SPRINGS PRESERVE

Rare Plant Research at the Springs Preserve
2000-2004

Las Vegas Valley Water District   Las Vegas, Nevada

Rare Plant Research at the Springs Preserve 2000-2004 (Draft)

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EXECUTIVE SUMMARY

Populations of the rare and unusual Las Vegas bearpoppy (*Arctomecon californica*) occur on the Springs Preserve, a cultural and educational facility soon to be open to the public in Las Vegas, Nevada. Springs Preserve staff has made a concerted effort to preserve these plants and their habitat on the Springs Preserve and to participate in the preservation and mitigation of other rare plants throughout Southern Nevada. The Springs Preserve is preparing educational exhibits to introduce the Las Vegas bearpoppy and other rare plants to the public and to educate them about the importance of these plants and their plight in Southern Nevada. Springs Preserve scientists are committed to identifying ways to preserve, restore and mitigate these rare plants and their habitat through research.

This document reports research conducted by the Springs Preserve on the Las Vegas bearpoppy and Las Vegas buckwheat [*Eriogonum corymbosum* var. *glutinosum*]) from 2000 to 2004. Featured in this report are studies that focus on several aspects of these rare species including plant morphology and phenology, plant salvage and transplanting, and seed production, germination and distribution. Results from this research will benefit the management of these two species on the Springs Preserve and will add to the body of knowledge used to mitigate and manage these two rare plant species and their habitat throughout their ranges.

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1. INTRODUCTION

1.1 Rare Plants at the Springs Preserve

During the 1990s, two rare plant species, Las Vegas bearpoppy (*Arctomecon californica*) and white bearpoppy (*Arctomecon merriamii*) were observed on land in Las Vegas that has since become the Springs Preserve. Since that time, the Las Vegas Valley Water District (LVVWD), the owners of the property, and now the Springs Preserve, have made a special effort to preserve rare plants and their habitat on the Preserve and to contribute to the preservation of other rare plants throughout Southern Nevada. In addition, the Springs Preserve is designing several exhibits to showcase the Las Vegas bearpoppy and other rare plants to the public and to educate them about the uniqueness of these plants and their plight in Southern Nevada. In addition to this education effort, Springs Preserve scientists are committed to identifying ways to preserve, restore and mitigate rare plants and their habitats through research.

1.2 Purpose and Scope

The purpose of this document is to report research conducted by the Springs Preserve on two rare plant species found in the Las Vegas Valley (Las Vegas bearpoppy and Las Vegas buckwheat [*Eriogonum corymbosum* var. *glutinosum*]) from 2000 to 2004. The research was funded by a grant from the Clark County Desert Conservation Program. Results from this research will benefit the management of these two species on the Springs Preserve and will add to the body of knowledge used to mitigate and manage these two rare plant species and their habitats.

1.3 Report Organization

This report includes a literature review that identifies information regarding the life history and past mitigation attempts used for Las Vegas bearpoppy and Las Vegas buckwheat. The body of this report features six studies that focus on several aspects of research including plant morphology and phenology, plant salvage and transplanting, and seed production, germination and distribution. A general conclusions and recommendations section summarizes the research and makes recommendations on how to apply the results.

2. LITERATURE REVIEW

2.1 Las Vegas Bearpoppy

2.1.1 Natural History and Status

Las Vegas bearpoppy (*Arctomecon californica*), a member of the Papaveraceae family, is one of the most beautiful of the Mojave desert wildflowers. It has large golden flowers and clusters of silvery-blue fuzzy leaves at its base that are shaped like the paws of a bear (Figure 2.1-1).

Figure 2.1-1. Las Vegas bearpoppy on the Springs Preserve.

Las Vegas bearpoppy is a short-lived, perennial evergreen herb that lives only 4-5 years (Meyers, unpublished manuscript). It has a deep taproot and flowers produced in April and May that need to cross-pollinate to produce viable seed. The plant initially produces a single cluster of leaves called a rosette and can quickly clone itself by producing several rosettes. Plants with 30 to 40 rosettes are not uncommon.

Las Vegas bearpoppy plants can produce large quantities of seed, several thousand per plant, but the number of plants producing seed varies from year to year. Seed viability is usually high and this viability has been shown to last for more than seven years in the soil (Meyers, unpublished manuscript).

Populations of Las Vegas bearpoppy plants repeatedly cycle through an explosion of growth, followed by large-scale die-off. The numbers of plants in a given year is determined by the amount of rainfall received, seedling survival, and how many mature seeds will germinate. Plant density for this species varies from 1 plant per acre to 750 plants per acre, with an average of 21 plants per acre (Mistretta et al. 1996).

Las Vegas bearpoppy exists only in the Mojave Desert of Nevada and Arizona and occurs at elevations between 316 m and 1092 m (1036 and 3583 ft) (Nevada Natural Heritage Program 2001). It grows in barren, gravelly desert flats, hummocks, and gypsum deposits. This species is associated with the gypsum barren plant community which is characterized by gypsum soils, cryptogamic crusts and the following plant species: Torrey's jointfir (*Ephedra torreyana*), desert pepperweed (*Lepidium fremontii*), Parry's sandpaper plant (*Petalonyx parryi*), Fremont's dalea (*Psorothamnus fremontii*), Southwestern ringstem (*Anulocaulis leiosolenus*), silverleaf sunray (*Enceliopsis argophylla*), wingseed blazingstar (*Mentzelia pterosperma*), matted crinklemat (*Tiquilia latior*), ladder buckwheat (*Eriogonum insigne*), Palmer's phacelia (*Phacelia palmeri*), beautiful phacelia (*Phacelia pulchella*), hairybeast turtleback (*Psathyrotes pilifera*), blackbrush (*Coleogyne ramosissima*), shadscale saltbush (*Atriplex confertifolia*) and creosote bush (*Larrea tridentata*) (Knight 1983).

Las Vegas bearpoppy was once widespread across the Las Vegas Valley. The explosive growth experienced in Clark County over the past decade has resulted in an unprecedented set of challenges for the Las Vegas bearpoppy. As of 1996, 12% of the known populations had been eliminated by development, another 16% were likely to be eliminated in the foreseeable future and 27% more were exhibiting the signs of negative habitat impacts (Mistretta, et al. 1996). Because of these impacts, the Las Vegas bearpoppy is currently listed by the Nevada Division of Forestry as "critically endangered", and as such is protected under Nevada Revised Statue 527.270. It is listed by the Northern Nevada Native Plant Society as "threatened", and is ranked as "imperiled", both globally and in the state, by the Nevada Natural Heritage Program. It is also listed as a covered species by the Clark County Multiple Species Habitat Conservation Plan (Clark County 2000).

2.1.2 Status of Las Vegas Bearpoppy on the Springs Preserve

The Springs Preserve, near U.S. 95 and Valley View Boulevard in Las Vegas, provides unique habitat for a variety of native Mojave Desert plants and animals. Among these are populations of the Las Vegas bearpoppy. The number of individuals in these populations has declined over the past few years. The Springs Preserve is committed to preserving these populations of poppies. The Springs Preserve provides an ideal setting in which to preserve populations of the Las Vegas bearpoppy and educate the public regarding the value of this endangered plant species.

Currently, two populations of Las Vegas bearpoppy are found on the Springs Preserve (Figure 2.1-2). These populations are referred to as Populations 1 and 2. The number of individual plants at each population has fluctuated over the years and has been declining in Population 1 for the past several years (Figure 2.1-3).

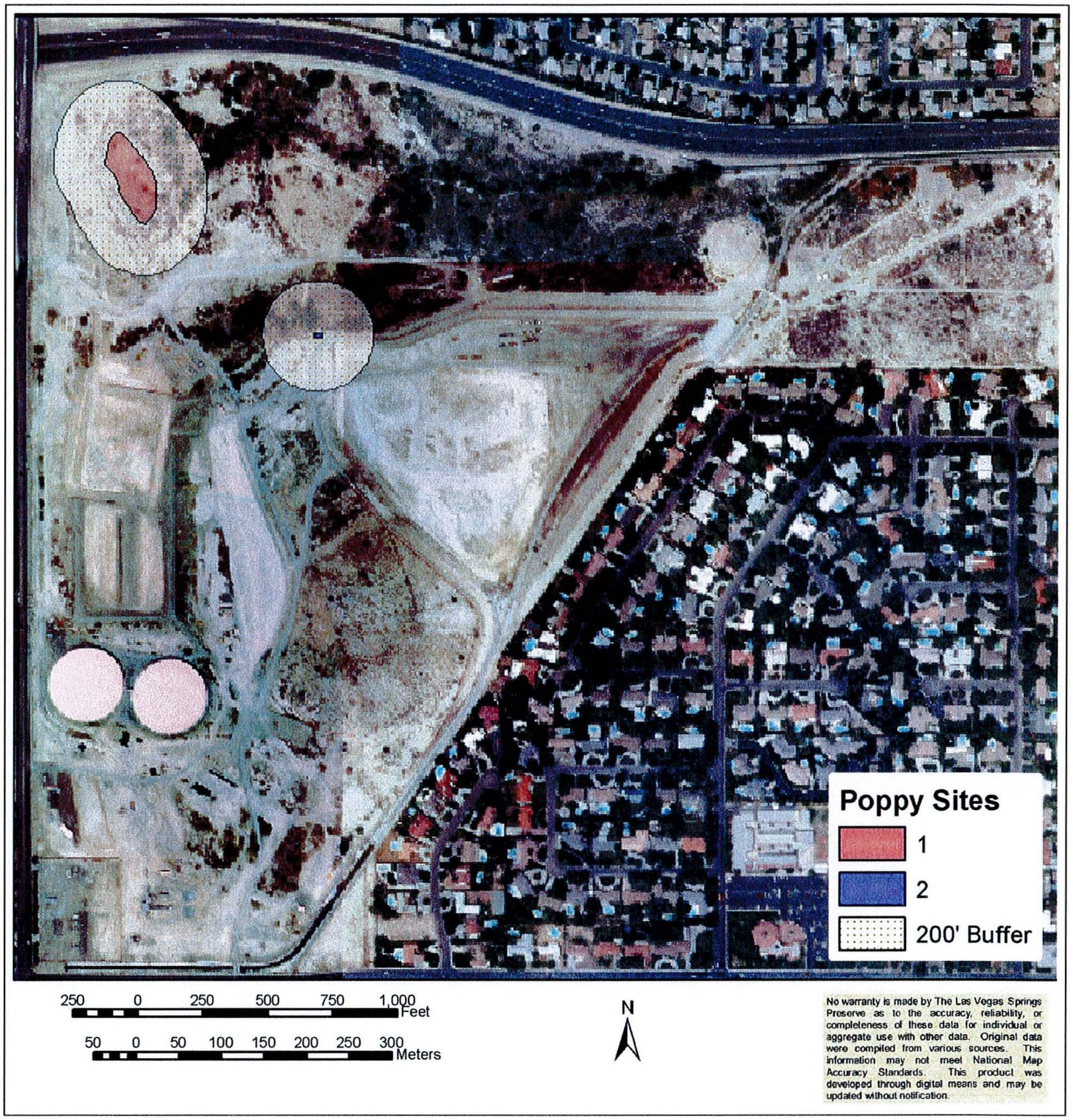

Figure 2.1-2. Locations of two populations of Las Vegas bearpoppies on the Springs Preserve in Las Vegas, Nevada.

A Habitat Management Plan for the Las Vegas bearpoppy on the Springs Preserve was completed in 2000 (Bardeen and Williams 2000). This plan outlines the management actions to be taken to preserve the Las Vegas bearpoppy on the Springs Preserve. These actions will be followed during any restoration or management of these poppy populations.

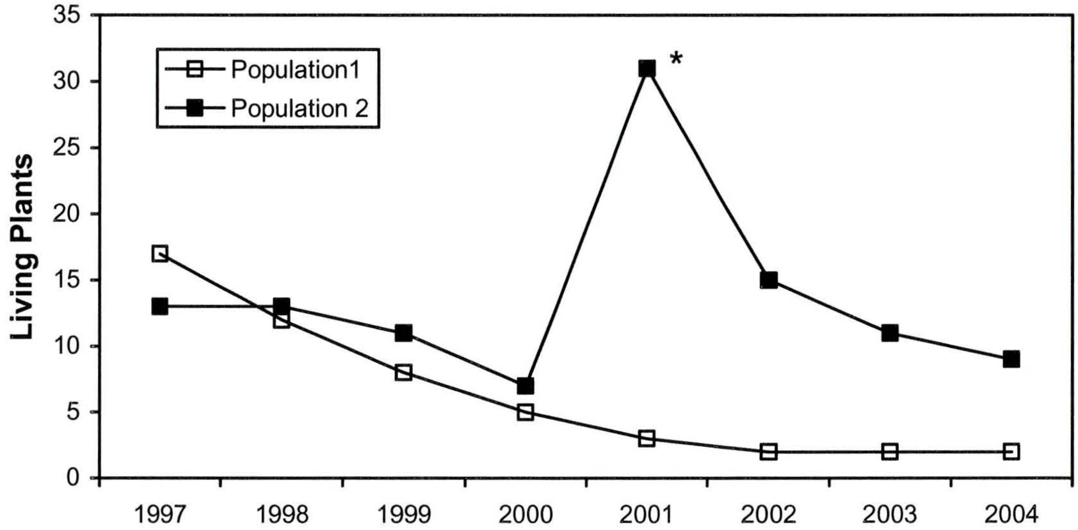

Figure 2.1-3. Numbers of bearpoppy plants during the period 1997 to 2004 in two populations on the Springs Preserve. * Twenty-five of these plants were seedlings and six were adult plants.

There are several options that could be attempted to bolster the Springs Preserve populations of Las Vegas bearpoppies. These include 1) adding soil containing poppy seed from other known populations to the Springs Preserve populations, 2) encouraging germination of seeds in the seedbank of the Springs Preserve populations with supplemental watering, 3) propagating poppies from seed and then planting these poppies into the Springs Preserve populations and 4) transplanting bearpoppy plants from other populations to the populations at the Springs Preserve. Springs Preserve scientists are most interested in pursuing the last two options because they have the most potential to bolster the Springs Preserve populations. New plants produced from these efforts could benefit the existing plants by providing additional sources of pollen and seed. Salvaged plants could come from populations that will be impacted by future urban development and must be moved as part of a mitigation plan. As a side note, it has been decided that the introduction of Las Vegas bearpoppies from other populations with possible dissimilar genetic makeup is not a concern because the origin of genetic material for the Springs Preserve populations is unknown.

2.2 Las Vegas Buckwheat

2.2.1 Natural History and Status

Las Vegas buckwheat (*Eriogonum corymbosum* var. *glutinosum*), a member of the Polygonaceae family, is a large, yellowed-flower shrub that flowers in the fall (Figure 2.2-1).

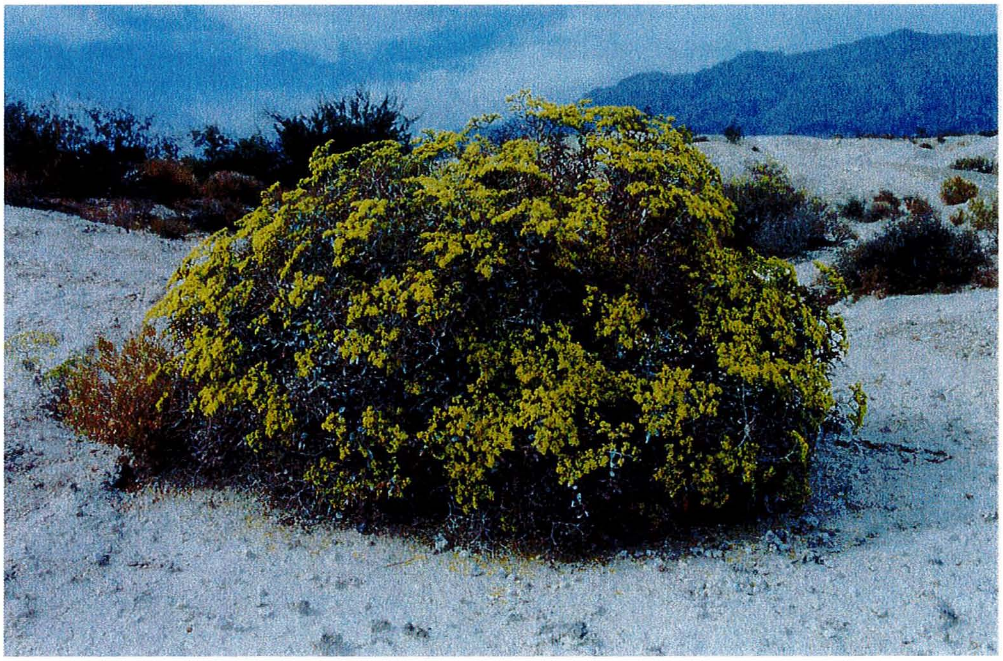

Figure 2.2-1. Las Vegas buckwheat in full bloom.

Las Vegas buckwheat is largely confined to the Las Vegas Valley in Clark County, Nevada It is typically found between elevations of 579–1170 m (1900–3839 ft) and occurs on gypsiferous soils frequently with Las Vegas bearpoppy (Nevada Natural Heritage Program 2001). Other species associated with the Las Vegas buckwheat include Nevada ephedra (*Ephedra nevadensis*), shadscale saltbush, seepweed (*Suaeda moquinii*), Anderson's desert thorn (*Lycium andersonii*), creosote bush, white bursage (*Ambrosia dumosa*), rhatany (*Krameria erecta*), winterfat (*Krascheninnikovia lanata*), big galletta grass (*Pleuraphis rigida*), brittlebush (*Encelia virginensis*) and desert prince's plume (*Stanleya pinnata*).

The range of Las Vegas buckwheat, is rapidly decreasing in the Las Vegas Valley because of urban expansion. It is listed as a species of concern by the U.S. Fish and Wildlife Service and has recently been proposed for listing under the State of Nevada list of critically endangered species. Las Vegas buckwheat is also listed as a high priority evaluation species in the Clark County Multiple Species Habitat Conservation Plan (Clark County 2000).

2.2.2 Status of Las Vegas Buckwheat on the Springs Preserve

The Las Vegas buckwheat is not currently found in native plant communities or landscapes on the Springs Preserve, however, Springs Preserve biologists are interested in showcasing this species and educating the public about the plight of this beautiful plant. The Springs Preserve has received the approval of the Nevada Division of Forestry to introduce the buckwheat to the Springs Preserve. Plant materials (salvaged plants and/or seed) from populations in other parts of the valley would be collected and introduced to the Springs Preserve. The buckwheat plants would most likely be transplanted into the Las Vegas bearpoppy populations so that they would be near proposed trails and exhibits that would be seen by the public. This is biologically appropriate because Las Vegas bearpoppy and Las Vegas buckwheat plants are often found in the same communities. Research regarding salvaging and propagation of the Las Vegas buckwheat is currently being conducted by Springs Preserve scientists to determine the feasibility of producing Las Vegas buckwheat plants by salvaging and from propagation.

2.3 Past Research

2.3.1 Las Vegas Bearpoppy

2.3.1.1 Past Salvage and Transplant Attempts

Various methods have been utilized in the past by Las Vegas Valley Water District (LVVWD) and Southern Nevada Water Authority (SNWA) biologists and others to salvage and transplant Las Vegas bearpoppy plants. These methods have focused on excavation and transport of plants, irrigation treatments, plant size, and time (season) of salvage.

In December of 1996, Dr. Teri Knight of The Nature Conservancy and LVVWD biologists made an attempt to transplant a single, small (5-cm [2-in] diameter) Las Vegas bearpoppy. Up to 15 cm (6 in) of the root was salvaged during excavation, and the poppy survived initial transplant. Although it was continuously watered and monitored by LVVWD biologists, after approximately 4-5 months it died.

A large transplanting effort occurred in the LVVWD's South Well Field in 1998. Construction of the SNWA's East Valley Lateral was to disturb 3.2 ha (7.9 ac) of Las Vegas bearpoppy habitat in the eastern portion of the Las Vegas Valley. The Nevada Division of Forestry granted a permit for this activity in February 1998 with conditions, including conducting topsoil salvage and a transplanting trial of live plants prior to the start of construction.

A total of 56 Las Vegas bearpoppy plants were transplanted from the East Valley Lateral to the South Well Field, up to 10 plants per month, from March through August 1998. Three different transplant methods were employed in this transplant trial. In the first method, the plants were excavated by hand and placed into one- or three-gallon nursery containers. The second method utilized a post-hole-digger to place the plant and soil into nursery pots. Only plants less than 7.6 cm (3 in) in diameter were transplanted with this method because of the limited range of the tool. The third method involved the use of 20- and 30-cm (8- and12-in) diameter PVC pipe cut into 30-cm (12-in) long segments that were slipped over the top of the plants to a depth of 30 cm (12 in). With the bottom end of the pipe secured, the PVC served as the container for transporting the plants.

At the transplant location, a hole for each plant was prepared and the PVC was placed in the hole. For most of the plants transplanted with this method, the PVC was slipped off of the soil column in the hole, but four plants were placed in the ground with the PVC. All plants were placed in the ground approximately one foot apart. The plants were watered once after potting and once following transplanting. Half of the transplants were selected (including plants from different size classes and from the various excavation methods) to be watered. Most plants, regardless of treatment, dehydrated and died within one to two months after transplanting (Nina Merrill, personal communication).

In January 2000, three Las Vegas bearpoppy plants were transplanted to the South Well Field. These plants were found during pre-construction surveys for the SNWA's North Valley Lateral pipeline. The Nevada Division of Forestry required that the plants be transplanted utilizing the 30-cm (12-in) diameter PVC method, only this time the containers were 61 cm (24 in) deep to facilitate salvage of more taproot. The inside surface of the PVC was waxed to prevent soil from sticking. These plants survived approximately two months.

Dr. Teri Knight of the Nature Conservancy transplanted approximately 40 small Las Vegas bearpoppy plants from a construction site in December 1998. At the time of salvaging, the soil was wet from rain. The soil was loosened around the plants and the plants were removed from the soil. The barerooted plants were then transported with salvaged gypsum soil from the site to a residential backyard were they were planted in the salvaged gypsum soil. During the remainder of the winter, spring and summer the plants received some water from lawn sprinklers. One-half of the poppies flowered during the summer, but by the end of August all plants had died (Dr. Teri Knight, personal communication).

Dr. Knight stated that there have been several other attempts to transplant Las Vegas bearpoppy plants in or near the Las Vegas Valley. Most if not all of these poppies were dug up with shovels (some with soil and some barerooted), transported to a new site and planted (Dr. Teri Knight, personal communication). It is assumed that most or all of these plants died within a few days or weeks after planting.

Past attempts by LVVWD and SNWA biologists and other persons to transplant bearpoppy plants have had limited success, most likely due to injuries to tap roots during excavation activities, and also due to the lack of understanding of the plant's complexity (e.g., requirement of specific soil types and root morphology). Las Vegas bearpoppy plants have a deep taproot that appears to be very sensitive to injury. Although some researchers have attempted to salvage up to 61 cm (24 in) of taproot, perhaps salvage of all or more of the taproot is necessary to obtain survival of Las Vegas bearpoppy plants.

To date, no one has successfully transplanted a Las Vegas bearpoppy plant and had it survive for more than 10 months. Each year many Las Vegas bearpoppy plants are salvaged as directed by mitigation plans, and are sacrificed because the knowledge of how to salvage and transplant these plants to maximize survival has not been determined. If this knowledge was obtained, many plants could be saved.

2.3.1.2 Seedbank Distribution Research

In 2000, a seedbank study was implemented by scientists of Science Applications International Corp. near Las Vegas. The objective was to identify the amount of seed in seedbank that was to be imported to a disturbed Las Vegas bearpoppy habitat. Only six bearpoppy seeds were found in

26 samples, and most of those were found near one plant, so little could be said about the distribution of seeds around Las Vegas bearpoppy plants in that population.

Sheldon (1994) collected seedbank samples around one Las Vegas bearpoppy and one White bearpoppy plant near Las Vegas. Her objective was to identify the distribution of seeds around plants of these two species. For both species, she found more seeds from 41 to 60 cm (16 to 24 in) from the plants than from 0 to 20 (8 in) or 21 to 40 cm (8 to 16 in) from the plant. She also discovered more seeds on the north and west sides of the plants than from the south and east sides. She attributed this disproportion to a slight topographic incline to the northwest.

2.3.2 Las Vegas Buckwheat

2.3.2.1 Salvage Attempts

Unlike Las Vegas bearpoppy, few attempts have been made to salvage Las Vegas buckwheat plants. In December 2002, Bureau of Land Management staff used hand spades to dig up 30 to 40 small Las Vegas buckwheat plants from vacant land near Simmons Street and Gilmore Street in North Las Vegas. Although an attempt was made to dig up the majority of the root system, due to the hardness of the soil, only a portion of the roots were salvaged. The plants were put into 1-gallon pots and transported to the Nevada Division of Forestry Nursery. The plants were watered and maintained for several months and some of them were eventually given to the Springs Preserve. Of the 16 plants delivered to the Springs Preserve, 15 were alive in June 2004.

In 2002, the Bureau of Land Management required mitigation of Las Vegas buckwheat habitat at a development north of the I-215 near Clayton Street. A contractor was hired to salvage approximately 50 medium to large Las Vegas buckwheat plants. The plants were dug up with a backhoe and hand spades, placed in burlap and transported to and planted in a growing bed at the Springs Preserve. After planting, these plants were apparently not watered soon enough and they all died.

2.3.2.2 Germination and Propagation Research

Meyers and Paulson (2000) reported viability of lace buckwheatbrush (*Eriogonum corymbosum* [variety not specified]) was 93%. They also reported 28%, 79% and 100% germination of viable seeds for this species after 0, 4, and 8 weeks of chilling, respectively at 1 degree C (33.8 degrees F) followed by 4 weeks of incubation at 10/20 degrees C (50/68 degrees F).

Although little information is available regarding the germination and propagation of Las Vegas buckwheat, other similar species have received extensive study. California buckwheat (*Eriogonum fasciculatum*) has been successfully propagated and used in revegetation programs for many years. At the Nevada Test Site, Winkel et al. (1999) found that California buckwheat was easily established by direct seeding and had higher survival rates three years after seeding than 18 other species. Shaw (1984) reported that Wyeth wild buckwheat (*Eriogonum heracleoides*) can be successfully produced as bareroot stock.

3. RARE PLANT RESEARCH AT THE SPRINGS PRESERVE

This section reports six studies that address several research questions regarding Las Vegas bearpoppy and Las Vegas buckwheat including morphology, phenology, salvage and transplant methods and seed production, germination and distribution.

3.1 Morphological Characteristics of Las Vegas Bearpoppy

3.1.1 Introduction

The Las Vegas bearpoppy is threatened throughout much of it's range. This is due in large part to development in the Las Vegas Valley. A variety of methods have been attempted to mitigate the loss of these plants and their habitat. One method involves the salvage and transplanting of individual plants. This method has been attempted several times in the past few years with limited success (see section 2.3.1.1). A variety of techniques have been employed, most of which involve different ways to excavate the plant. However, due to the fragile nature of the root system of these plants, very few transplanted plants have survived more than a few months.

In 2000, the North Las Vegas Airport proposed to expand facilities into existing Las Vegas bearpoppy habitat. The Nevada Division of Forestry required them to mitigate by salvaging Las Vegas bearpoppy plants and soil around the plants containing Las Vegas bearpoppy seeds (referred to as seedbank). The Springs Preserve was approached about participating in the mitigation effort. Springs Preserve staff proposed several studies utilizing the target population of Las Vegas bearpoppy at the Airport. One of the studies involved testing various salvaging methods. Before the methods could be finalized, it was determined that more information was needed regarding the morphology of Las Vegas bearpoppy root systems.

The objective of this study was to characterize the root systems of Las Vegas bearpoppy plants. This information would aide transplant efforts of Las Vegas bearpoppy by identifying the depth and lateral extent of the roots so that all or a majority of the root system could be contained in the excavated soil mass. Reports from other parties who had salvaged Las Vegas bearpoppy plants in the past reported that Las Vegas bearpoppy roots were very fragile and that the poor survival of transplanted Las Vegas bearpoppy plants were in part a result of impacts to these fragile roots. Therefore, the information from this study will help ensure Las Vegas bearpoppy plants are salvaged in a way that minimizes disturbance of the root systems.

3.1.2 Methods

3.1.2.1 Study Site

This study was conducted at the Las Vegas bearpoppy population situated along the northern boundary of the North Las Vegas Airport approximately half way between Rancho Drive on the west and Simmons Street on the east (Figure 3.1-1). This population of Las Vegas bearpoppy plants was one of several on North Las Vegas Airport property. Major associated plant species at this population included Anderson's desert thorn, shadscale saltbush, and seepweed. The soil at the site is a Skyhaven very fine sandy loam (Fine-loamy, carbonatic, thermic Petrocalcic

Paleargids) (Soil Conservation Service 1985). Depth to indurated, lime-cemented hardpan (petrocalcic layer) is approximately 30 cm (11.8 in).

Figure 3.1-1 Map of the Las Vegas Valley showing the location of the Springs Preserve and three study sites.

3.1.2.2 Study Design, Implementation and Data Collection

The scientific approach to this study was to document the morphological characteristics of the above- and below-ground portions of several sizes of bearpoppy plants. Six plants were selected based on the number of living rosettes (cluster of leaves) and volume of the above-ground portion of the plant.

The following data were collected for the above-ground portion of each plant during September 2000: 1) greatest width, 2) width perpendicular to the greatest width, 3) height (soil surface to top of tallest rosette), 4) number of living rosettes, 5) number of dead rosettes, 6) total rosettes, 7) number of current year flowering stalks and 8) number of opened seed capsules. Above-ground plant area and volume were calculated from the width and height data.

The root system of each plant was exposed in the following manner. A trench was excavated along one side of the plant with a backhoe. The edge of the trench closest to the plant was approximately 1 m (3.2 ft) from the plant to ensure that none of the roots were disturbed. Beginning at the edge of the trench, soil was carefully removed with small hand tools from around the roots until all roots were exposed (Figure 3.1-2). The exposed root systems were photographed, carefully measured and sketched and the following data were collected: 1) diameter of root at base of plant, 2) length of taproot, 3) width of root system, and 4) depth to a solid petrocalcic layer.

Figure 3.1-2 Excavated root system of a Las Vegas bearpoppy plant.

3.1.3 Results and Discussion

Above-ground portions of the six plants excavated in this study varied in area from 40 to 792 cm^2 (6.2 to 122.7 in^2) and volumes ranged from 200 to 10,296 cm^3 (12.2 to 628.3 in^3) (Table 3.1-

1). Number of living rosettes ranged from 2 to 42. See Table 3.1-1 for additional information on the attributes of the six excavated plants.

Table 3.1-1. Above- and below-ground attributes of six Las Vegas bearpoppy plants excavated at the North Las Vegas Airport.

Attribute	Plant Number					
	1	2	3	4	5	6
Plant width 1 (cm)	25	11	22	15	33	8
Plant width 2 (cm)	18	10	18	12	24	5
Plant area (cm^2), (width 1 x width 2)	450	110	396	180	792	40
Height of rosettes (cm)	11	7	10	6	13	5
Plant volume (cm^3), (area x height)	4950	770	3960	1080	10296	200
Number live rosettes	16	7	18	5	42	2
Number dead rosettes	15	4	7	1	14	0
Number total rosettes	31	11	25	6	56	2
Number of current year flower stalks	15	2	4	0	13	0
Number of current year opened capsules	32	2	15	0	26	0
Length of taproot (cm)	26	29[a]	35[a]	27[a]	45[b]	33[a]
Diameter of taproot at plant base (cm)	2.3	0.8	2.1	1	2.6	1
Width of root system (cm)	10	5	65	20*	6	6
Depth to solid petrocalcic layer (cm)	26	29	35	26	33	33

[a]Root broke at petrocalcic layer
[b]Root excavated 12 cm into petrocalcic layer before it broke off.

Regardless of plant size, most of the six root systems consisted of a single taproot (Figure 3.1-2), although a couple of plants had significant lateral roots Figure (3.1-3, 3.1-4, 3.1-5 and 3.1-6). All taproots grew vertically into the soil directly under the above-ground portion of the plant.

At this site, where the top of the petrocalcic layer was at an average depth of 30 cm (11.8 in), it was difficult to know how deep the taproots had grown into the petrocalcic layer, or would have grown in the absence of this layer. It was nearly impossible, given the hardness of the petrocalcic layer, to excavate the taproot from this layer. Therefore, the root had to be broken off at the point where the root grew into the layer. These data show that poppy roots can grow through a petrcalcic layer. Most taproots did not stop when they encountered this layer. It is unclear how far into the layer the taproots grew. Also unknown is the mechanism used by the poppy plant to grow through the layer. The root probably grew through existing pores in the layer. One attempt was made to follow a taproot into a petrocalcic layer. The root was followed for several centimeters into the layer. A photo of this taproot is shown in Figure 3.1-7.

This study confirmed that Las Vegas bearpoppy taproots are very fragile and vulnerable to water loss if broken. During the course of this study, Springs Preserve staff observed water leaking out of freshly-broken taproots.

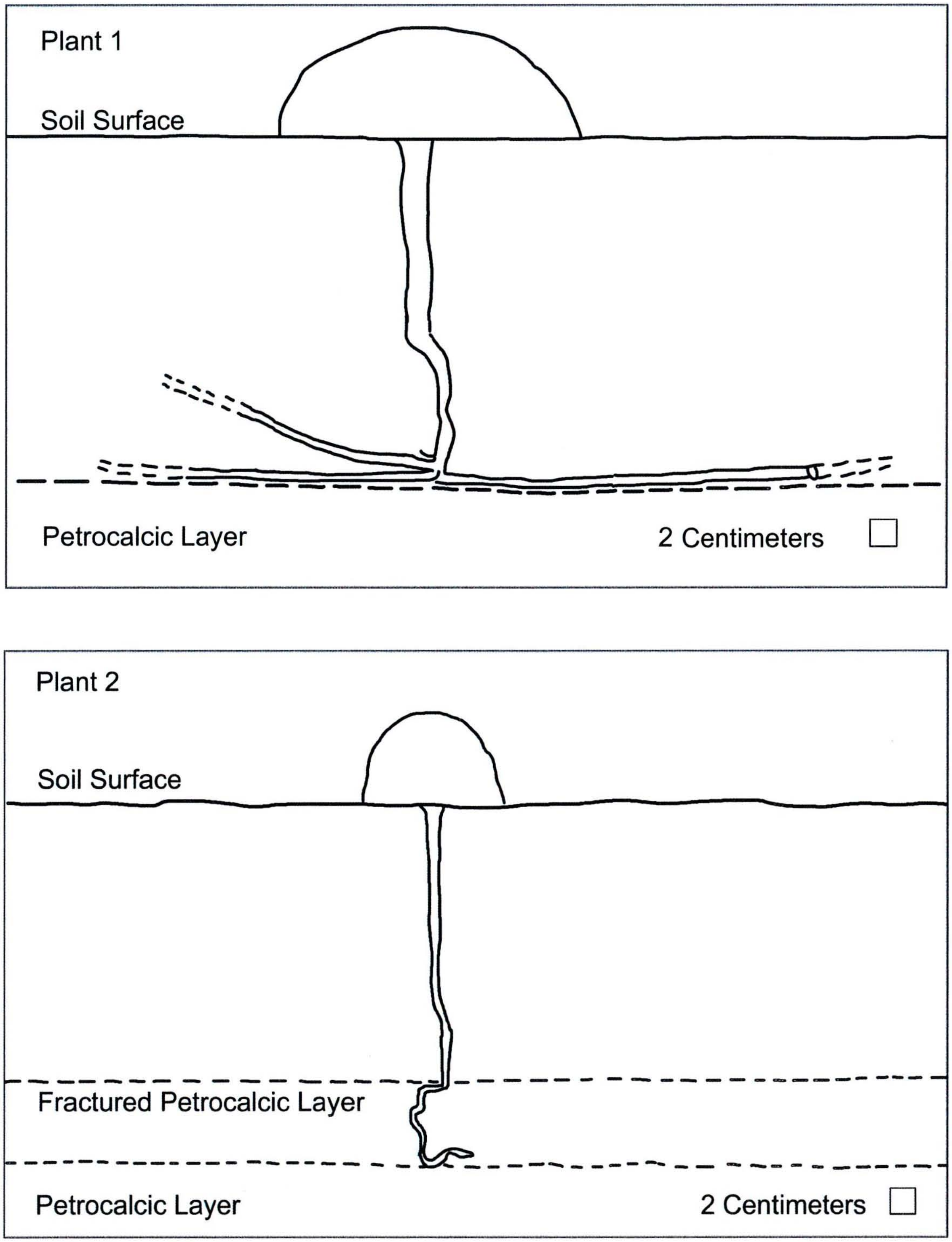

Figure 3.1-3. Diagrams of Las Vegas bearpoppy root systems excavated at the North Las Vegas Airport. Diagrams are based on hand field sketches.

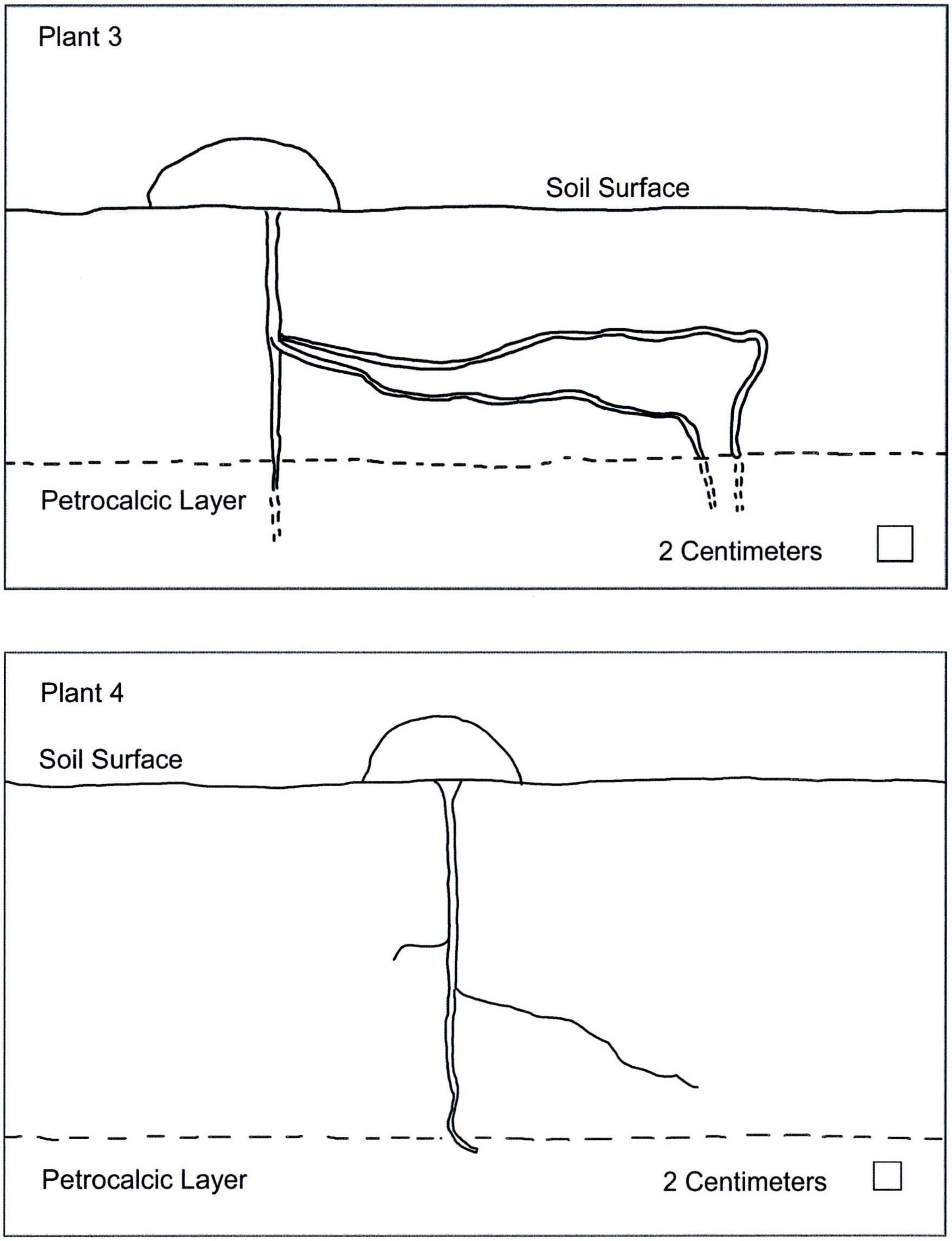

Figure 3.1-4. Diagrams of Las Vegas bearpoppy root systems excavated at the North Las Vegas Airport. Diagrams are based on hand field sketches.

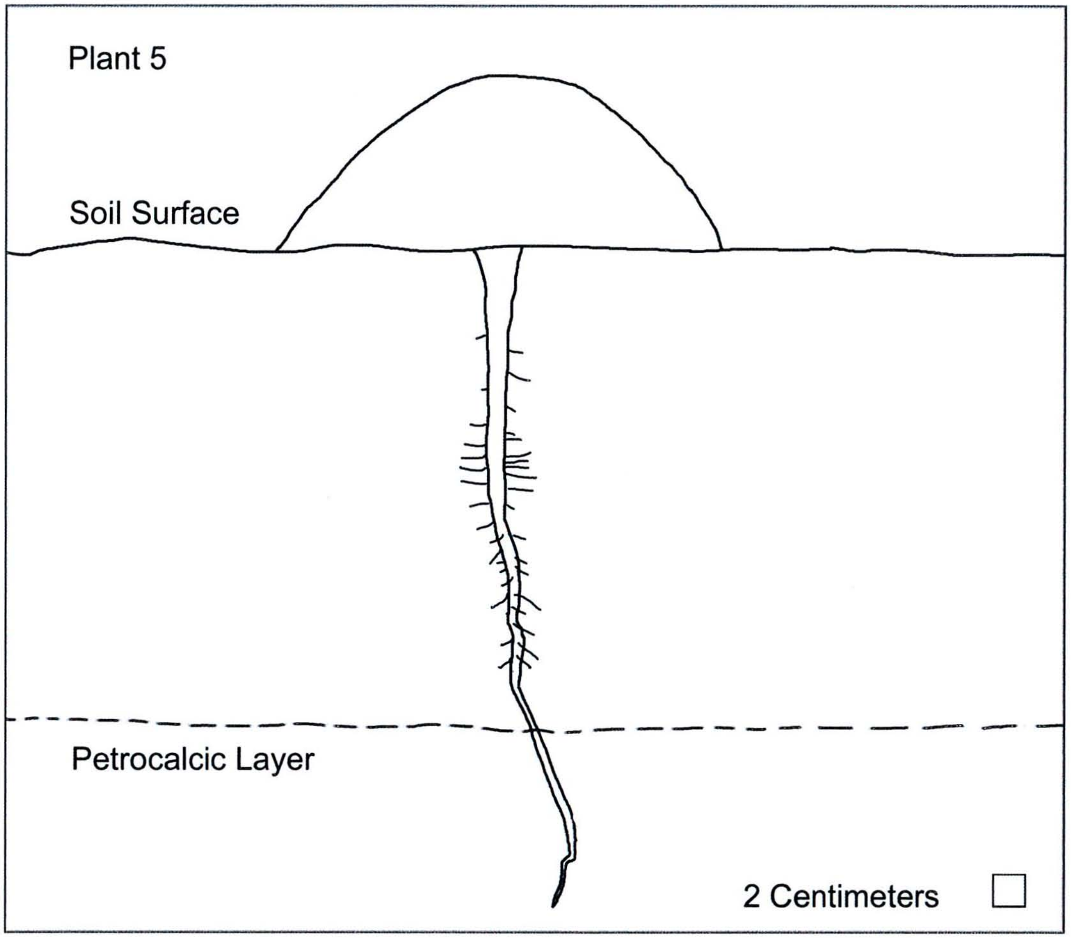

Figure 3.1-5. Diagram of a Las Vegas bearpoppy root system excavated at the North Las Vegas Airport. Diagram is based on a hand field sketch.

These data demonstrate that the size of root systems of Las Vegas bearpoppy plants varies little in relation to the size of the above-ground portion of the plant (Table 3.1-1, Figure 3.1-8). The plant with the smallest above-ground portion had only 2 total rosettes, yet it's root system was over 33 cm (12.9 in) deep (actual depth was unknown because the root broke off at the petrocalcic layer). In contrast, the plant with the second to the largest above-ground volume had a taproot that was only 26 cm (10.2 in) deep.

Las Vegas bearpoppy plants with 1 to 3 total rosettes have taproots that are similar in length to those excavated in this study. This was demonstrated in a salvage trial reported in this report (see section 3.3). In preparation for that trial, a single poppy plant with one rosette was excavated to determine the length of the taproot. The taproot was 36 cm (14 in) long. From this observation, an excavation method was determined. It consisted of pushing a 20-cm (8-in) diameter, 30-cm (12-in) long thin-walled stove pipe into the soil around the poppy plant (see section 3.3 for more detail). The resulting soil column almost always contained the entire root system of the plant. This is evidence that the taproots of poppy plants with single rosettes are typically shorter than 36 cm (14 in).

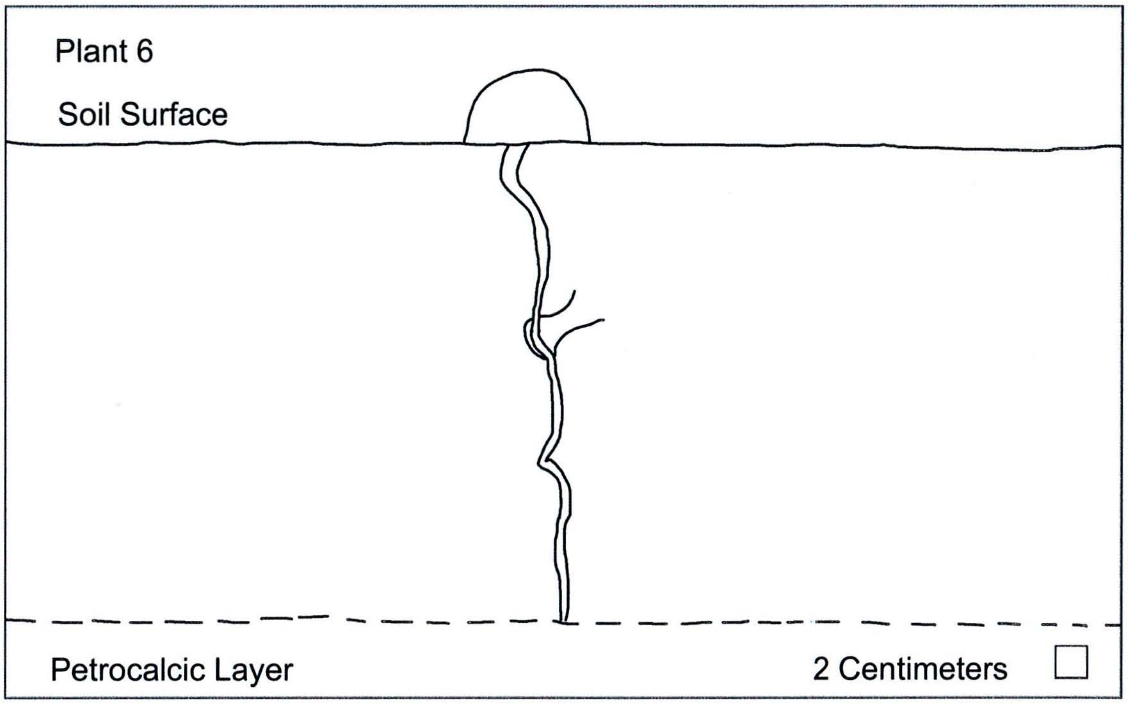

Figure 3.1-6. Diagram of a Las Vegas bearpoppy root system excavated at the North Las Vegas Airport. Diagram is based on a hand field sketch.

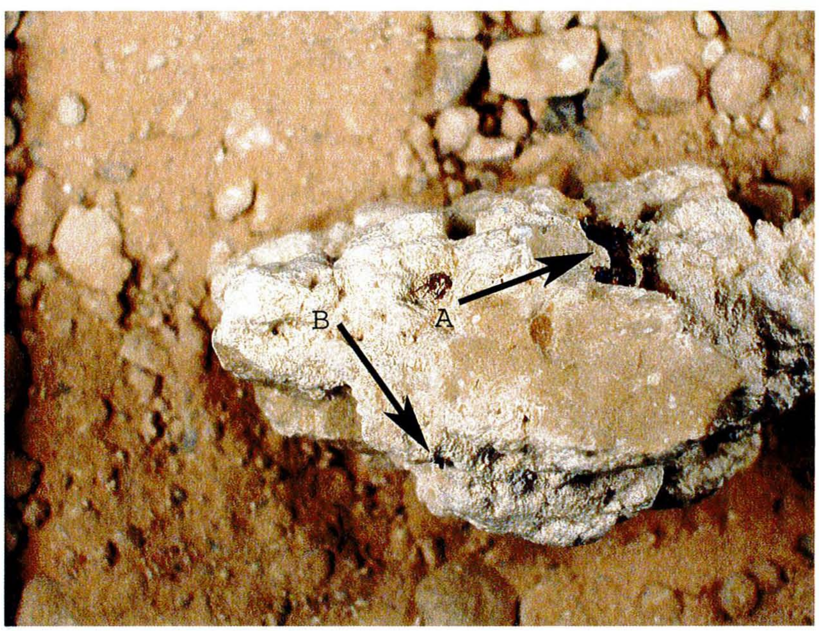

Figure 3.1-7. Las Vegas bearpoppy root growing through a petrocalcic layer. The root is shown protruding through the layer at "A" and "B".

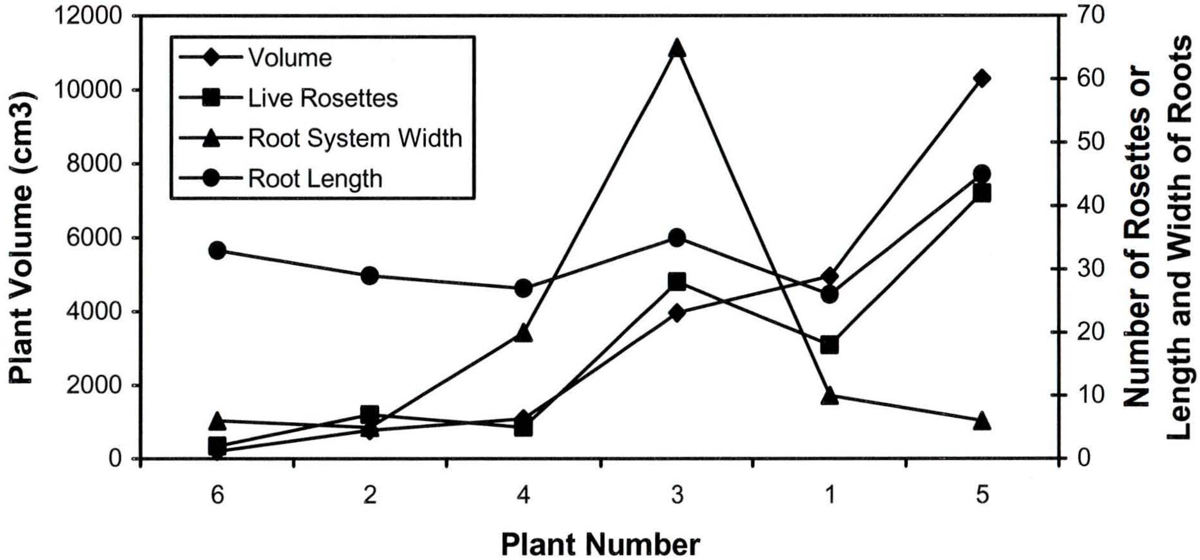

Figure 3.1-8. Comparison of several attributes of six Las Vegas bearpoppy plants. Plant numbers in the horizontal axis are ordered by increasing volume of live rosettes.

3.1.4 Conclusions and Recommendations

The taproots of the plants excavated in this study were generally confined to a column of soil extending vertically beneath the above-ground plant and usually within a column the diameter of the above-ground plant. For this reason, a column of soil slightly larger than the above-ground plant should be sufficient during salvage. The depth of the salvaged soil column should be at least 30 cm (11.8 in) deep for plants with at least 2 total rosettes (the smallest plant excavated in this study). In soils without a petrocalcic layer or with a petrocalcic layer deeper than 30 cm (11.8 in), It may be advantageous to excavate a column of soil deeper than 30 cm (11.8 in).

3.2 Effects of Salvage Method on Survival of Las Vegas Bearpoppy Plants Salvaged from the North Las Vegas Airport

3.2.1 Introduction

As reported in chapter 3.1, the North Las Vegas Airport desired to expand its facilities into existing Las Vegas bearpoppy habitat in 2000. The Nevada Division of Forestry required them to mitigate this proposed action by salvaging Las Vegas bearpoppy plants on Airport property. The Springs Preserve was approached about participating in this salvage effort.

Springs Preserve staff designed a trial to salvage and transplant Las Vegas bearpoppy plants from one of the Airport populations to the Springs Preserve. Based on the information identified in chapter 3.1, three salvage methods were chosen. They included tree spade, box and pipe. To the best of our knowledge, no one has attempted to salvage poppies with a tree spade or with the box method. These methods have the potential to not only salvage much deeper root systems, but also keep roots more intact during transport and planting. The objective of this trial was to determine whether Las Vegas bearpoppy plants could be successfully transplanted with the tree spade, box and pipe methods.

3.2.2 Methods

3.2.2.1 Scientific Approach

The scientific approach of this trial was as follows. Several Las Vegas bearpoppy plants would be identified and tagged at the salvage location. These plants would be randomly assigned to one of three salvage methods. The plants would then be salvaged and transported to the Springs Preserve nursery. The plants would be irrigated to maximize survival and monitored to measure survival, health, growth and phenology. Statistical tests would be performed on the data to determine which salvage method(s) maximizes survival of Las Vegas bearpoppy plants.

3.2.2.2 Study Site

The plants for this trial were salvaged from a Las Vegas bearpoppy population situated along the northern boundary of the North Las Vegas Airport approximately half way between Rancho Drive on the west and Simmons Street on the east (Figure 3.1-1). See chapter 3.1 for more information on the study site. The plants were transported to the Springs Preserve Nursery located behind the Gardens at the Springs Preserve. The Springs Preserve is located approximately 4.8 km (3 miles) west of downtown Las Vegas, Nevada on Alta Drive, 0.4 km (1/4 mile) east of Valley View Boulevard.

3.2.2.3 Study Design and Implementation

The experimental design was a completely randomized factorial with four replications for one salvage method (tree spade, see description of the salvage methods below) and 2 replications for two other salvage methods (box and pipe). Factors included salvage method and time.

A survey of the target population of Las Vegas bearpoppy plants was conducted during September 2000 and twenty-four plants were selected and flagged. The plants at the site varied by size. The plants were all located within an area approximately 1 ha (2.4 ac) in size. The flagged plants were growing in similar soils and topography. The plants were randomly assigned to one of three salvage techniques described below.

A day or two before salvaging, the soil around each of the plants to be salvaged was saturated with water by forming a basin around each plant and then filling the basin with water until the soil beneath the plant was saturated to at least 60 cm (23.6 in). The plants were then salvaged with one of the three methods described below.

Tree Spade Method. Plants were excavated with a Vermeer TS-50 tree spade (Figure 3.2-1). A conical-shaped rootball approximately 90 cm (35 in) in diameter at the top and approximately 60 cm (23.6 in) high was excavated and placed in a 91.4-cm (36-in) wood tree box. With the spades still in place around the rootball, the void between the rootball and box was carefully backfilled with native soil. When the void was nearly filled, the spades were slowly retracted from the box. The remainder of the backfill was deposited and tamped into the box.

Figure 3.2-1. Salvaging a Las Vegas bearpoppy plant at the North Las Vegas Airport with a tree spade.

Box Method. Plants were salvaged by excavating trenches with a backhoe and hand spades around each plant and then assembling 60-cm (24- in) plastic boxes around the rootball (Figure 3.2-2). The void between the box and rootball was then backfilled with native soil. The backfill was tamped to remove air voids.

Pipe Method. A 40.6-cm (16-in) diameter by 76-cm (30-in) tall steel pipe was pushed into the soil around a Las Vegas bearpoppy plant with a backhoe. The thickness of the pipe wall was approximately 0.5 cm (0.2 in). The soil around the pipe was then excavated with the backhoe. The pipe with the rootball inside was then lifted up a few inches and a heavy-gauge plastic bag was slipped over the bottom of the pipe and secured so that the soil would stay in the pipe. In most cases, the soil column in the pipe remained intact and the plastic bag was simply used as a precaution. With the bag in place, the pipe was lifted out of the ground and placed into a 60-cm (24-in) plastic tree box (Figure 3.2-3). The void between the rootball and box was then carefully backfilled with native soil. The soil column in the pipe was loosened with shovels and the pipe was lifted with the backhoe until the pipe slipped off of the soil column. The backfill was then tamped to remove air voids.

Figure 3.2-2. Salvaging a Las Vegas bearpoppy plant at the North Las Vegas Airport with the box method.

Figure 3.2-3. Salvaging a Las Vegas bearpoppy plant at the North Las Vegas Airport with the pipe method.

All salvaged plants were transported within 1 to 3 days after salvaging to the Springs Preserve Nursery. The boxes containing the 12 spaded plants were lined up next to each other in partial shade from nearby trees and a shade structure. The boxes containing the plants excavated with the box (6 plants) and pipe (6 plants) methods were lined up within a few feet from the spaded plants inside a shade structure covered with fabric that blocked 55% of the sun.

Plants were irrigated with a drip system. The irrigation schedule for all plants was as follows: 1 to 2 L (0.26 to 0.53 gal) approximately every two weeks from the middle of October 2001 through December 2001; 2 L (0.53 gal) monthly during the winter (January through February 2001); 2 L (0.53 gal) weekly from the middle of March 2001 through November 2001; 2 L (0.53 gal) monthly during December 2001 and January 2002 and 2 L (0.53 gal) every two weeks from February through May 2002.

Springs Preserve staff aided pollination of each flower on the salvaged plants during the flowering periods (April-May) of 2001and 2002. This was accomplished by removing pollen from the anthers of one plant with a small brush and transporting it to an adjacent plant ready for pollination and depositing it on the stigma of the receiving plant.

3.2.2.4 Data Collection and Analysis

The plants were monitored weekly and the following parameters were measured: (1) survival (alive or dead), (2) leaf color, (3) leaf flexibility and (4) irrigation amount. Leaf color and flexibility were an indication of plant health. Healthy plants had blue-green flexible leaves and plants with poor health had leaves that were stiff and yellowing. Miscellaneous field observations were also recorded. Observations included the presence of insects or insect damage, wilt or leaf drop and other health concerns.

Seeds were harvested and the number of seeds collected from each plant were counted and recorded. The seeds from each plant were weighed.

A significant interaction or differences among means generated from survival data were determined with the Univariate procedure (SPSS version 12.0 2004) and significant differences ($P < 0.05$) were identified using the protected Least Significant Difference (LSD) mean separation procedure (Lentner and Bishop 1986). The Univariate procedure was performed on the arcsin-square root of percentage data as suggested by Sokal and Rohlf (1981).

3.2.3 Results and Discussion

3.2.3.1 Plant Survival

Univariate analysis of survival data showed no significant ($P = 1.00$) interaction between salvage method and date. The salvage method and date main effects were significant ($P = 0.0001$ for both). Survival was significantly greater ($P < 0.05$) for plants salvaged with the box and pipe methods than for those salvaged with the tree spade (Figure 3.2-4). Percent survival across all sampling dates for box, pipe and tree spade methods was 50%, 49% and 32%, respectively.

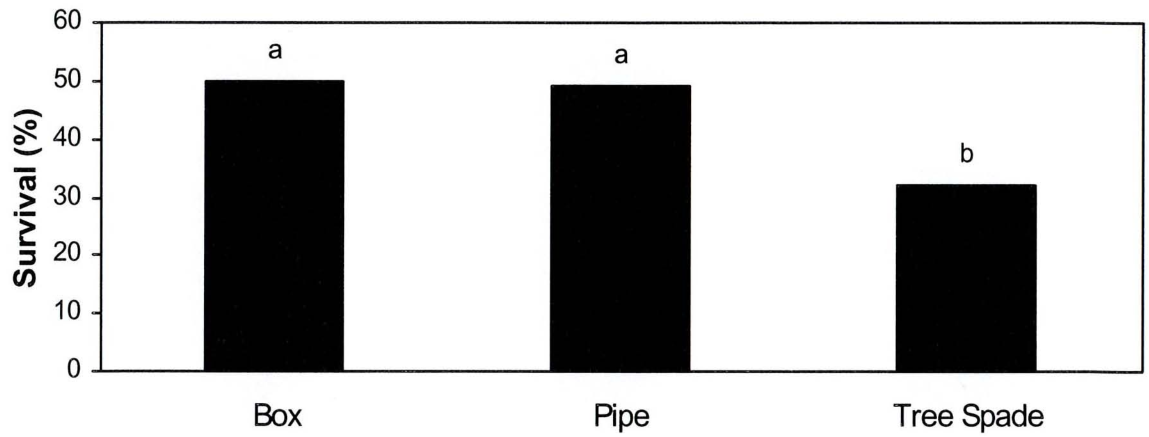

Figure 3.2-4. Percent survival of Las Vegas bearpoppy plants salvaged from the North Las Vegas Airport in relation to salvage method. Salvage means with the same letter are not significantly different ($P < 0.05$).

Several plants salvaged with the tree spade and box methods died within a few days after transplanting (Figure 3.2-5). These plants may have sustained damage to roots during salvaging. Although great care was taken during salvaging, the fragile nature of poppy roots made it difficult to salvage these plants without impacting the roots. The slightest movement or shift of the soil column during salvaging could have severed the fragile taproot of these plants. After the initial dieoff, mortality was fairly constant over the next 20 months except for the period from September 2001 to February 2002, when no plants salvaged with the pipe and box methods died and very few plants salvaged with the tree spade died.

It is unclear why there was greater mortality from plants salvaged with the tree spade. These plants were shaded on the east from a 3 m (10ft) tall shade structure and on the west from 3.7 m (12ft) tall trees. In contrast, the plants salvaged with the box and pipe methods were inside a shade structure that shaded the plants on the east, west and top. This minor difference may have contributed to the greater mortality of the spaded plants. The most likely reason was the impact to the taproot during salvaging with the tree spade.

3.2.3.2 Seed Production

Ten of the 14 plants (71%) alive during the spring of 2001 produced seed and 2 of the 3 plants (66%) alive in the spring of 2002 produced seed. Table 3.2-1 summarizes the seed production during this trial. The mean number of seeds produced per plant in 2001 and 2002 was 1185 and 1651, respectively. The mean weight of seed per plant in 2001and 2002 was 1.78 gm and 2.65 gm (0.06 oz and 0.9 oz), respectively.

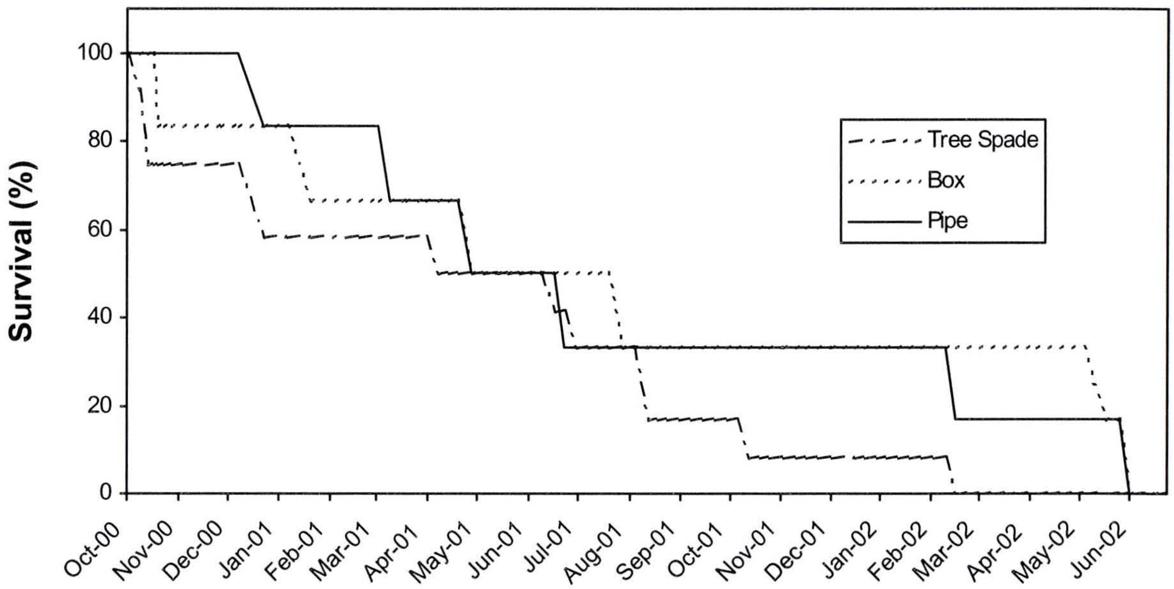

Figure 3.2-5. Percent survival of Las Vegas bearpoppy plants salvaged from the North Las Vegas Airport over time and in relation to three salvage methods.

Table 3.2-1. Seed data collected over two seasons from Las Vegas bearpoppy plants salvaged from the North Las Vegas Airport. Seeds were collected during June of 2001 and 2002.

Plant Number	2001		2002	
	Number of Seeds	Weight of Seeds (gm)	Number of Seeds	Weight of Seeds (gm)
6	1061	1.6	0	0
7	2365	3.9	0	0
9	479	0.6	0	0
10	991	1.7	0	0
11	900	1.7	0	0
15	1867	2.6	0	0
18	289	0.4	1630	2.4
19	795	1.2	0	0
20	1575	2.2	1671	2.9
24	1525	1.9	0	0
Total	11847	17.8	3301	5.3

3.2.4 Conclusions and Recommendations

Survival of Las Vegas bearpoppy plants salvaged with the box and pipe methods was higher than plants salvaged with the tree spade. This greater mortality was probably a result of impacts to root systems by the tree spade method.

The box method was labor intensive requiring first a backhoe and then hand tools to carve out a soil column and then assemble a box around the column. All the handwork required by this method made it slow and tedious. The plastic boxes used with this method and the hand tools were relatively inexpensive.

The tree spade method required a mechanized tree spade operated by a tree-care contractor. The plastic boxes used with the other methods were too small to accommodate the tree spade, so larger wooden boxes were used. The cost per plant using this method was $250. The cost would be less if the group or agency conducting the salvaging owned a tree spade.

The pipe method required the use of a backhoe tractor to push the pipe into the soil and lift the pipe and soil out of the ground and into a planting box. The pipe and boxes used with this method were relatively inexpensive. The overall cost of this method is dependent upon whether a backhoe and operator must be contracted or not.

Of the three methods, the pipe method was preferred by Springs Preserve staff. It was quick, and because the backhoe was owned and operated by Springs Preserve staff, it was also relatively inexpensive.

This trial demonstrated that Las Vegas bearpoppy plants could be salvaged and held above-ground in boxes for several months. This information is useful because it offers additional mitigation options to land managers. It shows that Las Vegas bearpoppy plants may not need to be relocated and planted immediately after salvaging. Salvaged plants may be removed from a site, held for several weeks to months, and then either returned to the salvage site or planted at a new site.

3.3 Growth and Survival of Las Vegas Bearpoppy Plants Salvaged from the Northern Beltway

3.3.1 Introduction

The Springs Preserve was given the opportunity to salvage gypsum soils and Las Vegas bearpoppy plants from the construction area of the northern segment of the Las Vegas Beltway. This salvage effort by the Springs Preserve was a way to mitigate these rare resources for this construction project.

During the winter of 2001, personnel from the Bureau of Land Management and State of Nevada Division of Forestry identified approximately six bearpoppy plants near the junction of I-215 (Northern Beltway) and North 5th Street. These plants were all mature with several rosettes. During spring 2001, several new seedlings emerged near the mature plants. Approximately 15 of these seedlings had survived by November 2001. Most of these seedlings had a single rosette. One of these seedlings was excavated on November 15, 2001 for the purpose of determining the depth and location of its taproot. The 36-cm (14-in) long taproot grew almost vertically beneath the plant. These data aided the selection of the salvage method used in this trial.

Due to the success of the pipe method in the salvage trial at the North Las Vegas Airport, the salvage effort at the Northern Beltway also utilized this method. However, due to the small size of the plants at the Beltway site, smaller pipes (20-cm [8-in] diameter by 30-cm [12-in] length stove pipe) were used and the soil was not pre-wetted.

The objective of this trial was to determine the feasibility of salvaging seedling Las Vegas bearpoppy plants with the stove pipe method and growing them in a growing bed.

3.3.2 Methods

3.3.2.1 Study Sites

Approximately 229 m^3 (300 yd^3) of soil and several Las Vegas bearpoppy plants were salvaged from land located near the intersection of I-215 (Northern Beltway) and North 5th Street (Figure 3.1-1). The topography of the area is characterized by rolling hills, badlands and dry washes. The soil at the site is Las Vegas gravely fine sandy loam (Loamy, carbonatic, thermic, shallow Typic Paleorthids) (Soil Conservation Service 1985). The top of a white, indurated, lime-cemented hardpan (petrocalcic layer) ranges from 8 to 36 cm (3 to 14 in) beneath the soil surface and is approximately 90 cm (36 in) thick.

Major plant species at this site included shadscale saltbush, desertholly (*Atriplex hymenelytra*), seepweed, Anderson's desert thorn, Nevada ephedra, snakeweed (*Gutierrezia sarothrae*), white bursage, creosote bush, rhatany, Fremont's dalea, and desert prince's plume.

Salvaged soil and Las Vegas bearpoppy plants were deposited at the Springs Preserve Nursery.

3.3.2.2 Study Design and Implementation

The salvaged soil from the Northern Beltway was transported to a growing bed in the Springs Preserve Nursery. The imported soil was excavated from the top 15 to 30 cm (6 to 12 in) of the profile and was transported in 20-yard end dump trucks. The soil was deposited to a depth of approximately 51 to 61 cm (20 to 24 in) in the growing bed.

A total of 22 seedlings (one rosette) and six mature plants (two or more rosettes) were salvaged with the pipe method during December 2001. The plants were salvaged in the following manner. A 20-cm (8-in) diameter by 30-cm (12-in) long black stove pipe was pushed into soil containing the plant. The soil around the pipe was then excavated down to the bottom of the pipe. The process of pushing the pipe and excavating around the pipe continued until the surface of the soil inside the pipe was approximately 2.5 cm (1 in) beneath the top rim of the pipe (Figure 3.3-1). The soil beneath the pipe was then excavated and a thin sheet of plywood was slid across the bottom of the pipe and secured across the top of the pipe with wire.

Figure 3.3-1 Las Vegas bearpoppy plant being salvaged near the Northern Beltway in the Las Vegas Valley.

The Las Vegas bearpoppy plants were planted in a growing bed in the Springs Preserve Nursery (Figure 3.3-2). The plants and soil were removed from the pipes in the following manner. A hole was dug in the growing bed. The hole was the depth of the soil column in the pipe and large enough to slide the board out from under the pipe. The pipe with the soil and plant was then set into the hole. The pipe was slid off of the soil column an inch or two. Soil was then deposited around the exposed soil column and packed firmly. The process of sliding the pipe and packing the soil was continued until the pipe was removed from the soil column. A small berm was constructed around each plant to hold irrigation water.

Following planting, an irrigation system was installed with an emitter at each plant. Plants received approximately 7 L (1.8 gal) every 2 to 3 weeks throughout the study.

Springs Preserve staff aided pollination of each flower on the salvaged plants during the flowering periods (April-May) of 2002 and 2003. This was accomplished by removing pollen from the anthers of one plant with a small brush and transporting it to an adjacent plant ready for pollination and depositing it on the stigma of the receiving plant.

Figure 3.3-2 Las Vegas bearpoppy plants salvaged from a site near the Northern Beltway in the Las Vegas Valley growing at the Springs Preserve.

3.3.2.3 Data Collection and Analysis

The plants were monitored weekly and the following parameters were measured: (1) survival (alive or dead), (2) number of live rosettes, (3) number of dead rosettes, (4) number of live flowering stalks, (5) number of flowers and (6) amount of irrigation. Miscellaneous field observations were also recorded.

Seeds were harvested and the number of seeds collected from each plant were counted and recorded. The seeds from each plant were weighed.

No statistics were used in this study to compare survival of seedlings with mature plants because there were not enough mature plants to adequately replicate this group of plants.

3.3.3 Results and Discussion

3.3.3.1 Survival of Salvaged Plants

Two seedlings died within one month after transplanting (Figure 3.3-3). Two more died within two months after transplanting. This initial die-off may have been a result of transplant shock. The rate of mortality for mature plants was greater than that for seedlings. Two mature plants died within 2 months after transplanting, probably from transplant shock and 3 more died within the next 5 months. The remaining 2 mature plants died after seed production in June 2003.

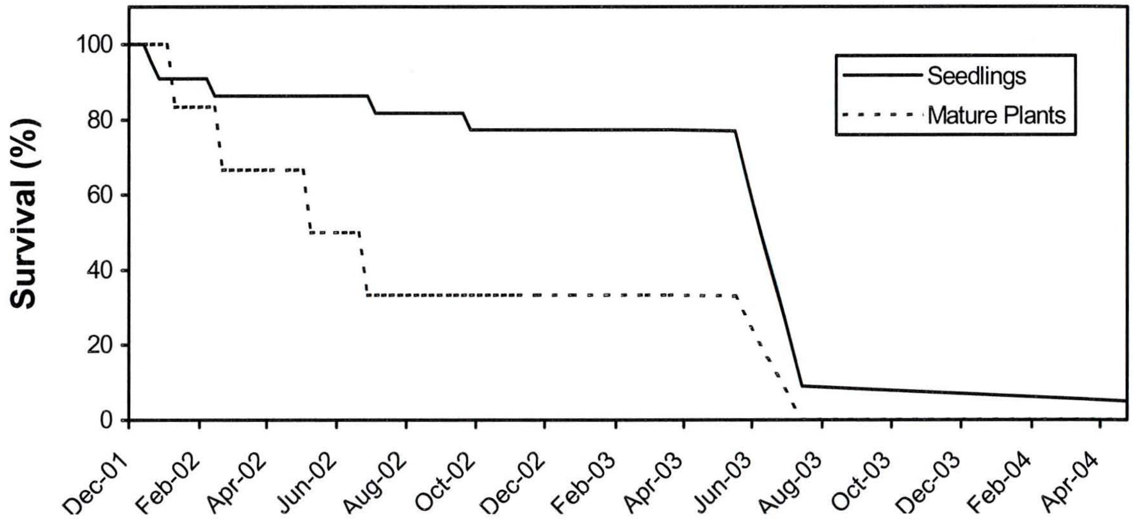

Figure 3.3-3. Percent survival of mature Las Vegas bearpoppy plants and seedlings salvaged from a site near the Northern Beltway in the Las Vegas Valley.

Seedlings had a much higher rate of survival than mature plants. This may be due in part to the fact that seedlings were easier to transplant and were therefore impacted less than mature plants. Nearly 80% of seedlings survived for 19 months after transplanting, then after producing seed in 2003, all but 2 of those plants died. At the time this report was written (June 2004), one plant was still alive.

Mortality among Las Vegas bearpoppy plants is common after seed production. Apparently, poppy plants divert so much energy into flowering and seed production that often the rosette that produced the flowering stalk and in some cases the entire plant dies. This is what appeared to have happened to these salvaged plants after seed production in 2002 and 2003.

3.3.3.2 Plant Growth

The number of rosettes on mature plants decreased within six weeks after planting (Figure 3.3-4); probably a result of transplant shock. The number of rosettes for both mature plants and seedlings tripled during May and June 2002. Some rosettes died after seed production in June and July 2002. Most plants added rosettes during September and October 2002.

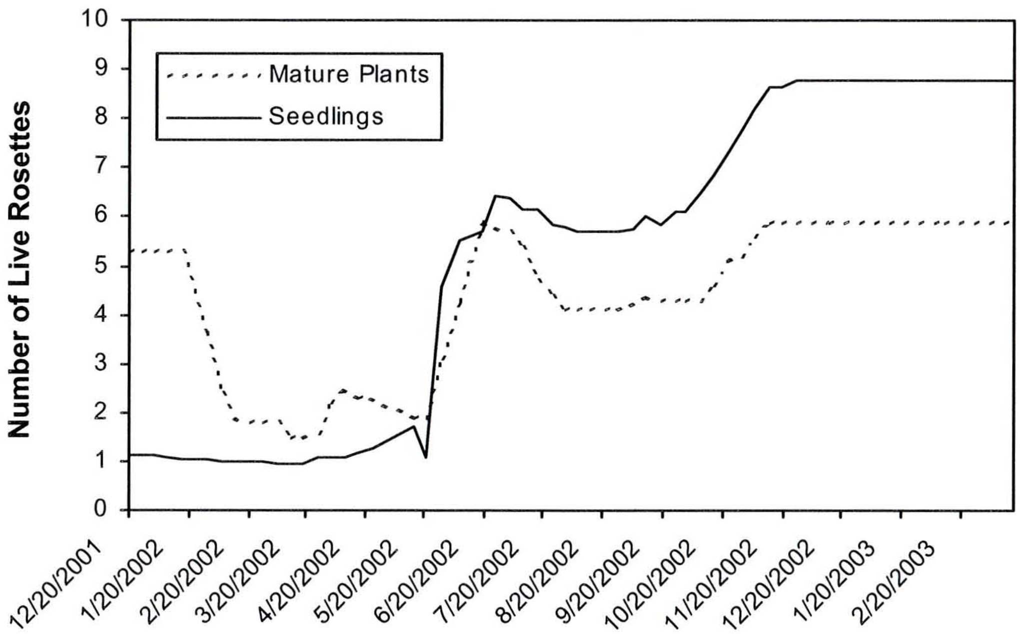

Figure 3.3-4 Mean number of live rosettes on mature Las Vegas bearpoppy plants and seedlings salvaged from a site near the Northern Beltway in the Las Vegas Valley.

3.3.3.3 Flowering and Seed Production

During 2002, 18 of the 23 living poppy plants produced flowers and seed (Table 3.3-1). During 2003 all of the 19 living plants produced flowers and seed. The mean number of seeds per plant and capsule in 2002 was 832 (SD = 330.1) and 44 (SD = 14.0). The mean number of seeds per plant and capsule in 2003 was 21,090 (SD = 9937) and 66 (SD = 20.3), respectively. Seed production per plant increased dramatically in 2003. This was due to the increase in capsules and the number of seeds per capsule. The mean number of capsules per plant in 2002 was 17 (SD = 6.3) compared to 322 (SD = 126.6) in 2003. Mistretta, et al. (1996) stated that the average number of seeds produced by each Las Vegas bearpoppy fruit is usually at least 100 and up to 160 and Meyer (1987) determined that the average number of seeds per capsule was 91. The mean number of seeds per capsule for this trial (66 and 44) during both years was much less than that.

3.3.4 Conclusions and Recommendations

This trial demonstrated that Las Vegas bearpoppy plants can be successfully salvaged with the stove pipe method. The following things may have contributed to the high survival of plants in this trial. (1) The stove pipe method allowed the plant to be salvaged with all or most of the root system intact. (2) The stove pipe method allowed the plant to be transported without damage to the root system. Other methods such as the tree spade used in section 3.2 allowed the soil mass containing the root to shift during transport. This may have damaged the fragile taproot of the plant. (3) The stove pipe method allowed the plant to be planted in the growing bed with minimal impact to the plant. (4) Plants were salvaged in December when the plants were dormant. (5) The plants were grown in a growing bed that was protected from the public. (6) The plants were irrigated as needed.

Table 3.3-1. Seed data collected over two seasons from Las Vegas bearpoppy plants salvaged from the Northern Beltway. Seeds were collected during May and June of 2002 and 2003.

Plant Number	2002				2003			
	Number of Capsules	Number of Seeds per Plant	Weight of Seed (gm)	Seeds Per Capsule[b]	Number of Capsules	Number of Seeds per Plant[c]	Weight of Seed (gm)	Seeds per Capsule[b]
1	20	882	1.2	35	155	11486	19.6	74
2	0	0	0	0	433	10372	17.7	24
3	0	0	0	0	0	0	0	0
4	8	378	--	--	189	8321	14.2	44
5	--[a]	1584	2.7	--	394	29300	50.0	
6	18	602	1	33	465	25022	42.7	54
7	14	776	1.4	59	240	23264	39.7	97
8	0	0	0	0	409	20686	35.3	51
9	0	0	0	0	339	21155	36.1	62
10	--	679	1.2	--	63	3164	5.4	50
11	0	0	0	0	0	0	0	0
12	0	0	0	0	0	0	0	0
13	0	0	0	0	0	0	0	0
14	--	1506	2.8	--	0	0	0	0
15	--	599	1.8	--	365	18342	31.3	50
16	--	734	1.6	--	545	33050	56.4	61
17	--	525	1	--	0	0	0	0
18	0	0	0	0	0	0	0	0
19	16	985	1.8	66	233	21858	37.3	94
20	--	729	1.3	--	213	10665	18.2	50
21	--	1017	2.7	--	354	32347	55.2	91
22	0	0	0	0	0	0	0	0
23	--	965	1.9	--	498	42075	71.8	84
24	0	0	0	0	338	31410	53.6	93
25	29	1078	2.3	46	0	0	0	0
26	14	758	1.2	50	239	13712	23.4	57
27	12	348	0.5	24	404	24202	41.3	60
28	23	822	1.5	38	243	20276	34.6	83

[a] Data unknown
[b] Calculated by dividing the number of seeds per plant by the number of capsules per plant
[c] Calculated by multiplying weight of seed by 586 seeds per gm.

The stove pipe method has several advantages over the methods used in section 3.2. The box, spade and pipe methods used in that trial required heavy equipment such as backhoes, cranes and tree spades. They also required skilled operators and special materials. They were also time consuming. A single plant was salvaged by two to four people with the spade, pipe and box methods in approximately 30, 30 and 60 minutes, respectively. In contrast, depending upon the soil type, a plant could be salvaged by two people with the stove pipe method in approximately 10 to 20 minutes.

Although the stove pipe method can be used for mature plants, due to the small size of the pipes, it is best for seedlings. The pipes used in this trial were 30 cm (12 in) long. This length was sufficient for seedlings, but may not be long enough for mature plants with longer taproots. The stove pipes used in this trial came in one length. If longer pipes are required, they may need to be custom made.

One of the advantages of the stove pipe method is that the walls of the pipe were strong and thin. Compared to the thick-walled PVC used by others in previous salvage efforts, the thin, knife-like edge of the stove pipe was pushed through the soil with relative ease.

We recommend that given a choice, seedlings be given priority over mature plants during salvage efforts. Seedlings are easier to salvage and due to the fact that Las Vegas bearpoppy plants are short-lived, they have the potential to live longer and contribute to a new habitat longer than larger (older) plants. It does not make much sense to expend so many resources salvaging an old plant that may only live a short time.

3.4 Survival of Las Vegas Bearpoppy Plants Salvaged from the Lambchange Property

3.4.1 Introduction

The main objective of this trial was to determine the feasibility of salvaging Las Vegas bearpoppy plants using the stove pipe method. Another trial utilizing this method was conducted a few months earlier at the Northern Beltway (see section 3.3) on a soil that contained gravel. Although, the plants at the Beltway site were salvaged relatively easily, the gravel interfered with salvaging. Springs Preserve staff had been given an opportunity to salvage Las Vegas bearpoppy plants from a property with deep, gravel-free soils, so we desired to test the stove pipe method on these soils. The salvage effort would also be conducted during another time of the year and would give us an opportunity to salvage plants during another season.

3.4.2 Methods

3.4.2.1 Scientific Approach

The scientific approach of this trial was as follows. Several Las Vegas bearpoppy plants with a single rosette were identified and tagged at the salvage location. The plants were then salvaged with the stove pipe method and transported to a growing bed in the Springs Preserve Nursery. The plants were irrigated to maximize survival and monitored to measure survival, health, growth and phenology.

3.4.2.2 Study Sites

The plants for this trial were obtained from private property located approximately 1 km (0.62 mile) north of the intersection of I-15 and Lamb Boulevard (Figure 3.1-1). Las Vegas bearpoppy plants are relatively abundant on this site, although most plants were small consisting of one to a few rosettes. Las Vegas buckwheat is common at this site. Other major plant species at this site included Nevada ephedra, shadscale saltbush, seepweed, Anderson's desert thorn, creosote bush, white bursage, rhatany, winterfat, big galletta grass, brittlebush and desert prince's plume.

The topography of the salvage area is characterized by small rolling hills and dry washes. The soil at the site belongs to the Las Vegas-McCarren-Grapevine Complex (Soil Conservation Service 1985). The soil is deep with almost no rocks or gravel in horizons above the hardpan. Depth to indurated, lime-cemented hardpan (petrocalcic layer) is approximately 30 cm (12 in).

The salvage trial was conducted in a growing bed at the Springs Preserve Nursery. The trial area was 7 x 7 m (23 x 23 ft). The soil is approximately 60 cm (24 in) deep and was salvaged from the top 30 cm (11.8 in) of an undisturbed soil within the construction zone of the northern portion of the Las Vegas Beltway (I-215). The salvaged soil was a Las Vegas gravely fine sandy loam (Loamy, carbonatic, thermic, shallow Typic Paleorthids) (Soil Conservation Service 1985). The top of a white, indurated, lime-cemented hardpan (petrocalcic layer) ranged from 20.3 to 35.6 cm (8 to 14 in) beneath the surface of the salvaged soil. The salvaged soil was transported in 20-ton end dump trucks, dumped into the growing bed and leveled with a front-end loader. Care was taken to minimize compaction of the soil.

3.4.2.3 Study Design and Implementation

A total of 22 seedlings with single rosettes were salvaged with the stove pipe method on March 28 and 29, 2002 (Figure 3.4-1). Permission was obtained from the landowner to salvage plants from the site. The plants were salvaged with the method described in section 3.3.2.2 of this report. Following salvaging, the plants were transported to and planted in the growing bed at the Springs Preserve Nursery (Figure 3.4-2). The plants were planted following the method described in section 3.3.2.2 of this report. A small berm was constructed around each plant to hold irrigation water.

Following planting, an irrigation system was installed with an emitter at each plant. Plants received approximately 4 L (1 gal) every 3 to 7 days throughout the study.

Springs Preserve staff aided pollination of each flower on the salvaged plants during the flowering periods (April-May) of 2002 and 2003. This was accomplished by removing pollen from the anthers of one plant with a small brush and transporting it to an adjacent plant ready for pollination and depositing it on the stigma of the receiving plant.

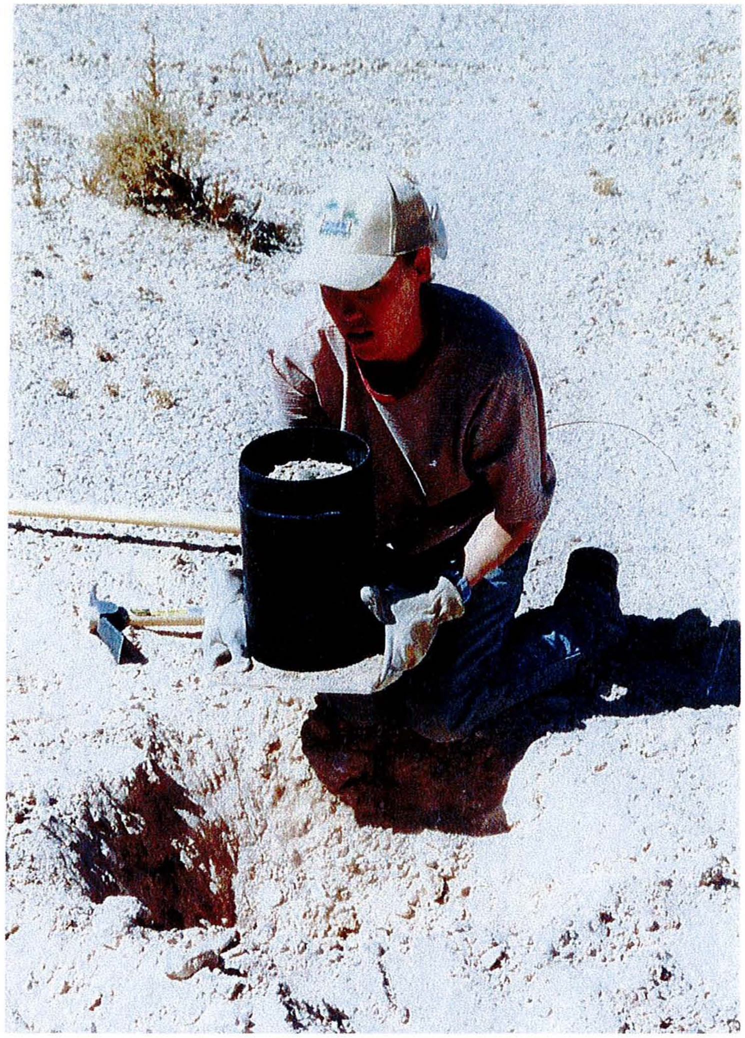

Figure 3.4-1 Las Vegas bearpoppy plant being salvaged from a site near I-15 and Lamb Boulevard in the Las Vegas Valley.

3.4.2.4 . Data Collection and Analysis

The plants were monitored weekly throughout the trial and the following parameters were measured: (1) survival (alive or dead), (2) number of live rosettes, (3) number of dead rosettes, (4) number of live flowering stalks, (5) number of flowers and (6) amount of irrigation. Miscellaneous field observations were also recorded.

Seeds were harvested and the number of seeds collected from each plant were counted and recorded. The seeds from each plant were weighed.

Figure 3.4-2 Las Vegas bearpoppy plants, salvaged near I-15 and Lamb Boulevard in the Las Vegas Valley, growing at the Springs Preserve.

3.4.3 Results and Discussion

Ten of the 22 plants in this trial died within 17 days after transplanting (Figure 3.4-3). Six more plants died within five weeks after transplanting. All but one plant had died within five months after transplanting. The remaining plant lived 14 months.

Only three plants ever produced more than one rosette. Two plants that survived for four months produced 8 and 9 rosettes, respectively, and the plant that survived for 14 months produced 31 rosettes.

Only two of the plants produced flowering stalks during the spring of 2002, but none of the plants produced flowers or seed during 2002. The last remaining plant produced 77 flowers on 5 flowering stalks in 2003. Capsules from the flowers on this single plant produced 7559 seeds. This plant died after flowering in June 2003.

It is unknown why plants in this trial died so quickly. The stove pipe salvaging method had been shown to be effective for Las Vegas bearpoppy seedlings at the Northern Beltway several months earlier (see section 3.3 of this report). Conditions for the two trials were similar in the following ways: (1) the same excavation method was used for both trials, (2) the plants were planted in the same growing bed with the same soil type and (3) the plants were irrigated. The only differences between the two trials were: (1) different soil types at the salvage sites and (2) the season of salvage and planting.

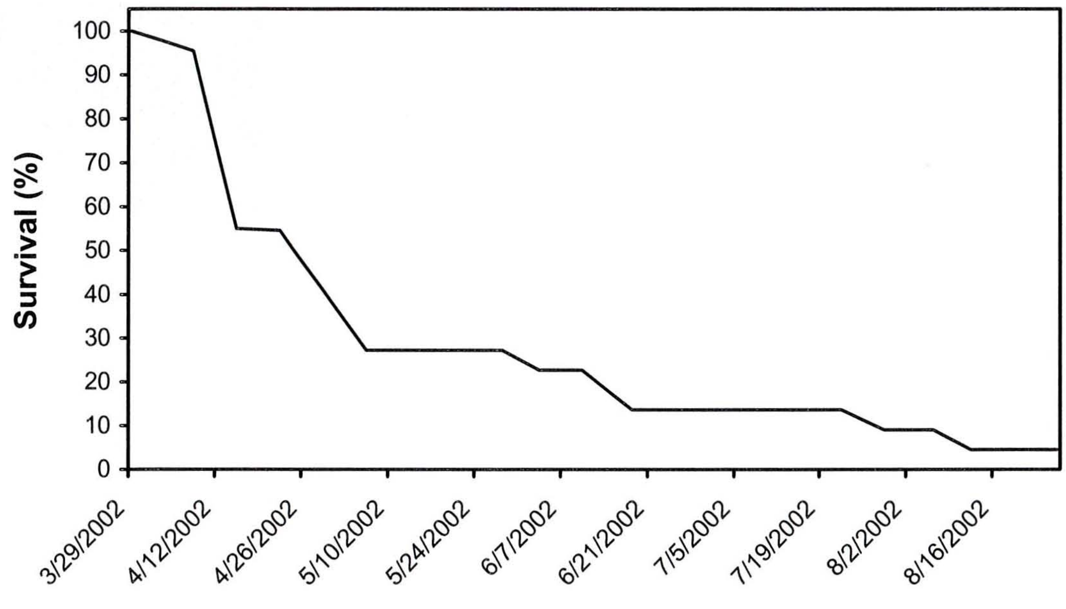

Figure 3.4-3. Percent survival of Las Vegas bearpoppy plants salvaged from land near I-15 and Lamb Boulevard in the Las Vegas Valley and grown in the Springs Preserve Nursery.

Soil conditions at the Lambchange property appeared to be ideal for this method; certainly better than conditions at the Northern Beltway site where rock and gravel made salvaging somewhat slow and tedious as well as increased the potential for impact to the fragile poppy roots. The soils at the Lambchange site were essentially rock-free and therefore the salvage process proceeded with very little impact to the plants. Plants at this site were salvaged in under 10 minutes, while those at the Northern Beltway site took twice as long to salvage.

These plants were salvaged in late March just before the period during which Las Vegas bearpoppy plants produce new rosettes and flowers. The salvage process and supplemental water from irrigation may have disturbed the physiology of the plants during this sensitive time.

3.4.4 Conclusions and Recommendations

This trial demonstrated that the stove pipe method can be used to quickly and effectively salvage Las Vegas bearpoppy plants. The soil at the Lambchange site was nearly rockfree, so salvaging was clean and quick and it is unlikely that the roots were impacted during salvaging, transporting or planting.

3.5 The Distribution of Seeds in the Seedbank Surrounding Las Vegas Bearpoppy Plants at the North Las Vegas Airport

3.5.1 Introduction

Recommended mitigation measures on lands containing Las Vegas bearpoppy plants often include the removal of soil containing poppy seeds around poppy plants. Las Vegas bearpoppies are short-lived perennials with long-lived seeds, therefore the salvage of the seedbank has been assumed to be critical to the survival of a poppy population. However, little information is available regarding the amount of seed that ends up in the seedbank, the distribution of that seed in relation to mother plants and the viability of those seeds. This information would give us a better understanding regarding the amount of soil to remove during mitigation, the potential for salvaging seeds for germination studies and propagation and the potential for encouraging recruitment of poppy plants from the seedbank. The objective of this study was to determine the distribution of seeds in the seedbank around Las Vegas bearpoppy plants in relation to plant size, distance from the plant and depth in the seedbank.

3.5.2 Methods

3.5.2.1 Study Site

The site for this study was the North Las Vegas Airport (Figure 3.1-1). Details regarding the study site are found in Section 3.1.2.1.

3.5.2.2 Study Design and Implementation

Six Las Vegas bearpoppy plants were randomly selected for sampling, three with approximately 10 live rosettes and three with approximately 30 live rosettes (Table 3.5-1). Each sampled plant was at least 3 m (9.8 ft) from any other living or dead poppy plant. This was to prevent contamination of the seedbank around sampled plants from the seed of other non-sampled plants.

Table 3.5-1. Number of live rosettes of Las Vegas bearpoppy plants sampled at the North Las Vegas Airport.

Plant Number	Number of Live Rosettes
1	8
2	9
3	29
4	10
5	31
6	39

The experimental design was a completely randomized 2 x 2 x 4 factorial with three replicates (number of plants). Factors included plant size, distance from the plants and depth in the seedbank. Levels of the plant size factor included plants with approximately 10 live rosettes or approximately 30 live rosettes. Levels of the depth factor included 0 to 2 cm (0 to 0.8 in) in the seedbank and 2 to 4 cm (0.8 to 1.6 in) in the seedbank. Sampling distances were the base of the plant and 50, 100 and 150 cm (19.6, 39 and 59 in) from the base of the plant (Figure 3.5-1). Four subsamples, one for each of the North, South, East and West sides of the plant for each of the distances and depths were collected at each plant.

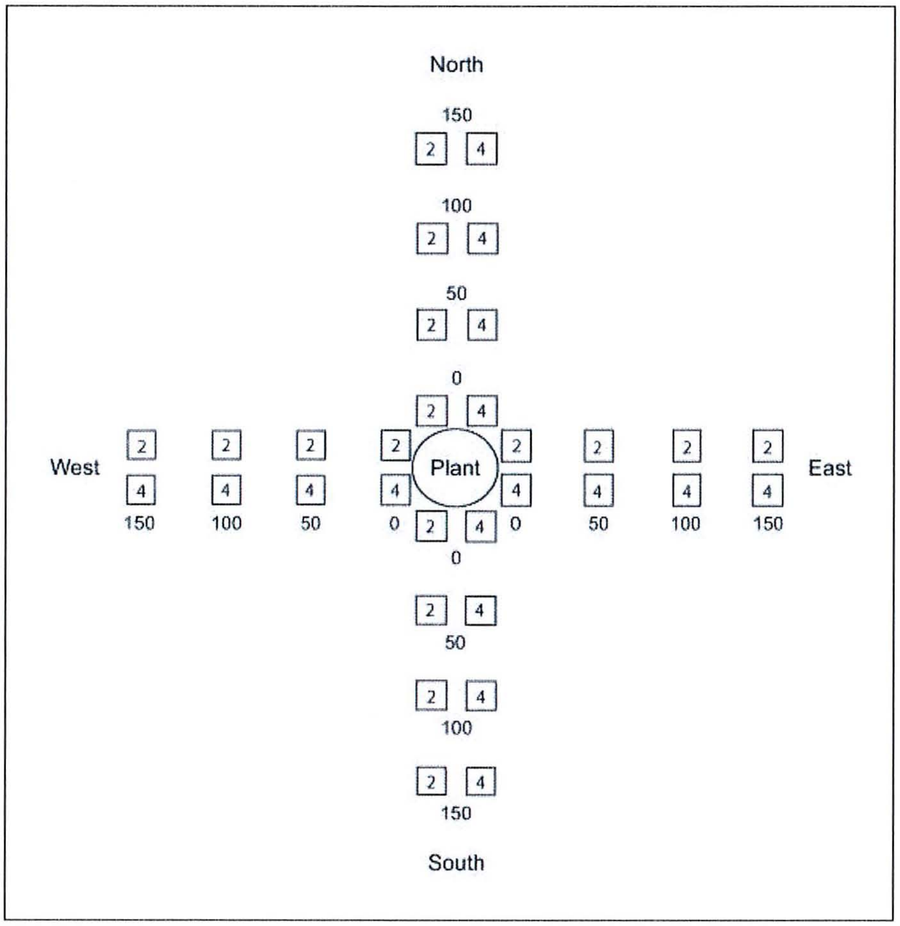

Figure 3.5-1. Sampling diagram used to determine the distribution of seeds around Las Vegas bearpoppy plants at the North Las Vegas Airport.

3.5.2.3 Data Collection and Analysis

Seedbank samples were collected using the following protocol. Sample locations around a plant were identified using measuring tapes and marked with pin flags. The 0- to 2-cm (0- to 0.8-in) subsamples were collected by removing approximately 300 gm (3/4 cup) of soil from the top 2 cm (0.8 in) of the soil surface and placing it into a plastic bag (Figure 3.5-2). The 2- to 4-cm (0.8- to 1.6-in) subsamples were collected by removing approximately 300 gm (3/4 cup) of soil from 2 to 4 cm (0.8 to 1.6 in) below the soil surface. The location for the 2- to 4-cm (0.8- to 1.6-in) depth was next to the 0- to 2-cm (0- to 0.8-in) depth, not below it.

Figure 3.5-2 Collecting seedbank samples around a Las Vegas bearpoppy plant.

The subsamples were sent to the Seed Laboratory at Colorado State University for processing (Figure 3.5-3). Lab analysis consisted of the following for each sample (1) weight of entire sample, (2) number of whole seeds and seed fragments and (3) weight of all whole and seed fragments in a sample. Categories for seed fragments were (1) 75-99% intact, (2) 51-75% intact, and (3) <51% intact. The data for the four subsamples for whole seeds and seed fragments were pooled into one sample for analysis.

Significant interactions and differences among means generated from numbers of whole seeds and seed fragments were determined with the Univariate procedure (SPSS version 12.0 2004) and significant differences ($P < 0.05$) were identified using the protected Least Significant Difference (LSD) mean separation procedure (Lentner and Bishop 1986). Separate analyses were performed on numbers of whole seeds and numbers of seed fragments.

Figure 3.5-3 Las Vegas bearpoppy seeds and capsule. One seed is approximately 2 mm (0.08 in) long.

3.5.3 Results and Discussion

3.5.3.1 Whole Seeds

Univariate analysis of whole seed data showed no significant ($P < 0.05$) interactions or main effects. In general, large plants had more seeds in the seedbank than small plants, although this was not significant ($P < 0.05$).

For large plants, similar numbers of seed were found at the 0- to 2-cm (0- to 0.8-in) and 2- to 4-cm (0.8- to 1.6-in) depths (Figure 3.5-4). However, for small plants, the number of seeds at the two depths varied (Figure 3.5-5). One sample at the 2- to 4-cm (0.8- to 1.6-in) depth had twice as many seeds as any other sample. This datum skewed the 2- to 4-cm (0.8- to 1.6-in) depth at the 150-cm (59-in) distance location. The analysis was rerun without this datum. The results of this analysis showed that even without this datum, none of the interactions or main effects were significant. The data reported in Figure 3.5-5 contain this datum.

Common sense would indicate that the number of seeds in the seedbank would decrease with increased distance from the plant. Results from this study show that, at least up to 150 cm (59 in) from the plant, this is not true; samples at 150 cm (59 in) contained as many seed as those closer to the plant.

Based on the mean number of whole seeds found in these samples (4.64), an estimated 762 whole seeds were present within the top 4 cm (1.6 in) of the soil and a radius of 150 cm (59 in) around each Las Vegas bearpoppy plant (with at least 9 live rosettes) at the North Las Vegas Airport. This translates to 1.5 seeds per 400 gm (approximately one cup) of soil. It is unknown how many seeds are present in the seedbank outside of these areas. Based on the fact that the number of seeds in the seedbank did not decrease with distance from the plant (up to 150 cm [59 in]), it is likely that a sizeable number of seeds are present in the seedbank beyond the 150 cm (59 in). Also unknown is the number of seeds lodged in the plant itself. Given the fact that these seeds are not dispersed by wind and given the location of the seed capsules above the rosettes, a large proportion of the seeds could be lodged in the plant.

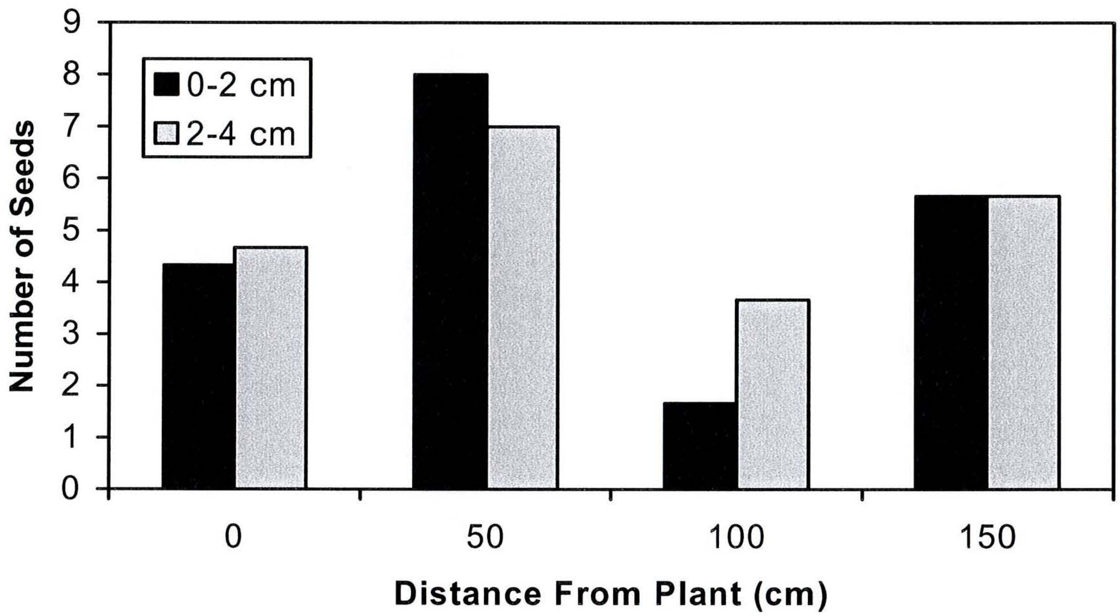

Figure 3.5-4. Mean number of whole seeds in the seedbank around large Las Vegas bearpoppy plants in relation to distance from the mother plant (0, 50, 100 or 150 cm) and depth (0-2 cm or 2-4 cm) in the seedbank. Standard error for all means is 4.14.

The number of seeds in the seedbank did not vary by depth in the seedbank. Samples obtained from 2 to 4 cm (0.8 to 1.6 in) beneath the soil surface contained as many seeds as samples obtained from the top 2 cm (0.8 in) of the seedbank (Figures 3.5-4 and 3.5-5). It is unknown how Las Vegas bearpoppy seeds become located so deep in the seedbank and whether or not these seeds are viable and capable of germinating and producing radicals that can emerge from these depths in the soil. Additional information that needs to be obtained is the depth of the seedbank around Las Vegas bearpoppy plants.

3.5.3.2 Seed Fragments

By definition, seed fragments were incomplete seeds and therefore would be unlikely to germinate and produce plants. For this reason these data may have limited value. However, they do give an indication of the distribution of seeds in the seedbank around Las Vegas bearpoppy plants.

Univariate analysis of seed fragment data showed a significant ($P < 0.05$) main effect for depth of seed in the seedbank. All other interactions and main effects were not significant ($P < 0.05$).

There were more seed fragments from 2 to 4 cm (0.8 to 1.6 in) in the seedbank than from 0 to 2 cm (0 to 0.8 in) in the seedbank regardless of plant size (Figure 3.5-6).

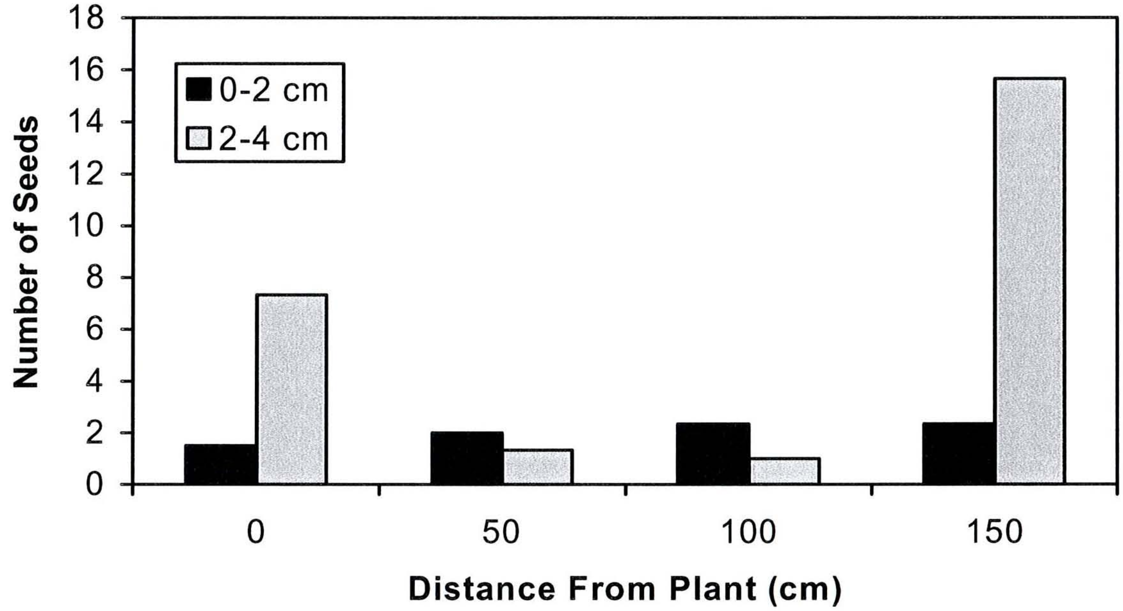

Figure 3.5-5. Mean number of whole seeds in the seedbank around small Las Vegas bearpoppy plants in relation to distance from the mother plant (0, 50, 100 or 150 cm) and depth (0-2 cm or 2-4 cm) in the seedbank. Standard errors range from 4.14 to 5.07.

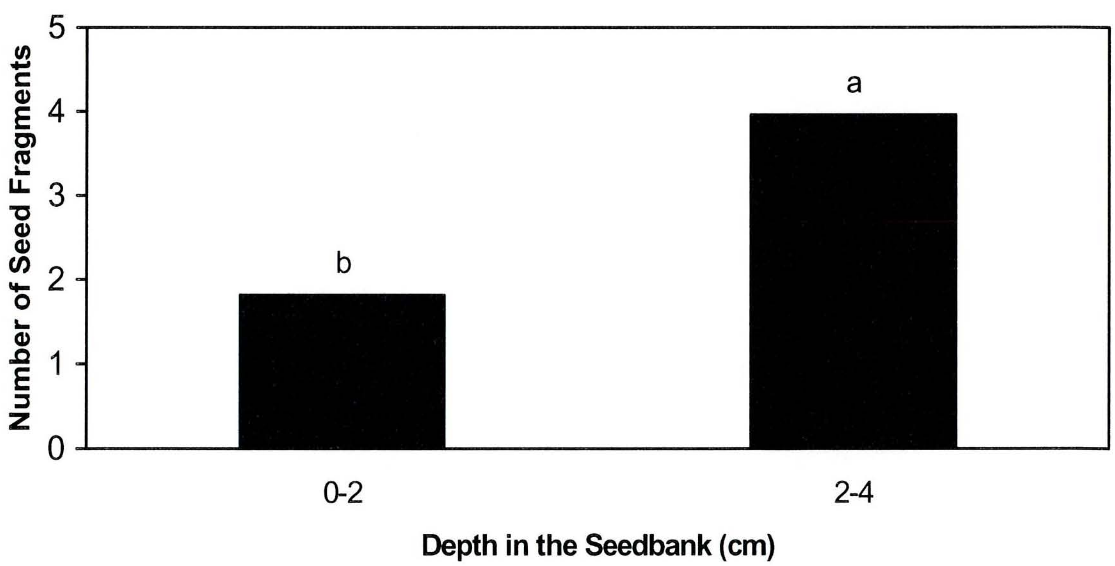

Figure 3.5-6. Mean number of seed fragments in the seedbank around Las Vegas bearpoppy plants in relation to depth (0-2 cm or 2-4 cm) in the seedbank. Bars with the same letter are not significantly different ($P < 0.05$).

Similar to whole seeds, the number of seed fragments did not vary with distance from the plant (Figures 3.5-7 and 3.5-8). These data indicate that the seedbank around Las Vegas bearpoppy plants may contain more seeds than previously thought, although many may be seed fragments that cannot produce plants.

Data from this study indicate that there are 1.6 whole seeds to every seed fragment. Most seed fragments were small. Seventy-four percent of fragments were smaller than ½ of a whole seed, 8% were over ½ of a seed and less than ¾ of a seed and 18% were over ¾ of a seed and less than 99% of a completely intact seed (Figure 3.5-9).

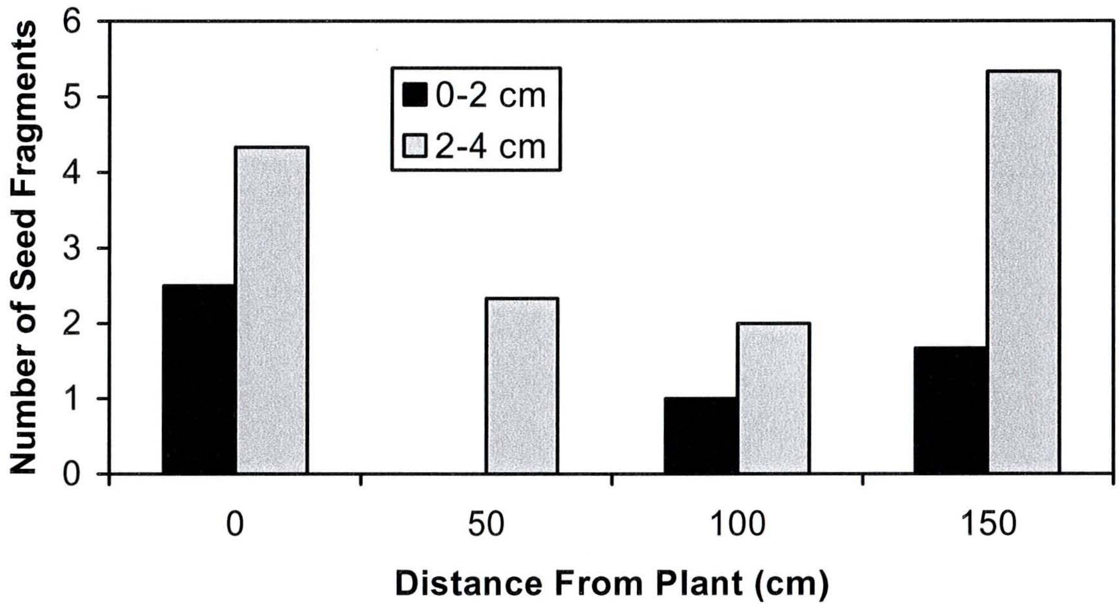

Figure 3.5-7. Mean number of seed fragments in the seedbank around small Las Vegas bearpoppy plants in relation to distance from the mother plant (0, 50, 100 or 150 cm) and depth (0-2 cm or 2-4 cm) in the seedbank. Standard errors range from 2.06 to 2.52.

3.5.4 Conclusions and Recommendations

This study attempted to determine the distribution of seed around Las Vegas bearpoppy seeds at the North Las Vegas Airport. This objective was only partially met because the data ranges set forth for this study did not bound the actual data. In other words, the number of seeds in the seedbank did not decrease with distance from the plant or depth in the soil. Additional samples further from the plant and deeper in the soil would be necessary to better define the distribution of seeds in the seedbank. The good news is that the seedbank is larger and deeper than we anticipated.

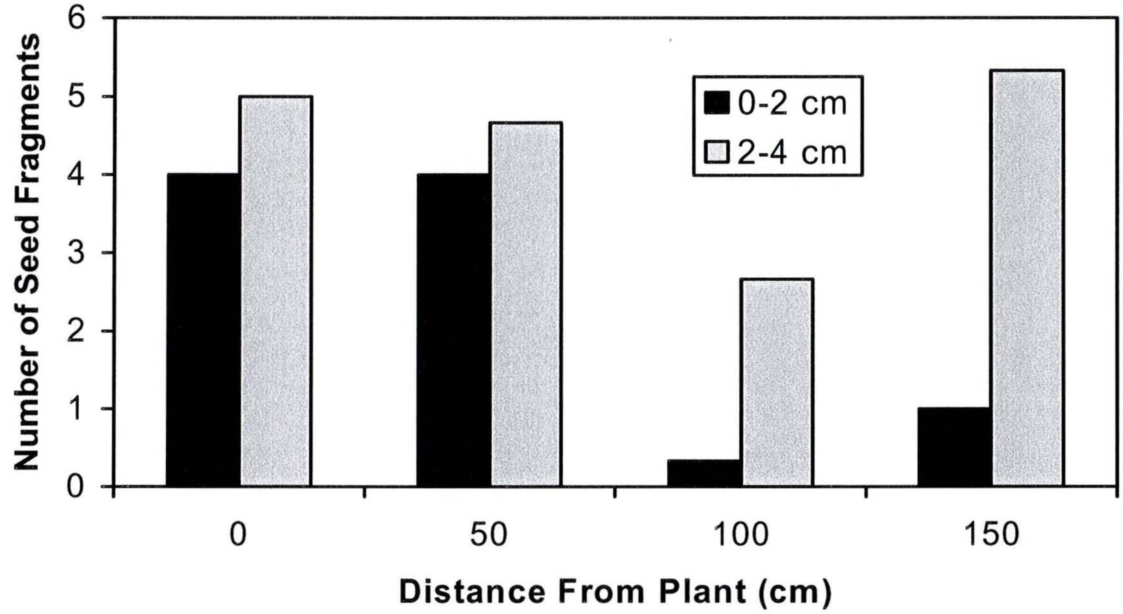

Figure 3.5-8. Mean number of seed fragments in the seedbank around large Las Vegas bearpoppy plants in relation to distance from the mother plant (0, 50, 100 or 150 cm) and depth (0-2 cm or 2-4 cm) in the seedbank. Standard error for all means is 2.06.

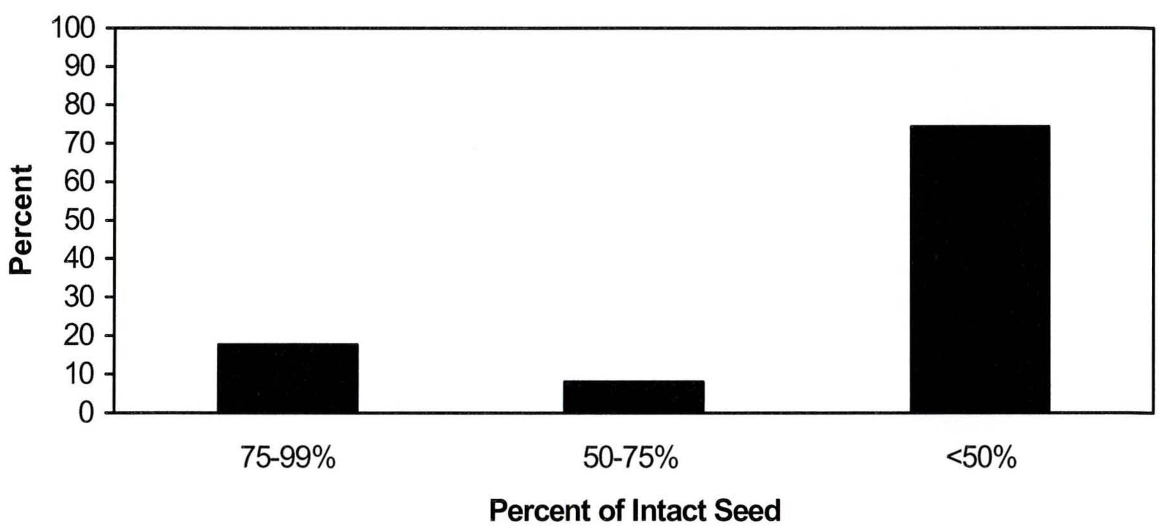

Figure 3.5-9. Percent of seed fragments found in the seedbank around Las Vegas bearpoppy plants at the North Las Vegas Airport in relation to three seed fragment categories.

These data indicate that there are sufficient numbers of poppy seeds in the seedbank around Las Vegas bearpoppy plants to consider the salvage of seedbank as a mitigation option. The seedbank should be salvaged to at least 150 cm (59 in) from the plant and at least 4 cm (1.6 in) deep. Seedbank salvage should only be conducted if the plant is to be salvaged and transplanted or sacrificed. If the plant is to be sacrificed, it is recommended that the entire plant (including all live and dead rosettes and flowering stalks) and all litter around the plant be salvaged and processed to extract all seeds. Seedbank salvage around dead plants is also recommended.

There are several research questions that could be addressed that would provide additional information regarding the seedbank around Las Vegas bearpoppy plants. They are: (1) how many seeds are in the seedbank outside the 150-cm (59-in) sample area measured in this study, (2) how many seeds are found in the seedbank below the 4-cm (1.6-in) depth measured in this study and (3) what proportion of seeds are deposited in the plant versus the seedbank around the plant.

3.6 Effects of Three Salvage Methods on the Growth and Survival of Las Vegas Buckwheat

3.6.1 Introduction

The main objective of this trial was to determine the feasibility of salvaging Las Vegas buckwheat plants. Salvaging may become an important option for mitigating Las Vegas buckwheat populations should this rare species be listed by the State of Nevada or the federal government. Information from this trial should help others to know whether or not it is feasible to mitigate by salvaging these plants.

The Springs Preserve requires Las Vegas buckwheat plants for a special rare plant community. Some of the plants in this landscape should be mature specimens. Due to the short timeframe before the Springs Preserve opens in 2006, mature plants may only be obtained by salvaging plants in the wild. This trial will help to determine whether or not it is feasible to salvage buckwheat for the Springs Preserve.

Knowledge is also needed regarding the germination and propagation of Las Vegas buckwheat. This knowledge could aid Springs Preserve staff in propagating plants for landscapes in the Springs Preserve and also be an option for mitigating Las Vegas buckwheat populations on other lands. Monitoring the phenology of these plants and germinating seeds collected from them should provide opportunities to obtain this knowledge.

3.6.1.1 Scientific Approach

The scientific approach of this trial was as follows. Several Las Vegas buckwheat plants in the same size range would be identified and tagged at the salvage location. These plants would be randomly assigned to one of three salvage methods. The plants would then be salvaged and transported to a growing bed in the Springs Preserve Nursery. The plants would be randomly assigned to a location in the growing bed and then planted. The plants would be irrigated to maximize survival and monitored to measure survival, health, growth and phenology. Statistical tests would be performed on the data to determine which salvage method maximizes survival and growth of Las Vegas buckwheat plants.

3.6.2 Methods

3.6.2.1 Study Site

The plants for this trial were obtained from private property located 1 km (0.62 mile) north of the intersection of I-15 and Lamb Boulevard (Figure 3.1-1). Las Vegas buckwheat is relatively abundant on this site. The size of most plants ranged from approximately 30 to 50 cm (12 to 20 in). Other major plant species at this site included Las Vegas bearpoppy, Nevada ephedra, shadscale saltbush, seepweed, Anderson's desert thorn, creosote bush, white bursage, rhatany, winterfat, big galletta grass, brittlebush and desert prince's plume.

The topography of the salvage area is characterized by small rolling hills and dry washes. The soil at the site belongs to the Las Vegas-McCarren-Grapevine Complex (Soil Conservation Service 1985). The soil is deep with almost no rocks or gravel throughout the top 30 cm (12 in) of the profile. Depth to indurated, lime-cemented hardpan (petrocalcic layer) is approximately 30 cm (12 in).

The salvage trial was conducted in a growing bed in the Springs Preserve Nursery. The trial area is 7 x 20 m (23 x 66 ft). The soil is approximately 60 cm (23 in) deep and was salvaged from the top 30 cm (12 in) of an undisturbed soil within the construction zone of the northern portion of the Las Vegas Beltway (I-215). The salvaged soil was a Las Vegas gravely fine sandy loam (Loamy, carbonatic, thermic, shallow Typic Paleorthids) (Soil Conservation Service 1985). The top of a white, indurated, lime-cemented hardpan (petrocalcic layer) ranged from 20.3 to 35.6 cm (8 to 14 in) beneath the soil surface. The soil was transported in 20-ton end dump trucks, dumped into the growing bed and leveled with a front-end loader. Care was taken to minimize compaction of the soil.

3.6.2.2 Root Morphology Study

The objective of this study was to characterize the root system of the Las Vegas buckwheat in order to determine the size of rootball to excavate during salvaging. Three buckwheat plants were selected and flagged. A trench was excavated alongside each plant and the roots were exposed with small hand tools. The above-ground plant and roots were measured and a sketch of the root system was developed. The root systems were then photographed (Figure 3.6-1).

3.6.2.3 Salvage Trial

A survey of known populations of Las Vegas buckwheat was conducted in the northern half of the Las Vegas Valley during October 2001. The survey was conducted to identify an area where Las Vegas buckwheat plants could be salvaged for this trial. The survey was conducted during October because buckwheat plants were in full bloom and easy to recognize. Several populations on lands that were either previously disturbed or soon to be disturbed were identified. One property was selected based on the following criteria: (1) there were adequate numbers of Las

Vegas buckwheat plants, (2) the petrocalcic layer was deep enough so that the salvaging of plants would not be impeded and (3) the site was easily accessible. The property known as Lambchange II is owned by a group of private speculators. Permission was obtained from the owners in December 2001 to salvage all the plants needed for this trial.

Figure 3.6-1. Excavated root system of a Las Vegas buckwheat plant.

During February 2002, sixty plants were selected and flagged. All plants were between 30 and 50 cm (12 in and 20 in) tall. Plants were determined to be alive by scratching a branch and checking for living tissue. The plants were all located within an area approximately 0.5 ha (1.2 ac) in size. The flagged plants were growing in similar soils and topography. The plants were randomly assigned to one of three salvage techniques described below and tagged with steel discs stamped with an identification number.

Salvage Method Description and Application

The following three methods were selected because they appeared to be the most feasible for Las Vegas buckwheat and Springs Preserve staff had successfully salvaged other species with them. The bag method requires a minimal amount of tools (a hand spade and a container to put the plant in). The box method is more intensive, but plants can be excavated with hand spades. This method requires that custom boxes be constructed or that prefabricated boxes be purchased. The spade method requires a mechanized tree spade usually only available from tree-care contractors. Other specialty materials required for this method include wire baskets and funnel-shaped burlap liners for the baskets.

Bag Method. Plants were excavated with a backhoe and hand spades (Figure 3.6-2). The rootball of the plant was placed in a large poly-weave bag and soil was placed around the roots. Care was taken to salvage as much of the soil around the roots as possible. The plants were then transported to the growing bed in the Springs Preserve Nursery (Figure 3.6-3). A hole large enough to accommodate the rootball was dug with a backhoe in the growing bed. The plant was suspended in the hole and soil was gently placed around the plant until the hole was filled and the roots were covered. The soil was gently tamped around the roots as it was placed in the hole. The level of the soil around the plant was the same as the pre-disturbance level. A basin was formed around the base of the plant to hold water.

Figure 3.6-2. Salvaging a Las Vegas buckwheat plant with the bag method.

Figure 3.6-3. Salvaged Las Vegas buckwheat plants growing at the Springs Preserve.

Tree Spade Method. The soil around each of the plants to be salvaged with this method was saturated with water by forming a basin around each plant and then filling the basin with water until the soil beneath the plant was saturated to at least 60 cm (23 in). Plants were excavated with a tree spade attached to a skid-steer loader (Figure 3.6-4). A conical-shaped rootball approximately 60 cm (23 in) in diameter at the top and approximately 50 cm (20 in) high was excavated and placed in a wire basket lined with burlap. The burlap and basket were secured around the plant. The plants were then transported to the growing bed in the Springs Preserve Nursery. A hole large enough to accommodate the rootball was dug in the growing bed at the Nursery with a backhoe. The rootball was placed in the hole and soil was tamped around the rootball. The wire basket and burlap were planted with the rootball. A basin was formed around the base of the plant to hold water.

Box Method. Plants were salvaged by excavating trenches with a backhoe and hand spades around each plant and then assembling 60 cm (23 in) wood boxes around the plant (Figure 3.6-5). The plants were then transported to the growing bed in the Springs Preserve Nursery. A hole large enough to accommodate the boxed root system was dug in the growing bed at the Nursery with a backhoe. The rootball was then placed in the hole. The box was removed from the rootball and the void between the rootball and edge of the hole was filled with soil. A basin was formed around the base of the plant to hold water.

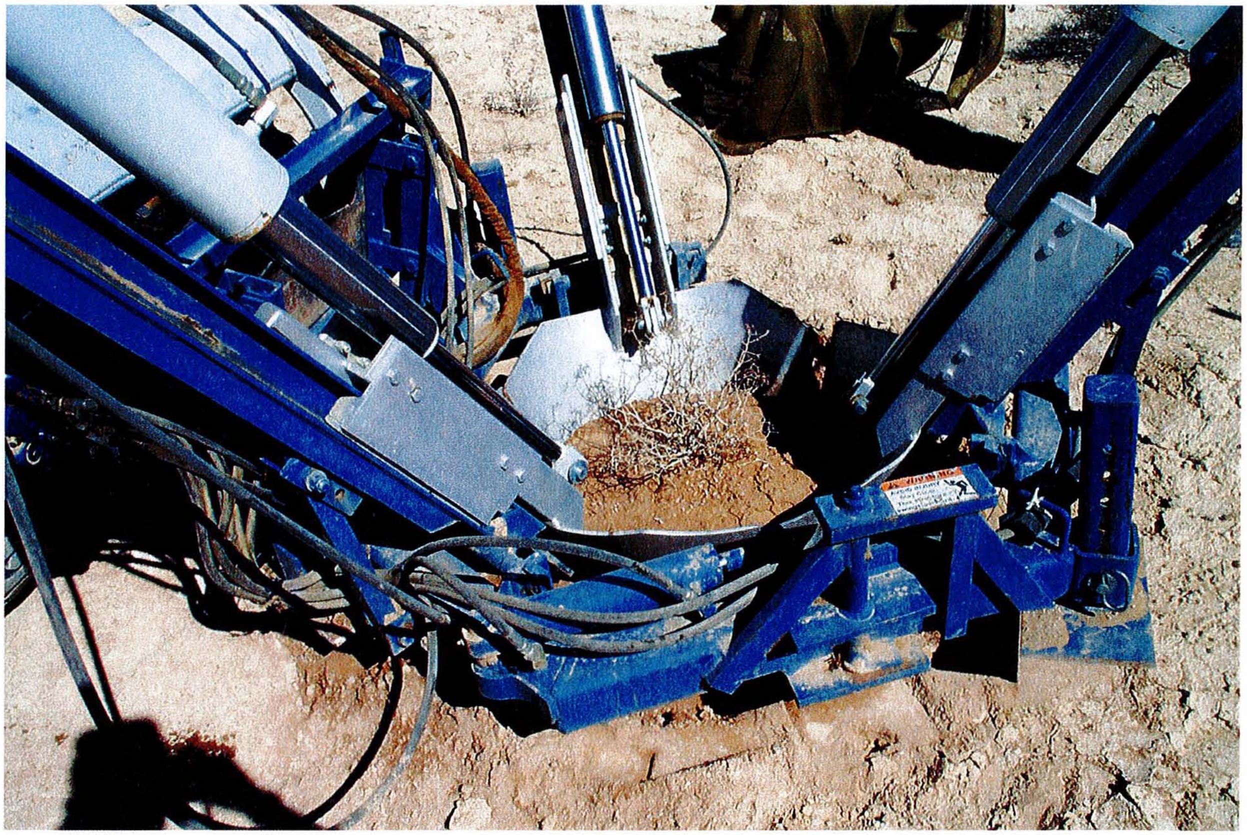

Figure 3.6-4. Salvaging a Las Vegas buckwheat plant with a tree spade.

Irrigation

All plants were watered with 20 L (5.3 gal) of water on the day of planting. Plants were then irrigated with approximately 8 L (2 gal) weekly from March 2002 through December 2002 and approximately 4 L (1 gal) weekly from May 2003 through September 2003. Plants were not irrigated during February, March or April 2003 because rain kept the soil moist throughout much of that period. The plants were irrigated with a drip irrigation system. The watering schedule was the same for all plants.

Experimental Design

The experimental design was a completely randomized design with three salvaged methods and four replications with five plants in each replication.

Data Collection

Survival. Plant survival was monitored weekly throughout the trial. During the growing season a plant was marked "alive" if it had green leaves and/or flowers. A plant was marked "alive" during the dormant season if living phloem was observed during a scratch test. A scratch test was performed by scratching a branch and observing moist, green phloem.

Figure 3.6-5. Salvaging a Las Vegas buckwheat plant with the box method.

Growth. Plant growth was estimated by measuring the volume of the plant immediately after planting in the growing bed (baseline) and annually in October at the peak of the growth period. Volume was calculated by measuring and multiplying the height of the plant, the greatest width of the plant and the width perpendicular to the greatest width. All measurements were based on the living portion of the plant.

Health. Plant health was monitored weekly throughout the trial. The presence of insects or insect damage, wilt or leaf drop and other health concerns were noted.

Flowering. The flowering of each plant was documented annually.

3.6.2.4 Germination Trial

From 2002 through 2004, two attempts were made to germinate and propagate Las Vegas buckwheat. Both attempts were conducted in a controlled greenhouse setting. Both attempts used direct seeding as the germination method and no seed treatments were applied. The soil medium consisted of one part sifted-screened peat, one part perlite, one part vermiculite and one cup 14 – 14 -14 Osmocote.
Two seed lots were tested. One lot (Lot 0046) was collected on December 4, 2001 and planted on August 19, 2002. The other lot (Lot 0283) was collected on January 5, 2004 and planted on

January 21, 2004. Ninety-eight seeds of each lot were planted into standard "Super-cell" containers and top dressed with fine-grained vermiculite.

Statistical Analyses

Significant differences (P<0.05) among means generated from survival and growth data were determined with the Univariate procedure (SPSS version 12.0 2004) and the protected Least Significant Difference (LSD) mean separation procedures (Lentner and Bishop 1986). The Univariate procedure was performed on the arcsin-square root of percentage data as suggested by Sokal and Rohlf (1981).

3.6.3 Results and Discussion

3.6.3.1 Root Morphology Study

Table 3.6-1 shows various attributes of three excavated Las Vegas buckwheat plants. Figures 3.6-6 and 3.6-7 show diagrams of those same plants prepared in the field. The root systems of the three medium-sized Las Vegas buckwheat plants excavated for this trial were restricted to the top 32 cm (12.5 in) by a petrocalcic layer. It is unknown how deep these roots would have grown in the absence of this restrictive layer. The lateral extent of these plants ranged from approximately 1 to 2 m (3.3 to 6.6 ft) in diameter. A high percentage of the roots were within 50 cm (20 in) from the base of the plant (Figure 3.6-6 and 3.6-7), therefore, all three salvage methods tested in this trial have the capacity to remove the majority of roots during excavation.

Table 3.6-1. Above- and below-ground attributes of three Las Vegas buckwheat plants excavated near I-15 and Lamb Boulevard.

Attribute	Plant Number			Mean	SD
	1	2	3		
Greatest width of above-ground plant (cm)	30	41	50	40	10
Perpendicular width of above-ground plant (cm)	28	32	45	35	9
Plant height (cm)	27	26	41	31	8
Plant volume (cm^3)	61500	40320	28782	49681	37307
Depth of root system (cm)	29	31	29	30	1
Greatest width of root system (cm)	124	194	176	165	36
Perpendicular width of root system (cm)	72	103	128	101	28
Depth to Petrocalcic layer (cm)	42	29	26	32	9

3.6.3.2 Plant Survival

Univariate analysis of survival data showed no significant (P = 1.00) interactions between salvage method and date. The date main effect was also not significant (P < 0.76). The salvage method main effect was significant (P = 0.0001). Survival was significantly greater (P < 0.05) for spaded and boxed plants than for bagged plants (Figure 3.6-8). During the 21 months of this trial, no plants salvaged with the tree spade died, only one of the boxed plants died and four bagged plants died. The single dead boxed plant died four months after planting. All bagged plants died within the first six months of the trial (Figure 3.6-9).

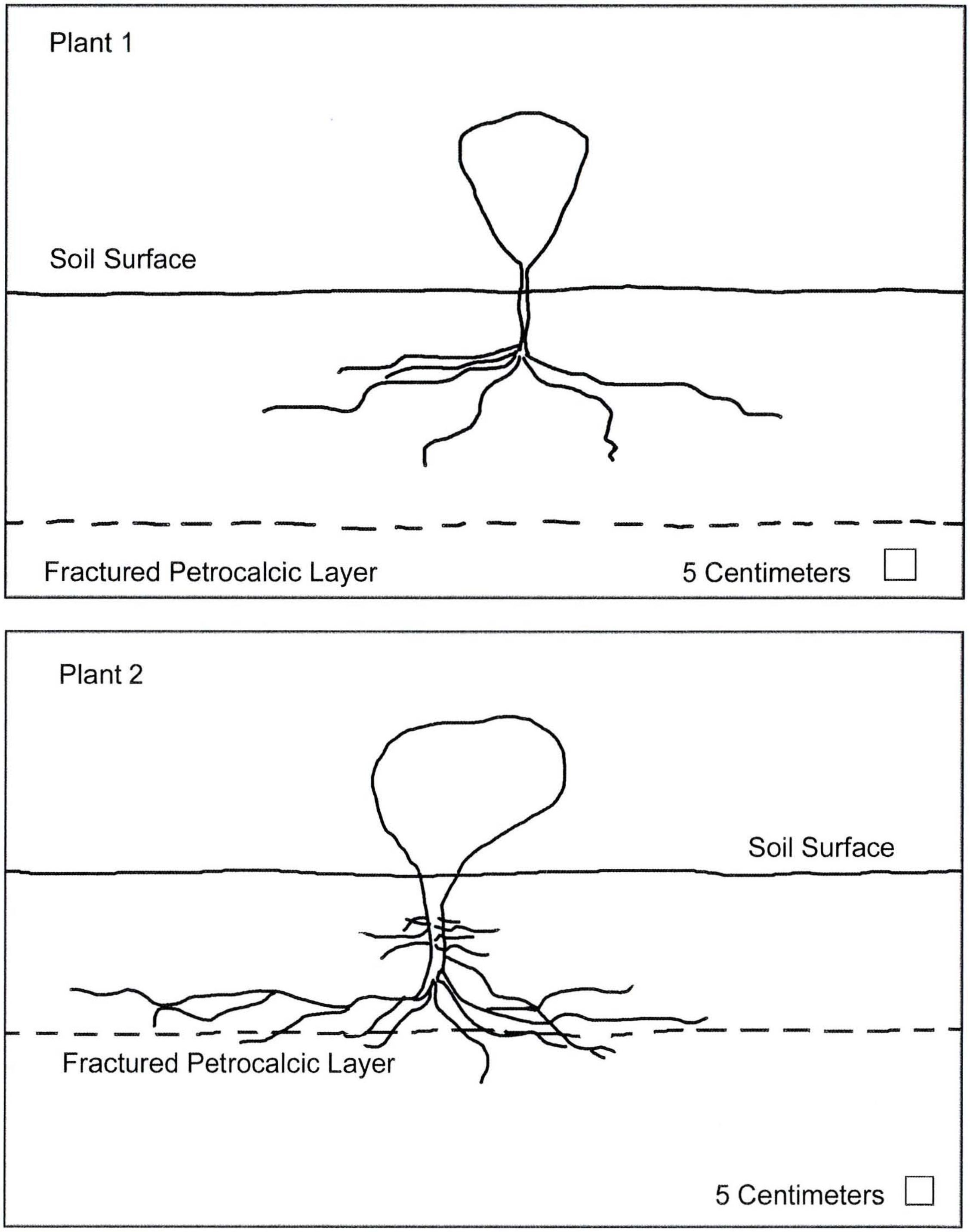

Figure 3.6-6. Diagrams of Las Vegas buckwheat root systems excavated in the Las Vegas Valley. Diagrams are based on hand field sketches.

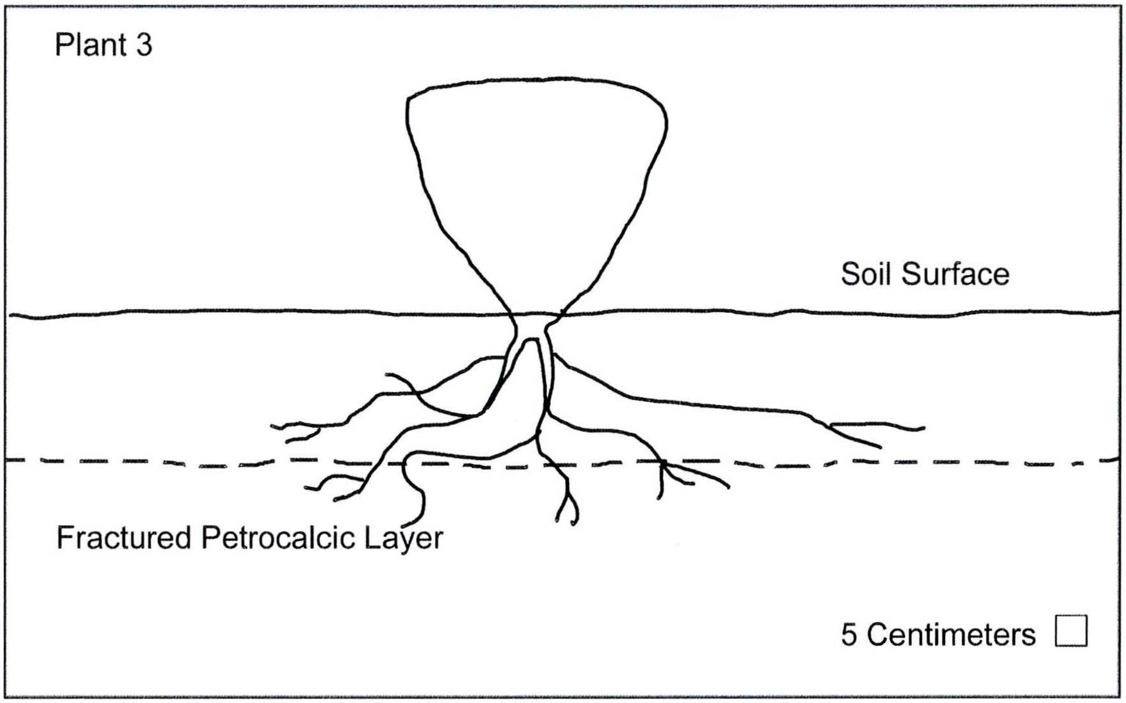

Figure 3.6-7. Diagram of a Las Vegas buckwheat root system excavated in the Las Vegas Valley. Diagram is based on a hand field sketch.

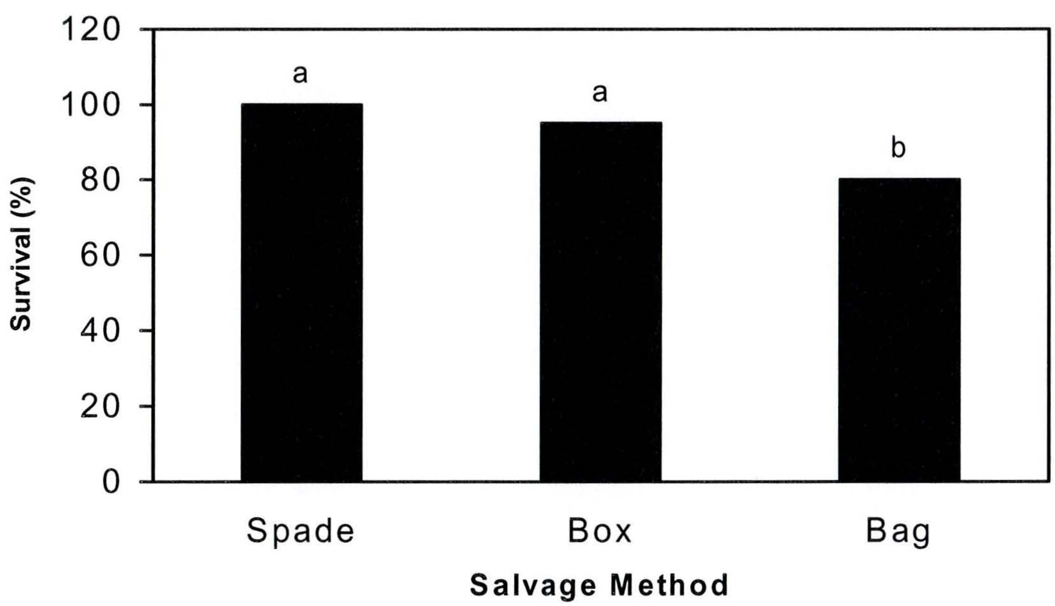

Figure 3.6-8. Percent survival of Las Vegas buckwheat plants salvaged from private land near I-15 and Lamb Boulevard in relation to three salvage methods. Bars with the same letter are not significantly different ($P < 0.05$).

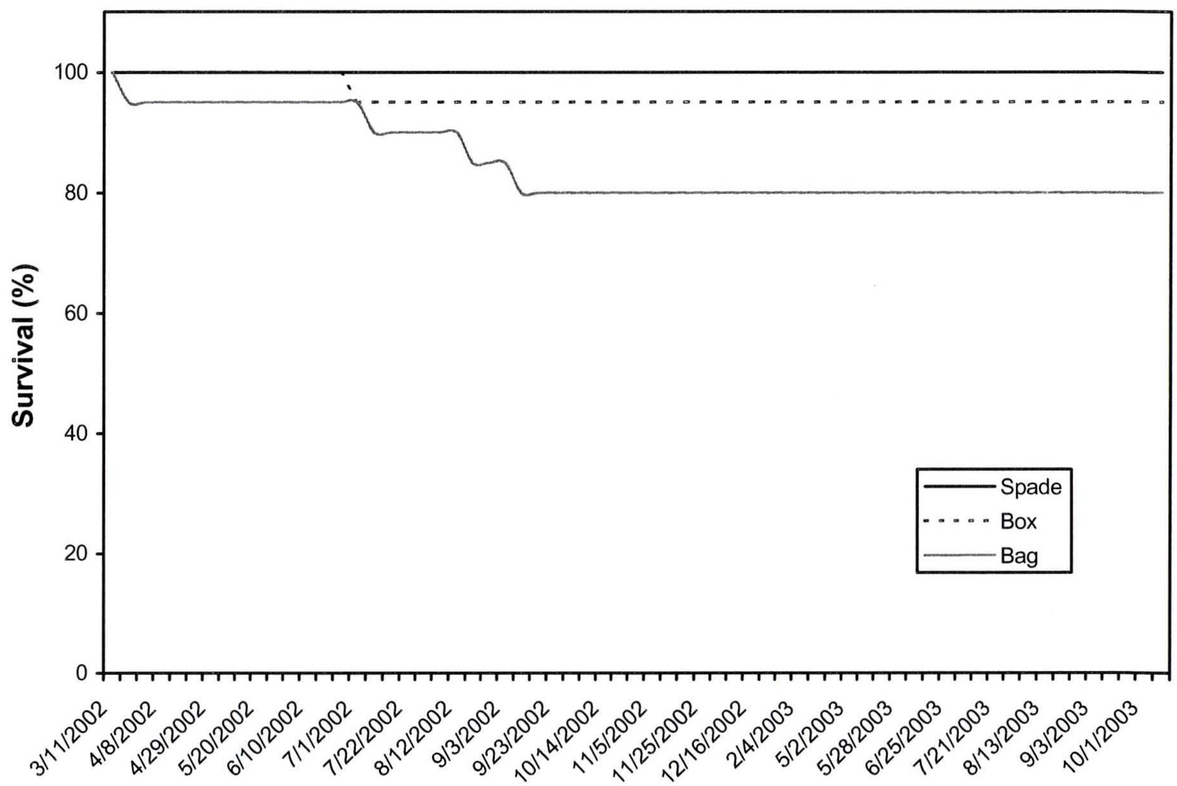

Figure 3.6-9. Survival of Las Vegas buckwheat plants salvaged from private land near I-15 and Lamb Boulevard over time in relation to three salvage methods.

3.6.3.3 Plant Growth

Univariate analysis of change in volume data showed significant ($P = 0.015$) interactions between salvage method and date. The date ($P = 0.007$) and salvage method ($P = 0.0001$) main effects were also significant. By October 2002, plants salvaged by all three methods had grown (increased in volume) slightly (Figure 3.6-10) and all plants regardless of salvage method were similar in size. However, by the following year (October 2003), most plants had increased substantially in volume and spaded and boxed plants were significantly ($P < 0.05$) larger than bagged plants (Figure 3.6-11). Spaded plants were 16% larger than boxed plants and 46% larger than bagged plants. Boxed plants were 35% larger than bagged plants.

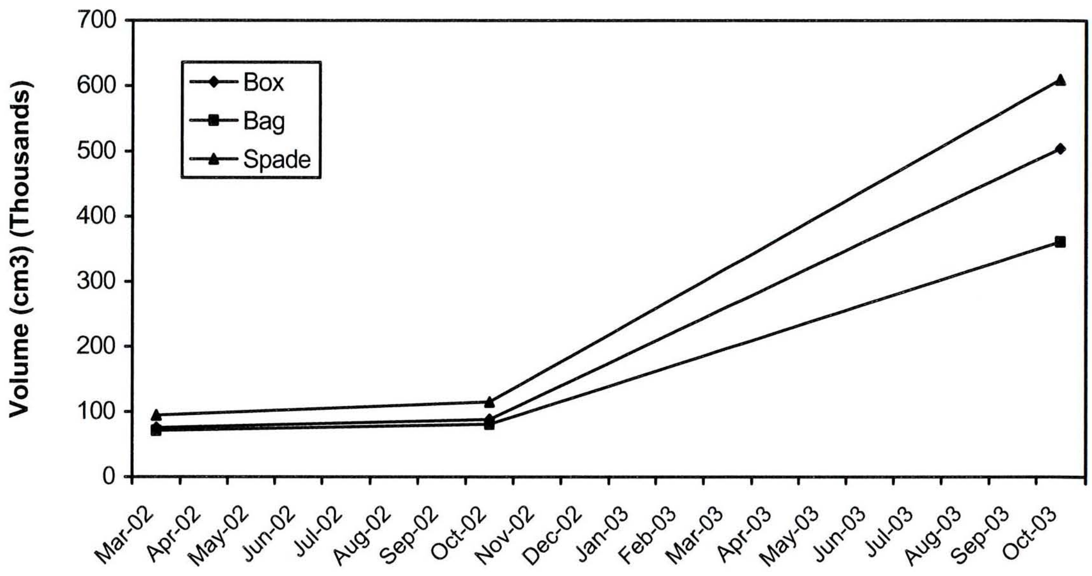

Figure 3.6-10. Volume means (growth) of Las Vegas buckwheat plants over time in relation to three salvage methods.

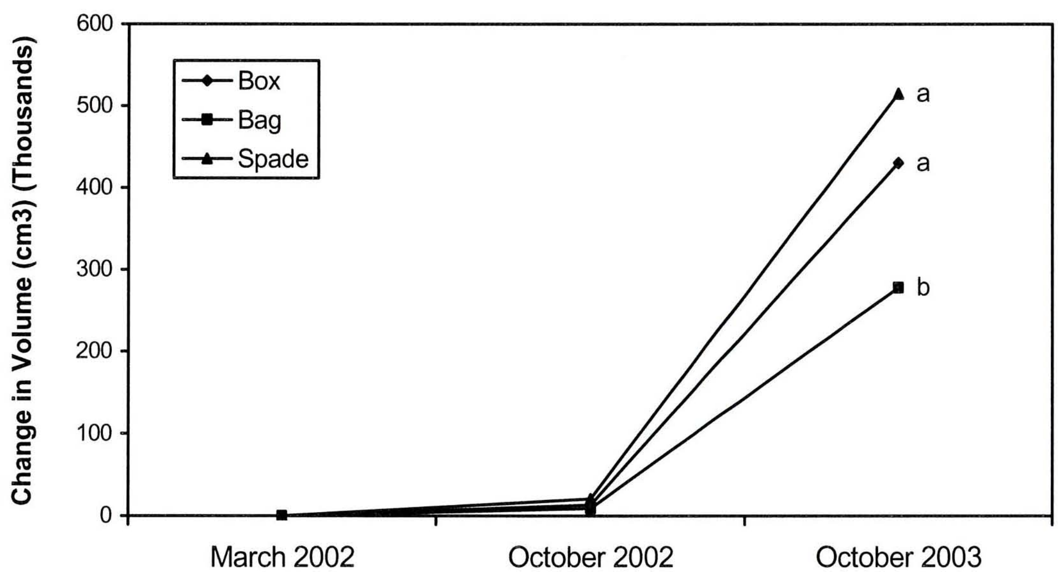

Figure 3.6-11. Change in volume means of Las Vegas buckwheat plants over time in relation to three salvage methods. Means on lines with the same letter are not significantly different ($P < 0.05$).

3.6.3.4 Flowering

The first flowers in 2002 were observed on 10 plants on September 9th (Figure 3.6.12). Flowering continued until December 2nd of that year. All living plants regardless of salvage method produced flowers during 2002. The first flowers in 2003 were observed on August 20th. Ninety-eight percent of the living plants were still flowering on December 4, 2003 when data collection ceased. All living plants produced flowers during 2003. The peak flowering period during 2002 was from September 30th to November 12th and the peak period during 2003 was from September 24th to probably the second week of December. It is unclear why the flowering period in 2003 was longer than the flowering period in 2002.

Due to supplemental irrigation, the phenology of the plants salvaged for this trial, including flowering, may be different than that observed under more natural conditions. Flowering may have been initiated earlier and prolonged with the additional water from irrigation.

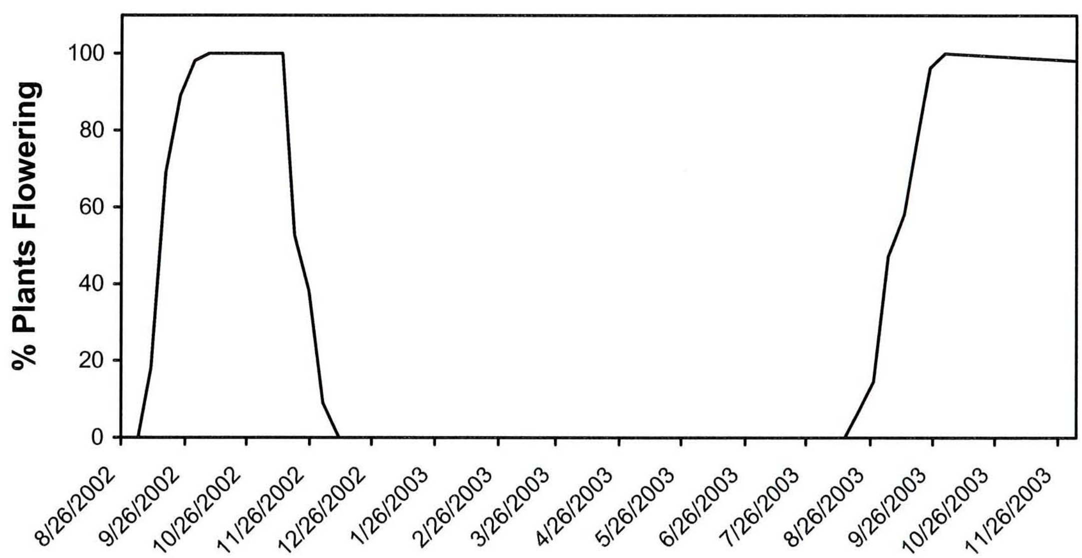

Figure 3.6-12. Percent of salvaged Las Vegas buckwheat plants flowering during two years at the Springs Preserve.

3.6.3.5 Seed Germination

Twenty percent of Lot 0046 and 60 percent of Lot 0283 germinated and produced seedlings. Seedlings emerged 22 and 6 days after planting for Lots 0046 and 0283, respectively. Most of these seedlings have survived and are currently (June 2004) growing in 1-gallon pots.

Germination for Lot 0283 was three times greater than germination for Lot 0046. Seed from Lot 0283 was planted two weeks after it was collected and seed from Lot 0046 was planted approximately 8 months after it was collected. Seeds of California buckwheat and sulphur flower buckwheat (*Eriogonum umbellatum*) have low germination (<30%), but remain viable for several years (Kay et al. 1988). Stevens et al. (1996) also showed high viability for sulphur flower buckwheat after 10 to 15 years of storage in a warehouse. It is possible that seeds of Las Vegas buckwheat loose viability more quickly than other species of *Eriogonum*. This may explain why germination from Lot 0046 was lower than germination from Lot 0283.

3.6.4 Conclusions and Recommendations

The bulk of Las Vegas buckwheat roots are found within the volume of soil salvaged by all three salvage methods used in this trial. All three salvage methods had high (over 80%) survival. Significantly more spaded and boxed plants than bagged plants survived, and spaded and boxed plants were significantly larger than bagged plants after 20 months. All living plants, regardless of salvage method, produced flowers in 2002 and 2003.

The general message of this trial is that Las Vegas buckwheat plants are easy to salvage as long as care is taken during salvaging and planting to keep the above-ground plant and rootball intact and that supplemental irrigation is provided to the plant during an establishment period of several months. It is probably unnecessary to irrigate as frequently as we did in this trial.

These plants were salvaged during early March at the end of the dormancy period for this species. It is unknown how well this species would survive if it were salvaged during other times of the year.

Las Vegas buckwheat seed appear to have good viability and moderate germination rates. These trials have shown that Las Vegas buckwheat is both easy to salvage and propagate. These are both valuable tools needed to aide the mitigation of this species.

4. GENERAL CONCLUSIONS AND RECOMMENDATIONS

4.1 Salvage of Las Vegas Bearpoppy Plants

The root systems of Las Vegas bearpoppy plants are generally confined to a column of soil the diameter of the above-ground plant and from approximately 30 cm (12 in) to 40 cm (16 in) deep in the soil. Therefore, the excavation of a column of soil slightly larger than these dimensions should be sufficient when salvaging Las Vegas bearpoppy plants.

Survival of Las Vegas bearpoppy plants salvaged and held above-ground in boxes was relatively high for three salvage methods. Survival was greater for plants salvaged with the box and pipe methods than for plants salvaged with a tree spade. Of the three methods, the pipe method was preferred by Springs Preserve staff. It was quick and relatively inexpensive because the equipment required for this method was owned and operated by the Springs Preserve.

This research demonstrated that Las Vegas bearpoppy plants can be salvaged and held above-ground in boxes for several months. This information is useful because it shows that Las Vegas bearpoppy plants may not need to be relocated and planted immediately after salvaging. They could be removed from a site, held for several weeks to months, and then either returned to the salvage site or planted at a new site.

A new method utilizing thin-walled steel stove pipe was used for two trials. Results from these trials were mixed. Survival of Las Vegas bearpoppy plants salvaged with this method was high for plants salvaged in December from a site near the Northern Beltway and low for plants salvaged in March from a site near I-15 and Lamb Boulevard. These results may demonstrate that Las Vegas bearpoppy plants should not be salvaged in early spring.

The new stove pipe method has several advantages over the box, pipe and spade methods. Not only were those methods time consuming and, in the case of the box method, labor intensive, they also required heavy equipment such as backhoes, cranes and tree spades. In addition, they required skilled operators and special materials. In contrast, the stove pipe method requires inexpensive stove pipe, plywood, wire and handtools. Depending upon the soil type (amount of rocks in the top foot of soil) plants can be salvaged by one to two people in about 10 to 20 minutes. When this method is utilized, the plant receives minimal impact because the stove pipe functions as both the salvage tool and the container during transport. Other methods require that the rootball be picked up in one container (tree spade or pipe) and put into another container (box). Our experience has taught us that the more the rootball is handled, the greater the probability that the taproot will be damaged.

Although the stove pipe method can be used for mature plants, due to the small size of the pipes, it is best for seedlings. If longer pipes are required, they may need to be custom made. For larger plants, a combination of the large pipe and stove pipe methods may be desired. We suggest that the pipe have a diameter of 25 to 30 cm (10 to 12 in) and be 40 to 45 cm (16 to 18 in) tall. The wall thickness should be 5 mm (0.2 in). The pipe would be pushed into the soil with the hoe or front bucket of a backhoe tractor or front-end loader. The pipe with the plant inside would then be excavated and transported to the planting location.

At the planting location, the plant and soil would be removed from the pipe in the following manner. A hole the depth of the soil column would be dug. The pipe with the soil and plant would then be set into the hole. The pipe would be slid off of the soil column an inch or two. Soil would be deposited around the exposed soil column and packed firmly. The process of sliding the pipe and packing the soil would be continued until the pipe was removed from the soil column.

We recommend that given a choice, seedlings be given priority over mature plants during salvage efforts. Seedlings are easier to salvage and due to the fact that Las Vegas bearpoppy plants are short-lived, they have the potential to live longer and contribute to a new habitat longer than larger (older) plants. It does not make much sense to expend so many resources salvaging an old plant that may only live a short time.

In general, survival rates for salvage trials reported in this document may have been greater than those from other previous attempts for the following reasons: (1) care was taken to salvage and plant plants in such a way as to minimize impacts to the root systems; (2) plants were irrigated during at least an establishment period; (3) plants were monitored regularly to check mortality and health; and (4) the plants were protected from the public. We realize that for some salvage efforts, although it may be possible to salvage and plant plants without impacting the roots, it may not be practical to irrigate, monitor and protect plants salvaged and transplanted to remote public areas.

4.2 Distribution of Seeds Around Las Vegas Bearpoppy Plants

We attempted to determine the distribution of seeds around Las Vegas bearpoppy plants. This objective was not completely met because we found as many or more seeds 150 cm (59 in) from the plant as we did at the base of the plant and as many from 2 to 4 cm (0.8 to 1.6 in) in the soil as we did from the top 2 cm (0.8 in) of soil. Additional samples further from the plant and deeper in the soil will be necessary to better define the distribution of seeds in the seedbank. The good news is that the seedbank is larger and deeper than we anticipated.

Our results indicated that there are sufficient numbers of poppy seeds in the seedbank around Las Vegas bearpoppy plants to consider the salvage of seedbank as a mitigation option. The seedbank should be salvaged to at least 150 cm (59 in) from the plant and at least 4 cm (1.6 in) deep. Seedbank salvage should only be conducted if the plant is to be salvaged and transplanted or sacrificed. If the plant is to be sacrificed, it is recommended that the entire plant (including all live and dead rosettes and flowering stalks) and all litter around the plant be salvaged and processed to extract all seeds. Seedbank salvage around dead plants is also recommended.

4.3 Salvage and Propagation of Las Vegas Buckwheat Plants

Most roots from a Las Vegas buckwheat plant are found within the volume of soil salvaged by the three salvage methods reported in this document. All three salvage methods (bag, box and tree spade) had high rates of survival, however, significantly more spaded and boxed plants than bagged plants survived, and spaded and boxed plants were significantly larger than bagged plants after 20 months.

This research has shown that Las Vegas buckwheat plants are easy to salvage as long as care is taken during salvaging and planting to keep the above-ground plant and rootball intact and that supplemental irrigation is provided to the plant during an establishment period of several months.

Las Vegas buckwheat seed appear to have good viability and moderate germination rates. In addition, this species appears to be easy to propagate.

This research has identified that plant salvaging and propagation are two valuable tools that will aide the mitigation of and help to ensure the continuation of Las Vegas buckwheat throughout it's range.

5. LITERATURE CITED

Bardeen, K. M. and H. Williams. 2000. Habitat Management Plan for the Las Vegas bearpoppy (*Arctomecon californica*) Populations on the Las Vegas Valley Water District North and South Well Fields. Unpublished Report. Las Vegas Valley Water District. Las Vegas, NV.

Clark County. 2000. Multiple Species Habitat Conservation Plan and Environmental Impact Statement for Clark County, Nevada. Clark County Department of Comprehensive Planning, Las Vegas, NV.

Kay, B. L., W. L. Graves and J. A. Young. 1988. Long-term Storage of Desert Shrub Seed. Mojave Revegetation Notes No. 23. University of California Agronomy and Range Science. Davis, CA.

Knight, T. S. 1983. Vascular flora of the Muddy Mountains, Clark County, Nevada. Madrano 30:31-51.

Knight, T. S. 2000. Natural Resource Conservation Service, Las Vegas, NV. Personal communication.

Lentner, Marvin and Thomas Bishop. 1986. Experimental Design and Analysis. Valley Book Company. Blacksburg, VA.

Merrill, N. 2000. Southern Nevada Water Authority, Las Vegas, NV. Personal communication.

Meyer, S. E. 1987. Life history of *Arctomecon californica* (Papaveraceae), a Mojave Desert endemic perennial herb. Unpublished manuscript.

Meyer, S. E. and A. Paulsen. 2000. Chilling requirements for seed germination of ten Utah species of wild buckwheat (*Eriogonum* Michx.: Polygonaceae). Native Plants J. 1:18-24.

Mistretta, O., R. Pant, T. S. Ross, J. M. Porter and J. D. Morefield. 1996. Current Knowledge and Conservation Status of *Arctomecon californica* Torrey & Fremont (Papaveraceae), the Las Vegas bearpoppy. Nevada Natural Heritage Program.

Nevada Natural Heritage Program. 2001. http://heritage.nv.gov/reports/arccarep.htm

Shaw, N. L. 1984. Producing bareroot seedlings of native shrubs. In: Murphy P.M., comp. The challenge of producing native plants for the Intermountain area. Proceedings, Intermountain Nurseryman's Association 1983 Conference; 1983 August 8-11; Las Vegas, NV. Gen. Tech. Rep. INT-168. USDA Forest Service, Intermountain Forest and Range Experiment Station. Ogden UT.

Sheldon, S. K. 1994. Life history and soil characteristics of two species of *Arctomecon* (Papaveraceae). Las Vegas: University of Nevada, unpublished M.S. thesis.

Soil Conservation Service. 1985. Soil Survey of Las Vegas Valley Area Nevada: Part of Clark County. USDA. Soil Conservation Service.

Sokal, Robert R. and James F. Rohlf. 1981. Biometry. Second Edition. W. H. Freeman and Company. New York.

Stevens, R., Jorgensen, K. R., Young, S. A., and S. B. Monsen. 1996. Forb and shrub seed production guide for Utah. Utah State University Extension Service. Logan, UT.

Winkel, V. K., K. W. Blomquist, J. P. Angerer, M. Wayne Fariss and W. K. Ostler. 1999. Reclamation Feasibility Studies at Yucca Mountain, Nevada: 1992-1995. TRW Environmental Safety Systems, Inc. Las Vegas, NV.