Ecological Economics 107 (2014) 447–456

Contents lists available at ScienceDirect

Ecological Economics

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

Methodological and Ideological Options

Applying Q-methodology to select and define attributes for non-market valuation: A case study from Northwest Wyoming, United States

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ARTICLE INFO

Article history:
Received 15 November 2013
Received in revised form 24 June 2014
Accepted 3 September 2014
Available online xxxx

Keywords:
Stated preference methods
Ecosystem services
Environmental goods
Environmental valuation
Factor analysis
Survey methods
Qualitative methods

ABSTRACT

The underlying validity of stated preference non-market valuation methods relies on the analyst's ability to identify, select, define, and articulate the goods being valued in a way that is relevant and understandable to the respondent, which requires detailed understanding of the respondents' experiences and points of view. Poor articulation of the good being valued will result in biased to useless information for decision-makers. It should therefore be of concern to economists and policymakers that the question of how best to perform pre-design qualitative work with local stakeholders is a neglected area of inquiry. This paper assesses Q-methodology as an objective, transparent, easily replicable, and statistically-rigorous approach to qualitative research to support the selection and definition of attributes for non-market valuation.

1. Introduction

Numerous approaches have been developed to identify natural resource values impacted by management and policy, and the importance of these values to different stakeholders, and to bring more structure to the process of developing and evaluating alternative policy and management options. Dryzek (2013) categorized these approaches into three major discourses: (1) administrative rationalism ('leave it to the experts'); (2) democratic pragmatism (public consultation, alternative dispute resolution, policy dialogue, and lay citizen deliberation); and (3) economic rationalism (deployment of market mechanisms). Dryzek (2013) argued administrative rationalism may be 'running out of steam'. Natural resource management decisions often involve complex, disputed and uncertain scientific, social and cultural facts, multiple and conflicting values of stakeholders, a rising perception among citizens that environmental management decisions must be legitimized by broad public input, and high stakes. Consequently, decisions are often politically-charged and result in local to international-scale disagreements (Albrecht, 2010; Cornatzer, 2014; Moy, 2011).

To improve the likelihood that management decisions will be greeted with public support and to avoid conflict, stakeholder participation in the design of natural resource management policy is increasingly regarded as important and is becoming common in practice (Buchy and Hoverman, 2000; Lennox et al., 2011; Menzel and Teng, 2009; Rutgers et al., 2012; Turner and Daily, 2008; Videira et al., 2006). Potential difficulties and pitfalls associated with public input and stakeholder participation (e.g. 'overcrowded policymaking', political manipulation, and decreased decision quality) have been recognized in the literature (Dietz and Stern, 2008; Richardson and Jordan, 1983). However, these criticisms are less germane when the purpose of public participation is primarily that of supporting sound environmental decision-making, as opposed to proposing solutions and reaching consensus (Dietz and Stern, 2008).

Natural resource decision-making is often supported by benefit–cost analysis (BCA). Practitioners have increasingly aimed at total economic valuation of proposed policy actions through accounting for costs and benefits of relevant market and non-market values. The most versatile methods for estimating non-market values are stated preference surveys (e.g. contingent valuation and choice experiments), and best practice recognizes the need for local stakeholder involvement in preliminary stages of survey development (Bateman et al., 2002; Bennett and Adamowicz, 2001; Louviere et al., 2000; Mansfield and Pattanayak, 2007). Typically, this involvement is through pre-design qualitative research focused on attribute development. Such methods include literature review, visits to the study area, and 'rapid appraisal methods' such as key informant, focus groups, direct observations, community surveys or workshops, and mini-surveys (Bateman et al., 2002; Blamey et al., 2002; Mansfield and Pattanayak, 2007; Powe, 2007).

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http://dx.doi.org/10.1016/j.ecolecon.2014.09.010
0921-8009/

However, details regarding which method(s) are most appropriate, and how they should be employed are scant (Coast and Horrocks, 2007; Coast et al., 2012).

The lack of guidance provided for the pre-design qualitative research phase of non-market valuation is potentially problematic. It is at this time that local input can be used to ensure the survey is sensitive to the local context of the policy question by informing the selection of goods and services (attributes) that will be the focus of tradeoffs made by respondents, the choices about which policymakers can be informed, and the text the respondent sees. If important attributes are excluded or respondents do not understand the meaning of the attributes they are faced with, then the findings from the non-market valuation survey are likely to be biased or even useless for informing policy (Coast et al., 2012). It should therefore be of concern to economists and policymakers that the question of how best to perform pre-design qualitative work with local stakeholders is a neglected area of inquiry (Coast and Horrocks, 2007; Coast et al., 2012; Louviere and Lancsar, 2009; Michaels-Igbokwe et al., 2014). The field needs more explicitly-defined procedures for pre-design qualitative research.

Michaels-Igbokwe et al. (2014) provided the only published example of an explicitly-defined procedure for pre-design qualitative research for non-market valuation. They suggested developing a decision map as an additional step in the non-market valuation survey development and design process. However, the qualitative aspect of their approach involving stakeholders is based solely on traditional focus groups and individual interviews. Baker et al. (2006) and Kerr and Swaffield (2012) proposed Q-methodology as an alternative, systematic and structured approach to attribute development, which builds upon the traditional approach by incorporating local stakeholder knowledge in an objective, transparent, easily-replicable and statistically-rigorous fashion. This paper assesses this proposal, providing specific examples of how Q-methodology can improve the design of non-market valuation surveys and interpretation of results relative to traditional approaches, which include:

- identifying and defining goods that are relevant to survey participants;
- informing the selection of a subset of important goods for inclusion in a non-market valuation survey;
- highlighting goods where respondents may employ cause and effect reasoning; and
- providing nuance and detail that can help distinguish protest responses from true willingness to pay (WTP) estimates.

This paper proceeds as follows: Section two describes the need for explicitly-defined qualitative research methods for preliminary design of stated preference surveys. Section three describes Q-methodology and section four presents a case study application of Q-methodology to support non-market valuation in Northwest Wyoming, USA. With reference to the case study, the fifth section discusses how pre-design qualitative research using Q-methodology can improve the design of stated preference non-market valuation surveys. Section six concludes.

2. The Need for Explicitly-defined Qualitative Research Methods for Preliminary Design of Stated Preference Surveys

Valuation of ecosystem services is considered to be an effective avenue for identifying and evaluating the range of tradeoffs between alternative natural resource policy and management actions (Bagstad et al., 2012; Bateman et al., 2013; Ingraham and Foster, 2008). For purposes of this study, ecosystem services are defined as the benefits provided by natural systems that directly and indirectly contribute to human well-being (Costanza et al., 1997; Millennium Ecosystem Assessment, 2005). Ecosystem services have been categorized in several ways (e.g. De Groot et al., 2002; Millennium Ecosystem Assessment, 2005). Hein et al. (2006) categorized ecosystem services into production services (tangible products obtained from ecosystems, e.g. food, timber, water), regulation services (benefits reaped from the maintenance of ecosystems, e.g. climate regulation, water purification), and cultural services (intangible benefits, e.g. recreation).

Despite the popularity of ecosystem services valuation, there are relatively few examples where such values have been applied to support environmental decision-making, because the results are often misunderstood or considered to be unreliable, even among economists (Adamowicz, 2004; Heal, 2000; Liu et al., 2010). Especially since the 1990s, numerous biases regarding the hypothetical payment and marketplace that are potentially introduced in non-market valuation survey instruments have been identified (e.g. payment mechanism bias, hypothetical bias, anchoring effects, embedding effects, and scale-perception bias), and some have been addressed through methodological improvements (Araña and León, 2012; Dodonova, 2009; McDaniels et al., 2003; Newell and Swallow, 2013). Methodological improvements regarding presentation of the goods being valued within the survey instrument have also been achieved, for example, through enhanced accounting for framing effects (Fischer and Hanley, 2007; Kragt and Bennett, 2012) and labeling effects (Blamey et al., 2000).

The underlying validity of stated preference non-market valuation methods relies on the analyst's ability to identify, select, define, and articulate the goods (e.g. attributes in a discrete choice experiment) being valued in a way that is relevant and understandable to the respondent, which requires detailed understanding of the respondents' experiences and points of view (Hall et al., 2004; Langlois, 1998; Sauer and Fischer, 2010). This may be especially important when the attributes being valued are ecosystem services, which have variable spatial and temporal provision, and stakeholders (policy-makers, natural resource managers, and the general public) differ in their perceptions about which ecosystem services are important and how valuable they are. Many biases and other concerns are likely to arise if pre-design qualitative research fails to elicit a sound understanding of stakeholder perspectives (Bateman et al., 2002; Blamey et al., 2002; Mansfield and Pattanayak, 2007).

For example, one major critique of stated preference approaches to non-market valuation is that the results are not stable because participants "have to construct their preferences for these unfamiliar, often abstract and complex environmental goods 'on the spot,' drawing on the information provided by the interviewer and any pre-existing knowledge they consider relevant" (Sauer and Fischer, 2010, p. 1). As noted by Langlois (1998, p. 58), consumers "are perfectly informed not in general but in respect of a particular structure set out for them by the analyst". In order to yield more stable preferences, it has been argued that the survey instrument should be consistent with respondents' generic worldviews, avoid overreliance on experts and researchers, and be presented in language that is understandable to lay stakeholders (Barkmann et al., 2008; Coast et al., 2012; Sauer and Fischer, 2010). Poor articulation of the good being valued will result in biased to useless information for decision-makers.

If policy-relevant, but not demand-relevant, attributes are included in a non-market valuation survey, then "no great confidence in the statistical significance of these variables will be expected in subsequent statistical analysis" (Bateman et al., 2002, p. 260). Great care must be taken when including both 'causal' and 'effect' attributes in non-market valuation surveys, where 'causal' attributes are those that can "cause the status or level of expression of another 'effect' attribute" (Blamey et al., 2002, p. 168). Respondents who establish cause–effect relationships between the attributes being valued may draw inaccurate conclusions that result in a greater weight being assigned to the more fundamental 'causal' attribute, or discount or dismiss particular scenarios that are considered to be unrealistic (Blamey et al., 2002). The easiest way to address this potential problem is to only include one type of attribute (i.e. causal or effect) in the survey. While, this approach may result in omission of an attribute that is important to respondents, it should not be an issue if the main reason the omitted attribute is valued is its effect (or dependency) on the included attributes (Blamey et al., 2002).

In non-market valuation, a respondent who rejects the valuation exercise because of an issue they have with the hypothetical market presented to them, is said to have given a protest response. Protesters can be identified among respondents who declare negative, zero and positive WTP, and this is typically achieved using ad hoc debriefing questions or attitudinal statements about the hypothetical market (e.g. fairness or ethical concerns) in order to determine if the respondent is protesting against the hypothetical market or stating a true WTP (Meyerhoff and Liebe, 2006; Meyerhoff et al., 2012). Much of the time, the process of identifying the protesters is poorly accounted for, as is the subsequent treatment of those protesters in analysis (Meyerhoff and Liebe, 2010). According to Meyerhoff and Liebe (2010), protest responses are commonly discarded before analysis with a researcher assertion downplaying the impact of such an action. Clearly, the treatment of protest responses can influence results of analysis.

Protest responses regarding the payment mechanism are common; however a refusal to pay for the good in question resulting from lexicographic preferences also qualifies. Lexicographic preferences may result in a refusal to pay based on ethical considerations such as "the notion that nature has intrinsic value irrespective of its utility to humanity" (Szabó, 2011, p. 37). According to Venn and Quiggin (2007), lexicographic preferences are one reason that total economic valuation of the cultural heritage of Australian indigenous communities may not be feasible. It is not that the estimation is difficult – in the conventional sense of problems with estimating values in contingent markets – but that the idea of accepting monetary compensation for the loss of particular types of cultural heritage is simply nonsensical to many indigenous people. Venn and Quiggin (2007) found that partial valuation of indigenous cultural heritage may be possible (e.g. use values, such as hunting), and that this could be complemented by quantitative constraints on the decision space that require minimum acceptable protection levels for cultural heritage that is not substitutable (e.g. a sacred site).

Despite the acknowledged benefits of rigorous pre-survey qualitative work involving a broad range of stakeholders, which can mitigate the issues described above, there has been little instruction and detail given with regard to such work in non-market valuation literature (Coast and Horrocks, 2007; Coast et al., 2012; Kløjgaard et al., 2012; Michaels-Igbokwe et al., 2014). Coast and Horrocks (2007) asserted that pre-survey qualitative work employed to develop attributes often lacks rigor, and details regarding sampling, data collection and analysis are usually poorly reported. More importantly, "there is almost no reflection on the analysis and refinement of complex information to derive a manageable number of attributes" (Coast and Horrocks, 2007, p. 25). This could be particularly problematic when considering that different pre-survey qualitative methods have been shown to yield different information and significantly impact the design of non-market valuation surveys (Kaplowitz, 2000; Kløjgaard et al., 2012; Powe, 2007). It is little wonder that the findings from non-market valuation studies are still viewed with suspicion and that their application to support natural resource decision-making is rare.

3. Q-methodology

Q-methodology provides a systematic, structured and statistically-rigorous approach for the study of human subjectivity (Barry and Proops, 1999; McKeown and Thomas, 1988). Participants complete a rank ordering exercise, known as the Q-sort, which obtains "insight into the values and preferences held by the public" (Steelman and Maguire, 1999, p. 362). The Q-sorts are subjected to factor analysis, which results in a methodical rendering of numerous perspectives into a small number of general perspectives. As a result of its statistical analysis and unique data collection process, Q-methodology is amenable to 'objective analysis' and minimizes the intrusion of researcher bias (Baker et al., 2006; Focht and Lawler, 2000; McKeown and Thomas, 1988).

A thorough discussion of the process of Q-methodology can be found in Brown (1980) and Watts and Stenner (2012). Here we present a brief description of Q-methodology, which can be completed in the following five steps:

1. creation of the concourse and Q-set;
2. recruitment of Q-sort participants (P-set);
3. completion of the Q-sort and exit interview;
4. data analysis; and
5. factor interpretation.

The concourse is an extensive collection of items or statements related to the research topic, which is pared down to form the Q-set that participants will rank order during the Q-sort (Stephenson, 1978). The methods used to develop the concourse and Q-set generally involve literature review, interviews, and focus groups to take local context into account and ensure representation of a broad range of sentiments regarding the topic of interest.

The second step requires the recruitment of participants to complete the Q-sort, who are collectively referred to as the P-set. The P-set is obtained by strategic sampling, not random sampling of a large number of participants, to ensure "comprehensiveness and diversity, rather than representativeness or quantity" (Eden et al., 2005, p. 417). This is because Q-methodology is "intended to identify subjectivities that exist, not to determine how those subjectivities are distributed across a population" (Brown et al., 1999, p. 602). Stainton Rogers (1995) asserted that a P-set of 40 to 60 participants is most effective in capturing a diverse range of viewpoints. Indeed, fewer than 60 participants are typically recruited in a Q-study (e.g. Gruber, 2011; Ray, 2011). Development of the theoretical target P-set is facilitated by the dimensional sampling approach developed by Arnold (1970), but the process of identifying actual Q-sort participants depends on the topic being investigated (e.g. Cuppen et al., 2010).

Step three requires the participants (P-set) to rank order the statements from the Q-set. This exercise requires the participants to decide, from their perspective, that which is important and, conversely, that which is not (Watts and Stenner, 2005). The participants are given a deck of shuffled cards (each card contains one statement from the Q-set) to be placed onto the Q-board, which provides the framework for the Q-sorting process. Q-boards typically (but not always) require participants to distribute the cards in a manner similar to a normal distribution, as illustrated in Fig. 1. Brown (1980) describes the rationale for alternative Q-board designs. By instructing the participants to rank the items from "most important" to "most unimportant", the poles of the Q-board capture the strong feelings and the middle of the Q-board captures those items that are more neutral or insignificant (Brown, 1980; Watts and Stenner, 2012). The logic behind this idea is that "those things which are uncharacteristic of us are just as important, in a

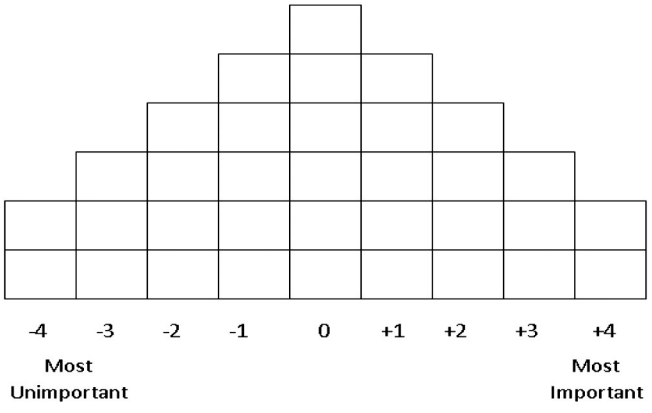


Fig. 1. Q-board and instructions given to the participant for the Q-sorting exercise in the case study.

negative sense, as those that apply to us in a positive sense" (Brown, 1980, p. 198).

In order to help the participants complete the Q-sort, Brown (1980) suggested that participants first divide all the statements into three groups: (1) those statements that are positively salient; (2) those that are negatively salient; and (3) the remainder that are relatively neutral. The participant is then instructed by the researcher to sort the cards onto the Q-board in order of salience, with each column denoting a different level of salience. The rows indicate how many cards from the Q-set belong in each column. For example, for the Q-board illustrated in Fig. 1, two cards must be selected as 'most important' +4, and three cards as +3 importance. After the Q-sort is complete, the researcher conducts an exit interview, in which the participant is asked to discuss the reasoning for ranking the statements in their unique way (Brown, 1980).

The data analysis stage involves factor analysis including varimax or judgmental factor rotation (Brown, 1980). Results are represented by factor arrays, which represent the general viewpoint of all the participants that load onto a particular factor. Each factor array is defined by Q-sorts which only have a significant factor loading with that factor. A Q-sort can also be confounded (loads significantly onto more than one factor) or null (does not significantly load onto any factor). Confounded Q-sorts are typically not used in the construction of the factor arrays because they are a reflection of at least two factors, which can increase the correlation between factors and make the resulting factor arrays less distinct. Nevertheless, confounded Q-sorts can still be explained in terms of the resulting factor arrays onto which they significantly load. Those Q-sorts that are null are considered to be idiosyncratic viewpoints, which are not explained by any of the resulting factor arrays and do not contribute to the interpretation of the factor arrays.

The final step, factor interpretation, typically involves a write-up exercise, which conveys the meaning of each factor array with the aid of information gathered during the exit interview. Factor interpretations identify those items for a particular viewpoint that are positively salient, negatively salient, and relatively neutral. By comparing factor arrays of each perspective, it is also possible to identify those items about which there is consensus, contention, and ambivalence among the perspectives.

4. Case Study Application of Q-methodology to Determine the Importance of Water-based Ecosystem Services Derived From the Shoshone National Forest, USA

Forest Service managers and scientists were interested in using information about the importance of water-based ecosystem services (WESs) to local people to support management of the Shoshone National Forest (SNF) in Montana and Wyoming in the United States. A Q-methodology study was conducted by Armatas (2013) to obtain a greater understanding of stakeholder values and interests regarding the diverse range of WESs produced by the SNF. The study area is approximately 4.5 million ha, and has a population of about 100,000 people (United States Census Bureau, 2010). Much of the benefit provided by water to the communities surrounding the SNF is employment related, with about 26.3% of jobs (19,041 out of 72,524) being derived from water-related industries (BEA, 2010). The three industries contributing to the majority of this employment are agriculture, oil and natural gas extraction, and tourism and recreation, all of which rely on water or affect water quality and quantity. Water in the study area is also culturally important for both Native and non-Native American populations.

4.1. Q-set and P-set

The purpose of the Q-set in this project was to identify the broad range of WESs being derived from the SNF. A preliminary concourse of 49 WESs was developed through a review of ecosystem services and study area specific academic and gray literature. Two focus group meetings were held and pilot testing of the Q-set was performed within the study area to define the final Q-set of 34 WESs.

The focus group meetings were attended by a total of 18 participants who had been identified via phone conversations with federal, state and local water resource managers, representatives of water-reliant businesses (e.g. river outfitters), and with citizens connected to water for professional and personal reasons (e.g. farmers and water recreation enthusiasts). Attendees included ranchers, farmers, whitewater rafting outfitters, an archeologist and a hydrologist from federal agencies, a state water engineer, a small business owner, and representatives from an environmental group and Wyoming Game and Fish. These meetings guided the authors' selection of WESs for the Q-set by providing local stakeholder recommendations about removing, splitting and combining WESs that were included in the preliminary concourse. For example, the concourse had separate WESs for river activities such as kayaking, rafting, tubing, and surfing, but the focus groups agreed that all these activities could be merged into one WES entitled "river-based recreation". Conversely, the focus groups helped to separate WESs that were originally too broad. For example, the concourse had only one WES for irrigation, but the focus groups felt that there are two types of irrigation in the study area — commercial and personal. The meetings also provided local context to improve definitions of WESs, and identified and defined several additional WESs not revealed by the literature review. For example, the WES entitled "preserving livelihoods, lifestyles, and landscapes" was included because the focus groups agreed that large working ranches and the prevalence of agriculture in the study area provided a layer of protection against residential development and preserved a culturally important way of life.

Pilot testing of the Q-sort by 20 members of the general public resulted in several changes to the Q-set and the definitions of WESs that came out of the focus group meetings. For instance, a WES devoted to the benefits provided by glacier melt water was removed after pilot testers noted that it was a benefit captured by another ecosystem service in the Q-set entitled "gradual discharge of stored water". Pilot testing revealed that the general public were comfortable sorting the WESs. Table 1 lists the 34 WESs in the Q-set, which are categorized into regulating services, provisioning services, and cultural services. Full definitions for each WES in the Q-set are available in the Appendix A.

The P-set was selected following extensive internet-based research of the study area, two meetings with local Forest Service employees, discussions during the two focus groups conducted to define the Q-set, and snowball sampling employed during the exit interview. These purposeful methods yielded a P-set of 96 stakeholders who were not participants in the two focus groups or pilot testers of the Q-set. Members of the P-set can be classified into the following seven categories: (1) private sector (e.g. fishing and hunting outfitters, recreation enthusiasts, farmers, and oil and natural gas representatives); (2) non-governmental organizations (e.g. Greater Yellowstone Coalition and Wyoming State Snowmobile Association); (3) Wyoming state government (e.g. State Engineers Office and State Parks); (4) tribal governments (e.g. Business Council and Environmental Quality Commission); (5) local government (e.g. county commissioners and irrigation district managers); (6) federal government (e.g. Forest Service and Bureau of Reclamation); and (7) randomly selected participants from public locales inside and outside the study area.

4.2. Administration of Surveys, Factor Analysis, and the Write-up Exercise

Each member of the P-set attended a one-on-one meeting with the lead author at a convenient location, which included residences, places of work, and public meeting places. During these meetings, each member of the P-set completed the Q-sorting exercise and exit interview without compensation. For the Q-sorting exercise, each participant was required to rank the 34 WESs on the Q-board illustrated in Fig. 1. The participants were instructed to rank order the WESs on a scale from "most important" to "most unimportant" where the middle of the Q-board was meant for

Table 1
The Q-set of categorized water-based ecosystem services derived from the Shoshone National Forest, Wyoming.

Ecosystem services
Regulating
(1) Water quality
(2) In-stream flow
(3) Conservation of keystone (critical) species
(4) Conservation of rare plant species
(5) Biodiversity conservation
(6) Gradual discharge of stored water
(7) Natural flood control
(8) Glacier-based services
(9) Nutrient cycling and sediment transport
Provisioning
(10) Household/municipal water
(11) Hydropower
(12) Commercial irrigation
(13) Personal irrigation
(14) Water for stock
(15) Manufacturing and industrial
(16) Oil and natural gas extraction, and mining
(17) Fighting forest fires
(18) Supporting of commercial land-based recreation
Cultural
(19) River-based fishing
(20) Lake/reservoir fishing
(21) Lake, reservoir, and river-based hunting
(22) Land-based hunting
(23) River recreation
(24) Lake/reservoir recreation
(25) Commercial water-based recreation
(26) Motorized ice and snow based recreation
(27) Non-motorized ice and snow based recreation
(28) Recreation/leisure activities done near water
(29) Physically and mentally challenging recreation
(30) Education, management and science
(31) Native American cultural and spiritual values
(32) Non-Native American cultural and spiritual values
(33) Preserving livelihoods, lifestyles, and landscapes
(34) Inspirational and aesthetic values

WESs that conjured feelings of neutrality and apathy. For the purposes of interpretation, the WESs at the poles (± 2, 3, 4) are referred to as positively and negatively salient, and those in the middle (− 1, 0, + 1) are referred to as relatively neutral. During the exit interview, they provided demographic information and reasoning supporting their Q-sort.

Factor analysis was performed on the 96 Q-sorts, and a three-factor solution explaining 48% of the study variance[1] was chosen following varimax rotation. In accordance with good practice in Q-methodology, the factor solution was chosen based on both statistically-objective criteria (e.g. the Scree test, Humphrey's Rule, the significant loading test, and the eigenvalue test) and theoretical significance (e.g. researcher intuition and social and political context) (Brown, 1980; Watts and Stenner, 2012). The three factor solution provided four perspectives for interpretation because of a bipolar third factor. That is, a factor defined by both positive and negative loading Q-sorts or viewpoints. Of the 96 total participants, 74 have a significant loading with one factor, 8 were confounded, and 14 were null-cases.

The four perspectives were named environmental, agricultural, Native American, and recreation, because of particular ecosystem services that were positively salient to the respondents who helped to define each perspective. For example, the environmental perspective was labeled as such because eight of the nine positively salient WESs were regulating services. The level of salience assigned to the WESs by each perspective is shown in the factor arrays presented in Fig. 2, and the numbers within the factor arrays correspond with the numbering of WESs in Table 1.

[1] Kline (1994) noted that any solution explaining 35–40% of the study variance is considered to be a sound solution.

5. Benefits of Q-methodology for Developing Attributes to be Valued in a Stated Preference Survey

The experience of applying Q-methodology to identify, select, define, and articulate WESs for the SNF has highlighted several benefits of the approach as an explicitly-defined procedure for the pre-design qualitative research step in ecosystem service valuation. The following subsections discuss these benefits with supporting evidence from the four perspectives yielded in the SNF case study. Throughout this section, numbers in parentheses that range from − 4 to + 4 represent the level of salience that particular viewpoints assigned to the WES being discussed. Italicized numbers in parentheses between 1 and 34 that accompany discussions of various WESs correspond with the numbering of WESs in Table 1 and can facilitate location of WESs within the factor arrays in Fig. 2. Additionally, several quotes gathered during the exit interviews from participants who loaded onto particular perspectives will be provided as support for assertions being made.

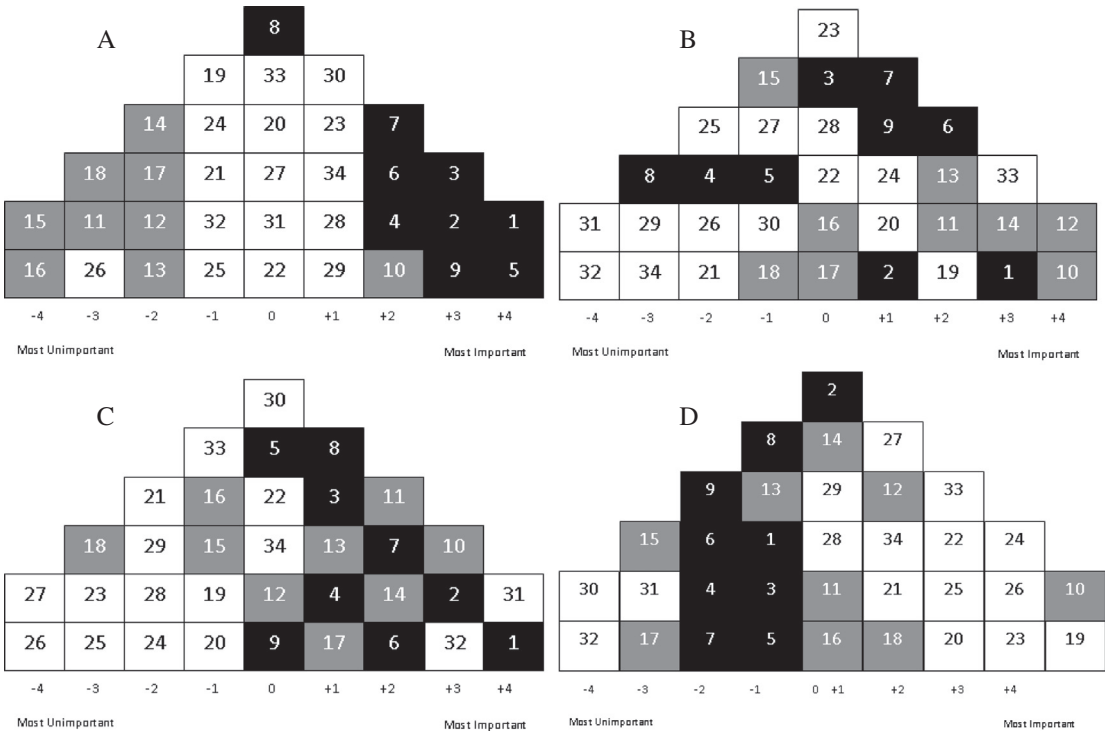
5.1. Q-methodology Uses Stakeholder Input to Identify and Define Ecosystem Services Relevant to Survey Participants

A critical aspect of stated preference valuation of ecosystem services is to build survey instruments that include descriptions of the ecosystem services that are understandable and meaningful to the respondent. This can be challenging considering the complex nature of particular ecosystem services (e.g. biodiversity conservation (*5*)), the spatial variability at which ecosystems provide benefits, and the varying levels of stakeholder knowledge regarding ecosystem services. In accordance with good practice in non-market survey design, the development of the Q-set provides a formal process for stakeholder involvement and collection of information relevant to the local population that can: (1) minimize the chance that important ecosystem services will be excluded from consideration; and (2) ensure ecosystem services are defined in ways that are clear and understandable to local stakeholders.

In the SNF case study, a review of literature highlighted the importance of agriculture for the economy, but focus groups with local residents revealed that the agricultural community is considered by non-farmers and ranchers as both a layer of protection against further residential development and a significant part of the region's identity. This knowledge of the study area resulted in the identification, definition and inclusion of the ecosystem service, preserving livelihoods, lifestyles and landscapes (*33*) within the Q-set.

The utility of attribute-based stated preference surveys is often diminished by the inclusion of attributes that are unclear or confusing for the respondent, and that consequently have little utility for the estimation of WTP. In the SNF case study, clear accommodation of water-based recreation required the inclusion of 12 recreation WESs in the Q-set. A literature review of the study area made it apparent that recreation opportunities related to boating and angling would need to be separated because of different levels of flow and turbidity that are optimal for each activity. Stakeholder interaction through focus groups and interviews also suggested that angling opportunities should be divided into those provided by lakes and reservoirs, and those provided by rivers. Stakeholders asserted the need for such a split because of the difference in fishing ethic; lake and reservoir fishing is more consumptive, whereas river-based fishing concentrates more on the sporting aspect and the preservation of fish populations through low impact fishing techniques, such as barbless hooks. Also, stakeholders identified the need to include motorized and non-motorized ice and snow based recreation as two separate WESs in the Q-set because of the different user groups participating in each activity.

By identifying what is relevant to survey participants, the perspectives yielded from factor analysis of the Q-sorts can inform efforts to report



Note: Regulating services are in black boxes; provisioning services are in grey boxes; and cultural services are in white boxes.

Fig. 2. Factor arrays illustrating the relative importance of water-based ecosystem services to participants who hold the: (A) environmental perspective; (B) agricultural perspective; (C) Native American perspective; and (D) recreation perspective.

implications of current policy and proposed policy changes in the background information section of the survey in a way that is meaningful to respondents. These perspectives can also be helpful for identifying specific characteristics that would enhance the definition of an attribute in a non-market valuation survey. For example, the definition for river-based fishing (*19*) in the Q-set was: "The rivers throughout the study area can be used for fishing, both for sport and the harvesting of fish for personal consumption". Through the exit interviews it became clear that river-based fishing in the study area is important largely because of the presence of Yellowstone cutthroat trout (*Oncorhynchus clarki bouvieri*). Participant 14 explained, "We have a reputation around here for being a world class, if not world class then national, fishing destination, and the cutthroat trout has a huge profile". This sentiment suggests that an attribute designed to capture the value of river-based fishing in the study area would need to include the cutthroat trout in its definition.

The Q-sorts and resulting factor arrays can help definition of an attribute in a non-market valuation survey by reinforcing (or challenging) the sentiments discovered in focus groups. For example, focus groups for the SNF case study suggested that ecosystem services related to biodiversity needed to be separated into biodiversity conservation (*5*), conservation of keystone species (*3*), and conservation of rare plant species (*4*). One focus group participant explained, "biodiversity covers the breadth of species, but specifically the keystone species are integral to the system itself". Another focus group participant suggested that rare plants should be featured in a separate WES because of the large number of rare plants in the study area. However, the factor arrays in Fig. 2 illustrate that these three WESs were ranked similarly by each perspective, suggesting it would be appropriate to combine these three services into one attribute for the purposes of valuation.

Exit interviews employed in Q-methodology can help to define units for quantification of attribute levels in a non-market valuation survey that are meaningful to local people. For example, Q-sort participants frequently commented that the number of large working farms is integral to preserving livelihoods, lifestyles and landscapes (*33*), which is suggestive of an appropriate metric for quantification. However, few members of the general public are likely to be sufficiently informed about the environmental policy problem of interest such that they can contribute to efforts to estimate levels (quantities) of ecosystem services for inclusion in the non-market valuation survey. This responsibility necessarily rests with the non-market valuation practitioner and selected experts.

Likewise, as with all pre-design qualitative research methods that accommodate stakeholder perspectives, Q-methodology is not a remedy against definitions of ecosystem services that invite double-counting or other WTP estimation biases. Sometimes, the preferred definitions of stakeholders will deliberately encompass multiple values. For example, in the SNF case study, preserving rural livelihoods, lifestyles and landscapes (*33*) was defined by locals to include two major values: the culture of agriculture; and the protection of large, contiguous landscapes by maintaining working farms. Clearly, this presents a double-counting issue that must be addressed by non-market valuation practitioners before this WES can be included in a survey.

5.2. Q-methodology Supplies Nuance and Detail That Can Assist With the Selection of Ecosystem Services to be Valued in a Stated Preference Survey

The tradeoffs made necessary by Q-methodology are lacking in Likert-type surveys, where a participant is allowed to assign a high level of importance to all attributes. This can be problematic for a researcher who is trying to pare down a large list of attributes to a manageable number to be included in a stated preference survey. Additionally, an unresolved challenge of pre-survey qualitative work, according to Coast and Horrocks (2007), is the tension between trying to gain a rich and nuanced understanding of the research topic using qualitative methods and the reductive aim of capturing all the key concepts in as few attributes as possible. The factor arrays yielded in Q-methodology highlight a limited number of potential attributes for non-market valuation through its

statistical and structured analysis of subjectivity. In other words, this approach provides a more objective interpretation of stakeholder perspectives than may be provided by other qualitative approaches such as focus groups and individual interviews.

Among the perspectives revealed by factor analysis, there may be consensus regarding ecosystem services that are positively salient, negatively salient, and relatively neutral. Ecosystem services that are positively salient to all factors, for example, household/municipal water (*10*) in the SNF case study, can be considered highly relevant for inclusion in a valuation survey and are likely to be relatively well-understood by respondents, decreasing the chance that 'on the spot' construction of preferences will be required. Conversely, those ecosystem services that are relatively neutral for all perspectives should not be candidates for inclusion in a non-market valuation survey. For example, the factor arrays in Fig. 2 reveal that the ecosystem services physically and mentally challenging recreation (*29*), manufacturing and industrial use (*15*), and supporting of commercial land-based recreation (*18*) are among those that are relatively neutral for most perspectives. Ecosystem services that are negatively salient may also be highly relevant for non-market valuation, because they may be viewed as threatening important ecosystem services. For example, oil and natural gas extraction (*16*) is extremely salient in a negative sense to the environmental perspective (−4). The importance of oil and natural gas extraction for the economy, and its prevalence within the study area suggests that land managers could benefit from knowledge regarding willingness to accept compensation for non-marketed externalities associated with this particular WES.

There is contention between perspectives when ecosystem services that are positively salient to some perspectives are negatively salient to others. Decisions about the management of such ecosystem services are likely to be politically charged and, therefore, inclusion in a valuation survey will provide useful information to support policy-maker and manager decision-making. An example of a WES that is contentious is motorized ice and snow based recreation, which was positively salient to the recreation perspective (+3) and negatively salient to all other perspectives.

The factor arrays and interpretive-write ups can also highlight policy-relevant ecosystem services that are not demand relevant, which is beneficial considering the need to include attributes that are both demand and policy relevant. For example, fighting forest fires (*17*) is not demand relevant for most of the four perspectives, as is evident by the neutrality or negative salience assigned to it by all four factors, but it is of policy and management concern for the SNF.

5.3. Q-methodology Provides Information to Assist in Distinguishing Between Protest Responses and True WTP

Including contentious ecosystem services in a valuation survey could lead some respondents to register protest responses. A benefit of Q-methodology is that factor arrays are accompanied by qualitative data regarding the logic and reasoning behind the construction of each viewpoint, which can help researchers avoid, or identify and better understand the reasons for protest responses. For example, the ecosystem service, Native American cultural and spiritual values (*31*) is contentious across the four viewpoints. Native American cultural and spiritual values (+4) are non-tradable, non-negotiable, inextricably tied to a way of life, and sacrosanct to those who align with the Native American perspective. This is evident from the following quote from Participant 77: "Our way of governing, our way of teaching, our love for each other came from that River corridor … that is our stories, we come out of the water". This sentiment suggests that people who hold the Native American perspective have lexicographic preferences in favor of Native American cultural and spiritual values. These values, however, are neutral for the environmental perspective (0), and are negatively salient to the recreation (−3) and agricultural perspectives (−4) due to the perception that increased protection of Native American cultural values threatens provision of water for recreation and agriculture, respectively. Thus, including Native American cultural and spiritual values in a valuation study could invoke a protest response from some respondents due to lexicographic preferences for ecosystem services that are perceived to be threatened by Native American cultural and spiritual values, and a true low WTP due to feelings of neutrality from others. In this case, information provided by Q-methodology could assist the researcher develop attitudinal questions for identification of lexicographic preferences, protest responses and true WTP.

5.4. Q-methodology Can Highlight Those Ecosystem Services Where Respondents May Employ Cause and Effect Reasoning

Q-methodology can help to identify those ecosystem services where respondents are likely to consider cause–effect relationships in a stated preference survey. A better understanding of these situations, which can be gleaned from the factor arrays and exit interviews, could allow the researcher to address the issue prior to survey administration. For instance, according to the agricultural perspective, water quality (+3) supports the preservation of livelihoods, lifestyles, and landscapes (+3). However, the WES in-stream flow (+1) has the potential to negatively impact commercial irrigation (+4). Participant 44 explained, "the quality of water and the quantity that has been supplied off the forest, and historically livelihoods have been developed. Agricultural communities, everything we do, the reason we live where we do is because of the water running off the mountains". Participant 45 noted that if there isn't enough water, "then those of us that depend on irrigation to produce crops and water for livestock would have to reduce our income basically, because that is how most of us make our income". According to this perspective, the quantity of water is threatened by conservation groups advocating for in-stream flow rights. Participant 31 commented, "increased pressure from conservation groups, fishing, in-stream flow and anything like that would influence the ability to use it for commercial irrigation".

The easiest way to avoid the cause–effect problem is to only include one type of attribute (i.e. causal or effect) in the survey (Blamey et al., 2002). Therefore, in defining the set of attributes for inclusion in a stated preference survey of water-based ecosystem services provided by the SNF, information gathered via Q-methodology suggests it would be appropriate to exclude water quality and in-stream flow, so long as important 'effect' attributes, such as Native American cultural and spiritual values, river fishing, and biodiversity conservation are included.

6. Conclusion

Non-market valuation of ecosystem services is increasingly recognized as being useful to support natural resource management and policy-making; however skepticism remains, particularly with regard to stated preference approaches. A major critique of stated preference surveys is the difficulty respondents may have deciding their WTP for complex and unfamiliar environmental goods, and consequently, how much confidence can be placed in statistically-derived non-market values. The validity of these methods rests on the analyst's ability to identify, select, define and articulate the goods being valued in a way that is relevant and understandable to the respondent. This requires a detailed understanding of the respondents' experiences and points of view. Pre-design qualitative research methods can provide complex and nuanced data for attribute development, while also guarding against the potential for mis-specification of attributes through too much reliance on experts and researchers. However, the question of how best to perform this qualitative research is a neglected area of inquiry. In this paper, we have demonstrated the potential for Q-methodology to provide a defined procedure for pre-design qualitative research in the context of ecosystem services valuation. However, Q-methodology could be employed to inform design of stated preference surveys in other fields such as health economics.

Q-methodology is a non-monetary preference elicitation method that can highlight ecosystem services that are suitable for valuation and

salient to a wide range of stakeholders. The development of the Q-set incorporates diverse stakeholder input to identify and define, in terms understandable to the local community, specific ecosystem services that are reaped in the study area. The Q-sorting exercise and exit interviews yield nuanced and detailed stakeholder perspectives that highlight those ecosystem services that are positively salient, negatively salient, and relatively neutral. Interpretation of the factor arrays can identify ecosystem services where there is consensus, contention, or ambivalence about their importance among the viewpoints. In addition, the detailed perspectives can indicate situations where cause and effect reasoning is likely to be employed by stakeholders, and highlight acceptable and unacceptable tradeoffs (e.g. lexicographic preferences), which provides a basis to differentiate between protest responses and true WTP.

Although Q-methodology is likely to cost more than other pre-design qualitative research methods, the explicitly-defined procedures, and methodical and statistical rendering of multiple perspectives into a limited number of general perspectives may be worth the additional costs in some contexts. For example, it may be especially helpful in public land management situations where a large number of ecosystem services affect a large number of stakeholders, none of whom have extraordinary claim or right to those services. The nuance and detail provided by the factor arrays will inform interpretation of the WTP estimates from a non-market valuation survey. Furthermore, the relative ease of replicating Q-sorts could facilitate cost-effective methods to test for changing preferences over time. However, employing Q-methodology may not be warranted in all valuation circumstances, such as where the ecosystem services requiring valuation are obvious, or the degree of controversy and contention is known or can be reasonably expected or anticipated.

Acknowledgments

This research was funded by the Aldo Leopold Wilderness Research Institute (09-JV-11221639-205), which is administered by the Rocky Mountain Research Station of the U.S. Forest Service. We would like to thank all participants who contributed their valuable time to this research, with a special thanks to the Crow, Eastern Shoshone, and Northern Arapaho Tribes for their cooperation. The information and support provided by the Forest Service in Cody, Wyoming, was greatly appreciated. We would also like to thank Dan McCollum (economist with the Rocky Mountain Research Station) for commenting on an earlier version of the manuscript.

Appendix A. Definitions of water-based ecosystem services in the Q-set

Ecosystem service title	Ecosystem service definition
(1) Water quality	The water in and flowing from the SNF is purified and filtered by natural systems like beaver ponds and wetlands resulting in clean water.
(2) In-stream flow	The water from the SNF that is not drawn from the river can help to create and maintain healthy aquatic habitats. For example, a certain amount of water in the stream can maintain channel form and function, and regulate water temperature.
(3) Conservation of keystone (critical) species	The water within the study area helps to support important plant and wildlife species. For example, the whitebark pine, beaver, and cutthroat trout are considered keystone species of the Greater Yellowstone Ecosystem (GYE), which means they are important for the conservation of a host of other species.
(4) Conservation of rare plant species	Wetlands within the study area support a number of rare plant species. The rare plants may have some use that is unknown to humans at this time, but they could be beneficial in the future.
(5) Biodiversity conservation	Aquatic and riparian areas fed by the SNF provide habitat for a diversity of species, and genetic variation within species. Species diversity may help maintain ecosystem structure, processes and functions.
(6) Gradual discharge of stored water	Water released into streams and rivers is naturally regulated by glaciers, wetlands, riparian areas, and aquifers, which provides a reliable flow of water throughout the year, even during the warmest summer months.
(7) Natural flood control	The storage of SNF water in glaciers, wetlands, riparian areas, and aquifers provides natural flood control, which avoids flooding damage costs.
(8) Glacier-based services	The glaciers in the SNF are of the largest concentration in the lower 48 states, and they provide unique services like stream-water temperature regulation, summertime skiing, and glacier sightseeing.
(9) Nutrient cycling and sediment transport	The water flowing from the SNF helps to cycle nutrients and transport sediment. Nutrients cycled throughout the natural system help to maintain healthy and diverse aquatic habitats. The transport of sediment helps to create floodplains and riparian areas.
(10) Household/municipal water	Water in the study area, both surface water and groundwater, can be used for drinking, washing, and other in-house use.
(11) Hydropower	Water provided by the SNF can be used to generate hydropower.
(12) Commercial irrigation	The water in the study area, both surface water and groundwater, can be used to irrigate commercial crops, which could include hay, sugar beets, corn, grain, barley, and beans. These crops could be sold on the market and/or used to support ranching activities.
(13) Personal irrigation	The water in the study area, both surface water and groundwater, can be used to fill private ponds, and irrigate gardens and lawns.
(14) Water for stock	Water provided by the SNF can be used for the watering of stock.
(15) Manufacturing and industrial	The water in the study area, both surface water and groundwater, can be used for manufacturing and industrial purposes.
(16) Oil and natural gas extraction, and mining	The water in the study area, both surface water and groundwater, can be used for the extraction of natural gas and oil, and to a lesser extent, in the mining of coal, bentonite, uranium and gypsum. Water is also used in these industries for dust control on roads.
(17) Fighting forest fires	Water provided by the SNF can be used for the fighting of forest fires.
(18) Supporting of commercial land-based recreation	Water provided by the SNF facilitates land-based recreational activities. For example, the watering of golf courses, the water used to make snow for the Sleeping Giant Ski Area, and the water used for amusement parks.
(19) River-based fishing	The rivers throughout the study area can be used for fishing, both for sport and the harvesting of fish for personal consumption.
(20) Lake/reservoir fishing	The lakes and reservoirs in the study area provide the opportunity for fishing, both for sport and the harvesting of fish for personal consumption.
(21) Lake, reservoir, and river-based hunting	The lakes, reservoirs, and rivers throughout the study area provide opportunities for hunting waterfowl from the water in a boat.
(22) Land-based hunting	The water resources in the study area provide habitat for game and, as a result, watercourses and wetlands can be used for land-based hunting.
(23) River recreation	The rivers flowing in and out of the SNF can be used for both whitewater and scenic recreational activities. Some include: rafting, kayaking/canoeing, stand-up paddle boarding, tubing, body boarding,

Appendix A (*continued*)

Ecosystem service title	Ecosystem service definition
	surfing, river-access hiking, and bird watching.
(24) Lake/reservoir recreation	The lakes and reservoirs in the study area provide opportunities for recreational activities. Some include: water skiing, wakeboarding, kneeboarding, skurfing, tubing, sailing, motorboating, parasailing, canoeing, kayaking, and kiteboarding.
(25) Commercial water-based recreation	Outfitted whitewater rafting trips and guided-fishing trips are two examples of commercial water-based recreation sold on the market. Both opportunities are provided by the water resources in the study area.
(26) Motorized ice and snow based recreation	The ice and snow within the study area can be used for motorized winter recreational activities like snowmobiling.
(27) Non-motorized ice and snow based recreation	The ice and snow within the study area can be used for a number of non-motorized winter recreational activities. Some include: skiing, snowboarding, ice climbing, winter camping, and snowshoeing.
(28) Recreation/leisure activities done near water	For example, the experience of wildlife viewing and hiking could be done in close proximity to a water resource within the study area. Additionally, reflective recreational activities like introspective thought may be done near water.
(29) Physically and mentally challenging recreation	The water environments within the study area can provide opportunities for physically and mentally challenging recreational opportunities.
(30) Education, management and science	The aquatic habitats and water-based ecosystem processes within the study area can be studied with the goal of improving both management and objective knowledge of natural and social sciences, which include biology, botany, hydrology, and history.
(31) Native American cultural and spiritual values	The water resources in the study area have special meaning to Native Americans, and can be used for cultural, spiritual, religious and ceremonial purposes.
(32) Non-Native American cultural and spiritual values	The water resources in the study area have special meaning to non-Native Americans, and can be used for cultural, spiritual, religious and ceremonial purposes.
(33) Preserving livelihoods, lifestyles, and landscapes	The water flowing from the SNF is used to support healthy agricultural communities and large working farms and ranches.
(34) Inspirational and aesthetic values	The rivers and lakes in and around the SNF can provide inspiration and enjoyment. For example, a scenic water vista can provide the motivation for an artist's work, and the beauty, smell, and sound of water can provide enjoyment.

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