An exploration of the human dimensions of riparian tamarisk control in Canyonlands National Park, Utah

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NPS PHOTO

Figure 1. Invasive tamarisk vegetation dominates much of the shore of the Green and Colorado Rivers in Canyonlands National Park. Human dimensions research sought to understand visitors' knowledge of tamarisk, support for its removal, norms and preferences for control methods, and the need for more interpretation of invasive species control and ecological restoration.

Abstract

We examined human dimension aspects such as visitor knowledge, acceptability, and social implications of invasive alien species management in Canyonlands National Park river corridors. Tamarisk control methods applied in riparian park visitation areas support restoration of natural resource landscapes and high-quality visitor experiences. River users (n = 330) were questioned about their knowledge of tamarisk and preferences for tamarisk management on the Green and Colorado rivers within the park. We examined overall self-assessed knowledge of tamarisk, norms for different control method application options (e.g., cut-stump, tamarisk beetle, prescribed fire, mechanical), soundscape implications, and desire for increased interpretation regarding tamarisk and related management. Findings revealed (1) a lack of overall knowledge of tamarisk; (2) weak acceptability and agreement among park visitors for removal by cutting, biological defoliation, and burning; (3) variation of acceptability of and agreement with the location of a proposed application method; (4) sensitivity among respondents related to soundscape impacts on wilderness settings; (5) and a strong desire for more interpretation of tamarisk management. Many respondents stated they supported tamarisk removal for reasons that align with ecological health. A discussion of social, management, and future research implications concludes the article.

Key words

interpretation, invasive species, land management practices, restoration, riparian recreation

DURING A PARK EXPERIENCE, what do visitors think about ecological resource management practices used to control invasive species? This is a question we sought to answer related to tamarisk control along river corridors in Canyonlands National Park in Utah.

Tamarisk is a prevalent invasive alien plant genus found commonly on the waterways of the Colorado Plateau in the western United States. To survive dry desert climates, tamarisk grows close to water sources and forms thick groves along riverine corridors such as the Colorado and Green rivers (fig. 1). Some public land management agencies, such as the National Park Service (NPS) and the Bureau of Land Management (BLM), have employed numerous efforts and resources to control invasive plant species and restore areas to a more natural state. Executive Order 13112 mandates federal agencies, where practicable and permitted by law, to take actions including preventing the introduction of invasive species, detecting and responding rapidly to and controlling populations of such species in a cost-effective and environmentally sound manner, and providing for restoration of native species and habitat conditions in ecosystems that have been invaded (Williams 2005). Methods used to control tamarisk have included manual removal (pulling trees and cutting stumps), mechanical (mulching trees), chemical control (foliar herbicide application), biological control (the release of the tamarisk leaf beetle, *Diorhabda elongate*), and prescribed fire (Belote et al. 2010; Harms and Hiebert 2006).

While diverse methods are used to control tamarisk, public natural resource management decisions may need to consider policy and social factors tied to visitor experiences. The National Park Service (NPS) mission, for example, strives to preserve park resources and values for visitor enjoyment (USDOI 2006). Studies have acknowledged that invasive species' presence along river corridors could alter opportunities for shade, shore access, safety elements, access to cultural sites, scenic viewing, and opportunities for viewing wildlife during river-based recreation experiences (Belote et al. 2010). Few studies have addressed the human dimensions of managing invasive species, such as stakeholder knowledge of ecological aspects of public lands, support for or opposition to invasive species control methods, and need for interpretation regarding these areas of public land management (Hultine et al. 2010). More research is also needed regarding human dimensions of invasive species management along river corridors closely tied to communities dependent on recreation and tourism uses of the river resource. This article examines river users' knowledge of tamarisk, desire and reasons for removal, acceptability of control methods, potential for disagreement about acceptable control methods, implications for visitor experience setting and soundscape, and preferences for additional tamarisk management interpretation and education along the Green and Colorado river corridors.

Invasive alien species management

The introduction and spread of invasive alien species is one of the major threats to environments worldwide. These species can alter habitat structure and reduce native species diversity (Belote et al. 2010; Daab and Flint 2010). Riparian ecosystems are vulnerable because they provide many opportunities for new species to become established through natural and human disturbances (Brown and Peet 2003; Tabacchi et al. 2005). Anthropogenic impacts on river ecosystems can include altered flow regimes, historical land use, and introduction of invasive species for purposes such as erosion control. These impacts can alter ecosystems' competitive hierarchies and favor species with different life-history traits (Tickner et al. 2001).

A plant genus on the Colorado Plateau that may have benefited from the alteration of riverine environments is tamarisk, or salt cedar (*Tamarix* spp.). Tamarisk was first introduced in the United States as an ornamental plant in the 1800s. Shortly thereafter, it was introduced on western rivers to provide ecosystem services such as erosion control (Stromberg et al. 2009). Today tamarisk is one of the most successful invasive alien plant species at outcompeting natives in riparian areas. It is the third most prevalent woody riparian plant in the western United States (Friedman et al. 2005); with life-history traits that allow it to endure higher soil salinity, heat, and excessive drought, tamarisk has the ability to outcompete native cottonwoods and willows (Di Tomaso 1998).

Research on invasive alien plant species includes impacts on native ecosystems and efficacy of potential for control methods on public lands and river corridors (see D'Antonio and Meyerson 2002, for example). Studies have identified the need for more research regarding the social implications of invasive alien species management on and around public lands and waterways (Friedman et al. 2005), such as the impacts of invasive alien plant management on public outdoor recreation areas and the visitor experience (D'Antonio and Meyerson 2002). For example, public land management agencies like the National Park Service seek an understanding of recreation-based stakeholders' input coupled with natural resource–based research to inform planning and decision making. Research regarding topics such as park visitors' preference for invasive alien plant management in riparian recreation corridors could provide managers with more information on the level of agreement among visitors about managing prevalent invasive species.

We were unable to make an exhaustive comparison of all possible tamarisk control methods (e.g., chemical) at Canyonlands National Park because of the limited selection of methods available to the National Park Service in this management setting. Therefore, we focused on an assessment and comparison of norms for the mechanical, cut-stump, burning, and tamarisk leaf beetle methods. Although tamarisk beetle release is not permitted by the National Park Service, the beetle control option is presented in this research site.

Conceptual background

Normative research

Human dimensions of natural resource management research includes the study of social norms, which provide descriptive and evaluative information necessary for managers to identify goals and set standards (Vaske and Whittaker 2004). Past recreation research has defined norms as standards that individuals use for evaluating actions, or conditions caused by actions, as good or bad, better or worse (Shelby et al. 1996). Norms are held by individuals personally, and the aggregate of personal norms can be considered social norms. Managers have used normative data reported by various research studies to understand and describe acceptable conditions, standards, or actions for management of public land- or water-based recreation areas (Vaske and Donnelly 2002).

One application of normative research is to compare norms in different settings. This application has been used to compare indicators, such as visitor encounters on high-use and backcountry trails, ecological conditions at wilderness campsites, biophysical conditions vis-à-vis river flows, and boat encounters on whitewater river trips (Whittaker and Shelby 2002). Various studies have helped managers determine standards for indicators like social carrying capacity. The river user norms addressed in this research may be of most importance to the National Park Service because of policy requiring that it protect visitor experiences within its jurisdictional areas. The study area for this research, along river corridors flowing mostly through Canyonlands National Park, included stretches of remote backcountry and proposed wilderness. In these areas, management decisions cannot be based solely on control methods that are most effective for ecological health. Even though the rivers themselves are not proposed wilderness, areas adjacent to them are. Thus, special consideration must be given to protecting social values for recreation experiences, such as tranquillity, solitude, and natural condition, that river users may desire when visiting these areas.

Managing parks and similar protected areas with the objective of preserving natural soundscapes is becoming an important aspect of public land and waterway management (Ambrose and Burson 2004). With various human-caused noises from aircraft, vehicles on roads, infrastructure maintenance, and park visitors, natural soundscapes are increasingly scarce resources (Park et al. 2009). Visitors in places like national parks want to experience natural quiet and not human-caused noise. Past research has revealed that 91% of visitors are drawn to national parks to enjoy natural soundscapes (Ambrose and Burson 2004; Marin et al. 2011). In general, visitors increasingly exposed to unnatural noise may find it an imposition on a naturally quiet, nature-based experience. This study also addresses river user acceptability (e.g., norms) and agreement (e.g., potential for conflict) regarding soundscapes and invasive alien species control in river recreation areas on the Green and Colorado rivers through Canyonlands National Park. Normative research may help managers set standards that are used in management-by-objective or indicator-based planning and management frameworks.

Management frameworks

Management frameworks are stepwise, sometimes iterative planning processes used to solve complex problems on public lands. Within these planning processes, managers can incorporate descriptive and evaluative aspects into management actions that include ecological, social, economic, cultural, and managerial dimensions. Public input from stakeholders about thresholds or standards for various indicator dimensions is frequently a part of the decision-making process. Management frameworks commonly implemented for this purpose have included, for example, Limits of Acceptable Change (LAC) (Stankey 1988), Visitor Impact Management (VIM) (Kuss et al. 1990), Visitor Experience and Resource Protection (VERP) (Manning 2001), and the Recreation Opportunity Spectrum (ROS) (Manning 2011). Little research exists regarding norms for tamarisk management that may be used in indicator-based planning and management frameworks and subsequent management strategy decision making or action. Our research addressed the norms and preferences of river users to aid in public land planning and management. Visitors may value aspects of the park experience such as scenic quality, access to campsites, shade, and soundscape rather than being knowledgeable of ecological phenomena such as invasive species presence and management. The potential for stakeholder disagreement should be considered when implementing management actions that could impact visitor experiences. This study considers the level of agreement among visitors regarding the acceptability of tamarisk control methods in park river corridors.

Research questions and hypotheses

This research addressed river users' knowledge, preferences, and norms regarding tamarisk management and interpretation along the Green and Colorado river corridors in Canyonlands National Park, Utah. We report on the following research questions in this article: (1) What level of overall, self-assessed knowledge about tamarisk removal exists among visitors? (2) Do visitors desire tamarisk removal? (3) How does acceptability vary among tamarisk control methods? (4) Does the acceptability of particular control methods differ depending on the location of application (within campsites or not)? (5) How much do visitors agree with one another regarding these evaluations? (6) How do visitors evaluate soundscape implications of tamarisk removal? (7) Is more interpretation warranted? The research project followed a line of research questions rather than hypotheses, as there are few studies on which to base a comparison. However, exploratory hypotheses (H) could have included the following:

H1: Visitors (e.g., river users) will have different mean acceptability ratings (e.g., norms) for tamarisk control methods.

H2: Visitors will be less accepting of control methods that could cause more impacts or impositions on their park experience.

H3: Acceptability evaluations (e.g., norms) will differ depending on the location of control method application.

H4: Visitors will have less agreement for rating the acceptability of control methods that could cause more impacts or impositions on their recreation experience.

H5: Visitors will be less accepting of the use of chainsaws for invasive species control in wilderness-type settings versus settings closer to a town or higher-use settings.

H6: Visitors will have more agreement regarding the use of chainsaws in proposed wilderness areas along the Green River corridor.

H7: More tamarisk management interpretation will be desired by visitors.

Methods

Study site and data collection

This research focused on river recreation areas along both the Green and Colorado rivers. Both river sections flow through areas of Canyonlands National Park, Bureau of Land Management (BLM) lands, and some private lands. River users participated in private flat-water (i.e., no rapids) boating trips (e.g., nonguided canoeing) starting at Mineral Bottom on the Green River and arriving at Spanish Bottom approximately 84 kilometers (52 mi) downstream. The flat-water river float section generally concludes at Spanish Bottom located shortly after the Green River flows into the Colorado River, immediately before the first white-water rapid of class IV Cataract Canyon. Researchers approached respondents to answer questionnaires after the completion of their river recreation experience while returning by jet boat shuttle approximately 81 kilometers (50 mi) upstream on the Colorado River to the Potash Boat Ramp take-out in Moab, Utah.

The area of study along the Green and Colorado rivers experiences approximately 2,000 annual river users. Lands adjacent to the river corridor in Canyonlands National Park are proposed wilderness areas. This section of the Green River generally receives nonmotorized, private boater use, whereas this section of the Colorado River experiences more frequent commercial jet-boat tours. Researchers gathered 330 completed questionnaires from river recreationists during the river recreation season, which spanned the months of April to October 2011. An unusually high-water year was experienced by researchers during data collection, which made access to the area unavailable for several weeks in May when the National Park Service and other commercial companies strongly recommended that recreationists not float the river for safety reasons. Data collection followed a systematic random sampling scheme, accounting for factors such as different days and times of use (e.g., low and high use) and varying influxes of river-based activities (e.g., commercial rafting season, private canoeing season) throughout the 2011 river season.

Researchers randomly varied the times of day and day of the week for administering surveys to every fifth person on the shuttle to control for selection bias and allow for generalization to the corridors' population of river users with 95% confidence that data were not found by chance (Salant and Dillman 1994). Visitors were not offered an incentive and were asked to complete the survey in confidential circumstances while riding the return jet-boat shuttle immediately after the trip. The on-site survey approach helped to control for memory loss and allowed for continued viewing of areas (matched with provided photographs and locations confirmed by researchers when questioned) where tamarisk control methods had been implemented along the river corridors. Refusal rates were less than 10% (90% participation rate) and a lack of nonresponse bias existed for this study.

Variables

The self-assessment of river users' knowledge of tamarisk used a single item of measurement on a four-point scale of 0, "no knowledge"; 1, "some knowledge"; 2, "advanced knowledge"; and 3, "expert knowledge." To serve as a baseline of information, four photos were placed on the questionnaire depicting each tamarisk control method. Photos included mechanical control methods: (1) large earthmoving machinery digging up woody debris, (2) smoke and flames rising from a burning tamarisk stand with burnt plants within view, (3) cut-stump treatment with laborers present using handsaws and chainsaws, and (4) browned tamarisk defoliated by tamarisk leaf beetle colonization.

Normative research has previously used image-capture technology, such as photographs, which may allow respondents to comprehend conditions more comprehensively than providing solely a written description of the indicator to be evaluated (Ceurvorst and Needham 2012; Manning and Freimund 2004; Manning et al. 1996; Moyle and Croy 2007; Shelby and Harris 1985; Shelby et al. 2003). User norms for the acceptability of tamarisk control methods in campsites and between campsites, for soundscapes, and in different river corridor settings were found through aggregated evaluative responses. Questions regarding the acceptability of control methods were evaluated on a scale of acceptability ranging from −2, "very unacceptable," to +2, "very acceptable," with 0, "neither," as a neutral point.

Respondents answered a closed-ended question concerning whether or not they wanted tamarisk to be removed from the river recreation area. Respondents were prompted with an open-ended question to elaborate on the main reason they did or did not want tamarisk to be removed. Finally, the questionnaire assessed whether or not more interpretation and education about tamarisk were needed by asking respondents for their preferences.

Results

Knowledge of tamarisk, support for its removal, and desire for more interpretation

Table 1 summarizes visitor level of tamarisk knowledge, preferences for its removal, desire for more interpretation of tamarisk, and saw type preference. Few respondents indicated having "advanced knowledge" (17%)

or "expert knowledge" (3%). Overall, most river users (80%) assessed their knowledge at low levels (e.g., some or no knowledge).

Most river users (88%) would like tamarisk to be removed from the river corridors. Many respondents (62%) stated they supported tamarisk removal for biocentric-based reasons (e.g., those that align with ecological health or the benefit of nature). For example, written comments from respondents expressed support for tamarisk removal because the plant is invasive or is not supportive of a healthy, native riverine ecosystem. Some respondents (9%) reasoned in favor of tamarisk removal for recreation-specific reasons (e.g., access to shore for recreation or safety). The remainder of respondents (29%) in favor of tamarisk removal did not articulate reasons for supporting its removal from the corridor. Few respondents (6%) provided reasons for opposing tamarisk removal. When asked to provide reasons why they did not want tamarisk to be removed, respondents provided open-ended sentiments, such as wanting to "leave nature alone," thinking the tamarisk removal "task was too large," and believing that "tamarisk was not a problem."

Since some interpretation and education materials on tamarisk exist at river access ramps, park visitor centers, and local community businesses, river users were asked about their desire for additional education and interpretation regarding tamarisk and tamarisk management in the questionnaire. Most respondents (84%) reported that they would prefer more educational or interpretive information regarding tamarisk (table 1). This finding offers public land managers a nonintrusive and effective way to inform the public about management actions. Offering additional education could assist public land managers in influencing awareness and social acceptability of tamarisk management.

Preferences for saw use and norms for chainsaw noise

Sixty-two percent of respondents indicated that they would prefer the use of chainsaws over handsaws for tamarisk removal (table 1). While the use of a chainsaw would alter the soundscape and potentially infringe upon visitor experience, river users in this sample evaluated the use of chainsaws as acceptable on both the Green and Colorado rivers. On the scale of acceptability for chainsaw noise from −2, "very unacceptable," to +2, "very acceptable," the average evaluation of acceptability (e.g., norm) on the Colorado River was 0.49. Chainsaw noise on the Green River was found to be slightly less acceptable, with a norm of 0.33 (table 1).

Norms for noise on the Green and Colorado rivers

Chainsaw noise produced while removing tamarisk on the Colorado River was found to be more acceptable than hand-sawing, and had a score of 0.25 in agreement among users, whereas the Green River had less respondent agreement, with a PCI_2 of 0.31 (table 2). Visitors rated chainsaw noise as less acceptable in the more wilderness setting of the Green River than in the higher-use areas on the Colorado River; however, chainsaw noise for the removal of tamarisk was found acceptable to river users regardless of location applied.

Norms and potential for conflict

Table 3 compares statistically significant differences in norms for application of the four different tamarisk control methods

Table 1. Visitor tamarisk knowledge, removal preference, and desire for more interpretation

Knowledge level	None: 23%	Some: 57%	Advanced: 17%	Expert: 3%
Removal preference	Remove: 88%		Do not remove: 12%	
More interpretation	Desired: 84%		Not desired: 16%	
Saw type preference	Chain saw: 62%		Handsaws: 38%	

Table 2. Comparison of visitor acceptability and agreement levels for saw use

	Green River	Colorado River
Acceptability (norms) for chain saw noise[1]	0.33	0.49
Normative agreement for chain saw noise[2]	0.25	0.31

[1]The mean is the sum of the individual values for each respondent divided by the number of cases. Evaluation is on a scale ranging from −2, "very unacceptable," to +2, "very acceptable," with 0, "neither," as a neutral point.

[2]The potential for conflict (PCI_2) is measured on a scale ranging from 0, "minimum potential conflict," to 1, "maximum potential conflict."

Table 3. Visitor norms for tamarisk control methods and application location

Tamarisk Control Method and Location	Mean[1]	PCI_2[2]	Standard Deviation	*p*-value[3]
Burn between camps	0.62	0.40	1.21	0.001
Burn in camps	0.41	0.45	1.26	0.001
Cut-stump between camps	0.97	0.23	1.00	0.072
Cut-stump in camps	0.93	0.25	1.05	0.072
Beetle between camps	0.95	0.33	1.19	0.001
Beetle in camps	0.86	0.36	1.24	0.001
Mechanical between camps	0.02	0.49	1.36	0.116
Mechanical in camps	0.05	0.48	1.34	0.116

[1]The mean is the sum of the individual values for each respondent divided by the number of cases. Evaluation is on a scale ranging from −2, "very unacceptable," to +2, "very acceptable," with 0, "neither," as a neutral point.

[2]The potential for conflict (PCI_2) is measured on a scale ranging from 0, "minimum potential conflict," to 1, "maximum potential conflict."

[3]Between camp and in and adjacent to camp values are paired-samples *t*-test analyses.

Table 4. Differences in the potential for conflict over tamarisk control methods

Areas Respective of Camps	Tamarisk Control Method and Location of Application: Burn Between	Burn In	Cut-stump Between	Cut-stump In	Beetle Between	Beetle In	Mechanical Between	Mechanical In
Burn between camps	—	1.04	3.81	3.36	1.45	0.83	1.99	1.79
Burn in camps	1.04	—	5.19	4.73	2.47	1.81	1.06	0.86
Cut-stump between camps	3.81	5.19	—	0.50	2.00	2.60	6.12	5.80
Cut-stump in camps	3.36	4.73	0.50	—	1.57	2.18	5.68	5.36
Beetle between camps	1.45	2.47	2.00	1.57	—	0.56	3.31	3.10
Beetle in camps	0.83	1.81	2.60	2.18	0.56	—	2.65	2.46
Mechanical between camps	1.99	1.06	6.12	5.68	3.31	2.65	—	0.13
Mechanical in camps	1.79	0.86	5.80	5.36	3.10	2.46	0.13	—

Note: Values >1.96 represent the difference between the methods' potential for conflict (PCI_2) values (Vaske et al. 2010). Values are Bonferroni corrected.

applied either between campsites or within or adjacent to campsites accessible from the river study area. Respondents reported that burning, cut-stump, and beetle tamarisk control methods were acceptable in areas both between river-accessible camps and within or adjacent to campsites along the Green and Colorado river corridors. Although a positive mean acceptability level of 0.02 for between camps and 0.05 for within or adjacent to camps was reported for the mechanical removal method, no statistical significance was found.

The potential for conflict (PCI_2, a measure of agreement with a particular control method) over tamarisk control methods implemented within or adjacent to river campsites resulted in PCI_2 values of 0.48 for mechanical removal, 0.45 for burning, 0.36 for salt cedar beetle, and 0.25 for the cut-stump method (table 3). Results indicate that the cut-stump and salt cedar beetle removal methods have the least potential for conflict when implemented within or adjacent to river-based campsites. The potential for disagreement over tamarisk control methods implemented between campsites resulted in PCI_2 values of 0.49 for mechanical removal, 0.40 for burning, 0.33 for salt cedar beetle, and 0.23 for the cut-stump method. These results indicate the cut-stump and salt cedar beetle removal methods have the least potential for causing conflicting social acceptability among visitors when implemented between camps.

Table 3 shows visitors' difference in acceptability ratings (norms) for tamarisk control methods in different settings. Differences in acceptability for burning and tamarisk leaf beetle methods depending on the location of application (e.g., between camps versus in or adjacent to campsites) had a statistically significant result. Both the cut-stump and mechanical removal methods did not result in statistically significant values for differences in application within or adjacent to campsites versus between campsites. In other words, for the mechanical and burning methods, river users did not draw much of a distinction between methods in and between camps (discussed in the previous paragraph); rather they focused on whether the method was acceptable regardless of where it was applied.

For the burning, cut-stump, and beetle control methods, respondents held more agreement for burning, cut-stump, and beetle methods when applied between camps rather than within camps. Respondents had less agreement regarding the acceptability of the mechanical method. In other words, the mechanical method had the largest standard deviation (1.36 for between camps and 1.34 for within or adjacent to camps) out of all the control method options (table 3). The most agreement or smallest standard deviation among respondents was found for the cut-stump and salt cedar beetle removal methods when implemented regardless of the location (e.g., between or within river-based campsites). We observed a general pattern that as the acceptability (e.g., higher mean value) of the control method increased, the potential for disagreement decreased among respondents regardless of whether the method was applied within or between camps.

The differences between potential for conflict for tamarisk control methods between river campsites versus within or adjacent to campsites were found using the PCI_2 difference (d) equation (table 4). In other words this equation compares the PCI_2 values of variables to determine if there is a statistically significant difference between the chosen variables. If the result of this equation is $d > 1.96$, the difference between the compared values is statistically significant at $a = 0.05$. The d values comparing the differences between control methods and location of application are shown in table 3.

Table 4 provides an exploratory approach into a comparison of multiple variables regarding tamarisk management methods and application locations and caution should be exercised regarding the use of this information. For example, the greatest distance in potential for conflict values was found between the cut-stump and the mechanical methods. The opposite is true for potential for conflict distance values between the burning and beetle methods. As a general pattern, more distance existed when the method was applied in campsites versus between campsites. Although this could mean river users may be more sensitive to management disturbances directly affecting their river recreation experiences, a confident conclusion cannot be made based on this study for several reasons. For example, the general pattern of river users being more sensitive or having more varied norms regarding tamarisk control methods implemented within river campsites differs depending on the nature of the control method implemented. Burning tamarisk, for instance, may cause more smoke and pose a safety threat to recreationists using the site. Mechanical removal may cause excessive amounts of noise impeding on the natural soundscape, and large machinery may result in an intolerable imposition on the viewscape of freshly cut stumps.

Discussion and recommendations

These findings have implications for management consideration and further examination. First, visitors who lack knowledge of tamarisk desire more information. River users' interest in receiving additional education should be addressed by public land managers, as outlined in EO 13112 (Williams 2005). In addition to mandating the control of invasive alien species, EO 13112 requires federal land management agencies to educate the public where possible and practical. Examples of this education include interpretive talks by rangers, increased or improved signage, engagement of interested volunteer groups in providing education opportunities, and informative multimedia approaches (e.g., Web site, video, brochures, and river permit packet information) for visitors and other stakeholders. Additional study is warranted as to specific reasoning for and the relationship between level of knowledge and desire for more interpretation. For example, are visitors mostly concerned about enjoying themselves in the outdoors and are they not aware of encroaching invasive species phenomena? Are river users more concerned about loss of beach space for tents, kitchens, or sports; loss of access to riverbanks, eddies, or trails; or loss of larger trees that provide better shade and boat anchoring than ecological decline from a monoculture invasive species? Social desirability could bias respondent concern toward ecological issues, rather than honest and practical reasons for tamarisk removal.

Although visitors had a low level of knowledge, a majority wanted tamarisk removed and many knew it compromised ecological health. Researchers and the survey, however, did not provide respondents with preamble material suggesting tamarisk was an exotic and spreads quickly in riparian areas. An assessment of whether river users knew about the specifics of tamarisk invasion, removal, and site restoration should be conducted. More depth in understanding stakeholder knowledge of tamarisk could be gleaned from a series of questions about knowledge, providing a baseline of information about tamarisk and examining how value orientations relate to knowledge and support for tamarisk removal. Because of the limited and exploratory nature of this study, these research improvements were not addressed. Future research could address these variables, analyze their influences and the potential for disagreement with different control methods, and broaden the scope to a more regional or landscape scale (e.g., areas where tamarisk is prevalent, an entire river corridor, or the entire Colorado Plateau). Combining ecological data with social data could be beneficial for planning and management in these areas.

Second, the vast majority of respondents found burning, use of the tamarisk leaf beetle, and the cut-stump method acceptable; however, acceptability ratings for the mechanical method were not statistically significant. The cut-stump method and use of the tamarisk leaf beetle had the highest acceptability and most agreement among users. Respondents agreed the least in their acceptability ratings for the burning and mechanical methods. Similar trends have been found in potential-for-conflict research where, for example, as degree of acceptability of a proposed action decreases, agreement in ratings also decreases. Previous findings have also shown less agreement among acceptability levels for more heated issues or in situations where it may be difficult to express a norm or rating of how people feel conditions should be or which management actions should be taken. Managers should consider the implications of visitor confusion about unknown tamarisk management methods or resistance from stakeholder groups when implementing actions evaluated with lower mean acceptability and less agreement or a higher level for potential disagreement among visitors.

Third, results additionally revealed different responses to the location of tamarisk management within the proposed wilderness area and for soundscape considerations. As a general pattern, river users were more sensitive or had more varied norms regarding their acceptability ratings for tamarisk control methods implemented within river campsites. Visitor acceptability differed depending on the nature of the control method implemented—in other words, the more impact the control method imposed on the visitor experience, the less acceptable the method was rated or the less it was agreed upon. For example, visitors held the least agreement and acceptability for the burning and mechanical methods within campsites perhaps because of the costs, access, air quality, scenic, and soundscape impacts a large piece of machinery could impose on or around campsites. Burning tamarisk, for instance, may cause more smoke and pose a safety threat to recreationists using the site. Mechanical tamarisk removal, for instance, may cause excessive amounts of noise impinging on the natural soundscape, and large machinery may result in an intolerable imposition on scenery because of freshly cut stumps. More in-depth inquiries could be made regarding the reason responses are given. Managers should exercise caution if using burning and mechanical removal. Respondents indicated less support, less acceptability, and more disagreement about norms for these removal methods. Respondents additionally held more disagreement regarding the acceptability of using these methods within, as opposed to between, campsites. Future research could further assess reasons for differences in stakeholder responses and differences in situational variables, such as location of implementation or other site attributes, and compare them in other locations that experience various levels and types of use.

River users expressed a preference for use of chainsaws over handsaws to remove tamarisk. As in previous studies (see Manning et al. 2006, for example), however, chainsaw noise was less acceptable to most respondents along the wilderness setting of the Green River than in the areas not managed as wilderness on the Colorado River. Contrary to previous soundscape studies in some national parks, respondents in this study found chainsaw noise acceptable for tamarisk removal regardless of location applied, for example close to or within visitation areas (Manning et al. 2006). As in other more in-depth soundscape research, this study neither offered an audio example of chainsaws nor asked about preferences for decibel levels in these settings—topics for further study.

Alteration of scenic views may be important in considering tamarisk control because of the dominant role tamarisk plays in riparian ecosystems. Removing the prevalent tamarisk invasive species from riparian areas could significantly alter the riverbank scenery. Future studies could further focus on visitor opinions regarding scenic quality related to removal of invasive species. For example, an assessment could include displaying before-and-after images of a restoration management site to gain respondents' scenery preferences or asking for input on unique attributes that comprise high-quality scenic viewing opportunities. In this study photographs of the different control method applications were shown to respondents above the line of questioning about rating the acceptability of each tamarisk control method.

This study addressed each aspect of tamarisk management as stand-alone variables and did not address the relationship or influences of knowledge, preferences, and norms. Further research regarding invasive species management might include statistical approaches (e.g., path analysis, cluster analysis) to analyze differences in or influences among variables such as user demographics, activity groups, stakeholder segments, recreation sites, or other social physiological variables relevant to managing recreation resource areas. Likewise, one could argue that the acceptability ratings are merely a social convention of an emerging norm rather than an established norm with the management of this particular invasive species. This is because respondent acceptability levels for any control method was not particularly high and more knowledge regarding tamarisk was desired.

Fourth, our findings may help managers understand norms for river recreationists but do not address any other stakeholders. Public land managers may want to address other stakeholders, such as different recreation-based user groups, commercial outfitters who use river corridors for economic gain, grazing permit holders, river managers, private landowners in or dependent on river corridors, and adjacent communities dependent on rivers with invasive species. In addition tamarisk is the only plant genus addressed in this study. These findings do not consider norms or acceptability for the other diverse gamut of invasive alien species (e.g., Russian olive or thistle) and related control methods available for implementation in the various national park ecosystems and settings. A more comprehensive examination of these topical areas could broaden managers' understanding of how the public responds to invasive alien species management to reduce the potential for conflict situations such as polarization among the public, creating costly measures in decision-making processes. An assessment of respondents' value orientations, or where respondents' values are on a range or continuum from anthropocentric (e.g., managing river corridors to benefit human use) to biocentric (e.g., managing for the benefit of ecosystems and nature), or using other scales based on stakeholders' basic beliefs, may increase understanding of responses to invasive species management and restoration. Overall, more information could be gathered for broader generalization as well as for reasons why visitors rated each method at varying levels of acceptability, which could help managers prioritize areas targeted for tamarisk removal.

Finally, researchers could extend more attention to issues that complement tamarisk management in river corridors. After managers implement the control or removal of prevalent invasive species such as tamarisk, other invasive species may immediately succeed, outcompete, and invade the area because of optimal growing conditions in the ecosystem (e.g., more sunlight and availability of nutrients in the soil). Future studies should address the effectiveness of follow-up restoration techniques that could increase success of native plant succession and support a natural ecosystem state as dictated by public land management policy. A focus of these future studies could be on other alien species associated with populations of tamarisk, such as Russian knapweed (*Rhaponticum repens*, previously called *Centaurea repens*). Finally, future research should further examine the multitude of social implications and human dimensions tied to invasive species control and restoration, thus broadening the scope to other recreation-based areas and beyond.

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