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RESEARCH ARTICLE

Representing future generations in the deliberative valuation of ecosystem services

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Even though decisions taken today about managing ecosystem services are likely to have an effect on future generations' well-being, decision making is based largely on current generations' values, including altruistic concern for posterity. Deliberative forms of citizen engagement can provide a methodological framework for incorporating sustainability considerations in the valuation task and for understanding the reasoning behind peoples' choices. This paper uses a deliberative form of citizen engagement to better understand the temporal dimensions of social values by incorporating into the valuation task two plausible future scenarios and assigning to the participants the role of trustees for future generations. In particular, we employed the deliberative multicriteria evaluation (DMCE) method with eleven groups in which a total of 67 participants assessed the relative importance of ten ecosystem services in the Upper Merrimack River watershed in New Hampshire. Our results suggest that a deliberative form of citizen engagement provides the appropriate space for incorporating intergenerational concerns into decision making. Participants set environmental targets by prioritizing the satisfaction of basic human needs, securing human and environmental health, and avoiding the loss of ecosystem services that cannot be substituted and may lead to irreversible future losses. This finding suggests that when preferences are socially constructed, then ethical values underpin valuations, making it possible to integrate ecosystem service tradeoffs into environmental decisions in a manner that respects the environmental rights of future generations.

Keywords: Deliberative valuation; Social values; Ecosystem services; Future generations; Intergenerational ethics

1. Introduction

Integrating ecosystem services into decision-making is essential for achieving sustainable pathways, yet it remains a challenge for reasons that include the paucity of tools to assess some categories of ecosystem service values and the fragmented knowledge of decision makers and the public with regard to the complex social-ecological interactions (Guerry et al. 2015).

Even though the public character, as well as the multidimensional properties, of most ecosystem services cannot be fully captured by the cost-benefit framework, the employment of pluralistic evaluation frameworks in the policy arena is relatively rare (Spash 2007, Wegner and Pascual 2011, Kenter et al. 2015, Kenter et al. 2016a). Exploring ecosystem service values over a large temporal scale adds another dimension of complexity to cost-benefit analysis since it hinges on the choice of the appropriate discount rate and the preferences of unborn individuals both of which may co-evolve endogenously with socioeconomic systems (Wegner and Pascual 2011, Díaz et al. 2015). The former issue has been extensively considered, but the latter issue requires further investigation.

Our paper attempts to provide insight into the ways that citizens think about the future generations in a way that does not explicitly depend on discount rates. We would like to understand the degree to which citizens are explicitly thinking about future socioeconomic conditions and generations when sustainability considerations are included in the valuation task by applying a deliberative form of citizen engagement. To do this, we applied the deliberative multicriteria evaluation (DMCE) process to assess the relative value of 10 ecosystem services, with a total of eleven panels of residents in the Upper Merrimack River Watershed, New Hampshire, USA. In doing so, we specifically: (i) assigned to participants representing the current generation the role of trustees who represent the interests of future generations under alternative scenarios; (ii) explored the relative importance that trustees place on various ecosystem services under a given scenario; and (iii) traced the reasoning behind choices to better understand the resulting weights through a qualitative analysis of the group deliberations.

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1.1. Sustainability and social values

Guidance for decision making is related to societal perceptions of sustainability and how social values regarding sustainability are formulated. Two opposing schools of thought, strong and weak sustainability, have been used to interpret the term sustainability, driven by different assumptions about the relationship between human made and natural capital and the preferences of future generations. For example, the "strong" interpretation of sustainability suggests that human made capital can only be complementary to natural capital and, due to this reason is less amenable to tradeoffs and more focused on maintaining the integrity and function of ecosystems while avoiding critical thresholds (Neumayer 2003, Farley 2012). In this view, the present generation should not dictate its own preferences to future generations by assuming that the preferences of future generations will be similar to those of the current generation. This view can be grounded on the premise that future generations should enjoy life opportunities at least as good as those enjoyed by the current generation, and that access to ecosystem services is one important constituent of life opportunities and an essential component of a fair bequest package (Howarth 2007, Klauer et al. 2017).

The "weak" interpretation of sustainability assumes that natural capital can be substituted by human made capital and it requires social values that allow tradeoffs among ecosystem services across generations as long as it is possible to find substitutes for ecosystem services with limited supply (Ekins et al. 2003, Neumayer 2003). Applications of this view typically project future preferences based on the preferences of the current generation as measured using revealed and/or stated preference techniques (Norton et al. 1998). This can allow for changes in willingness-to-pay based on economic growth and substitution between goods. It typically does not, however, allow for endogenous changes in the foundational values, attitudes, and beliefs that lie behind preference judgments.

It is not clear which interpretation most citizens will follow when explicitly asked to make tradeoffs for the future, especially given that it is not possible to predict future values. However, it is possible to integrate intergenerational concerns into current decision making by shifting the interest from individuals' future values to current's generation social values (Norton 2002). In this respect, social values represent the community's moral commitments – what it will be saved for the future generations – and their articulation requires the involvement of communities (Norton, 2002). There are various tools for conceptualizing and assessing social values resulting in different implications for future research needs and environmental decision making (Raymond et al. 2019). There is a call for integrating plural and diverse values into ecosystem assessments, which requires emphasizing the temporal dimensions of values, actively engaging the public in decision making processes, promoting social learning, and shedding light on the process of value formation (Kenter 2018, Christie et al. 2019, Eriksson et al. 2019). Preference elicitation for public and common resources using stated preference methods has been challenged for numerous reasons including the inability to capture the plurality of values, citizens' limited knowledge about the valuation task, and the importance of understanding the reasoning behind peoples' choices (Dryzek 2000, Vatn 2009, Wegner and Pascual 2011, Raymond et al. 2019). Responding to those challenges, deliberative forms of citizen engagement such as deliberative monetary valuation or deliberative multicriteria evaluation, have been proposed as an alternative framework to elicit shared social values (Howarth and Wilson 2006, Proctor and Drechsler 2006, Spash 2007, Kenter et al. 2016b). These methods rest upon the deliberative democracy theory that supports active citizen engagement in decision making through reasoned dialogue and debate (Dryzek 2000). In this respect, deliberative forms of citizen engagement provide space for identifying plural and diverse values, and understanding the sources of disagreement among citizens, including how they think about, and value, future generations and their socioeconomic conditions and preferences (Curato et al. 2017).

1.2. Making choices on behalf of future generations

Our analysis focuses on the challenge of making choices now given uncertainty about the future of both socioeconomic systems and the preferences of future generations (Díaz et al. 2015). Scientists studying social-ecological systems have been exploring this uncertainty by developing scenarios to understand the interactions between changes in land use, human activities, policymaking, climate change and the provision of ecosystem services (Byrd et al. 2015, Carpenter et al. 2015). Scenarios can shed light on the possible effect of current decisions on the future provision of ecosystem services and help decision makers shape the future with less ambiguity. However, developing plausible scenarios for the future is a complicated process that involves several steps (narratives, translation and, quantification) and actors (public, stakeholders, decision makers and scientists) (Berg et al. 2015, Mallampalli et al. 2016).

Even though it is scientifically possible to explore plausible scenarios and translate them in terms of ecosystem service provision, it is not possible to elicit preferences for those ecosystem services from individuals not yet born. This representation obstacle is well-described by O' Neill (2001) and Vatn (2009), who argue that the interests of future generations and non-humans are not well-represented by the willingness-to-pay of the current generation, and that deliberative approaches to value articulation can address this concern (Lienhoop and Völker 2016). In addition, deliberative approaches to public participation in the form of citizens juries seem more appropriate for addressing the potential for domination over future generations imposed by present day environmental decisions (Scholtes 2010). One possibility is to construct processes in which members of the citizen jury are charged with the task of serving as trustees on behalf of future generations (Goodin 1996). We acknowledge that the authorization of the current generation to act as trustees within deliberative processes "relies on epistemic claims coupled with care" (O' Neill 2001), and it may be challenging for the current generation to make decisions on behalf of future generations' need.

2. Eliciting social values using citizen juries

With the goal of understanding how citizens in deliberative settings discuss and value on behalf of future generations, we employed mixed methods to design and implement our experiments with residents in the

Upper Merrimack River Watershed in the US state of New Hampshire and analyze the results.

2.1. Study area

The upper Merrimack River watershed drains an area of about 8000 km^2 and is home to more than 410,000 people (Samal et al. 2017). As of 2016, land use within the watershed was 82% forest, 4.2% developed, 3.8% agriculture, 5.9% wetland, and 4.2% open water (Thorn et al. 2017). The region is experiencing rapid population growth as well as land-use change, resulting in various environmental impacts and threats (e.g. increased water use, nitrogen discharge, beach closures). Climate change is expected to result in warmer temperatures and greater and more variable precipitation patterns. Given that the area is a tourist destination, changes in the provision of ecosystem services may have important social and economic impacts.

2.2. A deliberative citizen engagement method

2.2.1. Background

In democratic societies, citizen participation is essential for decisions related to public and common resources; citizen juries have been used as a tool for effectively engaging citizens (Wakeford 2002). In this context, a small group of citizens and/or stakeholders is assembled in a focus group or "citizens' jury" with the goal of developing mutual understanding and reaching consensus about the value of public and common goods through discussion and deliberation (Wilson and Howarth 2002).

Designing and implementing a citizens jury engagement process successfully requires: (i) recruiting a representative sample of the overall population; (ii) building jurors' knowledge about the issue under consideration; (iii) creating space for self-reflection and; (iv) facilitating the discussion to allow for equal voices among the jurors (Kleinman 1998, Wakeford 2002). We employed the deliberative multicriteria evaluation (DMCE) that combines the advantages of multicriteria decision analysis (e.g. structure and transparency, inclusion into the assessment task of environmental attributes with different measurement units) with the benefits provided by deliberative processes (e.g. building social learning, mutual agreement) to apply the citizens' juries process operationally (Proctor and Drechsler 2006, Kenter et al. 2011).

Based on this method, we developed an assessment task in which we asked each citizen jury to arrange a set of cards representing different categories of ecosystem services (different possible states) along the length of a measurement stick scaled from 0 to 100 (**Figure 1**), with 0 representing the least preferred state and 100 the most preferred state. The selected attributes correspond to three domains: land, climate and water. The worst and best levels for each attribute represent two future scenarios developed by Samal et al. (2017), Thorn et al. (2017). In this context, ecosystem service tradeoffs mean the "relative importance" of the attributes, which is inferred from the participants ratings using the reverse swing weighting method (Mavrommati et al. 2017).

The selected attributes (**Table 1**, Text S1) correspond to environmental indicators that satisfy five properties (be

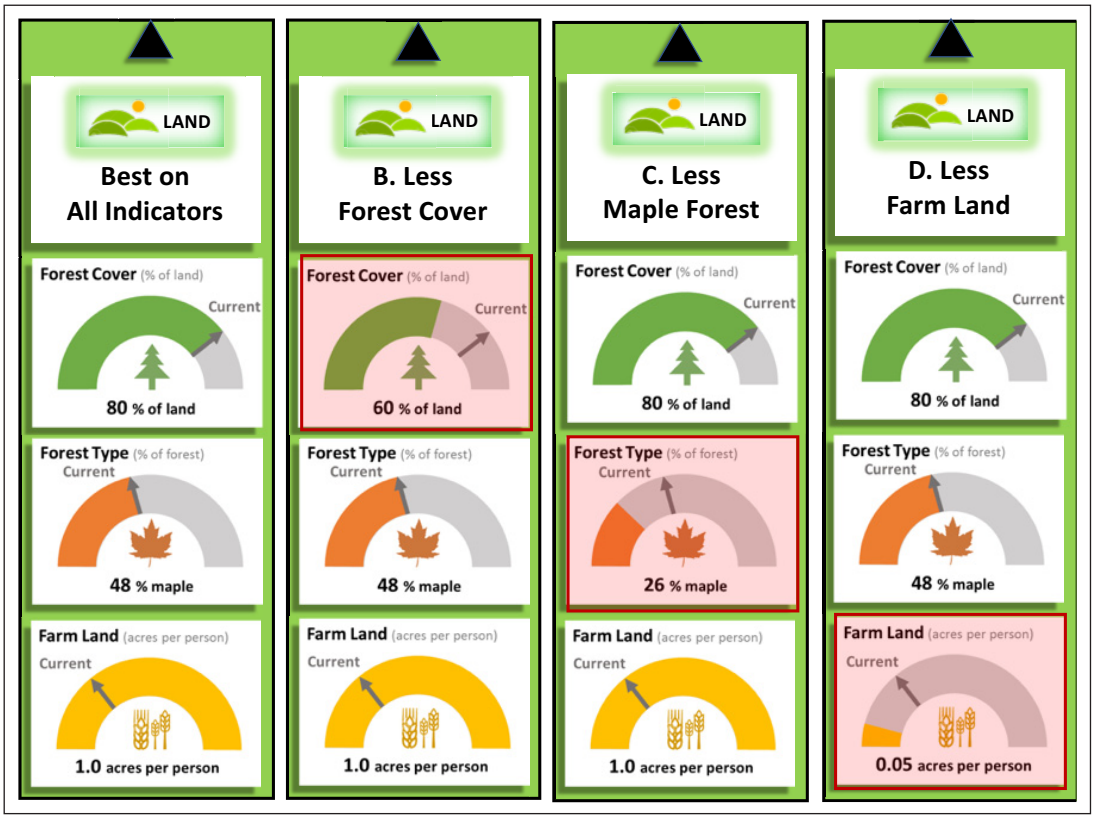

Figure 1: Examples of the cards used for the land domain in the assessment tasks. In the first card each attribute is set to its best foreseeable level, in the second and third cards, respectively, the forest cover and forest type were swung to their worst levels. The endpoints of the scales shown on the cards were chosen as 0 to 100% for attributes measured as percentages. DOI: https://doi.org/10.1525/elementa.417.f1

Table 1: Definitions of attrributes from Samal et al. (2017). DOI: https://doi.org/10.1525/elementa.417.t1

Domain	Attribute Name	Ecosystem Services Represented	Modelled Environmental Indicator*	Definition	Current Level	Worst Level	Best Level	Units
Land	Farm Land	Local food, agricultural heritage, aesthetic value	Agricultural Cover	Total area of agricultural land (both cropland and pasture) divided by the population	0.2	0.05	1.0	acres per person
	Forest Cover	Forest products, recreational opportunities, carbon storage, aesthetic value	Forest Cover	% of total watershed area that is forest	80	60	80	% of total land area
	Forest Type	Maple products, aesthetic value, tourism, cultural significance	Maple Suitability	% of forest suitable for maple trees	48	26	48	% of forest
Climate	Hot Days	Regulation of heat stress	Hot Days	Days per year with temperature >90°F	15	71	15	days
	Snow Cover	Winter recreation, tourism, cultural significance	Snow Days	Days per year with snow >6 inches	25	7	25	days
	Recreation Days	Outdoor recreation, climate comfort	Mild Temperature Days	Days per year with temperature between 70° to 90°F	123	109	123	days
Water	Fish Habitat Loss	Fishing, recreation, existence value	Fish Habitat Loss	Total upstream river length and duration impaired by temperature, chloride, or discharge	10	50	10	% river miles
	Coastal Harm	Coastal recreation, shellfish, aesthetic value, water purification	Nitrogen Export	Nitrogen export to estuary exceeding regulatory threshold	0.2	3.3	0.2	tons N per year
	Water Shortage	Household and industrial water supply, recreation, infrastructure needs	Water Shortfall Risk	Population duration of water supply stress	1.5	4.5	1.5	million person · days
	Flooding	Flood regulation, human safety, natural infrastructure	Flood Risk	Population duration of potential flood impact	0	5	0	thousand person · days

direct, operational, understandable, comprehensive and unambiguous) while also being amenable to being modelled by our scientific team for both current and future conditions, given available expertise and data (Samal et al. 2017). A detailed description of the DMCE method can be found in earlier publications (Mavrommati et al. 2017, Borsuk et al. 2019).

2.2.2. The process of forming citizen juries

We organized four workshops with eleven total groups of residents (a total of 67 residents) in the Upper Merrimack watershed. We followed a self-selection method to recruit participants through advertising in local media (radio and newspapers) and social media (Facebook) with an invitation to participate in our full-day workshops in exchange for a $100 incentive, free lunch, and reimbursed travel costs. Eligibility was determined through an online survey comprised of fourteen questions aiming at (i) gathering demographic information (sex, age, income, political affiliation); (ii) understanding public opinion on environmental quality in the watershed and (iii) determining availability and willingness to participate in an one day workshop (Text S2, Figure S1 and S2). We received 286 completed surveys, where 56% of the respondents were females, and most of the respondents (48%) live in the community between 1 to 20 years. Also, the vast majority of the respondents belong to the baby boom generation that is actively engaged in social and economic life in the US.

Based on the participants' responses and availability (286 in total), we invited 96 individuals. We divided them into groups based on their demographic characteristics and political affiliation to represent, to the greatest degree possible, the overall New Hampshire population (Table S1). A total of 67 participants showed up for the four workshops, which were held during September 2015 in Concord, NH.

2.3. Using scenarios to foster participants thinking of future generations

We employed two scenarios developed by Thorn et al. 2017 (**Table 2**) to foster participants thinking regarding the socioeconomic conditions of future generations. Each scenario illustrates differing conditions in 2100 with respect to population changes, land cover, environmental policy and economic growth (Thorn et al. 2017).

The Backyard Amenities scenario represents a future where development is driven by a combination of high population increase, relatively weak regulatory policies, and robust economic growth focused on the service industry. Economic growth follows the path of least resistance and federal and state public funds are directed more toward initiatives and efforts in support of development of land for residential and commercial use. An increase in impervious surfaces combined with little to no regulatory agency capacity to monitor and enforce water quality standards results in increased runoff from impervious surfaces that flows directly into the state's major bodies of water. The Community Amenities scenario represents a future where development is driven by slow population growth and a strong regulatory framework. Economic growth takes place within urban cores and village centers, primarily in areas already served by existing infrastructure. No additional land is developed beyond what is already developed. Instead, urban cores and village centers are redeveloped to accommodate expanding populations. **Table 2** represents the two scenarios (Thorn et al. 2017). More detailed description can be found on http://ddc-landcover.sr.unh.edu/resources/multimedia-library/#BA.

Our goal was for jurors to make tradeoff decisions for future generations that were based on a coherent understanding of the various conditions that these generations might face. Thus, we chose to expose participants to only one future scenario. This enabled them to think deeply about the conditions that future residents might encounter. To test whether the alternative methods to communicate science to the general public affect preference judgements, we presented the scenarios by using two different methods: a PowerPoint-style slide presentation and a theater performance (Mavrommati et al. 2017). Given that there was no statistically significant effect of

Table 2: Future Socioeconomic Scenarios for the year 2100 in the Upper Merrimack River Watershed and number of workshops and groups for each experimental treatment. DOI: https://doi.org/10.1525/elementa.417.t2

Socio-economic state in 2100	Backyard Amenities	Community Amenities
Population change (current population 410000)	+168%	−9%
Developed Land	Rapid and accelerating	All development as redevelopment
Economic growth	Service industry	New high tech and manufacturing businesses
Policy	Shrinking role of state agencies	Policies promoting sprawl are repealed
Primary mode of transportation	Cars	Public transportation and bikes
Agricultural Policy	Focus on short-term benefits	Focus on maximizing environmental benefits
Energy plan	No plan at state level	Plan for sustainable energy production
Number of workshops	2	2
Slide Presentation Style	1	1
Theater Presentation	1	1
Number of groups	5	6

presentation style on the weights in any of the domains except for Water, we do not take into consideration this aspect to analyze our findings.

2.4. Workshop structure and gathered data

The overall goal was for each "citizen jury" to rank and weight selected bundles of ecosystem services based on a given future socioeconomic scenario for the year 2100 in the Upper Merrimack River watershed. Participants were assigned the role of "trustees for future generations" and thus their mandate was to protect and promote future generations' interests and needs. To better communicate future scenarios and the selected ecosystem services attributes, we employed scientists in the process who served as "expert witnesses". A professional facilitator helped each citizen jury complete the assessment task but was careful not to influence the groups or leading them toward their final decisions.

During the first part, participants were introduced to the concept of ecosystem services, the deliberative process and their charge (role and assessment task). They were presented with a specific socioeconomic scenario, based on the experimental treatment method (e.g. the backyard amenities scenario was assigned to the first day's groups), and were given an overview of the science behind the selected attributes for each domain. Each participant also filled out an individual pre-deliberation questionnaire survey. In the second part, we divided participants into two or three predetermined citizen juries based on their demographic characteristics, and they were brought to different rooms where they completed a warm-up exercise to help them feel more comfortable with their groups and in their roles as residents in the watershed. Then, each facilitator reminded each group of their charge and several rounds of discussion and deliberation followed with the goal to complete the assessment task explained in section 2.2. Experts were available to answer questions as they came up.

After the deliberation, participants were asked to fill out an individual post-deliberation questionnaire survey as well as a workshop evaluation survey (**Table 3**). Previous manuscripts focused on the DMCE method to assess trade-off weights and on comparing group deliberation to other forms of preference aggregation in valuing ecosystem services (Mavrommati et al. 2017, Murphy et al. 2017, Borsuk et al. 2019). Here we focus on the outcomes from the deliberation process by using both qualitative and quantitative data.

2.5. Content analysis

The deliberations of each group were voice recorded and transcribed into a written text using Rev professional services. We read the transcripts and we listened to the voice recordings to fix inconsistencies or add missing words. We analyzed workshop transcripts using a grounded theory approach and with both manifest and latent content analysis (Hay 2010)**.** Latent content analysis focuses on understanding the underlying meaning of a text through the establishment and assignment of codes to transcripts of the deliberation. This approach was used first to determine the types of "future" terminology participants used. For example, we identified 42 words and phrases that referred to the future such as "safeguarding the watershed for future generations" or "in twenty years" or "in my children's generation." It was through this process that we saw the emergence of themes that focused on the "past" but were mentioned in connection to the discussion of participants' role as trustees for the future generations, such as discussions about how water quality had improved over time in a specific location or how a specific geography used to be compared to how it might look and feel in a future under climate change. Because of this realization, we began to also code for themes related to the past. After we established this list of words and phrases, we then employed a manifest content analysis, which is essentially going back through the transcripts with a specific list of words and phrases to code in order to determine the number of times each of those future themes were mentioned. Two coders reviewed the transcripts and discussed the themes for consolidation and congruency. We utilized the qualitative research software NVIVO, to manage the transcript data and to identify situations in which individuals made statements that could be categorized as referring to the "future" or the "past." We performed an agreement reliability analysis to test for the validity and

Table 3: Workshop structure, activities and gathered data. DOI: https://doi.org/10.1525/elementa.417.t3

Workshop Structure	Activities	Gathered Data
Part I: Participants Pre-Deliberation	Introduction of the process and participants charge	Not applicable
	Presentation of the socioeconomic scenario	Not applicable
	Presentation of the ecosystem services	Not applicable
	Individual questionnaire survey before the group deliberations	Individual participants' rankings before deliberation
Part II: Deliberation	Group warm up exercise	
	Deliberation	Voice recorded deliberations
	Performing the assessment task	Group trade-off weights
Part III: Post-deliberation	Individual questionnaire survey after the group deliberations	Individual participants' rankings after deliberation
	Individual questionnaire survey before the group deliberations	Workshop evaluation

replicability of our approach and the score was above 0.9 for each replicability test (Neuendorf 2016).

Content analysis is a widely accepted as an analytical approach to qualitative data. It is non-obtrusive as it allows researchers to review communications after the fact and without interfering with a discussion or interview. It is also an approach that has well established best practices and can be flexible for many types of research subjects. With the use of code books and multiple coders, error can be reduced and there is some degree of replicability (Hay 2010, Elo et al. 2014).

However, there are challenges to using this method for analysis that should be noted. While error can be reduced it cannot be eliminated and multiple rounds of coding are resource and time intensive and sometimes prohibitive. The selection of codes is inherently subjective and influenced by many circumstances. On its own, content analysis may not tell the entire story of a research question and it is often helpful to have other data analysis as the authors have done here with the quantitative attribute weightings.

3. Results

3.1. Future considerations: jurors' awareness of the scenario under consideration and their role

A content analysis of the transcripts and notes from the deliberation sessions suggested that workshop participants were well-aware of their role and the future scenarios during the ecosystem services assessment (**Tables 4, 5** and **6**).

Table 4: Aspects discussed by citizen juries (groups) during deliberations and used to test participants' awareness and understanding of the future scenario under consideration. DOI: https://doi.org/10.1525/elementa.417.t4

Workshop number	**Workshop 1**		**Workshop 2**			**Workshop 3**		**Workshop 4**	
Scenario considered	**Backyard Amenities**		**Community Amenities**			**Backyard Amenities**		**Community Amenities**	
Group number*	1	2	3	4	5	6	8	9	10
Scenario aspect									
Are participants aware of the scenario year?	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Are participants aware of population changes?	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Are participants aware of future land cover (e.g. urban, agriculture)?	Yes	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Are participants aware of economic growth/job/transportation?	Yes	No	Yes	No	Yes	Yes	Yes	Yes	No

* We did not include groups 7 and 11 into our qualitative analysis because the quality of transcripts is not sufficient.

Table 5: Future themes that emerged from a content analysis of the deliberation transcripts. DOI: https://doi.org/10.1525/elementa.417.t5

Future Themes	**Group #**
Climate refugees	6, 5
Safeguarding the watershed for the future	6,2
Uncertainty about the likelihood of climate and population projection, as well as economic impacts, especially on the winter tourism industry and subsequent impacts on quality of life	1, 3, 4, 5, 6, 8, 9
Perception of potential improvement based on scenario (e.g. more habitat for a certain species, less money spent on fuel, etc.)	4,5, 6, 10
Concerns for children and grandchildren	1,9,2
Pests (e.g. ticks) and invasive species changing quality of life	5, 9
Perception of less (e.g. access to water)	10
Inequality of the distribution of impacts	4
Geography- discuss changing residence based on projected changes in system	10

Table 6: Past themes that emerged from a content analysis of the deliberation transcripts. DOI: https://doi.org/10.1525/elementa.417.t6

Past Themes	**Group #**
Water quality in the watershed has improved over the past	4, 5, 6
Experience (either travel or a period of living) in another geography with a different climate/set of circumstances	1, 2, 3, 4, 5, 6, 8, 10
Experience with a major/traumatic climate/environmental event	4, 5, 10

Discussions within groups centered on the people living in the watershed in 2100. This focus was evinced by the frequency of words and phrases that concerned future scenarios, future generations and their role as trustees.

We examined certain dimensions of the scenarios such as population, land cover and economic growth and transportation that were explicitly discussed by group participants. For example, group 1 was able to associate higher population with car usage, road safety, and snow cover. One participant stated "...with higher population, the snow days would be concerning, just because of traveling and danger". In the same vein, a participant from group 9 said "we are thinking about 100 years from now and making decisions for that population and, seems to me food supply would be of great importance".

That said, considering future generations' needs under a given future scenario was not an easy task for participants. Facilitators and expert scientists addressed this challenge by mentioning several aspects of the future scenarios during the group deliberations. In particular, facilitators reminded participants of the scenarios in the beginning of their task assignments and asked participants if they had any questions about the scenario presentation. Expert scientists implicitly made reference to the scenarios to address participants' questions with respect to ecosystem services. For example, group 5 asked experts to remind them of the underlying assumption of scenario 2 concerning farmland production.

Digging deeper into the deliberative process, we found that each group discussed the future and, in all but one, made references to the past. Groups made consistently more references to the future. We identified nine unique themes from these discussions in **Tables 5** and **6**. Most of the future themes (**Table 5**) were consistent between the two scenarios, including the themes of climate refugees, uncertainty about model and climate projections and subsequent impacts on quality of life, concerns for children and grandchildren, impacts on winter tourism, and, on the positive side, a perception that there may be potential improvements based on the scenario presented. While the "concerns for children and grandchildren" may suggest a more egoistic perspective, other themes suggest a potentially altruistic perspective on future generations as a whole.

Uncertainty about the future state of the socioeconomic system and the challenge of making decisions based on the uncertainty inherent in the scenarios was a theme that emerged from almost all of the groups. One participant powerfully described this challenge by saying, "What you're asking us is [to make] Sophie's choice." This was a reference to the novel and subsequent film, "Sophie's Choice" that focuses on the experience of a holocaust survivor who had to make a tragic decision between her two children when entering Auschwitz. While other participants were not as dramatic in their use of analogies, they were still concerned, stating, "Where is the future where it all gets better? Where is that future?" Other participants made statements comparing the scenarios to geographic changes they could make in their living situations. One participant stated, "I'm going to tell you personally if I was going from fifteen to seventy-one hot days [per year], I'd be moving to Canada."

Another interesting and relevant component of the deliberation analysis was the frequency with which individuals not only spoke about the future but also made references to the past.

While there were fewer discussions focused on the past, four unique past themes did emerge (**Table 6**). Those that were shared between the two scenarios included perceptions that the water quality in the Upper Merrimack Watershed has improved over the past and personal experience in another locale with a different climate/set of circumstances (either travel or a period of living).

In making reference to past experiences, most groups had discussions regarding what it was like to live in another location that had different climatic conditions. For example, one participant stated, "I used to live and work in Dallas, Texas, and 71 days over 90 degrees ... I experienced over 100 straight days of over 100 degrees there. I'm telling you, it was one of the worst experiences." Another interesting theme that emerged in discussions of the past regarded the state of the watershed. Participants generally agreed that the water quality of the Merrimack River had improved from past conditions: "... [T]he Merrimack has really gotten a lot better in my opinion from the early '70s. The improvements have been tremendous." The emergence of themes around the past was somewhat unexpected and seemed to be indicative of the complex process required for making decisions as trustees.

3.2. Sustainability considerations during deliberations

We used the framing given by the schools of weak and strong sustainability to understand jurors concerns and thoughts about future generations. We found that the predicted magnitude of change for each ecosystem service compared to the current value (normalized change) as well as the potential for reversing its loss through avoidance measures or by using other substitutes drove groups' discussion and deliberation process. **Table 7** summarizes participants tradeoff weights in relation to (i) ecosystem services substitutability; (ii) the consideration of future generations' preferences and needs and; (iii) other considerations related to intergenerational wellbeing.

Overall, most groups discussed future generations' ability to meet their basic needs (food and water), to attain good health and to live in a secure environment. Also, we found that most groups were able to consider the various ways that ecosystem services contribute to human wellbeing and integrate into their assessments various components of wellbeing. For example, participants discussed local food production in terms of security and the contribution of snow days to local culture.

Ecosystem services with a high predicted magnitude of change that provide for basic human needs were weighted as the most important in each domain. For example, farmland, an indicator of local food production, has the highest mean tradeoff weight within the land domain, and participants highlighted the need to improve food production under the changing climate and socioeconomic conditions that may impose limitations on the global food supply. Similarly, participants determined that given the magnitude of change of heat stress, future populations in

Table 7: Mean tradeoff weights, normalized change and sustainability considerations. DOI: https://doi.org/10.1525/elementa.417.t7

Attribute	Mean	Normalized Change	Sustainability Considerations during the deliberations		
			Substitutability	Preferences and needs of future generations	Other considerations
Farm Land	0.38	0.69	No substitutes. Basic human need.	Food security under changing climate and socioeconomic conditions	Local food may be better for the local economy. The demand can be fulfilled through imports
Forest Cover	0.34	0.15	Forest cover cannot be substituted	This dimension was not explicitly discussed	New Hampshire forest attracts tourists and supports the economy
Forest Type	0.28	0.16	Maple trees could be substituted by other types of trees	Maple as an integral component of the local culture/aesthetics	Maple supports manufacturing, tourism and other businesses
Hot Days	0.48	0.57	No substitutes besides cooling systems for internal use. A requirement for good health.	Employment under high temperatures increases the risk for heat stress	Increased temperatures are linked to increased crime rates
Snow Days	0.37	0.37	Substitutes exist/snowmaking	Limitations to winter recreational activities such as skiing or ice-fishing.	Local economy depends on outdoor winter recreation; Cultural considerations
Recreation Days	0.15	0.06	Substitutes exist	Every day can be potentially a recreational day	NA
Fish Habitat Loss	0.27	0.16	Substitutes exist	Future generations may have to allocate resources to restore impaired waters	Fish industry will be affected. Existence value
Coastal Harm	0.28	0.3	No substitutes	Water quality as an essential component for human and non-human species health and wellbeing	Harmful algal blooms can affect quality of life and have economic consequences
Water Shortage	0.28	0.24	No substitutes	Human health is a basic need and right. Future generations may need to consume less water.	There are cases that you can import water from different regions
Flooding	0.16	0.3	Substitutes and solutions exist	Provide a secure space for future people	Local and individuals' decisions may affect flood management

the Upper Merrimack Watershed would possibly experience conditions that could have serious repercussions on human health and labor productivity. This idea also applies to the ecosystem service of coastal health. In deliberations about this indicator, participants highlighted the need to maintain nitrogen regulation in light of the absence of substitutes for final services that healthy coasts provide. For these ecosystem services, participants want their current decision not to lead to irreversible environmental losses.

In contrast, ecosystem services for which participants believe there are readily available substitutes or avoidance measures that can be implemented have lower tradeoff weights. For example, recreation days has the lowest mean tradeoff weight since participants consider that the magnitude of change is low, and every day can potentially be a recreation day. Similarly, flood control attenuation, irrespective of the high magnitude of change, was given a low tradeoff weight since participants discussed the various ways to prevent floods.

4. Discussion

Our results suggest that deliberated group values do not depend upon the impossible task to predict future values based on the expectations of the socioeconomic state that future generations may encounter, but rather on a desire to protect the interests of future generations and provide them the environmental assets necessary to pursue their own wellbeing. This has multiple implications for sustainability and ecosystem services research as well as for the way that environmental managers in democratic societies incorporate ecosystem service values into their decisions.

Our choice to incorporate future considerations into the valuation task was prompted by the need to integrate intergenerational considerations into the current decision making and explore the capacity of deliberative approaches

to do so given that the future is always designed by the current generation (Vatn 2009, Kenter et al. 2016a). At the same time, we used future scenarios as a way to foster participants' thinking of future generations (experimental treatments) to better understand the impact of different interventions on deliberated group values (Kenter et al. 2016a). Our findings show the appropriateness of deliberative approaches to integrate future considerations into the current environmental choices. Therefore, using deliberative approaches has the potential to improve intergenerational fairness and increase the legitimacy of decision making. Citizen jurors were able to understand the future scenario under consideration and their role as trustees representing future generations in the current decision making and complete the required tasks in a deliberative group setting. In this way, this paper contributes to the discussion about the role of deliberation in the valuation process with a particular focus on the current decision making in the light of future socioeconomic conditions.

By bringing into the valuation task future scenarios and, by assigning to the participants the role of trustees for future generations, we created the basis for a discussion that relates current environmental decisions to intergenerational concerns. Even though our decision framework did not allow for 'taboo' tradeoffs (not acceptable tradeoffs), we can make some general conclusions about more acceptable and less acceptable tradeoffs based on the content of the discussions. The present generations' "acceptable" ecosystem service tradeoffs are driven to a great extent by the predicted magnitude of change for each ecosystem service compared to the current value and the potential for reversing its loss through avoidance measures or by using other substitutes. This finding is compatible with the two-tiered system of values to understand sustainability (Norton 1992). In this respect, decisions that may result in irreversible future outcomes are non-negotiable, while decisions that result in minor inconveniences are acceptable as long as those impacts could be reversed by the appropriate human made capital or technology.

Participants' deliberation revolved around bequeathing to future generations basic materials for a good life, environmental security and quality that reduces exposure to health risks irrespective of future socioeconomic conditions. Discussions also included the importance of various ecosystem services to cultural identity such as maple trees and snow recreational activities. Therefore, predicting future socioeconomic conditions or what future generations may want for the current one, was less influential to the valuation assessment compared to determining a bequest package for attaining wellbeing in the long run. Therefore, even though the framing of the valuation task was based on a plausible future scenario, participants made their environmental choices based on what would be essential to future generations and to do so we considered various dimensions of sustainability such as substitutability, reversibility and future human needs.

Given that the general public is inevitably one of the key drivers of successful policy implementation, their engagement in decision making could determine the way that sustainability is currently understood by society and increase the legitimacy of decision making. Participants were able to complete the required tasks and come to a group assessment of the relative value of the various bundles of ecosystem services presented to them. The use of deliberative methods may address the temporal dimensions of ecosystem service tradeoffs in environmental management and provide an appropriate framework to assess social values that inform policy making. We found that when residents are assessing tradeoffs in a deliberative setting and the interests of voiceless future generations are explicitly considered, the current generation is willing to make sacrifices that protect the interests of future generations. However, it is vital to achieve inclusion into the recruitment and deliberative process respectively (Vargas et al. 2017). Equal and diverse voices is a challenge if we aim at scaling up the method and investigate how social values of sustainability are formulated at community level (Kenter et al. 2019). In our case, the main challenge was to recruit participants who work and are under the age of 50 even though we provided financial incentives.

We also added a piece of science communication to inform those decisions and build trust between scientists and participants. Given the complex properties of ecosystem services, providing science communication to residents is essential for assessing meaningful tradeoffs. The content analysis reveals that group participants were able to make choices with advanced understanding of both the future scenarios and the attributes of the selected ecosystem services. Cultivating social knowledge with respect to ecosystem services and future conditions may increase the participants' appreciation of the various ways that ecosystem services contribute to human wellbeing and their willingness to support conservation policies. This aspect plays a critical role in our study given that participants served as trustees on behalf of future generations.

Finally, we believe that our analysis has important implications for the ways in which resource managers from sustainability challenges in the search for solutions. Face a traditional perspective, resource management is sometimes viewed as a scientific undertaking focused on maintaining the productivity and resilience of resource systems with an emphasis on biophysical measures of system performance. But if resource managers are to serve the public interest, and if the public holds a concern for sustaining the life opportunities afforded to members of future generations, then it is necessary to employ performance metrics that are grounded in human values and subjective judgement. We see our approach as providing a bridge between these perspectives. On the one hand, the DCME framework is grounded in basic science and biophysical metrics that are communicated to lay stakeholders through science communication. On the other hand, it is citizen juries who – on behalf of their communities – reach decisions on how to value and aggregate each attribute. It is then not the manager's role to make value judgements that by their very nature exceed the scope of technical expertise. Nor are value judgements left entirely to elected or appointed political leaders, who – although accountable directly or indirectly to the public – are also influenced by elite stakeholders and special

interests. In a sense, the appeal of DCME is that it links elements of direct, participatory democracy with the demands of making decisions in administrative contexts that are potentially technocratic and distanced from the public. This is probably most salient for resource management decisions at the local to regional scale, where ecological boundaries are congruent with the scale of institutions and governance, and where good decisions require striking the right balance between alternative goals in ways that require deliberation and social judgement.

Data accessibility statement

No new or original data were generated for the purposes of this paper. The data largely comprise focus group transcripts that are subject to human subjects requirements regarding confidentiality.

Supplemental files

The Supplemental files for this article can be found as follows:

- **Text S1.** Ecosystem services (attributes selection). DOI: https://doi.org/10.1525/elementa.417.s1
- **Text S2.** Questionnaire survey S2. DOI: https://doi.org/10.1525/elementa.417.s1
- **Figure S1.** Demographic characteristics of the questionnaire survey. Age and years living in the community. DOI: https://doi.org/10.1525/elementa.417.s1
- **Figure S2.** Demographic characteristics of the questionnaire survey. Sex, gender, political affiliation and educational level. DOI: https://doi.org/10.1525/elementa.417.s1
- **Table S1.** Participants characteristics compared to New Hampshire population. DOI: https://doi.org/10.1525/elementa.417.s1

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I declare that my coauthors and I have no significant competing financial, professional or personal interests that might have influenced the performance or presentation of the work described in this manuscript.

Author Contributions

- Contributed to conception and design: Georgia Mavrommati, Richard B. Howarth, Mark Borsuk
- Contributed to acquisition of data: Georgia Mavrommati, Shannon Rogers, Richard B. Howarth, Mark Borsuk
- Contributed to analysis and interpretation of data: Georgia Mavrommati, Shannon Rogers, Mark Borsuk
- Drafted and/or revised the article: Georgia Mavrommati
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References

Berg, C, Rogers, S and **Mineau, M.** 2015. Building scenarios for ecosystem services tools: Developing a methodology for efficient engagement with expert stakeholders. *Futures*. DOI: https://doi.org/10.1016/j.futures.2015.10.014

Borsuk, ME, Mavrommati, G, Samal, NR, Zuidema, S, Wollheim, W, Rogers, SH, Thorn, AM, Lutz, D, Mineau, M, Grimm, C, Wake, CP, Howarth R and **Gardner, K.** 2019. Deliberative multiattribute valuation of ecosystem services across a range of regional land-use, socioeconomic, and climate scenarios for the upper Merrimack River watershed, New Hampshire, USA. *Ecology and Society* **24**. DOI: https://doi.org/10.5751/ES-10806-240211

Byrd, KB, Flint, LE, Alvarez, P, Casey, CF, Sleeter, BM, Soulard, CE, Flint, AL and **Sohl, TL.** 2015. Integrated climate and land use change scenarios for California rangeland ecosystem services: wildlife habitat, soil carbon, and water supply. *Landscape Ecology* **30**: 729–750. DOI: https://doi.org/10.1007/s10980-015-0159-7

Carpenter, SR, Booth, EG, Gillon, S, Kucharik, CJ, Loheide, S, Mase, AS, Motew, M, Qiu, J, Rissman, AR and **Seifert, J.** 2015. Plausible futures of a social-ecological system: Yahara watershed, Wisconsin, USA. *Ecology and Society* **20**: 10. DOI: https://doi.org/10.5751/ES-07433-200210

Christie, M, Martín-López, B, Church, A, Siwicka, E, Szymonczyk, P and **Mena Sauterel, J.** 2019. Understanding the diversity of values of "Nature's contributions to people": insights from the IPBES Assessment of Europe and Central Asia. *Sustainability Science* **14**: 1267–1282. DOI: https://doi.org/10.1007/s11625-019-00716-6

Curato, N, Dryzek, JS, Ercan, SA, Hendriks, CM and **Niemeyer, S.** 2017. Twelve key findings in deliberative democracy research. *Daedalus* **146**: 28–38. DOI: https://doi.org/10.1162/DAED_a_00444

Díaz, S, Demissew, S, Carabias, J, Joly, C, Lonsdale, M, Ash, N, Larigauderie, A, Adhikari, JR, Arico, S, Báldi, A, Bartuska, A, Baste, IA, Bilgin, A, Brondizio, E, Chan, KMA, Figueroa, VE, Duraiappah, A, Fischer, M, Hill, R, Koetz, T, Leadley, P, Lyver, P, Mace, GM, Martin-Lopez,

B, Okumura, M, Pacheco, D, Pascual, U, Pérez, ES, Reyers, B, Roth, E, Saito, O, Scholes, RJ, Sharma, N, Tallis, H, Thaman, R, Watson, R, Yahara, T, Hamid, ZA, Akosim, C, Al-Hafedh, Y, Allahverdiyev, R, Amankwah, E, Asah, ST, Asfaw, Z, Bartus, G, Brooks, LA, Caillaux, J, Dalle, G, Darnaedi, D, Driver, A, Erpul, G, Escobar-Eyzaguirre, P, Failler, P, Fouda, AMM, Fu, B, Gundimeda, H, Hashimoto, S, Homer, F, Lavorel, S, Lichtenstein, G, Mala, WA, Mandivenyi, W, Matczak, P, Mbizvo, C, Mehrdadi, M, Metzger, JP, Mikissa, JB, Moller, H, Mooney, HA, Mumby, P, Nagendra, H, Nesshover, C, Oteng-Yeboah, AA, Pataki, G, Roué, M, Rubis, J, Schultz, M, Smith, P, Sumaila, R, Takeuchi, K, Thomas, S, Verma, M, Yeo-Chang, Y and Zlatanova, D. 2015. The IPBES Conceptual Framework — connecting nature and people. *Current Opinion in Environmental Sustainability* **14**: 1–16. DOI: https://doi.org/10.1016/j.cosust.2014.11.002

Dryzek, JS. 2000. Deliberative democracy and beyond: liberals, critics, contestations. Oxford University Press.

Ekins, P, Simon, S, Deutsch, L, Folke, C and **De Groot, R.** 2003. A framework for the practical application of the concepts of critical natural capital and strong sustainability. *Ecological economics* **44**: 165–185. DOI: https://doi.org/10.1016/S0921-8009(02)00272-0

Elo, S, Kääriäinen, M, Kanste, O, Pölkki, T, Utriainen, K and **Kyngäs, H.** 2014. Qualitative content analysis: A focus on trustworthiness. *SAGE open* **4**: 2158244014522633. DOI: https://doi.org/10.1177/2158244014522633

Eriksson, M, van Riper, CJ, Leitschuh, B, Bentley Brymer, A, Rawluk, A, Raymond, CM and **Kenter, JO.** 2019. Social learning as a link between the individual and the collective: evaluating deliberation on social values. *Sustainability Science* **14**: 1323–1332. DOI: https://doi.org/10.1007/s11625-019-00725-5

Farley, J. 2012. Ecosystem services: The economics debate. *Ecosystem Services* **1**: 40–49. DOI: https://doi.org/10.1016/j.ecoser.2012.07.002

Goodin, RE. 1996. Enfranchising the Earth, and its Alternatives. *Political Studies* **44**: 835–849. DOI: https://doi.org/10.1111/j.1467-9248.1996.tb00337.x

Guerry, AD, Polasky, S, Lubchenco, J, Chaplin-Kramer, R, Daily, GC, Griffin, R, Ruckelshaus, M, Bateman, IJ, Duraiappah, A, Elmqvist, T, Feldman, MW, Folke, C, Hoekstra, J, Kareiva, PM, Keeler, BL, Li, S, McKenzie, E, Ouyang, Z, Reyers, B, Ricketts, TH, Rockström, J, Tallis, H and **Vira, B.** 2015. Natural capital and ecosystem services informing decisions: From promise to practice. *Proceedings of the National Academy of Sciences* **112**: 7348–7355. DOI: https://doi.org/10.1073/pnas.1503751112

Hay, I. 2010. Qualitative research methods in human geography. 3 edition. Don Mills: Oxford University Press.

Howarth, RB. 2007. Towards an operational sustainability criterion. *Ecological economics* **63**: 656–663. DOI: https://doi.org/10.1016/j.ecolecon.2007.02.009

Howarth, RB and **Wilson, MA.** 2006. A Theoretical Approach to Deliberative Valuation: Aggregation by Mutual Consent. *Land Economics* **82**: 1–16. DOI: https://doi.org/10.3368/le.82.1.1

Kenter, JO. 2018. IPBES: Don't throw out the baby whilst keeping the bathwater; Put people's values central, not nature's contributions. *Ecosystem Services* **33**: 40–43. DOI: https://doi.org/10.1016/j.ecoser.2018.08.002

Kenter, JO, Bryce, R, Christie, M, Cooper, N, Hockley, N, Irvine, KN, Fazey, I, O'Brien, L, Orchard-Webb, J, Ravenscroft, N, Raymond, CM, Reed, MS, Tett, P and **Watson, V.** 2016a. Shared values and deliberative valuation: Future directions. *Ecosystem Services* **21**: 358–371. DOI: https://doi.org/10.1016/j.ecoser.2016.10.006

Kenter, JO, Hyde, T, Christie, M and **Fazey, I.** 2011. The importance of deliberation in valuing ecosystem services in developing countries—Evidence from the Solomon Islands. *Global Environmental Change* **21**: 505–521. DOI: https://doi.org/10.1016/j.gloenvcha.2011.01.001

Kenter, JO, O'Brien, L, Hockley, N, Ravenscroft, N, Fazey, I, Irvine, KN, Reed, MS, Christie, M, Brady, E, Bryce, R, Church, A, Cooper, N, Davies, A, Evely, A, Everard, M, Fish, R, Fisher, JA, Jobstvogt, N, Molloy, C, Orchard-Webb, J, Ranger, S, Ryan, M, Watson, V and **Williams, S.** 2015. What are shared and social values of ecosystems? *Ecological economics* **111**: 86–99. DOI: https://doi.org/10.1016/j.ecolecon.2015.01.006

Kenter, JO, Raymond, CM, van Riper, CJ, Azzopardi, E, Brear, MR, Calcagni, F, Christie, I, Christie, M, Fordham, A, Gould, RK, Ives, CD, Hejnowicz, AP, Gunton, R, Horcea-Milcu, A-I, Kendal, D, Kronenberg, J, Massenberg, JR, O'Connor, S, Ravenscroft, N, Rawluk, A, Raymond, IJ, Rodríguez-Morales, J and **Thankappan, S.** 2019. Loving the mess: navigating diversity and conflict in social values for sustainability. *Sustainability Science* **14**: 1439–1461. DOI: https://doi.org/10.1007/s11625-019-00726-4

Kenter, JO, Reed, MS and **Fazey, I.** 2016b. The Deliberative Value Formation model. *Ecosystem Services* **21**: 194–207. DOI: https://doi.org/10.1016/j.ecoser.2016.09.015

Klauer, B, Bartkowski, B, Manstetten, R and **Petersen, T.** 2017. Sustainability as a Fair Bequest: An Evaluation Challenge. *Ecological economics* **141**: 136–143. DOI: https://doi.org/10.1016/j.ecolecon.2017.06.001

Kleinman, DL. 1998. Beyond the Science Wars: Contemplating the Democratization of Science. *Politics and the Life Sciences* **17**: 133–145. DOI: https://doi.org/10.1017/S0730938400012120

Lienhoop, N and **Völker, M.** 2016. Preference Refinement in Deliberative Choice Experiments for Ecosystem Service Valuation. *Land Economics* **92**: 555–577. DOI: https://doi.org/10.3368/le.92.3.555

Mallampalli, VR, Mavrommati, G, Thompson, J, Duveneck, M, Meyer, S, Ligmann-Zielinska, A,

Druschke, CG, Hychka, K, Kenney, MA, Kok, K and **Borsuk, ME.** 2016. Methods for translating narrative scenarios into quantitative assessments of land use change. *Environmental Modelling & Software* **82**: 7–20. DOI: https://doi.org/10.1016/j.envsoft.2016.04.011

Mavrommati, G, Borsuk, ME and **Howarth, RB.** 2017. A novel deliberative multicriteria evaluation approach to ecosystem service valuation. *Ecology and Society* **22**. DOI: https://doi.org/10.5751/ES-09105-220239

Murphy, MB, Mavrommati, G, Mallampalli, VR, Howarth, RB and **Borsuk, ME.** 2017. Comparing group deliberation to other forms of preference aggregation in valuing ecosystem services. *Ecology and Society* **22**. DOI: https://doi.org/10.5751/ES-09519-220417

Neuendorf, KA. 2016. The content analysis guidebook. sage.DOI:https://doi.org/10.4135/9781071802878

Neumayer, E. 2003. Weak versus strong sustainability: exploring the limits of two opposing paradigms. Edward Elgar Publishing.

Norton, B. 1992. Sustainability, Human Welfare, and Ecosystem Health. *Environmental Values* **1**: 97–111. DOI: https://doi.org/10.3197/096327192776680133

Norton, B, Costanza, R and **Bishop, RC.** 1998. The evolution of preferences: Why 'sovereign' preferences may not lead to sustainable policies and what to do about it. *Ecological economics* **24**: 193–211. DOI: https://doi.org/10.1016/S0921-8009(97)00143-2

Norton, BG. 2002. Searching for Sustainability: Interdisciplinary Essays in the Philosophy of Conservation Biology. Cambridge, United Kingdom: Cambridge University Press. DOI: https://doi.org/10.1017/CBO9780511613821

O' Neill, J. 2001. Representing people, representing nature, representing the world. *Environment and planning C* **19**: 483–500. DOI: https://doi.org/10.1068/c12s

Proctor, W and **Drechsler, M.** 2006. Deliberative multicriteria evaluation. *Environment and planning C* **24**: 169. DOI: https://doi.org/10.1068/c22s

Raymond, CM, Kenter, JO, van Riper, CJ, Rawluk, A and **Kendal, D.** 2019. Editorial overview: theoretical traditions in social values for sustainability. *Sustainability Science* **14**: 1173–1185. DOI: https://doi.org/10.1007/s11625-019-00723-7

Samal, NR, Wollheim, WM, Zuidema, S, Stewart, RJ, Zhou, Z, Mineau, MM, Borsuk, ME, Gardner, KH, Glidden, S, Huang, T, Lutz, DA, Mavrommati, G, Thorn, AM, Wake, CP and **Huber, M.** 2017. A coupled terrestrial and aquatic biogeophysical model of the Upper Merrimack River watershed, New Hampshire, to inform ecosystem services evaluation and management under climate and land-cover change. *Ecology and Society* **22**. DOI: https://doi.org/10.5751/ES-09662-220418

Scholtes, F. 2010. Whose Sustainability? Environmental Domination and Sen's Capability Approach. *Oxford Development Studies* **38**: 289–307. DOI: https://doi.org/10.1080/13600818.2010.505683

Spash, CL. 2007. Deliberative monetary valuation (DMV): Issues in combining economic and political processes to value environmental change. *Ecological economics* **63**: 690–699. DOI: https://doi.org/10.1016/j.ecolecon.2007.02.014

Thorn, AM, Wake, CP, Grimm, CD, Mitchell, CR, Mineau, MM and **Ollinger, SV.** 2017. Development of scenarios for land cover, population density, impervious cover, and conservation in New Hampshire, 2010–2100. *Ecology and Society* **22**. DOI: https://doi.org/10.5751/ES-09733-220419

Vargas, A, Lo, A, Howes, M and **Rohde, N.** 2017. The Problem of Inclusion in Deliberative Environmental Valuation. *Environmental Values* **26**: 157–176. DOI: https://doi.org/10.3197/096327117X14847335385472

Vatn, A. 2009. An institutional analysis of methods for environmental appraisal. *Ecological economics* **68**: 2207–2215. DOI: https://doi.org/10.1016/j.ecolecon.2009.04.005

Wakeford, T. 2002. Citizens Juries: a radical alternative for social research. *Social Research Update* **37**: 1–4.

Wegner, G and **Pascual, U.** 2011. Cost-benefit analysis in the context of ecosystem services for human well-being: A multidisciplinary critique. *Global Environmental Change* **21**: 492–504. DOI: https://doi.org/10.1016/j.gloenvcha.2010.12.008

Wilson, MA and **Howarth, RB.** 2002. Discourse-based valuation of ecosystem services: establishing fair outcomes through group deliberation. *Ecological economics* **41**: 431–443. DOI: https://doi.org/10.1016/S0921-8009(02)00092-7

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