

Revegetation and Monitoring the Cactus Forest Loop Road Saguaro National Park

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Overview

The Cactus Forest Loop Road Revegetation and Monitoring is comprised of several components. The first component was scouting the area for future impact and identifying vegetation that would be damaged or destroyed. Saguaro cacti to be impacted were removed and immediately transplanted in another area. Other cacti were salvaged, potted, and held over for transplanting post-construction. Some grasses and woody seedlings were also salvaged. Seeds, previously collected from the area were grown out at the Plant Material Center in Tucson. RECON Environmental Inc. was contracted to do the post-construction revegetation. Revegetation was conducted between January and March 2007. Thereafter, Park assumed responsibility of maintaining and monitoring the sites and individual plants.

There are a total of 104 revegetation sites with 1562 plants, dispersed over 8 miles, most of which is one-way. Maintenance included hand watering the transplanted plants, by far the biggest challenge, exotic plant removal, and removing the herbivory cages. An estimated 38 trees were removed during the project and to mitigate the loss of cactus ferruginous pygmy owl habitat, 260 mesquite and palo verde trees were planted. The survivorship of all plants was recorded after one year and the survivorship of trees was recorded after one and two years.

Post-construction long-term monitoring (2 years) monitoring assures the survival of the trees but provides us the opportunity to learn what species do well and what species are best suited for the different sites. As of January 2008, the overall survival rate is 85.6% and 65.5% for trees. As of January 2009 the survivorship of trees was 61.6%, marking only a loss of 10 trees that had previously survived to the one year point. Together the activities of revegetation and maintaining the plants has resulted in achieving restoration objectives.

Watering

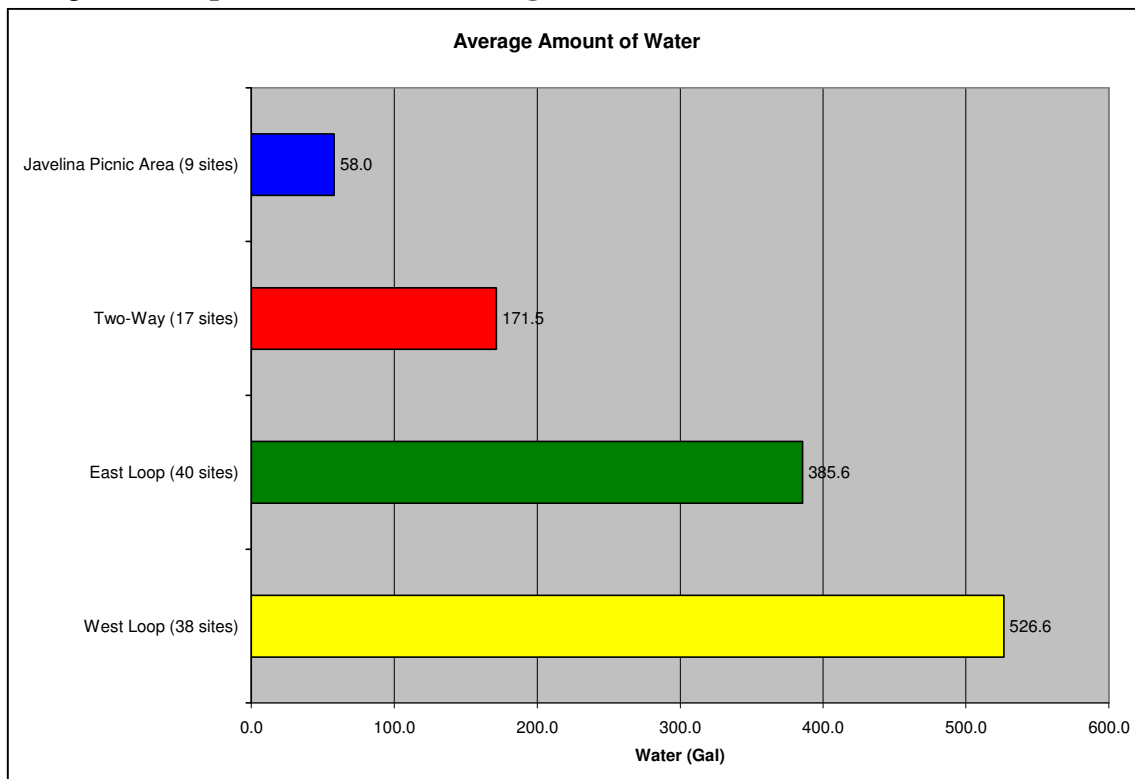
At the time of transplanting, wells were dug around individual plants to capture and more efficiently use water. The wells began to fill with dirt over time, therefore it is necessary to re-contour them. All of the transplanted plants were watered on a regular schedule during the months of May through July in the first year and during the months of May through June the second year. Watering over 1500 plants is a very intense and physically exhausting job; especially with temperatures exceed 100° F. During dry periods of the summer and following the monsoon season, plants required supplemental water.

Additional factors made watering even more challenging. Only about 100 gallons (approximately 800lbs) of water can be dispersed for each trip due to space and weight

constraints of the vehicle. Five-gallon plastic water jugs proved to be the most efficient and effective means for water transport and plant watering. It required ten trips to visit all 104 sites. To further complicate the issue, the Cactus Forest Loop Road is primarily one-way, has a speed limit of 25mph and takes approximately 45 minutes to drive. Thus for every trip, there is a considerable amount of time spent driving. Also, because many of the revegetated sites were obliterated pull-outs, a suitable place to pull over may be some distance from the site.

As of February 2009 a total of 14,200 gallons of water was used for maintaining the plants. On average this equates to 1142 gallons of water for one complete watering episode and approximately 0.8 gallons per plant per visit. Figure 1 depicts the average dispersion of water to the different sections of the road. The West Loop consists of 38 sites starting at the beginning of the loop road and continuing to Loma Verde Trailhead. The East Loop (40 sites) continues from the Loma Verde Trailhead to the end of the one-way section of the road. The Two-Way section (17 sites) includes all sites on the two-way portion of the road. The Javelina Picnic Area has nine sites.

Figure 1: Dispersion of Water amongst Different Sections



Exotic Plant Removal

Exotic plant removal is especially important to remove the competition for resources. The entire Cactus Forest Loop Road was walked in October 2007 to map and remove exotics. The road has been monitored for newly germinated plants since October 2007. The primary species that were removed along the roadway include: *Brassica tournefortii*

(Saharan mustard), *Bromus rubens* (red brome), *Centaurea melitensis* (malta starthistle), *Cynodon dactylon* (Bermuda grass), *Enneapogon cenchroides* (soft-feathered pappus grass), *Eragrostis cilianensis* (stink grass), *Eragrostis echinochloidea* (tick grass), *Eragrostis lehmanniana* (Lehmanns lovegrass), *Marrubium vulgare* (horehound), *Melinis repens* (natal grass), *Pennisetum ciliare* (buffelgrass), *Pennisetum setaceum* (fountain grass), *Sisymbrium irio* (London rocket), and *Sorghum halepense* (Johnson grass). Species were removed by using a rock hammer, hula hoe, or digging bar. Fortunately few sites had infestations; the majority of the sites only had a few individual exotic plants. Along the roadway, the patches of exotics tended to be isolated in micro-environments, for example: natal grass and horehound tended to be near washes. The most widespread exotic plant was London rocket, an annual cool-season mustard that the park does not actively manage. Lehmanns lovegrass is the second most widespread invasive. This grass was treated in and around the revegetated sites, but was left untreated in most other areas because of how widespread it is.

We feel confident that the construction equipment was not responsible for bringing these species in because all of the above mentioned species are found in the park.

Monitoring

Monitoring is essential not only for ensuring tree survivorship but also for future restoration projects. We conducted photo monitoring in addition to surveying each individual plant. Plant monitoring began in September 2007 and continued through January 2008, while tree monitoring continued through January 2009. Photographs are an important part of this monitoring process. They allow for the visual observation of change at each site. Twenty-three photo monitoring sites were set up pre-construction. Photographs were taken pre- and post- revegetation and in September 2007 and January 2009. Several examples are at the end of the report. The monitoring photos reside on the park's computer network.

To monitor the individual plants, each site had to be inventoried to ensure that it matched with the planting records provided by RECON Environmental Inc. Metal tags with labels were placed on the trees (*Prosopis velutina*, *Cercidium microphyllum*, and *Cercidium floridum*), to ensure identification in future monitoring events. Each individual plant was recorded as dead, alive, or missing. These tags were removed following the second year of monitoring in all areas except at Javelina Rocks, where extensive social trails exist.

Each of the transplanted individuals had a chicken wire cage placed around them to prevent herbivory. Nearly all of the plants had out grown their cage and needed to be removed by the second year of this project. In other cases, the plant had died so the cage was removed. Many of the cages were disturbed; several had been trampled, were missing and had blown over. It appeared that more cages tended to be trampled or go missing in areas where there is a high amount of human traffic (i.e. Javelina Rocks, site 68). It is also possible that animals may have been the source of these disturbances.

Monitoring Results

Overall, the results of the monitoring are encouraging. For individual tree species after the second round of monitoring: 100% survivorship (1 tree) of *Cercidium floridum*, 55.3% survivorship (68 trees) of *Cercidium microphyllum* and 67.2% survivorship (92 trees) of *Prosopis velutina*. The overall tree survivorship was 64.6%. A total of 1,340 plants (including the trees) survived the first year with a survivorship of 85.6%. *Digitaria californica* (Arizona cottontop), *Acacia greggii* (catclaw acacia), *Bouteloua curtipendula* (sideoats grama), and *Sphaeralcea ambigua* (globemallow) had 100% survivorship. *Ephedra trifurca* (Mormon tea) had the lowest survival of 15.4%. All of the grasses did well with the lowest survival rate of 90.3%. Figure 2 summarizes the survivorship by species.

The salvaged *Mammalaria sp.* (pincushion cacti) and *Echinocereus fasciculatus* (hedgehog cactus) did extremely well at most of the sites. Salvaged debris and natural litter helped provide shade for salvaged and transplanted plants. Salvaged *Ferocactus wislizenii* (fish-hook barrel) and *Fouquieria splendens* (ocotillo) appear to be doing well, especially the smaller individuals. *Opuntia sp.* (cholla) was the only cactus that seemed to have a difficult time transplanting. While they may not survive, they provide vertical mulch. Each site was sown with seeds collected in the area. Many of the sites appeared to have good germination and some appeared to have minimal or no germination. This is most likely due to different soil types.

Figure 2: Survivorship After One Year

	Total Planted	Total Surviving	% Survivorship
Species			
<i>Acacia constricta</i>	56	48	85.7
<i>Acacia greggii</i>	46	46	100.0
<i>Aristida purpurea</i>	34	32	94.1
<i>Baileya multiradiata</i>	2	1	50.0
**<i>Bouteloua curtipendula</i>	27	28	**103.7
<i>Bothriochloa barbinodis</i>	48	41	85.4
<i>Bouteloua repens</i>	77	71	92.2
<i>Calliandra eriophylla</i>	26	23	88.5
<i>Celtis pallida</i>	30	28	93.3
<i>Cercidium floridum</i>	1	1	100.0
<i>Cercidium microphyllum</i>	123	76	61.8
<i>Dalea pringlei</i>	16	12	75.0
<i>Dalea pulchra</i>	16	8	50.0
**<i>Digitaria californica</i>	29	35	**120.7
<i>Encelia farinosa</i>	94	87	92.6
<i>Ephedra trifurca</i>	13	2	15.4
<i>Ericameria laricifolia</i>	9	8	88.9
<i>Fouquieria splendens</i>	59	71	88.8
<i>Gossypium thurberi</i>	31	29	93.5
<i>Heteropogon contortus</i>	43	42	97.7
<i>Isocoma tenuisecta</i>	112	96	85.7
<i>Jatropha cardiophylla</i>	1	1	100.0

<i>Larrea tridentata</i>	85	68	80.0
<i>Menodora scabra</i>	44	33	75.0
<i>Muhlenbergia porteri</i>	32	31	96.9
<i>Nicotiana trigonophylla</i>	4	3	75.0
<i>Prosopis velutina</i>	137	92	68.6
<i>Psilostrophe cooperi</i>	37	33	89.2
<i>Senna covesii</i>	30	18	60.0
<i>Setaria macrostachya</i>	31	28	90.3
<i>Simmondsia chinensis</i>	50	39	78.0
<i>Sphaeralcea ambigua</i>	9	9	100.0
<i>Trixis californica</i>	49	44	89.8
<i>Zinnia acerosa</i>	193	185	95.9
TOTAL	1566	1340	85.6%

**More found during monitoring than reported during the revegetation.

Figure 3: Survivorship of Tree Species After Two Years

	Total Planted	Total Surviving	% Survivorship
Species			
<i>Cercidium floridum</i>	1	1	100.0
<i>Cercidium microphyllum</i>	123	68	55.3
<i>Prosopis velutina</i>	137	92	67.2
TOTAL	261	161	61.7

Summary

Based on these results, grass species, zinnia, creosote, globemallow, and acacia species would be ideal candidates for future restoration projects. It is important to maintain the local diversity of species and use seeds collected near the site. Overall, the sites appear to be re-establishing well; full recovery may take many years to decades. The objectives of the tree survivorship were met. A minimum of 100 trees were to survive and currently there are 161 trees surviving. This is 1.6 times as many trees that were required to survive to become habitat for the cactus ferruginous pygmy-owl.

Site 88

January 2007 (Before)



January 2007 (After)



September 2007



January 2009



Site 88 experienced a low survival rate for trees. Three out of the six trees died. All of the trees that did not survive were velvet mesquite (*Prosopis velutina*). Overall this site saw a 71.4% survival rate where ten out of the fourteen plants survived. The only other plant that did not survive was a single senna (*Senna covesii*). African lovegrass was present at this site.

Site 33

January 2007 (Before)



February 2007 (After)



September 2007



January 2009



Site 33 is site that still needs more work. It experienced a 41.7% survival rate. Only five out of the twelve plants survived. One of the plants that perished was the only tree at this site, a foothills palo verde (*Cercidium microphyllum*). The five plants that survived include: catclaw acacia (*Acacia greggii*), side oats grama (*bouteloua curtipendula*), creosote bush (*larrea tridentata*), senna (*Senna covesii*), and zinnia (*Zinnia acerosa*).

Site 84

January 2007 (Before)



January 2007 (After)



September 2007



January 2009



Site 84 experienced a 100% survival rate with all sixteen plants flourishing. The lone tree, a velvet mesquite, is thriving. On top of that, many plants have come up from seed, including several brittlebush (*Encelia farinosa*).

Site 38 (Loma Verde Trailhead)

January 2007 (Before)



February 2007 (After)



September 2007



January 2009



The Loma Verde Trailhead is one of the many successes of this project. This site consisted of fairly large area to revegetate. Despite this, it had an excellent survival rate. Out of the forty-eight plants to be monitored, only three did not survive. This is a 93.8% survival rate. The three plants that did not survive consisted of two of the thirteen desert cotton (*Gossypium thurberi*) and one foothills palo verde (*Cercidium microphyllum*). Seven out of the eight trees survived.