RESTORATION STRATEGIES FOR BAKERSFIELD CACTUS (*OPUNTIA BASILARIS* VAR. *TRELEASEI*):

TRIAL POPULATION ESTABLISHMENT AT THE BENA LANDFILL CONSERVATION AREA

PREPARED FOR U.S. BUREAU OF RECLAMATION

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EXECUTIVE SUMMARY

Bakersfield cactus (*Opuntia basilaris* var. *treleasei*) is endemic to the southeastern corner of the San Joaquin Valley. Many sites with cactus have been converted to agricultural and urban uses, and remaining populations are fragmented and generally occur on small parcels. Populations of Bakersfield cactus continue to be lost, and habitat conditions are being degraded for some remaining populations. Consequently, the species is listed as federally and state endangered. The establishment of additional populations could contribute significantly to the conservation and ultimate recovery of Bakersfield cactus. Translocation is a potential strategy for establishing new populations for this species.

We translocated Bakersfield cactus pads and clumps from the Center for Natural Land Management's Sand Ridge Preserve to Kern County's Bena Landfill Conservation Area, with the objectives of (1) establishing a population of Bakersfield cactus in currently unoccupied habitat, and (2) determining the most effective strategy for conducting such population establishment. In fall 2009, 10 clumps and 25 shed pads were translocated.

As of May 2011, 100% of clumps were still alive as were 48% of pads. Surviving pads were heavier and generally larger when initially collected. All 10 clumps and all 12 surviving pads had produced new pads. Also, 4 of the clumps and 1 of the pads produced flowers in 2011. Devices were installed over some plants in an attempt to protect them from damage by cattle. None of the 13 surviving plants with guards were damaged by cattle whereas 44.4% of the 9 surviving plants without guards were damaged.

Based on the results of this project, translocation may constitute an effective strategy for establishing new populations of Bakersfield cactus, although continued monitoring of the success of the Bena Landfill population would be prudent. After just 1.5 years, plants within the new population exhibited substantial growth in the form of new pads, and signs of attempted reproduction, including flower production and shed pads. Translocated clumps were more successful than shed pads, although removal of clumps might constitute more of an impact to source populations. Also, strategies such as supplemental water during the first summer or propagation of pads into small plants prior to translocation might increase the success of pads. Cattle guards were effective in preventing damage from cows. Translocation could contribute significantly to conservation and recovery efforts for Bakersfield cactus.

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INTRODUCTION

Bakersfield cactus (*Opuntia basilaris* var. *treleasei*) is endemic to the southeastern corner of the San Joaquin Valley. The species historically occurred from just north of Bakersfield down to the Wheeler Ridge area at the southern end of the valley; cactus populations may have been more or less continuous within this area. Many sites with Bakersfield cactus have been converted to agricultural and urban uses. Approximately one-third of cactus locations have been lost (U.S. Fish and Wildlife Service 1998). Remaining Bakersfield cactus populations are fragmented and generally occur on small parcels. Although some of these parcels are protected lands (e.g., California Department of Fish and Game, Center for Natural Lands Management), an increasing number are surrounded by incompatible land uses (e.g., urban development) and are subject to frequent disturbance from destructive trespass activities (e.g., off-highway vehicle use, fires). Also, some of the remaining cactus populations are on private lands where developments are planned. Thus, populations of Bakersfield cactus continue to be lost, and habitat conditions are being degraded for some remaining populations.

The probability of extinction decreases and long-term viability increases as the number of individuals and populations of a species increases. Thus, successful establishment of additional populations could contribute significantly to the conservation and ultimate recovery of Bakersfield cactus. Given the highly fragmented state of remaining natural lands and inherent characteristics of the species (e.g., dispersal mainly by down-hill or down-stream movement of shed pads), natural dispersal of Bakersfield cactus to unoccupied habitat is highly improbable.

New Bakersfield cactus populations potentially could be established in unoccupied habitat via the translocation of pads and clumps. Cactus pads commonly detach from plants and root resulting in new plants. Cactus plants also have successfully been excavated and planted in new locations. Using one or both of these means, small Bakersfield cactus populations have been established in several locations including the California Living Museum, Facility for Animal Care and Treatment, East Hills Mall, and China Grade Landfill (all sites are in Bakersfield). Thus, translocation of cactus pads and clumps may constitute a viable strategy for restoring Bakersfield cactus within its ecosystem.

We translocated Bakersfield cactus pads and clumps from the Center for Natural Land Management's Sand Ridge Preserve to Kern County's Bena Landfill Conservation Area, with the objectives of (1) establishing a population of Bakersfield cactus in currently unoccupied habitat, and (2) determining the most effective strategy for conducting such population establishment.

STUDY AREA

SOURCE POPULATION

Bakersfield cactus pads and clumps were collected from the Sand Ridge Preserve (Preserve), located approximately 15 kilometers east of the city of Bakersfield (Kern County, California), at the base of the Tehachapi Mountains (Figure 1). The 109-hectare Preserve is owned by the Center for Natural Lands Management. The Bakersfield cactus population at the Preserve is estimated to consist of over 2,000 clumps, and is among the four largest remaining populations. Bakersfield cacti are most abundant on top of the ridge and along the eastern slope. For the area of the Preserve from which we collected the cactus pads and clumps, the soil is sandy and well drained. The elevation of the collection area was ca. 250 m. The plant community at the Preserve is a relatively unique combination of San Joaquin Valley and Mojave Desert species. Dominant shrub species include cheesebush (*Hymenoclea salsola)*, Mormon tea (*Ephedra californica)*, and bladderpod (*Isomeris arborea)*. Dominant herbaceous species include non-native grasses such as wild oats (*Avena fatua)* and ripgut brome *(Bromus diandrus*), and native forbs such as sand verbena (*Abronia pogonantha)*, Coulter's jewelflower (*Caulanthus coulteri)*, and chia (*Salvia columbariae)*.

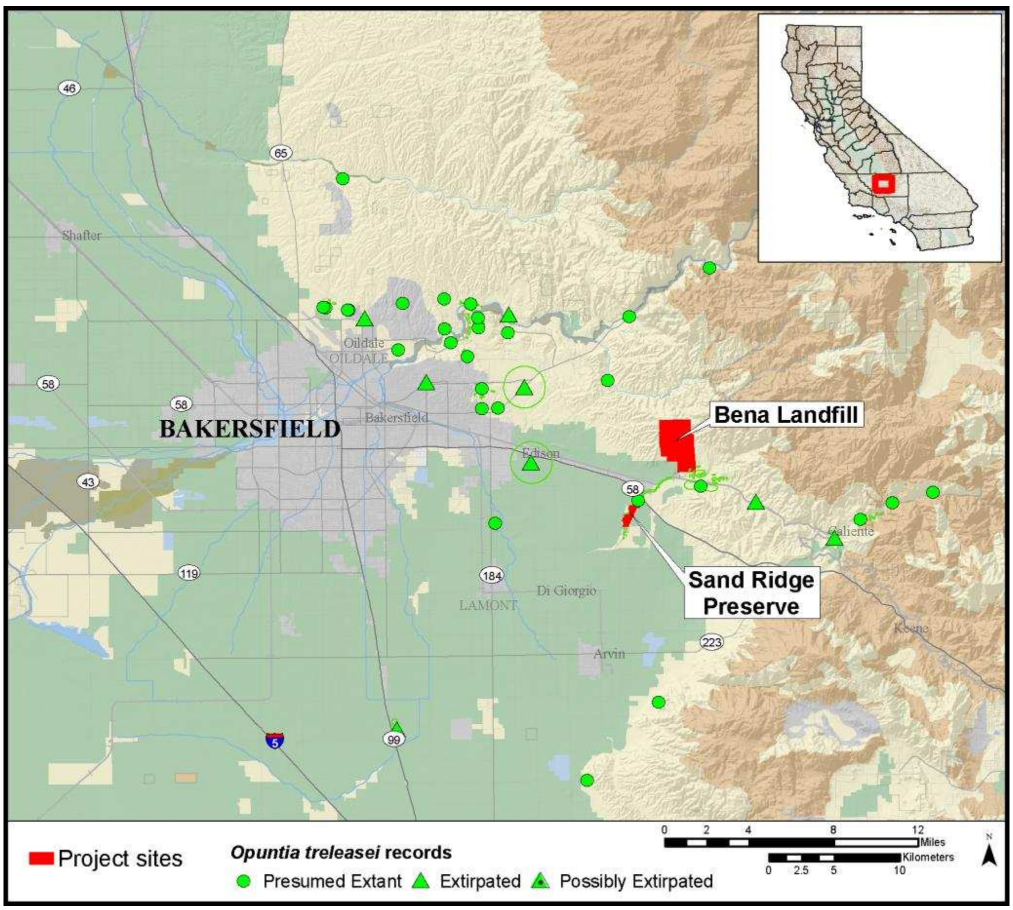

Figure 1. Locations of Sand Ridge Preserve and Bena Landfill Conservation Area, Kern County, California.

INTRODUCTION SITE

Bakersfield cactus pads and clumps collected from the Preserve were introduced to the 390-hectare Bena Landfill Conservation Area (BLCA; Figure 1). Bena Landfill is owned and operated by Kern County, and is located approximately 5 km upstream from the Preserve, along Caliente Creek. The BLCA is centrally located within the historic range of Bakersfield cactus, and a number of extant cactus locations occur just outside the landfill boundaries. In the area of the BLCA where we introduced the cacti, the plant community is non-native grassland. Dominant species include non-native annual grasses such as red brome (*Bromus madritensis)* and wild oats (*Avena spp.*), and forbs such as red-stemmed filaree (*Erodium cicutarium*), blue dicks (*Dichelostemma capitatum*), and fiddleneck (*Amsinkia spp.*). Topographically, the area ranges from gently rolling hills to moderately steep slopes with deep ravines. The elevation of the site was ca. 350 m. For the area of the BLCA to which we introduced the cactus pads and clumps, the soil is sandy clay loam and is well drained.

METHODS

PAD AND CLUMP COLLECTION

We collected 25 cactus pads and 10 cactus clumps from the Sand Ridge Preserve on 19 October 2009. We collected pads that had been naturally shed from plants yet had not become rooted to the ground (Figure 2). Each pad had already formed a callus at the point where it detached from the plant, and therefore it was not necessary to allow the pads to "heal" before translocating them. Each collected pad was assigned a code (P1-P25), then weighed and measured (length and width). Also, some pads that exhibited signs of partial desiccation (i.e., yellowish or brownish coloration) were collected to determine the success of these pads relative to pads that were green with no signs of desiccation. Each pad was transported to the introduction site in a small paper bag that was labeled with the appropriate pad number. The pads that we collected ranged in weight from 3.0 to 93.0 g (mean = 25.1 g; standard deviation = 22.6 g).

Figure 2. Shed pad from Bakersfield cactus and clump being collected at the Sand Ridge Preserve, Kern County, California.

When collecting cactus clumps, we followed recommended protocols (M. Showers, California Department of Fish and Game, in litt.). We collected clumps that had five or fewer pads and that were relatively isolated from other cacti (to avoid disturbance to adjacent plants when digging up targeted clumps). Each clump was assigned a code (C1-C10). We marked the east-facing side of each clump, so that plants could be planted with the same orientation at the introduction site. We dug at a minimum distance of 15 cm (6 in) beyond the perimeter of each clump. Each clump was transferred to a bucket that was lined with a large piece of fabric, along with a sufficient amount of soil to cover the roots and stabilize the plant (Figure 2). The clumps that we collected ranged in height from 7.0 to 19.5 cm.

PAD AND CLUMP INTRODUCTION

We introduced the cactus pads and clumps to the Bena Landfill Conservation Area on 20 October 2009. We established 5 plots at varying positions on an east-facing slope; each plot contained 5 pads and 2 clumps (Figure 3). We documented the location of each pad and clump (using their assigned codes) within each of the plots, which facilitated the monitoring of each individual over time.

Figure 3. Bakersfield cactus reintroduction plot at the Bena Landfill Conservation Area, Kern County, California.

Before placing the pads on the ground, we removed thatch from the soil surface and loosened the top few centimeters of soil. Some of the pads had roots that were 1-5 mm in length. For any pad that displayed root growth, we positioned it so that the roots were in contact with the soil surface. For any pad that did not have roots, we placed it in a position that maximized contact between the pad and the soil surface. We secured each pad in place with a wooden skewer (Figure 4). After each pad was installed, we photographed it to document its initial shape and appearance (e.g., green and fresh versus brown and dry).

Figure 4. Translocated Bakersfield cactus pads at the Bena Landfill Conservation Area, Kern County, California.

For each clump, we dug a planting hole that was approximately 30 cm (1 ft) in both depth and width. Each clump and its soil were removed from their bucket by grasping and lifting the fabric that was lining the bucket. Clumps were transferred into the planting holes by hand and the holes were filled in with a combination of soil transported from the source population site and soil native to the introduction site (Figure 5). Clumps were transplanted into dry soil and watered after one week (Showers 2005).

Figure 5. Translocated Bakersfield cactus clumps at the Bena Landfill Conservation Area, Kern County, California.

Because cattle were to be grazing the site in future months, we took some measures to protect the cacti from disturbance associated with grazing practices. We installed 1.5-m (5 ft) metal t-stakes at each of the plot corners, so that ranch hands all-terrain vehicles could avoid the plots. We installed two pieces of bent rebar over each pad and clump to discourage cattle from trampling the plants (Figure 6). To test efficacy, cattle guards were placed over clumps and pads in 3 plots while no guards were installed on 2 plots.


Figure 6. Cattle guards placed over translocated Bakersfield cactus at the Bena Landfill Conservation Area, Kern County, California.

MONITORING AND MAINTENANCE

We visited the introduction site approximately monthly to assess the status of the pads and clumps. One week after translocating the cactus (27 October 2009), we provided water to each clump (approximately 3.5 liters each). Water was provided again on 25 November 2009. After this date, sufficient precipitation precluded the need for further supplemental watering. During monitoring visits, we also “weeded” the translocated cacti by removing any vegetation growing immediately next to or overhanging the pads and clumps. This weeding was conducted to increase the probability of successful establishment by the cacti by reducing competition for light and water.

During monitoring visits, we determined whether each pad and clump were still alive. We also looked for evidence of new pad growth and of flowering. Finally, at the conclusion of the project, we counted the number of live pads present for each plant.

The proportion surviving was compared between pads and clumps using contingency table analysis and a chi-square test. For pads, we compared the mean weight at initial collection between pads that lived and pads that died using a *t*-test. We determined the proportion of pads and clumps that produced new pads in the spring of 2010 and 2011, and documented growth by determining the number of pads per plant in spring 2010, fall 2010, and spring 2011. We also determined the number of pads and clumps that produced flowers in the spring of 2010 and 2011. Finally, we assessed damage caused to translocated cactus plants from cattle.

RESULTS

SURVIVAL

Through May 2011, all 10 translocated cactus clumps were still alive yielding a 100% survival rate. Among the translocated shed pads, 12 of the 25 were still alive in May

2011 for a 48% survival rate. The proportion surviving was significantly higher for the clumps (χ^2 = 5.33, 1 df, *P* = 0.021).

Among the pads, those surviving to May 2011 were significantly heavier (*t* = 2.11, 14 df, *P* = 0.05) at the time of collection from the source site. Mean (± SE) weight was 34.8 ± 8.2 g for those that survived and 16.2 ± 3.3 g for those that did not survive. Mean pad size (length x width) tended to be larger for surviving pads 42.5 ± 6.9 compared to non-surviving pads 29.8 ± 3.6, but the difference was not statistically significant (*t* = 1.64, 17 df, *P* = 0.12). Also, pads that exhibited no signs of desiccation had a higher survival rate (8/16 = 50%) compared to pads that exhibited some signs of desiccation (3/9 = 33.3%), but the difference was not statistically significant (χ^2 = 0.15, 1 df, *P* = 0.70).

GROWTH

Among the clumps, 8 of the 10 (80.0%) produced new pads in spring of 2010 (Figure 7). These 8 clumps produced 20 new pads for a mean of 2.5 per clump (range 1-4). In spring of 2011, 9 of the 10 clumps produced 23 new pads for a mean of 2.6 per clump (range 1-7). Among the translocated pads, 20 of the 22 surviving pads produced 37 new pads in spring 2010 for a mean of 1.9 per translocated pad (range 1-5). In spring of 2011, 7 of the 12 surviving translocated pads produced 14 new pads for a mean of 2.0 per translocated pad (range 1-4).

Figure 7. New pads on a translocated Bakersfield cactus clump (left) and pad (right) at the Bena Landfill Conservation Area, Kern County, California.

The clumps consisted of 1-5 pads when translocated in October 2010. By spring of 2010, the clumps consisted of 3-9 pads for a mean of 6.0 per plant. After some mortality during the summer, the clumps consisted of 3-8 pads for a mean of 5.4 per plant in October 2010. By spring of 2011, the clumps consisted of 3-11 pads for a mean of 6.4 per plant. Among the translocated pads, plants consisted of 1-6 pads in spring of 2010 for a mean of 2.7 per plant. After some mortality during the summer, the plants consisted of 1-3 pads for a mean of 1.7 per plant in October 2010. By spring of 2011, the plants consisted of 1-7 pads for a mean of 2.2 per plant. By spring of 2011, 12 plants that had originated from the translocated pads were still alive, but only among 3 of these was the original pad still alive. For the other 9 plants, the original translocated pad had died but was survived by new pads it had produced in spring of 2010 or 2011.

Five pads associated with 4 plants were detached and laying on the ground. It is possible that cattle or some other agent broke pads off of plants, but at least some of these pads appear to have been naturally shed. One of these detached pads had 2 new pads growing on it.

FLOWERING

Among the 10 translocated clumps, 2 (20.0%) produced flowers in spring of 2010, and 4 (40.0%) produced flowers in spring of 2011 (Figure 8). Of the 4 plants producing flowers in 2011, 2 of these were the same plants that produced flowers in 2010. One of the 4 plants in 2011 produced 3 flowers while the other 3 plants produced 1 flower each. Among the translocated pads, one produced a flower in spring of 2010 and this same one produced another flower in 2011.

Figure 8. Flower on translocated Bakersfield cactus clumpat the Bena Landfill Conservation Area, Kern County, California.

CATTLE DAMAGE

In the 3 plots in which cattle guards were installed, no damage from cattle was observed on the 6 clumps and 7 surviving pads in May 2011. On the 2 plots where guards were not installed, potential damage from cattle was observed on 3 of the 4 clumps and on 1 of the 5 surviving pads. Thus, 44.4% of unprotected plants sustained possible damage from cattle. This damage was in the form of broken pads and possibly an eaten flower (Figure 9).

Figure 9. Cattle damage on Bakersfield cactus at the Bena Landfill Conservation Area, Kern County, California: crushed pad (left) and clump with a broken pad and chewed flower (right).

DISCUSSION

Translocation and reintroduction are strategies that have been employed in conservation efforts for a number of rare plant species (Allen 1994, Given 1994, Falk et al. 1996). These strategies offer immense potential for re-establishing populations on formerly occupied sites or for establishing new populations at suitable sites. However, some risk is always involved when moving individuals to new sites and attempting to establish a self-sustaining population. Thus, all reasonable efforts should be taken to reduce this risk and also to avoid any detrimental effects to source populations.

In the Bakersfield cactus translocation we conducted, shed pads and small clumps were taken from a large population. The cactus population at the Sand Ridge Preserve may consist of as many as 10,000 plants (CSUS ESRP unpublished data). Therefore, the removal of 10 small clumps and 25 shed pads was unlikely to cause any detrimental impacts to that population.

All of the translocated clumps survived and appear to be thriving after 1.5 years. As of spring 2011, 90% of the clumps had added one or more new pads, and 40% had flowered. Thus, clumps exhibit immense potential for successful translocation. However, removal of established clumps from a source population constitutes more of an adverse impact than the removal of shed pads. Also, translocating clumps is more labor intensive as the clumps must be carefully excavated at the source site, transported in sufficiently large containers, and then carefully extracted from the containers and planted in earthen holes dug at the translocation site.

The use of naturally shed pads for translocations is highly desirable because no established plants are impacted and some proportion of shed pads in a source population does not become established and naturally dies. Also, the pads are easy to collect, transport, and plant at the new site. The obvious disadvantage of using shed pads in translocations is that they appear to have a lower survival rate compared to clumps. In the translocation we conducted, just 48% of the pads were still alive after 1.5 years. Also, growth rates, as measured by new pads, were slower among translocated pads compared to clumps. Pads are smaller propagules compared to clumps, and also may have suffered some loss of resources, particularly moisture, prior to collection. Thus, pads likely have smaller energy reserves available for establishment. As evidence of this, higher survival rates were observed among translocated pads that were larger and heavier.

Although success metrics were lower among pads, the implications of this are not clear with regards to successful population establishment. Although only 48% of pads were still alive, this survival rate might be sufficient to establish a new population, particularly if a sufficiently large number of pads are initially translocated. Additionally, measures might be taken to increase the success of pads. For example, based on our results, choosing larger, heavier pads for translocation apparently would increase rates of survival and successful establishment, particularly root production. Also, pads without obvious signs of desiccation tended to survive better.

Additional supplemental water might also increase survival of pads. Pads and clumps were provided with supplemental water after planting until such provisioning was no longer needed due to sufficient natural precipitation. The translocation was specifically conducted in fall to take full advantage of winter precipitation, reduce the need for supplemental watering, and provide plants with maximum opportunity to establish prior to the hot temperatures and arid conditions of summer. Indeed, mortality of translocated pads appeared to occur primarily during summer months when hot and very dry conditions prevailed. These conditions apparently were sufficient stressors to cause death. Supplemental watering over the first summer might have helped reduce such mortality.

Cattle appeared to have caused some damage to unprotected cactus plants. This damage likely was caused by cattle moving through a given plot and inadvertently striking a plant with a hoof. Such damage from cattle has been observed in other cactus populations subject to grazing (CSUS ESRP unpublished data). The severity of impacts from cattle is unclear. At some locations, pads that appear to have been crushed and killed by cows have been observed. This may have been the situation for one pad at the Bena Landfill. In the Bena population as well as in other populations, pads appear to have been broken off of plants by cattle. Some of these detached pads likely develop roots and produce a new cactus plant. Thus, at least on occasion, actions of cattle actually might facilitate pad dispersal and the production of new plants. However, it may be prudent to allow a translocated cactus population to become securely established before subjecting it to possible impacts from cattle. The cattle guards we used at Bena Landfill appear to have effectively protected cactus plants from cows. Furthermore, using the guards around individual plants affords the additional benefit of allowing cattle to graze near plants. Such grazing helps to reduce competition, particularly from non-native grasses (CSUS ESRP unpublished data), and also reduces fuel loads thereby reducing the threat of wild fire, which can injure or kill Bakersfield cactus (U.S. Fish and Wildlife Service 1998).

Despite the positive results to date, the Bakersfield cactus at the Bena Landfill should be monitored for several more years before the translocation and population establishment can be considered a success. Long-term survival is one measure of success. An equally important measure is reproduction. As with other cacti, Bakersfield cactus reproduces vegetatively by way of shed pads and sexually by way of flower and seed production. In the Bena Landfill population 5 shed pads were observed in May 2011, and 5 plants (4 clumps and 1 pad) produced flowers in spring 2011. It is unknown at this time whether any of the shed pads have rooted and become established, or if any of the flowers produced viable seed. However, the fact that reproductive efforts may be occurring after only 1.5 years is encouraging. Minimally, the production of new plants needs to equal mortality of existing plants in order to maintain a stable, persistent population. Ideally, the production of new plants eventually will exceed mortality of existing plants resulting in an expansion of the new population. Hopefully, sexual reproduction would play a role in any such population expansion. Genetically, a translocated population is a depauparate clone of the source population. Sexual reproduction will expand the genetic diversity of a new population, which hopefully will help increase its long-term viability.

Several smaller scale translocations of Bakersfield cactus have been conducted previously, and all have resulted in plants becoming established at new sites (E. Cypher, CDFG, personal observation). Those efforts along with the results of this project suggest that translocation appears promising as a strategy for increasing the number of Bakersfield cactus populations. Translocation may be particularly valuable given the fragmented nature of remaining habitat in the San Joaquin Valley and the challenges this poses to natural dispersal mechanisms. Translocation and establishment of Bakersfield cactus to permanently conserved and appropriately managed sites could significantly advance conservation and recovery of this species. Indeed, recovery of Bakersfield cactus, as defined in the recovery plan for this species (U.S. Fish and Wildlife Service 1998), may already be precluded due to continuing habitat loss. Thus, translocation and the establishment of new populations may be necessary to recover this species and ensure long-term viability of the metapopulation.

RECOMMENDATIONS

Based on the results of this project, the following recommendations are offered:

1. Implement translocation as a conservation strategy for Bakersfield cactus

Based on the results of this project as well as previous efforts by others, translocation appears to constitute an effective strategy for expanding existing Bakersfield cactus populations and creating new populations. Translocations can be conducted in a manner that causes minimal impact to source populations, and translocated cactus have a relatively high probability of successfully establishing at reintroduction sites, assuming that the sites are appropriately prepared and managed. Translocation and the establishment of new populations may be necessary to recover this species and ensure long-term viability of the metapopulation.

2. Identify potential source and recipient sites for translocations of cactus

Potential recipient sites for translocated cactus should be identified, both for situations in which cactus are salvaged from private lands about to be developed and for proactive efforts to create new populations. Recipient sites should be permanently conserved through ownership by a federal or state conservation agency, or by a conservation easement. In addition, the sites should be appropriately managed to reduce threats to cactus populations from non-native plants, fire, and external influences (e.g., off-highway vehicles). Appropriate source populations for proactive conservation efforts would be those that are relatively large with evidence of reproduction. Such populations would be minimally impacted by the removal of small clumps or shed pads for translocation.

3. Use small clumps if possible for translocation

In this project, translocated clumps exhibited higher survival and more robust growth than shed pads. Thus, where possible, use of clumps for translocation may increase the probability for successful population establishment. If small clumps are not available or their removal is not desirable (e.g., from a smaller source population), then shed pads still offer sufficient potential to justify their use in translocation efforts. If shed pads are used, then the probability of success will be increased if larger and fresher (e.g., green, no desiccation) pads are translocated. Another possibility is to collect pads and propagate them into small clumps before translocating. This would require holding them in captivity for 1-3 years to allow them time to grow by adding additional pads and establishing a root system. This strategy would enhance the potential for successful translocation using shed pads. The CSUS ESRP recently received funding to investigate the efficacy of propagating shed pads prior to translocation.

4. Conduct translocations in the fall and provide water in the first summer

Translocated cactus, particularly shed pads, appear to be susceptible to desiccation and death from hot, dry conditions, such as those experienced in the summer in the San Joaquin Valley. Therefore, translocations should be conducted in the fall when temperatures are more moderate and just prior to winter rains. Translocated plants should still be provided with supplemental water every 1-2 weeks until the rains begin. If translocation has to occur at other times of year, particularly late spring to early fall, then again, plants should be provided with supplemental water every 1-2 weeks until the rains begin in the late fall or early winter. Particularly if shed pads are translocated, supplemental water probably should be provided once every 2-4 weeks during the first summer following translocation.

5. Use cattle guards to protect translocated cactus

The simple devices used in this project to protect translocated cactus from damage by cattle appeared to be effective. These devices consisted of bent rebar rods and were both inexpensive and simple to install. Use of these or similar devices should be considered when translocating cactus into areas actively grazed by cattle. If cacti are sufficiently protected from direct damage from cows, grazed areas may be highly desirable as threats from non-native plants and fire will be reduced.

6. Conduct a population-wide genetic analysis to determine where cactus can be appropriately translocated relative to source populations

A potential issue is the conservation of any genetic differentiation and local adaptation within the Bakersfield cactus metapopulation. A population-wide genetic analysis would help to identify such differentiation and this information can then be used to define appropriate regions for translocation of cactus from a given source population. Indeed, Dr. Paul Smith of CSU-Bakersfield has been awarded a Section 6 grant to conduct the population-wide genetic analysis and CSUS ESRP has been assisting this study through the collection of genetic samples from most of the remaining Bakersfield cactus populations.

7. Conduct a population viability analysis for Bakersfield cactus

A population viability analysis should be conducted for Bakersfield cactus to determine the optimal number of individual populations necessary to sustain a metapopulation with long-term viability. Such an analysis would provide a target number of new populations. Having such a scientifically-based target might facilitate efforts to secure funding for additional translocations. The population viability analysis also might help identify the optimum or at least the minimum size necessary to maintain viability for individual populations.

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