

RestoreNet: Distributed Field Trial Network for Dryland Restoration

What is RestoreNet?

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. RestoreNet 1.0 (2018-22) treatments included soil-surface treatments (pitting, ConMods, and wood mulch), seeding vs. outplanting seedlings from a greenhouse, and altering timing of planting. RestoreNet 2.0 (2022-present) treatments include pitting, seedballs, soil inoculation to potentially increase beneficial microbes with soil from intact reference sites, and targeted flash grazing. Participation in RestoreNet contributes to a growing body of knowledge on cutting edge ecological restoration methods for use in the southwestern U.S. to benefit land managers, landowners, and restoration practitioners.

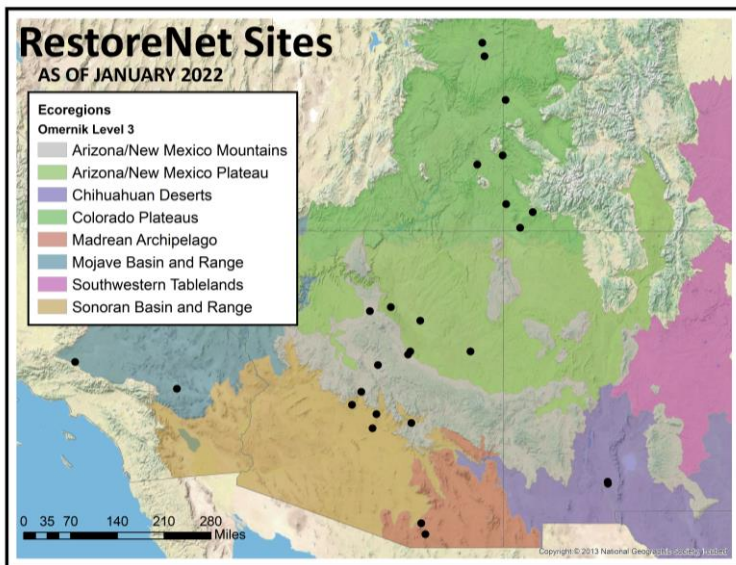


Fig 1 (Above). Current RestoreNet locations spanning dryland regions of the Southwest. We work with diverse partners to improve the condition of the land in the face of a changing climate. Results referring to the ‘Colorado Plateau’ include the Colorado Plateaus, Arizona/New Mexico Plateau, and Arizona/New Mexico Mountains Ecoregions.

Fig 2 (Right). Left: Diverse plants growing in a ConMod in the Sonoran Desert in RestoreNet 1.0. Right: Pitting and seedball (white balls in photo) treatments in RestoreNet 2.0. Credit: Molly McCormick and Hannah Farrell, USGS.

What did we learn from RestoreNet 1.0?

The seeding trial paired two native seed mixes with soil-surface treatments of pitting (small depressions, Fig 2), ConMods (artificial nurse plants, Fig 2), and wood mulch. The ‘local/cool’ seed mix contained species adapted to the historic site climate and the ‘warm’ mix contained species more adapted to hotter and drier conditions expected under climate change. The outplant trial involved growing seeds in a greenhouse, then planting them as seedlings in the field, at a subset of RestoreNet sites on the Colorado Plateau.

Seeding trial results:

- Up to three times more seedlings emerged with the use of treatments compared to seeding alone.¹
- Pits and mulch increased soil moisture and seedling density¹, and pits limited non-native species on the Colorado Plateau.²
- The positive effect of treatments became more prominent with increasing cumulative precipitation since seeding.¹
- The ‘local/cool’ seed mix performed better than the ‘warm’ seed mix.^{1,2}

Outplant trial results:

- Different plant traits promoted survival along a temperature and aridity gradient on the Colorado Plateau.³
- Outplant survival was lowest and trait variation was restricted at the most arid sites.³
- No changes in the soil microbiome 1-year after installation of the restoration outplants compared to an unplanted site.⁴

Key Messages

- Consider creating or utilizing areas rich in micro-topography (to mimic pits) to increase soil moisture.
- Consider seeding many species that span adaptations to both cool and warm conditions.
- Consider using near-term seasonal climate forecasts and seeding multiple times to align seeding with precipitation.
- Matching plant traits to environmental and ecological site conditions may improve outplant outcomes.



Expanding RestoreNet in New Mexico

Who: USGS and New Mexico BLM (NM BLM) would like to partner to install a series of RestoreNet sites in New Mexico to address state-specific restoration questions.

Where: RestoreNet sites will be located in ecoregions that have native plant materials produced for them and have high restoration needs; specifically, the Arizona/New Mexico Plateau and Chihuahuan Deserts Ecoregions.

What kind of seeds: The seed mix may include species that have been increased by NM BLM for restoration, and commercially available seeds and/or cultivars for comparison.

What treatments: Treatments are to be determined, and will include methods to increase seeding success and ecosystem health. These may include soil pitting (shown to increase seeded-species emergence and soil moisture while limiting exotic species), soil imprinting (similar to pitting but easier to apply at a larger-scale), mulching, seeding at different times of year (i.e. fall vs. pre-monsoon).

Proposed contributions of NM BLM: We propose to jointly identify up to 5 areas for potential RestoreNet sites on NM BLM land, establish clearance for these sites, and install exterior fencing. Criteria for potential RestoreNet sites will be made available, and include a degraded area in need of restoration that is able to support native plants and has relatively intact soils, a flat surface with room for about 50x50 m. USGS can lead experimental design, installation, and data analysis for experiments.

How will RestoreNet potentially benefit NM BLM:

- 1. Restoration Guidance:** RestoreNet sites can produce site-specific and ecoregion- or state-wide actionable science and best management practices for reclamation, revegetation, and restoration.
- 2. Knowledge Co-production:** Ecologists and land managers work together to decide which treatments to test, interpret results, and explore new ideas.
- 3. Demonstration Sites:** RestoreNet sites are used to show clear proof of concept and generate important conversations about ecosystem restoration.
- 4. Low-Risk:** Small test plots reduce cost and build understanding that later supports larger-scale projects.

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: 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.
- 4: 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.

Current RestoreNet Partners:



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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