



Best Management Practices

Restoring Perennial Plants

Sites denuded of perennial plants have exhibited limited use by desert tortoises. Native perennial plants are critical to healthy desert tortoise habitat for at least three reasons. First, desert tortoises heavily use shrubs for cover and to construct burrows beneath. Second, certain species of perennials (such as herbaceous forbs) are forage preferred by desert tortoises, even when annual plants are available. Third, perennials provide key functions for ecosystem functioning, such as facilitating recruitment of native annual plants as desert tortoise forage.

Best-management practices for restoring or augmenting perennial plants in desert tortoise habitat include:

- **Consider variability in effectiveness of seeding or outplanting nursery-grown plants, which are the two main methods for establishing perennial plants.** Effectiveness of seeding perennial species has been inconsistent in the Mojave Desert, even during periods of relatively abundant rainfall. Intensive seed predation by mammals and invertebrates, combined with herbivory on seedlings and infrequent environmental conditions suitable for plant establishment, reduce effectiveness.
- **Treatments such as seed pelleting have potential but should be considered experimental.** Seed pelleting – enclosing seeds in coatings of clay or other materials – has both increased and decreased plant establishment. Type of material used for coating seeds may influence effectiveness. Responsiveness to pelleting might be species-specific, based on a species’ seed size and germination ecology. As a result, pelleting and other treatments (such as seeding onto mulched soil surfaces) aimed at increasing seeding effectiveness should be considered as having potential, but experimental, given uncertain success.
- **If high risk of failure is unacceptable, then outplanting should be used.** Many perennial species have had > 50% survival through outplanting. Outplanting can be criticized for not covering large areas compared to seeding. But even if a million acres are seeded, the area revegetated is still zero if seeding fails.
- **Strategic planting arrangements have potential for stimulating recovery across broad areas.** Using good planting stock and effective plant care at field sites can result in rapid growth of outplants, flowering, and seed production within three years (Fig. 1). Consider clumped planting arrangements to create islands of native vegetation that may help encourage recruitment of other plants across an area larger than which was planted.
- **Species selection is critical.** Shrubs have generally performed well during outplanting. Creosote bush, Nevada jointfir, and other perennials that tortoises use for cover have become established in several projects (Table 1). Performance of perennial forbs and grasses is highly variable. Until further research refines which species are most amenable to outplanting, hedging bets by using diverse plantings (> 5 species) is a conservative strategy.

Table 1. Examples of best-performing species through outplanting in the Mojave Desert.

Common name	Scientific name	Total no. studies	No. studies \geq 50% survival
White bursage	<i>Ambrosia dumosa</i>	10	5
Fourwing saltbush	<i>Atriplex canescens</i>	5	4
Nevada jointfir	<i>Ephedra nevadensis</i>	3	3
Creosote bush	<i>Larrea tridentata</i>	8	5
Anderson thornscrub	<i>Lycium andersonii</i>	3	2

- **Using good planting stock is critical.** Lead times of at least 6-12 months are required for container-grown plants to develop good root systems under nursery care. Plants already in poor health leaving nurseries likely have reduced chance of survival when outplanted at restoration sites.
- **Effective plant care at field sites can be essential to avoid failure.** The most important plant care for most species is protection from relentless herbivory at planting sites by numerous animals. Wire cages, plastic shelters, and other materials can protect plants (Fig. 1). Without protection from small and large herbivores, losses of outplants are typically rapid and heavy.



Fig. 1. Left: flowering desert marigold and other perennials protected by mesh cages at a restoration site within desert tortoise habitat at Lake Mead National Recreation Area. Right: two-year-old creosote bush outplanted with a plastic shelter on the Goodsprings burn, southern Nevada. Photos by S.R. Abella.

- **Benefits of irrigating outplants is species-specific.** Some species, like cacti, do not necessarily benefit from irrigation at restoration sites. Other species do show increases in survival. Application of surface water (e.g., by hand or through drip irrigation) or Driwater (a slow-release gel) are two methods for delivering water to outplants. Some examples of species that benefitted from one type or another of irrigation in eastern Mojave Desert tortoise habitat are in Abella et al. (2015).
- **Fertilizing outplants is generally not recommended but removing non-native annuals may be.** The disadvantages of fertilizing (e.g., cost, increasing habitat invasibility by non-native plants) likely outweigh benefits at many project sites. Non-native annuals can compete with native perennials, but evidence is mixed for whether treating non-native annuals (such as via herbicide) increases outplant survival. If non-native fuels are so abundant that risk of fire threatens the restoration site, treating non-natives may be important.
- **Planting on restored soil – such as salvaged topsoil – can enhance survival.** By retaining moisture, nutrients, and soil microorganisms, salvaged topsoil can be among the most effective treatments (along with protection from herbivory) for enhancing outplanting success.

Example References and Further Reading

Abella, S.R., and A.C. Newton. 2009. A systematic review of species performance and treatment effectiveness for revegetation in the Mojave Desert, USA. Pp. 45-74 in Fernandez-Bernal, A., and

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