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Knowledge co-production in climate adaptation planning of archaeological sites

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Abstract

Climate adaptation is a process for minimizing the risks of damage or loss to coastal archaeological sites. Yet, adaptation requires identifying and prioritizing among the diverse aspects of a site's significance, as not all sites can be simultaneously adapted due to financial and human capital constraints. Developing a measurement framework that can ascertain the relative significance between sites necessitates the collaboration of multiple perspectives, including experts who set policy and on-the-ground managers who must translate policy into practice while accounting for the management preferences of associated communities. This paper explores if a values-based process enables co-production of knowledge related to the significance of archeological sites. Specifically, this paper examines the influences of a workshop—conducted with diverse archaeological experts working for the U.S. National Park Service—on knowledge co-production and documents the extent of changes in experts' opinions using a pre–post survey design. Findings suggest that the values-based approach applied during the workshop can have a positive impact on knowledge co-production among experts. Changes were found in experts' perceptions of the importance of various considerations influencing archaeological site prioritization, as well as of the extent to which uncertainties challenge archaeological preservation. This paper presents novel findings about the importance of knowledge co-production in relation to coastal archaeological site preservation and climate adaptation in the U.S. Prioritization considerations and challenges of various uncertainties assessed in this study can provide valuable insights for progress in climate change policy for cultural heritage both in the U.S and globally.

Keywords Climate change adaptation · Social learning · Prioritization · Uncertainties · Values-based approach

Introduction

Archaeological sites are a static and non-renewable type of cultural heritage, which provide valuable social, cultural and economic benefits for the communities. For example, archaeological sites can foster social cohesion and identity among communities, increase community resilience, enhance education and advance scientific knowledge (Appler and Rumbach 2016; Flatman 2009; Hollesen et al. 2018). Archeological sites can also enhance capacity for learning and transferring archaeological knowledge into current social contexts and experiences, such as mitigation and adaptation to climate change (Lafrenz Samuels 2016; McVey Erlandson 2012). Furthermore, archaeological sites are important drivers of local and national economies, as they can contribute to increased tourism flows and generate or stimulate the tourism employment sector (Graham 2002; Cullinane Thomas et al. 2018). Yet, climate change-related impacts—such as, sea level rise, accelerated coastal erosion and flooding, more frequent and intense storms and hurricanes, increasing temperatures and precipitation changes, more frequent wildfires, increasing desertification, increasing permafrost thaw and decay of organic material (e.g., Anderson et al. 2017; Aryee and Apoh 2018; Breen 2007; Daly 2016; Dawson 2013; Daire et al. 2012; Hollesen et al. 2018; Rowland and Ulm 2012; Westley et al. 2011)—when combined with ongoing geomorphological processes (Howard et al. 2008; Reeder-Myers 2015) or biogeomorphic impacts (e.g., invasive species; Hilton et al. 2018) have major implications for archaeological sites preservation.

Climate-related impacts have already been observed to alter and accelerate archaeological sites' vulnerability in many places

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around the world (e.g., Aryee and Apoh 2018; Dawson 2013; Hollesen et al. 2018; Rowland and Ulm 2012). In this study, vulnerability is defined as the probability (degree) of losing archaeological sites' historical significance due to climate variability or change (Fatorić and Seekamp 2017b). Vulnerability of an archaeological site is characterized by (a) its location that could be adversely affected by a climatic event (i.e., exposure), and (b) the degree to which its historical significance could be affected by that exposure (i.e., sensitivity) (Rockman et al. 2016). Therefore, to reduce vulnerability and minimize the risks of damage or loss to archaeological sites, climate adaptation planning and implementation are crucial processes.

Climate adaptation of archaeological sites is a newly emerging research and policy area (Fatorić and Seekamp 2017a; UNESCO 2008) that aims to reduce the damages or enhance the benefits associated with current or potential future climate change impacts through planned action (IPCC 2014). Within the context of archaeological site adaptation, Heathcote et al. (2017) described two types of climate adaptation strategies. The first is a set of low-risk actions that focus on improving protection from changing climate conditions that are already happening, such as increased capacity of drainage systems to ensure archaeological sites are protected from water inundation and saturation. The second type are higher risk actions, which require adjustment of practices or even changes to what archaeological management or historic preservation currently find acceptable, such as changes to archaeological sites in areas of high wildfire risk to increase their fire resiliency. Yet when planning for adaptation, a careful and clearly defensible (i.e., transparent) process is needed since adaptation strategies can not only enhance resilience of the archaeological sites, but poorly designed strategies can also cause adverse impacts—even irreversible damage—to the values and characteristics associated with a site's significance. Additionally, there is a critical need for climate adaptation process that occurs before climate change-related damage to or loss of archaeological sites are further observed (i.e., proactive adaptation; IPCC 2014).

Setting priorities in archaeological site preservation and adaptation is a major challenge, especially where climate change risks are high, multiple archaeological sites are located across the landscape, and financial resources are limited (Rockman et al. 2016). One of the first attempts to address this challenge in the United States is federally issued policy guidance (NPS 2014), which urges heritage managers to make decisions that "*are directed to resources that are both significant and most at risk*". However, while we agree with the intention of this policy memorandum, a more proactive response is required to identify and analyze which factors or considerations are important when decision-makers prioritize sites for preservation and adaptation interventions, especially in the case of archaeological sites that are already facing the degradation or loss.

To solve the challenge of climate adaptation prioritization, we emphasize the need for applying a collaborative approach among policy-makers, decision-makers and practitioners to co-produce knowledge. Such co-production contrasts the traditional approach to knowledge creation, which is developed by researchers and then transferred to decision-makers (Polk 2015). Co-production of knowledge is defined as an iterative and transdisciplinary process of bringing multiple actor's knowledge and expertise together to address a decision problem and build an integrated understanding of that problem (Armitage et al. 2011). In this sense, co-production can better highlight knowledge differences and similarities, embrace a diversity of knowledge cultures, and allow for an expanded understanding of the problem or issue, which a single context might not produce (Simon et al. 2018). Furthermore, it is used to explore how multiple actors' knowledge develop and shift through iterative processes, building respect and trusted relationships among actors, and exploring the ways in which production of knowledge can occur in a more equitable and democratic process (Cundill 2010; Moser 2010; Filipe et al. 2017; Puente-Rodríguez et al. 2016; Richards et al. 2018). Maasen and Lieven (2006) pointed out that encouraging multiple actors' participation in the production of knowledge can foster the accountability of science, including the quality of the usability of results and outcomes (Polk 2015). Consequently, this can influence changes to practices, behaviors and values, and changes to and support of evidence-based policy making process (Filipe et al. 2017; Rist et al. 2006).

Co-production of knowledge has been increasingly acknowledged in environmental management and, more recently, climate adaptation as an important issue to enable discourse, transparency, validate knowledge and shared stewardship of the environment or natural resources, including promotion of sustainable practices (e.g., Armitage et al. 2011; Frantzeskaki and Kabisch 2016; Lebel et al. 2010; Muro and Jeffrey 2008; Puente-Rodríguez et al. 2016). To date, however, only one study (Fatorić and Seekamp 2017b) illustrates how co-production of knowledge among diverse practitioners, decision-makers, policy-makers and researchers occurs and serves as valuable approach to inform climate adaptation planning of cultural heritage (i.e., historic buildings). In this paper, we address this important gap and explore if the co-production of knowledge about the prioritization considerations for climate adaptation planning occurred during a workshop with experts from archaeological site preservation, management and policy in the U.S. By advancing the understanding of knowledge co-production in climate adaptation and archaeological site context, we not only inform the evidence-based decision-making process, but also respond to Intergovernmental Panel on Climate Change (IPCC 2018) and U.N. Educational, Scientific and Cultural Organization (UNESCO 2008)'s call for capacity building, knowledge development and exchange among cultural heritage stakeholders.

Methods

Findings presented in this paper are part of a larger project and only represent a part of the data collected during a values-based, deliberative workshop on climate adaptation planning of archaeological sites in the U.S. The specific goals of this paper were: to (1) assess the extent to which knowledge co-production occurred during a deliberative and values-based workshop with an array of policy-makers, decision-makers, and practitioners about prioritization of archeological sites for climate adaptation, and (2) identify and discuss the most and least important climate adaptation prioritization criteria as perceived by the workshop participants.

A multidisciplinary project team of four female researchers (two from the North Carolina State University and two representatives of the National Park Service) organized and facilitated a two-day workshop that was held in Washington, DC in November 2018. The workshop participants (identified through purposive sampling) consisted of 17 experts from various National Park Service (NPS) programmatic offices who have diverse expertise in archaeological site preservation and management at local, Tribal, state and national scales, as well as in climate change, and NPS national policy and regulations.[1] It is important to note that careful consideration was given to select a group of experts with diversity of professional backgrounds and expertise who work on the frontline of policy- and decision-making (various NPS programs and offices), rather than from a statistically representative sample of a broader archaeological experts in the U.S. (Bryman 2008) or broader definitions of knowledge co-production that focus on the participation of citizens, decision-makers and researchers to restore public trust in science (Bäckstrand 2004). The intention of this study was to achieve analytic generalization which can yield new data on unexplored issues of knowledge co-production in climate adaptation of archaeological sites (Polit and Beck 2010), rather than statistical generalization (i.e., expert sample need to be *representative* of the population). Moreover, our focus on select NPS experts is an important first step for the agency to address climate adaptation policy guidance (NPS 2014) given not only the complexities of climate change science but also the predominance of a preservationist paradigm (DeSilvey 2017) that is challenged by both measuring relative significance and accepting losses of archaeological resources.

Drawing on work conducted in the field of decision analysis and behavioral decision theory (Keeney 1992), a values-based approach, similar to the one applied by Fatorić and Seekamp (2017b), was applied to explore a limited understanding on knowledge co-production in climate adaptation of archaeological sites. Value-based approaches place emphasis on the importance of integrating experts' values with technical and scientific information in more transparent, inclusive and holistic response to environmental challenges (e.g., Espinosa-Romero et al. 2011; Gregory et al. 2012; Moore and Runge 2012). In our study, the research team first developed a beta framework of attributes (i.e., indicators) for measuring archaeological site significance (the values of a site) and the sensitivity of archeological sites to climate change impacts. The beta framework was developed from the scientific literature and policy documents over a two-month period prior to the workshop. At the beginning of the workshop, the research team provided an overview of ongoing challenges facing archaeological site preservation from climate change—including technical information on climate change impacts and uncertainties, as well as policy guidance and limitations—and an overview of similar efforts to develop measurement frameworks for historic buildings (Fatorić and Seekamp 2018), and an overview of an ongoing process for coastal archaeological site adaptation at a National Historical Park. Then, the research team facilitated a discussion about the key values and adaptation considerations of coastal archaeological sites, followed by an overview of the beta framework and a discussion about their initial reactions to the beta framework. Next, the participants worked in multidisciplinary subgroups to revise framework, which continued into the second day of the workshop, and culminated in a group-led presentations and subsequent facilitated discussion of the revisions.

A part of the workshop goals, and those that are the focus of this paper, was to explore whether there were any changes in experts' opinions after the workshop, and the extent of such changes, using a pre-survey and post-survey design. Pre-post survey research aimed to assess the extent to which a participatory workshop influenced opinions about coastal archaeological site adaptation. At the beginning of the workshop, experts were asked to complete a pre-survey before delivery of any information. At the completion of the workshop, all participants were asked to fill out the post-survey. Both surveys included the following 4 questions and corresponding themes: (1) influence of value-based process on their perceptions, (2) potential for co-production of knowledge, (3) importance of considerations in prioritizing archaeological site for climate adaptation planning, and (4) challenges related to the uncertainties in archaeological preservation and climate adaptation planning (see Table 1). Additionally, the post-survey included a question that sought the feedback on the workshop's utility. Experts' perceptions were measured on a five-point agreement Likert scales (1 = lowest score, and 5 = highest

[1] Experts were employed within the following NPS programs, offices, and parks: Archaeology Program, Climate Change Response Program, Cultural Anthropology Program, National Historic Landmarks Program, National Register of Historic Places Program, Vanishing Treasures Program, Northeast Region Archaeology Office, Alaska Region Archaeology Program, National Capital Regional Office, Southeast Regional Office, and Colonial National Historical Park.

Table 1 Influence of workshop in changing participants' opinions from pre-workshop survey to post-workshop survey ($n = 10$)

Survey questionnaire items	Pre-Workshop Mean (SD)	Post-Workshop Mean (SD)	Unchanged	Increase in strength	Decreasein strength
1. To what extent do you think this value-based process will/did influence your thoughts on archaeological site preservation process? [a]					
a) Extent that value-based process will/did influence the thoughts on archaeological site preservation	3.2 (0.42)	3.8 (0.92)	40%	50%	10%
b) Extent that value-based process will/did influence the thoughts on archaeological site preservation under changing climate	3.9 (0.57)	4.1 (0.88)	60%	30%	10%
2. To what extent do you think this workshop will demonstrate the potential for co-production of knowledge? [b]					
	3.2 (0.67)	3.8 (0.79)	56%	44%	0%
3. How important are the following considerations in prioritizing archaeological site for climate adaptation planning and preservation on a 30-year time horizon? [c]					
a) A preservation treatment has been applied to the site	3.5 (1.43)	3.2 (1.03)	40%	20%	40%
b) Cost of treating the site	3.4 (0.84)	3.1 (1.10)	50%	10%	40%
c) Cost of maintaining the site	3.4 (0.70)	3.2 (1.03)	30%	30%	40%
d) The site has meaning to a group of individuals	4.5 (0.71)	3.8 (1.03)	40%	10%	50%
e) The site has meaning to a local community	4.2 (1.23)	3.8 (1.03)	60%	0%	40%
f) The site plays a central role in the cultural landscape	3.1 (0.88)	3.4 (0.70)	40%	40%	20%
g) The site provides significant tourism revenue to local communities	2.4 (0.84)	2.6 (0.84)	50%	30%	20%
h) The site is widely visited by the public	2.5 (0.97)	2.8 (0.63)	80%	20%	0%
i) The site has high scientific value (helps us better understand aspects of our historic past	4.4 (0.84)	4.6 (0.70)	80%	20%	0%
j) The site holds a particular historical value because it is the only one like it (rare example)	4.4 (0.70)	4.6 (0.70)	60%	30%	10%
k) The site illustrates something of national importance	4.1 (0.99)	4.5 (0.71)	80%	20%	0%
l) The programmatic function of the site to a National Park unit (link to the foundational purpose of the park unit)	3.7 (1.16)	4.1 (0.88)	60%	40%	0%
m) The interpretive function of the site to a National Park unit (link to the interpretive plan of the park unit)	3.2 (1.14)	3.3 (0.82)	30%	40%	30%
n) The vulnerability of the site to climate-change threats (severity of risk)	4.1 (0.88)	3.9 (0.74)	60%	10%	30%
o) The immediacy of climate-change related impacts (urgency of action)	4.3 (0.67)	4.0 (0.67)	50%	10%	40%
p) The vulnerability of the site due to deferred maintenance	3.4 (0.97)	3.1 (0.99)	30%	30%	40%
q) The vulnerability of the site due to insufficient funding	3.1 (1.10)	3.3 (1.16)	30%	50%	20%
4. How challenging are the following uncertainties in archaeological preservation and climate adaptation planning? [d]					
a) Timing of changes in precipitation, sea level, hurricanes	4.0 (0.82)	3.4 (1.07)	50%	10%	40%
b) Magnitude of changes in precipitation, sea level, hurricanes	4.0 (0.94)	3.7 (1.06)	30%	30%	40%
c) Coastal planning & management	3.2 (1.40)	3.4 (1.17)	30%	50%	20%
d) Predictability of budget	4.1 (0.88)	4.0 (1.25)	60%	20%	20%
e) Federal political environment	4.0 (1.05)	4.0 (1.15)	70%	10%	20%
f) State political environment	3.0 (0.82)	2.8 (1.14)	50%	20%	30%
g) Decision-makers' values and priorities	3.9 (1.20)	4.1 (0.99)	50%	30%	20%
h) Stakeholders' values and priorities	3.6 (0.97)	3.4 (0.52)	40%	20%	40%
i) Changes in archaeological policy	2.8 (1.30)	2.7 (0.67)	45%	22%	33%
g) Working with SHPOs to preserve or adapt sites	2.6 (0.84)	2.7 (0.95)	30%	40%	30%
k) Prioritizing unknown sites (those sites that haven't been surveyed yet)	3.4 (1.33)	3.3 (1.42)	67%	11%	22%

[a] Measured on a 5-point Likert-type scale from "No influence" to "Extremely influential"

[b] Measured on a 5-point Likert-type scale from "No co-production" to "Complete co-production"

[c] Measured on a 5-point Likert-type scale from "Not at all important" to "Extremely important"

[d] Measured on a 5-point Likert-type scale from "Not at all challenging" to "Extremely challenging"

score). Each participant was provided with a set of surveys that were assigned a unique identification number to enable a matched pairs design. No demographic and background data were collected to enhance

confidentiality of responses. All protocols and instruments were approved by the North Carolina State University Institutional Review Board.

Of 17 workshop participants, only 14 were eligible for the pre-post study as 3 experts participated in the workshop remotely. Of those 14, 12 participants completed pre-surveys, while 10 participants completed post-surveys. Thus, 10 matching pre- and post-surveys were analyzed using the Microsoft Excel software to calculate means, standard deviations, and direction of change in responses: unchanged strength, increased strength, and decreased strength. Both surveys took about 10–15 min to complete.

Results

The results of this study suggest that experts' opinions about various aspects of climate change and archaeological site intersection were different before and after the workshop for the majority of questionnaire items (58%), as shown in Table 1. Moreover, for those experts who changed their perceptions about the influence of value-based processes on their thoughts about archaeological site preservation, generally and under a changing climate, and the potential for co-production of knowledge, a greater proportion increased (as opposed to decrease) the strength of their opinion (50% vs. 10%, 30% vs. 10%, and 44% and 0%, respectively). Specifically, experts perceived that the values-based approach applied during the workshop held a moderate to high level of influence on their opinions about archaeological site preservation in general (pre-survey $\overline{X}$ =3.2; post-survey $\overline{X}$ =3.8) and archaeological site preservation under changing climate (pre-survey $\overline{X}$ =3.9; post-survey $\overline{X}$ =4.1). Experts opined that participating in the workshop resulted in high levels of knowledge co-production (post-survey $\overline{X}$ =3.8), which increased from their expectations documented in the pre-survey ($\overline{X}$ =3.2).

Some changes in experts' perceptions of the importance of various considerations influencing archaeological site prioritization were found (Table 1). At least 50% of experts did not change their opinions about the importance of ten of the seventeen (59%) considerations, with 80% of experts not changing their opinions about the sight being open to the public (pre-surveys $\overline{X}$ =2.5; post-surveys $\overline{X}$ =2.8), sites with high scientific value (pre-surveys $\overline{X}$ =4.4; post-surveys $\overline{X}$ =4.6), and sites that illustrate national importance (pre-survey $\overline{X}$ =4.1; post-survey $\overline{X}$ =4.5). The most important considerations for prioritizing archaeological sites for climate adaptation planning in both pre- and post-surveys included: sites with high scientific value and sites holding a particular uniqueness or rarity (both pre-surveys $\overline{X}$ =4.4; post-surveys $\overline{X}$ =4.6), sites that illustrate national importance (pre-survey $\overline{X}$ =4.1; post-survey $\overline{X}$ =4.5), and sites in which action is urgent due to the immediacy of climate change threats (pre-survey $\overline{X}$ =4.3; post-survey $\overline{X}$ =4.0). Additionally, the post-survey results reveal that sites hold a programmatic function was also an important prioritization consideration (post-survey $\overline{X}$ =4.0). The lowest rated prioritization considerations (slight to moderate importance) perceived by experts in both the pre- and post-surveys included: sites that provide significant tourism revenues for local communities (pre-survey $\overline{X}$ =2.4; post-survey $\overline{X}$ =2.6) and sites that are widely visited by the public (pre-survey $\overline{X}$ =2.5; post-survey $\overline{X}$ =2.8).

For all but one of the considerations (sites that hold meaning for local communities), we found at least one expert increased the strength of perceived importance, ranging from 10% to 50% (Table 1). The considerations with the largest proportions of experts' strengthening their opinion on their importance included: a site's vulnerability due to insufficient funding (50%), a site's central role in the cultural landscape (40%), a site's programmatic function (40%), and a site's interpretive function (40%). For all but three considerations, we found at least one expert decreased the strength of perceived importance, ranging from 10% to 50%. Sites that hold meaning for a group of individuals revealed the greatest decrease (50%) among the considerations for archaeological site prioritization. Other considerations with large decreases in perceived importance (40%) included: sites with prior preservation treatments (pre-survey $\overline{X}$ =3.5; post-survey $\overline{X}$ =3.2), costs of continuous treatment (pre-survey $\overline{X}$ =3.4; post-survey $\overline{X}$ =3.1), future maintenance costs (pre-survey $\overline{X}$ =3.4; post-survey $\overline{X}$ =3.2), sites that hold meaning for a local community (pre-survey $\overline{X}$ =4.2; post-survey $\overline{X}$ =3.8), sites in which action is urgent due to the immediacy of climate change threats (pre-survey $\overline{X}$ =4.3; post-survey $\overline{X}$ =4.0), and sites that are vulnerable due to deferred maintenance (pre-survey $\overline{X}$ =3.4; post-survey $\overline{X}$ =3.1).

Among the challenges related to the uncertainties in archaeological preservation and climate adaptation planning, we found that the greatest challenges reported at the beginning and end of the workshop included: the predictability of budgets (pre-survey $\overline{X}$ =4.1; post-survey $\overline{X}$ =4.0) and the federal political environment (pre-survey $\overline{X}$ =4.0; post-survey $\overline{X}$ =4.0) (Table 1). These uncertainties, along with those affiliated with the timing of climate change impacts, state's political environments, the values and priorities of decision-makers, and the ability to prioritize unknown sites, were affiliated with at least half (50%) of the experts not changing their opinion between the pre- and post-surveys. The least challenging uncertainties reported at the beginning and end of the workshop included: the state political environment (pre-survey $\overline{X}$ =3.0; post-survey $\overline{X}$ =2.8), changes in archaeological policy (pre-survey $\overline{X}$ =2.8; post-survey $\overline{X}$ =2.7), and working with State

Historic Preservation Offices (SHPOs) to preserve or adapt sites (pre-survey $\overline{X}$ =2.6; post-survey $\overline{X}$ =2.7). Substantial (40% of experts) decreases in the strength of several challenges were found: the timing *and* the magnitude of changes in precipitation, sea level and hurricanes, as well as uncertainty in stakeholders' values and priorities. Half of the experts (50%) demonstrated increases in the strength of the challenges associated with uncertainties in coastal planning and management. Several experts also demonstrated increases in the strengths associated with uncertainties related to working with SHPOs to preserve or adapt sites (40%) and decision-makers' values and priorities (30%).

Lastly, experts were asked to rate the impact and usefulness of the workshop (Table 2). In general, experts agreed that the workshop was an engaging process to provide input about archaeological site prioritization under changing climate ($\overline{X}$ =4.4), and also rated that it was a good way to provide input into decisions about archaeological sites ($\overline{X}$ =4.2). Furthermore, experts agreed that values-based approach applied during the workshop helped them understand other's values and preferences for archaeological site prioritization under changing climate ($\overline{X}$ =4.1). Such a process was also perceived as a good strategy for the National Park Service to support archaeological site prioritization decisions ($\overline{X}$ =4.1). Experts disagreed that the process was too complicated to understand ($\overline{X}$ =2.3) and that was not enough information to make well-considered responses ($\overline{X}$ =2.6).

Discussion and conclusions

Despite recognition that co-production of knowledge can have positive impacts on evidence-based decision-making in climate change and environmental management disciplines (Rist et al. 2006), co-production of knowledge to support cultural heritage management and preservation under changing climate conditions remains poorly understood. This paper fills this knowledge gap by demonstrating that it is possible to achieve knowledge co-production about archaeological site preservation and climate adaptation using a deliberative and values-based process. It should be noted that this study is based on a small and purposive expert sample and, as such, the results should be treated with caution; however, the novel insights reveal the importance of knowledge co-production in relation to coastal archaeological site preservation and climate adaptation. Specifically, the findings of this study suggest that the values-based approach applied during the workshop can have a positive impact on co-production of knowledge and social learning among experts. Furthermore, it is likely that this study itself contributed to the enhanced adaptive capacity of the 14 experts who participated in the workshop by increasing their awareness and understanding of values-based approaches, co-production of knowledge, importance of considerations in prioritizing archaeological sites for climate adaptation, and challenges in connection with various policy, management and data uncertainties.

Our results demonstrate that experts were interested in understanding in greater depth how their own and others' values and preferences influence archaeological site adaptation and preservation. Additionally, our findings suggest that the values-based process reduced the extent to which the experts felt challenged by many (nearly two-thirds) of uncertainties related to archaeological preservation and adaptation planning. These findings confirm some previous studies (e.g., Dietz 2013; Gregory et al. 2012), which have demonstrated that values-based approaches can improve the quality of decisions and enhance the capacity of the participants for future decision-making. As such, our study provides evidence of the need for deliberative discussions that raise awareness and knowledge co-production about the poorly understood intersection between archaeological site preservation and climate adaptation.

Table 2 Workshop participants' opinions about the workshop and value-based process (n = 10)

Survey questionnaire items	Mean (SD)
Feedback on the workshop and value-based process: [a]	
a) This is a good way to provide input into decisions about archaeological sites.	4.2 (0.79)
b) There was not enough information to make well-considered responses.	2.6 (1.07)
c) The process helped me to understand and express my values about archaeological site prioritization under changing climate.	4.0 (0.67)
d) The process helped me to understand and express my preferences for archaeological site prioritization under changing climate.	4.0 (0.82)
e) The process helped me to understand others' values about archaeological site prioritization under changing climate.	4.1 (0.57)
f) The process helped me to understand others' preferences for about archaeological site prioritization under changing climate.	4.1 (0.57)
g) The process was too complicated.	2.3 (0.67)
h) This workshop was an engaging process for providing input about archaeological site prioritization under changing climate.	4.4 (0.70)
i) This process is a good strategy for the National Park Service to make archaeological site prioritization decisions.	4.1 (0.99)

[a] Measured on a 5-point Likert-type scale from "Strongly disagree" to "Strongly agree"

Several scholars (e.g., Appler and Rumbach 2016; Cassar and Pender 2005; Hambrecht and Rockman 2017; Hollesen et al. 2018; Sabbioni et al. 2010) highlighted that, in cultural heritage and climate change disciplines, knowledge production and improved knowledge sharing among diverse stakeholders, decision-makers and researchers are of utmost importance to respond efficiently to climate change challenges and to support evidence-based decision-making. Furthermore, co-producing and sharing knowledge and best practices, including the failures, can enhance adaptive capacity of decision-makers and increase resilience of archaeological sites to better adapt under changing climate (Pelling et al. 2008; Phillips 2014; Rockman et al. 2016). The process we outlined in this paper does not exclude or preclude specific actors but rather proposes that a variety of knowledge holders is essential for a successful knowledge co-production. Further research is needed to understand the values, preferences and knowledge of other stakeholders and community groups, as well as to explore the impact of values-based processes that involve multiple actors on co-production of knowledge and social learning.

The growing urgency of identifying how to create transparent and robust climate adaptation prioritization process for coastal archaeological sites presents a great challenge to wide range of stakeholders and decision-makers globally (e.g., Heilen et al. 2018; Carmichael et al. 2018; Dawson 2013). Within this initial phase of identifying and understanding considerations that might guide prioritization of adaptation across multiple archaeological sites, our findings suggest that knowledge about diverse prioritization considerations was exchanged and co-produced during the workshop. Additionally, our findings suggest that sites' scientific value, uniqueness, spatial importance (i.e., national level sites), and programmatic function were perceived as the most important prioritization considerations.

Uniqueness has been found to be an important climate adaptation consideration within some NPS park units. For example, the Gateway National Recreation Area considered uniqueness, condition, and use potential as important characteristics of cultural heritage (including archaeological sites) in development of prioritization process (Rockman et al. 2016). Similarly, Heilen et al. (2018) suggested that site's uniqueness should be a critical component in the process of prioritizing vulnerable sites for preservation and adaptation interventions. Often times uniqueness and rarity are interchangeably used. For example, Manders et al.'s (2012) training manual for underwater archaeological site management in Asia and Pacific suggested that sites' uniqueness or rarity is one of the criteria for assessing historical significance of the archaeological sites. Likewise, Dawson (2013) developed a prioritization process for vulnerable coastal archaeological sites in Scotland that uses site rarity as one of the main criteria.

Regarding the site's scientific value, Australian International Council on Monuments and Sites (Australia ICOMOS 2013) includes scientific value as one of the five values within cultural significance assessment processes. Similarly, Manders et al. (2012) uses scientific value as one criteria to determine the intrinsic values of underwater archaeological sites. There is, however, limited information about archaeological site's scientific value used in guiding decisions in the context of archaeological sites at risk from climate change beyond these documents.

In terms of sites' spatial importance, limited policy guidance and published literature discusses the relevancy of an archaeological site's significance at international, national or local scales. For example, the ShoreDIG project (Graham et al. 2017) developed in Scotland, focuses on assessment and monitoring of locally-valued coastal sites that are already vulnerable to climate-related impacts. A study conducted in Denmark (Lundhede et al. 2013) found that survey respondents were more willing to pay for preserving nationally and internationally unique archaeological sites than biodiversity in the same area, since biodiversity was perceived as easier to substitute than the archaeological sites (i.e., irreversible loss of archaeological sites). Interestingly, the experts participating in this study opined that community (both traditional and contemporary) engagement in decision-making process is crucial for more transparent and equitable preservation and adaptation of archaeological sites (i.e., local scale sites), but yet they rated a national level archaeological sites as being one of the most important consideration in prioritization process. This raises several questions that need further exploration in future research efforts. For example, can different groups of stakeholders (e.g., site managers, heritage practitioners and associated community members) agree on what aspects of archaeological sites are most important for guiding prioritization during climate adaptation planning processes? Additionally, how can we adapt archaeological sites considering a diversity of spatial levels and move beyond only focusing on nationally and internationally (e.g., World Heritage Sites) significant sites?

We also found that fiscal considerations—specifically, prior investments, ongoing investments, future investments, and vulnerability associated with deferred maintenance—were perceived to be among the least important considerations for prioritizing archeological sites for adaptation and associated with reduced importance by the end of the workshop. In particular, these results are interesting as the experts reported budget uncertainties to be one of the greatest challenges facing archaeological preservation and adaptation planning (and the strength of their opinions about the extent of this challenge remained relatively stable throughout the workshop). Anderson et al. (2017) pointed out that the costs of preservation efforts are important factor in decision-making process since the funding is often limited and require a substantial justification. Similarly, Cassar and Pender (2005) suggested that the acceptance of what cultural heritage is worth safeguarding for future generations depends of value,

significance, and financial resources. Moreover, a study on barriers to cultural heritage preservation and adaptation (Fatorić and Seekamp 2017c) found that available funding is one of three most salient barriers for heritage preservation and adaptation in the U.S. Some scholars (e.g., Barr 2017; Heilen et al. 2018) also stressed that cost of comprehensive assessments and surveys of both known and unknown archaeological sites is an important aspect in preservation and adaptation. We agree with these previous works and argue that addressing costs of maintenance, preservation or adaptation strategies is a critical consideration, as relative management costs are equally important as benefits in budget allocation decision-making (Courtois et al. 2018). As such, more research is needed to better understand the various socio-cultural, economic, environmental and political considerations that actually influence on-the-ground prioritization of cultural heritage for climate adaptation, in general, and of archaeological sites, specifically. Yet, perhaps even more important is the need for studies that assess the acceptability of climate adaptation decisions when decision-makers' considerations for selecting priorities are made transparent to diverse stakeholder groups.

As shown in some previous studies (e.g., Armitage et al. 2011; Dietz 2013; Lebel et al. 2010), knowledge sharing and co-production, including the incorporation of lessons learned, can reduce uncertainties and improve proactive climate adaptation outcomes. As Huitema et al. (2016) argued, the presence of uncertainties and related knowledge gaps do not justify adaptation policy inaction, especially not in regard to irreplaceable and non-renewable archaeological sites. Prioritizing archaeological sites for preservation and adaptation is not a simple task under climate, economic and social uncertainties, but current archaeological site preservation decisions are typically set on the basis of available data (NPS 1983). We consider that "best-bet" approach, which uses available data, is better than ad-hoc decisions, which are often based on decision-maker's preferences, biases, or power dynamics. As such, there is a need to advance the understanding of various uncertainties in archaeological site preservation and climate adaptation.

In conclusion, previous studies suggest that co-production can reduce conflicts and foster empowerment and synergies among multiple actors in a deliberative process who can, in turn, perceive the resulting knowledge as credible and legitimate, and adopt such knowledge for decision-making (Lebel et al. 2010; Polk 2015). We found that during a deliberative and values-based workshop, experts developed the sense that their peers were transparent in information sharing, thus suggesting that credibility improved. Yet, additional work to integrate the values and knowledge of other extra-scientific actors (e.g., tribal elders and associated community groups) is needed to ensure more holistic climate adaptation planning of cultural heritage in the U.S., as well as in other developed and developing countries. Creating and sharing knowledge between researchers and multiple stakeholders (e.g., policy-makers, decision-makers, practitioners, and associated communities) can form a more democratic basis for joint action in safeguarding archaeological sites against anthropogenic climate change. In the meantime, the set of prioritization considerations assessed in this study can provide valuable insights for cultural heritage and climate change policy-making in the U.S. and globally.

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Compliance with ethical standards

Conflict of interest None.

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