long-term Monitoring Program. This will include vegetation and Cactus Wren monitoring.

If funding becomes available, NROC will complete enhancement of Site 6 by planting Mexican elderberries and lemonadeberries. Further expansion of cactus scrub along the extent of the alignment in order to provide additional breeding habitat is also a future priority.

4.2 Management Recommendations

- If funding can be obtained, the restoration sites should be expanded to increase the amount of cactus scrub so it is sufficient to support breeding Cactus Wrens
- Additional restoration sites should be established and integrated into the habitat linkage to further facilitate dispersal and support breeding Cactus Wrens
- If large intact cactus become available for salvaging, these should be planted in the vicinity of the restored cactus patches to immediately provide taller cactus and improve habitat suitability for breeding wrens
- The restoration sites should be surveyed periodically for color banded birds that were marked as part of NROC's Cactus Wren Reproduction, Dispersal and Survival Monitoring Study
- NROC should look for other opportunities to enhance Cactus Wren habitat to facilitate dispersal in the Coastal Reserve and promote local population persistence
- The results of this restoration project should be compared with other projects to better understand the effectiveness of different restoration approaches

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6.0 APPENDICES

6.1 Appendix A: Project Photographs

6.1.a Site 1



Appendix Figure 1. Example of harvested cactus pad cuttings from Laguna Coast Wilderness Park “hardening off” and forming callus tissue prior to planting. These pads were located next to Restoration Site 1, February 1, 2010.



2A. July 17, 2009 – Site 1 prior to site preparation (panoramic view looking south).



2b. July 17, 2009 – Site 1 prior to site preparation.

Appendix Figure 2. Images of Restoration Site 1 prior to site preparation (2a, 2b), following weed and thatch removal (2c), after cactus installation (2d), and after site maintenance (2e).



2c. February 1, 2010 – Site 1 following weed and thatch removal (looking north).



2d. February 23, 2010 – Site 1 following cactus pad and container installation (looking north).

Appendix Figure 2. Images of Restoration Site 1 prior to site preparation (2a, 2b), following weed and thatch removal (2c), after cactus installation (2d), and after site maintenance (2e).



2e. November 19, 2010 – Site 1 after spot herbicide and seeding.

Appendix Figure 2. Images of Restoration Site 1 prior to site preparation (2a, 2b), following weed and thatch removal (2c), after cactus installation (2d), and after site maintenance (2e).



3a. February 1, 2010 – Site 2 after weed and thatch removal.



3b. February 18, 2010 – Site 2 after cactus planting.

Appendix Figure 3. Restoration site 2 prior to site preparation (3a) and after cactus was planted (3b).



4a. July 17, 2009 – Site 3 prior to site preparation.



4b. July 17, 2009 – Burned cactus adjacent to Site 3

Appendix Figure 4. Restoration site 3 prior to site preparation (4a), a view of adjacent burned cactus scrub (4b), and site 3 after cactus was planted (4c).



4c. February 1, 2010 – Site 3 after cactus planting.

Appendix Figure 4. Restoration site 3 prior to site preparation (4a), a view of adjacent burned cactus scrub (4b), and site 3 after cactus was planted (4c).



5a. July 17, 2009 – Site 4 prior to site preparation



5b. February 1, 2010 – Site 4 after weed and thatch removal.

Appendix Figure 5. Images of restoration site 4 prior to (5a) and after (5b, 5c) site preparation and after cactus planting (5d).



5c. February 1, 2010 – Site 4 after weed and thatch removal.



5d. February 18, 2010 – Site 4 after cactus planting.

Appendix Figure 5. Images of restoration site 4 prior to (5a) and after (5b, 5c) site preparation and after cactus planting (5d).



6a. February 1, 2010 – Site 5 after weed and thatch removal.



6b. February 1, 2010 – Site 5 after cactus planting.

Appendix Figure 6. Images of restoration site 5 before preparation (6a) and after planting (6b).