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Estimated Dryland Restoration Treatment Costs

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Introduction

Ecological restoration—the process of assisting in the rehabilitation of a system that has been degraded or destroyed—can be used to address changing landscapes as our understanding of ecosystems and how to manage them improves (Gann et al. 2019). As a result, numerous research papers and guidebooks have been published to provide science-based recommendations for designing and deploying restoration projects, particularly in dryland systems. Despite these advances, many of these resources lack a range of cost estimates for restoration treatments (but refer to Kimball et al. 2015, Copeland et al. 2018, and Meldrum et al. 2025 for broad overviews). Restoration costs can vary widely based on treatment type, location deployed, level of degradation, and specific goals (e.g., Birch et al. 2010). Cost estimates could be used to inform development of site-specific management plans that are logistically and financially feasible.

Here, we provide an overview of the estimated range of costs that could be associated with several manual dryland restoration treatments that aim to increase seeding success and soil health. We applied these treatments via RestoreNet—a collaborative network led by the U.S. Geological Survey that tests restoration treatments in collaboration with land managers, landowners, and rightsholders across the southwestern United States (Havrilla et al. 2020). Using actual material costs and labor requirements of RestoreNet partner treatments conducted at a small experimental scale (80 one-meter-squared plots at five sites), we scaled up these estimates to a larger management-relevant scale (estimated cost and time per acre; Table 1, Fig. 1). These scaled projections may overestimate labor costs, as costs per acre tend to decline as spatial scale increases (Meldrum et al. 2025). We provide options that could potentially reduce treatment costs by using more cost-effective materials and mechanizing manual treatments to reduce labor costs (e.g., using bulk materials or heavy machinery instead of applying treatments by hand, described under each treatment below and summarized in Table 1). Estimated costs are in 2024–2026 U.S. dollars (based on estimated market rates in Arizona or the United States) and labor costs are calculated at an hourly wage of $15.15 per hour (Arizona minimum wage; Department of Labor 2026), which is slightly lower than Arizona hourly wages for farmworkers or greenhouse laborers. However, costs may change over time with changing market rates.

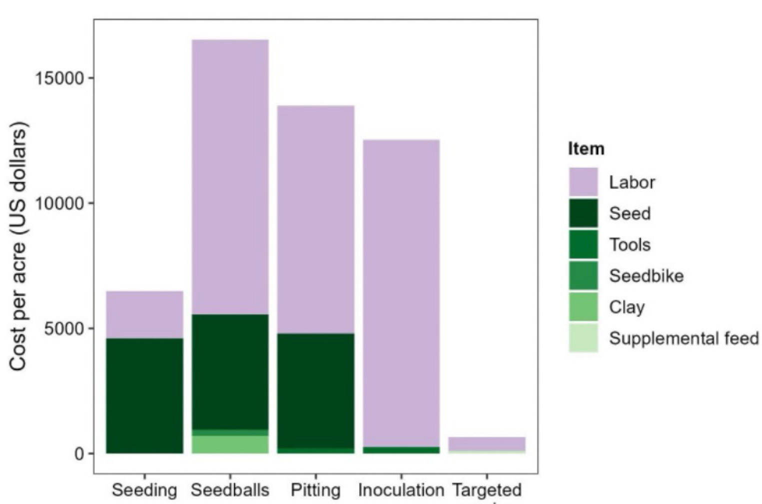

Figure 1. Estimated per-acre costs that may be incurred during restoration treatments, including labor costs and estimated material costs (seed, tools, seedbike, clay, or supplemental feed).

Table 1. Treatments and the estimated per-acre costs, based on scaling up manual RestoreNet treatments, and estimated reduced per-acre costs with more cost-effective materials and mechanized application methods. Estimated costs are broken down by individual materials and labor, and an asterisk indicates a one-time materials or labor cost (i.e., costs and hours that would not increase as area treated increases and thus become negligible at larger areas). All costs are general estimates based on 2024–2026 estimated market rates in Arizona or the United States (U.S. dollars) and may change over time.

Treatment	**Scaled cost per acre**	**Potential savings per acre**
Seeding	$6,494: $4,600 seed $1,894 labor (~125 hours manually spreading and raking seed)	$46–266: $30–150 seed (Meldrum et al. 2025) $16–116 aerial or drill seeding (Meldrum et al. 2025)
Seedballs (or "seed pellets")	$16,534: $4,600 seed $250 seedbike* $700 fire clay (estimated for bulk 50lb bags) $10,984 labor (~725 hours total including 5 hours building seedbike*, 690 hours collecting local soil and creating seedballs with seedbike, and 30 hours manually spreading seedballs)	$10,884–11,154: $30–150 seed (Meldrum et al. 2025) $250 seedbike* (Gornish et al. 2018) $0-50 wet newspaper instead of fire clay $75-175 drone operation to spread seedballs (using estimated rental prices in Arizona in 2026) $10,529 labor (~695 hours total including 5 hours building seedbike* and 690 creating seedballs)
Pitting	$13,890: $4,600 seed $200 hand tools* $9,090 labor (~600 hours total including 505 hours manually digging pits and 95 hours manually spreading and covering seed)	$296–1,683: $30–150 seed (Meldrum et al. 2025) $250–1,500 operating a tractor with a rented pitting attachment (using estimated rental prices in Arizona in 2026) $16–33 aerial seeding (Meldrum et al. 2025)
Soil inoculation	$12,522: $250 collection tools* $12,272 labor (~810 hours total including 505 hours manually collecting inoculum and 305 hours manually spreading inoculum)	Option 1: local healthy soil collection: $1,577–4,081: $300–600 renting a compact track loader to collect inoculum (using estimated rental prices in Arizona in 2026) $121–606 labor for using machinery to collect inoculum $20–600 renting machinery (mulch or manure spreader) to spread inoculum (using estimated rental prices in Arizona in 2026) $1,136–2,275 labor for using machinery to spread inoculum Option 2: commercial inoculum: $25–1,170 $10–1,140 commercial inoculum $15-30 mixing and spreading commercial inoculum
Targeted grazing	$661: $100 supplemental feed $561 labor (~37 hours total including 3 hours spreading supplemental feed, 5 hours moving cattle in/out of enclosures, and 29 hours of time cattle spent in enclosure)	$515: $515 labor (~34 hours total including 5 hours moving cattle in/out of enclosures and 29 hours of time cattle spend in enclosure)

Seeding

What's included: Seeding with desired species is a common treatment to reestablish healthy, resilient plant communities (Young et al. 2025). Seeding costs can include the direct costs of purchasing, shipping, and storing seed and machine rental for distribution, as well as the labor costs of designing a seed mix, and sourcing, cleaning, mixing, and weighing seed, applying pretreatments (e.g., breaking seed dormancy), and seed distribution (both applying the seed and post-seeding treatments such as raking).

Our estimated general cost: For RestoreNet, we deployed a mix of 18 commercially available pre-cleaned native grasses, forbs, and shrubs at the high end of recommended seeding rates for single-species mixes, broadcast seed by hand, then raked or spread soil over the seed (Fig. 2). Total costs were estimated to include approximately $4,600 for seed and $1,894 for 125 hours of labor per acre (Table 1, Fig. 1; based on market price ranges in Arizona for 2024-2026). We weighed and pre-mixed seeds in individual bags to ensure we applied the same species at the same rates per plot but did not include this in labor costs, as this process can be time-consuming and not necessary outside of controlled experiments.

Options to reduce cost: Options to reduce material and labor costs could include: designing a seed mix with fewer species, choosing species that are the least expensive options, purchasing pre-cleaned, pre-mixed, and/or pre-treated seeds; applying seed aerially or with a seed drill instead of broadcasting and raking by hand; using average seeding rates; adjusting seeding rates for a multi-species mix (Tables 1, 2).

Figure 2. A bag full of native seed mix (left); spreading seed by hand (right). Photos by Jane Brady (Sonoran McDowell Conservancy; left) and Katy Stites (Colorado State University; right).

Seedballs

What's included: Seedballs are structures that are generally created by mixing seed, soil, and a tackifier (often clay) to protect seeds from wind, granivory, and solar insolation prior to germination (Gornish et al. 2019). They can be made by hand or with machinery and can be deployed by hand or via machine (e.g., drones). Seedball costs include the estimated costs of purchasing seed and seedball components (e.g., soil and clay), and the purchase of seedball production equipment (the entire machine or parts to create a machine); as well as the labor costs of identifying and procuring seedball components, assembling and testing seedball production machines, creating seedballs, and distributing them in the field.

Our estimated general cost: For RestoreNet, we created seedballs with a seedbike (Gornish et al. 2018; Fig. 3, Table 2) to create seedballs using a seed mix (the same species applied at the same rates per area; refer to Seeding section above), locally sourced soil, and fire clay (as tackifier) with a general material cost of approximately $5,500 ($4,600 of which is seed costs) and a labor cost of approximately $10,984 for 725 hours of labor per acre (Table 1, Fig. 1).

Options to reduce cost: Seed tends to be the most expensive material cost (Fig. 1), so using a lower-cost seed mix can help reduce costs (refer to suggestions in the Seeding section above; Table 1). Using a seedbike or other machine can quickly create a large number of seedballs and is typically more efficient than making seedballs by hand or with pasta machines or molds. Fire clay is our preferred tackifier for this study, but wet newspaper or other free or inexpensive items can be used instead (Table 1). Locally sourced soil or manure can be cheaper than purchasing soil, depending on labor costs.

Figure 3. Operating the seedbike (left); seedballs drying (middle); holding a seedball above a plot (right). Photos by Laura Shriver (U.S. Geological Survey; left, middle) and Mary Fastiggi (Sonoran McDowell Conservancy; right).

Pitting

What's included: Pitting creates depressions in soil that passively collect water, seed, soil, and organic material, and can be combined with seeding to help promote plant establishment (Johnston & Mann 2024). This technique has been used by Tribes in arid regions of North America for over 1,500 years to capture storm water and improve agriculture (e.g., by creating “waffle gardens”, Johnston & Mann 2024). Seeding into pits is especially effective in water-limited dryland areas (Johnson & Mann 2024), including across the RestoreNet network (Farrell et al. 2023). Pitting costs can include the direct costs of equipment (e.g., shovels, other digging tools) or machinery to create pits, and gasoline needed to run machines, as well as the labor costs of installing pits by hand or via machine.

Our estimated general cost: We used hand tools for the study (specialized rakes called McLeods and gloves; Fig. 4) to install and seed into one pit (approximately 15x15 inch by 4 inch deep, Laushman et al. 2022; Table 2) per square meter with a material cost of approximately $4,800 (or $200 for pitting without seed/seedball application) and labor cost of approximately $9,090 for 600 hours (or 505 hours without seed application) of labor per acre (Table 1, Fig. 1).

Options to reduce cost: Although hand digging pits could be one of the least expensive restoration treatments in terms of non-seed materials (Fig. 1), manual pitting is best suited for small scales due to high labor requirements (Table 1). Machine installation of pits has higher material costs but can efficiently create pits across orders of magnitude more land (Johnson & Mann 2024, Tables 1, 2). As with seedballs, seed tends to be the most expensive material cost for pitting (Fig. 1), so using a lower-cost seed mix can help reduce costs (refer to suggestions in the Seeding section above; Table 1).

Figure 4. Digging a pit (left); a hand-dug pit (right). Photos by Katy Stites (Colorado State University; left), Laura Shriver (U.S. Geological Survey; right).

Soil inoculation

What's included: Soil inoculation is a process where live bacteria, fungi, and other beneficial microbes are added in solid or liquid form to soil or seeds in order to enhance plant and soil health (Koziol & Bever 2017; O'Callaghan et al. 2022). There are many ways to procure inoculum, including purchasing commercial products or using locally sourced healthy soil (Koziol & Bever 2017; Farrell et al. 2020). Additionally, applying manure as a soil amendment can increase nutrients and organic matter that can support beneficial microbes (Goldan et al. 2023). Inoculation can include the direct costs of purchasing and shipping commercial products, purchasing tools for collection and transfer (e.g., bags, buckets, and gloves), renting industrial coolers or greenhouse space for storage, and purchasing carriers to mix with the inoculant to enhance distribution; as well labor costs of sourcing, mixing, and maintaining inoculants, field collection (e.g., of healthy soil), transportation, application, and post-application watering.

Our estimated general cost: We collected locally sourced, healthy soil (Fig. 5) and spread the soil by hand at a depth of ~0.8 inches (Fig. 5), or incorporated it into seedballs, with an estimated material cost of approximately $250 (for soil collection and application tools, not including seed or seedball costs) and labor cost of approximately $12,272 for 810 hours of labor per acre (Table 1, Fig. 1). We also bulked soil by mixing it with a sterile, inert medium (sand) and grew our seed mix in the soil-sand mix for two months to reduce the amount of soil we had to collect from donor reference sites. We do not include the cost/hours associated with this bulking process in per-acre estimates as the brand of non-bulk sand we used for this study (Sakrete multi-purpose sand, chosen to meet our requirements for sterility) and the space and time in the greenhouse may not be feasible/realistic at an acre scale.

Options to reduce cost: Using commercial inoculants can reduce costs associated with collecting and applying local healthy soil (Table 1), but they may not be as effective, and can introduce issues (e.g., soil pathogens) that may not occur when using non-commercial products such as healthy soil (Koziol et al. 2024, 2025). Labor costs associated with collecting and spreading local healthy soil can be reduced by using machinery (e.g., skid steers or compact track loaders for collection; mulch or manure spreaders for distribution) instead of moving soil by hand (e.g., with shovels and buckets, Table 1). We describe above how our RestoreNet methods of moving soil off-site, bulking it with sterile sand, and growing our native seed mix in it may not be realistic/feasible at an acre scale or larger. However, buying sand or another inert material in bulk and mixing it with soil on-site could reduce impacts to the healthy donor site by making less soil go further. Whether bulking soil on-site reduces direct treatment costs depends on the cost and availability of sand or another inert material (which can be bought in bulk to reduce prices) and the amount of time it would take to mix soil and sand versus the time it would have taken to collect additional healthy soil that is replaced by sand. Spreading inoculum in patches/clumps, instead of continuously or at a lower depth/coverage can also reduce costs, time, and impact to the donor site for soil. While bulking inoculum or spreading less per area (i.e., applying inoculum at a lower density, or depth) can reduce labor and impacts, it could also potentially reduce efficacy (Koziol et al. 2020). Aligning inoculation with precipitation can also reduce watering needs and, thus, cost.

Figure 5. Collecting soil from a reference site (left); seed mix growing in soil in the greenhouse as part of the "bulking" process (middle); spreading inoculum (right). Photos by Laura Shriver (U.S. Geological Survey; left), Ri Corwin (Northern Arizona University; middle), Katy Stites (Colorado State University; right).

Targeted grazing

What's included: Targeted grazing—the application of a specific type, number and duration of animals in a particular space—is increasingly used to manage plant communities (Marchetto et al. 2021). Availability of space and animals can be a limiting factor for targeted grazing use. Direct costs of targeted grazing can include land or cattle rental, water and supplemental feed, transportation of animals, infrastructure, insurance, and veterinary pay; as well as the labor costs of livestock and predator management, monitoring, and compliance.

Our estimated general cost: We worked with ranching partners to move six cows into fenced enclosures where we spread hay to encourage cattle to move around for ~5-6 hours (per site, or 29 hours per acre). General material costs were approximately $100 (for 5 bales of weed-free Timothy hay for supplemental feed; no supplemental water was needed) and labor costs were approximately $761 for 37 hours of labor per acre (also includes 3 hours to spread hay and 5 hours to move cattle into/out of the enclosures, Table 1, Fig. 1).

Options to reduce cost: Targeted grazing treatments could be less expensive and more efficient for managers who already have a herd of cattle and equipment (e.g., cross fencing or virtual fencing). Aligning grazing treatments with biomass production of forage plants (such as invasive species) can reduce or eliminate the need for supplemental feed (Table 1), as can grazing in areas with existing access to water. Grazing intensity is calculated based on a combination of the number of adult cattle, area, and time, so labor hours could be reduced by increasing the number of cattle and/or decreasing the total area grazed (Table 2).

Notes

Any use of trade, firm, or product names is for descriptive purposes only and does not imply endorsement by the U.S. Government.

Table 2. Resources for planning, developing, and applying the treatments discussed here.
Version for online publication with descriptive hyperlinks; this is the 508-accessible method for online links

Treatment	Resource description	Resource link	Citation
Seeding	Table 1 lists tools for seed-based restoration, including species and seed source selection tools	Practitioner tools for addressing knowing–doing gaps in seed-based restoration	Young et al. (2025)
	Table 2 lists decision-support tools and frameworks for species and seed source selection tools	Bridging theory and practice to inform seed selection for restoration	Shriver et al. (2025)
	Describes how to choose and calculate seeding rates for seed mixes	Calculating seed mixtures	Natural Resources Conservation Service (2009)
	Describes germination methods for common Arizona restoration species	Germination information for common Arizona restoration species	Gornish et al. (2024)
Seedballs	Instructions for constructing a bicycle for creating seed pellets/ seedballs	How to construct a bicycle-powered seed pelletizer for use in gardening and restoration	Gornish et al. (2018)
	Highlights seedball strategies	Seed ball strategies for gardening and restoration in arid landscapes	Gornish (2022)
	Guides readers through seedball design options, including contents and seedball size	Seedball design to optimize germination	Mueller et al. (2021)
Pitting	Describes materials needed and methods to create pits by hand	RestoreNet protocol	Laushman et al. (2022)
	Describes the history, efficacy, and use of rangeland pitting, including machines that can create pits at larger scales	Rangeland pitting for revegetation and annual weed control	Johnston & Mann (2024)
Inoculation	Overviews the benefits of inoculation with native mycorrhizal fungi	Plant Microbiome and Native Plant Restoration: The Example of Native Mycorrhizal Fungi	Koziol et al. (2018)
	Summarizes manure and composted manure use	Manure and composted manure use in Arizona agriculture	Pierce (2025)
	Summarizes soil microbial inoculants and use	Soil inoculant overview	Gaskin et al. (2013)
Targeted grazing	Provides a primer for targeted grazing	Targeted grazing: A primer for landowners and land managers	Macon (2020)
	Overviews targeted grazing for vegetation management	The effectiveness of using targeted grazing for vegetation management: a meta-analysis	Marchetto et al. (2021)
All	Summarizes past and current RestoreNet projects through publications, research briefs, and newsletters	RestoreNet website	U.S. Geological Survey (undated)

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