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Subject: Final Report for project entitled: "Coastal Cactus Wren Habitat Enhancement In San Pasqual Valley.

Dates of Report: 4/16/2010 through 4/16/2013

Project Summary:

The Safari Park Biodiversity Reserve is one of the last remaining strongholds for coastal cactus wrens in San Diego County, and the cactus scrub supports the greatest abundance of cactus wrens in San Pasqual Valley. The 2007 Witch Creek fire damaged much of the cactus scrub at the Safari Park and throughout the San Pasqual Valley. In 2010, we were awarded a TransNet grant to support and enhance the survival of coastal cactus wrens in the Valley using a strategic, multi-faceted approach. Specifically we proposed to: (1) construct a cactus propagation and salvage center that will serve as a long-term resource providing native cacti materials for restoration projects throughout the North County; (2) collect/propagate over 1,200 prickly-pear cacti per year for restoration in the San Pasqual Valley (including the Safari Park Biodiversity Reserve and partner-managed MSCP lands); (3) enhance 45 acres within the Safari Park Biodiversity Reserve through cacti enrichment plantings; (4) monitor establishment and growth of planted cacti; and monitor cactus wren abundance, distribution, and habitat use in relation to habitat characteristics and enhancement efforts.

Task 1: Cactus Salvage and Propagation Center

In April 2010 we selected a site and began to design a Cactus Salvage and Propagation Center to serve as additional space for a container nursery for both cacti propagated on-site and for salvaged cacti collected as part of new regulations established by the County of San Diego that would require salvage of cacti as part of mitigation for development projects.

We hired A&P Ag Structures to construct a large (60' x 60') shade house, which functions as the main propagation and long term holding area. Staff from the San Diego Zoo Horticulture and Construction and Management departments assisted with bench installation and irrigation set-up as an in-kind contribution to the project. Two storage sheds for propagation supplies, a shaded 10' x 10' potting area,

and compost areas were constructed adjacent to the shade house. Construction began in late July and the center was fully operational by the end of 2010.

In 2010, we also received our first group of salvaged succulents from R. Mitchel Beauchamp of Pacific Southwest Biological Services, which included 11 pads (cladodes) of Coast Prickly Pear *(Opuntia littoralis),* 17 large clusters of San Diego Coast Barrel Cacti (*Ferrocactus virdescens var. virdescens*) and one Chalk Dudleya *(Dudleya pulverulenta).*

Figure 1: The Cactus Salvage and Propagation Center was completed in 2010.

Task 1 Deliverables:

- *Construction of Cactus Salvage and Propagation Center completed in 2010*
  - *Functioning facility able to propagate more than 2,000 cacti/year.*

- *Functioning facility that is able to store and maintain salvaged cacti and succulents as part of new regulations.*

Task 2: Cacti Propagation

Over the course of three years (2010-2012), we propagated 2,800 cacti in 1-gallon size pots for restoration efforts in the Safari Park Biodiversity Reserve. In addition to these propagated cacti, almost 5,500 single-pad cuttings have been stored and cared for at the propagation facility for callousing and/or dry-rooting prior to being planted directly into the restoration sites.

Year	Propagated in 1-gal pots for 6 months	Propagated in 1-gal pots for 1 year	Dry-rooted cladodes (not potted, stored for 6 months)	Calloused cladodes (not potted, stored for 2-4 weeks)	Total
2010	1100	N/A	1000	765	2865
2011	450	450	988	821	2709
2012	800	N/A	N/A	1847	2647

Table 1: Number of cacti held and cared for at the Cactus Propagation and Salvage Center each year for Restoration at the Safari Park Biodiversity Reserve. The exact number of cacti collected and propagated varied by year as we became more confident in our propagation success rates. Throughout all three years, we had very minimal levels (less than 100 individuals/year) of die-off prior to planting in the field.

In addition to cacti propagated for restoration at the Safari Park, in 2012 we began propagating an additional 1700 cacti in large (3-5 gallon) containers for restoration efforts in San Pasqual Valley.

Propagation Methods:

All cuttings were collected as single pads from mature cacti already growing within the Biodiversity Reserve adjacent to the Safari Park. We collected no more than 6 pads per cactus and took care to collect only from large cacti that were greater than three meters in height, so as to minimize our impact on any existing cactus wren nesting habitat. We also made sure to collect only from spiny cacti and avoided collecting from any cacti that looked like they might be hybrids with the non-native Mission Prickly Pear *(Opuntia ficus indica).*

Figure 2: High school students enrolled in the Zoo's Conservation Corps and Zoo Corps programs helped collect a large number of the cactus cuttings used for propagation and restoration.

Pad collections occurred both in November and May. The one-year propagated stock was grown from cuttings collected in November while cacti propagated for only 6 months were grown from cuttings collected in late May/June. These pads were laid flat on ground and left for 1-3 weeks to callous prior to potting. The pads were potted in 1-gal size pots in an upright/vertical position with approximately 1/3 of the cladode buried in the soil. The soil mix used was Sunshine #4. We used a manually controlled drip irrigation system to water the cacti as needed. Over-watered cacti are prone to rot and diseases so we took care to allow the potting soil to dry completely before administering additional water. Any cacti that appeared to be rotting or diseased were removed from the area immediately and disposed of to prevent spread of disease to other cacti. We also monitored the cacti for cochineal scale-insect infestations that were treated as needed either by spraying them with a strong stream of water or by using a modified toothbrush to scrub the surface of the cactus with a dilute insecticidal soap solution.

We observed, but did not measure, differences in the quality of the collected material. Pads collected in November showed signs of water stress - they were thin, slightly wrinkled and difficult to pry from the parent cactus. Meanwhile, pads collected in May were thick and succulent and easily snapped off the parent cactus. Due to the cool moist weather, pads collected in November took 2-3 weeks to callous while those collected in May calloused in less than a week. We did measure differences in growth and reproduction and found significant differences between these two cohorts of cacti. Interestingly, cacti propagated for only 6 months put on more vegetative growth than cacti propagated for 1 year (these results are discussed further under Task 4); therefore, we decided to only use cacti propagated for 6 months in year 3.

Task 2 Deliverables:

- *More than 2,000 cactus propagules per year available for restoration projects in San Pasqual Valley including restoration at the Safari Park Biodiversity Reserve.*

Task 3: Restoration

Over the course of 3 years (2010 through 2012) more than 7,000 cactus propagules (a mix of single pads and propagated cuttings) were planted across 45 acres at the Safari Park Biodiversity Reserve. All restoration activities were implemented according to our habitat restoration plan developed in 2010.

Site Selection:

Restoration sites were selected based on restoration need, accessibility, and topography. Restoration need was determined based on percent cover of native shrubs and cactus and percent cover of invasive species data that was gathered during vegetation surveys conducted in the spring of 2010 across the Biodiversity Reserve. Where possible, sites are located within 50 meters of roads to maximize feasibility of management actions such as planting, watering, and monitoring. Since cactus generally grows on south facing slopes, all sites are confined to southward facing slopes (90-270°) or areas where cactus was known to exist prior to the 2007 fires (based on photographic evidence).

We used ArcGIS software to digitize 45 one-acre plots within the enhancement areas and vegetation monitoring transects within each plot for long term monitoring of vegetation percent cover and structure.

Because cactus wren territories are known to extend well beyond one acre, multiple adjacent acre plots were grouped into 3-4 acre “enhancement areas” wherever terrain permitted. These enhancement areas were selected at random such that over the course of three years a total of 15 acres would be planted each year.

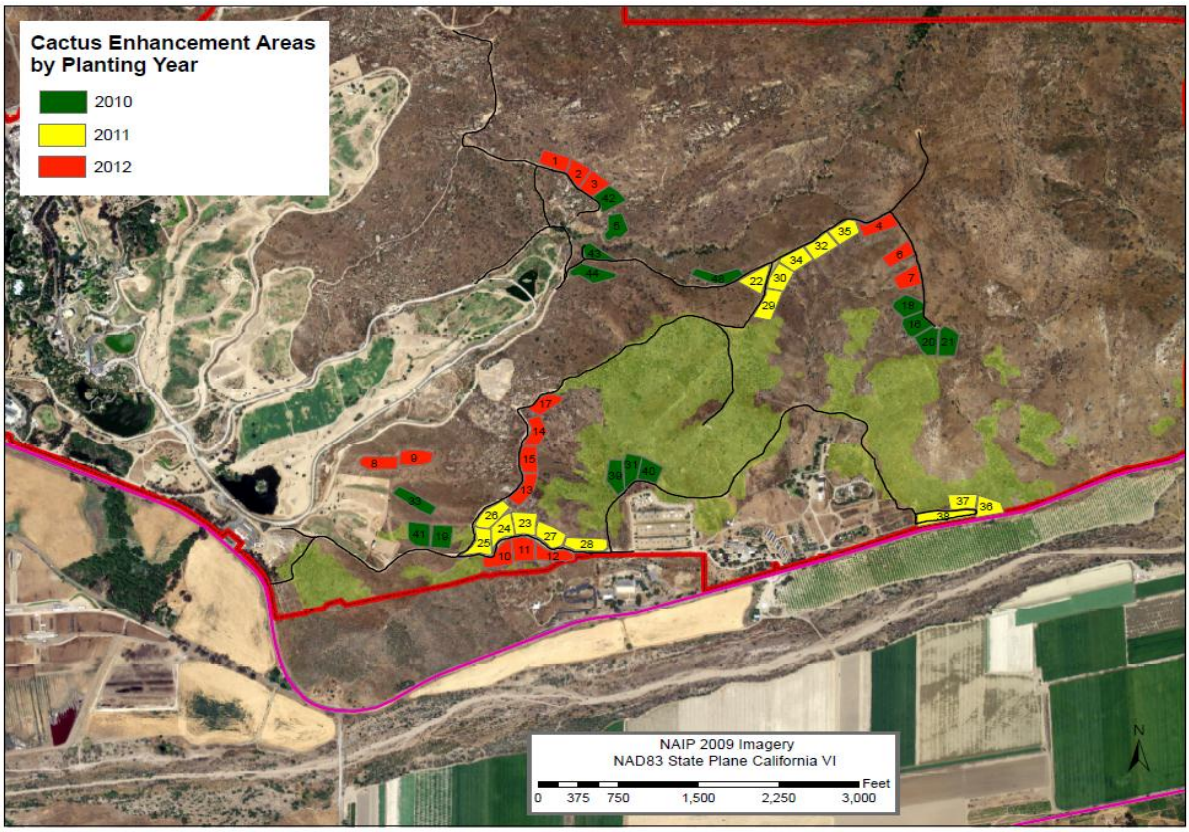


Figure 3: Cactus Enhancement Areas by Planting Year. Each year we planted over 2,250 cacti across 15 once acre plots. The plots were grouped into larger 3-4 acre "enhancement areas" which were more reflective of cactus wren territory size. The light green background layer indicates existing cactus scrub habitat.

Field Planting:

All field plantings occurred in late November/December of each to year to allow the winter rains to aid establishment. The labor was performed by a large number of San Diego Zoo volunteers, local high school students enrolled in the Safari Park Conservation Corps and Zoo Corps programs and ICR staff.

Within each plot, we randomly selected 5 circular subplots, or “islands”, each measuring 5 meters in diameter. Each island was planted with 10 propagated (larger) cacti. One hundred cactus psfd were also directly planted throughout each plot, both within and around the “islands.” As such, a total of 150 cacti, 50 from propagated stock and 100 supplemental pads, were planted in each plot. By using this

planting design we hoped to create a mosaic of tall cactus patches that would establish relatively quickly surrounded by smaller cacti that would take a longer time to reach suitable nesting height but still may help to deter predators and link habitat patches.

In 2010 and 2011, we used a mix of 50% dry-rooted and 50% fresh (calloused but not rooted) pads to supplement the propagated cacti. However, preliminary results from our monitoring efforts indicated that dry-rooting did not provide any establishment benefit and was not a cost-effective strategy. Therefore, in 2012 we used only fresh pads to supplement the propagated plantings.

We often had "extra" cactus cuttings left over at the end of each planting season which we dispersed randomly throughout the plots. To save time/labor, these extras were laid flat on the soil surface in piles rather than planted into the ground. Their locations were not marked and they were not included in any experiments or survival monitoring.

We also supplemented eight plots that had low, less than 15%, native perennial cover with native shrubs and grasses. Non-cactus species planted included Buckwheat (*Eriogonum fasiculatum*), California Sage Brush (*Artemisia californica*), California Sunflower (*Encelia californica*) and Indian Rice Grass (*Stipa coronatum*). Approximately 300 native shrubs were planted per acre.

Herbivore Protection:

Field pilot studies conducted in 2009-2010, indicated that herbivory of the cacti by rodents such as woodrats and brush rabbits would be a constraint to cactus growth and survival, especially during the summer months when water is scarce. To deter herbivores we constructed over 1,000 cages of 1/4" wire mesh (aviary wire) measuring 1.5' in diameter and 2.5' in height. These cages were placed over a subset of the cacti for 1-2 years to protect them from herbivores while they became established. These cacti were monitored through time to assess whether the cages were an effective strategy of deterring herbivores.

Figure 4: Cages were placed over a subset of cacti to test the efficacy of herbivore exclusion.

Supplemental Watering:

In an effort to aid the establishment, we administered supplemental watering to a subset of the cacti and all of the native shrubs during the summer months. Supplemental watering of the cacti was conducted within an experimental framework (discussed further in the Monitoring and Applied Research section of this report) to compare the cost effectiveness of different watering regimes, while the native shrubs were watered monthly.

Task 3 Deliverables:

- *More than 7,000 cacti planted across 45 acres over the course of 3 years*
    - *150 cacti (50 from propagated stock + 100 single-cladode cuttings) planted per acre plus any extra cladodes dispersed throughout restoration sites at the end of each planting season.*

Task 4: Monitoring and Applied Research

4.1 Reserve-wide Habitat Assessment:

We conducted extensive habitat surveys in May and June 2010 to evaluate habitat quality of the cactus scrub across the Biodiversity Reserve and to determine areas in need of enhancement/restoration.

Methods:

Vegetation structure and composition data were collected at a total of 123 points across the reserve to evaluate overall habitat quality. At each point we measured the following habitat variables within a 30x30 square meter area: topographic position; slope; aspect; % cover of shrubs, live cacti, burned cacti, exotics and bare ground; maximum cactus height; shrub species diversity; and native shrub recruitment. Percent cover was rapidly estimated using a Bruan-Blanquet scale. We also thoroughly searched each area for cactus wren nests and recorded the location as well as information on the nest status, i.e. active, old or unknown.

Results:

Results from this survey indicated that habitat quality varies considerably across the reserve from high (large cacti, abundant native shrubs, open bare ground) to low (few cacti or native shrubs, dominated by exotic grasses). Areas with low habitat quality were considered high priority for restoration. A total of 83 coastal cactus wren nests were located during this survey effort, of which 22 were active and 49 were no longer in use. We could not determine the status of 12 nests due to obscured positions in the cactus. As we expected, nest presence was often associated with taller (>1m) cactus height.

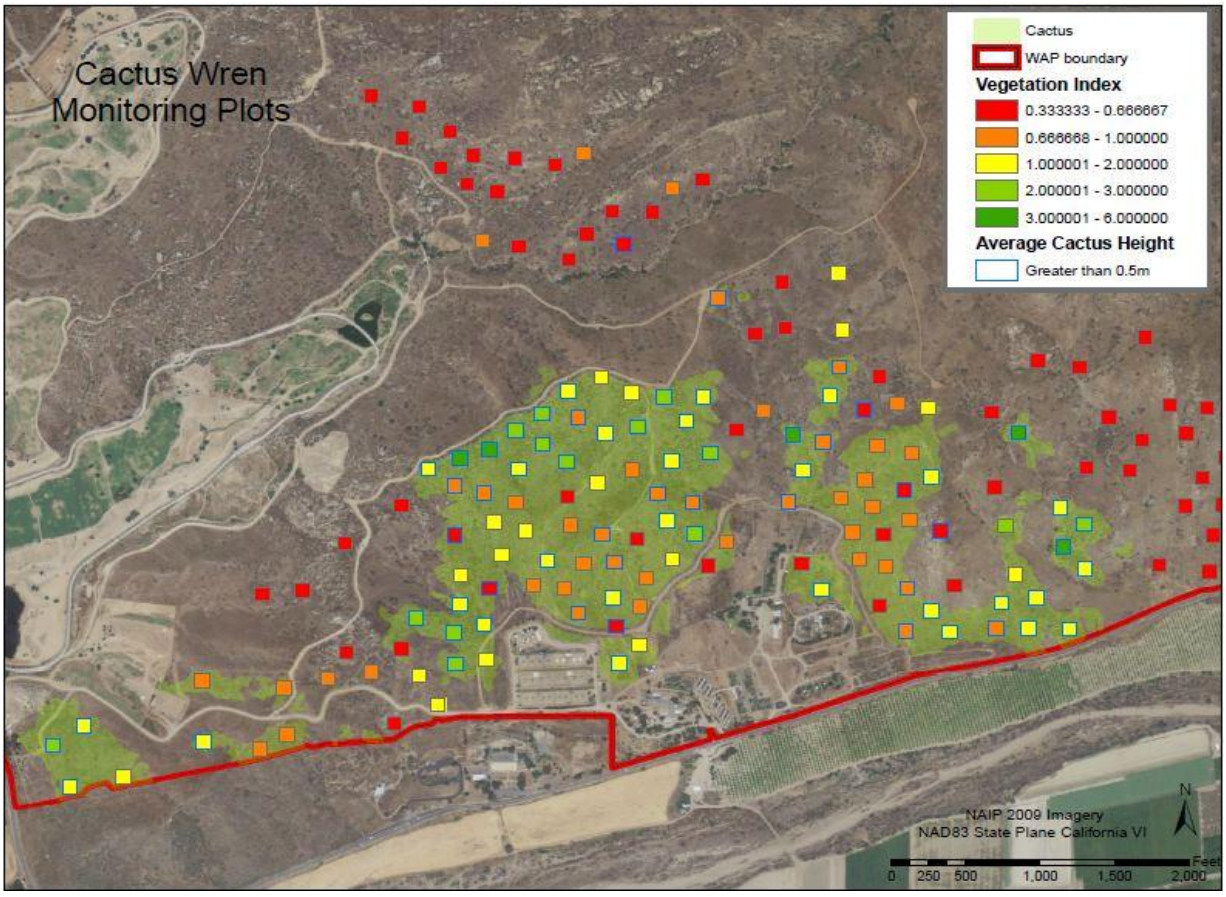


Figure 5: In 2010, 150 30x30 plots were randomly placed within the cactus scrub habitat and were surveyed for cactus wren nests (when found we GPS the location) and several vegetation/habitat variables were measured including cactus abundance, shrub abundance and species composition, exotic grass/forb abundance, presence of perching structures, height of cactus, evidence of burned cacti from 2007, etc. Presented here is an index of 'habitat quality'- the greater the value, the better the habitat quality. Values below 1 are dominated by exotic species and are targeted for restoration. The plots sampled outside of the cactus habitat areas that were cactus scrub in the past, but have been degraded. They are optimal areas for future restoration.

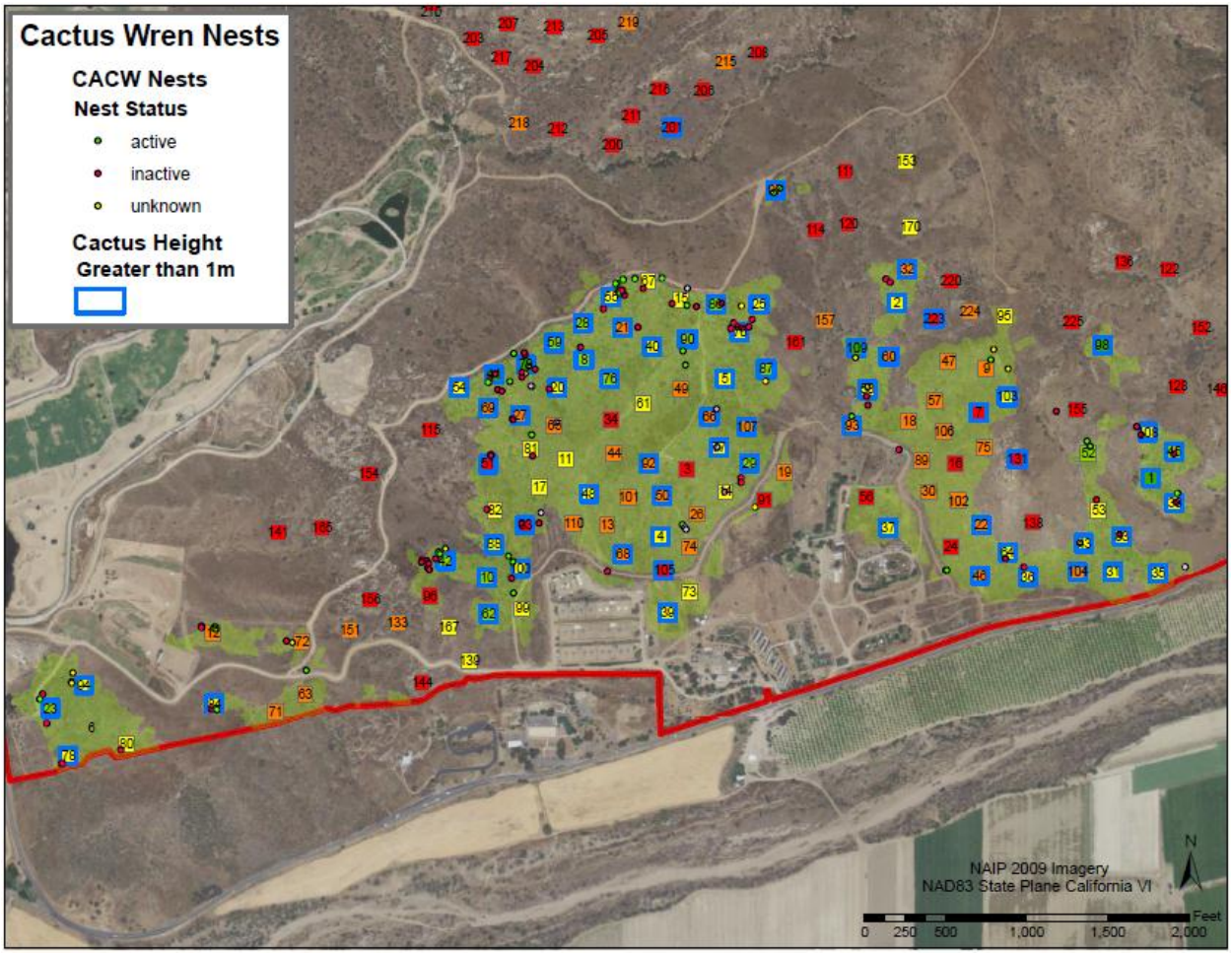


Figure 6: Map of known cactus wren locations and tall cacti. This map shows locations of cactus wren nests within the context of our habitat assessment plots, habitat quality (color like previous map), and cactus height (blue box with larger cacti >1m; i.e. suitable for nesting).

Task 4 Deliverables:

- *Habitat quality assessments across the Safari Park Biodiversity Reserve to prioritize location of enhancement activities.*
- *Cactus wren nest locations mapped in association with habitat quality.*

4.2 Long-Term Vegetation Monitoring in Restoration Areas:

Monitoring of restoration sites is important for evaluating restoration progress and success. As part of our management plan, we established a long-term habitat monitoring protocol that would allow us to assess vegetation changes over time within our restored sites. Due to the relatively long time-frame for cactus growth, we determined that 3 year intervals between vegetation sampling events would be adequate to assess changes in vegetation and structure. Prior to planting, we collected baseline

vegetation data for each site to document site condition prior to any restoration efforts. The first post-restoration sampling for plots planted in 2010 is scheduled to occur in June 2013.

Methods:

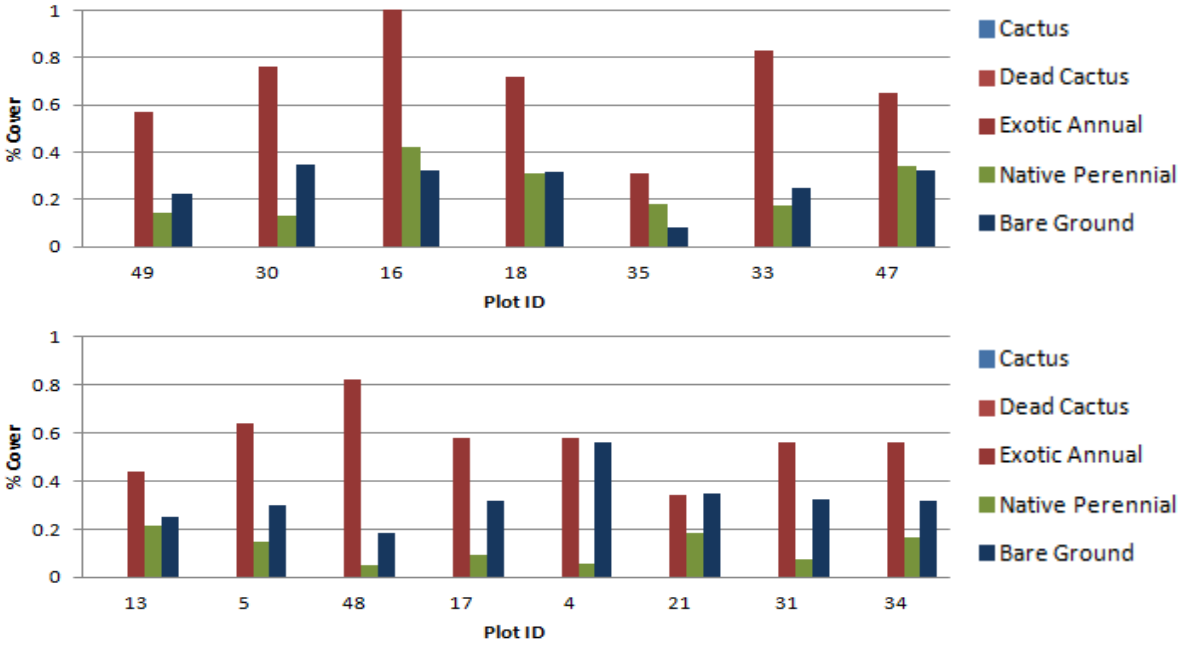
Vegetation monitoring transects were established at varying lengths totaling 200 meters within each restoration plot. All transects run parallel to each other from North to South and are spaced at 15 meter intervals. The start (North) points and lengths for each transect were assigned using ArcGIS software to avoid any bias that may result from selecting transect locations in the field. Once a start point is located in the field, one team member holds the "zero end" of the meter tape at the point while the other walks Southward (using a compass bearing of 180 degrees) while laying out the tape until reaching the length assigned to that transect. Standard line-intercept method is then used to collect data on % cover of vegetation and open ground, as well as vegetation height along the length of each transect.

Figure 7: Interns measure and record data on vegetation cover and structure along a transect line.

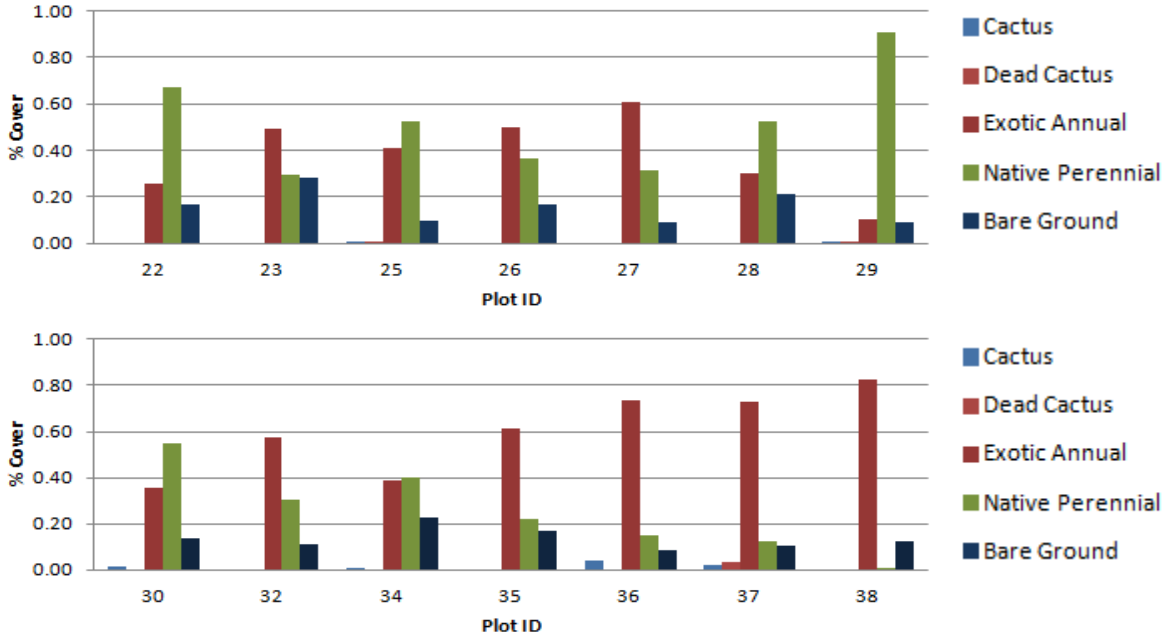
Results:

Baseline vegetation sampling showed that most restoration plots had no cactus cover prior to planting. The few plots that did have preexisting cactus had only a very minimal amount (less than 5% cactus cover). Percent cover of exotic annuals varied considerably and was high (greater than 40%) in most plots. Other functional groups sampled, native cover and bare ground, were also quite variable among plots. This variability is likely due to a variety of factors including year sampled, soil conditions, topographic position, etc.

% Cover of Vegetation in Restoration Plots Planted in 2010



% Cover of Vegetation in Restoration Plots Planted in 2011



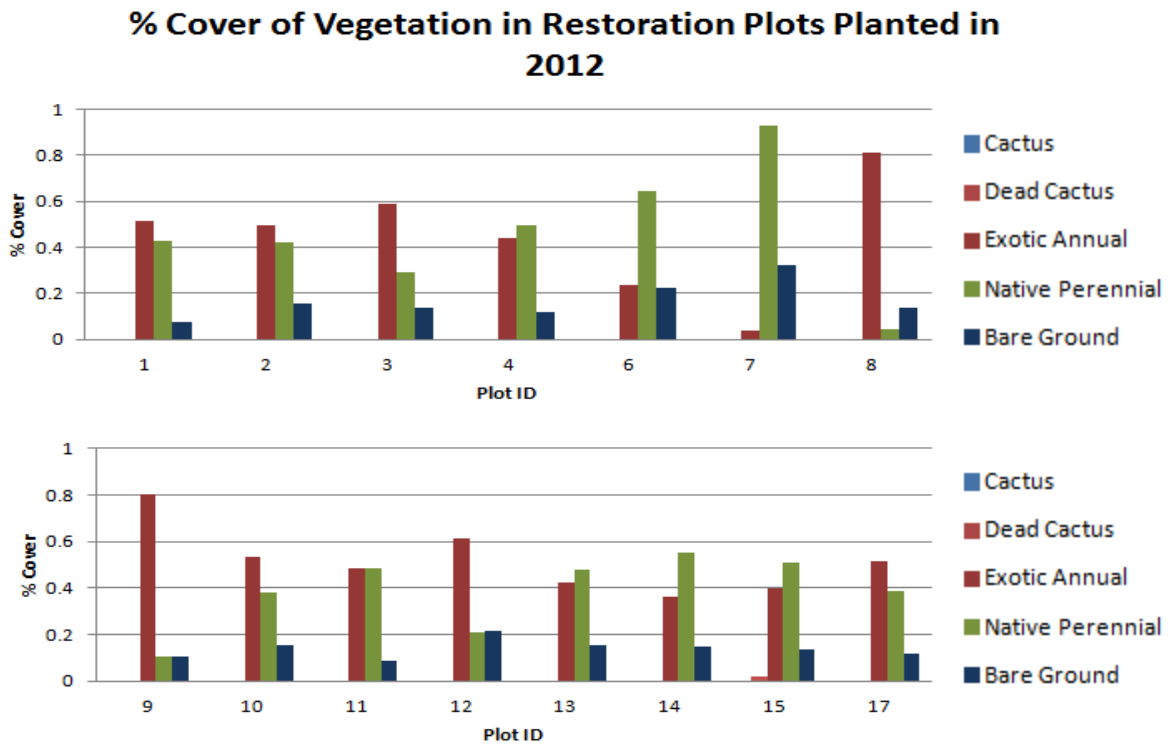


Figure 9: These charts show percent cover of vegetation measured in restoration plots prior to planting. This data will be compared to data collected in future monitoring efforts to evaluate restoration progress.

Task 4 Deliverables:

- *Establishment of a long-term monitoring plan for assessing restoration progress and success.*
- *Baseline habitat data collected for all restoration sites.*

4.3 Cactus Establishment Monitoring:

Within the context of this large-scale restoration effort, we evaluated several techniques for improving cactus survival, establishment and accelerating growth. We compared different head-starting techniques, tested supplemental watering regimes, and examined the efficacy of herbivore exclusion.

During the first year, a subset of plantings were the subjects of relatively small-scale pilots studies. Treatments included supplemental watering at 4, 6 and 8 week intervals during the summer, and using cages to prevent predation by herbivores. We also compared the health and survival of cacti from the different head-starting treatments: propagated cacti, dry-rooted cuttings and fresh "new" cuttings. Based on the results of these pilot studies, larger scale experiments were conducted on the year 2 cactus plantings to evaluate cost-effective techniques for cactus wren habitat enhancement.

Methods:

Year 1 pilot study

	Caging Treatment:	No Cage	Cage			
	Watering Regime:	No Water	No Water	4 Weeks	6 Weeks	8 Weeks
Head starting treatment	Fresh "New" Cladodes	25	25	25	25	25
	Dry-rooted Cladodes	25	25	25	25	25
	Propagated 6 Months	25	25	25	25	25

Table 2: A total of 375 cacti planted in December of 2010 were the subjects of pilot studies testing different methods of increasing cactus establishment. We compared the different head starting treatments, examined the effects of caging, and tested different watering regimes within the caged subset. Each treatment group consisted of 25 randomly selected individual cacti. Cages were placed on the cacti approximately 1 month after planting. Supplemental watering treatments were administered from May through October at 4, 6 and 8 week intervals.

Year 2 Full Study

	Caging Treatment:	No Cage	Cage			
	Watering Regime:	No Water	No Water	4 Weeks	6 Weeks	8 Weeks
Head starting treatment	Fresh "New" Cladodes	40	40	40	40	40
	Dry-rooted Cladodes	40	40	40	40	40
	Propagated 6 Months	40	40	40	40	40
	Propagated 1 Year	40	40	40	40	40

Table 3: Based on preliminary results from the year 1 pilot study, a larger "full" study was conducted in 2011-2013 with more replicates and an additional head starting treatment - cacti propagated for 1 year. For this study each treatment group consisted of 40 randomly selected cacti planted in December of 2011. Cages were placed on the cacti immediately after planting. As with the pilot study, supplemental watering was administered from May through October at 4, 6 and 8 week intervals.

All cacti selected as subjects for these experiments were tagged with individual identification numbers and marked with colored flags that corresponded to watering treatments. We also GPSed the location of each cactus. We revisited these cacti several times to measure growth and survival over time. Variables measured at each visit included: height, number of cladodes (or "cladodes"), number of reproductive structures (buds, flowers and fruits), overall condition or health of the cactus and evidence of browse damage.

Preliminary Results (Data collection and analysis still in progress):

The results presented here are only preliminary results from the pilot study. Data collection is still underway for both the pilot study and the full study as we evaluate the long term effects of the experimental treatments and survival 1-year post-cage removal. Data collection will be complete in Fall 2013 and final analyses for both pilot and full studies will follow.

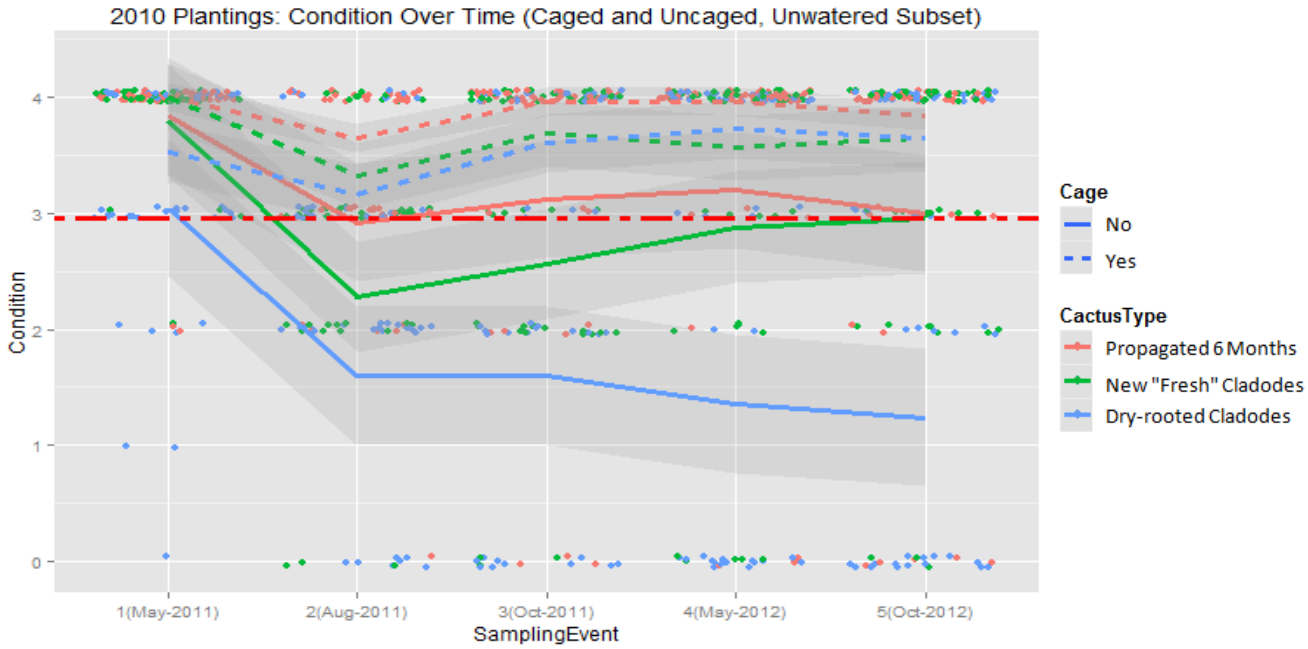


Figure 10: The effect of caging and head-starting treatments on cactus condition and survival over time. Condition was rated on a categorical scale where 4 = healthy (green and plump), 3 = water stressed (thin and wrinkling), 2 = severely water stressed (dry and crispy), 1 = rotting and 0 = dead/gone. Condition scores below 3 (indicated by the red dashed line) were considered unlikely to survive. Condition scores for caged cacti were significantly higher than for uncaged cacti in all three head-starting treatments. Surprisingly, uncaged dry-rooted cacti had the lowest condition scores and lowest survival, possibly because these cacti were most prone to herbivory.

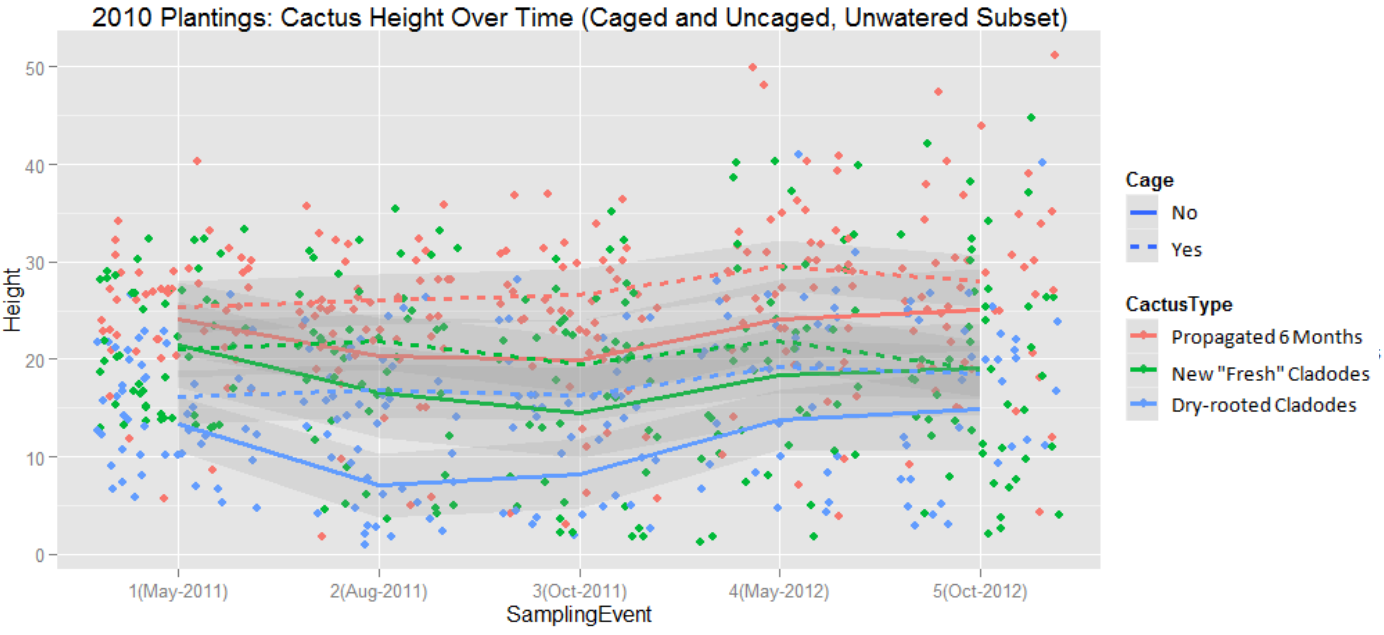


Figure 11: The effect of caging and head-starting treatments on height of surviving cacti over time. Cactus height decreased slightly during the first year of growth but has since been rising. Overall caged cacti were taller than uncaged cacti within each head-starting group though these differences were only significant during the first year of growth.

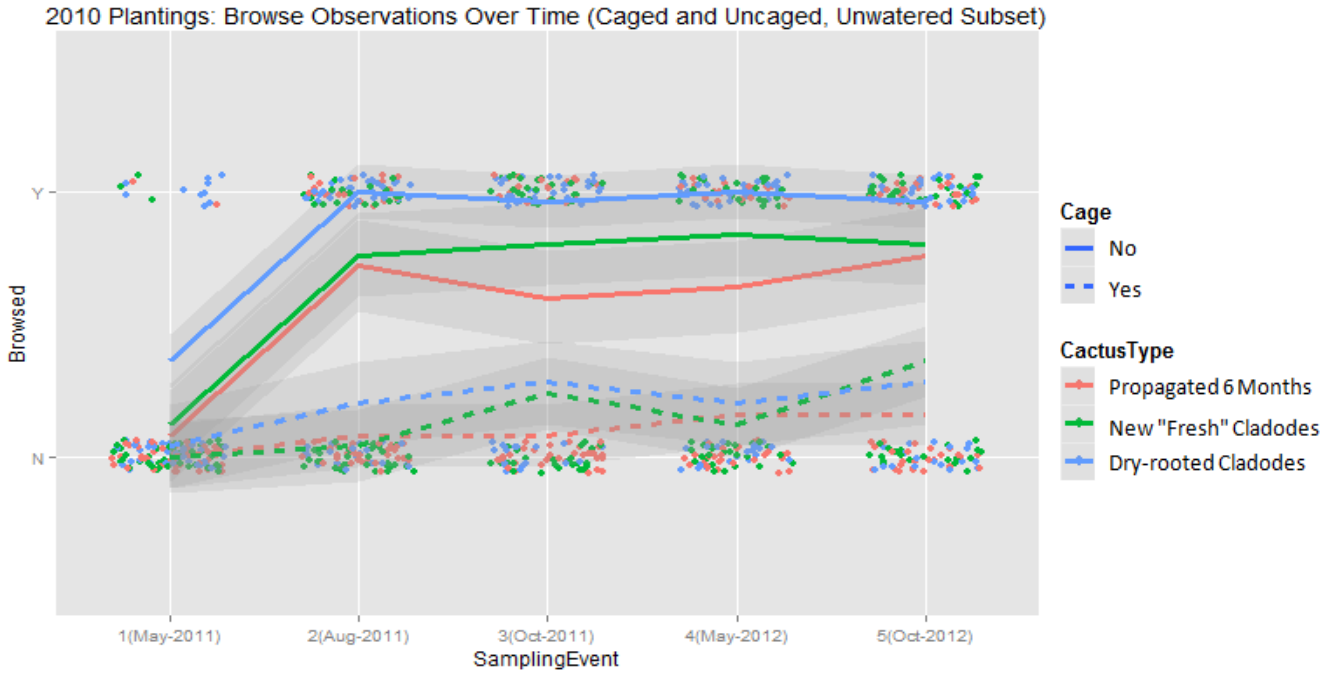


Figure 12: Observed browse damage over time. Caged cacti had significantly fewer recorded browse observations than uncaged cacti.

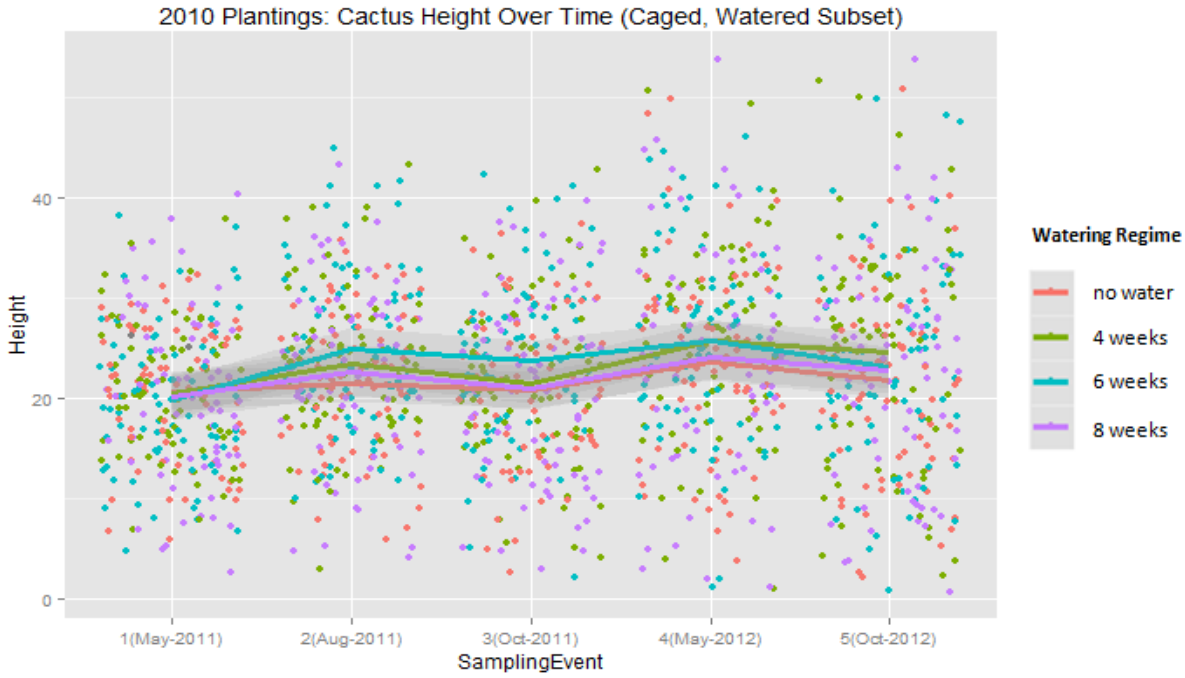


Figure 13: Effect of different watering treatments on cactus height over time. None of the watering treatments had a significant effect on height. Interestingly, watering did not appear to have an effect on any of the measured variables.

Preliminary Conclusions and Recommendations:

Head-starting treatments were found to be correlated with overall height, health and herbivory. Propagated cacti seemed to do the best – they were tallest in height, produced more pads, and had the highest condition scores. Despite already having root system at the time of planting, dry-rooted cladodes seemed to fair the worst of the three treatments. This reduced establishment ability is may be due to internal water loss during the time period between collection and planting.

Preliminary results show that caging is highly effective at reducing incidences of browse; which translates to caged cacti being taller and healthier than uncaged cacti as well as high survival. As such future restoration projects should consider using caging or some other form of herbivore protection, as it appears to be the most effective method of increasing survival and establishment.

Preliminary analyses from the supplemental watering trials suggest that watering during the summer months does not result in any establishment benefit in terms of cactus height or overall health. This is a surprising finding, though for complete statistical analyses are needed to make final recommendations.

Task 4 Deliverables:

- *Evaluation of techniques for improving cactus establishment, growth and survival.*

4.4 Cactus Wren Point Counts:

The Safari Park Biodiversity Reserve is home to one of the largest populations of coastal cactus wrens in San Diego County. After the 2007 Witch Fire, there were strong concerns about the impacts of the fire on the cactus wren population and habitat at the Safari Park. One of our objectives was to evaluate the long-term effects of our restoration efforts on the cactus wren population. To measure this, we established a protocol and survey grid for monitoring the size of the cactus wren population over time.

Methods:

We used variable distance point counts to estimate the number of cactus wrens in the Biodiversity Reserve. Point count surveys were conducted twice per year—once in the breeding season (spring) and once in the non-breeding season (fall)—from fall 2010 through spring 2013. We created a systematic random grid over the reserve in a GIS using the two layers Figure 1 (enhancement areas and cactus scrub) buffered by 50m with points spaced at 175 meters. Each point was visited once per week for three weeks, and all surveys were conducted before 10 AM. At each point, we performed a 10-minute survey in which all cactus wrens seen and heard were recorded, along with each bird's distance and direction from the point. We calculated density estimates by dividing the number of cactus wren detections by the survey area (1.8 km2).

Preliminary Results:

Our estimates of cactus wren density ranged from 0.12-0.17 birds/acre. The highest density occurred in Fall 2011, which followed a particularly productive breeding season. The point count data will be formally analyzed in Program DISTANCE to account for variation in detectability upon completion of data collection. The results of this study will be published and shared with collaborators and other land managers to help inform management of coastal cactus wren populations.

Survey	mean birds/ha	mean birds/acre
2010 Fall	0.29	0.12
2011 Spring	0.30	0.12
2011 Fall	0.41	0.17
2012 Spring	0.32	0.13
2012 Fall	0.29	0.12
2013 Spring	Survey ongoing	

Table 4: Cactus wren density estimates for the Safari Park Biodiversity Reserve.

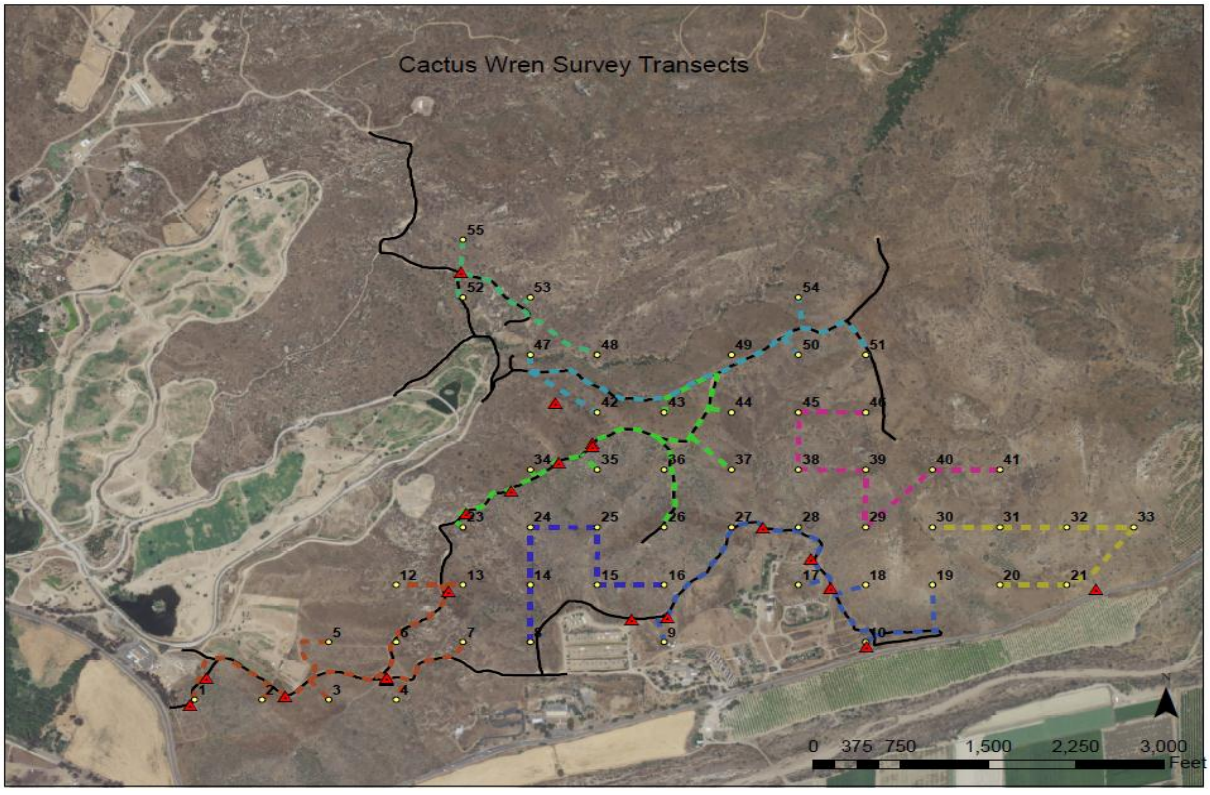


Figure 14: Map of point count locations and transect routes. Point count locations, "points", are shown as yellow dots labeled with their respective identification numbers. The colored dashed lines represent the routes or "transects" travelled to reach consecutive points during surveys.

4.5 Nesting Habitat Vegetation Assessment:

In the summers of 2011 and 2012 we time focusing on the development of a habitat suitability model for the coastal cactus wren. While the presence of cactus is certainly an important factor for cactus wren habitat, very little is known about what other factors make up desirable habitat for the coastal cactus wren. A clear understanding of cactus wren habitat characteristics will inform successful restoration. In this study, we sought to characterize successful nesting habitat by comparing the structure and composition of vegetation in areas with active cactus wren nests to areas in cactus where nests are not present at the Safari Park and San Pasqual Valley.

Methods:

We randomly selected fifty, cactus containing, 1-acre square sites spanning San Pasqual valley using ArcGIS10.1. We visited each site and searched for the presence of nests and used a GPS to mark the location of all nests detected. For sites in which there were no nests, the most centrally located cactus was selected as a control. Our nest search resulted in the mapping of 88 nests and 24 control sites from which we randomly selected 19 of each type for a total of 38 survey sites.

We evaluated cactus characteristics to determine the importance of cactus size and relative location to *Sambucas nigra* and other shrubs. Maximum height, circumference, and nest height within the cactus were recorded. In addition, we measured the distance to the nearest *S. nigra* if one was visible as well as the distance to the nearest shrub from the nest opening. Percent cover of surrounding vegetation was assessed using line-intercept method along five ten-meter transects centered over the nest or control cladodes were placed 2.5 meters apart (see Figure 9).

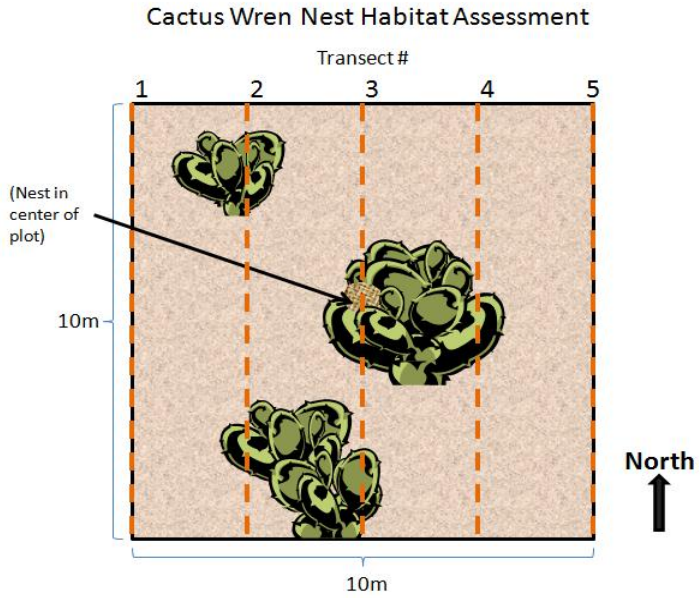


Figure 15: Illustration of a nest-habitat assessment plot. Line-intercept method was used to measure percent cover of vegetation along five parallel ten-meter transects spaced 2.5 meters apart centered over the nest or control cactus.

Preliminary Results (data collection and further analysis are still underway):

Preliminary analyses show that cactus wrens tend to select areas with greater cactus cover and larger cacti. They also seem to prefer areas with more open space and reduced annual herbaceous cover. Furthermore, the relative height of surrounding shrubs to cacti appears to be an important factor in nest site selection. We plan to continue these sampling efforts in the summer of 2013 (post breeding season) to increase our sample size. The results of this study will be published and shared with collaborators and other land managers to help inform restoration efforts.

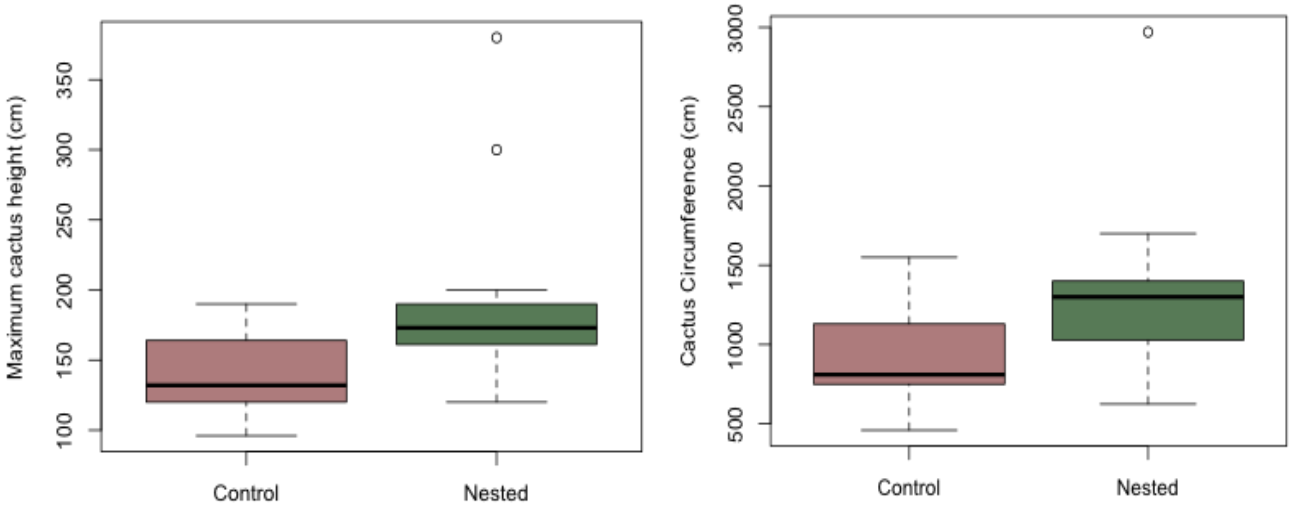


Figure 16: Nests were typically found in taller cacti with a relatively wide circumference.

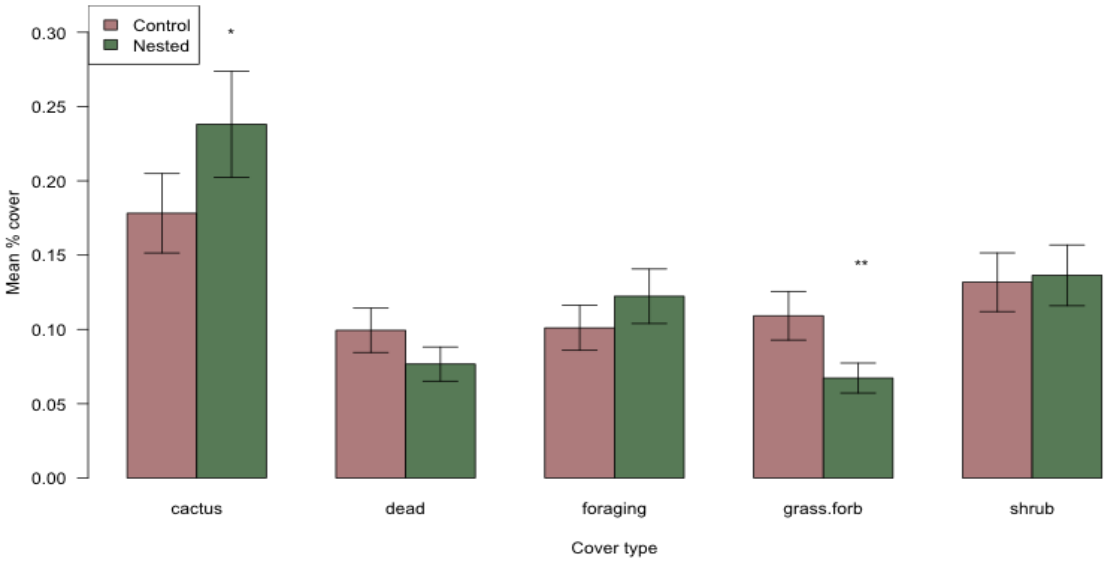


Figure 17: Nests were found in areas with greater cactus cover (20-30%), low annual grass/forb cover (less than 8%) and more open bare ground for foraging.

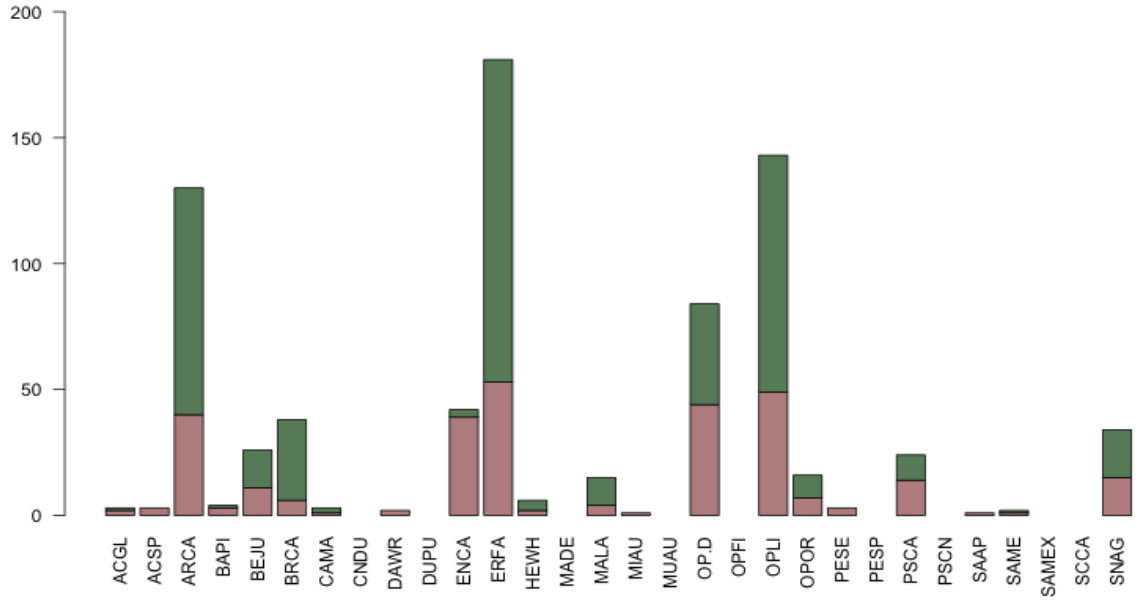


Figure 18: Species highly associated with cactus wren nests include California Sage Brush *(Artemisia californica*), California Buckwheat *(Eriogonum fasiculatum)* and Coast Prickly Pear *(Opuntia littoralis).* Interestingly, California sunflower (*Encelia californica*) appears to be negatively associated with cactus wren nest locations.

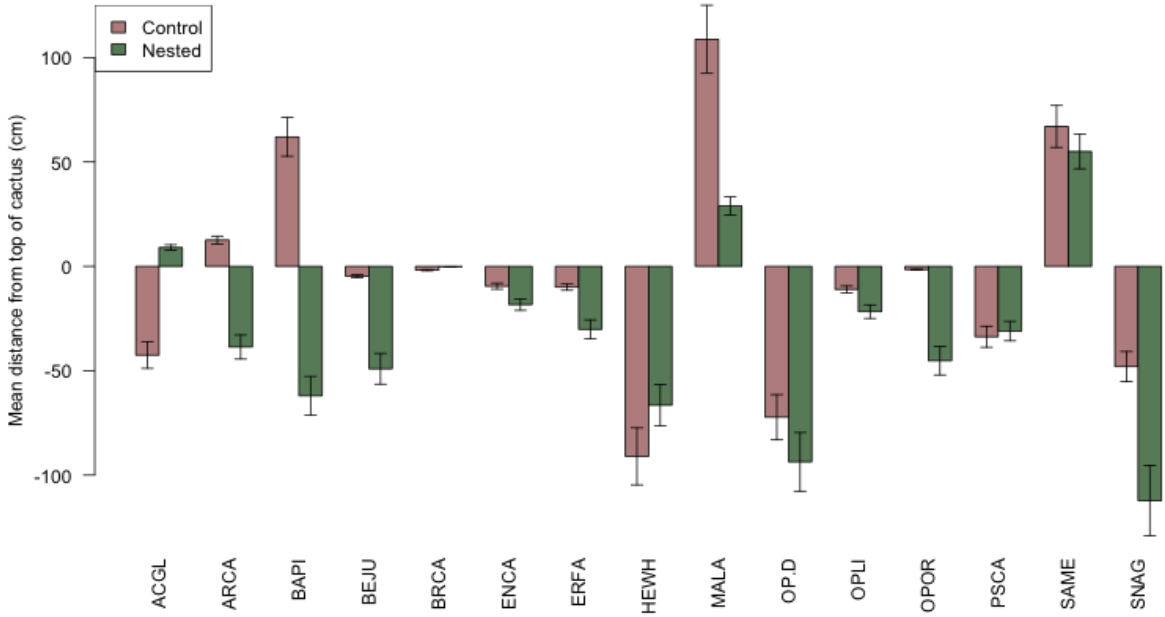


Figure 19: Cactus wrens appear to build nests in cacti that are taller than surrounding vegetation. This could be to protect the nest from predators that may use the surrounding tall vegetation to access the cactus.

Preliminary Conclusions and Recommendations:

Large cacti that are taller than surrounding vegetation may afford maximum protection from nest predators. As such, care should be taken, during restoration efforts, to ensure that favored shrubs are planted such that they will not overtake cactus or exceed preferred heights. An open foraging area free of invasive annuals surrounding the nest site appears to be important, as such future restoration efforts should control for exotic annuals in addition to planting cactus and shrubs. Furthermore, we may be able to refine "near perfect" habitat sites that already have large cacti through invasive species control and selective pruning of large shrubs growing close to cacti.

Task 4 Deliverables:

- *Evaluation of habitat characteristics at nest sites, which will contribute to the creation of a habitat suitability model for San Pasqual Valley cactus wrens.*

4.6 Cactus Wren Banding and Genetics

We assisted the ICR Genetics division with their efforts to band and collect genetic samples (blood or feathers) from the cactus wrens in Spring 2012. In 2012, we captured 32 cactus wrens (22 adults, 2 fledglings, and 8 nestlings). Genetic samples were taken from each, except one fledgling. Each individual captured was marked using a numbered green anodized aluminum leg band and plastic colored bands allow us to identify individuals during point counts, which in turn gives us information on cactus wren dispersal and survival within the Safari Park population. We are also coordinating with USGS, who captured and banded 37 cactus wrens (5 adults, 11 fledglings, and 21 nestlings) in 2011 as part of a study examining cactus wren genetic connectivity. Out of the 32 cactus wrens captured in 2012, 4 adults were recaptures, already banded by USGS.

Researchers from the ICR Genetics division performed analyses comparing the Safari Park populations of cactus wrens and mockingbirds, using both historic and current samples. Surprisingly, the Safari Park cactus wren population had a higher genetic diversity and two more alleles per locus on average than northern mockingbirds on Catalina Island. This suggests that the assumed isolation created by urbanization and habitat degradation has not yet reduced the genetic diversity of this cactus wren population to levels similar to an island population of a species as abundant and healthy as the northern mockingbird. The population of northern mockingbirds on Catalina Island did have lower genetic diversity than northern mockingbirds in San Diego County, consistent with theories of island-mainland dynamics.

Task 4 Deliverables:

- *65 cactus wrens banded at the Safari Park Biodiversity Reserve*
- *Genetic evaluation of cactus wren population status at the Safari Park*

Summary:

Over the past three years we have successfully accomplished all of our objectives. We created a cactus propagation and salvage center that will serve as a long-term resource providing native cacti materials for restoration projects throughout the North County. We collected and propagated more than 2,000 prickly-pear cacti per year for restoration and enhanced of 45 acres of habitat within the Safari Park Biodiversity Reserve over the course of three years. We also monitored establishment and growth of planted cacti, measured cacti responses to different methods of enhancing establishment, collected baseline habitat data for restoration plots and monitored cactus wren abundance and habitat use in relation to habitat characteristics and enhancement efforts. Due to the slow growth of cacti and our interest in measuring long-term effects of management, we plan to continue collecting data and monitoring into the future. We expect that data collection and analysis on cactus growth and survival in response to the different establishment treatments will be complete for publication by the end of 2013. Data collection and analysis for nest-habitat suitability and cactus wren population estimates will also be complete by the end of 2013. Long-term monitoring of restoration sites will continue until planted cacti are mature and capable to supporting cactus wrens. This data will be published and shared with local partners and other land managers to help inform future management and restoration for coastal cactus wrens.

Please, let me know if you have any questions.

Sincerely,

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