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Adaptive Management as an Effective Strategy: Interdisciplinary Perceptions for Natural Resources Management

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Abstract Adaptive management is a well-established approach to managing natural resources, but there is little evidence demonstrating effectiveness of adaptive management over traditional management techniques. Peer-reviewed literature attempts to draw conclusions about adaptive management effectiveness using social perceptions, but those studies are largely restricted to employees of US federal organizations. To gain a more comprehensive insight into perceived adaptive management effectiveness, this study aimed to broaden the suite of disciplines, professional affiliations, and geographic backgrounds represented by both practitioners and scholars. A questionnaire contained a series of questions concerning factors that lead to or inhibit effective management, followed by another set of questions focused on adaptive management. Using a continuum representing strategies of both adaptive management and traditional management, respondents selected those strategies that they perceived as being effective. Overall, characteristics (i.e., strategies, stakeholders, and barriers) identified by respondents as contributing to effective management closely aligned with adaptive management. Responses were correlated to the type of adaptive management experience rather than an individual's discipline, occupational, or regional affiliation. In particular, perceptions of characteristics contributing to adaptive management effectiveness varied between respondents who identified as adaptive management scholars (i.e., no implementation experience) and adaptive management practitioners. Together, these results supported two concepts that make adaptive management effective: practitioners emphasized adaptive management's value as a long-term approach and scholars noted the importance of stakeholder involvement. Even so, more communication between practitioners and scholars regarding adaptive management effectiveness could promote interdisciplinary learning and problem solving for improved resources management.

Keywords Adaptive management · Effective · Perceptions · Stakeholders · Barriers · Interdisciplinary

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Introduction

Natural resources managers are tasked with the challenge of making management decisions with incomplete knowledge and high complexity, risk, and uncertainty in outcomes. Complex management decisions necessitate a management approach that supports effective decision-making and incorporates changes in practitioner knowledge as management progresses. Adaptive management (AM) is meant to be a systematic and iterative process for improving ecosystem management policies and practices by increasing knowledge and reducing uncertainty (Holling 1978; Walters 1986). Defined and developed by Holling (1978), the concepts of AM directly link management with the hypothesis-driven scientific method and address opportunities for wider stakeholder participation. The AM approach acts as a

learning tool by iterating the process of initiating management action, monitoring the outcomes, analyzing the data, and then adjusting the management action as needed. Well-established throughout the global management community, the AM strategy has been adopted by many conservation organizations, such as the United States Environmental Protection Agency (2009), the Convention of Biological Diversity (2004), the Conservation Measures Partnership (2013), The Nature Conservancy (2007), the World Wildlife Fund (2007), and the United States Department of Interior (2007), making AM prevalent in natural resources management and conservation (Callicott et al. 1999). As such, the theory, applications, and contentions surrounding AM continue to be of interest in the natural resources disciplines.

Despite the popularity of AM in natural resources management discussions, there is contradicting evidence about the effectiveness of AM as a management approach. Reasons include misinterpretations of AM (Rist et al. 2013), the infancy of AM implementation (Lee 2001), and the lack of data that are necessary to make such judgments (McFadden et al. 2011). Due to the length of time required to implement the iterative process of AM fully, and thus make a fair assessment about the AM approach, evidence demonstrating the effectiveness of AM remains sparse. In a selective search of the peer-reviewed literature on AM by McFadden et al. (2011), only 14 % of journal articles reported a case of AM implementation. Much of the literature surrounding AM effectiveness is either based on theory and predictive models generated by academic scholars or on inferential knowledge from management practitioners (e.g., Linkov et al. 2006; Moore and Conroy 2006; Olsson et al. 2006; Rout et al. 2009). This dichotomy has led to concerns regarding a separation between science and management, or a "research-implementation gap", in which peer-reviewed assessments and frameworks are not translated into management action (Bosch et al. 2003; Knight et al. 2008; Medema et al. 2008). For example, Prendergast et al. (1999) recognized that methods designed to identify and organize more effective conservation reserves were rarely implemented due to breakdowns in communication between researchers and managers. We cannot assume that because AM is a "…well-established concept that has received significant theoretical attention" (Eberhard et al. 2009), that it is well-perceived as an effective management approach, or that these perceptions are shared across scholar and practitioner groups. This is especially true when the current body of AM literature alludes to imbalanced sources: theoretical support for AM is published largely by scholars, while evidence of social perceptions of AM are drawn from natural resources practitioners.

Currently, many studies addressing AM call for the implementation of an AM framework (e.g., Shea et al.

2002; Park 2004; Bierwagen et al. 2008; Foster et al. 2010; Foxcroft and McGeoch 2011; Bolte et al. 2014). McFadden et al. (2011) found that only 3 % of articles did not view AM positively, and more than 65 % of the articles analyzed advocated for AM as an appropriate approach for a particular management problem. This might suggest an overall positive perception of AM among scholars. However, AM is a socioecological management approach requiring shared goals and understanding among scientists, managers, and local stakeholders (Szaro et al. 1998). Therefore, a holistic analysis of AM effectiveness should include a broad range of groups, disciplines, and experience levels. Previous literature exploring the social perceptions of AM has narrowly focused on a single discipline, affiliation, or country. In those studies, focus groups are heavily dominated by United States federal government practitioners, as AM implementation is statutorily mandated for several land-management agencies due to the adoption of AM by the US Department of Interior. These studies have often been limited to discussion of a single agency (e.g., US Fish and Wildlife Service—Jacobson et al. 2006; and US Forest Service—Butler and Koontz 2005) or narrowed discipline (e.g., coastal restoration—Downs and Kondolf 2002; Thom et al. 2005; Boesch 2006; forest regeneration—Moore and Conroy 2006; and single species management—Innes et al. 1999; Rout et al. 2009; Belton and Jackson-Smith 2010; Davies and White 2012). As a result, such studies may speak more to the effectiveness of a particular organization or case study than to the effectiveness of the AM approach itself. Broad generalizations on AM effectiveness based on these case studies may not be appropriate, as it remains unclear whether positive responses to AM are consistent across all natural resources disciplines.

Given the shortcomings of the current body of AM literature, a more complete understanding of AM effectiveness can be achieved by analyzing the combined perceptions of both natural resources scholars and practitioners. To our knowledge, this is the first study to concurrently explore responses from both scholars and practitioners and to consider AM perceptions across occupational, geographic, and disciplinary boundaries. Our research objectives were to explore (1) the extent to which management strategies that are perceived as effective align with AM strategies, (2) the stakeholder groups (e.g., policymakers, local citizens, mediators) and barriers (e.g., budgets, limited stakeholder involvement, lack of management experience) associated with perceived AM effectiveness, and (3) how these perceptions compare across disciplines, occupations, geographic regions, and experience. We asked respondents to use their personal experience with AM, whether through direct implementation or research-based study, to identify strategies, stakeholders, and barriers which often lead to or inhibit achievement of

management objectives (i.e., effective management; Table 1). We assessed AM effectiveness by the extent to which effective management was perceived as synonymous with characteristics typically associated with AM. From that assessment, we hypothesized that there would be a high degree of alignment between perceived effective strategies and AM strategies. We also hypothesized that the particular characteristics (i.e., stakeholders, strategies, and barriers) associated with perceived AM effectiveness would vary across respondent disciplines, geographic regions, professional affiliations, type of AM experience (i.e., studying vs. implementing), and years of experience with AM. In analyzing perceptions of AM effectiveness from various groups, we hope to gain a more comprehensive understanding of the perceived effectiveness of AM and to promote interdisciplinary learning, and problem solving for improved resources management.

Methods

Survey Sample and Questionnaire

To define our sample, we identified natural resources practitioners, scholars, and other professionals using a search of publications, management plans, and reports on AM from 2000 to 2015. Searches were conducted in Google Scholar as well as in local and federal government and non-governmental organization (NGO) databases (see Appendix in supplementary material). We used an electronic survey to determine respondent perceptions of AM strategies, stakeholders, and barriers (Table 2). We distributed the survey using the online Qualtrics platform (Qualtrics, Provo, UT) in May 2015 (see supplementary material). The survey design followed an electronic format adapted from the "Total Design Method", a two-wave, mail survey including an email introducing the survey, and a follow-up reminder sent 2 weeks later (Dillman 2000). To decrease the potential for bias, we did not inform respondents at the onset that assessment of AM was an objective of the study, but rather focused on effective natural resources management.

Survey Variables

The goal was to make comparisons between strategies, stakeholder groups, and barriers perceived as characteristic of effective management with those associated with AM. As such, we designed the survey in two parts; one to explore respondent perceptions of effective management and a

Table 1 Types of management that were presented to survey respondents and their corresponding definitions

Management Type	Definition	Source
Effective	Strategies which have the greatest likelihood of achieving management objectives.	Based on goal approach of effectiveness; Etzioni 1964
Adaptive	Flexible decision-making that can be adjusted in the face of uncertainties as outcomes from management actions and other events become better understood.	National Research Council 2004
Traditional	Options aimed at accurate predictions and short-term system equilibrium through top-down policies of control and exclusion.	Agrawal 2002

Definitions of "effective" and "adaptive" management were directly provided in the survey. What is discussed as "traditional" management in the article was more generally referred to as "other management strategies" in the survey

Table 2 Potential barriers and stakeholder groups involved in natural resources management

Barriers	Stakeholders
Budgetary constraints or limited resources	Policymakers
Stakeholder have limited involvement	Land managers
Compliance issues restricting implementation	Government organizations
Interest groups' agendas do not align	Academic researchers/scientists
Management experience is lacking	Mediators
Leadership or organization is lacking	Non-governmental organizations
Management success is not well defined	Local citizens
Learning is not incorporated into the management process	

Options were assembled from the literature (Allen and Gunderson 2011; Williams and Brown 2014)

second to explore perceptions of AM. Because AM is a collective set of integrated strategies and concepts, we aimed to incorporate all strategies together in a holistic measure of perceptions toward effective natural resources management. We achieved this by developing an eight-item question to determine an "AM Score" for each respondent. This question was asked in the first part of the survey, prior to formal mention of "adaptive management". The resulting score reflects the extent to which each respondent considered AM strategies to be characteristic of effective management strategies. We defined AM strategies using the eight steps as described in Rist et al. (2013) and guided by seminal AM literature (Walters 1986; Holling 1978; Table 3). Items related to these steps were each paired with a traditional management strategy that served as a realistic alternative reflective of short-term system equilibrium through top-down policies (Agrawal 2002; Table 1). AM Scores were based on all eight items for which respondents self-reported their experience with effective management by choosing strategies that often lead to achieving objectives.

Likert scales were used to calculate the AM Score. For each of the eight items, management strategies were placed at each end of a four-point Likert scale (Likert 1932) with strategies that aligned with the AM steps at one end and those that aligned with the paired traditional management strategy at the other (Table 3). A four-point scale was used between paired strategies to prevent respondents from satisficing by choosing a neutral response (Garland 1991; Krosnick 1991; Krosnick et al. 2002). We coded responses for each of the eight pairings to a 0–3 point scale, with 0 given to those who chose the traditional management approach and 3 to those who chose the AM approach, allowing for a maximum potential raw AM Score of 24 points. Summing multiple Likert-based statements into a single score allowed for a more robust interpretation of responses with less sensitivity to unintended fluctuations that might occur with eight separate responses (McIver and Carmines 1981; Spooren et al. 2007). Greater values reflected stronger agreement with AM strategies as effective management strategies; lower values reflected stronger agreement with traditional management strategies as effective management strategies. We excluded respondents who answered fewer than six out of eight statements and standardized the remainder of responses based on the total number of statements that were answered (the quotient of AM Score and maximum possible score based on the number of questions answered *100).

Other questions in the first part of the survey were aimed at respondent perceptions of stakeholders and barriers in relation to effective management. Effective management was broadly defined as "an approach that optimizes the likelihood of achieving the management objectives at hand" (Table 1). We asked respondents to rate, on a five-point

Table 3 To calculate an "Adaptive Management (AM) Score", AM strategies were defined using the eight steps described in Rist et al. (2013) and paired with traditional management strategies aimed at accurate predictions and short-term system equilibrium through top-down policies

AM Step	Traditional management strategy	Adaptive management strategy
1. Participation of stakeholders	Top-down regulation of activities by a single agency	Stakeholder involvement and participation
2. Definition of the management problem	Definition of the management objectives and deadlines	Definition of the management problem and uncertainties
3. Establishment of a baseline understanding	Reduction of further risk to the system by immediate implementation of best management practices	Collection of initial information for a baseline understanding of resource
4. Identification of alternatives and uncertainties	Identification of a single, focused management goal	Identification of management alternatives for implementation
5. Incorporation of learning into policy to reduce uncertainty	Implementation of actions and policies to avoid risk	Implementation of actions and policies to increase manager learning potential
6. Monitoring effect of management	Monitoring to determine the progress toward achieving the management objective(s)	Continuously monitoring to increase understanding of the system
7. Reflection and revision based on results	Use of results for annual reporting or publication	Use of results for reflection on management actions based on outcomes
8. Iteration of the AM process	Continued maintenance of the end goal	Revisit and revise original goals based on management outcomes

Respondents were asked: "For the purposes of this survey we choose to define 'effective management' as that strategy which has the greatest likelihood of achieving management objectives. For each pair of management strategies, represented in Columns A and B below, please select the answer between them which reflects the approach that, in your experience, is more likely to lead to effective management". Whether a column held the traditional or adaptive management strategy was randomized for each of the eight steps. There were four possible responses for each pair: "mostly column A", "somewhat column A", "somewhat column B", and "mostly column B", each resulting in a score of 0–3

Likert scale, the potential barriers to effective management and the degree to which objectives are achieved when different stakeholders participate (Table 2). Responses ranged from "strongly disagree" to "strongly agree", and were scored on a −2 to +2 scale. Respondents were then asked whether they were familiar with AM and whether they had experience directly implementing AM strategies. We removed respondents that answered they were unfamiliar with AM from the study prior to analyses (6.3 %, $n = 7$). These questions also determined which respondents had studied, but not implemented, AM (38.2 %, $n = 42$, hereafter "AM scholars"), and which respondents had implemented AM (55.5 %, $n = 61$, hereafter "AM practitioners"), and the number of years of experience studying or implementing AM. It was possible that practitioners could also include scholars who have had implementation experience.

Questions in the second part of the survey were based on a respondent's self-reported experience with AM; they were worded to address either an AM scholar and their "knowledge" or an AM practitioner and their "experience" with AM. This part of the survey posed similar questions as the first, but instead of effective management, questions asked about AM as defined by the National Research Council (2004; Table 1). Given that definition, we asked respondents to identify barriers to AM and stakeholder groups whose participation (a) leads to achievement of AM objectives and (b) would benefit AM. Respondents selected from the same list of multiple barriers and stakeholder groups provided in part one of the survey (Table 2). We also gave respondents the option to write in their own barrier or stakeholder group if they felt one of importance had not been included. Finally, we directly asked respondents to evaluate the effectiveness and cost of AM in comparison to "other management strategies", on a scale ranging from "much less" to "much more". We scored responses for this five-point Likert-type question on a −2 to +2 scale.

Analytical Methods

For analyses, dependent variables included the AM Score from part one of the survey and the direct perceptions of AM in relation to other management strategies from part two of the survey. Independent variables included: (a) gender, (b) age, (c) highest degree received, (d) current career affiliation, (e) professional discipline, (f) continent on which the majority of research or management activities were conducted, (g) if located in the United States, region (e.g., Northeast, Plains, Southwest) in which majority of research or management was conducted, and (h) type of AM experience (scholar or practitioner).

We analyzed data using the statistical software JMP (v.5). A series of correlational tests were used for quantitative analyses. A Shapiro-Wilk test was used to test for normality of AM Scores. We employed one-way analysis of variance (ANOVA) and Student's t-tests for normally distributed variables and either Kruskal–Wallis or Wilcoxon tests for non-parametric variables. We considered relationships significant at $\alpha = 0.05$.

Results

After removing invalid email addresses, surveys were successfully delivered to 579 out of 620 individuals, and 131 surveys were completed (23 % response rate). This response rate is consistent with rates for internet-based surveys (Hayslett and Wildemuth 2004; Shih and Fan 2009). We received responses from five continents: Africa (3 %, $n = 3$), Asia (3 %, $n = 3$), Australia (10.6 %, $n = 11$), Europe (10.6 %, $n = 11$), and North America (73 %, $n = 75$). Ages of respondents ranged from 27 to 72 years with a median age of 49.5 years. Respondents represented a wide variety of natural resources disciplines, including wildlife (30.1 %, $n = 31$), ecology (16.5 %, $n = 17$), social sciences (16.5 %, $n = 17$), forestry (13.6 %, $n = 14$), fisheries (11.6 %, $n = 12$), and water resources (10.6 %, $n = 11$). Respondents included professionals affiliated with universities (40.8 %, $n = 42$), national governments (35 %, $n = 36$), NGOs (13.6 %, $n = 14$), and local governments (10.6 %, $n = 11$). Local government was defined as government positions not associated with the national government (e.g., state, provincial, municipal). Years of AM experience ranged from < 5 (28.1 %, $n = 29$) to > 25 (5.8 %, $n = 6$). Those respondents familiar with AM demonstrated diversity of experience in both studying (40.8 %, $n = 42$) and implementing (59.2 %, $n = 61$) AM across affiliations, disciplines, and continents.

Management Strategies

AM Scores, which compared alignment between AM strategies and strategies perceived as effective (Table 3; $n = 103$ respondents) were normally distributed ($W = 0.98$, $p = 0.29$). AM Scores did not vary by respondent age ($F_{1,95} = 2.77$, $p = 0.10$), gender ($t = 0.10$, $p = 0.92$), natural resources discipline ($F_{8,91} = 1.54$, $p = 0.15$), professional affiliation ($F_{4, 94} = 0.71$, $p = 0.58$) or type of experience ($W = −1.77$, $p = 0.07$; Fig. 1a). However, when directly asked whether AM is more, equally, or less effective than other management strategies, a difference existed in the number of scholars (99 %) and practitioners (87 %) that perceived AM as effective. Among AM scholars, a positive relationship existed between direct perception of AM and AM Score ($F_{5,42} = 5.65$, $p < 0.01$; Fig. 1b). In contrast, AM Scores were not related to the direct perception of AM as an
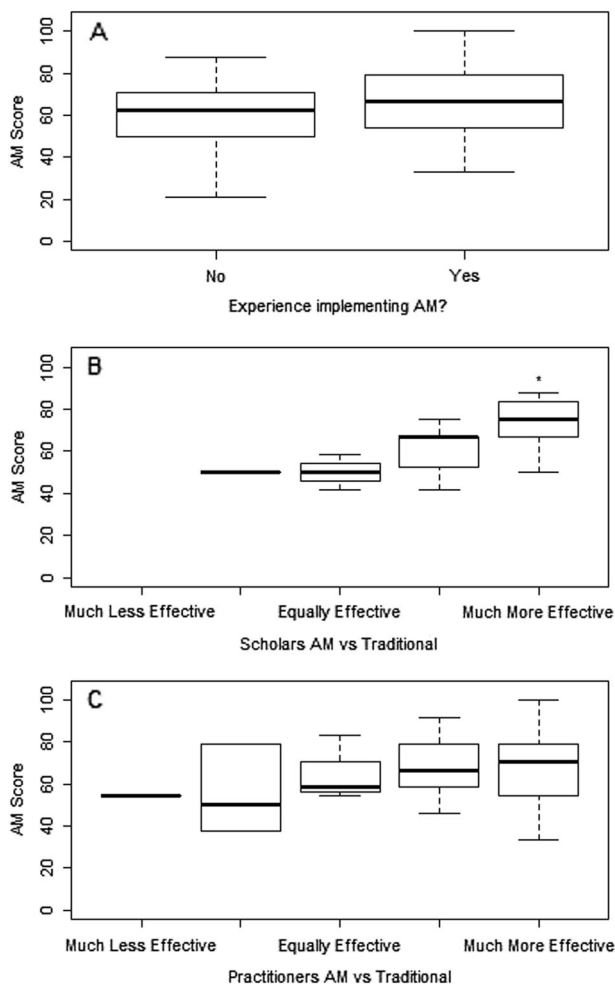
Fig. 1 Standardized "Adaptive Management (AM) Score" of AM scholars and AM practitioners (A, $T = -1.77$, $p = 0.08$) and these scores as they related to direct perceptions of AM effectiveness relative to other management strategies, broken up into scholars (B, $F = 5.65$, $p = 0.003$) and practitioners (C, $F = 1.04$, $p = 0.39$). Significance (*) was determined with a Tukey's *post hoc* test of AM score

effective management strategy among AM practitioners ($F_{5,61} = 1.04$, $p = 0.39$; Fig. 1c).

Overall, when asked to identify effective management strategies, respondents were more likely to select AM strategies over traditional management strategies (Fig. 2). The AM strategies that were selected most often were those concerning identification of management alternatives, reflection on results, iteration of the management process, and involvement of stakeholders ($H = 118.2$, $p < 0.01$). When presented with monitoring strategies, respondents were more likely to select the traditional management strategy (to assess progress toward the end goal) than the AM strategy (to promote learning). Perceptions of effective strategies were consistent across disciplines, geographies, and occupational affiliations, but differed with type of AM

experience. AM practitioners were more likely than AM scholars to choose AM strategies as effective strategies ($W = 7.24$, $p = 0.02$; Table 3). This relationship was particularly strong for the strategies "use of results for reflection on management actions based on outcomes" and "revisit and revise original goals based on management outcomes" ($W = 4.43$, $p = 0.04$ and $W = 7.40$, $p = 0.01$, respectively; Fig. 2).

Stakeholder Groups

Respondents across all disciplines, affiliations, and experiences generally agreed that management objectives are achieved with the participation of land managers, government organizations, NGOs, and local citizens (Fig. 3). However, there was some discordance in responses to the participation of academic researchers and moderators ($H = 58.5$, $p < 0.01$; Fig. 3). Practitioners were less likely than scholars to agree that the participation of moderators ($W = 3.06$, $p = 0.08$) and academic researchers ($W = 4.07$, $p = 0.04$) led to achievement of management goals (Fig. 3c). However, practitioners were more likely than scholars to agree that AM objectives are met with the participation of all stakeholders in general ($W = 4.55$, $p = 0.03$; Fig. 3d). Practitioners were also more likely than scholars to agree that land manager participation led to greater AM effectiveness ($W = 5.43$, $p = 0.02$). Practitioner perceptions of stakeholder participation were more likely than scholars to remain the same whether referring to effective management strategies or AM strategies specifically ($W = 17.70$, $p < 0.01$). Respondents were also asked to identify stakeholder groups that would benefit AM. Scholars were more likely than practitioners to agree that AM would benefit from participation of all groups ($W = 6.70$, $p = 0.01$).

Barriers to Management

Both scholars and practitioners agreed that limited budgets were the greatest barrier to effective management and AM. Compliance and lack of experience were less likely than other potential obstacles to be considered major barriers (Figs. 4a, c). There was consensus across most disciplines regardless of referring to barriers inhibiting effective or AM approaches. However, barriers identified for effective management were similar between AM scholars and AM practitioners. Practitioners generally scored barriers to effective management and AM higher than scholars ($W = 6.04$, $p = 0.01$ and $W = 7.73$, $p = 0.01$, respectively). Specifically, practitioners were more likely to identify a lack of learning, a lack of leadership, and a poor definition of success as barriers to AM ($W = 4.17$, $p = 0.04$, $W = 7.66$, $p = 0.01$, and $W = 5.92$, $p = 0.02$, respectively; Fig. 4d).
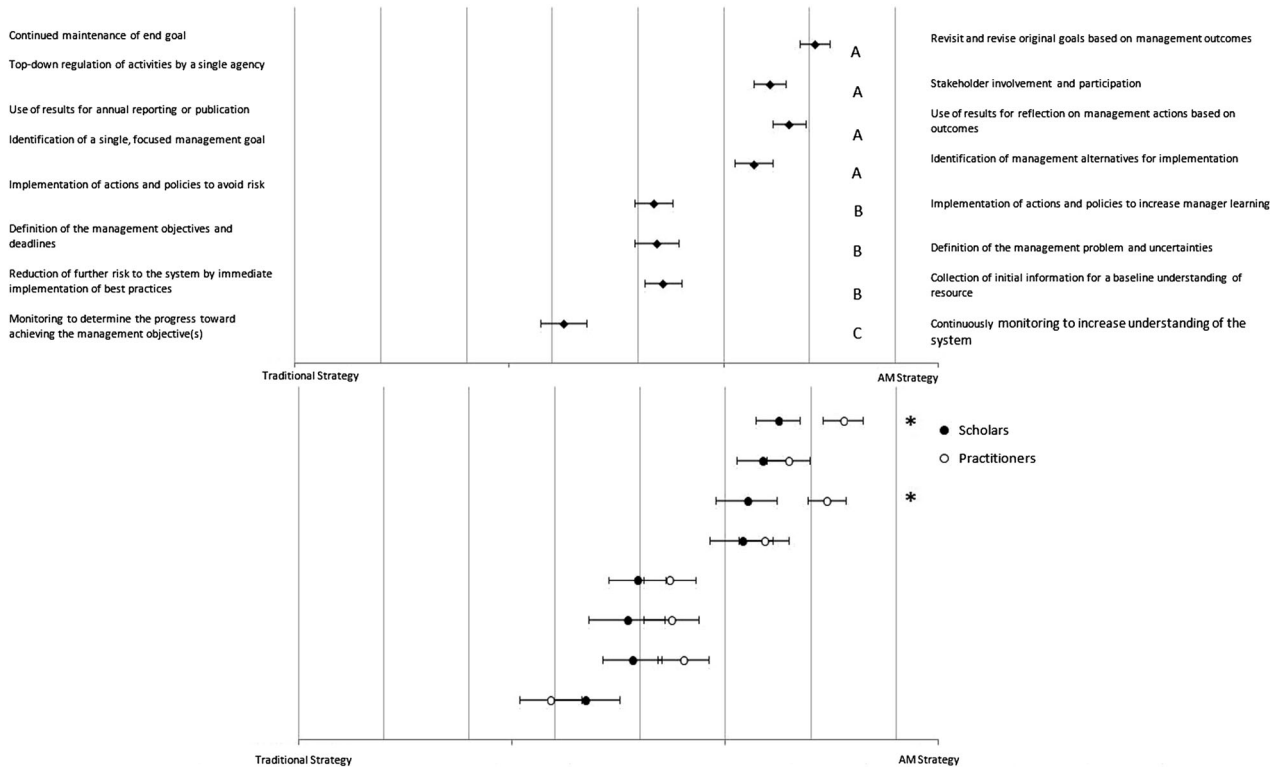
Fig. 2 Alignment (±SE) between effective management strategies and adaptive management or traditional strategies for (**a**) all respondents (*p* < 0.0001) and (**b**) scholars and practitioners. Different letters indicate significant differences between management strategies and asterisks (*) indicate significant differences between adaptive management scholar and practitioner responses
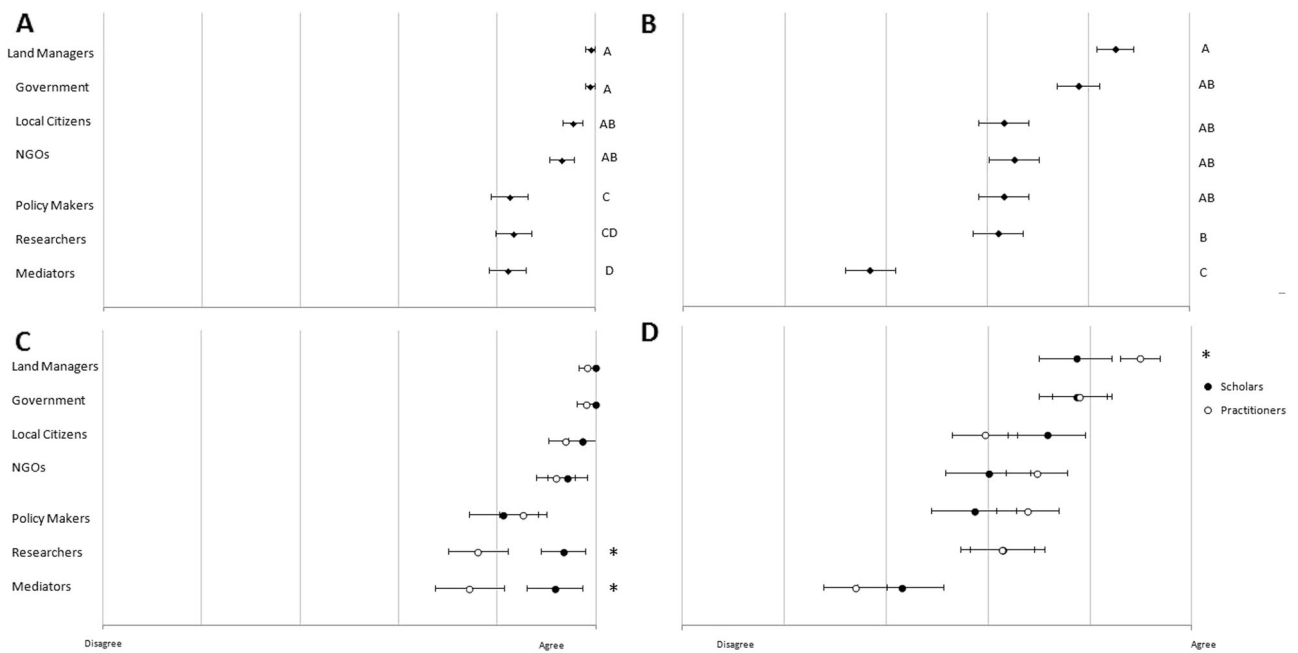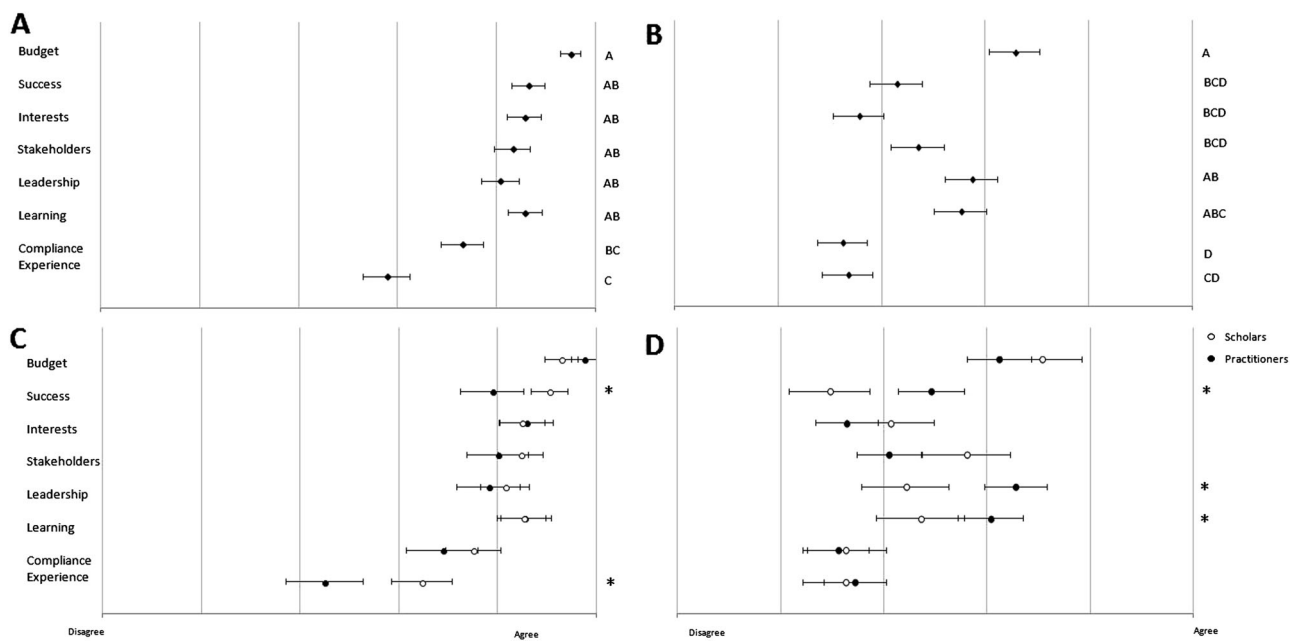

Fig. 3 Agreement (±SE) that stakeholder group participation leads to achieving effective management (**a** and **c**) or adaptive management (**b** and **d**) objectives for all respondents (**a** and **b**, both *p* < 0.0001) and scholars and practitioners, separately (**c** and **d**). Different letters within plots indicate significant differences between stakeholder groups and asterisks (*) indicate significant differences between adaptive management scholar and practitioner responses

Fig. 4 Agreement (±SE) that barriers inhibited achievement of effective management (**a** and **c**) or adaptive management (**b** and **d**) objectives for all respondents (**a** and **b**, both $p < 0.0001$), and scholars and practitioners, separately (**c** and **d**). Different letters within plots indicate significant differences between potential barriers and asterisks (*) indicate significant differences between adaptive management scholar and practitioner responses

Discussion

Overall, our results suggest that respondents across natural resources disciplines, affiliations, and geographic locations generally perceive AM as effective. While these results may not be generalizable outside of our group of respondents, they supported our hypothesis that perceived effective management strategies align more with AM than traditional management. AM is, however, not without challenges, as respondents also perceived barriers to its implementation. Contrary to our second hypothesis, perceptions concerning strategies, stakeholder groups, and barriers influencing AM effectiveness were not significantly different across most independent variables, suggesting consistency regardless of location, discipline, and role in the process. However, we found that perceptions of strategies, stakeholder, and barriers did vary between AM scholars (i.e., no implementation experience) and AM practitioners. Together, perceptions of these groups highlighted two tenets that make AM effective: practitioners emphasized AM's value as a long-term approach and scholars noted the importance of incorporating stakeholders in natural resources management.

Variations in responses between scholar and practitioner respondents in regards to AM effectiveness may suggest a perceptual gap based on different AM experiences. Higher AM Scores were revealed by scholars who also reported AM to be more effective than other management strategies. In contrast, practitioners with relatively greater AM Scores did not necessarily perceive AM as more effective than traditional management. Previous studies have noted similar disconnects, suggesting that a research-implementation gap limits effective implementation of AM in some US agencies. US Forest Service employees scored AM implementation as the least attained objective when given a list of the organization's objectives emphasized by the policy directives (Butler and Koontz 2005). Similarly, Rigg (2001) and Mullins et al. (1998) suggested that difficulties with integrating AM into US Forest Service, and US Fish and Wildlife Service programs were due to limitations in research, communication, leadership, and budget. In this study, responses identifying AM as a less effective strategy were just as likely to come from respondents affiliated with local government, federal government, or universities, which suggests a similar trend beyond US federal agencies mandated to incorporate AM. However, our results cannot distinguish a specific dissociation between knowing and doing (i.e., research-implementation gap) as there was high agreement between practitioner responses to questions addressing effective management in general, and those addressing AM specifically. While both AM scholar and practitioner respondents agreed that AM concepts are effective in theory, practitioners with on-the-ground AM experience had a different perspective about the characteristics contributing to AM effectiveness. This may suggest that, in the case of AM, the gap is not between actively knowing and doing, but in the different perceptions gained from AM experiences.

While all respondents were more likely to select AM strategies as effective, AM practitioners perceived two particular AM strategies as more effective than scholars: reflecting on management outcomes and revising actions based on those reflections. Both ideas are indicative of the iterative and long-term process of "learning-by-doing", which is critical to AM. This iterative feedback loop of learning from and reacting to management outcomes is an essential part of making management adaptable (Williams and Brown 2014). It makes AM not only a management strategy, but a way of thinking about management. One AM practitioner commented that "…stakeholders and policy makers often have the impression that AM is a research endeavor, with a defined endpoint, rather than a way of doing management over an indefinite time frame." As such, practitioner respondents perceived logistical and institutional barriers as a greater threat to AM success over the long term (Jacobson et al. 2006). A lack of learning, leadership, and properly defined objectives were all identified as potential barriers to AM and suggest a need for more management support and guidance, the absence of which would prove detrimental to effective long-term management. Committed, knowledgeable people (Butler and Koontz 2005) and sufficient leadership (Mullins et al. 1998; Selin et al. 2000; Jacobson et al. 2006) have also been noted in previous studies as being vital to effective management. Consequently, perceived AM effectiveness may also be driven by the stakeholder groups involved in the management process.

Among all respondents, stakeholder participation was generally perceived as a highly effective strategy for both AM and effective management overall. This supports previous findings (Selin et al. 2000; Rigg 2001; Benson and Stone 2013), though these studies did not specify particular stakeholder groups. In this study, scholars were more likely to agree that AM would benefit from the involvement of all participants regardless of specific stakeholder group. Scholars were also more likely to believe that academic researchers play an important role in achieving effective management objectives. Conversely, practitioners were more likely than scholars to report land managers as having an important role in AM effectiveness. However, both groups consistently scored moderators lower, suggesting that their participation may be another perceived barrier to AM effectiveness. These differences may reflect challenges with integrating local and scientific knowledge sources in ecosystem management (Raymond et al. 2010) and may lead to the "lack of communication and information flow" that some practitioners reported experiencing. By encouraging multiple stakeholder involvement, AM attempts to mitigate difficulties that arise in recognizing the need for both scientific knowledge and experience. Rynes et al. (2001) explored barriers to communication and knowledge transmission among stakeholders, and specifically between practitioners and scholars. In their review of submissions to the *Academy of Management Journal* for a special issue on academic–practitioner relationships, fewer than 20 % of studies involved practitioners in the study design or included them as coauthors, even though over 60 % of articles stressed the importance of academic–practitioner collaboration. Other studies suggest the lack of communication is due to cultural differences between the two communities. For example, scholars often hold different ideals on quality and transfer of knowledge, preferring academic journals to face-to-face meetings (Caplan 1979; Oh and Rich 1996; Crona and Parker 2012). However, it may be that in some cases an invitation to such meetings is not extended, as one practitioner respondent in our study felt that "academic researchers are relegated to the peanut gallery and are excluded from the primary conversations and decisions." There is also a lot of pressure on both the scholar and practitioner communities as, another respondent suggested, "stakeholders and individuals [are] hoping science will have the 'correct' answer." Facilitating open communication and cultivating a shared perception of long-term management will help to enforce the notion that what is "correct" for the system may not remain the same through time, which is the true identity of adaptive management.

While AM strategies were generally perceived by almost all respondents (98.2 %) as more effective than traditional management strategies, there was also a general consensus on barriers to AM. Shared perceptions of AM barriers came from respondents with a wide range of natural resources backgrounds, suggesting that experiences, though separate, led to a shared understanding of AM limitations. Budget limitations were perceived as the greatest barrier to AM, indicating that concerns for funding to adequately monitor dynamic systems (Cardinale et al. 2012) also crossed occupational and disciplinary boundaries. Similar to our study, a review of the literature on watershed partnerships found that the presence of an effective leader was the second most frequently identified key to effectiveness after adequate funding (Leach and Pelkey 2001). Effective leaders may also work to alleviate other barriers to AM by balancing the many interests and personalities of stakeholders (Allen and Gunderson 2011) and facilitating an environment for social and scientific learning (Folke et al. 2005) to bridge the perception gap between scholars and practitioners. In broadening our study to include responses from both scholars and practitioners, we found consistency in perceived effectiveness of strategies associated with AM over traditional management strategies, perhaps suggesting common ground to foster communication between these groups. Though some variation existed in scholar and practitioner perceptions, together they highlighted the defining concepts of AM. Practitioners indicated the utility

of AM as a long-term approach, while scholars emphasized stakeholder involvement as a driver of AM effectiveness. As such, it seems fitting that natural resources professionals of all disciplines and affiliations should use AM to communicate shared management perceptions and learning experiences. The complementary nature of scholar and practitioner perceptions of characteristics leading to AM effectiveness can provide pathways for communication and facilitate discussions aimed at improving natural resources management.

Conclusions

This study is the first to assess AM effectiveness as perceived by both scholar and practitioner professionals, and provides insights into characteristics of effective natural resources management. Strategies identified by respondents as leading to effective management closely aligned with AM. Perceptions were similar across natural resources disciplines, and occupational and regional affiliations, potentially reflecting consistency in AM education and experiences. This may also suggest that AM has created a broad "community of practice", implying potential for social learning and interdependent collaboration across demographics for improved natural resources management (Wenger 1998; Bouwen and Taillieu 2004). However, variations in responses among respondents with and without direct experience implementing AM (AM practitioners and AM scholars, respectively) reflect perceptual differences. These similarities and complementary differences in scholar and practitioner perceptions of AM as an effective management approach suggest potential utility in AM as common ground for facilitating AM learning and communication. Harnessing the complementarity of different institutional actors is a fundamental principle of collaborative management, and could help shift the focus of AM discussions from personal or institutional positions to underlying management perceptions (Borrini-Feyerabend et al. 2000). We conclude that increased communication between practitioners and scholars to promote a shared perception of AM is necessary for improving natural resources management.

Compliance with Ethical Standards

Conflict of Interest The authors declare that they have no conflict of interests.

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