Lower Colorado River Multi-Species Conservation Program

Balancing Resource Use and Conservation

Mass Transplanting Demonstration 2005-2006 Final Report

U.S. DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION

October 2007

Lower Colorado River Multi-Species Conservation Program
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Lower Colorado River
Multi-Species Conservation Program

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Introduction

The Lower Colorado River Multi Species Conservation Program (LCR MSCP) is a partnership of Federal and non-Federal stakeholders, created to balance the use of the Lower Colorado River (LCR) water resources and the conservation of native species and their habitat in compliance with the Endangered Species Act. This is a long-term (50-year) program to conserve at least 26 species along the LCR from Lake Mead to the Southerly International Boundary with Mexico through the implementation of a Habitat Conservation Plan (HCP). In accordance with the goals outlined in the HCP, it is anticipated portions of existing active agricultural land will be converted to native land cover along the LCR.

Purpose/Need

The purpose of the Mass Transplanting Demonstration was to evaluate, through a demonstration, the efficacy of adapting commercially available mass transplanting technology to establishing native riparian species. The technology is a potential tool to increase efficiency in establishing the large, dense stands of cottonwood-willow envisioned by the program.

The demonstration used the mass transplanting technique to convert agricultural fields into cottonwood-willow land cover types, ultimately resulting in habitat credit. The technique involved mechanized, rapid, dense planting of a minimum 4,500 seedlings per acre to inhibit growth of nonnative plant species and achieve dense growth of native tree species. The demonstration was held within Unit 1, located on Cibola National Wildlife Refuge (NWR). The site consisted of two active agricultural fields totaling approximately 37 acres.

A simplified acquisition was generated, and contractors competed in the demonstration of mass transplanting of cottonwood and willow. The contract required the utilization of commercially available equipment and was awarded to two contractors: Contractor A, located in Arroyo, California, and Contractor B, located in Brawley, California. Each contractor was provided with an agricultural field and required to provide their approach to mass transplanting cottonwood and willow trees. The intent was to demonstrate and compare the respective techniques. Each technique was evaluated for the effectiveness of creating quality land cover at a reasonable cost (currently, mass transplanting methods are being utilized in the agriculture industry to produce high quality fruits and vegetables at a reasonable cost).

Participating Contractors

Contractor A

Contractor A was awarded a contract for $150,000 on January 21, 2005, for mass transplanting of cottonwood (*Populus fremontii*) and willow (Salix *gooddingii)* on a 20-acre alfalfa field located within Unit 1 at Cibola NWR.

Contractor A started collection of *Populus fremontii* the last week of January in 2005 and continued until mid-February. Plant material collected consisted of small (<4-inch diameter) dormant poles. Collection became difficult because of unusual climatic conditions during the winter of 2005. Heavy rainfall followed by a quick rise in temperature ended the dormancy period, prohibiting further collection of plant material. Limited numbers of *Salix gooddingii* were collected, because the success of cuttings from the targeted species is dependent on the collection of plant material during dormancy.

The poles arrived at Contractor A's facility located in Arroyo Grande, California, for propagation. The cuttings were soaked in a weak bleach solution to reduce the chances of disease. Cuttings were reduced in size to approximately 3 inches in length, treated with a rooting hormone, and then placed in trays with individual cells filled with soil medium (Figure 1). The trays/cells were designed to hold the cuttings until they were removed for planting in the field.

Figure 1. Tray/Cell Preparation—Automated cell preparation for cuttings. Soil and amendments such as fertilizers and vermiculite were inserted into each cell automatically.

The trays of cuttings were mechanically moved from greenhouse to greenhouse, and then eventually to the outdoors. The greenhouses had computer-controlled environments (heat, light, and moisture), with a series of rolling benches, shade systems, and high-intensity discharge (HID) lighting. The cuttings, called plantings at this stage, were kept in the first greenhouse for approximately 3 weeks. Once the plantings established a primary root system, they were moved to the second greenhouse (Figure 2). While in this greenhouse, the plantings increased their root growth to 50-75% of the area within each cell (Figure 3).

The plantings remained in the second greenhouse to further develop healthy root balls and top growth. Excess top growth was cut with an overhead mower, keeping the plantings at a uniform height for planting. The plantings were moved to the outdoors approximately 2 weeks prior to planting, where the plantings were “hardened off”. The hardening off process acclimatized the plantings to the outdoor environment.

Figure 2. Greenhouse #2—Plantings were started in an environmentally controlled (moisture, temperature, and light) greenhouse. Once the plantings developed roots, they were moved into a second greenhouse.

Figure 3. Developed Root System— Pictured above is the initial root system. Plantings were kept in the 2nd greenhouse to develop a vigorous root system.

Prior to shipping, the plantings were sprayed with an anti-desiccant and watered to prevent dehydration and wilting during shipping. The plantings were loaded in closed containers that held approximately 9,000 plantings each.

Plantings were shipped on April 24, 2005, from Arroyo Grande, California, to Cibola NWR. The containers were opened at the restoration site. The plantings arrived in superior condition, showing no signs of stress (Figure 4). The roots had developed a good root system, which helped the plantings establish in the fields (Figure 5).

Figure 4. Delivery Containers for Plants— Plants arrived in closed containers. Each container held approximately 9,000 plants.

Figure 5: Cottonwood Planting— Cottonwood plantings prior to planting, showing vigorous root development.

Initially, the field was disked and laser-leveled 1 month prior to planting, then the ground was re-disked 2 days before planting. On the planting day, April 25, 2005, the temperatures were mild and without wind (Figure 6). A commercially available tomato planter was used for the planting. However, because of the actual size of the plantings, which were larger and had more branch development than the smaller tomato plants, the plantings did not efficiently drop through the funnels for planting. Some of the small branches hung up on the funnel feeder (Figure 7), resulting in unequal spacing. The contractor suggested that using a heavier soil medium and a different shape for the propagation cells would allow the plants to drop through the feeder more easily and thereby correct the problem.

As the temperature increased during the morning, the ground became increasingly harder, making it difficult for the planter to cut through the soil. The depth of the planting channel was not deep enough for the plantings to drop in. This caused the plantings to sit on the surface and not be buried. The ground was reworked during planting using a harrow and a ring roller attachment to break up dry clods of soil, allowing the planter to pass through the soil. The plantings then dropped into the channel, which could then be closed, burying the plantings to the appropriate depth.

Figure 6. Field Preparation—Field was prepared for planting. A tomato planter filled with cottonwood and willow trees was connected to the tractor for planting.

Figure 7. Feeder Funnels—Funnel feeder filled with cottonwood and willow trees. Trees dropped through at a designated rate for spacing of the trees.

The first eight rows of plantings were spaced in-line approximately 1 foot or less apart, with a row width spacing of 38 inches. The rest of the plantings were all approximately 3 feet apart. The total number of plantings was 46,000 planted in 8.5 acres.

Flood irrigation was started immediately after planting (Figure 8) to keep the root ball moist. The acreage was then irrigated every 3 days for the first 4 weeks and finally once a week until October.

Figure 8. Irrigating Plantings—A border was placed by the tractor so that the irrigation water could be controlled. Planting continued on the dry side of the field.

Contractor A's fields were closely monitored for survivorship for the first 12 weeks and then once a month during the first growing season. Photos were taken documenting growth of the trees.

One week after planting, the previous alfalfa crop started to grow back. All of the plantings appeared to have survived (Figure 9). The alfalfa and the density of the plantings appeared to be suppressing the weeds.

During weeks 2-5 (Figures 10-14), the alfalfa continued to grow and blossom, along with an invasion of nutgrass. As the weeks progressed, grass seeds were transported in the irrigation system. Germination was quick and the grass developed rapidly, entwining and partially covering the trees.

Fertilizers and herbicides were not used on the field during the 2005 growing season. As a result of not using a pre-emergent herbicide, there was an explosion of a water grass in the field. Competition for light between the water grass and cottonwood-willow trees became apparent. The water grass started invading the field in week 6 (Figure 15), and continued to be present throughout the growing season.

Figure 9: Week 1—Survival growth was greater than 95% after 1 week.

Figure 10. Week 2—Increased growth of alfalfa at week 2.

Figure 11. Week 3—Nutgrass had started to grow at week 3.

Figure 12. Week 4—Alfalfa and nutgrass continued to fill in.

Figure 13: Week 5—Trees were just above the nutgrass and alfalfa.

Figure 14. Week 5—Willow trees measured 21 inches.

Figure 15. Week 6—Explosion of water grass, an invasive grass. Seeds were transported in the irrigation water.

Figure 16. Week 7—Cottonwood trees competed with the water grass for light. The alfalfa and water grass apparently kept out other invasive plants.

The water grass had reached its maximum height of approximately 3 feet and seeded at the end of the 2005 season. Some of the trees remained under 3 feet and still were competing for light (Figure 16).

At the end of the first growing season in 2005, the trees that had not been entwined and covered in water grass had grown to an average height of 6 feet (Figure 17). The trees that were inundated by the water grass were just visible above the grass, with an average height of 3 feet (Figure 18).

By fall of the 2006 growing season, all trees had grown to an average of 15 feet tall. It appeared that the water grass had a short-term effect on growth for the first year but not for the second year. Most of the trees formed a thick forest (Figure 19) with an understory of short grass (Figure 20).

Figure 17. Week 8—Cottonwood trees after first growing season. Trees were more than 6 feet tall.

Figure 18. Week 9—Cottonwood trees entwined in water grass.

Figure 19. Cottonwood Trees, Fall 2006—Trees after second growing season. Some reached 20 feet in height. Year 2006 plantings appear in the foreground.

Figure 20. Understory of Grass—An understory of short grass was present during fall 2006.

Due to the unfavorable weather conditions for collection of plant material in the winter of 2005, Contractor A completed the contract in the spring of 2006. The collection technique was identical to the technique used in 2005; however, the collected plant material was slightly thicker in diameter than material collected the previous year. All plant material was collected in the dormant stage. Lessons learned during 2005 were applied to the 2006 propagation. Propagation failures during 2005 led to over-collection of at least 25% during 2006 to compensate for the loss. Soil mixture and weight were increased to allow the finished plantings to pass though the planter more efficiently. The timing of nutrients and water were adjusted in the greenhouse setting. Contractor A's experience and trials from the propagation and planting of 2005 helped avert most failures and added a higher level of success.

Contractor A planted 11.5 acres in 2006 to complete the contract. Approximately 39,000 cottonwood and willow trees were planted at spacings between 5 feet in-line and 7 feet in-line; rows were 38 inches apart. The ground had been left fallow for the year and no irrigation had been applied. Preparation of the ground for year 2006 planting consisted of disking several times so that the top 4 inches of soil were fluffy and without clods. The planting went smoothly and quickly. The trees were delivered and planted the next day in approximately 3 hours. With Contractor A's experience from the 2005 planting, the planting time was decreased from 8.5 acres planted in 8 hours to 11.5 acres planted in 3 hours. The total cost was $7,500 per acre with an average of 4,250 trees per acre.

The trees that were planted in April of 2006 experienced the same inundation of water grass (Figure 21). However, more invasive plants were observed in the 2006 planting. It appears that leaving the ground fallow for a year allowed invasive species to germinate and grow (Figure 22). In September 2006, the height of the trees varied from 2 feet to 4 feet.

Figure 21. Water grass in 2006—Water grass and other nonnatives were growing among trees. Note the 2005 planting in background.

Figure 22. Invasive Plants—Saltcedar, Johnsongrass, and other nonnative vegetation.

Contractor B

Contractor B was awarded a contract for $132,000 on January 21, 2005, for mass transplanting of cottonwood (*Populus fremontii*) and willow (*Salix gooddingii)* on a 17.2-acre alfalfa field located with Unit 1 at Cibola NWR.

Contractor B started the collection of plant cuttings during early February and continued until the first week of May. Contractor B continued to collect cuttings when the trees were out of dormancy (Figure 23).

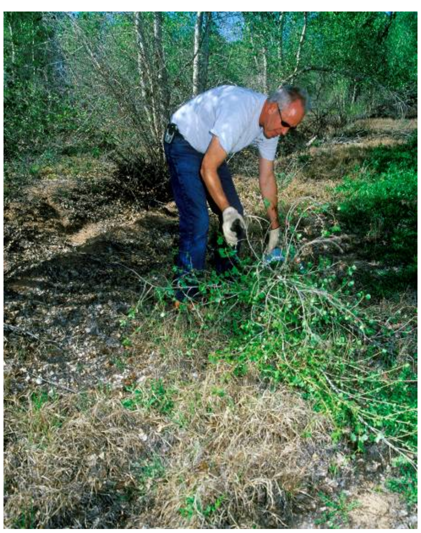

Figure 23. Pole Collection— Poles were cut and collected for propagation. Poles were no longer dormant.

Contractor B placed all cuttings in water in preparation for transport to the greenhouse facility. The poles arrived at Contractor B's facility located in Brawley, California, for propagation. The cuttings were soaked in a weak bleach solution to reduce the chances of disease. Cuttings were reduced in size to approximately 3 inches in length, treated with a rooting hormone, and then placed in trays filled with soil medium (Figure 24). The trays were designed so that the cuttings were manually planted in one tray, and later would have to be removed and manually replanted into trays with individual compartments.

The greenhouse facilities were basic, with shade covers to control light and some benches for trays. The watering system was dependant on a hose to each planting area (Figure 25).

Plantings stayed outside in a partially covered greenhouse for approximately 4 months. A site visit to the greenhouse in mid-April revealed that plantings had not formed a healthy root ball (Figure 26). The actual planting date was delayed to allow for additional root growth.

Figure 24: Poles in Trays—Poles were placed in trays. In the following weeks, an overhead irrigation system and hoses were used. Each planting had to be removed by hand and replanted into trays that were compartmentalized.

Figure 25. Greenhouse—The greenhouse was manually controlled. Shade cloth was placed by hand over the ribs of the greenhouse. Watering was done using a hose.

Figure 26. Plantings—Two weeks prior to planting, the trees had not developed roots.

Figure 27. Plantings at CNWR—Plantings arrived in fair condition.

The plantings were shipped in a tarp-covered trailer from Brawley, California, to Cibola NWR on May 30, 2005. No anti-desiccant was applied to plantings prior to shipping (Figure 27). The plantings arrived in fair shape.

A variation of a vegetable planter was used for planting. Contractor B was able to plant without any of the problems encountered by Contractor A, such as soil clodding and dry soil.

Temperatures on the planting day were in excess of 110 degrees with a moderate wind. The planting was completed in 1 day. Irrigation was started as soon as the field was planted. A total of 76,500 *Populus fremontii* and *Salix gooddingii* were planted over the entire 17 acres, at a cost of $6,600 per acre (Figure 28).

Immediately after planting, the trees became stressed. Within a 24-hour period, tree survival was 0% (Figure 29).

Figure 28. Planting of Trees—Over 17 acres of trees were planted.

Figure 29. Survival of Trees—It appeared that none of the trees survived.

DISCUSSION

The contract goal was to mechanically plant live plants in the ground, although it was understood that propagation techniques and producing live plantings were essential aspects of the contract. The following paragraphs contain a discussion and lessons learned through implementation of this demonstration project.

Propagation Experience

Both contractors have been successfully propagating flowers and vegetables for a number of years, but neither is experienced in propagating native cottonwood and willow trees. It was unknown at the time of the demonstration what the success rate would be for riparian tree propagation. A number of propagation treatments were explored by both nurseries. Each nursery experienced failures and successes with propagation of the trees, depending on the treatments used.

Plant Collection

The collection period was a factor for both nurseries. Contractor A was unable to collect enough plant material (mostly willow) in a dormant state for the entire 20 acres. Rainfall and early warming temperatures limited access to collection sites and shortened the dormancy period of the trees. Contractor B did not collect in the wet weather, opting to wait for drier conditions, resulting in collection of non-dormant stock. Collection of hardwood cuttings during dormancy traditionally has the highest success rate of 80% (NRCS Plant Guide, Bureau of Reclamation, 2003). As a result of non-dormant plant material, propagation techniques for this project appeared less successful.

Climate Control

Even though the propagation technique chosen by both nurseries was the same (cuttings), the greenhouse facilities vastly differed. Contractor A's plantings (climate controlled) had extensive root ball growth with more than 75% root mass to soil mixture. Contractor B's plantings (limited climate control) had non-existent to limited root ball mass to soil mixture.

Planting Method

This was the first time this method of planting was utilized for tree planting. The planting equipment, through trial and error, was calibrated to handle the larger plantings. Soil consistency and weight of the plantings were factors in the ease of plant delivery through the funnels for planting. Both contractors were successful in demonstrating that mass transplanting of trees is fast and potentially economical.

Planting Temperatures

Contractor A planted during the last week of April when weather conditions were more conducive for planting: temperatures ranged from the high 70s to the mid-80s (°F). Contractor B planted during the beginning of June when temperatures exceeded 110 degrees. The higher temperature raised the soil temperature, drying out the roots faster and apparently stressing the plants.

Plant Survivability

Although survivability of the trees was not the goal of this contract, several observations were made after the initial planting demonstration. A few issues were problematic and many lessons were learned. It appears that the difference in survivability of the trees is dependant on a number of factors: time of collection of plant material, propagation techniques, and time of planting. However, both nurseries demonstrated that cottonwood and willow trees could be planted utilizing the mass transplanting technique. In the future, equipment modifications are needed to the standard tomato planter to allow for the size of the trees

Mass Transplanting Technique

This technique can be appropriate for most agricultural conversions for the creation of habitat; however, the genetic diversity is minimal because of the current collection method for cuttings. A possible choice may be growing the plantings from seeds. Seed propagation for mass transplanting is not an option at this time. Mass transplanting is limited to level ground conversion with a significant ground preparation required prior to planting. Mass transplanting on contoured fields has not yet been demonstrated.

Cost

A coarse cost comparison of the mass transplanting technique to conventional tree planting with a tractor-pulled tree planter was conducted (Table 1). The comparison is based on the cost of collecting, propagating, and planting native trees at other LCR MSCP restoration sites. Mass transplanting indicates a significant decrease in cost for planting trees over conventional tree planting. Row width and spacing can be decreased with mass transplanting, creating dense habitat conditions. A time shown in Table 2 reveals the efficiency of mass transplanting when compared to the other method.

Table 1. Cost comparison: mass transplanting and conventional planting techniques.

LCR MSCP Project	Cost of: 1 gallon tree (G) 64 cell planting(P)	Spacing	Labor (L) per tree, Tractor (T), Mass transplanter (MP)	Total cost per tree planted
Beal Lake Riparian-2005	$2.50 (G) cottonwood/willow	5 feet on center (1743 per acre)	$1.29 (L,T)	$3.79
Palo Verde Ecological Reserve: Phase 2-2007	$2.75 (G) mesquite	20 feet on center (109 per acre)	$1.09 (L)	$3.84
Mass Transplanting Demonstration-2005, 2006	$1.40 (P) cottonwood/willow	1-6 feet in line, 38-inch rows (13,560-2260 per acre)	$0.37 (MP)	$1.77

Table 2: Time comparison: mass transplanting, conventional tree planting technique.

Project	Number of trees planted	Planting technique	Planting Time
Beal Lake Riparian	6,740	Tractor	5 days
Palo Verde Ecological Reserve Nursery 2006	600	Hand Planting	7 hours
Mass Transplanting Demonstration 2005, 2006	85,000	Mass Transplanting	1.5 days

Summary

The mass transplanting effort demonstrated a practical method of planting large numbers of riparian trees in a short period of time. Both contractors achieved the goal of successfully demonstrating that the commercially available mass transplanting technique could be used on native cottonwood and willow. Therefore, we anticipate the mass transplanting technique will be used, where appropriate, in the future for land cover establishment and ultimately habitat credit.

In reviewing the lessons learned, it is important to note that the level of plant dormancy during collection, climate control of plants in the greenhouse, level of field preparation, and temperature during the planting period can significantly alter the survivability of mass transplanted trees.

Although the demonstration of mass transplanting technique has been completed, the trees will be maintained for a period of 5 years through an agreement with Cibola NWR, after which time a decision will be made to either include the land cover into the LCR MSCP and manage the site as habitat or end the LCR MSCP involvement. General observation will be noted during that period.

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