CALIFORNIA FIRE SCIENCE CONSORTIUM

JOINT FIRE SCIENCE PROGRAM

Research Brief for Resource Managers

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Status of Knowledge Synthesis for Desert Habitat Restoration and Post-Fire Rehabilitation

Abella, S.R., K.H. Berry, and S. Ferrazzano. 2023. Techniques for restoring damaged Mojave and western Sonoran habitats, including those for threatened desert tortoises and Joshua trees. Desert Plants 38:4-52.

Supported by the Clark County (Nevada) Desert Conservation Program and the California Fire Science Consortium, we completed a status of knowledge synthesis of restoration practices aimed at enhancing recovery of damaged habitats in the Mojave and western Sonoran Desert, some of the driest locations in North America.

The synthesis was organized around improving habitat of the iconic and threatened desert tortoise and Joshua tree, and the broader ecosystem in which they occur. To be effective, restoration actions deployed strategically need to halt and reverse habitat degradation, replenish or enhance resources used by both species (e.g., large shrubs for protection of tortoises and nurse plants facilitating recruitment of Joshua tree seedlings), and ideally foster resilience during likely future environmental changes.

We synthesized restoration techniques and their effectiveness in the Mojave and western Sonoran Desert, provided estimated costs of candidate techniques, and anticipated future research needs for effective restoration in changing climates and environments. Over 50 published studies in the Mojave and western Sonoran Desert demonstrate that restoration can improve soil features (e.g., biocrusts), increase cover of native perennial and annual plants, enhance native seed retention and seed banks, and reduce risk of fires to conserve mature shrubland habitat.

Management Implications

- Over 50 published studies in the Mojave and western Sonoran Desert demonstrate that restoration can improve soil features, increase cover of native plants, and reduce risk of wildfires to conserve mature shrubland habitat.
- Bet-hedging techniques to manage risk of project failure and use of abiotic restoration techniques may become increasingly important in future climates.

Creosote bush, enclosed in a shelter, outplanted on a desert wildfire site. Here, the creosote grew out of the shelter and flowered within 3 years. Photo by S.R. Abella.

We placed restoration techniques into three categories: restoration of site environments, revegetation, and management actions to limit further disturbance and encourage recovery. Within these categories, 11 major restoration

techniques (and their variations) were evaluated by at least one published study and range from geomorphic (e.g., reestablishing natural topographic patterns) and abiotic structural treatments (e.g., vertical mulching) to active revegetation (e.g., outplanting, seeding).

For example, 16 outplanting studies assessed performance of 46 species to begin identifying top-performing species, associated treatments (e.g., protection from herbivory) required to aid outplant survival, and potential for outplants to trigger formation of self-sustaining populations. Creosote bush (*Larrea tridentata*), a shrub that tortoises use for cover and that serves as a nurse plant for Joshua tree recruitment, achieved at least 50% survival in five of eight studies.

Estimated costs for restoring desert habitats varied primarily with the severity of the disturbance, site factors including the diversity of vegetation that was lost, logistical factors such as accessibility of sites (influencing transportation costs), and the cost-effectiveness of the restoration techniques chosen.

The synthesis highlights six major research and adaptive management needs for advancing desert habitat restoration. These needs include: 1) continued development of innovative techniques and bet-hedging approaches to provide managers with "tool boxes" of candidate treatments to deploy in dynamic environmental and management conditions, 2) identifying how to optimize spatial deployment of limited restoration resources, 3) developing practical techniques for reducing non-native annual grasses across spatial scales, 4) improving linkages between habitat enhancements and short- and long-term indicators of tortoise usage and responses and Joshua tree population sustainability, 5) mitigating multiple, interacting stressors with cumulative impacts, and 6) integrating biotic (e.g., seeding) and abiotic (e.g., fencing, shade structures) treatments to complement each other at site and landscape scales in dynamic climates and environments.

Bet-hedging approaches employing multiple treatment types (or phased treatments across years) and greater incorporation of abiotic treatments, which are less sensitive to timing of precipitation compared with biotic treatments, may become increasingly important under future climates projected to be drier and more variable. Existing research suggests that restoration can be deployed effectively even under adverse climatic conditions, but success requires identifying techniques tailored to dynamic environments.

Disturbed, unrestored (left side) and disturbed, restored (right side) paired locations within Lake Mead National Recreation Area, southern Nevada. The restoration treatment here included applying an artificial desert varnish to rocks for color restoration to blend the disturbance into the landscape and outplanting of desert perennials. Photo by S.R. Abella.

Topsoil salvage and re-application treatment, shown to the right of the gray line. Topsoil application was one of the most effective treatments.

Suggestions for further reading:

Chiquoine, L.P., J.L. Greenwood, S.R. Abella, and J.F. Weigand. 2022. Nurse rocks as a minimum-input restoration technique for the cactus *Opuntia basilaris*. Ecological Restoration 40:53-63.