Managing invasive annual grasses, annually: A case for more case studies

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On the Ground

- The continued expansion of invasive annual grasses is a complex ecosystem management problem requiring a shift in focus from a discrete, single treatment approach to one of adaptive management with sustained investment.
- Four case studies shared at the 2020 Invasive Annual Grass workshop provide lessons learned and opportunities to advance future management efforts to inform the direction for new science.
- Tackling the complex problem of invasive annual grass management will require an expansion of science-based case studies of real-world management efforts, strong science and management partnerships, and a platform for continuous learning and communication, such as a comprehensive database to document management outcomes along with Open Access journals that allow publishing of negative and null outcomes.
- Managers can use existing tools such as the Land Treatment Digital Library, Land Treatment Exploration Tool, and the Rangeland Analysis Platform to understand the efficacy of invasive annual grass treatments under a variety of site and environmental conditions.

Keywords: Invasive annual grass, Case studies, Science and management partnerships, Ecosystem management, Ecological complexity, Adaptive management.

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Invasive annual grasses are proliferating across western rangelands at an alarming rate, leading to altered fire regimes, degraded wildlife habitat and loss of forage for wildlife and cattle.[1,2] Land managers cannot keep pace with the unrelenting waves of invasion by exotic annual species (such as cheatgrass [*Bromus tectorum* L.], medusahead [*Taeniatherum caput-medusae* (L.) Nevski], and ventenata [*Ventenata dubia* (Leer) Coss.]).[3] The continued expansion of invasive annual grasses is a complex ecosystem management problem. The problem has multiple interactive social and ecological causes, strong self-perpetuating properties, ecosystem level effects, and is within a temporally and spatially variable environment. As such, no single "silver-bullet" solution exists. Instead, an effective multiyear management strategy varying from site-to-site is needed. In addition, the invasive annual grass issue is too complex and large to be solved by any single organization and significant knowledge gaps continue to persist.[4,5] This "wicked" problem will persist and require continued adaptive management even if land managers were granted unlimited resources and discretion to address it.[6] This is not to say we do not need additional resources; knowledge-limited problems that vary markedly over time and space require sustained investment in adaptive management and research. Tackling this problem requires prolonged investment (see Smith et al. this issue)[7] from a diversity of actors with complementary capacities and supportive policies to shift focus from an event-based "silver-bullet" approach to managing invasive annual grasses annually (see Johnson et al. this issue).[8]

A dominant focus of this Special Issue is on implications of scientific discoveries for improving the outcomes of invasive annual grass management and sagebrush ecosystem restoration in the northern Great Basin of the western United States (e.g., Davies et al.; Baughman et al. this issue).[9,10] This science-centric focus demonstrates significant knowledge gaps exist surrounding management of invasive annual grasses. However, science plays an important role in addressing invasive annual grass management. Scientific discovery often only informs a logical starting point for management because researched management practices do not always align with the fiscal, logistical, and societal realities of large-scale management of invasive annual grasses across mixed ownership landscapes.[11] Furthermore, researchers frequently conduct science within a small range of temporal and spatial variation compared with land managers who contend with large geographies and long planning horizons.[12] Experimental designs including treatment replication over space and time broaden inferences about management efficacy across wider climatic, environmental, and biotic conditions. However, they only account for a small fraction of the whole range of ecosystem variability. Such research is not conducted in vain and is important to informing viable alternatives. In practice, however, scaling up implementation to management scales often produces results not aligned with expectations. Furthermore, many studies of land treatments that failed are underreported in the peer-reviewed literature,[13] which contribute to an inflation of expected efficacy from land treatments. Tackling the complex problem of invasive annual grass management requires a science-based approach, strong partnerships, and a platform for continuous learning and communication.[4,5,11,14]

We suggest more case studies of real-world management efforts are needed to expand existing knowledge for informing the efficacy of invasive annual grass management strategies and treatments under a wider range of conditions. The value of these case studies is maximized when they are designed to address specific management/research questions from the start. Therefore, we suggest, as others have, closer collaboration between researchers and land managers (and other stakeholders), and better integration of research within the management process where science evaluates the effectiveness of multiple strategies when and where management opportunities arise.[5] Additionally, we advocate for a dynamic management database to capture the variability and successes or failures of past treatments and provide ongoing learning between managers and researchers.[14]

A case for more case studies

Case studies offer an opportunity to evaluate the efficacy of current science at management scales, further inform scientific research by tightening the link between science and management,[15] and cross-pollinate lessons learned among agencies.[11] We use four management case studies shared at the 2020 Invasive Annual Grass Workshop organized by the High Desert Partnership, the SageCon Partnership, and Oregon State University, to highlight lessons learned and opportunities to improve success with the complexities of managing invasive annual grasses. These case studies were conducted in Oregon and shared by the Burns District Bureau of Land Management (BLM), Vale District BLM, Burns Paiute Tribe, and Crooked River Weed Management Area. These case studies yielded valuable information about what did and did not work, conditions contributing to success or failure, as well as challenges and opportunities associated with scaling up management, that otherwise might not have been broadly shared. We present summaries of the four case studies where we identify the lessons learned and the opportunities to advance future management efforts to inform the direction for new science (Table 1). When applicable, we also highlight where closer integration of science and management could have resulted in opportunities for amplifying implications of lessons learned.

Case study 1

Lesson learned: preplanning postfire rehabilitation improves resource prioritization and implementation

In Case Study 1, Burns District BLM, Oregon aimed to reduce medusahead, increase perennial bunchgrasses, and reduce future fire risk after the 2007 Bartlett Mountain Fire, which burned 13,076 ha (32,312 acres). Treatments to the burned area included seeding, dormant season grazing, and targeted herbicide application. Restoration seeding included a mixture of native perennial bunchgrasses and crested wheatgrass (*Agropyron cristatum* [L.] Gaertn, drill seeded in the fall of 2007, and aerial seeded in the spring of 2008). Dormant season (i.e., fall and winter) livestock grazing began in 2012 within a 3,141-ha (7,762-acre) pasture and periodic imazapic (pre-emergent herbicide) applications at 0.44 liters per hectare (6 ounces per acre) of formulated product at a rate of 105.17 g · acid equivalent (ae) · ha^{-1} (0.09 lb ·ae ·$acre^{-1}$) were made along roadsides throughout the project area to reduce fuels and control primary weed spread corridors. Two of three photo-monitoring locations showed a post-treatment decrease of medusahead cover and ongoing recovery of perennial bunchgrasses in response to dormant season grazing and seeding efforts. More monitoring sites would have been needed to capture the variation between the effects of dormant season grazing, drill, and aerial seeding. Ecological site type was a major determinant of the efficacy of dormant season grazing and seeding to promote desired perennial plants in the medusahead-invaded rangeland. Perennial plants reestablished on ecological sites with deep and porous soils, and flat and clayey sites experienced lower reestablishment. Additionally, the seeding, grazing, and roadside herbicide treatments demonstrated some management success for reducing wildfire spread. This area burned again in 2014, as a part of the Buzzard Fire complex (which burned about 116,145 ha [287,000 acres]), and one of the ignition sites was stopped in a roadside fuel break where medusahead had been previously treated with imazapic in the dormant season grazing pasture.

In a separate 7,000-ha (17,300-acre) area burned by the 2014 Buzzard Fire Complex, managers applied imazapic in 2015 to control medusahead at a rate of 105.17 g · ae · ha^{-1} (0.09 lb ·ae ·$acre^{-1}$). However, inconsistent herbicide application across the treatment area in 2015 did not result in medusahead control and led to a follow-up treatment in 2016, which performed better. The area was also seeded post fire during the spring of 2015 (aerial), fall of 2016 (drill), and winter of 2015/early 2015 (broadcast). Burns BLM staff learned that treating medusahead infested areas with imazapic immediately post wildfire greatly improved treatment results.

Table 1
Summary of case studies presented, including name and organization of original presenter at 2020 Invasive Annual Grass Workshop organized by the High Desert Partnership, the SageCon Partnership, and Oregon State University

Case Study	Objective/Action	Lesson Learned	Opportunity
1. Burns District BLM – Bill Dragt, Natural Resources Supervisory Specialist	Reduce medusahead, increase perennial bunchgrasses and reduce future fire risk using: - Annual dormant season livestock grazing and - Roadside and helicopter applied pre-emergent herbicide treatments	**Preplanning postfire rehabilitation improves resource prioritization and implementation**	Need for researcher/manager integration
2. Vale District BLM – Lynne Silva, Vale District Weed Management Specialist	Application of pre-emergent herbicide to protect a relatively intact, yet annual grass prone area from converting to medusahead after wildfire	**Pretreatment plant community matters**	Need for a formal database to share lessons
3. Burns Paiute Tribe – Carter Crouch, Wildlife Program Manager	Restore desired perennial plants to an area of rangeland heavily invaded by medusahead through the use and comparison of two herbicides (imazapic and indaziflam) in conjunction with prescribed burning, followed by planned seeding with a mix of native and introduced perennials	**Implementation at management scales presents unique challenges**	Need for more management-scale research
4. Crooked River Weed Management Area – Debbie Wood, Weed Management Area Coordinator	Evaluation of the efficacy and cost-analysis of using soil enhancement bacteria and or herbicides to restore rangeland health by reducing annual invasive grasses and increasing native grass production	**Translating science to management scales can be costly and ineffective**	Database documenting success/failures under various conditions

Note. The objective and main management action presented, authors' perspectives on primary lesson learned, and opportunity for advancing future management are included.

Opportunity: need for researcher/manager integration

This case study highlights an opportunity to tighten the research-management relationship; researchers could work with managers to develop postwildfire rehabilitation and monitoring plans for testing multiple management strategies. Managers and researchers could team up before wildfire season to proactively develop "on-deck" ecological-site-specific management strategies and related hypotheses for postfire implementation plans providing BLM staff with tailored management and researchers with more robust experimental designs (see Wollstein et al. this issue for a description of an applicable proactive planning framework).[16] Collaboratively planning monitoring sites would have helped disentangle the grazing, seeding, and herbicide treatment effects. Unfortunately, management project needs exceed the capacity of academic researchers, and involving researchers inevitably requires more time from both parties. Although most managers do not have easy access to researchers at a university or research station, they likely interact with local cooperative extension agents from universities as well as federal and state agencies, who engage in applied research. Extension agents translate science into management for stakeholders, have established relationships with land managers, and are located beyond the university campus, making them more accessible to partner with land managers. An extension agent/land manager team could provide the scientific community with management-scale feedback on science-based practices, while the land managers receive defensible and improved land management strategies. Extension agents could facilitate broader communication of lessons learned from case studies and enable more information sharing among land managers.

Lastly, BLM Resource Management Specialists indicated concerns about the potential for development of herbicide resistance in the project area from repeated roadside applications of a particular pre-emergent herbicide to control medusahead and reduce fuels. The 2020 Invasive Annual Grass Workshop provided Burns District BLM staff and other participants from around the West the opportunity to learn about Rejuvra (indaziflam), which is registered for invasive annual grass control on rangelands. A single application provides multiple years of annual grass control[17] and, importantly, offers a different mode of action than other pre-emergent herbicides. Strategies of repeated applications of herbicides to control weed vector pathways or for fuels reduction should consider the potential for herbicide resistance and use mixtures or rotate among chemistries offering different modes of action whenever possible.[18]

Case study 2

Lesson learned: pretreatment plant community matters

In Case Study 2, Vale District BLM staff used 0.44 liters per hectare (6 oz per acre) of formulated imazapic at a rate of 105.17 g · ae · ha^{-1} (0.09 lb ·ae ·$acre^{-1}$) to protect a relatively healthy, yet invasive annual grass-prone area from converting to medusahead after the 2014 Saddle Draw Fire (Buzzard Fire Complex), which burned 113,369 ha (280,141 acres). This case study demonstrated pretreatment knowledge of perennial plant abundance was key in explaining post-treatment outcomes. Areas with sufficient perennial plant cover responded favorably to herbicide treatments while areas lacking perennial plants, although initially showed control of invasives, were ultimately reinvaded by medusahead near the end of a 4-year monitoring period. Managers also learned that applying pre-emergent herbicides to control invasive annual grasses provided an opportunity to evaluate the need for seeding the fol-

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lowing year after herbicide application. In this case, the interdisciplinary team evaluating postherbicide vegetation response determined investing in large-scale aerial seeding was not necessary. However, BLM staff drilled seed, planted shrub seedlings, and restored areas damaged by dozer firebreak lines in other areas of the Saddle Draw fire in 2015. In the end, approximately 40,470 hectares (100,000 acres) were identified as needing postfire herbicide treatments on the Vale BLM District, but funding was only available to treat 8,093 ha (20,000 acres).

Opportunity: need for a formal database to share lessons

Prior knowledge of the process and treatment outcomes associated with previous case studies could have provided Vale District BLM managers with relevant information to better target treatment areas using the limited funding available. Furthermore, valuable lessons learned could inform future planning and implementation efforts across the western rangelands if a user-friendly database existed that provided a continuous form of shared learning and communication among managers and researchers. The new Collaborative Conservation Adaption Strategy Toolbox (CCAST) provides an example of a platform with which to share case studies such as these, but currently lacks Great Basin examples.[19] CCAST is a great first step toward a comprehensive database, but it lacks critical biotic and abiotic site details that influence success.

Case study 3

Lesson learned: implementation at management scales presents unique challenges

In Case Study 3, the Burns Paiute Tribe shared lessons learned from an ongoing management-scale replicated study. The study was planned by the manager with research in mind. It employs prescribed fire, pre-emergent herbicide application, and reseeding for medusahead control and perennial grass restoration similar to methods used by Davies[20] at a plot-scale. In this case study, a replicated design of three management treatments (i.e., prescribed fire/imazapic, prescribed fire/indaziflam, and a control) will likely produce peer-reviewed published results to serve as a meaningful contribution to the scientific and management communities. Implementation of these treatments at the management scale presented unforeseen challenges. Applying prescribed fire in a heterogeneous landscape was difficult, and incomplete burning occurred in areas where complete burning was intended, while sagebrush areas outside of the project area were unintentionally burned. Prescribed fire was expensive to implement in remote (i.e., >130km [80 miles] from Tribal headquarters) treatment areas. Additionally, using all-terrain vehicles fitted with boom sprayers (i.e., a sprayer with multiple nozzles spread out along arms, aka booms, pointed downward) to apply herbicide on uneven, rocky, recently blackened soil made uniform coverage difficult.

Opportunity: need for more management-scale research

The unanticipated challenges that arise by scaling up from small plot-scale science to management scales present more complicated and less controllable conditions. This highlights the need for more research at a management scale.[5] Unfortunately, these challenges may deter researchers from pursuing management scale research, but publishing these results, precisely because they encompass a wider range of heterogeneity and complexity, may prove more informative than results from small plot-scale trials (e.g., the SageSTEP project experienced issues with spatial and plant community heterogeneity while greatly advancing our understanding of ecosystem processes across an unprecedented, multistate scale).[21] Other management-scale treatments on invasive annual grasses can and should incorporate research when feasible. Large-scale research provides an opportunity for land managers and researchers to collaborate simultaneously on management and research. However, integrating management and science presents several challenges. Publishing results in peer-reviewed publications is important for moving science forward and researchers' jobs often depend on developing publications; thus, they possess great skill in data collection and analysis that addresses testable hypotheses as well as publishing their results. These results are important, but often only include investigating a small area where variation can be minimized and intensive measurements taken. Conversely, managers are skilled in applying large-scale treatments but have limited time and resources for intensive data collection and analysis. Researchers may slow down the management process, and management scale treatments do not easily provide publishable results. Despite these challenges, integrating the skill sets of researchers and land managers holds tremendous promise for improving information and communication related to science-based management scale treatments.

Case study 4

Lesson learned: translating science to management scales can be costly and ineffective

In Case Study 4, the Crooked River Weed Management Area (CRWMA) conducted a cost-analysis of the efficacy of using soil enhanced bacteria (e.g., MB906) and herbicides to reduce invasive annual grasses and increase native perennial grasses.[22] In October 2016, the CRWMA treated 7 sites with bacteria only (794 ha [1,962 total acres]) and 4 sites with both herbicide and bacteria treatments (426 ha [1,053 total acres]). Weather challenged the implementation and treatment success, and soils were thought to have influenced treatment outcomes. Ultimately the managers learned the bacteria treatment was costly and not worth using again. Herbicide treatments were successful in reducing invasive annual grasses in the short term, but limited funding prevented re-treatment or follow-up re-seeding efforts. Management effectiveness varies across soil types and weather conditions, which again highlights the complexity of the issue and persistent knowledge gaps.

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Opportunity: database documenting success/failures under various conditions

Although previous research documented the success of MB906 bacteria,[23] it was only under a narrow range of spatial and weather conditions. Furthermore, recent research demonstrated soil-enhancing bacteria was ineffective [24,25] or had mixed results.[26] Managers continue to attempt to scale up science-based land management strategies with minimal success under certain conditions. This highlights the need for a comprehensive land treatment database containing information about site characteristics, weather conditions, and treatment outcomes associated with land treatment projects. While science plays an indispensable role of vetting potential management treatments, scientific results often do not align well with fiscal constraints, management planning, and decision-making imperatives. A land treatment database could supplement decision-making with timely information for evaluating "untested" treatments. Ideally, a land treatment database would include information to provide robust interpretations of treatment (project) success or failure and likely contributing factors. Attaching basic information such as elevation, ecological site, pretreatment vegetation composition, and annual precipitation to treatments and treatment outcomes would greatly increase data available for evaluating efficacy of management practices under a broader range of ecosystem variability compared with conventional plot-based research.

Case studies: capturing complexity and capitalizing on collaboration

These four case studies (Table 1) exemplify many of the challenges managers face when implementing science-based invasive annual grass management in a complex environment. Each case study provides a wealth of lessons learned and opportunities for future change, and the 2020 Invasive Annual Grass Workshop provided an opportunity to share them with fellow managers and researchers. While workshops represent an effective method for communication among colleagues, they cannot convey the wealth of knowledge and expertise of current natural resource professionals. Furthermore, to tailor workshops to the specific information needs of individual managers and their unique circumstances would be challenging. Managers need more timely information than can be delivered via periodic workshops. CCAST is an example of a platform to share case studies such as these described here but has limitations: case studies can only be shared by CCAST members, and the search ability is limited to tag words. An easily searchable database documenting management efforts, site characteristics, weather conditions, and treatment outcomes could improve the efficacy of future restoration projects and quicken the pace of knowledge transfer.

Currently, this database does not exist, but we have a system for documenting land treatments on primarily BLM land using the Land Treatment Digital Library (LTDL),[27,28] and the integration of those treatments within a land management planning tool in the Land Treatment Exploration Tool (LTET).[29] Indeed, LTDL houses an inventory of BLM land treatments searchable by treatment type, spatial location, and planning or implementation using specific identifiers (e.g., project number). However, LTDL does not include information about site characteristics, weather conditions, or treatment outcomes associated with land treatment projects, and currently is focused predominately on BLM lands. As in any library, LTDL is only as good as the information recorded and submitted for archiving, so the completeness and quality of records can vary within the database. LTET integrates data from LTDL, the Soil Survey Geographic Database (SSURGO), and National Resources Conservation Service (NRCS) ecological site descriptions. It contains information on climate and drought histories, US Fish and Wildlife Service information for planning and consultation, and a 12-month drought forecast to identify when treatment success might be favorable as well as drought predictions for the next year. Although the LTET is a useful tool for planning future treatments, it was not designed to capture information related to project outcomes.

Building a comprehensive database to document management outcomes is challenging because assembling such a database requires substantial coordination between different federal, state, local, and tribal agencies, and buy-in from a rangeland community lacking implementation capacity and that can be fiercely independent. The creation of this database requires sufficient investment in additional capacity to focus on the coordination, communication, population, and maintenance of a formal system for learning from adaptive management efforts. While perhaps ideal, this would be a long-term process. So where does that leave us in the meantime?

Working with what we have

We have useful and relevant tools to understand the efficacy of invasive annual grass treatments under a variety of site and environmental conditions. We can leverage the LTDL and LTET, by pairing them with the other remotely sensed products like the Rangeland Analysis Platform (RAP)[30,31] or Rangeland Cover Map (RCMAP)[32] to inform adaptive management efforts. For example, if we are interested in controlling invasive annual grasses in an area of rangeland located within or near the Burns District BLM, we can query the LTDL or LTET for relevant treatments in the geographic area of interest. An authorized user would query LTDL or LTET for Case Study 1 (Table 1) to retrieve the site characteristics, boundary, year, treatment type, implementation details, and any discoverable documentation accompanying the treatment or project such as planning documents and monitoring reports. Unfortunately, only about 21% of treatments/projects within LTDL have documentation on effectiveness monitoring, because there is a lack of reported documentation to the LTDL.[33] The LTDL and LTET provide a shapefile to download containing the boundaries of

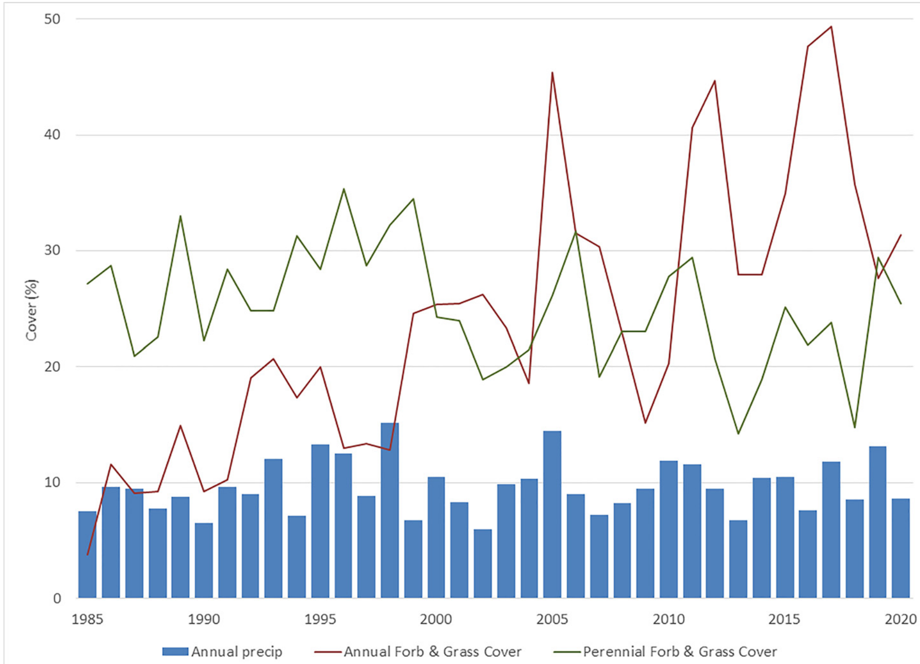

Figure 1. Output from a downloaded shapefile of treatment areas from the Land treatment Data Library (LTDL) from Case Study 1 in the Burns BLM district. The 2020 perennial herbaceous plant cover layer from the Rangeland Analysis Platform (RAP). The treatment area was used to create the cover estimates in the graph showing the percent foliar cover of annual (red) and perennial (green) herbaceous vegetation through time, from 1985 to 2020. The blue bars represent annual precipitation in inches.

treatment or project areas, which when paired with RAP provides plant cover and precipitation data before, during, and after treatment. For example, using the treatment area boundaries in the downloaded shapefile associated with a Burns BLM District 2017 application of pre-emergent herbicide to query RAP for plant functional group cover and precipitation values indicated (Fig. 1):

- Pretreatment (2017 before fall herbicide treatment) cover of annual plants was high (50%) relative to perennial plants (24%).
- Herbicide treatments were conducted during a relatively high precipitation year preceded by a year with lower precipitation.
- Cover of invasive annual forb and grass declined in 2018 and 2019, the 2 years after herbicide treatments, respectively.
- Cover of invasive annual forb and grass increased slightly in 2020 during a year with less precipitation.
- Cover of perennial plants increased in 2019, 2 years after herbicide treatment, but decreased slightly in 2020.

This information indicates pre-emergent herbicide treatments were, at least initially, effective for reducing annual plant cover and increasing perennial plant cover. However, we need additional years of data to fully understand the longer-term effects of herbicide and seeded treatments. Also, although the data from the LTDL/LTET, and RAP provided a general evaluation of treatment outcomes, it does not substitute for on-the-ground monitoring and observations conducted by resource management professionals. Therefore, we suggest contacting project leads and other resource professionals whenever possible. Furthermore, combining multiple decision-support tools could prove problematic for time-limited managers who may be unfamiliar with the LTDL/LTET, RAP, or RCMAP. Managers are unlikely to adopt practices that are overly complex, less accessible (i.e., requiring authorized use), or are not reliably advantageous.[11] Despite these challenges, we are fortunate to be managing in the digital information age, where digital decision support and remotely sensed tools exist free of charge, providing information compatible with the scale of management.

Conclusion

Management case studies present unique opportunities to translate best available science into effective on-the-ground restoration. However, translating science conducted within a narrow range of temporal and spatial conditions into large-scale management presents implementation challenges and often surprising, and sometimes disappointing results. Although awareness and implementation of cutting-edge science can improve management success, researchers often overlook the practical side of scaling up to land management levels and sometimes a reality check is needed. Whenever possible, management and research should complement each other to cultivate closer collaboration between science and land management by integrating research into management opportunities and testing multiple land treatments at management scales. Management benefits from using the most current information to tackle the complex and ever-changing problem of invasive annual grass management, and reality checks provided by managers accelerate scientific breakthroughs from the study plot to the open range. In rangelands combining research and management is the exception, not the rule. With more managers than researchers, most management projects are not conducted near a research facility already conducting similar work. However, remotely sensed tools continue to improve in accuracy and reliability, offering a unique opportunity to bridge the historic gap between researchers and managers.[30,31] Researchers typically restrict the number and scale of sites by necessity, but landscape level analyses conducted by researchers might help land managers better understand where exactly on the landscape a treatment might succeed (or fail). Furthermore, extension agents may help play a critical role in bridging this gap as key management partners conducting applied research.

To advance the learning portion of the adaptive management process used by rangeland managers, we need a tool such as a dynamic management database capturing the variability and successes or failures of past treatments. Such a user-friendly, comprehensive tool is in the future, but in the meantime, managers should use currently available tools such as the LTDL, LTET, SSURGO, and RAP or RCMAP to infer treatment effectiveness across spatial and temporal differences. These tools can inform implementation and hopefully increase a manager's rate of success in conducting land treatments. Lessons learned from management case studies should be accessible through workshops, multiagency and discipline collaborations, and scientific journals that accept case studies with negative or null results (e.g., AoB Plants, or Ecological Solutions and Evidence) and are open access so managers can access these publications to tackle the complex problem of invasive annual grass management.

Declaration of Competing Interest

The authors declare the following financial interests/personal relationships which may be considered as potential competing interests. DDJ and VMS are Guest editors for this Special issue but were not involved with the review or decision process for this manuscript. HEQ is an employee of Bayer R&D Services, LLC. The authors certify that they have no financial interest in the subject matter discussed in the manuscript.

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