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Novel Approaches to Ecological Restoration in Semi-Arid and Arid Habitats

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As climate change, excessive land use and dominance by weedy species continue to degrade natural systems at an accelerating rate, management approaches, such as ecological restoration, become more critical for mitigating habitat destruction. The immense challenges posed by widespread environmental change highlight the importance of identifying best management practices for designing and deploying effective restoration strategies that are logistically and monetarily feasible. This is particularly important in systems characterized by high stress, such as semi-arid and arid habitats. Ecological restoration strategies in these systems is challenging and often results in poor outcomes, despite significant resource inputs. For example, conventional restoration approaches (generally involving the singular approach of seeding of continuous habitat) are often unsuccessful in reestablishing healthy plant communities in degraded areas. Degradation in arid systems (particularly when the degradation denudes the land of vegetation and destroys the physical land structure) can eliminate many of the elements that dryland plants have evolved to use to establish in harsh environments. This includes shelter from the elements, water supply, and soil fertility, which is why adding seeds alone is often not successful. Here, we describe four promising approaches for successful and cost-effective semi-arid and arid land restoration: strip seeding, fertile island seeding, rock/brush piles and seedballs. All four of these approaches have indigenous origins, but are relatively novel to the field of restoration.

Strip seeding

Strip seeding is particularly well suited for semi-arid environments (Shaw et al. 2020) and involves seeding species in strips, resulting in alternating strips of seeded and unseeded areas (Fig. 1). Strip seeding is often employed in areas that have been treated with herbicide or mowed to achieve a more conducive environment for seed germination. Over time, the seeded species are expected to disperse into unseeded areas and establish, resulting in outcomes similar to the more expensive method of seeding the entire area. Preliminary work (JS unpublished research) suggests that five years after project initiation, target areas that were seeded at rates as low as 33% cover using strip seeding result in a density of restoration species that is comparable to areas that were seeded at 100% cover (e.g. conventional approach). Strip seeding has the proposed benefits of reducing seed cost (less area seeded), increasing diversity (through an increase in spatial and structural heterogeneity of plants), and increasing logistical feasibility of project deployment (less labor required to seed an area) compared to conventional approaches. However, this planting method can take longer than traditional active restoration methods to achieve the same outcomes, particularly in terms of total plant cover. This might be a particular challenge for industrial projects where regulations often require a specific percentage of cover over a fixed number of years.

Figure 1. Seeded (left hand side of image) and unseeded (center) strips in a four year old strip seed experiment in Davis, CA (Mediterranean climate with a mean annual precipitation of 17.6 inches).

For more information

1. Rayburn AP, and EA Laca. 2013. Strip-seeding for grassland restoration: past successes and future potential. Ecological Restoration 31:147–153
2. Shaw J, Roche LM, and Gornish ES. 2020. The use of spatially-patterned methods for vegetation restoration and management across systems. Restoration Ecology DOI: 10.1111/rec.1198
3. https://tinyurl.com/stripseeding

Fertile island seeding

Facilitation is a positive species interaction that often operates in arid systems in the form of a nurse-plant relationship where the benefactor plant (typically a tree or shrub) that is particularly resilient to moisture stress provides more favorable conditions for plants under or near the canopy (typically grasses and forbs). Changed conditions under the canopy of nurse plants often include increased soil moisture and enhanced soil nutrients. Some restoration practitioners leverage facultative relationships with fertile island seeding where restoration species are strategically dispersed under nurse plants (Fig. 2). This is typically done in the absence of any pretreatment such as herbicide application or targeted grazing. Seeds are expected to demonstrate higher germination under nurse plants than in open areas as they are shielded from desiccation stress and predation by granivores. Germinated plants and transplants are expected to exhibit higher survival under nurse plants compared to open areas due to an increase in resources and physical protection from grazing animals. Once desired plants are established under canopies, they are expected to disperse into open areas, slowly forming larger restoration 'islands' (Hulvey et al. 2017). A dominant challenge of this approach is that woody canopies are often co-opted by weedy species, so restoration species used for this approach should be highly competitive.

Figure 2. Shrubs provide opportunities for canopy seeding to create fertile islands in the Altar Valley, AZ (arid environment with a mean annual precipitation of 10.7 inches).

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2. Pueyo Y, Alados CL, García-Ávila B, Kéfi S, Maestro M, and Rietkerk M. 2009. Comparing direct abiotic amelioration and facilitation as tools for restoration of semiarid grasslands. Restoration Ecology 17: 908-916
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Rock/brush piles

The use of strategic rock and brush piles for land management is an ancient technique largely used to change microsite environmental conditions. Piles are layers of rocks (Fig. 3) or brush (Fig. 4), less than one foot in hieght, typically placed 5-20 feet apart in a strip or half moon shape. These piles can serve many purposes: shading the soil to reduce surface temperatures and evaporation, which can increase seed germination and seedling establishment; trapping seeds and organic material, enhancing revegetation and soil health; and reducing sheet flow of water, dissipating energy of flood waters, reducing erosion and increasing water infiltration. Rock and brush piles can be used alone or in conjunction with seeding to enhance restoration and are largely used in relatively bare (<40% vegetation cover) landscapes. Rock pile designs, in particular, can be targeted for specific management goals and are described by names such as one rock check dam, Zuni bowl and Media Lunas.

Figure 3. Rock pile deployed in the Altar Valley, AZ to reduce sheet flow of water and capture seeds for revegetation.

Figure 4. Mesquite brush pile on the Sierrita Pipeline (Altar Valley AZ), three years after seeding. The piles recruited different plant species and facilitated more robust cover. Additionally, the piles were largely used by wildlife (e.g. packrats, jackrabbits, birds).

For more information

1. Zeedyke B and Clothier V. 2014. Let the water do the work. Chelsea Green Publishing 272 pp.
2. Oreja B, Goberna M, Verdú M. and Navarro-Cano JA. 2020. Constructed pine logs piles facilitate plant establishment in mining drylands. Journal of Environmental Management 271
3. https://tinyurl.com/rockpile1
4. https://tinyurl.com/rockpile2

Seedballs

Seedballs are typically made of clay, compost, water and seed (Fig. 5) and have been documented as used for agriculture as far back as ancient China, the Middle East and North Africa (YueJuan et al. 2004). Seedballs (sometimes called seed pellets or seed bombs) can ameliorate conditions that contribute to failure in arid land restoration, including dry conditions that exacerbate seed desiccation stress and create soil crusts that limit seedling establishment, as well as seed loss via predation. Seedballs also serve to enhance seed to soil contact and reduce seed redistribution by wind. In theory, seeds are protected in the structure until adequate rainfall removes the surrounding clay and then a small pocket of nutrients from the compost component of the seed ball nourishes the seedlings as they emerge. Seed balls are cheap and easy to make and can enhance germination of seeded species.

Figure 5. Newly made seedballs composed of screwbean mesquite seeds, clay, soil and water.

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2. Fukuoka F. 2009. The one-straw revolution. New York Review of Books. 184pp.
3. https://tinyurl.com/seedballs1
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