

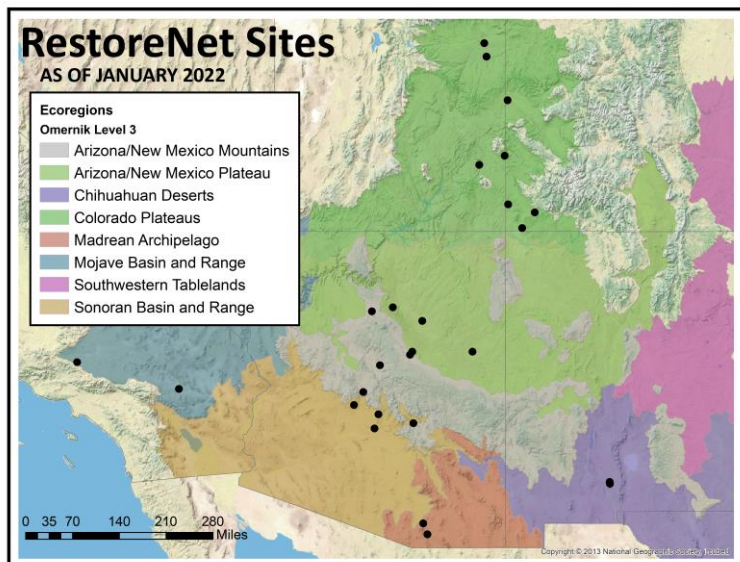
RestoreNet: Distributed Field Trial Network for Dryland Restoration

Starting in 2017, U.S. Geological Survey (USGS) researchers and land managers co-produced a network of restoration field trial sites on Department of the Interior (DOI) and surrounding lands in the southwestern U.S. The network systematically tests restoration treatments across a broad range of landscape, soil, and climate conditions. Each site in the network is used to test suitable seed mixes and treatments that promote plant establishment and growth.

The treatments include ground modifications (e.g. soil amendments, physical alterations, mulching), seeding vs. outplanting seedlings from a greenhouse, timing of planting, herbicide treatments to suppress invasive species, and others. Participation in RestoreNet contributes to a growing body of knowledge on cutting edge ecological restoration methods for use in the southwestern United States to benefit land managers, landowners, and restoration practitioners.



Left: Diverse plants growing in a ConMod treatment in the Sonoran Desert. Right: In 2022, we piloted RestoreNet V2.0 testing soil inoculation from undegraded reference sites, seed balls (white balls in photo), and pitting treatments (small indentions). Soil inoculation with healthy soils is expected to increase beneficial microbes at the degraded restoration site. Soil microbes can help reduce water stress in plants. Credit: Molly McCormick and Hannah Farrell, USGS



Current RestoreNet locations spanning dryland regions of the Southwest. We work with diverse partners to improve the condition of the land in the face of a changing climate.

Current RestoreNet Partners:



Benefits to land managers:

- 1. Knowledge Co-production:** Ecologists and land managers work together to decide which treatments to test, interpret results, and explore new ideas.
- 2. Demonstration Sites:** Locations are used to show clear proof of concept and generate important conversations about ecosystem restoration.
- 3. Low-Risk:** Small test plots reduce cost and build understanding that later supports larger-scale projects.

Join the network by using the RestoreNet Protocol

The RestoreNet protocol guides new partners on how to set up a RestoreNet site to expand the network. The protocol contains information for site selection, materials acquisition, experiment installation, data collection and monitoring, and data curation. The protocol includes an optional experiment using container plants initially propagated in a greenhouse.

Find it at www.usgs.gov/sbsc/restorennet

What are we learning?

The seeding experiment paired two different native seed mixes along with soil-surface treatments of pitting (small depressions, see photo on page 1), ConMods (artificial nurse plants, see photo on page 1), and wood mulch. The ‘local’ seed mix contained native species adapted to current site climate and the ‘warm adapted’ mix contained native species more adapted to hotter and drier conditions expected under climate change.

RESULTS ACROSS THE COLORADO PLATEAU¹

How did seeds respond to treatments on the Colorado Plateau?

- Timing of precipitation and soil-surface treatments promoted seeded species recruitment.
- Pit and mulch treatments increased seedling density.
- Pits improved native seed germination the most while also limiting non-native species.
- Germination increased if it was followed by suitable precipitation windows in the weeks after sowing.

Which seed mix performed better on the Colorado Plateau?

Seeded plots contained more seedlings than control plots. The ‘local’ seed mix had higher germination success than the ‘warm adapted’ seed mix, which could be explained by cooler and wetter than average conditions at sites over the course of the experiment.

Key Messages

- The pit treatment increased germination the most.
- Consider creating or utilizing areas rich in micro-topography (to perhaps mimic pits) that work to capture sheet flow and increase soil moisture.
- Consider seeding many species that span adaptations to both cool and warm conditions.

Additional Results

- Traits of seedlings shift during development, which affects restoration success³.
- Different plant traits promote survival along a temperature and aridity gradient on the Colorado Plateau.⁴
- Functional composition of restored plant communities drives and interacts with biomass production to influence indicators of soil functioning and weed suppression.⁵
- No changes in the soil microbiome 1-year after installation of the restoration plantings compared to a nearby reference site.⁶

Recent RestoreNet Publications

- 1: Havrilla, C.A., Munson, S.M., McCormick, M.L., Laushman, K.M., Balazs, K.R. and Butterfield, B.J., 2020. RestoreNet: An emerging restoration network reveals controls on seeding success across dryland ecosystems. *Journal of Applied Ecology* 57: 2191-2202.
- 2: Farrell, H.L., Munson, S.M., Butterfield, B.J., Duniway, M.C., Faist, A.M., Gornish, E.S., Havrilla, C.A., Larios, L., Reed, S.C., Rowe, H.I., Laushman, K.M., McCormick M.L., 2023, Soil surface treatments and precipitation timing determine seedling development across southwestern US restoration sites. *Ecological Applications*, DOI: 10.1002/eap.2834
- 3: Havrilla, C.,A., Munson, S.M., Yackulic, E.O., Butterfield, B.J., 2021, Ontogenetic trait shifts: Seedlings display high trait variability during early stages of development, *Functional Ecology* 35: 2409-2423
- 4: Balazs, K.R., Munson, S.M., Havrilla, C.A. and Butterfield, B.J., 2022. Directional selection shifts trait distributions of planted species in dryland restoration. *Journal of Ecology*, 110: 540-552.
- 5: Balazs, K.R., Munson, S.M. and Butterfield, B.J. 2022. Functional composition of plant communities mediates biomass effects on ecosystem service recovery across an experimental dryland restoration network. *Functional Ecology* 36: 2317-2330.
- 6: Yang, B., Balazs, K.R., Butterfield, B.J., Laushman, K.M., Munson, S.M., Gornish, E.S., and Barberán, A., 2022, Does restoration of plant diversity trigger concomitant soil microbiome changes in dryland ecosystems?: *Journal of Applied Ecology* 59: 560-573.

RESULTS ACROSS THE SOUTHWEST²

How did treatments work across the Network?

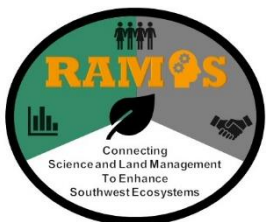
- Timing of precipitation and soil-surface treatments promoted seeded species emergence, survival, and growth.
- Three times more seedlings emerged with the use of treatments compared to seeding alone.
- The positive effect of treatments became more prominent with increasing cumulative precipitation since seeding.

Which seed mix performed better across RestoreNet?

The ‘local’ seed mix performed better than the ‘warm adapted’ seed mix.

Key Messages

- Treatments improved seeding success, but these effects became diminished over time.
- Exotic species had little effect on native species emergence but impacted seedling survival and growth.
- Consider using near-term seasonal climate forecasts and align seeding with precipitation.
- Consider seeding at multiple times to catch a favorable weather window.



RestoreNet is a project of the Restoration Assessment and Monitoring Program for the Southwest. RAMPS is located at the Southwest Biological Science Center.

For more information & a list of publications:

Website: <https://usgs.gov/sbsc/restorenet>

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