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Perceiving Patagonia: An Assessment of Social Values and Perspectives Regarding Watershed Ecosystem Services and Management in Southern South America

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Abstract Research on human dimensions of ecosystems through the ecosystem services (ES) concept has proliferated over recent decades but has largely focused on monetary value of ecosystems while excluding other community-based values. We conducted 312 surveys of general community members and regional researchers and decision-makers (specialists) to understand local perceptions and values of watershed ES and natural resource management in South America's southern Patagonian ecoregion. Results indicated that specialists shared many similar values of ES with community members, but at the same time their mentalities did not capture the diversity of values that existed within the broader community. The supporting services were most highly valued by both groups, but generally poorly understood by the community. Many services that are not easily captured in monetary terms, particularly cultural services, were highly valued by community members and specialists. Both groups perceived a lack of communication and access to basic scientific information in current management approaches and differed slightly in their perspective on potential threats to ES. We recommend that a community-based approach be integrated into the natural resource management framework that better embodies the diversity of values that exist in these communities, while enhancing the science-society dialog and thereby encouraging the application of multiple forms of ecological knowledge in place-based environmental management.

Keywords Ecosystem service · Community-based management · Environmental values · Local ecological knowledge · Traditional ecological knowledge

Introduction

Frequently, environmental management and conservation strategies are driven by political and economic priorities

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informed by "expert" opinion, rooted in scientific and technical knowledge (Fleeger and Becker 2008; Norton 2005). As a result, value systems derived from particular scientific disciplines become the basis of decision-making processes, while the potential diversity of perspectives from broader segments of society, which are directly affected by the outcomes of such decisions, is often excluded (Lynam et al. 2007). Consequently, traditional environmental management strategies may force the specific worldview on communities that is foreign to them, and therefore, such plans can meet with local resistance or ultimately fail to support local social well-being (Menzel and Teng 2009).

As applied by the Millennium Ecosystem Assessment (MA 2005), the ecosystem services (ES) approach to environmental research and management attempts to clarify and incorporate into decision-making a broader set of values embodied in ecosystems (Raymond et al. 2009) by considering the "goods and services" they provide as constituents of social well-being. Nevertheless, the concept is heavily rooted in economic theory and terminology, thereby leading proponents and detractors to frequently focus on monetary values of ecosystem processes (Brauman et al. 2007; Brander et al. 2007; de Groot et al. 2002, 2010; Petrosillo et al. 2010). The development of ES theory since the MA (2005) has produced a dichotomy in ES valuation methods, manifesting in an academic debate over the ideal ES categorization scheme (see Wallace 2007; Costanza 2008). In one approach, researchers favor valuation methods and ES classifications that facilitate integration with economic accounting systems to better address market failures and externalities (Boyd and Banzhaf 2007; Fisher et al. 2008). An alternative agenda expresses the need to account for values that go beyond the consideration of market failures and adheres to the core principles of the MA (2005) typology to achieve broad understanding of the underlying constituents of social well-being and the impacts to them (Collins et al. 2011; Kelble et al. 2013). As a result, ES typologies vary in their scope and implications. There is no single ideal method and in selecting an ES typology for a particular case, it should be modified to address the specific objectives of the study and fit the context of the locale where it is being implemented. It is imperative, however, that with the wide adoption of economic-based ES valuation, ES research also continue to employ methods which capture the greater diversity of value types that exist outside of monetary value. Jax et al. (2013), for example, warn that over-emphasizing instrumental values in ES research risks repressing the voices of those who are affected by environmental management decisions, but are not directly involved in decision-making. It is important, therefore, that society address market failures and include ecosystems' monetary worth into economic models (e.g., Costanza et al. 1997), but it is also crucial to consider the diversity of ways that we perceive and relate to ecosystems when making environmental decisions, since social well-being is not derived solely from economic valuation (Clayton and Myers 2010).

To help broaden our understanding of the values used to study and implement the ES paradigm, we studied knowledge, expectations, and perceptions of local ecosystems and current environmental management in the southern Patagonian ecoregion of South America. We used the MA approach to ES classification to further our understanding of a broad range of ecosystem constituents that support social well-being, while adapting it to provide a practical valuation method that is potentially more amenable for use in local decision-making. Value in this study is broadly defined as "being deemed important," allowing us to capture the various types of considerations that might exist for an individual, such as instrumental, economic, cultural, social, and intrinsic values without imposing the use of any one particular type. Focusing our analysis on watershed ecosystems, the assessment of ES considered how they are valued and social views regarding potential threats to their continuation. The implications of these factors on management were determined by comparing whether the general population (i.e., "community") and natural resource managers and scientists (i.e., "specialists") viewed these factors differently. Specifically, the following research questions were addressed through quantitative and qualitative surveys:

(1) Do respondent groups believe they have the ability to affect current ecosystem management processes through access to ecological information and the ability to communicate with the specialists who determine the management of natural resources?
(2) Do respondent groups have basic scientific or technical understanding of their local watersheds, such as knowing the source of their drinking water?
(3) Do respondent groups value ES and perceive potential threats differently?

Academic and natural resource management institutions in these communities are not currently implementing public participatory or stakeholder-driven management strategies for environmental issues, even though community integration in environmental management and policy is widely recognized as a necessary step to improve performance outcomes and societal acceptance (Armitage 2005; U.S. National Research Council 2008). For these reasons, we expected to find a gap in the communication between the community and specialists in addition to a general lack of science-based watershed knowledge from community members. Moreover, previous research conducted elsewhere on ES has shown that specialists place higher value on the regulating and supporting categories of ES, compared to the general public, which in turn places greater importance on provisioning and cultural services (Raymond et al. 2009). Furthermore, different relationships and views of nature held by the community and specialists may manifest themselves in their particular concerns about the threats to ecosystems. Such differences would also be both a cause and an effect of an overall lack of dialog between communities and specialists. In summary, understanding community perceptions of ES and ecosystem threats is intended to establish a baseline for quantitatively evaluating whether current environmental management and conservation strategies meet local needs and expectations. At the same time, the assessment of perceptions and values can also provide information for the development of community-based approaches that integrate the broader society into ecosystem management and outcomes.

Study Sites

This research was conducted in the southern Patagonian biome of South America (Chile and Argentina), which provided an ideal location to perform an assessment of the social dimensions of ES. The region is considered to be one of the most pristine in the world, due to three main factors: (i) low human population densities (<5 people km^{-2}), (ii) high percentage of intact native vegetation cover (>70 %), and (iii) extensive size (>10,000 km^2) (Mittermeier et al. 2003). Nonetheless, the area is experiencing the increasing pressures from local urban development and the broader-scale dimensions of global environmental change (Amin et al. 2011; Anderson et al. 2006; Iturraspe 2010; Rozzi et al. 2006). Furthermore, in spite of an overall low human population density, urban areas aggregate the vast majority of regional populations in both countries. In the Magellan and Chilean Antarctic Region of Chile, 93 % of the 150,826 population is found in urban areas—including Punta Arenas, Puerto Natales, Porvenir, and Puerto Williams. In the Tierra del Fuego, South Atlantic Islands and Antarctica Province of Argentina, 97 % of a total population of 101,079 is urban, which includes the cities of Río Grande, Ushuaia, and Tolhuin. The present study focused on three urban centers: Puerto Williams (Chile), Punta Arenas (Chile), and Ushuaia (Argentina); all were sites that showed some cultural similarities, such as being colonized by Euro-centric, national governments after independence from Spain, and using Spanish as the dominant language. A number of differences also exist, however, including cultural and demographic features that differentiate these settlements. Particularly, total population and population growth rates varied between sites (Table 1).

Table 1 Demographic data for each city

	Puerto Williams (Chile)	Punta Arenas (Chile)	Ushuaia (Argentina)
Area (km^2)	1.19	39.03	40.58
Population	1,952	116,005	45,430
Population density (#/km^{-2})	1,600	2,970	1,120
Growth rate (# $year^{-1}$)	40.2	233.9	2,028.4
Percent increase (%)	25	2	56
Indigenous (%)	8.5	5.7	No information

Data from INE (2011) and INDEC (2010) for Chile and Argentina, respectively. Growth rate calculated over 10 years from 1991 to 2001 in Ushuaia and 1992 to 2002 in Punta Arenas and Puerto Williams. Urban area for Ushuaia is based on a measurements of urban boundary data conducted in Google Earth

Materials and Methods

Determining Ecosystem Service Values and Threats

Research questions were tested through the application of a quantitative and qualitative survey instrument (Appendix). Before survey application, a period of approximately 2 months was spent engaging in participant observation, which allowed (i) development of an appropriate survey to address our research questions, (ii) testing of the survey with regional residents, and (iii) making cultural adjustments to the survey based on responses from trials. Through this process, we developed basic explanations that were integrated into all questions such that every survey was consistent and would not require additional clarification from the surveyor, which might influence the application method. Two social groups were defined a priori based on the interests of these specific research questions: "specialists" were scientists and academics related to the biological and ecological sciences and decision-makers in natural resource management institutions; and all other survey participants were defined as the "community" population.

The survey, applied over a nine month period in 2011, was divided into five main sections: (1) general demographic information from the participant (e.g., age, home town, place of birth, education level, gender, and profession); (2) ability to access scientific information and decision-makers; (3) level of scientific/natural resource knowledge of watersheds; (4) perceived values and status of ES; and (5) perceived threats to ES. For the ES portion of the survey (section 4), the total list of services was based on the MA (2005) typology. For each ES and threat, participants were asked to assign a relative value between 1 and 10. In the case the ES did not exist, they were asked to put a 0, and if they did not understand the ES, then they were asked to skip it. In addition, for each ES, the participants were asked if it was deteriorating, improving, or maintaining its status. For potential threats, the existing literature was reviewed for the region to generate a list of activities that pose some sort of risk to ES quality in the near- or long-term. All survey tools and protocols were approved by the University of North Texas (UNT) Institutional Review Board (IRB #11175) and regional authorities (TDF Science & Technology Commission Resolution #09/11, UMAG Bioethics Committee Certification). Before each survey was conducted, willing participants were asked to sign a consent form, as required by the UNT IRB, which included a brief explanation on the purpose of the study, a list of the researchers involved, an explanation on the process to protect confidentiality and an explanation of basic rights as a study participant.

To obtain completed surveys from the general community, a number of different methods were employed. Most surveys in Punta Arenas and Ushuaia were obtained through convenience sampling by selecting a variety of public spaces including hospitals, clinics, local businesses, schools, shopping malls, city parks, and waiting areas for governmental public services. This methodology was deemed to be sufficient for obtaining a sample of the population, since all surveys were collected in areas where a broad suite of social sectors come together. In Puerto Williams, surveys were applied using a systematic sampling design through door-to-door interviews to ensure a representative sample of a relatively small, but heterogeneous community. All streets in the community were numbered. Then, using a random number generator, one street was selected each day of sampling, and the first four houses on each street were approached for an interview between 5 and 9 p.m. (when household members were most likely to be available). Puerto Williams required this specific sampling strategy since the majority of its residents do not congregate in any one area, due to the fact that it is a small community with very few public spaces. To sample the specialist population, a mix of purposive and chain-referral sampling methodologies were used, whereby participants at research and natural resource management institutions were recruited through mail, email, by phone, or in person. First, institutional directors were contacted to seek permission and assistance to subsequently apply the survey to the professionals and staff under their supervision. Though most specialists understood that they were identified as such, it was made clear that all responses were to reflect personal perspectives and not that of the institution they represented. No minors were surveyed in this study.

Data Analysis

Only surveys in which participants answered at least sections one and two were entered into a unified database and then cross-checked for accuracy. The average value for each ES category (provisioning, regulating, cultural, and supporting) and total ES mean were calculated per survey. The first four questions of the survey had binary responses (yes/no). These related to basic scientific/technical information on watersheds (knowing the definition of watershed and knowing source of drinking water) and also perceptions regarding information and decision-making (access to information and ability to communicate with decision makers). These results were analyzed with a logistic regression (X^2 test). Next, differences between the mean value of each ES, each ES category, and each threat were determined using independent *t*-tests, comparing "community" versus "specialist." Logistic regression was also used to determine differences in the percentages of respondents selecting whether each ES was perceived as degrading, improving, or staying the same within each ES category. Finally, the top three threats identified by each group were ranked in the order they appeared in terms of frequency as being categorized "top 3" by each survey respondent. All analyses were conducted in JMP 9.0 (SAS Institute 2009).

To have a better understanding of the overall similarity of ES valuation between the community and specialists groups, a Non-metric Multidimensional Scaling (NMDS) process was performed, using PC-Ord 3.4 (McCune and Grace 2002). This analysis allowed the determination of whether the entire suite of values expressed in each survey for community and specialist respondents were clustered as per the pre-defined groups. The NMDS uses a Bray–Curtis Index to compare the similarity of the entire suite of ES values between individual respondents. Since this procedure requires no blank data cells only surveys that answered at least 80 % of the questions were included. We then excluded the ES that were reported in less than 90 % of surveys from the analysis, which left us with a dataset that conformed to the requirements.

Results

Survey Data Demographics

A total of 312 surveys from all three communities and both study populations were obtained and used in the analyses.

Table 2 Total numbers of completed surveys for each city by community & specialist and male & female categories

Groups	Total	Puerto Williams	Ushuaia	Punta Arenas
Community	277	39	114	124
Specialist	35	7	18	10
Male (%)	56	51	56	56
Female (%)	44	47	43	44
Total *N*	312	46	132	134

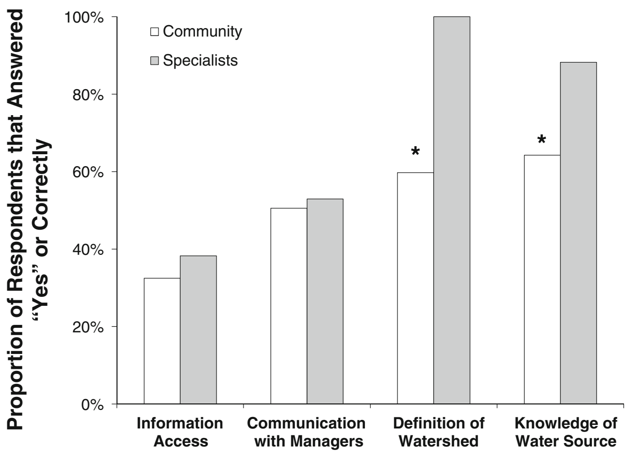

Fig. 1 Proportion (%) of respondents (community vs. specialists) who answered in the affirmative or correctly to binary questions regarding overall levels of information and access to information about watersheds. *Stars* indicate questions with significant differences between social groups with a X^2 test ($P < 0.05$)

Total surveys for each site were 7, 18, and 10 specialists and 39, 114, and 124 community members from Puerto Williams, Ushuaia, and Punta Arenas, respectively. Slightly over half of all participants completing surveys at each site were male (Table 2).

Access to Information and Decision-Making and Scientific Knowledge

There was no difference in the perceptions of community and specialist groups regarding access to information ($P = 0.50$) and access to decisions-makers ($P = 0.81$). Only 32 % of the community and 38 % of specialists perceived that sufficient access to information existed, and 51 and 53 %, respectively, believed sufficient access to decision makers existed. Significant differences, however, were found between the community and specialist populations with regards to familiarity with basic ecological terminology, such as the term watershed (community = 60 % yes, specialists = 100 % yes, $X^2 = 32.28$, $P < 0.0001$) and whether or not participants knew from which watershed their drinking water came (community = 64 % correct, specialists = 88 % correct; $X^2 = 9.11$, $P = 0.003$) (Fig. 1).

Perceptions of Ecosystem Services Values

Among the MA's ES categories, only provisioning services were valued differently between the community and specialists ($t = 2.46$, $P = 0.012$). On average, the community valued this group of services more than specialists. For all other categories, though no significant differences existed, but an overall trend emerged of the general community valuing regulating and cultural services more highly than specialists, who in turn reported higher values for supporting services (Table 3).

For individual services, the community reported higher valuation than specialist respondents for the provisioning of food ($P = 0.009$), fiber products (i.e., firewood, $P = 0.03$) medicinal/pharmaceutical products ($P = 0.005$), ornamental products (i.e., material for handicrafts, $P = 0.03$), geological resources ($P = 0.03$), and the regulation of air quality ($P = 0.01$) (Table 3). On the other hand, the specialists more highly valued the regulation of water ($P = 0.04$) and recreational cultural services ($P = 0.0003$). The ability to generate knowledge systems was an ES that was also valued higher by specialists, though this result was only marginally significant ($P = 0.06$) (Table 3). No significant differences existed in how community and specialist participants valued specific supporting services.

The percentage of community participants who actually comprehended the meaning of the individual ES categories was the lowest for supporting services (73 %) and regulating services (73.4 %). Cultural services were the most understood by the community (86.9 %), while provisioning services were in between (79 %). The least understood specific services by the community were: (1) the provisioning of genetic resources (49.8 %); (2) the supporting service of soil formation (56.3 %); and (3) the provisioning of medicinal/pharmaceutical resources (58.6 %). The regulation of erosion (59.8 %) and of air quality (59.8 %) also had relatively low levels of understanding by community respondents (Table 3).

Regarding the ranking of the top three ES, both groups showed the same prioritization for the ES in the provisioning category, but had somewhat different arrangements for regulating, cultural, and supporting services. Overall, the community prioritized water cycling and photosynthesis in supporting services. Esthetic, inspirational, and water provisioning services were the second, and intrinsic/bequest type services were the third. Specialists, on the other hand, prioritized recreational services first, provisioning of water second, and esthetic services third (Table 4).

Perceptions of Status and Threats to ES

The community was apparently more optimistic regarding the status (i.e., degrading, improving or the same) of ES than specialists. We discovered that while almost half of

Table 3 Mean values (±SE) for ecosystem service categories and all ecosystem services included in the survey shown for community and specialist populations

Ecosystem service	Community	Specialists	*t*	d.f.	*P*	Percent understood
Provisioning	7.4 ± 0.1	6.6 ± 0.3	2.46	40.78	**0.012**	**79.0**
Food	7.9 ± 0.2	6.4 ± 0.5	2.74	38.51	**0.009**	98.5
Water	8.5 ± 0.1	9.0 ± 0.4	1.41	44.09	0.08	98.1
Fiber	7.5 ± 0.2	6.3 ± 0.5	2.23	35.42	**0.03**	94.3
Medicinal	6.0 ± 0.2	4.1 ± 0.6	3.03	26.98	**0.005**	58.6
Genetic	6.9 ± 0.2	6.7 ± 0.5	0.28	37.22	0.78	49.8
Ornamental	7.1 ± 0.2	5.7 ± 0.6	2.23	33.49	**0.03**	93.1
Geological	7.0 ± 0.2	5.7 ± 0.5	2.31	33.94	**0.03**	80.1
Regulating	7.3 ± 0.1	7.1 ± 0.4	0.41	41.82	0.69	**73.4**
Climate	7.1 ± 0.2	7.7 ± 0.5	1.27	41.23	0.21	65.5
Disease	7.2 ± 0.2	7.0 ± 0.5	0.34	25.87	0.73	73.6
Water	7.4 ± 0.2	8.5 ± 0.5	2.08	38.36	**0.04**	88.1
H_2O purification	7.1 ± 0.2	7.8 ± 0.5	1.40	37.73	0.09	78.9
Pollination	7.0 ± 0.2	6.4 ± 0.6	0.95	31.35	0.35	59.8
Air quality	8.1 ± 0.2	6.4 ± 0.6	2.74	33.99	**0.01**	82.8
Erosion	7.0 ± 0.2	7.3 ± 0.5	0.52	43.41	0.61	59.8
Pests	7.6 ± 0.2	6.8 ± 0.6	1.30	24.29	0.2	68.6
Natural disasters	7.4 ± 0.2	7.8 ± 0.4	1.00	26.71	0.32	83.1
Cultural	7.9 ± 0.1	7.7 ± 0.3	0.54	42.90	0.59	**86.9**
Spiritual	7.4 ± 0.19	6.7 ± 0.67	1.01	26.71	0.32	80.1
Recreation	8.2 ± 0.14	9.2 ± 0.19	3.82	73.11	**0.0003**	91.2
Esthetics	8.5 ± 0.14	8.8 ± 0.25	1.12	54.79	0.27	93.5
Inspiration	8.5 ± 0.15	7.7 ± 0.42	1.72	40.35	0.09	92.0
Education	7.1 ± 0.17	7.8 ± 0.46	1.36	42.09	0.18	89.3
Sense of place	8.0 ± 0.16	7.2 ± 0.45	1.56	40.97	0.13	85.8
Cultural heritage	7.8 ± 0.15	7.3 ± 0.46	1.07	37.67	0.29	83.9
Knowledge systems	7.2 ± 0.2	8.0 ± 0.4	1.92	43.2	0.06	76.6
Social relations	8.2 ± 0.2	7.5 ± 0.4	1.72	41.29	0.09	91.2
Cultural diversity	7.7 ± 0.2	7.4 ± 0.5	0.57	30.15	0.57	85.8
Intrinsic or bequest	8.4 ± 0.1	7.7 ± 0.5	1.40	35.08	0.17	87.0
Supporting	8.0 ± 0.1	8.2 ± 0.3	0.36	45.96	0.72	**73.0**
Soil formation	7.2 ± 0.2	7.8 ± 0.4	1.34	41.39	0.19	56.3
Nutrient cycling	7.9 ± 0.2	8.4 ± 0.4	1.36	50.55	0.18	65.9
Primary production	7.7 ± 0.2	7.5 ± 0.4	0.50	39.70	0.62	78.2
Photosynthesis	8.6 ± 0.1	8.0 ± 0.4	1.27	39.75	0.21	79.3
H_2O cycling	8.6 ± 0.1	8.7 ± 0.3	0.18	47.61	0.86	85.1

Results of independent *t*-tests are given, and significant differences are highlighted in bold ($P < 0.05$). The percentage of community respondents that understood each service and average for each category are given as well

both groups felt that ES conditions were maintaining themselves ($t = -0.67$; d.f. $= 51.46$; $P = 0.51$), the specialists had a significantly greater proportion who believed that ES in fact were degrading ($t = 2.54$; d.f. $= 43.90$; $P = 0.02$). Conversely, the community believed more often than specialists that ES were improving ($t = -2.70$; d.f. $= 60.64$; $P = 0.01$) (Fig. 2).

Furthermore, the community and specialists perceived the most threats in a similar manner, but two threats were rated significantly higher by the community. These were

Table 4 Ecosystem services with the highest mean average value per community and specialist groups were ranked for the top three services per category

Ecosystem service category	Community	Specialist
Provisioning		
1	Water	Water
2	Food	Food
3	Fiber	Fiber
Regulating		
1	Air quality	Water flow
2	Pest control	Natural disaster
3	Water flow	H_2O purification
Cultural		
1	Esthetics	Recreation
2	Inspiration	Esthetics
3	Intrinsic or bequest	Knowledge systems
Supporting		
1	H_2O cycling	H_2O cycling
2	Photosynthesis	Nutrient cycling
3	Nutrient cycling	Photosynthesis

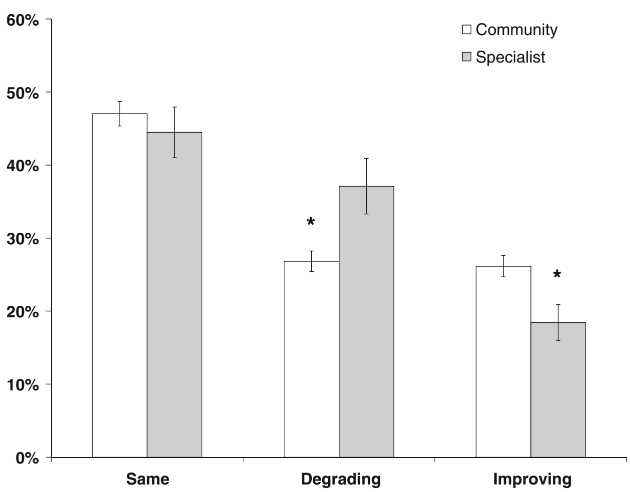

Fig. 2 Proportion (%) of ecosystem services believed by respondents (community vs. specialists) to be staying the same, increasing or decreasing. *Stars* indicate significant differences between social groups with a X^2 test ($P < 0.05$)

deforestation ($P = 0.003$) and the ozone hole ($P = 0.002$), while specialists perceived the threat from livestock grazing significantly more than the community ($P = 0.007$, Table 5). The ranking order for total threats were: climate change, deforestation, and the ozone for community respondents; and urban development, introduced species, and deforestation for the specialist population (Table 6).

Table 5 Mean (±SE) for each perceived threat to ecosystem services (ES) were determined for each social group

Threats to ES	Community	Specialists	*t*	d.f.	*P*
Climate change	8.1 ± 0.2	7.5 ± 0.4	−1.53	46.83	0.13
Industrial pollution	7.1 ± 0.2	6.4 ± 0.5	−1.25	47.22	0.22
Deforestation	7.8 ± 0.2	6.2 ± 0.5	−3.2	41.22	**0.003**
Introduced species	7.1 ± 0.2	7.7 ± 0.4	1.28	47.18	0.21
Ozone hole	8.2 ± 0.2	6.5 ± 0.5	−3.30	37.2	**0.002**
Peat extraction	6.2 ± 0.2	6.6 ± 0.5	0.68	43.14	0.5
Tourism	5.0 ± 0.2	5.7 ± 0.4	1.81	57.60	0.08
Urban development	6.7 ± 0.2	7.3 ± 0.4	1.45	49.82	0.15
Livestock grazing	4.3 ± 0.2	5.8 ± 0.5	2.86	44.33	**0.007**

Statistical differences were determined with *t*-tests, and significant results ($P < 0.05$) are in bold

Table 6 The ranking of each threat per social group

Threat	Community	Specialist
Climate change	**1 (65.8 %)**	4 (35.3 %)
Industrial pollution	4 (39.9 %)	3 (38.2 %)
Deforestation	**2 (51.8 %)**	**2 (41.2 %)**
Introduced species	6 (22.8 %)	**2 (41.2 %)**
Ozone hole	**3 (48.2 %)**	7 (11.8 %)
Peat extraction	7 (8.8 %)	6 (17.7 %)
Tourism	8 (8.3 %)	8 (8.8 %)
Urban development	5 (24.9 %)	**1 (52.9 %)**
Livestock grazing	9 (6.2 %)	5 (20.6 %)

Percentages are based on the number of respondents who identified each as a "top 3" threat. Bold indicate the top 3 within each social group

Overall Similarity of ES Values Between Participant Groups

Non-metric Multidimensional Scaling (NMDS) results showed a high degree of overlap regarding the overall valuation of ES for both study groups. These results also indicated that greater diversity (wider spread of data points) was found for the values that were held by the community, compared to specialists, which were more homogeneous. However, in general, while there were particular differences between the two groups, the NMDS illustrated that overall the value systems of these two groups have a great deal in common and overlapped, but specialists' overall valuation did not capture the full array of the broader society's values (Fig. 3).

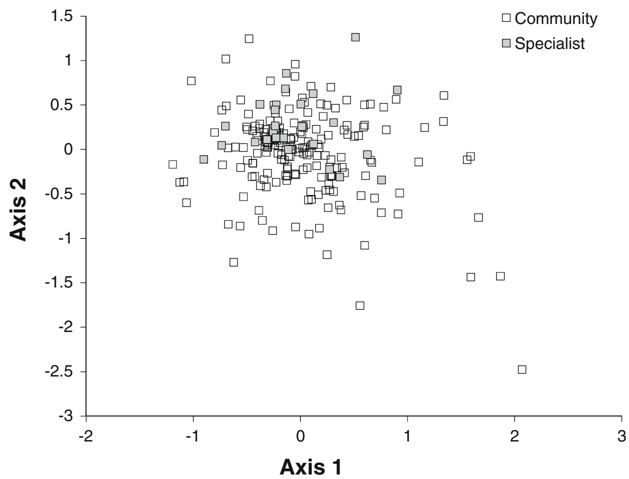

Fig. 3 Graphic representation using Non-metric Multidimensional Scaling (NMDS) of the similarity (Bray–Curtis) for the entire survey responses of ecosystem service values between social groups (community and specialists)

Discussion

Science-Society Dialog

Public participation in environmental management is being sought as an alternative to traditional command-and-control strategies that have failed to consider the local ecological and social contexts where management is being implemented (Tuler and Webler 2010; Brosius et al. 2005). Though both Argentina and Chile recognize the need to integrate public participation into environmental management processes (e.g., Argentina: Resolution 766/03; Chile: Article 4, Law 19,300), it is clear that community members feel that they lack the ability to affect decision-making regarding the management of local ecosystems. However, the fact that the specialist community, made up of scientists and decision-makers, also reflected the same view was surprising, considering that these are precisely the individuals who are charged with engaging the community.

It was also evident that a large portion of the general community does not have a basic understanding of common ecological terms (e.g., watershed) nor a basic knowledge of some local natural resources (e.g., knowing the source of one's drinking water), which are important baseline concepts that would help enable them to engage in the ecosystem management process. At the same time, the community has extensive knowledge of other terms and values that watersheds provide, which specialists do not necessarily consider (e.g., firewood, medicinal herbs, and plants for handicraft materials). In particular, the provisioning of genetic diversity was an ES poorly understood by community members. When participants were presented with this service in the survey, a brief general description was given illustrating how genetic resources were closely tied to biodiversity (see Appendix), as described by the MA (2005). In many cases, the term biodiversity itself seemed to raise a number of questions, and therefore, the relation of genetic resources to biodiversity only incited more confusion. Though community members perceived some of the benefits derived from biodiversity, such as medicinal uses of a variety of plants, the scientific concept of biodiversity per se was often poorly understood. This was in contrast to specialists, who were generally very familiar with the term biodiversity and its role in providing ecological benefits. This finding also is not surprising since the term has developed out of scientific disciplines and is, therefore, familiar to academics and practitioners, but less so to nonscientists.

It is important to consider the implications, however, of the isolation of scientific terminologies when there exists such a great deal of concern among the scientific community about the loss of biodiversity and its relationship to ecosystem function and ES (Brooks et al. 2002; Worm et al. 2006; Hooper et al. 2005). This phenomenon perhaps reflects the larger issue of the poor dialog that exists between science and society. Indeed, the previous point is reinforced by the fact that perceptions of ES status and potential threats to ecosystems, which usually play a major role in influencing the decisions managers make, differed somewhat between community members and specialists. However, taken together, the two groups' high priority concerns make up a fairly comprehensive list of potential threats, showing how the inclusion of both perspectives can provide a more holistic vision of issues. Clearly, improved dialog between these two social sectors is necessary and more efforts should be taken by specialists to communicate information regarding important topics such as biodiversity to nonscientists, as well as encouraging the reciprocal dialog needed from the community for developing more holistic management.

Recognizing that dialog cannot occur unidirectionally is critical. Even if outreach and education are considered products of science-based management institutions, it is highly unlikely that local citizen groups, which contain informal ecological knowledge obtained through cultural traditions or simply through outdoor recreation, will be able to contribute to the overall knowledge-base of local ecosystems. Such local ecological knowledge (LEK) and traditional ecological knowledge (TEK) can enhance the adaptability and long-term resilience of management strategies, while simultaneously promoting the cultural diversity of a region and creating reservoirs for diverse knowledge systems (Berkes et al. 2000; Lertzman 2009). For example, Olsson and Folke (2001) found that LEK of crayfish in a Swedish watershed built ecological resilience into the watershed and created an adaptive capacity to manage them. Furthermore, they suggested that scientific-based management strategies could greatly benefit from using community-based and collaborative approaches to fully take advantage of diverse knowledge types. Although our study did not specifically seek to investigate the existence of LEK and/or TEK in southern Patagonia, during the survey period of this research, there were numerous occasions where such knowledge surfaced through conversation with community members and could, therefore, be an area of future investigation.

Overall, our results indicated a current lack of dialog between "science and society" at the southern tip of the Americas. This has even greater implications when one considers that there are some value differences for local ecosystems between those who influence their management and those who depend on and live in them. Many of the provisioning services that were valued significantly greater by community members than specialists were those that can be converted into local tangible products, such as Patagonian lamb, the *calafate* berry (*Berberis microphylla*—a food and drink ingredient), and marsh reeds that are used to make regional handicrafts. Indeed, the people surveyed in this study were proud of their local natural products, and such values should be incorporated in the management of these ecosystems and the broader understanding of how society perceives "biodiversity" and ES.

Considering Both the Diversity and Similarity of Values in Adaptive Management

Perhaps the lack of dialog and participatory processes in management identified in the previous section would be of less concern if all people valued ecosystems in the same way, but that is clearly not the case. Even if the differences were not large, the fact that there is a greater diversity of values among community members than within specialists shows that scientists and natural resource authorities, who are more likely to have the power to insert their values into management strategies, are less likely to capture the overall array of values from local communities. Similarly, Berghoefer et al. (2010) found through a set of 69 qualitative interviews with residents and authorities in Puerto Williams that relationships with nature varied considerably across four preidentified social groups. Given that there exists diverse ways of relating to nature, we would expect that values of "nature's" services would also be diverse, particularly in the case of our study which extends across national borders. In this context, it is important for environmental managers and decision-makers to recognize the diversity in the way inhabitants value their ecosystems, which can thereby facilitate more transparent and participatory processes in planning and management actions.

It is a positive sign, however, that because many ecosystem values are shared between the community and specialists, a foundation does exist for transitioning to more collaborative processes of ecosystem co-management. On the other hand, because both groups recognized a general deficiency in extant participatory processes, it is important to analyze the institutional obstacles that are currently preventing such society-science integration. Furthermore, we would recommend that it is a priority to determine the values that have been imbedded institutionally in the agencies, laws, and policies that regulate and manage natural resources and assess to what extent they differ from the diversity of values expressed by the community and specialists themselves.

Assessing Nonmonetary ES Values

The MA (2005) defines ES as "the benefits people obtain from ecosystems" (p. 40), and the typology developed by the MA provides a general, yet comprehensive, list of ecosystem benefits applicable across multiple ecosystems. Therefore, it is a potentially useful framework for initiating ES research in a variety of settings and clarifying a diversity of values. In this study, we found that indeed it was particularly appropriate to detect those services that are difficult to put into monetary terms (e.g., intrinsic/bequest values, regulation of air quality), which were highly valued by all respondents. This has important implications for future environmental management that employs ES as a central unit. As the discussion of ES valuation continues, it is crucial that these value types are considered in the debate—and not only those that can be easily expressed in monetary terms—if we are to address the ecological constituents that support overall human well-being. Lockwood (1999) discusses some of the difficulty in capturing these types of values in economic terms, as well as concerns about economists using stated preference (SP) techniques, a common monetary-based valuation tool. In particular, he finds that a major problem with this strategy is the inability of individuals to express "noncompensatory" values when conducting value assessments using SP, leading to erroneous results. The methodology used in this study relied on nonmutually exclusive ranking of ES to determine relative differences in an arbitrary scale to interpret overall valuation, rather than simply placing it into a defined monetary scale.

Chan et al. (2012) also recognized the deficiency in current valuation methods, particularly those focused on economic valuation, to appropriately integrate cultural services and other nonmaterial benefits of ecosystems in ES research and decision-making. In response, they proposed a framework that serves as a guide to facilitate focused discussions among stakeholders for addressing these ES in a decision-making context. Their proposal may be used as a complimentary follow-up step to the ES research tool implemented in this study, which generates a general understanding of ES that are important to the public, including cultural and other nontangible services. Such information can aid decision makers in the identification of potential stakeholder groups for future-targeted discussions.

Conclusions

As environmental management institutions increasingly align themselves with the ES paradigm and efforts to create community-based administrative and research plans (e.g., MA, Inter-Governmental Platform on Biodiversity and Ecosystem Services), it is essential that ES research seeks to understand the range of values that exist in the communities where management is taking place and to continue to develop practical yet regionally, locally, and culturally-relevant tools for use in decision-making. If a goal of environmental management, and society as a whole, is to support the well-being of current and future generations, then values and knowledge systems represented within a society must be considered in the management decisions. Lockwood (1999) warns against the biased decision-making that can occur when values are only attempted to be expressed indirectly through normal political processes and influenced by privileged stakeholders. Therefore, it is highly recommended that community-based and participatory processes be developed within management institutions to initiate dialog for adaptive management strategies in southern Patagonia's sub-Antarctic ecoregion. The results of this study have shown that a diversity of values exists for local ecosystems and that values may differ between those who influence the management of ecosystems and the rest of the community. At the same time, the study population had a solid foundation of shared values that provide a starting point for constructive dialog between science and society.

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Appendix

English version of the survey applied to all participants at all sites. The version received by participants was translated to Spanish and contained basic explanations to ES based on observations during the participatory research period.

English version of the survey applied to all participants at all sites. The version received by participants was translated to Spanish and contained basic explanations to ecosystem services based on observations during the participatory research period.

General Information

Age ____ Hometown: ___________ ( ) male ( ) female

1. **Number of years you have been resident or periodic resident in the community? ____________________**
2. **Name the neighborhood or district you live in? ________________________________**
3. **Do you identify yourself most as (mark one): ( ) scientist/academic ( ) natural resource manager ( ) politician or government worker ( ) long-time resident ( ) military officer ( ) student ( ) teacher**
4. **Identify your profession or job. ____**
5. **Education Level: ( ) high school ( ) university ( ) masters or above**

Watershed Information (***a watershed is the region draining into a river, river system, or other body of water; a river and its valley***):

6. **Are you familiar with this term ____? Do you have another way of defining this term?**
7. **Do you feel the general public in your community has sufficient access to scientific information concerning regional watersheds and rivers? Explain?**
8. **Do you feel the general public in your community has sufficient ability to communicate with regional scientists and natural resource managers? Explain?**

9. Specific place-based watershed information:

Watersheds in Puerto Williams	Identify the river that provides your drinking water	Rank in order from highest valued to least valued	Annual frequency of visits to the river or its tributaries	General location of where you visit the river or its tributaries	Comments
Río Róbalo					
Río Ukika					
Other:					
Other:					
Do not know					

Watersheds in Punta Arenas	Identify the river that provides your drinking water	Rank in order from highest valued to least valued	Annual frequency of visits to the river or its tributaries	General location of where you visit the river or its tributaries	Comments
Río Las Minas					
Río de los Ciervos					
Río Tres Puentes					
Other:					
Do not know					

Watersheds in Ushuaia	Identify the river that provides your drinking water	Rank in order from highest valued to least valued	Annual frequency of visits to the river or its tributaries	General location of where you visit the river or its tributaries	Comments
Río Pipo					
Río Olivia					
Arroyo Grande					
Arroyo de Buena Esperanza					
Other:					
Do not know					

	Ecosystem Services	Value from 1 (low) to 10 (high) for the service you believe to be present. Mark 0 if it does not exist or skip if it is not understood	Is the service ***deteriorating (d)***, ***improving (i)***, or ***maintaining (m)***	***Comments***
Provisioning	**Food** (crops, livestock, wild food, fisheries)			
	Freshwater			
	Fiber (timber, plant material, fuel wood)			
	Biochemicals, natural medicines, pharmaceuticals			
	Genetic resources (biodiversity; genetic mat'l of current or future value; sources of unique biological products)			
	Ornamental (ex. artisan crafts)			
	Geological resources (ex. minerals)			
Regulation	**Climate regulation** (ex regulation of extreme changes in climate)			
	Disease regulation (value that ecosystems/nature regulates the birth of diseases)			
	Water regulation (which affects water flow in rivers)			
	Water purification and waste treatment (natural purification and regulation)			
	Pollination (of plants)			
	Air quality regulation			
	Erosion regulation (ex. stream bank erosion)			
	Pest regulation (natural pest resistance)			
	Natural hazard regulation (ex. natural flood regulation)			

10. Ecosystem Services Information (continued).

	Ecosystem Services	Value from 1 (low) to 10 (high) for the service you believe to be present.	Is the service ***deteriorating (d)***, ***improving (i)***, or ***maintaining (m)***	Comments
Cultural	**Spiritual and religious** (related to local environment; ex. meditation along side a river)			
	Recreation and ecotourism			
	Aesthetic (ex. beauty of the landscape)			
	Inspirational (that the local environment inspires you)			
	Educational (on local ecosystems and biodiversity)			
	Sense of place			
	Cultural heritage (that the local environment permits growing of cultural roots now or historically)			
	Knowledge systems (ex. a system to identify local plants or animals)			
	Social relations (ex. the ability to enjoy a river with family over a barbecue)			
	Cultural diversity (ex. a variety of cultures can access local ecosystems and share their knowledge of them)			
	Bequest, intrinsic, existence (ex. the value that plants and animals have their own right to live)			
Supporting	**Soil formation**			
	Nutrient cycling (ex. the movement of nutrients between plants, insects, carnivores, detritivores; cycle of life)			
	Primary production (`the growth of plants			
	Photosynthesis (*oxygen production*)			
	Water cycling (ex. clouds-rain-plants-ground-river-ocean-cluds)			

11. Place a number from 1 (low) to 10 (high) for the potential level of threat that exists to local ecosystems and biodiversity and rank the top three threats for your local watersheds.

Potential Threats	Severity of Threat (1-10)	Rank Top 3 Threats
1. Climate change (ex. global warming)		
2. Industrial contamination		
3. Deforestation and logging		
4. Exotic species		
5. Ozone hole		
6. Peat extraction		
7. Tourism		
8. Urban development		
9. Ranching		
10.Other: __________________		
11.Other: __________________		
12.Other: __________________		

12. Do you have any general or additional comments regarding the services provided by watersheds in your community or threats that they face?

References

Amin O, Comoglio L, Spetter C, Duarte C, Asteasuain R, Freije RH, Marcovecchio J (2011) Assessment of land influence on a high-latitude marine coastal system: Tierra del Fuego, southernmost Argentina. Environ Monit Assess 175:63–73

Anderson CB, Rozzi R, Torres-Mura JC, McGehee SM, Sherriffs MF, Schüttler E, Rosemond AD (2006) Exotic vertebrate fauna in the remote and pristine sub-Antarctic Cape Horn Archipelago, Chile. Biodivers Conserv 15:3295–3313

Armitage D (2005) Adaptive capacity and community-based natural resource management. Environ Manage 35:703–715

Berghoefer U, Rozzi R, Jax K (2010) Many eyes on nature: diverse perspectives in the Cape Horn Biosphere Reserve and their relevance for conservation. Ecol Soc 15(1):18

Berkes F, Colding J, Folke C (2000) Rediscovery of traditional ecological knowledge as adaptive management. Ecol Appl 10:1251–1262

Boyd J, Banzhaf S (2007) What are ecosystem services? The need for standardized accounting units. Ecol Econ 63:616–626

Brander LM, van Beukerin P, Cesar Herman SJ (2007) The recreational value of coral reefs: meta-analysis. Ecol Econ 63:209–218

Brauman KA, Daily GC, Duarte TK, Mooney H (2007) The nature and value of ecosystem services: an overview highlighting hydrologic services. Annu Rev Environ Resour 32:67–98

Brooks TM, Mittermeier RA, Mittermeier CG, da Fonseca GAB, Rylands AB, Konstant WR, Flick P, Pilgrim J, Oldfield S, Magin G, Hilton-Taylor C (2002) Habitat loss and extinction in the hotspots of biodiversity. Conserv Biol 16:909–923

Brosius PJ, Tsing AL, Zerner C, Alcorn J (2005) Communities and conservation: histories and politics of community-based natural resource management. Altamira Press, Lanham

Chan KMA, Guerry AD, Balvanera P, Klain S, Satterfield T, Basurto X, Bostrom A, Chuenpagdee R, Gould R, Halpern BS, Hannahs N, Levine J, Norton B, Ruckelshaus M, Russell R, Tam J, Woodside U (2012) Where are ‘cultural’ and ‘social’ in ecosystem services? A framework for constructive engagement. Bioscience 62(8):744–756

Clayton S, Myers G (2010) Conservation psychology: understanding and promoting human care for nature. Wiley, Hoboken

Collins SL, Carpenter SR, Swinton SM, Orenstein DE, Childers DL, Gragson TL, Grimm NB, Groves JM, Harlan SL, Kaye JP, Knapp AK, Kofinas GP, Magnuson JJ, McDowell WH, Melack JM, Ogden LA, Robertson GP, Smith MD, Whitmer AC (2011) An integrated conceptual framework for long-term social-ecological research. Front Ecol Environ 9:351–357

Costanza R (2008) Ecosystem services: multiple classification systems are needed. Biol Conserv 141:350–352

Costanza R, d’Arge R, de Groot R, Farber S, Grasso M, Hannon B, Limburg K, Naeem S, O’Neill RV, Paruelo J, Raskin RG, Sutton P, van den Belt M (1997) The value of the world’s ecosystem services and natural capital. Nature 387:253–260

de Groot RS, Wilson WA, Boumans RMJ (2002) A typology for the classification, description and valuation of ecosystem functions, goods and services. Ecol Econ 41:393–408

de Groot RS, Alkemade R, Braat L, Hein L, Willemen L (2010) Challenges in integrating the concept of ecosystem services and values in landscape planning, management and decision making. Ecol Complex 7:260–272

Fisher B, Turner K, Zylstra M, Brouwer R, de Groot R, Farber S, Ferraro P, Green R, Hadley D, Harlow J, Jefferiss P, Kirkby C, Morling P, Mowatt S, Naidoo R, Paavola J, Strassburg B, Yu D, Balmford A (2008) Ecosystem services and economic theory: integration for policy-relevant research. Ecol Appl 18(8):2050–2067

Fleeger WE, Becker ML (2008) Creating and sustaining community capacity for ecosystem-based management: is local government the key? J Environ Manage 88:1396–1405

Hooper DU, Chapin FS, Ewel JJ, Hector A, Inchausti P, Lavorel S, Lawton JH, Lodge DM, Loreau M, Naeem S, Schmid B, Setala H, Symstad AJ, Vandermeer J, Wardle DA (2005) Effects of biodiversity on ecosystem functioning: a consensus of current knowledge. Ecol Monogr 75:3–35

Iturraspe R (2010) Las Turberas de Tierra del Fuego y el Cambio Climático Global. Fundación Humedales/Wetlands International, Buenos Aires. http://www.wetlands.org/?TabId=56&mod=1570&articleType=ArticleView&articleId=2722. Accessed April 6, 2013

Jax K, Barton DN, Chan KMA, de Groot R, Doyle U, Eser U, Görg C, Gómez-Baggethun E, Griewald Y, Haber W, Haines-Young R, Heink U, Jahn T, Joosten H, Kerschbaumer L, Korn H, Luck GW, Matzdorf B, Muraca B, Neßhöver C, Norton B, Ott K, Potschin M, Rauschmayer F, von Haaren C, Wichmann S (2013) Ecosystem services and ethics. Ecol Econ 93:260–268

Kelble CR, Loomis DK, Lovelace S, Nuttle WK, Ortner PB, Fletcher P, Cook GS, Lorenz JJ, Boyer JN (2013) The EBM-DPSER conceptual model: integrating ecosystem services into the DPSIR framework. PLoS ONE 8(8):e70766. doi:10.1371/journal.pone.0070766.eCollection

Lertzman K (2009) The paradigm of management, management systems and resource stewardship. J Ethnobiol 29:339–358

Lockwood M (1999) Humans valuing nature: synthesizing insights from philosophy, psychology and economics. Environ Values 8:381–401

Lynam T, de Jong W, Sheil D, Kusumanto T, Evans K (2007) A review of tools for incorporating community knowledge, preferences, and values into decision making in natural resources management. Ecol Soc 12:5

McCune B, Grace JB (2002) Analysis of ecological communities. MjM Software Design, Gleneden Beach

Menzel S, Teng J (2009) Ecosystem services as a stakeholder-driven concept for conservation science. Conserv Biol 24:907–909

Millennium Ecosystem Assessment (MA) (2005) Ecosystems and human well-being. http://www.maweb.org. Accessed October 9, 2010

Mittermeier RA, Mittermeier CG, Brooks J, Pilgrim J, Konstant J, da Fonseca GAB, Kormos C (2003) Wilderness and biodiversity conservation. PNAS 100:10309–10313

National Research Council (2008) Public participation in environmental assessment and decision making. National Academies Press, Washington, DC

Norton BG (2005) Sustainability: a philosophy of adaptive ecosystem management. University of Chicago Press, Chicago

Olsson P, Folke C (2001) Local ecological knowledge and institutional dynamics for ecosystem management: a study of Lake Racken Watershed, Sweden. Ecosystems 4:85–104

Petrosillo I, Zaccarelli N, Zurlini G (2010) Multi-scale vulnerability of natural capital in a panarchy of social-ecological landscapes. Ecol Complex 7:359–367

Raymond CM, Bryan BA, MacDonald DH, Cast A, Strathearn S, Grandgirard A, Kalivas T (2009) Mapping community values for natural capital and ecosystem services. Ecol Econ 68:1301–1315

Rozzi R, Massardo F, Anderson CB, Heidinger K, Silander JA Jr (2006) Ten principles for biocultural conservation at the southern tip of the Americas: the approach of the Omora Ethnobotanical Park. Ecol Soc 11:43. www.ecologyandsociety.org/vol11/iss1/art43/

SAS Institute Inc. (2009) JMP 9. Cary, NC

Tuler S, Webler T (2010) How preferences for public participation are linked to perceptions of the context, preferences for outcomes, and individual characteristics. Environ Manage 46:254–267

Wallace KJ (2007) Classification of ecosystem services: problems and solutions. Biol Conserv 139:235–246

Worm B, Barbier EB, Beaumont N, Duffy JE, Folke C, Halpern BS, Jackson JBC, Lotze HK, Micheli F, Palumbi SR, Sala E, Selkoe KA, Stachowicz JJ, Watson R (2006) Impacts of biodiversity loss on ocean ecosystem services. Science 314:787–790