Journal of Environmental Management 206 (2018) 807–816

Contents lists available at ScienceDirect

Journal of Environmental Management

journal homepage: www.elsevier.com/locate/jenvman

Research article

Surveying managers to inform a regionally relevant invasive *Phragmites australis* control research program

C.B. Rohal [a, *], K.M. Kettenring [a], K. Sims [b], E.L.G. Hazelton [a], Z. Ma [c]

[a] Department of Watershed Sciences and Ecology Center, Utah State University, United States
[b] Department of Economics, University of Tennessee, United States
[c] Department of Forestry and Natural Resources, Purdue University, United States

ARTICLE INFO

Article history:
Received 22 May 2017
Received in revised form
21 August 2017
Accepted 23 October 2017

Keywords:
Invasive species
Knowledge co-production
Knowing-doing gap
Phragmites australis
Utah
Wetland restoration

ABSTRACT

Managers of invasive species consider the peer-reviewed literature only moderately helpful for guiding their management programs. Though this "knowing-doing gap" has been well-described, there have been few efforts to guide scientists in how to develop useful and usable science. Here we demonstrate how a comprehensive survey of managers (representing 42 wetland management units across the Great Salt Lake watershed) can highlight management practices and challenges (here for the widespread invasive plant, *Phragmites australis*, a recent and aggressive invader in this region) to ultimately inform a research program. The diversity of surveyed organizations had wide-ranging amounts of *Phragmites* which led to different goals and approaches including more aggressive control targets and a wider array of control tools for smaller, private organizations compared to larger government-run properties. We found that nearly all managers (97%) used herbicide as their primary *Phragmites* control tool, while burning (65%), livestock grazing (49%), and mowing (43%) were also frequently used. Managers expressed uncertainties regarding the timing of herbicide application and type of herbicide for effective control. Trade-offs between different *Phragmites* treatments were driven by budgetary concerns, as well as environmental conditions like water levels and social constraints like permitting issues. Managers had specific ideas about the plant communities they desired following *Phragmites* control, yet revegetation of native species was rarely attempted. The results of this survey informed the development of large-scale, multi-year *Phragmites* control and native plant revegetation experiments to address management uncertainties regarding herbicide type and timing. The survey also facilitated initial scientist-manager communication, which led to collaborations and knowledge co-production between managers and researchers. An important outcome of the survey was that experimental results were more pertinent to manager needs and trusted by managers. Such an approach that integrates manager surveys to inform management experiments could be adapted to any developing research program seeking to be relevant to management audiences.

1. Introduction

The management of invasive species is a major priority for land managers, but in many cases managers lack species-specific information to inform management actions (D'Antonio et al., 2004). While the peer-reviewed literature on biological invasions is expanding rapidly (Lowry et al., 2013), land managers who regularly contend with controlling invasive species consider it only moderately useful for guiding their invasive species management programs (Matzek et al., 2014). Often described as a "knowing-doing gap," it is widely recognized that managers rarely incorporate scientific evidence into management decisions (Sutherland et al., 2004; Anonymous, 2007; Arlettaz et al., 2010; Esler et al., 2010). The reasons for this divide are multifaceted. Some culpability rests with managers who may not have easy access to scientific information (Walsh et al., 2015), or lack time to find and interpret scientific findings (Pullin and Knight, 2003). At the same time, scientists have not done enough to translate their research into real-world applications, or to produce research that is relevant to management decisions (Palmer, 2009; Kettenring and Adams, 2011; Braunisch et al., 2012). Broadly speaking, researchers have

* Corresponding author.
E-mail address: christine.rohal@gmail.com (C.B. Rohal).

https://doi.org/10.1016/j.jenvman.2017.10.049
0301-4797/

moved beyond the traditional information deficit model to understanding this "knowing-doing gap" through a lens of knowledge co-production (Dilling and Lemos, 2011; Pouliot and Godbout, 2014; Laatsch and Ma, 2016), the idea that citizens have the ideas and competence to participate in defining issues and producing legitimate knowledge (Pouliot and Godbout, 2014).

While there is extensive discussion about the shortage of research directly relevant to invasive species management (Kettenring and Adams, 2011; Bayliss et al., 2013; Matzek et al., 2015), there is less clarity about *how* scientists can develop a research program that is pertinent to management audiences. For researchers to produce findings that practitioners will find not only "useful" but also "usable" (Prokopy et al., 2013), invasive species scientists should begin by opening up paths of communication (Anonymous, 2007; Hulme, 2014; Larson et al., 2011). Managers and scientists recognize the value of cooperation, yet this realization has not been translated into widespread collaboration and knowledge sharing (Renz et al., 2009; Dickens and Suding, 2013). By reaching out to a wide spectrum of managers early in the research process, and integrating their feedback into research decision-making, scientists will increase their ability to produce results that will have more significance to on-the-ground practice (Wagner et al., 2008; Matzek et al., 2014).

Specifically, applied invasive species researchers should seek to understand managers' current knowledge and uncertainties, their management goals and objectives, and the constraints that limit management action when developing research programs. Managers have a wealth of experience and knowledge that is not well-reported (Rowe, 2010), but is critical in identifying common practices that are in need of improvement or those that have been inadequately evaluated (Sutherland et al., 2004; Palmer, 2009). Researchers need to question managers about their goals for a desired state following management in order to identify uncertainties (opportunities for research) in how to achieve this target (Wagner et al., 2008; Ntshotsho et al., 2015a). Researchers should also inquire about the practical, economic, and socio-political constraints to management actions, in order to ensure their research is useful within this context. Organizational structure and the priorities of management objectives often determine whether certain applied science informs practice (Ntshotsho et al., 2015b). Furthermore, researchers need to understand the scale at which management efforts take place in order to take into account the practical and budgetary constraints under which managers operate (Kettenring and Adams, 2011; Matzek et al., 2015).

Here we present the results of a survey of wetland managers in the Intermountain West with a focus on a communication effort initiated by scientists to inform the direction of invasive species research that would be most applicable to management needs. Beyond informing research development, this survey served as at first step in communication which led to collaborations and knowledge co-production between managers and scientists, improving the credibility and usability of research results. The focal invasive species is *Phragmites australis* (Cav.) Trin. Ex Steud., one of the most studied invasive plant species in North America (Pyšek et al., 2008; Kettenring et al., 2012; Meyerson et al., 2016). Yet, mirroring the pattern noted with invasive plants in general (Matzek et al., 2015), applied research is heavily under-represented, and there is an expressed need for greater cooperation between *Phragmites* managers and scientists (Hazelton et al., 2014).

Phragmites is a widespread and growing invasion in the wetlands of the Intermountain West, particularly Utah's Great Salt Lake (GSL) watershed (Kettenring et al., 2012). The GSL watershed is designated a site of hemispheric importance due to the millions of shorebirds and waterfowl who stage here on the Pacific and Central flyways (Western Hemisphere Shorebird Reserve, 2016). Managers thus view the invasion of *Phragmites* as particularly problematic as it outcompetes native plants and can replace mudflats and open water that are important habitats for these species (Kettenring and Mock, 2012; Kettenring et al., 2012). Private, state, and federal land managers have begun control efforts in this region, though there are no region-specific studies to guide management decisions, so control programs are still being developed and refined. In addition, because the regional invasion is relatively recent, with evidence of its presence starting in the mid-1990s (Kulmatiski et al., 2011), coordinated efforts to evaluate *Phragmites* management efforts and communication amongst managers have lagged behind other regions (see Braun et al., 2016 for an initiative in the Great Lakes region of Midwestern North America).

Managers must make decisions within a landscape that is inherently complex (with spatial, functional, and qualitative dimensions) (Papadimitriou, 2010, 2012), making it important to gain insight into how they address competing and complex decisions regarding *Phragmites* management in the context of the GSL watershed landscape. Managers must contend with meeting multiple management objectives in addition to addressing a challenging new invasion, while region-specific constraints likely influence management decisions and options. Furthermore, the GSL watershed has both native (*Phragmites australis* subsp. *americanus*) and non-native, invasive *Phragmites* (Kulmatiski et al., 2011; Kettenring and Mock, 2012), which are morphologically similar but differ in their ecological impact, leading to added complexity in management decisions. We conducted a survey of Utah wetland managers to assess wetland managers' local knowledge regarding the establishment and extent of native and invasive *Phragmites* in this region, characterize invasive *Phragmites* management programs, and determine conflicts and trade-offs between *Phragmites* management strategies and other forms of management. This survey was a first step in developing regionally-relevant, large-scale experiments to evaluate *Phragmites* control efforts in the Intermountain West region. The research community can use this project as a case study on how they can engage managers to guide and improve their own management-focused research.

2. Methods

2.1. Survey region

The GSL watershed is a basin of approximately 90,000 km^2 (Mann and Lall, 1995) located in the Great Basin Desert. Water availability for wetlands is limited by frequent drought and water diversions throughout the basin, leading managers to seek innovative solutions to protect their wetlands (Downard et al., 2014). Managers acquire water rights to ensure water has a legal basis for arriving in management units, though the timing and amount of water delivered is not always certain. In addition, wetland managers maintain shallow impoundments to mitigate water scarcity, which gives managers some control over water levels in management units (Downard et al., 2014). Managers must also contend with a large urban population in the vicinity of their wetlands, as approximately 88% of Utah's population lives in the counties adjacent to the GSL and Utah Lake wetlands (Utah Economic Council, 2016). The close proximity to urban populations leads to restrictions on land management techniques in management units, particularly with burning, because of air quality concerns.

2.2. Survey methods

We conducted a comprehensive survey of all known wetland managers across public and private lands in the GSL watershed. While we did not know the exact location of all *Phragmites* in the