LEAD AGENCY

National Park Service

Featured Project

Plant Material Production for Interagency Restoration Program

Project Description

Restoration of Desert Tortoise habitat and other special status species require the use of native plants that are not available from local nurseries. The National Park Service presently has a three-acre nursery with three commercial-quality greenhouses and irrigated grow-out areas. This nursery can be staffed to provide native plants to the Forest Service, Fish and Wildlife Service, Bureau of Land Management, National Park Service, and other agencies using their own native seed stock which will allow them to restore impacted habitats using genetically-native material. The National Park Service is developing methods for germinating, growing, and outplanting many native Mojave Desert species, which differ substantially from commercially grown species. The Lake Mead NRA staff has been involved in propagating, planting, and maintaining native plants in numerous successful restoration projects throughout Southern Nevada for ten years.

This project will provide a base level of service to keep critical horticultural skills available at all times.

Nevada Conservation Corp member tending to grape vine *Vitis arizonica*.

Project Status

Lake Mead Native Plant Nursery staff has produced written propagation methods reports on six native plant species. In addition they have provided native plant material propagation or propagule collection and storage services to the following entities: Bureau of Land Management; US Fish and Wildlife Service, National Park Service, Las Vegas Wash, Big Springs Preserve, and Spring Mountain Ranch.

Environmental Careers Organization member examining Cottonwood seedlings.

Partners

Bureau of Land Management, US Forest Service, US Fish and Wildlife Service, Clark County, State of Nevada

Project Contact

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Funding Awarded

$51,750

Funding Spent

$51,750

Completion Date or Status

This project is complete as of June 30, 2005.

Products Produced from Project

- Propagation reports for the following species:
  - *Penstemon bicolor roseus*
  - Enceliopsis argophylla
  - Larrea tridentata
  - Pluchea sericea
  - Fraxinus velutina
  - Baccharis emoryi
- Over 2880 native plants were provided to park partners for restoration projects.

Plant Material Production for Interagency Restoration Program

Final Project Report

Introduction

Restoration of Desert Tortoise habitat and other special status species require the use of native plants that are not available from local nurseries. The National Park Service presently has a three-acre nursery with three commercial-quality greenhouses and irrigated grow-out areas. This nursery can be staffed to provide native plants to the Forest Service, Fish and Wildlife Service, Bureau of Land Management, National Park Service, and other agencies using their own native seed stock which will allow them to restore impacted habitats using genetically-native material. The National Park Service is developing methods for germinating, growing, and outplanting many native Mojave Desert species, which differ substantially from commercially grown species. The Lake Mead NRA staff has been involved in propagating, planting, and maintaining native plants in numerous successful restoration projects throughout Southern Nevada for ten years.

Using best horticultural industry practices as well as methods designed by NPS, this project will collect propagules (seed, divisions, cuttings, etc), maintain propagules, grow out propagules into suitable containers, and maintain containerized plants for agency outplanting. By utilizing a range of proven technologies, this project will determine the most efficient methods of reproduction of many native plant species.

Anticipated projects include propagation and holding services for the Federal Highways Administration (Hoover Dam Bypass), US Fish and Wildlife Service/Department of Defense (Desert National Wildlife Refuge), Bureau of Reclamation, Bureau of Land Management, US Forest Service, and other state and local agencies.

This project will provide a base level of service to keep critical horticultural skills available at all times. Horticulturist's duties will include coordination of plant production with cooperating agencies, research on plant propagation techniques, and general management of all nursery operations.

The MSHCP Conservation Actions addressed by this project include: NPS 33 – Protect existing stands of mesquite and catclaw; NPS 39 – Monitor and protect water sources, including springs, seeps, and springs. These actions are addressed indirectly by providing plant material for restoration projects that will protect these places.

Goals and Performance Achieved

The goals (milestones and deliverables) of this project included:

- Propagation research for six native plant species not routinely grown (three per year)
- Plant material for FWS Warm Spring restoration project propagated and available for outplanting by November 2004
- Annual production plans submitted to the county
- Quarterly reports submitted to Clark County MSHCP database
- Final Project report submitted to Clark County MSHCP database

All these goals have been achieved and in some cases, exceeded.

Propagation Research

Six propagation reports (*Penstemon bicolor roseus, Enceliopsis argophylla, Larrea tridentata, Pluchea sericea, Fraxinus velutina, and Baccharis emoryi*) are included here, plus a preliminary report on one additional species, *Samolus parviflorus*.

***Penstemon bicolor roseus* (Two-tone rosy beardtongue)**

This species was propagated from seed, the original provenance of which was the River Mountains (north of Boulder City and west of Lake Mead). Seed was collected at two different times and sown separately: the first lot stored, stratified, and planted; the second lot sown fresh, with no pretreatment.

Stored and Pretreated

Seed was collected in June 2003 from plants growing in the nursery. This seed was then stored in the nursery seed room at approximately 80º F for six months until beginning stratification on December 22nd 2003. Stratification was tried because many species of Penstemon are known to benefit from it as a means of pretreatment for breaking dormancy and enhancing germination. The stratification technique used was folding the seed in moistened paper, sealing it in a ziplock bag and keeping it refrigerated at about 40 ºF. Ideally the seed should have been sown following 2 to 4 months of this treatment, however it was allowed to remain longer than originally planned and was sown in early June 2004, over 5 months after stratification began.

The stratified seeds were planted on June 14th 2004 in a flat filled with a 50/50 mixture of coir and our standard nursery soil (which is itself a mixture of 50/50 sand and organic matter). These flats were watered using the greenhouse misting system for about 30 seconds every hour during the daylight hours. Average air temperatures in the greenhouse at this time varied from highs around 90º F to lows around 70º F. Soil temperature was not measured.

Up until September 20th 2004 no germination was observed. The three months allowed are likely more than adequate time for any surviving seeds to germinate. Consequently it is unlikely that at this point any germination will occur, and the flat was disposed of. It is not likely that the seeds were dead when stratification began as they were fairly fresh (about 6 months old), and though not kept refrigerated, had been stored under controlled dry cool conditions in the nursery seed room. It is more likely that the seeds were killed by the stratification technique used, which may have been either unnecessary, or excessive. To investigate that, a second lot was sown as detailed below.

Fresh and Untreated

On July 17th 2004 fresh fully mature seed was collected from *Penstemon bicolor* growing in the nursery and sown directly into a germination flat filled with 100% coir material. This different substrate was chosen because during simultaneous work with other plant species, roots had been found to come free of the lighter coir material more easily with reduced breakage, resulting in better survival. These flats were watered using the greenhouse misting system for about 30 seconds every hour during the daylight hours. Average air temperatures in the greenhouse at this time varied from highs around 94° F to lows around 72° F. Once again soil temperature was not measured

Germination was observed within about three weeks time. The initial rate of germination was quite low (less than 10%). Several germinants looked as if they might be suffering from over watering with the potential for damping off. Consequently the flat was removed the misting system, and hand watered lightly three times a week (Monday, Wednesday, Friday). For the next several weeks little or no additional germination occurred, and neither did much growth.

On September 2nd 2004, forty (almost all) of the initial germinants were transplanted into deepots filled with standard 50/50 sand and organic matter mix. These were hand watered three times a week (Monday, Wednesday, and Friday). Meanwhile the germination flat was returned to the mister system, receiving water for 30 seconds every hour during daylight.

Within two weeks all but three of the transplanted seedlings had died. Meanwhile a second wave of several hundred germinants appeared in the flat. The death of significant numbers of the initial transplants was not entirely surprising as they were quite small when moved, however the extent (92%) of mortality exceeded expectations. It suggests that the seedlings were either transplanted too early, or needed more water than periodic hand watering provided. During this time, the flat was returned to the misting system, and a pronounced second wave of germinants emerged (250-300). If there is no subsequent germination, this will suggest a fresh seed germination rate of 60-70%.

Despite earlier concerns about the potential for damping off, this time the flat was maintained under the misting system for a week. Once again little growth (above ground) was evident; however there appeared to be little or no damping off actually occurring, so that concern can probably be discarded.

After that week, on September 24th, forty more seedlings were transplanted into deeppots. Above ground, these seedlings were approximately the same small size as the initial forty. It is possible that the root length of these seedlings may have been a bit longer. No comparison was possible as no measurements were made on the initial germinants.

Misting was maintained on these seedlings since damping off was no longer a concern. A week later (September 30th) just under 60% (23) of these seedlings became successfully established. Little additional mortality occurred. By the end of December twenty plants remained and all had grown significantly. Consequently *Penstemon bicolor* appears to be a species that does not require stratification, and in fact can be easily killed by excessive cold stratification. It is not sensitive to damping off, and does far better if misting is maintained. Additionally, transplantation of small seedlings into depots appears to be less successful than those with larger more developed roots.

After establishment and subsequent growth, root development of the twenty was less than expected, particularly given how good they looked aboveground. This may have been due to the soil mix used in the depots, which appeared to be higher in clay than initially intended. Alternatively it may be an idiosyncrasy of the species, since they transplanted successfully into PVC short pots, with 100% survival. At the time of writing

(August 2005) the plants have filled out well, survived most of a summer in the compound, and are ready for planting in the field.

There are some older penstemon cuttings in the nursery (unrecorded propagation) dating from some time in 2002 or early 2003. The existence of these suggests that vegetative propagation could also be an option, though it has not been investigated systematically as part of this report. Given that penstemon seems to grow reasonably well from seed, vegetative propagation does not appear to be necessary. The reduction in genetic diversity inherent to such clonal propagation, is a good reason to use such techniques only when other options fail.

Enceliopsis argophylla (Sunray)

This species has been difficult to propagate due to exceptionally low germination rates (around 5%), and pronounced sensitivity to transplant shock. It is gypsophilic, so these problems could be attributed to having very specific requirements, however those that have survived in this nursery have done so without special soil amendments or other unusual attention. The Big Springs Preserve in Las Vegas is successfully propagating a close relative, *Enceliopsis nudicalis,* without such measures, suggesting that they may not be needed for *E. argophylla* either. This work was undertaken to see what relatively simple changes in technique might improve success with Sunray. It focused on two areas for improvement- germination and transplantation.

Several possible factors limiting germination were considered- age of seed, need for a soak (to leach out plant chemicals maintaining dormancy), and the need for hormonal stimulation (to break chemically induced dormancy). Accordingly, two seedlots were selected for this experiment: the first (ENAR 01-3) was collected May 31st 2001 on road 100 in the Overton Arm of Lake Mead NRA; and the second (ENAR 0401) was collected April 11th 2004 near Las Vegas Bay, also in the park. Both had been stored in the nursery seed room at a maximum of 80º F since collection- the first for over three years and the second for about six months. These were then each divided into three treatments: 1) untreated (control), 2) soaked for an hour in tap water, 3) and soaked for an hour in a solution of tap water with Gibberellic Acid added (ProGibb 4%, Valent U.S.A. Corporation, Dublin California).

On November 11th 2004 the seed was then sown into flats filled with 100% coir, one for each of the three treatments of the two seedlots for a total of 6 flats. Earlier work with Sunray had been done in flats filled with a 50/50 mixture of coir and our standard nursery soil (which is itself a mixture of 50/50 sand and organic matter), but this practice had been dropped as part of our standard protocol in favor of pure coir because plant roots seem to come free of the lighter coir material more easily with reduced breakage. A factor that had been assumed was that the viability of the seed (particularly the older seed) was low, so seed was sown generously in order to compensate for this. These flats were watered using the greenhouse misting system for about 30 seconds every hour during the daylight hours. Average air temperatures in the greenhouse at this time varied from highs around 90º F to lows around 60º F. Soil temperature was not measured.

Plants emerged within about two weeks, slightly more rapidly in the fresher (2004) flats but by no more than a day or so, which was not significant. By late November all the flats were quite full. Germination was high, well beyond any precedent for Sunray regardless of age or treatment. While there was no additional increase in germination caused by soaking, or Gibberellic Acid, age was marginally important as about 80% of seeds from 2004 germinated compared to only about 70% of seeds from 2001. Consequently, viability of the seeds was not a limiting factor though it did decline slightly with age. Nor does there seem to be a need for pretreatment.

Apparently the previous problems with germination had been caused by the substrate being used earlier. Unfortunately this experiment did not consider substrate, however the differences are readily apparent. Being a 50/50 mix, earlier flats did not drain as readily as 100% coir and may have been too wet for Sunray. Having less organic matter, these flats may also have been slightly less acidic, though being Gypsophilic, Sunray would not be expected to require high acidity. Regardless, since seed was sown generously to compensate for perceived low viability, many more germinants were produced than had been expected. However these were put to good use as they allowed sufficient numbers to conduct a second experiment in order to examine transplantation.

Sunray had proven difficult to transplant successfully in the past, though this was difficult to quantify since poor germination (around 5%) meant that there were never many individuals to work with. Fortunately with progress on the question of germination, a large number of plants became available for transplantation.

Initial attempts to transplant these germinants began shortly after emergence, once plants formed their first true leaf. In mid November 2004 several hundred were transplanted from germination flats into D40 (40 cu. in.) Deepots (Stuewe & Sons Inc., Corvalis Oregon) filled with our standard (50/50 sand & organic matter) nursery soil. Watering was held constant with what the flats had been and still were getting, since seedlings in the flats were enduring it with no signs of damping off or other stress. Within two weeks there was nearly100% mortality of transplants, though seedlings remaining in the flats were still fine. In early December several hundred more were transplanted with similar results.

By mid December it was decided that substrate was the problem, since obviously the Sunray liked the coir, and didn't mind the watering regime. Two substrate combinations were tried. The first was a 50/50 mix of coir and nursery soil, and the second was dual-layer with the bottom half of the pot having the nursery soil, and the top half 100% coir like the seedlings in the flats. After two weeks, survival in the 50/50 mix was 40%, while it was 70% in dual-layer pots, both of which were an improvement over the straight nursery soil.

Young plants in the dual-layer are primarily exposed to pure coir, which may account for their better survival. As they grew larger, their roots began to use the nursery soil in the lower half of the pot. In addition to the dual-layer, a mix richer in coir was examined. In late December 2004 a 60/40 coir and soil mix was tried, and was well tolerated by the plants. However it proved initially difficult to determine a difference in plant response between the two, since survival remained at about 70% in each.

This changed when over the course of the first week in May 2005 the 83 surviving seedlings were transplanted from Deepots to PVC shortpots. The roots of dual layer pots typically did not hold together well during transplantation, resulting in much more stress on the seedling. Within two weeks mortality became apparent with 70% of dual layer pots surviving transplantation compared to 95% of rich mix pots. Little mortality occurred after that point. By August 2005 there were 65 plants remaining all of which were vigorous. Black aphids began to attack the plants in mid August, a problem that will likely disappear (due to lower humidity) when they are moved outside. However, the potential for extreme temperatures in the compound (120° F+) during is August currently preventing us from doing so. The shock of transition from the artificially cool greenhouse to the outside could be even more harmful. Instead the aphids are being killed with Safer Insecticidal Soap (Woodstream Corporation, Lititz PA), while damage is monitored.

Now that germination has been solved, the biggest challenge seems to be getting Sunray to survive the initial transition from the germination flat. The last transplants were admittedly on average more mature (often having three or four true leaves) than the early transplants. However in these later attempts there was good mix of sizes, with no apparent trend emerging related to size/age. Consequently it seems unlikely that the high mortality was a function of germinant age. Presumably the problem is a combination of transplant shock with the substrate. The discovery that the seed is reasonably viable and that germinating Sunray prefer coir opens the possibility of direct sowing into pots with a coir-rich mix. If germination remained reliably high, then doing so would improve survival by removing the stress of initial transplantation. It would also benefit subsequent transplanting stages by providing a material which roots hold together well.

Larrea tridentata (Creosote Bush)

This species is extremely susceptible to damping off, a condition that describes a fungal attack on recently germinated seedlings which typically occurs under very moist conditions. Prior to this work, the only means of minimizing such mortality that we had found to be successful was removing newly germinated Creosote seedlings from automated misting and periodically hand watering them. *Gliocladium virens* has been identified as a beneficial fungus that interacts with and protects newly germinated seedlings of other species from damping off. We experimented with treating Creosote with *Gliocladium virens* to see if it is of similar benefit to Creosote.

Seed was collected from the Overton Arm of Lake Mead on June 18th 2001. This seed was then stored in the nursery seed room at approximately 80° F for about three years. On June 3rd 2004 the seed was pretreated for planting by placing it in a jar filled with room temperature water and allowing it to soak over night. The following day (June 4th) it was divided in two and sown into two separate germination flats.

The first flat was filled with a 50/50 mixture of coir and our standard nursery soil (which is itself a mixture of 50/50 sand and organic matter). The second flat contained the same substrate mixed with a light dusting of SOILGARD (Thermo Trilogy Corp., Columbia MD), a commercial preparation of *Gliocladium virens*. These flats were watered using the greenhouse misting system for about 30 seconds every hour during the daylight hours. Average air temperatures in the greenhouse at this time varied from highs around 90° F to lows around 70° F. Soil temperature was not measured.

By June 21st germination became evident in the untreated flat, with no sign of it occurring in the treated flat. Initially this was interpreted as a delay in germination of the treated seed. Typically Creosote in this nursery germinates in at least two well defined waves, the first about two weeks after sowing, and the second four to five weeks after sowing. By July 21st (about seven weeks) none had germinated in the treated flat and it was declared dead and disposed of. In the mean time germination in the untreated flat proceeded as normal (approximately 40 to 50%) except that in order to maintain the comparison, we did not remove it from the misting system, and these seedlings suffered significant damping off up to the 21st when the experiment ended.

At this point the surviving untreated seedlings (33 in all) were transplanted into D40 (40 cu. in.) Deepots (Stuewe & Sons Inc., Corvalis Oregon) filled with our standard 50/50 sand and organic matter mix, and a hand watering regime. Survival of these transplanted seedlings was low (9), a little over 25%, which unfortunately has consistently been the norm for our transplanted Creosote seedlings. As a consequence there doesn't seem to have been anything unusual about the seed used, which was treated exactly the same up to the point where it was separated for planting in the treated and untreated soil. Differences which arose appeared to be due to the treatment with *Gliocladium virens*.

Our initial conclusions were that *G. virens* may not be beneficial to Creosote, and may have attacked and destroyed the seed. However the experiment itself was not scientific as it lacked replication, so it was not possible to say definitively that the SOILGARD was what prevented germination. However given the absolute lack of germination among seeds placed in treated soil, and the fact that this treatment was the only difference between the flats, it did appear anecdotally to be the case. As a consequence further tests were tried.

Seed selected for the trial had been collected in the Boulder Basin in 1997 and stored in the nursery seed room at a maximum of 80° F for about seven years. It was pretreated by soaking overnight on November 17th 2004. Planting was delayed on the 18th, but on the 19th it was separated into 4 lots and sown. Two of the lots were planted in flats treated with SOILGARD, and two into untreated control flats, in order to provide replication.

The flats themselves were filled with 100% coir. This difference in substrate from the first trial was chosen because plant roots seem to come free of the lighter coir material more easily with reduced breakage. These flats were watered using the greenhouse misting system for about 30 seconds every hour during the daylight hours. Average air temperatures in the greenhouse at this time varied from highs around 90° F to lows around 60° F. Once again soil temperature was not measured.

Germination in both treatments was quite good, with little apparent difference between the two- approximately 70%, within 2 weeks and close to 80% within a month. The Germinants were allowed to remain in the flat for this time to see if any differences in damping off would emerge, but none did. Germination and survival in the pure coir was dramatically better than it had been in the previous 50/50 mix of coir and nursery soil. This may have masked any benefits the SOILGARD provided to seedlings in the flat, but either way, use of pure coir provides an alternative solution to the problem. While it remains unclear what killed the seeds exposed SOILGARD in the first trial, in light of these results, SOILGARD is unlikely to have been responsible.

On December 16th, the seedlings were transplanted into Deepots filled with a 2:2:1 mix of sand, coir, and nursery soil. This experimental mix was used because simultaneous experiments with *Enceliopsis argophylla* (Sunray) indicated an extremely poor tolerance for the commercially produced nursery soil we had been using, and it was thought that *L. tridentata* may have been affected similarly. Due to personnel absences during the

Holidays, automated watering was used instead of hand watering; however it was set to a minimal level- 6 seconds every 3 hours during daylight.

Survival of transplant shock and damping off in this new mix was significantly improved over the nursery soil alone. Following transplantation seedlings treated with SOILGARD had a 70% survival rate (84 out of 120), and control seedlings a 76% survival rate (92 out of 120), which is essentially the same. That was somewhat surprising since during transplanting it was observed anecdotally that SOILGARD treated plants tended to retain fragments of coir attached to their roots more so than the controls, reducing injury to fine hairs.

Subsequent mortality meant that by early May 2005 only 68 plants remained, essentially evenly divided between SOILGARD treated and non treated (33 vs. 35) seedlings. As a consequence there seems to be little value in treatment with SOILGARD, at least as we have used it. At about 25% the survival rate to this stage was somewhat improved over the earlier soil mix, but still disappointingly low. These were then transplanted into PVC short pots. By August 2005 there were 52 plants remaining, all of which appear healthy and have grown to fill out the pot. Though better than previous efforts, getting 52 plants out of 240 germinants is still not a very good success rate.

The limited improvements achieved by changing germination substrate and transplant soil support the notion that many of the problems we have experienced to date propagating Creosote may be addressed through improved technique. The nature of those improvements is elusive however, as Creosote remains a challenge to produce.

***Pluchea sericea* (Arrowweed)**

This species was propagated from both seed and cuttings collected from stands at several locations in Lake Mead NRA. In each case the plants from which the material was taken did not appear to have been planted, but instead looked as if they had grown from (presumably local) seed that had germinated naturally.

<u>Seed</u>

The seed used was collected fresh from two locations: The Las Vegas Wash immediately down stream from the North Shore Road Bridge, and the "Corral" a location near the nursery with a drinker for Bighorn sheep. The Las Vegas Wash seed was collected in April 2004 and stored in the nursery seed room at approximately 80º F for two months until being sown. The seed from the "Corral" was collected in July and sown immediately. Additional seed collected in 2001 is also available in the nursery collection, but was not used due to the availability of fresh seed.

The "Wash" seeds were planted on June 15th 2004 in a flat filled with a 50/50 mixture of coir and our standard nursery soil (which is itself a mixture of 50/50 sand and organic matter). These flats were watered using the greenhouse misting system for about 30 seconds every hour during the daylight hours. Average air temperatures in the greenhouse at this time varied from highs around 90º F to lows around 70º F. Soil temperature was not measured.

The "Corral" seeds were planted on July 26th 2004 in a flat filled with coir. This difference in substrate (from the "Wash" seeds) was chosen because roots seem to come free of the lighter coir material more easily with reduced breakage. These flats were watered using the greenhouse misting system for about 30 seconds every hour during the daylight hours. Average air temperatures in the greenhouse at this time varied from highs around 94° F to lows around 72° F. Once again soil temperature was not measured.

Viability of the seed in both cases appears to have been poor: seed from the "Wash" had about a 10% germination rate; and seed from the "Corral" a 25% germination rate. No pretreatment was used, and it is possible that germination might have been improved with a cold water soak, or exposure to Gibberellic Acid. Seed is only available on a seasonal basis, but is fairly abundant during that time. Consequently low viability need not be a problem if it is collected in sufficient quantities, and then sown generously to compensate for poor germination.

The "Wash" seedlings were transplanted shortly after forming their first pair of true leaves (in addition to the cotyledons). These were placed in D40 (40 cu. in.) Deepots (Stuewe & Sons Inc., Corvalis Oregon) filled with our standard (50/50 sand & organic matter) nursery soil. There was a nearly 60% mortality rate among transplants, suggesting room for improvement on the technique. The most likely cause of problems was that the seedlings were very small and delicate with fragile root systems. Later transplantation of the "Corral" seedlings was much more successful (only 20% mortality). These seedlings were allowed to grow slightly larger (though still transplanted at the first leaf pair stage), and were grown in a lighter substrate that allowed the lifting of a more intact root system. Otherwise the two transplant techniques were identical. Once established in their pots the seedlings have done well, even tolerating browsing injury caused by the high level of rodent activity in the greenhouse.

<u>Cuttings</u>
Several phases of Arrowweed cuttings took place. The first was a test group grown in deepots. However subsequent production used 1 gallon containers because of the high rate of success we experienced growing *Baccharis salicifolia* in such pots. The wider spacing required by the larger container appears to allow better distribution of water by misters, as well as providing a larger catchment for each cutting. The spacing also reduces competition for light as compared to cuttings in deepots. Consequently survival and growth of cuttings in 1 gallon pots appear to be improved as compared to deepots.

Deepots
Initial experimentation with cuttings involved twenty taken from Arrowweed growing at the "Corral" a location near the nursery with a drinker for Bighorn sheep on June 3rd 2004. These were produced by taking several stems one to two yards long which were cut near the ground and sectioned into 4 to 5 pieces each approximately 12 inches long and not less than ½ an inch in diameter at the base. These were placed in a bucket of water to soak overnight. The next day, prior to being stuck, a rooting hormone and biostimulant (Essential Plus, Growth Products Ltd., White Plains New York) was added to the water and the cuttings were allowed to sit in that mixture for about 5 minutes. The cuttings were then stuck into D40 (40 cu. in.) Deepots (Stuewe & Sons Inc., Corvalis Oregon) filled with our standard nursery soil (50/50 sand & organic matter) These were then watered using the greenhouse misting system for about 45 seconds every hour during daylight hours.

Within three weeks 8 (40%) of the cuttings showed some signs of growth. All development occurred below the soil, branches emerging to the sides of the cutting, with quick establishment of apical dominance. By six weeks 14 (70%) of cuttings were growing, robustly, even tolerating herbivory by rodents. At eight weeks, no additional live cuttings had been seen, so those that remained ungrown were removed from their pots and examined. No roots or callous tissue were evident, so these were considered dead and discarded. The remaining 14 had well developed root systems and were transplanted into 1 gallon (PRO-CAN #1 Regular) nursery pots (PRO-CAL, Southgate California), treatment which they tolerated quite well as all but one survived. This was done to integrate them into the general population of Arrowweed cuttings that had been started by this time by being stuck directly into1 gallon pots.

One Gallon Pots
The clonal nature of cuttings invites future problems due to lack of genetic diversity. To minimize this, cuttings were collected from several locations at different times. The three locations used were the "(Fish) Hatchery", the "Corral", and the "Wash". The last two have already been described. The "Hatchery" is a location watered by wastewater released from the Lake Mead Fish Hatchery on Lake Shore Road near the Nursery. Conditions at each of these locations produced cuttings that looked fairly different prior to being stuck, and so they were kept separate to see what effects, if any, those morphological differences would have on the plants produced.

Cuttings from the "Hatchery" and the "Corral" were collected the same day, July 1st 2004. Though no larger in diameter, "Hatchery" cuttings appeared to be more mature than "Corral" cuttings as they possessed thin weathered grey bark. This bark also often showed signs of injury where stems had rubbed against each other in the wind. Injured lengths of stems were avoided, however the impression remained that "Corral" cuttings came from younger more vigorous plants.

The cuttings were placed in buckets of water to soak overnight. July 2nd, prior to being stuck, a rooting hormone and biostimulant (Essential Plus, Growth Products Ltd., White Plains New York) was added to the water and the cuttings were allowed to sit in that mixture for about 5 minutes. "Hatchery" cuttings rooted, but at a lower frequency (30%) compared to "Corral" cuttings (60%). The rate at which growth became evident was similar to the original 20 - by the end of the first month, most of the plants that were going to grow were showing signs of it, and by 6 weeks all of them had. At this point additional cuttings were taken from the "Corral" source as it was deemed to be superior.

Every "Hatchery" cutting exhibited behavior like the original 20 "Corral" cuttings in deepots- i.e. all growth initiated below soil level with a leader growing up beside the cutting. However, about 10% of the "Corral" cuttings that grew expressed a different behavior. Latent buds on the stem above soil level flushed. Growth among these cuttings was noted more quickly as it was immediately visible, and given location along the stem, produced a taller plant more quickly. In contrast the aboveground stems of plants which produced leaders from below the soil line appear to have been superseded by the new leader and died off.

On September 7th 2004 a third source of cuttings was tried, from the "Wash", which was the same location at which seed was collected earlier in April. While individual cuttings were approximately the same diameter and length as those taken from the "Hatchery" and the "Corral", the source plants were shorter, and had a much smaller proportion of large diameter stems available. These plants were obviously old enough to have produced seed (as noted earlier), but appeared to be more juvenile than either of the other two source stands. The juvenile nature of the tissue was evident in the cuttings themselves as well given the presence of numerous obvious buds along their length.

Similar buds had not been evident in such numbers on either "Hatchery" or "Corral" cuttings.

These "Wash" cuttings were soaked overnight and stuck the next day in the same manner as earlier cuttings. Within two weeks (50%) of "Wash" cuttings had flushed, mostly from these above ground buds. This suggests that once below ground growth becomes measurable, the final total for rooted "Wash" cuttings is likely to be greater than the 60% for "Corral" cuttings. It seems unlikely that this difference is due to genetics (Given that all are found within about 10 miles of each other), but is instead a consequence of the vigorous juvenile nature of the source material at the "Wash".

Consequently (and not surprisingly) younger, more vigorous stems should be considered to be the best source for Arrowweed cuttings. However when factoring in concerns about genetic diversity of propagules, older more mature material can be used, so long as one is prepared to accept reduced viability and slower growth. Similarly, if sufficient seed is available to compensate for low viability, seed is valid alternative for optimizing the genetic diversity of Arrowweed planting stock.

Five Gallon Pots

In November 2004 both the seedlings and the cuttings were transplanted into 5 gallon pots in the mid-compound south and provided with Tubex protectors (Treesentials, St. Paul MN) to prevent rodent damage. They handled transplanting well, and grew quickly. One unfortunate side effect of the Tubex tubes however is that seedlings can be quite flimsy after spending significant time in them. There are two reasons. The first is that they are not exposed to wind which would force them to firm up. The second is that in the slightly shaded environment of the Tubex tube, the seedling is forced to grow vertically quickly since it perceives itself as being shaded. This also contributes to flimsiness since the plant focuses growth on developing stem height rather than girth. The tubes however are definitely necessary for this species. Several were blown off by wind during storms and were not replaced quickly enough. Rodents or rabbits quickly consumed exposed plants. As noted previously in the greenhouse, Arrowweed tolerated the browsing and recovered, however obviously such damage is not desirable. As of August 2005 most 5 gallon Arrowweed are approximately 4 feet tall and though somewhat flimsy, are ready for planting out.

Fraxinus velutina (Arizona Ash)

This species was propagated experimentally using both cuttings and seed collected from the trees planted around the nursery compound. The original provenance of these trees is the Spring Mountains in southern Nevada.

The seed was 2 years old, having been collected in December of 2001, and stored at a temperature maximum of approximately 80 °F in the nursery seed room. Prior to planting seeds were stratified by setting them on moistened paper inside a ziplock bag, and placing it in a refrigerator at about 40 °F for about 6 weeks (Dec 22 2003 – Feb 3 2004).

The seeds were planted on February 3rd 2004 in flats filled with a 50/50 mixture of coir and our standard nursery soil (which is itself a mixture of 50/50 sand and organic matter). These flats were watered using the greenhouse misting system for about 30 seconds every hour during the daylight hours. Average air temperatures in the greenhouse at this time varied from highs around 95 °F to lows around 50 °F. Soil temperature was not measured.

Germination began after about 2 weeks (Feb 19th) with significant first and second waves, about two weeks apart and seemed to have ended after about 6 weeks (March 15th). Overall germination was poor – approximately 10%. It is possible that if left long enough an additional wave of seedlings might have emerged, but there was no sign of that by mid April, and the flat was discarded.

The seed may not have been allowed to stratify long enough or the viability may have been poor due to age or issues in storage. Because of the need for lengthy stratification, simple germination tests to investigate this will be time consuming. Alternatively, viability of the seed could be quickly assessed using tetrazolium. Given that the seed is abundant, low viability is not necessarily a significant problem, especially since demand in the park for this species is currently limited to ornamental plantings and is thus relatively low. Consequently sowing of large numbers of seeds to compensate for low viability would be an option.

Seedlings were transplanted shortly after forming their first true leaf (in addition to the cotyledons). These were placed in D40 (40 cu. in.) Deepots (Stuewe & Sons Inc., Corvalis Oregon) filled with our standard nursery soil (50/50 sand & organic matter). They were then watered using the greenhouse misting system for about 45 seconds every hour during the daylight hours. There was a nearly 50% mortality rate among transplants suggesting room for improvement on the technique. The most likely cause is that the seedlings were transplanted too soon, and so should probably be allowed to grow larger prior to transplantation. Once established in their pots however, the seedlings did well.

In mid October 2004 the seedlings were transplanted into 5 gallon pots in the upper compound and provided with Tubex protectors (Treesentials, St. Paul MN) to prevent rodent damage. Though initially stressed they recovered and grew well. One unfortunate side effect of the Tubex tubes however is that seedlings can be quite flimsy after spending significant time in them. There are two reasons. The first is that they are not exposed to wind which would force them to firm up. The second is that in the slightly shaded environment of the Tubex tube, the seedling is forced to grow vertically quickly since it perceives itself as being shaded. This also contributes to flimsiness since the plant focuses growth on developing stem height rather than girth.

In May 2005 the tubes were removed from five trees to experiment with encouraging the development of a firm stem (this had been tried successfully earlier in January with *Chilopsis linearis* seedlings subsequently protected with Deer Away (Woodstream Corporation, Lititz, PA)). Unfortunately the same technique did not have an opportunity to work for the Ash. Within a week, two of the five were girdled by rodents despite the Deer Away. It is difficult to say if this was a consequence of time of year rather than difference in species, since the population of rodents was higher following the winter rains. As a result all now remain protected. As of August 2005 they average three to four feet in height and though somewhat flimsy, are ready for planting out.

On February 2nd 2004 twenty cuttings were taken from the lower branches of ash trees around the nursery, four from each of five trees. The branches were dormant at this time. Each cutting was 6 to 7 inches long, with a terminal bud attached. The average diameter was half an inch at the base. These were placed in a bucket of water to soak overnight. The next day, prior to being stuck, a rooting hormone and biostimulant (Essential Plus, Growth Products Ltd, White Plains New York) was added to the water and the cuttings were allowed to sit in that mixture for about 5 minutes. The cuttings were then stuck into D40 (40 cu. in.) Deepots (Stuewe & Sons Inc., Corvalis Oregon) filled with our standard nursery soil (50/50 sand & organic matter). These were then watered using the greenhouse misting system for about 45 seconds every hour during daylight hours.

During the next two weeks, 6 (30%) of the cuttings flushed but sat without growing for about eight weeks, at which time they died within a few days of each other. When removed from the pots there was little evidence of root or even callous formation. Cuttings this size were used in order to work with the large apical buds present in the hopes that endogenous hormones produced by these buds would drive root growth. Obviously however this did not work. Having heard anecdotal reports of growing ash from cuttings, it seems as if further work might be justified either using larger diameter cuttings with no concern for the presence of buds, or by air layering during the growing season.

Baccharis emoryi (Emorys Seepwillow)

This species was propagated from cuttings collected from five individuals growing near the main house at Warm Springs Ranch, a site managed by the U.S. Department of Fish and Wildlife, in the Moapa valley. Given that these plants appeared to be part of a landscape, it is possible that they were planted. However this is not a horticulturally significant species, and so planted or not, the genetics are likely to be local. A close relative, *Baccharis salicifolia* grows easily and reliably from cuttings, with well over 95% of cuttings that are stuck, taking root and flushing. However, an earlier, informal attempt at growing an unidentified species of *Baccharis* was unsuccessful (few flushed, none rooted, and all died), so it was unclear what to expect of *B. emoryi.*

A total of 55 cuttings were collected Friday May 20th 2005. These were produced from straight branches approximately a yard long. The branches were stripped of leaves and sectioned into 3 or 4 pieces each approximately 12 inches long and not less than ½ an inch in diameter at the base. Injured lengths of stems were avoided, with young vigorous growth being favored. The cuttings were placed in buckets of water to soak over the weekend.

On Monday May 23rd, prior to being stuck, a rooting hormone and biostimulant (Essential Plus, Growth Products Ltd., White Plains New York) was added to the water and the cuttings were allowed to sit in that mixture for about 5 minutes. They were then stuck into 1 gallon (PRO-CAN #1 Regular) nursery pots (PRO-CAL, Southgate California) filled with our new standard nursery soil (75/25 sand & organic matter). These were then misted using the greenhouse automated irrigation (run by an Irritrol clock) twice a day for 2 minutes, seven days a week, with supplemental hand watering weekday mornings. Average air temperatures in the greenhouse at this time varied from highs around 104° F to lows around 70° F. Soil temperature was not measured.

Over the next 6 weeks no above ground development (bud flushing etc.) was seen. This was in stark contrast to *B. salicifolia* which typically flushes within a week to two weeks under similar treatment. Even the unidentified species of *Baccharis* experimented with previously had a few individuals flush before dying. On Tuesday July 5th 2005 all 55 cuttings were pulled from the pots and examined, with no sign of roots or callous tissue evident on stems or as fragments in the soil. Most appeared to be dead, with the bark having faded from red-brown to a gray-black.

One attempt with cuttings taken from five individuals at a single location is insufficient to say definitively that *B. emoryi* cannot be grown from cuttings. However, the complete lack of growth or survival suggests that *B. emoryi* is neither as simple or reliable to produce in this way is as its cousin, *B. salicifolia.* The speed and simplicity of cuttings is the primary justification for their use. With such benefits absent, the cost of the clonal nature of cuttings (invitation of future problems due to lack of genetic diversity) becomes a significant consideration. Instead, future work with *B. emoryi* seed may be more appropriate.

Samolus parviflorus (Water Pimpernel)

This species was grown from wildlings collected along the bank of a stream flowing through Warm Springs Ranch, a site managed by the U.S. Department of Fish and Wildlife, in the Moapa valley. Seed was unavailable at the time of collection. Earlier, two larger specimens were collected from Blue Point Springs in Lake Mead NRA and it was noted then that they tolerated transplantation well. Fully mature individuals of this species at Blue Point Springs tend to grow in multi-stemmed clusters.

The initial expectation at Warm Springs Ranch had been to collect and break up several of these clusters to try to propagate pimpernel vegetatively. However, once on site, no clusters were observed. Given the desire for site specific genetics, we decided to work with what was available. There were large single stemmed individuals and numerous small recently germinated wildlings growing at a density well in excess of likely long term survival. Considering earlier success with transplantation it was decided to try collecting and transplanting the wildlings. Collection of significant numbers of large single stemmed individuals would have simply denuded the site, and resulted in no net gain of plants.

A total of 82 wildlings were collected on Friday May 20th, 2005. Typical size was a rosette an inch to an inch and a half in diameter, half an inch tall, with roots about an inch deep. These were uprooted and kept in a bucket of water. Typically the fine roots held tenaciously on to the soil in which they had grown, even when immersed. As a result, most individuals maintained a “plug” of soil around their roots, which simplified transplantation and reduced shock.

That afternoon, upon returning to the nursery, the wildlings were planted into 1 gallon (PRO-CAN #1 Regular) nursery pots (PRO-CAL, Southgate California) filled with our new standard nursery soil (75/25 sand & organic matter). Following planting, approximately half of the leaves on each plant were removed to compensate for root damage by bringing the root to shoot ratio back towards parity. These were then misted using the greenhouse automated irrigation (run by an Irritrol clock) twice a day for 2 minutes, seven days a week, with supplemental hand watering weekday mornings. Average air temperatures in the greenhouse at this time varied from highs around 100º F to lows around 70º F. Soil temperature was not measured.

At the time of writing (August 16th, 2005) 77 individuals remain (94% survival), all of which look quite healthy. Most have grown into large single stemmed rosettes about seven inches in diameter and six inches high with flower spikes an additional four inches high. The earlier pair of plants taken from Blue Point Springs began to suffer some fungal damage to their leaves after spending significant time in the greenhouse at this size. Therefore, ideally these plants should be moved outside at this point to take advantage of the lower humidity. However, the potential for extreme temperatures in the compound (120° F+) during August is preventing us from doing so. The shock of transition from the artificially cool greenhouse to the outside could be even more damaging. So far fungal damage has not become an issue on the plants from Warm Springs Ranch, but monitoring is ongoing.

Pimpernel seeds became available in early August and were collected at Warm Springs Ranch where this material came from. Future work may be attempted with propagation from seed. In the mean time however, the Department of Fish and Wildlife took much of the seed they collected and tried direct sowing. Given how easily transplanted pimpernel seems to be, they also intend to salvage plants from parts of the site that will disturbed by earthmoving and directly transplant them to other portions of the site where they are desired. It will be interesting to follow up on that. Considering the ease of transplanting pimpernel (at least in the greenhouse) there could be a significant savings in expense and effort if the nursery can be bypassed by achieving a reasonable survival rate through directly transplanting in the field. That then could reserve nursery capacity to be used more appropriately for plant species that do not lend themselves to such treatment.

Plant Materials for Agency Restoration Projects

Plant material for the FWS Warm Springs and Moapa restoration projects is propagated and available for outplanting, but the restoration projects were delayed and so that material remains at the nursery. (Those species are listed under *Annual Production Plans* below.) However, the following plant material was delivered to agencies as shown:

Entity	Species	Size	Amount
NPS	*Acacia greggii*	1g	75
	Ambrosia dumosa	shortpot	41
	Asclepias subulata	shortpot	17
	Baccharis salicifolia	5g	122
	Baccharis salicifolia	1g	47
	Bebbia juncea	1g	16
	Chilposis linearis	5 g	108
	Chilposis linearis	1g	34
	Curcurbita palmata	deepot	12
	Encelia farinosa	shortpot	87
	Encelia farinosa	5g	2
	Enceliopsis argophylla	1g	3
	Ephedra nevadensis	shortpot	8
	Fraxinus velutina	5g	20
	Larrea tridentata	shortpot	97
	Opuntia basilaris	1g	86
	Penstemon bicolor roseus	shortpot	12
	Pluchea sericea	5g	4
	Populus fremontii	5g	149
	Prosopis glandulosa	15g	7

	Salix exigua	5g	1
	Salix gooddinggii	5g	18
	Sphaeralcea ambigua	shortpot	4
	Sporobolus airoides	1g	32
	total	**all sizes**	**1002**
BLM	*Larrea tridentata*	shortpot	22
	Prosopis glandulosa	1g	50
	total	**all sizes**	**72**

In addition, a total of 948 plants were delivered to the Big Springs Preserve (Las Vegas Valley Water District), 7 trees were delivered to the Spring Mountain Ranch (State of Nevada), and 25,485 plants were delivered to the Las Vegas Wash (Clark County) for riparian and wetland restoration work there.

Annual Production Plans

Annual productions plans were submitted to the Clark County MSHCP Database, and are also included here.

Agency requests for propagated material are submitted through the Southern Nevada Restoration Team, must be for limited amounts of small size material or cuttings, and must include all propagules required. Outplant date must be at least 18 months from propagule provision if methods must be researched. All requests must include the following information: species name, collection location, collection location soil type, collection date, collectors names, agency name, agency contact, amount needed, container size, outplant date, and any other relevant information desired.

Production Plan submitted for FY04

These goals were developed by the Southern Nevada Restoration Team with input from the National Park Service, US Fish and Wildlife Service, the Bureau of Land Management, and the USDA Forest Service.

US Fish and Wildlife Service
Phase 1 Warm Springs National Wildlife Refuge

All are one gallon size. Delivery date October 2004 if seed or other propagules are provided by March 2003. Delivery date October 2005 if seed or other propagules are provided by March 2004.

Number	Species	Seed Provided?
75	white bursage *Ambrosia dumosa*	N
5	catclaw *Acacia greggii*	N
40	honey mesquite *Prosopis glandulosa* var. *torreyana*	Y
25	honeysweet *Tidestromia oblongifolia*	N
10	bushy bluestem *Andropogon glomeratus* var. *scabriglumis*	N
20	leather-leaf ash *Fraxinus velutina*	N
25	desert isocoma *Isocoma acradenius* var. *eremophilus*	N
25	California loosestrife *Lythrum californica*	N

25	scratchgrass *Muhlenbergia asperifolia*	N
25	screwbean mesquite *Prosopis pubescens*	Y
100	alkali sacaton *Sporobolus airoides*	N

Moapa Wildlife Refuge

All are one gallon size. Delivery date March/April 2004.

100 alkali sacaton *Sporobolus airoides* LAME provides propagules

Moapa Wildlife Refuge

All are five gallon size. Delivery date October 2005 if seed or other propagules are provided by March 2003.

Number	Species	Seed Provided?
200	honey mesquite *Prosopis glandulosa* var. *torreyana*	Y
200	screwbean mesquite *Prosopis pubescens*	Y

Bureau of Land Management
Desert Riparian Restoration Projects in Clark County.

All are one gallon size. Delivery date is September 2004.

Number	Species	Seed Provided?
200	alkali sacaton *Sporobolus airoides*	Y

National Park Service
Lake Mead National Recreation Area Restoration Projects in Clark County.

All are one gallon size. Delivery date is October/November 2004. All seed is provided by NPS.

Overton/Echo Bay area
100 creosote *Larrea tridentata*

Callville/Government Wash area
100 creosote *Larrea tridentata*
100 white bursage *Ambrosia dumosa*

Boulder Beach area
300 creosote *Larrea tridentata*
100 white bursage *Ambrosia dumosa*
300 brittlebush *Encelia farinose*
50 desert fir *Peucephyllum schottii*
50 globemallow *Sphaeralcea ambigua*
50 sweetbush *Bebbia juncea*

Cottonwood area
100 creosote *Larrea tridentata*

100 white bursage *Ambrosia dumosa*

Newberry Mountains area
50 creosote *Larrea tridentata*
50 white bursage *Ambrosia dumosa*
25 catclaw *Acacia greggii*
25 juniper *Juniperus californica*

Production Plan submitted for FY05

These goals were developed by the Southern Nevada Restoration Team with input from the National Park Service, US Fish and Wildlife Service, the Bureau of Land Management, and the USDA Forest Service. Only the NPS had planned restoration projects requiring plant material at that time.

Lake Mead National Recreation Area Restoration Projects in Clark County.

All are one gallon size. Delivery date is October/November 2005. All seed is provided by NPS.

Overton/Echo Bay area
100 creosote *Larrea tridentata*
100 white bursage *Ambrosia dumosa*

Callville/Government Wash area
100 creosote *Larrea tridentata*
100 white bursage *Ambrosia dumosa*

Boulder Beach area
300 creosote *Larrea tridentata*
100 white bursage *Ambrosia dumosa*
300 brittlebush *Encelia farinose*
50 desert fir *Peucephyllum schottii*
50 globemallow *Sphaeralcea ambigua*
50 sweetbush *Bebbia juncea*
20 rosy penstemon *Penstemon bicolor roseus*
10 sunray *Enceliopsis argophylla*

Cottonwood area
100 creosote *Larrea tridentata*
100 white bursage *Ambrosia dumosa*

Newberry Mountains area
50 creosote *Larrea tridentata*
50 white bursage *Ambrosia dumosa*
25 catclaw *Acacia greggii*
25 juniper *Juniperus californica*

Quarterly Reports

Quarterly reports were submitted to the Clark County MSHCP Database and are available from that database.

Final Project Report

This report fulfills the obligation for the Final Project Report submitted to the Clark County MSHCP Database.

Challenges Addressed and Lessons Learned

One of the biggest challenges of successful native plant production is to be able to respond quickly to agency needs with appropriate expertise and propagation material. Experienced nursery managers and propagation technicians are in relatively short supply simply because there is very little agriculture or nursery industry in Southern Nevada. Although degreed botanists may know a great deal about individual species, the majority have no experience pertaining to large-scale nursery management and production. Nursery facilities managers must have extensive knowledge of propagation techniques as well as potting soils, water quality, greenhouse management, fertilization, irrigation design and repair, integrated pest management, equipment maintenance and repair, etc.

Appropriate propagation material may also be difficult to obtain. Many native plant species have limited distributions or have low seed viability. Seed set and viability is highly dependent on annual rainfall and temperature regimes, and can vary greatly from year to year. Vegetative propagation material for perennial plants is generally more available than seed, however, serious "genetic bottleneck" concerns may arise. Vegetative methods for annual plants are usually not appropriate at all. In addition, collection windows for species are usually very brief, and it is difficult to catch remotely-located stands before the seeds are eaten or dispersed.

Another, less obvious, challenge to successful nursery production for restoration work is the elimination of *nursery bias* in propagule collection, propagation, and outplanting. Nursery bias in native plant production results in plant material that is more suited to human management than survival under natural conditions. Nursery-grown plant material available for restoration may not express the full array of genetic attributes required for successful establishment and reproduction. It occurs when collectors target only the most robust, or least insect-riddled, or the tallest, etc, plants for seed or other propagule collection. It also results when only a few areas are collected from, or, in the case of seed available over an extended time, when collected for a limited time. This initial bias is exaggerated when propagation methods select only the initial germinants or sprouters from a batch of seed or cuttings, or try only a few temperature or wetting routines from many that could be used. Extensive irrigation or fertilization practices create healthy, robust plants, but also select for plants that do well under circumstances not common in the wild. Excessive water and fertilization also actively discourages a native plant from making the appropriate mycorrhizal and other biotic connections necessary for survival at outplanting.

Standard nursery practices encourage nursery bias simply because those plants are grown for human needs, management and enjoyment. Consistency in form, color, leaf size, growth habit, fertilizer requirements, water use, etc. is desirable when propagating for landscape or agricultural purposes. Eliminating nursery bias in native plant production requires methods that are more time-consuming and therefore, more costly than standard practices. For this reason alone, *plant material suppliers for restoration projects should never be chosen simply because they are the lowest bidder.*

Appropriate restoration material collection and propagation practices will always cost more than traditional industry practices, and should not be judged according to the same standards.

Another challenge in restoration nursery production is what to do with plant material when the outplanting had been delayed or cancelled. Even brief postponements of six or eight weeks may result in unplanned maintenance costs and degradation of plant quality. If delays are more than three months, most plant material must be moved up to larger size containers at considerable expense in order to salvage them. This also results in the loss of premium nursery production space until the order is delivered. Sometimes the project is cancelled altogether, and the material is not needed at all. This puts a huge burden on the nursery which has in good faith performed all obligations, and unless compensated, takes a huge loss. Although many agencies do not want to be seen as paying a lot of money for "nothing", the nursery must be compensated somehow for labor and materials expended.

Many commercial nurseries deal with this situation by requiring non-refundable deposits before production begins, and establishing holding fees similar to liquidated damages in construction contracts. If the customer does not take delivery within a pre-established time frame, not only does he lose the deposit, the plant material then becomes available for the nursery to sell on the open market. For the agencies, selling (or otherwise making available) unclaimed restoration plant material may not be an option since production was highly focused on a particular area, and the species or genetics may not be suitable for elsewhere. When it is possible that restoration projects may be delayed or cancelled, adequate provisions must be made in advance to compensate the propagating nursery when that situation occurs.

Project Impact

The Lake Mead Native Plant Nursery is the only one in Southern Nevada dedicated to native Mojave Desert plants. There are two other facilities that grow native plants (the Nevada Division of Forestry facility at Floyd Lamb State Park and The Community College of Southern Nevada campus in Henderson) but they propagate non-native landscape material as well. They also do not have the means for extensive propagation research, nor do they have facilities for long-term seed bank maintenance. The Lake Mead facility has the flexibility and the means for long-term propagule storage, native plant propagation research, and mass production that other facilities do not.

Although the facility provided fewer than 1100 plants to federal agencies during the two-year grant period, this was largely a function of demand rather than capacity. Over 27,000 native plants were provided to (and funded by) other local entities, and the nursery could have provided more. Continued support of this facility will keep critical expertise and facilities available when needed.

Additional Research

There are well over a thousand species of vascular plants native to Southern Nevada that could be used for restoration purposes. Propagation methods are known for only a handful, and these studies are incomplete. Continued funding for propagation and outplanting research is sorely needed, and encouraged by the federal agencies conducting extensive restoration work in Southern Nevada.

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The following is a list of publications that are used to provide guidance in Lake Mead Native Plant Nursery operations:

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