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OPINION ARTICLE

Functional traits are used in restoration practice: a response to Merchant et al. (2022)

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A recent *Restoration Ecology* article by Merchant et al. (2022) suggested that practitioners do not regularly use functional traits in restoration planning. We disagree and provide our collective experience that practitioners do leverage trait-based approaches and information, but in ways that are different from researchers. Here, we provide an expanded perspective that incorporates practitioner voices to provide a more complete assessment of how traits are used in restoration practice. We highlight that a major challenge in the field of restoration ecology that leads to a disconnect between researchers and practitioners is a different set of knowledge systems, goals, incentives, and limitations. We provide approaches that researchers can use to connect with practitioners and leverage their knowledge.

Key words: land and natural resource management, local ecological knowledge, plant functional traits, restoration practitioners and stakeholders

Implications for Practice

- Restoration practitioners use traits during restoration project planning.
- Restoration practitioners and restoration researchers often operate under differing knowledge systems, which influence whether and how the term "trait" is applied.
- Strengthening working relationships between restoration researchers and practitioners will enhance knowledge sharing and learning from ongoing management efforts.
- Co-production of research will lead to greater a priori hypothesis testing that can expand the utility of traits in restoration.

Introduction

In a recent issue of *Restoration Ecology*, Merchant et al. (2022) highlighted that functional traits are often missing from restoration practice. The article identifies some of the logistical challenges associated with trait use and provides potential solutions to the major challenges associated with integration of functional traits in the design, deployment, and monitoring of restoration. We agree with the authors that integration of functional targets into restoration can be critical for effective mitigation of ecological degradation (Funk & McDaniel 2010), providing resilience to future stressors, and reestablishing healthy ecosystems (Temperton et al. 2013). We also agree that there is a need for collaboration across groups associated with the field of restoration (Leger & Baughman 2015; Gornish et al. 2021), and appreciate the framework described in the paper. However, we disagree with the premise that restoration practitioners fail to incorporate functional traits into restoration practice.

We assert that practitioners do use traits in restoration. These traits are often functional as they relate to resource acquisition, growth, and reproduction and can include quantitative traits such as root biomass, growth rate, and size at flowering (Gisler 2021; Leger et al. 2021*a*, 2021*b*). Practitioners are using this diverse suite of traits to achieve multiple management goals across many regions. In Hawai'i Volcanoes National Park, natural resource managers are seeking to understand the fire tolerance of seeds and resprouting ability of plants to shift the species mosaic of post-fire landscapes toward fire-resilient communities (Loh et al. 2009). Land managers in the Great Basin shrub steppe are actively restoring with bunchgrass species that have traits allowing them to outcompete invasive annual grasses (Davies et al. 2021*a*, 2021*b*). Restoration practitioners in the Pacific Northwest are currently leveraging phenological traits for restoration projects devoted to creating nectar resources for endangered butterflies (T. Roberts, personal communication). In Western Australia, diverse restoration groups are considering a wide range of both seed and plant traits in restoration efforts,

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including the use of prescribed fire with topsoil transfer practices to overcome seed physiological dormancy and sourcing seed based on species' genetic resilience to stress (Ritchie et al. 2021). Similarly, in the restoration of shrub encroached Caldenal Woodlands in Argentina, palatable C3 shortgrasses are planted in areas with rolling treatments that have increased exposure, while unpalatable shade tolerant C3 and C4 mid-grasses are planted in areas where tree and shrub canopies have been maintained (Adema & Babinec 2002).

The use of functional traits in ecological restoration is evident in the development of plant materials, which is rife with examples of trait-based approaches occurring across practitioner-researcher divides (Massatti et al. 2019). For example, many common garden studies that define seed transfer guidelines involve measurements of morphological traits to infer fitness and local adaptation across a species' distribution (St. Claire et al. 2013; Germino et al. 2019). When available, this research has been adopted and supported by land management agencies as a driving guideline for seed sourcing (Erickson & Halford 2020). This is an important distinction from implicit incorporation of functional traits in that it shows a strong link between restoration practice and trait-based research.

Plant materials development for restoration also includes trait screening and selection to produce cultivars with a very specific range of functional traits related to fitness or management considerations (e.g., forage quality, productivity, and germination). Many practitioners, land managers, and landowners regularly employ guides produced by the Natural Resources Conservation Service to find information on resources for restoration and land conservation (NRCS 2022*a*), including potential plant materials for restoration (NRCS 2022*b*). Similarly, the Bureau of Land Management, which implements large restoration projects across public lands nationally, runs native plant materials development programs to provide land managers with knowledge of plant materials, including their traits and even genetic makeup, to guide seeding decisions (Massatti et al. 2019; BLM 2022).

Despite the history of practitioners using functional traits in ecological restoration, researchers are often not aware of this regular practice. Driving this disconnect may be that researchers and restoration practitioners operate under a different set of knowledge systems, goals, incentives, and limitations, which impact how each group leverages traits-based approaches and information. Below, we identify key differences between restoration researchers and practitioners that may obscure how plant traits are used in ecological restoration.

Differing Goals, Approaches, and Incentives

Although a portion of the gap between restoration researcher and practitioner goals, approaches, and incentives is pointed out by Merchant et al. (2022), they assume that much of the division is due to practitioner decision-making being narrowly limited by "ecological intuition" and "in-house" knowledge. In reality, there are many other differences between these groups that further limit adoption of traits in practice. Restoration researchers are typically promoted and rewarded for publishing results from statistically rigorous, hypothesis driven, externally funded projects that do not necessarily require on-the-ground benchmarks or outcomes, or the input of stakeholder groups that can benefit from successful outcomes. Restoration practitioners, in contrast, typically have goal-oriented practical targets (e.g., area revegetated) influenced by one or more stakeholders that do not necessarily rely on testable hypotheses or statistical rigor. Our experience suggests that practitioners rarely receive resources for quantifying traits and monitoring how these and other environmental and management factors affect outcomes. Furthermore, only 22% of the projects noted in the Society for Ecological Restoration (SER) database (https://www.ser-rrc.org/project-database) list a stakeholder or practitioner project partner, which indicates limited engagement between groups. This disconnect is further exacerbated by researchers generally communicating results and interpretations almost exclusively via peer-reviewed publications; while practitioners often do not have the time, interest, money, or motivation to publish descriptions of their work in peer reviewed journals (Matzek et al. 2014). Moreover, many practitioners may not stay up to date with the restoration- and trait-based literature due to accessibility issues, such as paywalls, and limitations on time. Practitioners, therefore, might be unfamiliar with new and accepted restoration research and trait jargon (e.g., "functional redundancy"). Although practitioners can communicate with researchers through, for example, Cooperative Extension or professional organizations, such as the SER, they tend to rely on very small, immediate networks for environmental and decision-making information (Borelli et al. 2018).

Merchant et al. (2022) suggest solutions to use traits to complement existing restoration practices better as being pivotal steps toward deeper integration of traits in natural resource management. We strongly agree with this sentiment. However, we find that managers often do not have the capacity, resources, knowledge, or partnerships that would be needed to make this assimilation more common. These proposed solutions appear to rely on either the expectation that practitioners have more time and money to adopt trait-based approaches than they actually do, or that academics, who generally are not paid to perform an extended amount of outreach, provide free labor to create tools for stakeholders to employ traits in the field. Moreover, the creation of novel and effective restoration tools for stakeholders can be time-consuming and difficult, and requires knowledge that many typical faculty members do not have (Sutherin et al. 2015). Even in the case of scientists at state and federal agencies, who often have a formal research and outreach requirement, support to help determine appropriate plant materials has historically not been prioritized (but see McCormick et al. 2021) and there is generally a lack of monitoring post-restoration outcomes, particularly at the landscape scale (Copeland et al. 2018). Furthermore, restoration tools, including those that are trait-based, which are created by university, agency, or industry partners may not be used by practitioners due to lack of time or training, which is not helped by the somewhat recent proliferation of management tools that take time and effort to sort through and learn.

Thus, the Merchant et al. (2022) paper highlights a common roadblock in knowledge co-production wherein academic

Box 1 Selecting species for restoration in the Great Basin sagebrush steppe based on functional traits and ecosystem services. Photo by CD Clements.

In the Great Basin sagebrush steppe, efforts to restore perennial vegetation cover in degraded areas began in the early part of the 20th century (Svejcar et al. 2017). Following overgrazing, the spread of exotic annual grasses (EAGs), severe drought and accelerated soil erosion in the 1930s, land managers selected non-native perennial bunch grass species, particularly crested wheatgrass (*Agropyron cristatum* [L]), for their high drought tolerance (Sharpe 1986) and greater establishment rates compared to native bunchgrass species (Hull 1974). Bunchgrasses in the sagebrush steppe, both native and non-native, are also selected because their functional traits allow them to outcompete exotic annual grasses when established and help to break the positive feedback loop with fire that EAGs drive (Davies et al. 2021*a*, 2021*b*). These traits include the ability to quickly spread from seed, and in the case of crested wheatgrass, rapid seedling growth rate. Without selection for these traits, successful seeding of species that compete with EAGs would not have been possible. In the late 1900s, a recognition for biodiversity arose, including the need to maintain diverse native plant species that provide habitat and forage for endangered species such as sage-grouse (Svejcar et al. 2017). Thus, while crested wheatgrass has functional traits that make it desirable in certain circumstances, there is a major drive to improve the establishment success of native species, especially bunchgrasses. Land managers and restoration practitioners are currently searching for characteristics, or traits, that will allow native species to be successful in environments with a high abundance of EAGs. For example, selecting locally adapted seed sources that have traits leading to higher seedling establishment and resistance of hot, dry conditions compared to commercially grown native seed sources is both actively researched (Leger & Baughman 2015, Leger et al. 2021*a*, 2021*b*) and applied by practitioners (Leger et al. 2021*a*, 2021*b*). These traits include early emergence, long roots, and high root mass ratio. The term "traits" may not explicitly be used by land managers, who instead refer to the function of the species being selected, such as outcompeting EAGs or fast establishment rates.

researchers assume the flow of information on traits is "top down" from scientific researchers to practitioners. We contend that the roadblock is also due to researchers not always understanding the rich goals and approaches of practitioner decision-making that could make traits more applicable.

Differing Semantics

Merchant et al. (2022) identified a lack of integration of plant traits in restoration practice based on the absence of the word "traits" in descriptions of projects in the SER database. Although the authors very briefly acknowledge that this might stem from differences in this issue is nontrivial semantics (Shaw et al. 2020). Practitioners we work with do not typically use the term "trait(s)" when discussing restoration design and deployment. Instead, they use terminology that aligns with land knowledge, which incorporates a broader set of considerations and objectives than traits alone (Box 1). Even within the restoration ecology scientific community, use of the term "traits" is fairly recent (Fig. 1), with the term only gaining popularity in the last decade. Lack of widespread use of the term "trait" can influence how practitioners discuss and report species selection, restoration goals, and how restoration outcomes are measured.

Based on this difference in semantics, Merchant et al. (2022) suggest that restoration practice is primarily concerned with historical reference conditions and taxonomic targets, and that functional targets are not generally considered. However, recent shifts in management priorities extend beyond the core restoration goal of simply "replace what was lost" or "promote recovery to historical conditions." Restoration practitioners are

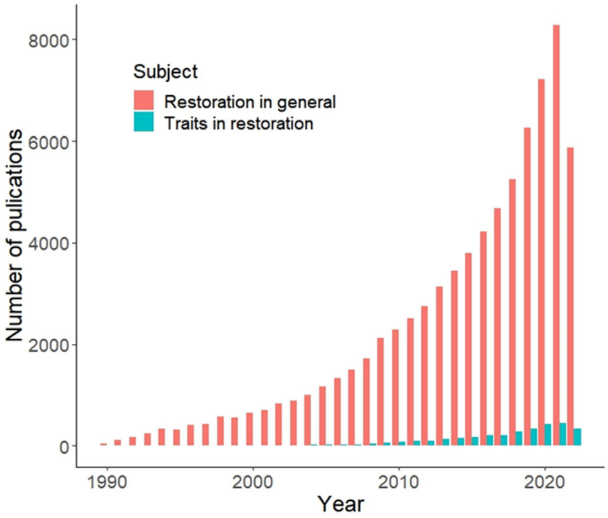

Figure 1. Number of journal articles published in the general field of restoration ecology (red bars) and restoration-focused articles which utilize the term "traits" (blue bars) as compiled from a Web of Science search. The term "traits" among restoration researchers is relatively new, and the term is even more novel among restoration practitioners. The search used terms (restor* OR rehabilitation OR revegetation) AND (ecol* OR environ*) AND (plant trait* OR functional trait*). Exclusion terms to remove papers from medical and other unrelated fields were used.

focused on implementing treatments that achieve multiple management outcomes (e.g., promoting pollinators, erosion control, and wildlife habitat) when replacing lost or degraded plants, landforms, and processes (Li & Gornish 2020; Von Holle et al. 2020). This is highlighted, for example, by case studies described in the Collaborative Conservation and Adaptation Strategy Toolbox (CCAST), an inventory of management projects managed by the USDA Southwest Climate Hub, U.S. Fish and Wildlife Service, Bureau of Reclamation, and USDA Forest Service. All restoration projects noted in CCAST describe functional management goals including: invasive plant management, drought resilience, fire regime change, and water utilization. Indeed, popular tools developed for practitioners often accommodate this approach. The Mojave Seed Menu (Shryock et al. 2022), for example, is an online plant materials selection tool that allows users to use functional objectives to generate restoration seed mixes. This shift toward restoration of ecosystem functions and services requires that practitioners use traits to meet these goals, albeit without always adopting trait-based terminology or quantifying all traits used.

Approaches to Strengthen Researcher–Practitioner Linkages

We applaud the many recommendations noted in Merchant et al. (2022) regarding the provision of more useful trait-based tools and data to practitioners as compelling and agree that researchers should consider them. Although the research-implementation gap in applied ecology is well known (Knight et al. 2008), it persists, likely limiting management outcomes. For researchers to connect with practitioners better on actionable trait-based science and tools, we suggest the following:

Recognize Local Ecological Knowledge

Local ecological knowledge, or LEK, is site-specific, contextualized knowledge generated by practitioners via local restoration projects (Gadgil et al. 2003). Restoration practitioners often have deep stores of LEK and are connected to other land-users and stakeholders that can serve as rich repositories of critical information that is not present in the scientific literature or framed using scientific terminology. One of our key critiques of the Merchant et al. (2022) paper is that it appears to disregard LEK in favor of scientific knowledge. We suggest restoration researchers can overcome this barrier and find room for trait-based approaches within this context in at least two ways. First, they can seek out training in science communication to avoid a "top-down" unidirectional communication approach that assumes practitioners will immediately adopt research findings. Second, acknowledging that stakeholders and practitioners are rich sources of LEK (Li et al. 2020) will enhance the bi-directional flow of information to strengthen potential application of restoration and trait research. Greater communication through meetings, workshops, surveys, and interviews can ensure sources of LEK are used to complement and enhance trait-based restoration research (Funk et al. 2020). Current trait-based restoration research can benefit from more engagement of practitioners than suggested by Merchant et al. (2022), for example, by inspiring practitioners through more accessible tools.

Engage with Practitioners Directly

Researchers should endeavor to co-produce restoration and trait-based science with practitioners, seeking a win–win relationship where the needs of both groups are met (Covey 1989). Co-production involves the creation of science (research win) in partnership with stakeholders (everyone wins) without a huge input of additional resources (Hastings et al. 2020). Although there are many conceptual papers that describe how traits can be used in restoration, and many that test how traits affect results after restoration has already taken place, there are fewer that describe explicit tests of trait-based approaches using experimental approaches that are established before projects have started. A recent review found that only 12% of papers took such an a priori hypothesis testing approach (Carlucci et al. 2020). We suggest that individuals who are incentivized to work with stakeholders, such as Cooperative Extension or specific research arms of state and federal agencies, serve as translators between basic ecological science and applied science and its practice (Gornish & Roche 2018). Collaborating with stakeholders to co-produce science is particularly helpful for the integration of restoration and trait-based tools and technologies that require a very specific set of skills, such as the use of remote sensing to inform restoration plans at large scales (Cordell et al. 2017).

Work with Practitioners to Re-imagine the Future

Moving forward, ecological degradation will likely be accelerated by land-use intensification, invasives species, wildfire, and climate change. In many cases, these stressors will create "novel" or "no-analog" abiotic and biotic conditions that may require re-imagining plant and ecosystem targets for restoration because the historical conditions cannot be recreated (Hobbs et al. 2014). Traits can have a large role to play in this reimagining process, in which future restoration will require more systems thinking, greater management intervention, and flexible strategies. If restoration researchers are considering LEK and engaging practitioners directly, there will likely be opportunity to seed a successful path moving forward by using functional traits to meet new targets for ecosystem form and function.

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LITERATURE CITED

Adema E, Babinec F (2002) Area accesible al pastoreo en un arbustalpastizal rolado de Chacharramendi, La Pampa. Pages 49–51. Actas VIII Jornadas Pampeanas de Ciencias Naturales, Santa Rosa, La Pampa, Argentina

Borelli KA, Roesch-McNally GE, Wulfhorst JD, Eigenbrode SD, Yorgey GG, Kruger CE, Houston LL, Bernacchi LA, Mahler RL (2018) Farmer's trust in sources of production and climate information and their use of technology. Journal of Extension 56:V56-3a7

Bureau of Land Management (BLM) (2022) Plant conservation and restoration. https://www.blm.gov/programs/natural-resources/native-plant-communities. (accessed 7 November 2022)

Carlucci MB, Brancalion PHS, Rodrigues RR, Loyola R, Cianciaruso MV (2020) Functional traits and ecosystem services in ecological restoration. Restoration Ecology 28:1383. https://doi.org/10.1111/rec.13279

Copeland SM, Munson SM, Pilliod DS, Welty JL, Bradford JB, Butterfield BJ (2018) Long-term trends in restoration and associated land treatments in the southwestern United States. Restoration Ecology 26:311–322. https://doi.org/10.1111/rec.12574

Cordell S, Questad EJ, Asner GP, Kinney KM, Thaxton JM, Uowolo A, Brooks S, Chynoweth MW (2017) Remote sensing for restoration planning: how the big picture can inform stakeholders. Restoration Ecology 25:S147–S154. https://doi.org/10.1111/rec.12448

Covey SR (1989) The 7 habits of highly effective people. Pages 381. Free Press, New York

Davies KW, Bates JD, Perryman B, Arispe S (2021*a*) Fall-winter grazing after fire in annual grass-invaded sagebrush steppe reduced annuals and increased a native bunchgrass. Rangeland Ecology & Management 77:1–8. https://doi.org/10.1016/j.rama.2021.03.001

Davies KW, Leger EA, Boyd CS, Hallett LM (2021*b*) Living with exotic annual grasses in the sagebrush ecosystem. Journal of Environmental Management 288:112417. https://doi.org/10.1016/j.jenvman.2021.112417

Erickson VJ, Halford A (2020) Seed planning, sourcing, and procurement. Restoration Ecology 28:S219–S227. https://doi.org/10.1111/rec.13199

Funk JL, McDaniel S (2010) Altering light availability to restore invaded forest: the predictive role of plant traits. Restoration Ecology 18:865–872. https://doi.org/10.1111/j.1526-100X.2008.00515.x

Funk JL, Parker IM, Matzek V, Flory SL, Aschehoug ET, D'Antonio CM, Dawson W, Thomson DM, Valliere J (2020) Keys to enhancing the value of invasion ecology research for management. Biological Invasions 22: 2431–2445. https://doi.org/10.1007/s10530-020-02267-9

Gadgil M, Olsson P, Berkes F, Folke C (2003) The role of local ecological knowledge in ecosystem management. In: Berkes F, Colding J, Folke C (eds) Navigating social-ecological systems: building resilience for complexity. Cambridge University Press, Cambridge, United Kingdom

Germino MJ, Moder AM, Sands AR (2019) Adaptive variation, including local adaptation, requires decades to become evident in common gardens. Ecological Applications 29:1–7. https://doi.org/10.1002/eap.1842

Gisler M (2021) Native seed germplasm study and development project, 12th quarter report submitted to the research bureau, New Mexico Department of Transportation. Pages 10

Gornish ES, McCormick M, Begay M, Nsikani MM (2021) Sharing knowledge to improve ecological restoration outcomes. Restoration Ecology. e13417. https://doi.org/10.1111/rec.13417

Gornish ES, Roche LM (2018) The value of cooperative extension for involving society in restoration and conservation. Restoration Ecology 26:1051–1054. https://doi.org/10.1111/rec.12861

Hastings Z, Ticktin T, Botelho M, Reppun N, Kukea-Shultz K, Wong M, Melone A, Bremer L (2020) Integrating co-production and functional trait approaches for inclusive and scalable restoration solutions. Conservation Science and Practice 2:e250. https://doi.org/10.1111/csp2.250

Hobbs RJ, Higgs E, Hall CM, Bridgewater P, Chapin FS III, Ellis EC, et al. (2014) Managing the whole landscape: historical, hybrid, and novel ecosystems. Frontiers in Ecology and the Environment 12:557–564. https://doi.org/10.1890/130300

Hull AC Jr (1974) Species for seeding arid rangeland in southern Idaho. Journal of Range Management 19:216–218

Knight AT, Cowling RM, Rouget M, Balmford A, Lombard AT, Campbell BM (2008) Knowing but not doing: selecting priority conservation areas and the research-implementation gap. Conservation Biology 22:610–617. https://doi.org/10.1111/j.1523-1739.2008.00914.x

Leger EA, Agneray AZ, Baughman OW, Brummer EC, Erickson TE, Hufford KM, Kettenring KM (2021*b*) Integrating evolutionary potential and ecological function into agricultural seed production to meet demands for the decade of restoration. Restoration Ecology e13543. https://doi.org/10.1111/rec.13543

Leger EA, Baughman OW (2015) What seeds to plant in the Great Basin? Comparing traits prioritized in native plant cultivars and releases with those that promote survival in the field. Natural Areas Journal 35:54–68. https://doi.org/10.3375/043.035.0108

Leger EA, Barga S, Agneray AC, Baughman O, Burton R, Williams M (2021*a*) Selecting native plants for restoration using rapid screening for adaptive traits: methods and outcomes in a Great Basin case study. Restoration Ecology 29:e13260. https://doi.org/10.1111/rec.13260

Li YM, Gornish ES (2020) General attributes and practice of ecological restoration in Arizona and California, U.S.A., revealed by restoration stakeholder surveys. Restoration Ecology 28:1296–1307. https://doi.org/10.1111/rec.13221

Li YM, Roche LM, Gornish ES (2020) Bridging the research-implementation gap in weed management on California rangelands. Rangeland Ecology & Management 73:348–357. https://doi.org/10.1016/j.rama.2020.01.007

Loh R, Ainsworth A, Tunison T, D'antonio C (2009) Testing native species response to fire—a first step towards building fire resilience native plant communities at Hawai'I Volcanoes National Park. Technical Report No. 167. Pages 30. Pacific Cooperative Studies Unit, University of Hawai'i, Honolulu, Hawai'i

Massatti R, Winkler D, Reed S, Duniway M, Munson S, Bradford J (2019) Supporting the development and use of native plant materials for restoration on the Colorado Plateau. USGS FY19 Report. Pages 15

Matzek V, Covino J, Funk JL, Saunders M (2014) Closing the knowing-doing gap in invasive plant management: accessibility and interdisciplinarity of scientific research. Conservation Letters 7:208–215. https://doi.org/10.1111/conl.12042

McCormick ML, Carr AN, Massatti R, Winkler DE, De Angelis P, Olwell P (2021) How to increase the supply of native seed to improve restoration success: the US native seed development process. Restoration Ecology 29:e13499. https://doi.org/10.1111/rec.13499

Merchant TK, Henn JJ, de Silva I, Van Cleemput E, Suding KN (2022) Four reasons why functional traits are not being used in restoration practice. Restoration Ecology. e13788. https://doi.org/10.1111/rec.13788

Natural Resources Conservation Service (NRCS) (2022*a*) Field Office Technical Guide (FOTG). https://www.nrcs.usda.gov/resources/guides-and-instructions/field-office-technicalguides (accessed 7 November 2022)

Natural Resources Conservation Service (NRCS) (2022*b*) Plant materials program. https://www.nrcs.usda.gov/plant-materials. (accessed 7 November 2022)

Ritchie AL, Svejcar LN, Ayre B, Bolleter J, Brace A, Craig MD, et al. (2021) Corrigendum to: a threatened ecological community: research advances and priorities for Banksia woodlands. Australian Journal of Botany 69:111. https://doi.org/10.1071/BT20089_CO

Sharpe LA (1986) Crested wheatgrass, its values, problems and myths. Pages 3–6. In: Johnson KL (ed) Crested wheatgrass, its values, problems and myths: symposium proceedings; 3–7 October 1983, Logan UT. Utah State University, Logan

Shaw JA, Roche LM, Gornish ES (2020) The use of spatially patterned methods for vegetation restoration and management across systems. Restoration Ecology 28:766–775. https://doi.org/10.1111/rec.13198

Shryock DF, DeFalso LA, Esque TC (2022) Seed menus: an integrated decision-support framework for native plant restoration in the Mojave desert. Ecology and Evolution 12:e8805. https://doi.org/10.1002/ece3.8805

St. Claire JB, Kilkenny FF, Johnson RC, Shaw NL, Weaver G (2013) Genetic variation in adaptive traits and seed transfer zones for *Pseudoroegneria spicata* (Bluebunch wheatgrass) in the northwestern United States. Evolutionary Applications 6:933–948. https://doi.org/10.1111/eva.12077

Sutherin S, Lombard KA, Hilaire RS (2015) Website? Video? Facebook? Mobile app? One group's experience developing and comparing urban landscape water conservation digital outreach resources. Journal of Extension 53:v53–1a1

Svejcar T, Boyd C, Davies K, Hamerlynch E, Svejcar L (2017) Challenges and limitations to native species restoration in the Great Basin USA. Plant Ecology 218:81–94. https://doi.org/10.1007/s11258-016-0648-z

Temperton VM, Hobbs RJ, Nuttle T, Halle S (2013) Assembly rules and restoration ecology. Island Press, Washington, DC

Von Holle B, Yelenik S, Gornish ES (2020) Restoration at the landscape scale as a means of mitigation and adaptation to climate change. Current Landscape Ecology Reports 5:85–97. https://doi.org/10.1007/s40823-020-00056-7

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