

New Arid Land Revegetation Techniques at Joshua Tree National Monument

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Abstract—Joshua Tree National Monument's nursery created methods for using native desert vegetation on disturbed areas in the desert southwest; most notable is our "tall pot", a 30 inch tall PVC pipe that allows deep tap root development. We continue to research other methods of arid land restoration. Although direct seeding shows little success in the desert, a site preparation method called imprinting improves success of direct seeding. Another modification to existing technology is Joshua Tree's use of containers smaller than our tall pot. Being lighter and more economical to grow and plant, these containers offer benefits for use in remote areas, such as abandoned mine sites.

Joshua Tree National Monument conceived its native plants nursery and revegetation program to mitigate impacts to the park's vegetation systems from historic and current activities. The nursery grows over 80 species of desert plants, used along roadsides following road improvements, on closed dirt roads and jeep trails, abandoned mine sites, as well as for facilities landscaping, and historic plant restoration. Joshua Tree's work has attracted the attention of a number of outside agencies and we have entered into cooperative work with a number of these: Death Valley National Monument, Lake Mead National Recreation Area, Anza-Borrego Desert State Park (plants for landscaping, roadside work, and mitigating off-highway vehicle damage), the USDA Forest Service and the U.S. Bureau of Mines (growing plants for mine restoration projects), and the USDA Soil Conservation Service (species ecotype and direct seeding trials).

Through our work and contact with others we have collected information on the restoration of vegetation in deserts. To this end, in cooperation with UNESCO's Man and the Biosphere Program we created the Center for Arid Lands Restoration, a clearinghouse for information and consultation on desert revegetation.

Joshua Tree has developed methods and materials well suited to successful propagation and planting of desert plants. However, these methods are not always economically or logistically feasible and we have researched new techniques for our work. For instance, larger disturbed areas requiring restoration may become expensive to plant.

Direct seeding is an economical means of reestablishing vegetation, but has proven ineffective in deserts due to the harsh environment. Smaller nursery material is more economical for larger sites, but rarely hardy enough to survive the harsh environment. Joshua Tree has used variations on these methods which may prove successful for the desert.

Imprinting

The desert does not afford a favorable environment for the establishment of vegetation. The climate is harsh—high winds, extremes in temperature and sparse rainfall hamper seedling survival. Disturbance in desert areas compound these conditions. In many cases, the thin top organic layer of soil containing seeds and protective cryptobiotic organisms has been stripped away. Soil compaction is also a problem: a sealed interface between the air and soil impedes water infiltration and causes surface run-off and erosion.

While there is little restorationists can do about the desert climate (save irrigation), one strategy for restoration is proper site preparation. Ripping is often used to break up soil compaction; however, rainfall can quickly recompact soil and reseal the surface. A method of site preparation that has shown success in the desert is imprinting, which roughens a smooth, closed soil surface. The benefits include providing favorable microsites for seed establishment and concentrating scarce site resources, namely water and organic matter. This process was developed by Robert Dixon following applied research at the USDA's Agricultural Research Service in Tucson, AZ, and has continued with Dixon's Tucson-based Imprinting Foundation.

Imprinting forces depressions into the soil surface. The depressions are wedge, cone, or pyramid shaped, made by hand or foot-attached implements or specially designed tractor-towed rollers. By their shape, the imprints can infiltrate rainwater rapidly and funnel limited seed, topsoil and finely-divided plant litter to a common point or line at the bottom the depressions. This helps germinate seeds and establish seedlings with a minimal amount of rainfall. Thus, compacted soil is roughened, opened, mulched, and stabilized (Dixon, 1989).

Results have been favorable on grasslands and shrub lands of the Sonoran and Chihuahuan deserts and in the sagebrush-bunchgrass areas of the Great Basin desert. Imprinting has proven superior to other methods, especially where low precipitation is the main limiting factor to seedling establishment. The process has not been used to a great extent in the Mojave desert.

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We wanted to test the effectiveness of imprinting as a means of site restoration. If successful, it could prove more economical for revegetation on larger disturbed areas than using nursery grown plants. We chose three disturbed sites within Joshua Tree National Monument: an inactive borrow pit near the park's west entrance, a section of closed dirt road (both in the Mojave desert), and a second inactive borrow pit in the Mojave/Colorado desert interface.

We devised four treatments; half the treatment areas were ripped, the other half ripped and imprinted. Treatments included sowing with native seed (seed sown by hand at approx. 6 lbs./acre); sowing with a sterile wheat as a cover crop (Yecora Rojo Wheat, 99.0% sterile, sown at 40 lbs./acre); sowing native seed and sterile wheat together (sown at 6 lbs./acre and 20 lbs./acre, respectively); and no seed or wheat. The National Park Service Denver Service Center advised us on the seeding rate for the wheat cover crop; the amount of native seed sown was dictated by the amount collected and available for sowing. Treatment plots measured 6 x 12 feet; our response variable is the germination and survival of native seedlings on each plot.

We collected the native seed within the monument during summer 1992. These were collected, dried, cleaned, weighed, and stored in refrigeration until needed for the project. We used the following species: needle grass (*Achnatherum speciosum*), burrobush (*Ambrosia dumosa*), coyote melon (*Cucurbita palmata*), jimson weed (*Datura meteloides*), brittlebush (*Encelia farinosa*), goldenbush (*Ericameria* spp.), cheesebush (*Hymenoclea salsola*), bladderpod (*Isomeris arborea*), white ratany (*Krameria grayi*), creosote bush (*Larrea tridentata*), galleta grass (*Pleuraphis rigida*), paperbag bush (*Salazaria mexicana*), chia (*Salvia columbariae*), desert senna (*Senna armata*), jojoba (*Simmondsia chinensis*), globe mallow (*Sphaeralcea ambigua*), and desert aster (*Xylorhiza tortifolia*) (Jepson, 1993).

We imprinted in January 1993; Robert Dixon supplied the imprinter, and was also on hand during the imprinting process. Before imprinting, Joshua Tree's Maintenance Division used a road grader to rip the soil on all sites to break up and decompact the soil and make the surface amenable for holding the imprints. The teeth on the grader penetrated to approximately 18 inches. We seeded each plot by hand, then towed the imprinter roller over the plots. The imprints depressed the soil approximately 4-6 inches.

Following the imprinting treatment, normal winter rainfall was lower than average, and we have seen little germination of the native species. We plan to monitor the plots in spring 1994 following the winter rains to assess germination and growth for each treatment, and will continue to monitor for a number of years.

Recommendations from Dixon and Wendell Hassell (National Park Service, Denver Service Center) for the use of imprinting in the Mojave include slight variations on the original process. Dixon states the three factors that affect imprinting in any environment are good seeds, good rains, and good imprints.

A good mix of both annuals and perennials is thought to be the best for returning the range of natives to a site.

Native plants are best adapted to local site conditions; the National Park Service requires use of locally collected propagules and genetic material. Of course, viable seed is required for best germination. Dixon and Hassell state a sterile cover crop provides cover for newly emerging seedlings, acts as mulch, increases soil organic matter, and improves soil aggregation. A sterile or non-returning species reduces competition for resources with native seedlings. Another tactic is sowing the cover crop the first year, waiting for at least 70% mortality, then sowing native seeds the second year.

Imprinting is best done in the fall, or just after the first rain: damp soil will hold imprints better, and sown seed can take advantage of the remainder of the season's precipitation. This is especially important in the Mojave where most precipitation falls in the winter months, unlike the regular summer and winter precipitation in the Sonoran desert.

For good imprints, Dixon recommends using the imprinter on lighter (sandier) soils. On heavier (clayey) soils, there may be a need to weight the imprinter, or wait for right soil moisture. Clayey soils may also have a tendency to stick to the roller, pulling up the top soil layer. Ripping or disking first may be beneficial on heavier soils. Besides being more economical than planting on larger disturbed areas, imprinting may also be more successful because of the reduced edge effect. Adjacent undisturbed perimeter provides cover for herbivores, who prefer to browse close to protection. Hence, the larger a disturbed area, the smaller the perimeter to area ratio. Newly emerging seedlings, highly palatable to herbivores, may be safer because of the distance from cover. Dixon also counsels patience when waiting for results; a few seasons may be required until all conditions to be right for germination.

Experimental Containers

Joshua Tree's native plants nursery has provided containerized plant material for roadside revegetation projects since 1988. We developed the containers specifically for growing native desert plants. These plants must survive the rigors of the Mojave desert life (extreme air and soil temperatures and low average rainfall) virtually unassisted, and indeed they have. Our "tall pot" is a PVC cylinder 6 inches in diameter, 30 inches deep, and weighs about 40 lbs. when filled. In our largest revegetation project to date, we planted 1509 plants in early spring of 1990, 1991 and 1992. As of spring 1993, our monitoring showed 77% planting survival. Just to be alive in that environment is deemed successful; however, a large percentage of nursery stock had already set flowers and fruit within the first year in the field.

Revegetation techniques developed by Joshua Tree may prove troublesome to restorationists not working on a roadside. Not only are our tall pots difficult to transport to remote sites, but a power auger is necessary to drill the planting holes. Finally, plants grown in this manner are fairly expensive (\$10 to \$12 each) and larger projects may not be cost effective.

In the summer of 1992 the U.S. Bureau of Mines came to us with a proposal to revegetate an abandoned mine site within our park boundaries. This project afforded us the chance to try to answer two questions: were containerized plants able to survive on such heavily disturbed arid sites; and what kinds of results could we get from pots of smaller size and varying designs? We chose the Silver Bell Mine as project location, an abandoned silver mine 22 miles south of the town of Twentynine Palms, .6 miles by air from the nearest paved road and more than 3/4 mile overland with a moderately difficult climb to the mine. Smaller, lighter containers were called for but how small could we go and still ensure survival in the harsh environment?

A few years earlier the nursery grew desert plants in 10 cubic inch super cells for a cooperator; we felt these containers were too small for desert planting. We also propagated plants for the University of California at Riverside using Stuewe & Sons "Tall One" citrus pots (4 inches x 4 inches x 14 inches tall). The university reported these plants grew successfully in their experimental plots. In 1991 we tested three different plant species in 36 citrus pots planted in conjunction with our regular roadside revegetation. When monitored in 1992 we found 76% survival. In May 1993, after three months of very low precipitation, we planted 60 citrus pots containing nine species in another small test plot. The summer continued with little or no rainfall. When we returned to the site in mid-September, we found 52 of the 60 plants were alive and in various stages of vigor. Because of the positive results of those two trials, we chose this as the smallest container size to use for the mine revegetation project.

Looking for a container size between the citrus pot and our PVC tall pot, we selected another Stuewe & Sons pot, the "Treepot" (5½ inches square at the top x 7¾ inches square at the base x 18 inches tall). We made changes to both the citrus pot and the treepot to facilitate the way we plant containerized stock. When using the PVC tall pot we snip the bailing wire at the bottom of the pot, pull off the hardware cloth circle that holds the soil in place, place the pot in the augered hole and pull the pot up and over the plant, back-filling and watering as the pot is removed. With this method there is no disturbance to the plants root-ball. The Stuewe & Sons pots are wider at the top than the bottom; in order to pull the pot over the plant, we invert it. We make the wide top the new bottom, and install hardware cloth and bailing wire which holds the soil in place.

We created a third pot size when we ran out of hardware cloth for the bases of the treepots. We had pre-cut pot bottoms to fit our 6 inch diameter tall pots. We cut tall pots in half enabling us to use the pre-cut wire circles in a shorter container, the "half-tall" pot (6 inches in diameter x 15 inches tall).

Once we established container sizes we began propagating the plants. When using the tall pot for revegetation, germinated seed is first planted into a rolled newspaper cylinder (the paper pot) and grown for 12-14 weeks. Once roots appear at the bottom of the cylinder we transplant the seedling into the tall pot where it continues growing for another 9-12 months. The treepot and the half-tall pot

seedlings require the intermediate paper pot stage but total growing time is shortened by 6 or 7 months. The citrus pot is too small for a paper pot transplant so germinated seed is planted directly into the container. The citrus pot seedling is treated the same as the paper pot for the first two weeks but many labor hours have been eliminated by avoiding a transplant stage. The citrus pot seedling is ready for planting in less than 4 months.

The smaller containers weigh less than tall pots. A mature plant in a tall pot can weigh 40 lbs. as mentioned earlier. The ready-to-plant smaller containers weigh as follows: the treepot, 23 lbs.; the half-tall pot, 18 lbs.; and the citrus pot, 7 lbs. We appreciated the reduced weight each time we lifted a pot and when we transported the pots to the mine site. Lastly, the shorter the pot, the shallower the planting hole. The workers running the auger attest to the benefit of digging 15 inches or less in the mine's rocky substrate, rather than 30 inches or more.

In February 1994 we began the Silver Bell Mine revegetation project. A helicopter transported the plants, the auger and other planting tools, wire and rebar for caging, a portable water tank, and 1,500 gallons of water to the mine site. The reduced weight of the smaller containers allowed the helicopter to carry more pots per trip, considerably reducing air time.

The rocky substrate of the mine's 7,500 square feet of benches and tailings created difficult planting conditions. Rocks (up to melon-sized) frequently stopped the auger from digging to the prescribed depth and often the hole could not be dug at all. The crew then used hand trowels to dig the holes on the tailings slopes. If these problems weren't enough, the plants may have a difficult time getting established due to extremely fine soil particles coupled with the rocks. The combination of these results in air pockets that dry roots, a major inhibitor of plant survival.

The shallow soil depth hampered planting of all but the citrus pots. A lip around the top (now bottom) of the treepots hindered slipping the pot up around the plants. Despite the problems and difficult conditions, the planting crew planted 382 plants of 24 different species on the site in 74 treepots, 77 half-tall pots, and 231 citrus pots. We will continue to monitor plant survival and growth at the Silver Bell Mine site.

References

- Dixon, R. M. 1989. Air-Earth Interface Model for Ecosystem Restoration and Maintenance. Proceedings from First Annual Meeting, Society for Ecological Restoration, University of Wisconsin Arboretum, Madison, WI.
- Dixon, Robert. The Imprinting Foundation, 1231 East Big Rock Road, Tucson, AZ 85718.
- Hassell, Wendell. Soil Conservation Service, National Park Service Denver Service Center, PO Box 25287, Denver, CO 80225-0287.
- The Jepson Manual, Higher Plants of California (1993). James Hickman, ed. University of California Press, Berkeley, CA.