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Understanding expert and public perceptions of ecosystem services in the Portneuf Watershed, Idaho: Lessons for environmental planning

by

Scott Greeves

A thesis
submitted in partial fulfillment
of the requirements for the degree of
Master of Science in the Department of Biological Sciences
Idaho State University
Fall 2020
Committee Approval

To the Graduate Faculty:
The members of the committee appointed to examine the thesis of Scott Greeves find it satisfactory and recommend that it be accepted.

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Dr. Katrina Running, Graduate Faculty Representative
IRB Approval.
September 5, 2019

Scott Greeves
Biological Sciences
MS 8007

RE: Study Number IRB-FY2019-116: Linking expert and community knowledge on ecosystem services and risks: toward a co-production knowledge strategy

Dear Mr. Greeves:

I have reviewed your request for expedited approval of the new study listed above. This is to confirm that I have approved your application.

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Sincerely,

Ralph Baergen, PhD, MPH, CIP
Human Subjects Chair
Acknowledgments

I would like to take the opportunity to thank my thesis committee, including Dr Colden Baxter and Dr Antonio J. Castro, who without this project would not have been possible. I would also like to thank all those involved in the design, creation, and sampling of the ‘public’ Portneuf.
Table of Contents

List of Figures .................................................................................................................... vii

Abstract ............................................................................................................................... viii

1. Introduction ..................................................................................................................... 1

2. Methodology .................................................................................................................. 12

   2.1 Study area: the Portneuf River watershed ................................................................. 12

   2.2 Methodology for addressing social assessment of expert and public values and associated study goals and hypotheses .................................................. 14

   2.3 Designing a questionnaire to suit expert and public knowledge types .................. 17

       2.3.1 Questionnaire design: Use of resource panels for photo elicitation ............... 18

   2.4 Sampling Strategy .................................................................................................... 19

       2.4.1 Public sampling strategy and questionnaire design ........................................... 19

       2.4.2 Expert sampling strategy and questionnaire design ......................................... 22

       2.4.3 Comparing academic and non-academic expert perceptions ......................... 24

   2.5 Data analysis ............................................................................................................. 25

3. Results ............................................................................................................................ 29

   3.1 Public and expert sample description ...................................................................... 29

       3.1.1 Public sample description ................................................................................ 29

       3.1.2 Expert sample description ................................................................................ 29
<table>
<thead>
<tr>
<th>Section</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>3.2 Perception of ecosystem services in the Portneuf Watershed</td>
<td>30</td>
</tr>
<tr>
<td>3.3 Ranking ecosystem service importance</td>
<td>31</td>
</tr>
<tr>
<td>3.4 Perceived ecosystem service change in the last decade</td>
<td>32</td>
</tr>
<tr>
<td>3.5 Social perceptions of ecosystem service impact by land-use change</td>
<td>32</td>
</tr>
<tr>
<td>3.6 Expert perceptions of scientific certainty and management</td>
<td>34</td>
</tr>
<tr>
<td>3.7 Expert perceptions of the ecosystem service framework for management</td>
<td>35</td>
</tr>
<tr>
<td>4. Discussion</td>
<td>36</td>
</tr>
<tr>
<td>5. Study Limitations and Future Directions</td>
<td>52</td>
</tr>
<tr>
<td>5.1 Study Limitations</td>
<td>52</td>
</tr>
<tr>
<td>5.2 Future Directions</td>
<td>53</td>
</tr>
<tr>
<td>6. Citations</td>
<td>56</td>
</tr>
<tr>
<td>7. Appendix</td>
<td>66</td>
</tr>
<tr>
<td>7.1 Figures</td>
<td>66</td>
</tr>
</tbody>
</table>
List of Figures

Figure 1, Graphical abstract highlighting the key components, challenges, and opportunities to place-based sustainability research ................................................................. 66

Figure 2, Map of the Portneuf Watershed .................................................................. 67

Figure 3, Breakdown of expertise, self-reported by experts ....................................... 68

Figure 4, Percentage of respondents in each response category to the question ‘Do you think ecosystem services in the Portneuf River watershed provide contributions to human wellbeing in the region?’ in both the public and expert groups ................................................................................................................................. 69

Figure 5, Mean number of free-listed ESS per respondent, categorized into provisioning, regulating and cultural services ................................................................................................. 69

Figure 6, Mean perceived ecosystem service importance ranking for both public and expert groups ................................................................................................................................. 70

Figure 7, Mean perceived change in the provision of each ES over the last ten years ................................................................................................................................. 71

Figure 8, Mean perceived impacts on ES under four hypothetical land-use change scenarios ................................................................................................................................. 72

Figure 9, Mean scientific certainty and mean management across four land-use types ................................................................................................................................. 73
Figure 10, Mean scientific certainty and mean management across ten ecosystem services .......................................................... 74

Figure 11, Count of expert free-listed responses to why, or why not, an ecosystem service-based approach to management affect the people and ecosystems of the Portneuf Watershed .......................................................... 75

Figure 12, Ecosystem services panel, categorized, and color coded into provisioning, regulating and cultural services .......................................................... 76

Figure 13, A resource panel highlighting local land-use types ............................... 77
Understanding expert and public perceptions of ecosystem services in the Portneuf Watershed, Idaho: Lessons for environmental planning

Thesis Abstract – Idaho State University (2020)

Globally, human activities are transforming landscapes through habitat fragmentation, degradation and removal, creating new anthropogenic habitats. However, as natural landscapes are degraded or lost, their capacity to provide ecosystem services, which underpin human wellbeing and societal functioning, is commonly distorted and reduced. Socio-ecological systems (SES) research represents one methodology to tackle the impacts of global change drivers (such as land-use change or climate change), providing a holistic framework for environmental management. SES science conceptualizes the environment as an interconnected open system comprised of ecological and social processes. SES research reframes environmental issues as social-ecological issues, investigating and highlighting how better management of ecosystem services (ESS) can improve social-ecological resilience and associated human wellbeing linkages. Applying SES research to smaller scale, place-based studies, is gaining traction and has been praised for fostering the co-production of knowledge and environmental management solutions between related local stakeholders. In this case study of a semi-arid watershed in southeastern Idaho, we used a questionnaire to conduct a social assessment of ecosystem services, to investigate and compare expert and public perceptions and seek lessons for environmental planning.
Our results indicated a nuanced relationship between expert and public perceptions of ESS, with the expert and public groups reporting remarkably similar perceptions in some instances but starkly different perceptions in others. In our study, the expert group that reported ESS provide greater contributions to human wellbeing compared to the public group. However, our results indicated that expert and public perceptions of which ESS are most important to human wellbeing, how ESS have changed over the last decade, and the impact of four hypothetical land-use change scenarios on ESS, were unexpectedly similar. We discuss the implication of these results both locally and beyond, and highlight the importance of such findings to be translated into a policy narrative.

Key Words – Ecosystem Services, Social-Ecological Systems, Place-Based, Case Study, Policy Narrative, Expert, Public
1. Introduction

Globally, human activities are transforming landscapes through habitat fragmentation, degradation and removal, creating new anthropogenic habitats (Kremen et al, 2007; Rockström et al, 2009). As natural landscapes are degraded or lost, their capacity to provide ecosystem services (ESS), which are the direct and indirect benefits people derive from ecosystems and maintain human wellbeing (MEA, 2005), are commonly distorted and reduced (Costanza et al, 1997). ESS underpin societal functioning and human wellbeing by providing a plethora of regulating, provisioning and cultural services, ranging from climate regulation and freshwater provision to recreational opportunities (Costanza et al, 1997; MEA, 2005). However, many ESS are frequently not included in anthropocentric market systems, and consequently their valuable contributions are not quantified or considered in the same manner as other economic goods. Subsequently, the negative effects of land-use change and associated modifications and losses of ESS are given little weight or importance in policy decisions and actions influencing the environment.

Socio-ecological systems (SES) research represents one methodology to tackle the impacts of global change drivers (such as land-use change or climate change), providing a holistic framework for environmental management. SES conceptualizes the environment as an interconnected open system comprised of ecological and social processes (Virapongse et al, 2016). Processes within SES are interconnected through
practices, including environmental management, adaptation, and resource use, and are influenced by factors such as political and economic conditions, and global biogeochemical conditions (Chapin et al, 2009a: Chapin et al, 2009b: Balvanera et al, 2017a) (Figure 1). By adopting a holistic and interconnected approach, SES research reframes environmental issues as social-ecological issues, investigating and highlighting how better management of ESS can improve social-ecological resilience and associated human wellbeing linkages (Berkes et al, 2008; Palomo et al, 2016). A comprehensive meta-analysis of SES studies concluded that SES research is most commonly centered on pressing sustainability issues, including climate change, biodiversity loss, livelihoods, poverty, policy, land use change, water, and social and environmental justice (de Vos et al, 2019). Additionally, methodological pluralism is common in SES research, with spatial mapping and analysis, historical profiling and reconstruction, interviews, and futures analysis most typical.

In SES research, ESS are commonly considered because they reflect the interconnected nature of ecological and social systems and processes. ESS are assessed using separated or combined biophysical, economic or socio-cultural methodologies (Castro et al, 2013). The use of ESS in SES research is valuable for a number of reasons. Firstly, investigating ESS may help to reduce the inherent anthropocentric market bias towards environmental goods and services, therefore reducing market externalities (Muradian et al, 2013). Largely, this is because the ESS framework can facilitate a focusing
on ecosystem-human well-being interlinkages, translating ecosystem properties into benefits or contributions for humans (Harrison, 2010). Secondly, ESS provide a common language and set of metrics for assessing benefits that are related to environmental management decisions (Daily et al, 2009). Thirdly, the use of ESS can be an effective tool in limiting cultural, demographic and political biases when engaging with stakeholders (Cornell et al, 2019). Principally, this is because the use of an ESS framework may remove politically charged jargon and replace it with relatable services on which people depend.

Applying SES research to place-based studies is gaining traction. The SES research directive ‘Future Earth’ (Future Earth, 2020) named the ‘Programme on Ecosystem Change and Society’ (PECS) (Programme on Ecosystem Change and Society, 2020), one of its core projects. PECS endeavors to support a focused and in-depth understanding of SES and opportunities to foster sustainable stewardship using comparative, place-based research (Programme on Ecosystem Change and Society, 2020). Case studies and place-based research can be used to generate an in-depth, multi-faceted understanding of a complex issue in its real-life context (Crowe et al, 2011). Typically, case studies, which are anchored in a specific time and place, are necessary when it is impossible or impractical to investigate a system that is too large to capture within one study. The case study methodology, which employees a logic of informal inferences, has been criticized for providing limited foundation for generalization (i.e. producing findings that may be scalable and transferable to other situations) (Yin, 1998). However, case studies represent
a powerful tool in gaining practical control over real-life problems, using informal inferences to make rough generalizations, which often present sensible explanations and associated practical actions (Shrader-Frechette et al, 1994). Furthermore, descriptions of specific cases can be used to study different, but partially similar cases. By selecting a SES case study site that has similar social, environmental, and economic conditions to the broader area of comparison can improve the ease of upscaling and comparison (Crowe et al, 2011). As such, the logic of case studies is best described as pragmatic (Shrader-Frechette et al, 1994)

PECS case studies recognize the value of ESS as a means to understand feedback loops between ecosystems, human wellbeing and the indirect and direct drivers of ecosystem change (Carpenter et al, 2012). PECS and its place-based SES approach, has been praised for fostering the co-production of knowledge and environmental management solutions (sensu Jasanoff, 2004) between related local stakeholders, such as local experts, businesses, local governance and the public (Balvanera et al, 2017 b; Armitage et al, 2011), and for working at the science-policy interface (de Vos et al, 2019). Place-based SES research represents a bottom-up approach to management and sustainability. Balvanera et al (2017) writes “By establishing a network of transdisciplinary research teams, the complex dynamics of socio-ecological systems can be further unraveled from the identification of key processes that operate across sites, the context dependent interactions among them, as well as commonalities and specificities
of the alternatives identified among places facing similar sustainability issues.” This approach considers that although local issues may not be significant at a global scale, the interconnected nature of multiple local systems is significant to understanding and addressing larger global challenges. Subsequently, two major goals of placed-based SES research are identifiable: (1) to address local, place-based issues and (2) establish an interconnected network of SES research, proving a holistic, bottom-up approach to sustainability.

Despite growing interest and application of place-based SES research, the practice by its very nature must consider local particularities, and consequently is challenged by the use of inconsistent practices and study designs. For instance, in Idaho, USA, the lens of SES has been used to characterize social demand for ESS using land use change projection models (Narducci et al, 2019), spatially investigate correspondence between conservation targets and ESS (Quintas-Soriano et al, 2020) and analyze how people prioritize different ecosystem services with respect to issues of climate change (Cornell et al, 2019). Whilst this research is valuable, methodological pluralism can act as a barrier to the comparison of experiences and findings from place-based SES research. It is difficult to evaluate the relative strengths and weaknesses, making it challenging to define success and support the refinement of methodologies (Carpenter et al, 2012). Additionally, the heterogeneity of current methods may constrain the scalability of place-based SES
research, and limit its application within an interconnected network of such research (Balvanera et al, 2017a).

To address this issue and identify the key features that make place-based SES research valuable in environmental management, Virapongse et al, (2016) identified five important theoretical needs in SES science. The five concepts are (1) The need for a systematic worldview, whereby case studies are not considered in isolation, but instead as part of an interconnected web of local to global sustainability. (2) The need to adopt a transdisciplinary approach in management that recognizes the interconnected nature of social and ecological systems. Principally, this should include the identification and involvement of local stakeholders in initiatives from the onset. (3) The need for adaptive governance, particularly with respect to environmental management, which is required to enact stakeholder goals that are co-produced and reflect stakeholder equity. (4) The need for consistent social and ecological monitoring to assess the success of transdisciplinary projects. (5) The need for education and training regarding how SES thinking and investigations can positively influence institutional norms for environmental stewardship.

Similarly, a meta-analysis of 42 SES case studies, conducted across 25 countries, identified a number of important practical and crosscutting features of successful place-based research (Balvanera et al, 2017b). (1) The study established that it is key to consider the local and regional context, including the social and political setting before formulating
placed-based projects goals. (2) It is necessary for consultative methods to understand and address local levels of social organization, before identifying pertinent stakeholders. (3) To ensure successful capture of stakeholder perspectives, the participatory processes should be engaging, and researchers should have some level of epistemological agility (the ability to work across multiple knowledge domains). (4) It is important to consider stakeholders at multiple stages of SES research, including preparatory consultations to the co-design of research and co-implementation of practices and policies. Equally, successful stakeholder involvement should include consideration for stakeholder power relations and the ability to compare and contrast differing stakeholder perspectives.

Stakeholder consultation is critical to SES research and action because it encompasses different types and sources of knowledge used in the coproduction process (Jasanoff, 2004). For the successful integration of knowledge types, Raymond et al (2010) suggests that it is important to consider the ontological challenges regarding knowledge categorization, the philosophical or epistemological biases regarding knowledge types held by those conducting the research, and how different knowledge types should be applied to environmental management solutions. This type of science works to erode the boundaries between forms of knowledge, rationality and social and ecological systems (Raymond et al, 2010). In practice, Raymond et al (2010) describes the “need to integrate knowledge held by academic researchers (often across traditional academic disciplinary boundaries) and non-academic participants, such as land managers and the public” for
successful environmental management. Academic researchers, non-academic experts (such as land and natural resource managers) and the public are likely to hold different knowledge types, but the development of common theory, methods and new knowledge can promote shared understanding of environmental management problems and solutions (Raymond et al, 2010).

In place-based SES research, it is important to consider the role of each stakeholder, including academic experts, non-academic experts and the public, and the interactions among these. For instance, it is non-academic experts who are typically tasked with local landscape management, although their chosen management practices may rely on shared knowledge derived from academic experts (Pleninger et al, 2013). The quality of discourse and knowledge sharing between academic and non-academic experts is important to ensure that the best available science is being applied and implemented in management. However, in practice the discourse can be difficult, often due to incompatible epistemologies, which may result in a lack of practical resolutions and compromise (Finewood et al, 2010). Additionally, there is often a disconnect between the scales at which academic research is conducted versus the scales at which management policies and decisions must be implemented. Typically, academic research addresses questions over small spatial and short temporal scales and therefore knowledge outcomes may only be weakly applicable to problems at larger scales that non-academic experts must address (e.g., Fausch et al, 2002). Similarly, before SES
consultation, publics were often not directly involved in environmental management decisions, but were critical to their long-term success or failure (Alberts, 2007). It has long been established that experts and the public contribute very different but equally valid perspectives to decision-making (Beierle et al, 1999). Castro et al (2011) suggests that varying perspectives between experts and the public exist due to different interests and goals, across different temporal and spatial scales, arising from differing knowledge types and values. Consequently, a disconnect between experts and the public may occur which could limit the success of place-based socio-ecological management.

Place-based SES research, which investigates academic and non-academic expert and public perceptions of environmental topics at local (city and rural township) levels, can be the foundation for environmental action. By analyzing matches (cases in which expert and public perceptions are similar) and mismatches (instances when expert and public perception are different), it may be possible to identify opportunities for socially equitable positive environmental action. Matches represent opportunities for experts and the public to participate in projects of shared interest. Identifying mismatches, supported by an understanding as to why different societal actors hold differing perceptions, may represent an opportunity to start valuable and informed discourse to mitigate environmental trade-offs and avoid conflicts.

In this study, we applied the above SES concepts to a case study in southeastern Idaho, USA. The US state of Idaho is a contemporary example of where rapid land-use
change is altering ESS and their capacity to support human wellbeing (Narducci et al, 2019). Predominantly driven by amenity related migration, many resource-dependent rural settlements are experiencing fast population growth of people seeking low-cost homes in areas rich in natural amenities (Narducci et al, 2019). A report by the US Census Bureau found that Idaho experienced the second largest percentage population growth of all US states between 2017 and 2018, amounting to a 2.1% population increase of 35,305 people (United States Census Bureau, 2018). Such an influx of people is causing rapid land-use change, intensification of anthropogenic activities and direct modification of previously heterogeneous landscapes (Smutny, 2002).

In this case study of a semi-arid watershed in southeastern Idaho, we used social assessment of ESS to investigate and compare expert and public perceptions and seek lessons for environmental planning. We hypothesized that expert and public perceptions of ESS would differ. In particular, we anticipated that recognition of ESS, perceived ecosystem service (ES) importance, perceived changes to ESS over the last ten years and perceived impact on ESS under hypothetical future land-use scenario would all differ between the public and experts. Additionally, we hypothesized that an imperfect discourse exists between academic and non-academic experts, resulting in the optimal environmental practices not being adopted.

The overarching goal of this study is to apply a novel technique to explore expert and public perceptions of ESS, both currently and under future land-use scenarios, and
seek lessons for environmental planning. With this aim, we used a local watershed in southeastern Idaho that is projected to undergo significant land use change in the near future (Felt et al, 2018; Huang et al, 2019; Jones et al, 2019, Narducci et al, 2019). Specifically, targeting both experts and the public, we first used a survey technique to explore the diversity of benefits provided by the ecosystem within the watershed. Second, a ranking technique was used to capture the perceived importance and vulnerability of ESS. Third, we explored the perceived impact of land-use change on ESS. Fourth, using the results from the above investigations and an analysis of the scientific versus management expert discourse, we identified and characterized matches and mismatches in perceptions, and evaluated their potential implications for landscape planning. Finally, we consider the possible implications of our novel approach for place-based SES research, in general.
2. Methodology

2.1 Study Area: the Portneuf River watershed

The Portneuf River watershed, located in southeastern Idaho, drains an area of approximately 3,440 km² (Figure 2). Sixty three percent of the watershed is located within Bannock County, 33% in Caribou County, 2.5 % in Bingham County, with the remainder (1.5%) split between Power, Oneida and Franklin Counties (Natural Resource Conservation Service Idaho, 2007). The climate is semi-arid, with hot and dry summers and moderately long winters. Rangeland is the dominant land-use, covering 55.6% of the total watershed, with the remainder being comprised of cropland (22.3%), forest (17%), and urban development (4.2%). Elevation within the watershed, which is a locally important determinate of habitat distribution, ranges from 1255 to 3843 meters above sea level.

The Portneuf River, which is a tributary of the Snake River, provides a crucial irrigation source for local agriculture, but subsequently experiences an approximate 70% reduction in base flow during the summer months (Marcarelli et al. 2010). However, it should be noted that irrigation impacts in the watershed are typical of most watersheds in the western United States of a similar size. Responses to flooding of the river during the mid-twentieth century resulted in the creation of concrete levees and channels, which have been cited as reducing river–community connections that are increasingly desired by local residents (Portneuf River Vision Study, 2015; Quintas-Soriano et al, 2018). The
Portneuf River experiences reductions in water quality, in particular elevated levels of NO$_3$-N and PO$_4$-P, resulting from agriculture, industrial pollution and animal grazing (Idaho Department of Environmental Quality, 2010; Hopkins et al, 2011; Bechtold et al, 2012). Local political support for restoring the Portneuf River is tenuous; with agricultural and ranching interests concerned that restoration would impact their livelihoods (Lybecker et al, 2016). Furthermore, some local residents are apprehensive of river restoration activity because they fear it would involve the removal of flood control levees and channelization, leaving the community vulnerable to flooding (Lybecker et al, 2016).

The most populous settlement in the area is Pocatello, which is home to approximately 79,000 residents. Within this city, 90.5% of the population is white, 1.0% is African-American, 1.7% is Native American, 1.6% is Asian, 0.2% is Pacific Islander, 2.3% belong to other races, and 2.8% is report belonging to two or more races (US Census, 2010). The City of Pocatello reports that the median household income per year is $47,132, 14% of the population has a high school degree, 28.3% has some college education, and 36.5% has a college degree. Multiple recreational opportunities exist throughout Pocatello and the wider Portneuf River watershed, including numerous trails and campgrounds maintained by the Bureau of Land Management (BLM) and the United States Forest Service (USFS) and skiing areas in the winter.

It is foreseeable that the Portneuf River watershed will experience rapid land-use change, predominantly urban development, in the near future (Felt et al, 2018).
Neighboring metropolitan areas within Idaho, namely the region in and around Boise, are amongst some of the fastest growing cities in America, experiencing a 120% population increase between 1990 and 2015 (U.S. Census Bureau QuickFacts). In the past year, the likelihood of increased urban development in the Portneuf River watershed is supported by the emergence of numerous development projects in the area, including the “Northgate project” that includes plans for thousands of new homes and a shopping district (Evensen, 2019) as well as the “West Bench” housing development that hopes to add hundreds of new homes (O’Connell, 2019). Such land-use change threatens to be a source of conflict among differing groups of interest, challenging ideas of local identity and cultural heritage, and straining the provisioning and supporting services that make the area such a desirable place to live.

2.2 Methodology for addressing social assessment of expert and public values and associated study goals and hypotheses

A wealth of scientific literature supports the need to integrate knowledge held by academic and non-academic experts, and the public, to improve environmental planning (Raymond et al, 2010: O’Brien et al, 2013: Virapongse et al, 2016: Balvanera et al, 2017b:). To identify these key stakeholders, we recognized that the study location encompasses the main campus of Idaho State University, an institution active in local and regional environmental research. Additionally, we considered the social organization in the Portneuf Watershed as it pertains to environmental management. We recognized that
management is highly departmentalized, with eight key agencies identifiable, including federal (U.S Forest Service, U.S Bureau of Land Management, Portneuf Soil and Water Conservation District – U.S Department of Agriculture) state (Department of Environmental Quality, Idaho Department of Fish and Game, Idaho Department of Transportation, Idaho Department of Water Resources), and local (City of Pocatello). Additionally, the Portneuf River has its headwaters and confluence with the Snake River on a Native American Reservation (Fort Hall Indian Reservation). On the reservation, management of natural landscape and resources is independent of the agencies. However, in recent years, increasing collaboration and coordination has been occurring between the above agencies and Tribal leadership (Yupe, 2020).

To investigate stakeholder knowledge types and values, we used social assessment of ESS. Martín-López et al (2014) states that the use of different ESS assessment methods will, in part, shape and define the values that can be described by each technique. Consequently, it is crucial to adopt the ESS assessment method most appropriate to the type of research being conducted and understand the limitations of the selected method. Here, we outline the rationale behind why we adopted social assessment as best suited to this study.

Castro et al (2013) describes the three distinct components of ESS assessment as biophysical, economic and social. (1) The biophysical dimension describes the mapping
and modeling of ESS and their associated functional groups of provisioning, regulating and cultural (Millennium Ecosystem Assessment, 2005). This approach is useful for developing an understanding of stocks, demands and flows of ES (Burkhard et al, 2013).

(2) The economic dimension describes market preference, revealed preference, stated preference, deliberative monetary valuation, and economic value analysis of ESS. This approach is used to assign monetary value to goods and services within the context of the anthropocentric market system, but has been criticized for failing to capture benefits that fall outside of the market, known as negative externalities (Owen, 2004).

(3) Social assessment, which often includes stakeholder identification and consultative methods, uses noneconomic methods to analyze human perceptions regarding valuation of ESS. Past research has identified the ability of social assessment, in particular the use of questionnaires, to investigate public perceptions of ESS (eg., Cornell et al, 2019; Hartel et al, 2014; Martín-López et al, 2012). Additionally, social assessment is preferred in areas of land-use change, where the importance of capturing non-economic values is great (Abram et al, 2014). As social assessment most readily pertains to collaborative environmental planning, has demonstrated capacity for representing local perceptions of ESS, and is appropriate in areas of land-use change, we chose to adopt a questionnaire-based methodology.

We used face-to-face questionnaires to measure respondent perceptions of ESS and recognition of the benefits obtained from ecosystem processes, principally as they
pertain to maintaining and improving human well-being. Based on previous research conducted in the region (Cornell et al. 2019; Quintas-Soriano et al. 2020), we identified eleven key ESS, of which three were categorized as provisioning services, five were categorized as regulating services and three were categorized cultural services (Appendix 1). Through our social evaluation of ESS we investigated perceived (1) ES contributions to human wellbeing (2) ES recognition, (3) ES importance, (4) ES change over the last ten years and (5) impact on ES under four hypothetical land-use change scenarios. We also aimed to (1) seek local lessons for environmental planning using integrated knowledge types and (2) contribute to the conception of a network of transdisciplinary research, an important sub-goal of SES research and (3) contribute to the PECS goal of a focused and in-depth understanding of SES and opportunities to foster sustainable stewardship using comparative, place-based research.

In this study, we broadly hypothesized that expert and public perceptions of ESS would differ due to opposing interests and goals, across different temporal and spatial scales, arising from differing knowledge types and values (Castro et al, 2011).

2.3 Designing a questionnaire to suit expert and public knowledge types

Key to the success of SES research and in particular, stakeholder engagement is the ability for researchers to work across multiple knowledge domains (Balvanera et al,
Considering this, we designed a dual-questionnaire to meet the differing knowledge types that might be held by the expert and public groups.

Due to the likelihood of experts possessing a higher level of knowledge when compared to the public, it was necessary to design the social assessment tool for the intended audience. Appropriate question difficulty was important to ensure that respondents remained engaged with the survey, were able to understand the questions and accurately report their perceptions. However, it was important that the dual-questionnaire allowed for a comparison between the two groups. To ensure comparisons could be drawn between the public and expert groups, key questions regarding ES importance ranking, ES change, and impacts on ES under land-use change scenarios, were kept the same in both surveys. However, in the expert group, additional complex questions were posed, designed to provoke critical thinking and elicit higher-level responses, providing deeper insight into their perceptions of ESS. Finally, we investigated the discourse and limitations to successful knowledge sharing between the two types of expert (academic experts and non-academic experts).

2.3.1 Questionnaire design: Use of resource panels for photo elicitation

We utilized two resource panels during the face-to-face surveys. The first resource panel (ES resource panel) provided images and descriptions of locally important ESS (Appendix 1). The second resource panel (land-use resource panel) provided images and
descriptions of prominent local land-uses (Appendix 2). Resource panels were used to encourage ‘photo elicitation’ (Collier, 1967). The concept of ‘photo elicitation’, which describes the use of photographs and props as visual aids during interviews, suggests that images are more effective at evoking insights from experiences than written or spoken language (Harper 2002; Carlsson 2001). Additionally, the resource panels aided individuals translate complex socio-ecological processes into more easily understood benefits for humans. This is important to remove jargon and reduce question complexity for individuals who may be unfamiliar with the ESS concept.

2.4 Sampling Strategy

In the Portneuf watershed, individuals were sampled from the respective public and expert populations. The public sampling frame was limited to a convenience sample of individuals over 18 years old and the expert sampling frame was restricted to individuals working as applicable academics or natural resource managers. In total, 471 individual face-to-face surveys were conducted with the public and 28 detailed interviews were conducted with experts.

2.4.1 Public sampling strategy and questionnaire design

In summer 2016, we recruited a convenience sample of people from within the Portneuf River watershed. Conducting 471 individual face-to-face surveys at 14 sites throughout the watershed (Figure 2), we asked respondents about their perceptions of
ES provided by the study-area. We surveyed in a variety of locations, including urban settings, recreational settings, a university campus, and outside shopping areas. Each survey typically took between 15-20 minutes to complete. No contact was made with any of the respondents prior to the survey. Every respondent was informed that participation was voluntary, anonymous, for academic purposes, and that responses were subjective without correct or incorrect answers.

The suitability of the public questionnaire design was tested by conducting a preliminary survey within the watershed and subsequently the wording was revised. This was critical in ensuring that respondents were able to comprehend the specific questions and that scientific terminology and jargon was not affecting respondent understanding (Quintas-Soriano et al, 2014). Furthermore, in some questions, maps, panels, and photographs were used in relation to ES definitions and land-use definitions to improve respondent comprehension (Appendix 1 and 2). Additionally, at the beginning of each public survey, the ES concept was simplistically introduced as ‘the benefits or contributions that the ecosystems of the area provide to people and maintain human well-being’. This ensured that the terminology was understood by each respondent and was intended to mitigate the impact of educational biases (Martín-López et al. 2012).

To broadly characterize perceptions of ESS, we began by asking each respondent if they thought ecosystems in the Portneuf River watershed provide benefits
contributions to people in the region. Then, we followed up with a free-listing question, asking respondents to name all the possible benefits they could think of that the ecosystems in the study area provide. The free-listing technique was adopted because it provides unprompted, direct consultative responses that are not influenced by the listed options given, thus eliminating framing effects (Martín-López et al. 2012). Resulting qualitative data were then coded into ESS and associated ES categories of provisioning, regulating, and cultural services. Ambiguous or non-ES responses, such as “for nature” “for work” and “for money”, were subsequently removed from the analyses.

We then used an ES ranking technique to investigate which ES the respondents perceived as most important to maintaining and improving the wellbeing and quality of life for people in the Portneuf River watershed. To avoid survey fatigue, each respondent was only asked to rank the four ES they perceived as most important. Then, to explore perceived changes in ES delivery, we asked each respondent to report whether they thought the ES has decreased, remained the same or increased in the last ten years. To limit survey fatigue, we only asked respondents to report change across the four categories they perceived as most important.

Next, we asked respondents to consider hypothetical land-use scenarios. In four separate scenarios, we asked respondents to consider the impacts of increased urban development, agricultural expansion, rangeland expansion and natural forest expansion. Specifically, we asked respondents to select two ES from the panel that would be
positively affected and two that would be negatively affected. For each ES cited, we then asked respondents to provide a severity score between 1 and 10, where 1 was a minor effect and 10 was major effect. Next, we collected a range of variables related to environmental behavior and socio-demographic (e.g., age, gender, and ethnicity). Finally, the questionnaire concluded with case-based follow-up questions, enabling the interviewer to gauge and record their perception of respondent understanding and interest (Castro et al., 2015).

2.4.2 Expert sampling strategy and questionnaire design

In the fall of 2019, we recruited an opportunity sample of experts from within the Portneuf River watershed. First, we defined experts as individuals who were (1) academics scientists who conducted biological, environmental or socio-ecological research within the watershed, or (2) non-academic experts, including natural resources managers and agency staff whose work pertains to the management of the ecosystems, landscapes or human-environment interactions within the Portneuf River watershed. Additionally, individuals who previously contributed to the ‘Managing Idaho’s Landscapes for Ecosystem Services’ (MILES) project, a National Science Foundation-funded initiative aimed at building capacity to link social and ecological science, were identified as key experts to include within the study. All previous MILES participants had been involved in research projects associated to their mission statement, which refers to the study of “the relationship between humans and their natural environment, in particular
the use of ecosystem services provided by nature” (MILES, 2019). We expected MILES participants were highly likely to hold an array of relevant expertise and be familiar with the required scientific language and jargon within both the field of ecosystem services and SES science. MILES participants were present in both the academic and management subsets.

To recruit the expert sample, 45 experts were contacted by email, given details about the study and asked if they wished to participate. Of the 45 experts contacted, 28 responded and were successfully interviewed, a success rate of 62.2%. The sample was comprised of 14 academics from Idaho State University (located within the watershed) and 14 natural resource managers whose work pertains to the Portneuf River watershed. Of the 14 academics, nine were from the Department of Biological Sciences, two were from the Department of Sociology, two were from the Department of Geosciences and one was a research administrator. Of the 14 natural resource managers, four were from federal agencies (U.S Forest Service, U.S Bureau of Land Management, Portneuf Soil and Water Conservation District – U.S Department of Agriculture) seven were from state agencies (from the Department of Environmental Quality, Idaho Department of Fish and Game, Idaho Department of Transportation, Idaho Department of Water Resources), and three from a local township agency (City of Pocatello).

Each survey took between 30-80 minutes to complete and every respondent was informed that participation was voluntary, anonymous and for academic purposes. It
was reinforced that there were no right or wrong answers and this was a survey of their perceptions as an expert. Due to the complex nature of some of the questions, I often facilitated an elicitation discussion with the expert. Such elicitation discussions provided an array of information that was not always recorded within the survey. However, many of the discussions provided key foundational information regarding key issues, concerns, and lessons for environmental management in the Portneuf Watershed.

2.4.3 Comparing academic and non-academic expert perceptions

Included in the expert questionnaire, but not the public questionnaire, were several additional questions designed to elicit higher-level knowledge. Specifically, we asked experts to report why they thought changes were occurring in ES delivery. Additionally, to investigate the communication of best management practices between academic and non-academic experts, we asked experts to report their perceptions of ‘scientific certainty’ and ‘management’. In this study, ‘scientific certainty’ is described as expert perceptions of scientific consensus relating to how well something is known within the scientific community. Specifically, the capacity of the land-use type within the watershed and its contained ecosystem processes to deliver an ES. Expert perceptions of ‘management’ described the extent to which best management practices, arising from the aforementioned scientific certainty, are currently being applied to environmental management in the Portneuf watershed. Finally, we asked experts to briefly describe if they thought an ES based approach to management would benefit the people and
ecosystems of the Portneuf River watershed. These discussions were crucial to ensure that each expert understood the question in the manner we had intended.

2.5 Data analyses

Individual questionnaire responses from both experts and the public were coded into Microsoft Excel. During this process, quantitative and categorical responses remained unchanged. Free-listed, qualitative responses regarding perceived contributions to human wellbeing were categorized into one of the eleven ESS (Appendix 1). For instance, “bike riding” was categorized as Recreation and “for good air” was categorized as Air Quality. Ambiguous responses (e.g., “feelings,” “money”) that could not be categorized into any ES were excluded from the analyses.

For analysis regarding ES recognition, ES importance and ES change over the last ten years, ESS were assessed both individually and as ESS categorizes of provisioning, regulating and cultural services. ESS were categorized into provisioning, regulating, and cultural services following the international ES classification of the Common International Classification of Ecosystem Services guidance (CICES; www.cices.eu) (Haines-Young and Postchin 2013).

To investigate expert and public perceptions of ESS, we first used a multiple-choice question. The question, ‘Do you think ecosystem services in the Portneuf Watershed provide contributions to human wellbeing in the region?’ had four fixed responses. This
question was designed to elicit a basic background understand of perceptions towards the underpinning value of ES. To further explore perceptions of ESS contributions, we used a free-listing technique, whereby respondents were asked to list as many ES provided by the watershed as possible. No time limit was applied for this question. For ease of interpretation and analysis, all free-listed responses were categorized into ES categorizes.

To investigate expert and public perceptions regarding which ESS are most important to human wellbeing, we asked respondents to select the four ESS that they perceived as the most important and to rank them from most to least important. This question was supported by the use of an A3 resource panel, which detailed the 11 pre-selected ESS, including a description and associated image of each (Appendix 1).

To investigate expert and public perceptions of change to the delivery of ESS over the last ten years, we used a multiple-choice question to ask respondents if delivery had ‘Decreased’, ‘Remained the same’, ‘Increased’ or ‘Don’t Know’. However, to limit survey fatigue, we asked respondents to describe ES change for just the four ES they previously described as most important. During this period of the survey, respondents were able to access the additional ESS resource panel.

To investigate expert and public perceptions of the impact that four hypothetical land-use change scenarios would have on ESS, we asked respondents to choose two ESS
that would be positively impacted and two ESS that would be negatively by an increase in each respective land-use type. In addition to the selected ES, respondents were asked to describe the severity of the impact, using an ordinal score, with 10 representing a large impact and 1 representing a small impact. The four land-use types investigated were urban development, agricultural land, rangeland and natural forest. For this question, respondents were provided with the original ESS resource panel and a land-use panel that included a description and associated image of each land-use (Appendix 2). The results for each land-use scenario were visually assessed using four spider diagrams, where the shaded area denotes a negative impact and the clear area denotes a positive impact on the ESS.

To investigate the flow and application of knowledge between academic and non-academic experts surrounding how different land types produce ESS and how to best manage land-use types to maximize ESS provision, we asked experts to report their perceptions of ‘scientific certainty’ and ‘management’. ‘Scientific certainty’ described expert perceptions of how well something is known within the scientific community, in this instance, the capacity of a land-use type and its contained ecosystem processes to deliver an ES. Expert perceptions of ‘management’ described the extent to which best management practices, arising from the aforementioned scientific certainty, are currently being applied to environmental management in the Portneuf watershed. ‘Scientific certainty’ and ‘management’ were assessed across the four land-use types and ten ESS.
All data analyses were conducted in the statistical software package R studio. The Wilcoxon test, a nonparametric statistical test that compares two paired groups (Aho, 2013), was the primary statistical test used in this study. The test calculates the difference between each set of pairs and analyzes these differences. We adopted a graded method to define our certainty that results differed from what would be expected by chance alone. Understanding that p-values describe a ‘continuous measure of evidence’ and recognizing the conventions in biostatistics (Gerstman 2014), we considered p < 0.05 significant. We considered it appropriate to refer to results for which p values fell between 0.05 and 0.1 as marginally significant due to the limited sample size and associated limitations to the statistical power of our study (Gelman, 2013).
3. Results

3.1 Public and expert sample description

3.1.1 Public sample description

Overall, considering the socio-demographic variables, the sampling technique provided a sample similar to the known population in the Portneuf River watershed (Table 1). About 55% of our respondents identified as male and 45% as female. The reported ethnic background of respondents was 75% white, 11% Latino or Hispanic, 9% Black, African American, 3% Native American and 2% Asian American. Political orientation was 41% moderate, 30% conservative and 29% liberal. Almost 33% of the sample reported that they were active in community affairs and 71% of the sample reported that government decisions do affect the Portneuf. Overall, we found the respondent attitude to be overwhelmingly good (94%), with just 6% of the respondents reporting that they were not very interested. Equally, we found understanding of the questionnaire to be high (77%), with just 23% of respondents judged to have a medium understanding.

3.1.2 Expert sample description

The expert sample was evenly split between academic and non-academic experts, with 14 experts in both categories. However, when asked to self-report the ESS and land-use type for which they held the most expertise, there was an uneven
distribution of expertise (Figure 3, a). A large proportion of experts reported that their expertise was related to the ESS of ‘Water Quality’ and ‘Habitat for Species’, whilst no experts reported expertise in four of the other ESS, including ‘Air Quality’, ‘Alternative Energy’, ‘Cultural Heritage’ and ‘Food for Agriculture’. Similarly, far more experts reported expertise in the land-use of ‘Natural Forest’, when compared to the other three land-uses (Figure 3, b).

3.2 Perception of ecosystem services in the Portneuf Watershed

We hypothesised that the expert and public groups would hold differing perceptions of ESS contributions to human wellbeing. Consistent with this hypothesis, we found that when using a multiple-choice question, the expert group exhibited a significantly higher recognition of ES contributions compared to the public (P<0.05) (Figure 4). The overwhelming majority of experts (96%) reported that the watershed provides ‘very many’ contributions to human wellbeing, compared to just 49% in the public sample. Overall, the public reported a lower recognition of ES contributions, with the remainder of the public sample reporting ‘many’ (38%), ‘few’ (9.0%) and ‘very little to none’ (4%).

Similarly, when asked to free-list ESS, the expert group showed a significantly higher recognition of ES contributions compared to the public, across all three ESS categories (P = <0.05, for all categories) (Figure 5). Experts reported more than twice the
number of provisioning and cultural services and more than eleven times the number of regulating services, when compared to the public. Within just the expert group, there were not significant differences among the three ESS categories ($P = 0.648$), indicating that the experts exhibited consistent reporting of ESS among the provisioning, regulating and cultural categories. Conversely, we found the intra-group variability within the public group to be significant, indicating that they had inconsistent reporting across the three ESS groups, and were over five times less likely, on average, to cite regulating services compared to provisioning and cultural services ($P < 0.05$).

3.3 Ranking ecosystem service importance

We hypothesized that experts and the public would rank ESS by importance differently. However, contrary to this hypothesis, we found that the two groups generally held similar perceptions of ES importance (Figure 6). Notably, across all cultural and regulating services, none of the mean ranking scores differed by more than 0.15, and none of these differences were statistically significant. The provisioning service ‘Food from Agriculture’ was the only ES that differed significantly between two groups, with the expert group perceiving it as more important compared to the public ($P < 0.05$). Across the ES categorizes, we observed no differences between experts and the public with respect to perceived importance of regulating and cultural services. However, the experts assigned a significantly higher importance to provisioning services than the public ($P < 0.05$).
3.4 Perceived ecosystem service change in the last decade

We hypothesized that expert and public perceptions of ecosystem service change in the last decade would differ. Using a multiple-choice question, we asked respondents in both the public and expert groups about their perceptions of ES change over the last ten years; responses were limited to ‘decreased’, ‘remained the same’, ‘increased’ and ‘don’t know’. (Figure 7). Using the mean rank-score, we identified that in general the expert group was more positive compared to the public, perceiving an increase or lesser decrease in seven of the ten ESS. However, the only differences between the groups that were statistically significant were those associated with recreation, local identity, and water quality ($P = <0.05$). On average, members of the public were more positive compared to the experts regarding changes in water regulation, climate regulation and food from agriculture, but none of these differences were statistically significant ($P = >0.1$). Across the broader ES categories, we found that the experts perceived a significantly greater increase or lower decrease in both regulating and cultural services ($P = <0.05$), whilst there was no statistical difference between the groups regarding perceptions of changes in provisioning services ($P = >0.1$).

3.5 Social perception of ecosystem services under land-use change scenarios

In contradiction of our hypothesis (we expected expert and public perceptions would differ regarding the impacts of future land-use change on ESS), we found that
expert and public perceptions were generally similar across all four scenarios of future land-use (Figure 8). Specifically, we found that both groups expected urban development to have a predominantly negative impact on ESS, whereas any increase in agricultural land and rangeland to deliver trade-offs in ES delivery, and natural forest to have a predominantly positive impact on ESS. However, whilst the majority of expert and public perceptions matched, there were exceptions associated with specific land-use change scenarios, which we describe next.

Under the scenario of future urbanisation, the experts predominantly anticipated a more detrimental impact on ESS compared to the public. However, only three of the ten ESS (air quality, food from agriculture and local identity) differed significantly between the groups (Figure 8, a). Under the scenario of agricultural expansion, the experts reported a significantly greater positive impact on food from agriculture and local identity, compared to the public (Figure 8, b). Furthermore, the experts reported that agricultural expansion would have a significantly greater negative impact on freshwater provision and water quality, compared to the public. Under the scenario of rangeland expansion, we found that the public group reported a significantly greater positive impact on food from agriculture and habitat for species, compared to the experts. Finally, under the scenario of natural forest expansion, the two groups reported similar perceptions. However, we found that the public reported that natural forest would have a significantly greater positive impact on climate regulation, compared to the experts.
3.6 Expert perceptions of scientific certainty and management

In general, across the land-use types we found that experts perceived a higher level of ‘scientific certainty’ regarding knowledge of land-use impacts on ESS compared to the application of such knowledge to ‘management’. For two of the four land uses (agriculture and natural forest), ‘scientific certainty’ was significantly higher than ‘management’ (P<0.05) (Figure 9). For the urban land-use, we found that ‘scientific certainty’ was marginally significantly higher than ‘management’ (P<0.1) and that there was no significant difference in the rangeland land-use (P = 0.684).

When assessing ‘scientific certainty’ and ‘management’ of individual ESS, irrespective of land-use type, we found in general ‘scientific certainty’ to be higher than ‘management’ (Figure 10). ‘Scientific certainty’ was significantly higher than ‘management’ in four of five regulating services investigated (P < 0.05). Of the regulating services, we found just ‘Habitat for Species’ not to be statistically different (P = 0.127). Across the cultural services, we found the opposite trend, with experts reporting lower ‘scientific certainty’ than management for ‘Cultural Heritage’ and ‘Recreation’ and very similar scores for ‘Local Identity’. However, of the cultural services, we found just ‘Recreation’ to be significantly different. We found no significant difference across either of the two investigated provisioning services or the provisioning services group (P = 0.222).
3.7 Expert perceptions of the ecosystem service framework for management

Overall, using a freelisting technique, we found that experts perceived that an ESS approach to local management would be beneficial to the people and ecosystems of the Portneuf watershed. An overwhelming majority of experts reported ‘fairer holistic decision making’ and ‘limiting trade-offs’ in ESS delivery as the two major outcomes of incorporating ESS in local scale management. We found that of the 35-freelisted outcomes, the vast majority (33) described a positive impact of integrating ESS into management, with just two responses stating that an ES approach to management is ‘too anthropocentric’.
4. Discussion

In this study, we investigated expert and public perceptions of ESS in the Portneuf Watershed, Idaho, USA, seeking to provide insights for environmental planning. Our results indicated a nuanced relationship between expert and public perceptions, with the expert and public groups reporting remarkably similar perceptions in some instances but starkly different perceptions in others. We found that experts and the public had differing recognition of ESS and differing perceptions of ES contributions to human wellbeing. Conversely, our results indicated that expert and public perceptions of ES importance, ESS change over the last decade and the impact of four hypothetical land-use change scenarios on ESS, were unexpectedly similar. Furthermore, when investigating if experts perceived a different of ‘scientific certainty’ regarding knowledge of land-use impacts on ESS compared to the application of such knowledge to ‘management’, we identified that experts felt there were mismatches between the management and science when it came to the impacts of agricultural and natural forest land-uses on regulating ecosystem services.

As hypothesized, perceptions of ESS, investigated using the question ‘Do you think ecosystem services in the Portneuf River watershed provide contributions to human wellbeing in the region?’ varied between the expert and public groups. Likely the result of greater knowledge regarding ecosystem-human interlinkages, a higher percentage of experts reported ‘very many’ ES contributions (96%), compared to the public (49%). Numerous
studies have identified a link between public demographic variables, notably political and religious affiliations and level of education, and environmental attitudes (Mildenberger et al, 2017: McMillan et al, 1997). For instance, Cornell et al (2019) reported that within the Portneuf Watershed, political conservatives were less likely to report concern of climate change. We identified that in our public sample, 23% of individuals self-identified as having a conservative ideology, compared to just 4% of the expert group. Indeed, the population within the study region primarily registers as Republican and has some of the highest percentage of Republican voters in the nation (Lybecker et al, 2016). Conversely, 75% of the experts identified with a liberal ideology compared to the just 23% of the public sample. Similarly, Peterson et al (2008) reported that in the Teton Valley, individuals belonging to the Church of Jesus Christ of Latter-day Saints (LDS), commonly referred to as Mormons, exhibit less environmentally oriented worldviews than other groups. Although this was not explicitly investigated within our study, the LDS church has a large presence within the study area but is underrepresented in the expert group compared to the public. Both demographic factors of political and religious affiliations may be contributing to the disparity between the public and expert perceptions we observed regarding ES contributions. Despite this, 87% of the public sample reported that ESS contribute ‘very high’ or ‘high’ measures of benefit to human wellbeing. This promising foundational finding supports the notion that expert and public consultation may contribute to successful environmental planning.
As hypothesized, perceived ESS recognition, categorized into provisioning, regulating and cultural services, differed between the expert and public groups. Experts reported more than twice the number of provisioning and cultural services, when compared to the public. Experts also reported eleven times the number of regulating services than the public. It is likely that this can be largely explained by the aforementioned differences in knowledge types. Interestingly, the intra-group variability (the variability between reporting of provisioning, regulating and cultural services within the expert and public groups, respectively) was low within the expert group but was high within the public group. This suggests that the experts had consistent reporting of ESS among the provisioning, regulating and cultural groups, likely due to an expansive knowledge of ESS. Correspondingly, this finding suggests the public has an unequal distribution of knowledge regarding ESS types, and notably were over five times less likely to cite regulating services compared to provisioning and cultural services. This finding reflects not just public preferences towards ESS but ability to recognize ESS. Regulating services are often less visible to the public than provisioning and cultural services, thus reducing the likelihood of reporting (McInnes, 2013). For instance, a layperson is likely to encounter provisioning services, such as the need for freshwater, but is required to a lesser extent to consider the role of the environment in regulating the quality of the water. However, the contemporary literature regarding social preference towards ESS recognition suggests that local particularities are critical factors in
determining which ESS category (i.e., provisioning, regulating and cultural services) are most recognized. For instance, Agbenyega et al (2009) reported that in Eastern England provisioning services are more readily identified than regulating services. Yet, Martín-López et al (2012) stated that across eight Spanish watersheds, regulating services were the most recognized ESS group. The authors suggested this was due to a local particularity regarding the high levels of air pollution in Spanish cities, placing a greater importance on air quality regulation. In reality, ESS recognition is likely the outcome of a complex combination of local particularities, ESS visibility and demographic biases in perception and reporting.

Unlike our investigations of ESS recognition and perceptions of ESS contributions to human wellbeing, we used the ESS resource panel when investigating perceptions of ESS importance. The ESS resource panel, which provided images and descriptions of locally important ESS, was used to encourage ‘photo elicitation’ (Collier, 1967). The concept of ‘photo elicitation’, which describes the use of photographs and props as visual aids during interviews, suggests that images are more effective at evoking insights from experiences than written or spoken language (Carlsson, 2001: Harper 2002). When combined with the ESS framework, the ESS resource panel may lessen the knowledge disconnect between the experts and the public by visually displaying ecosystem processes that are relatable benefits to humans. Indeed, our results indicated that unlike ESS recognition and ESS contributions (which were not investigated with the aid of an
ESS resource panel), expert and public perceptions of ESS importance were very similar. Typically, without ‘photo elicitation’, expert perceptions of ESS are practical and management-centered, whereas public perceptions often prioritize the enjoyment of nature (Riechers et al, 2017). Previously, we identified that the public had much lower identification of regulating services compared to experts. However, following the introduction of the ESS resource panel, the public reported a marginally higher ESS importance score for four of the five regulating services than they had without these images. This suggests that within the public group, knowledge types, including a lower recognition of regulating services, is a barrier to accurate reporting of ESS perceptions. Our results suggest that the ESS framework combined with ‘photo elicitation’, may be a powerful tool to lessen the knowledge gap between experts and the public, and limit public underreporting of the importance of regulating services. As such, the use of the ESS resource panel, possibly explains why we found substantial similarities between the expert and public perceptions of ESS importance, unlike what we observed for ESS recognition and perceptions of ESS contributions.

The same ESS resource panel was used to investigate expert and public perceptions of change to ESS over the last decade (ESS change). We found that experts and public perceptions of ESS change were quite similar, with just perceptions of ‘recreation’, ‘local identity’ and ‘water quality’ differing between the groups. However, it was notable that for seven of the ten ESS, the experts perceived a marginally greater
increase or lesser decrease in each ESS, when compared to the public. One simple explanation for this may be due to local particularity within the Portneuf watershed; many experts, both academic and non-academic, are tasked with observing or collecting data that may support their cause for optimism (e.g., Hopkins et al, 2011, IDEQ 2020). This notion is supported by many unrecorded discussions with experts during interviews. During interview discussions, numerous experts reported that they frequently engage with local conservation activity. Most commonly associated with water quality restoration projects, including stream bank stabilization and stream fencing (to reduce cattle intrusion and association bank erosion), nearly all interviewed experts were aware of local efforts to maintain and improve ESS. Local restoration and conservation projects described by experts during the interviews were highly consistent with restoration activity described by the ‘Portneuf Watershed Partnership’ (Portneuf Watershed Partnership, 2020). Conversely, public skepticism towards ES change in the Portneuf watershed may arise from public knowledge types (i.e. local knowledge), typically obtained from observations of local surroundings and from legacies of past conditions. Legacies of past environmental conditions are important because they can persist beyond measured environmental improvements (Pendleton et al, 2001). In the Portneuf watershed, the phenomenon of a poor environmental legacy (Hopkins et al, 2011; Minshall et al, 1973), coupled with local observations of land-use change, particularly urbanization, may explain public perceptions of ES change.
To investigate expert and public perceptions regarding the impacts of land-use change on ESS, we used four hypothetical land-use change scenarios. To support questioning about each land-use scenario, we again used the ‘photo elicitation’ technique, combining the ES resource panel with a land-use scenario resource panel. In nearly three-quarters of the ESS investigated across all four land-use change scenarios, expert and public perceptions were similar. In general, we found that both groups expected urban development to have a predominantly negative impact on ESS, agricultural land and rangeland to deliver trade-offs in ES delivery and natural forest to have a predominantly positive impact on ESS. Notably, under the scenario of future urban development, expert and public perceptions differed in just three of the ten ESS that were assessed (‘Air Quality’, ‘Food from Agriculture’ and ‘Local Identity’). Within a management context, this is important, as urban sprawl, and associated losses and modifications of ESS are identifiable as one of the key threats facing both the Portneuf watershed and the wider western US (Lawler et al, 2014).

When assessing the discourse between the two types of expert (academic and non-academic), we found mismatches between ‘scientific certainty’ and ‘management’ regarding two of the four land-uses (agricultural land and natural forest) and a weaker mismatch when it came to the urban development land-use. This finding suggests that across these land-uses, experts apparently feel that the best available science may not inform local management practices. During interviews with both academic and non-
academic experts, it was commonly discussed that agricultural policies, standards, and market conditions, were the primary cause for such mismatches in agricultural land-uses, both in the Portneuf watershed and more generally in the western US. In the US, agriculture represents the largest non-point source of water pollution (Ribaudo et al, 2007), contributes to biodiversity loss (Mattison et al, 2005), and is a primary cause of species endangerment (Kerr et al, 2004). Environmental regulation for agriculture remains weak in the US, with no controls for non-point source pollution from agriculture present in the Clean Water Act (Stuart et al, 2013). During interviews, experts described that in the Portneuf watershed agriculture is closely aligned with cultural values and identity and attempts to stringently manage agriculture for environmental reasons would likely be met with local opposition. This sentiment was stronger amongst non-academic experts, who are more commonly tasked with management. Indeed, some non-academic experts reported minor grievances with academic experts, citing their inability comprehend issues and challenges beyond their fields of study, despite the interconnected nature of such challenges. Regarding natural forests, many experts perceived issues with management due to the high number of agencies that contribute to forest management. Whilst having many agencies contribute to forest management may have some benefits, such as increasing the funding size and workforce, many experts reported concern that this may have led to in-efficiencies in communication and management direction between agencies, diluting the potential success of each agency.
Specifically, experts reported that in the Portneuf watershed, natural forests represent an area of conflict between recreation and private property, where many landowners are trying to restrict access to cycling and walking trials through or beyond their properties.

Similarly, when investigating expert ‘scientific certainty’ and ‘management’ of individual ESS, irrespective of land-use type, we found mismatches across regulating and cultural ESS categorizes. Notably, these mismatches were opposite in direction for regulating versus cultural ESS categorizes. Experts expressed that ‘scientific certainty’ regarding the impacts land uses on regulating services was high compared to the degree to which this is reflected in management, whereas they perceived the reverse for the cultural service category. During interviews, many experts described their unease when discussing cultural services in the Portneuf watershed, a sentiment that was stronger among academic experts. Indeed, many experts were comfortable when using terms relating to regulating and provisioning services but would wish to discuss the meaning and full definition of cultural services, particularly regarding local identity and cultural heritage. This uncertainty was reflected in expert reporting; experts reported low ‘scientific certainty’ relating to cultural services when compared with regulating or provisioning services. This finding supports the notion that in the Portneuf watershed, academic research less frequently considers cultural services compared to regulating and provision services, despite ‘scientific certainty’ being low in this area.
The above findings highlight that whilst the relationship is nuanced, expert and public perceptions of ESS are, in general, quite similar. Additionally, our findings suggest that many of the locally specific and context-dependent challenges, including opposing expert and public political ideologies and knowledge types, and legacies of environmental degradation in the Portneuf watershed, can be overcome. In support of this notion, there is a promising precedent for collaborative stakeholder SES action in the Portneuf watershed. A prominent example is the ‘Portneuf River Vision Study’, which is “designed to assist the City of Pocatello and its residents by integrating existing policies, plans, and innovative ideas into a single plan; outlining goals and recommendations for improved River corridor management; and identifying opportunities for environmental improvement and restoration”. Our findings identify key matches and mismatches between expert and public perceptions of ESS, which could be integrated in current projects, such as the ‘Portneuf River Vision Study’ or similar future endeavors. However, to maximize the utility of this study when seeking lessons for local environmental planning, matches and mismatches regarding expert and public perceptions of ESS in the Portneuf watershed must be translated into a clear narrative.

“A narrative is a way of presenting or understanding a situation or a series of events that reflects and promotes a particular point of view or set of values” (Merriam-Webster). Narratives play an important role in communication (Crow et al, 2014; Jones, 2014) and are critical to consider because they no do not elicit rational reactions, but rather emotional, linking
issues to what people see as their beliefs, values, and identity (McBeth et al, 2016). The key challenge within narrative creation is to recognize that humans are inherently emotional beings, and as such, there is a need to translate complex science-based evidence into understandable values, across political ideologies and knowledge types (Dahlstrom, 2004). Indeed, narratives are particularly important when people encounter topics of complexity (such as ESS and environmental management), because they are more dependent upon their trusted groups to interpret the world around them (Kahan et al, 2006). Within the context of our study, which involves experts and the public, narratives are key when avoiding traditional logical-scientific communication, which has been found to be less engaging and harder to comprehend for non-expert audiences (Bruner, 1986; Green, 2006; Dahlstrom, 2004).

Central to the contemporary literature on narrative construction is the work of Dalton (See Dalton, 2008 and Dalton, 2016). Dalton suggests that there are two types of citizen; (1) the duty-based citizen, who is focused on norms that reflect formal obligations including fiscal responsibilities and (2) the engaged citizen, who could be considered a globalist, partaking in volunteer and social activities, with a diverse set of values. Using Dalton’s understanding of the two types of citizen, both Lybecker et al (2013) and McBeth et al (2014) demonstrated that a duty-based citizenship narrative was effective in producing support for an environmental cause (recycling), regardless of political ideology. Conversely, an engaged citizen narrative produced division along boundaries.
of political ideologies, lowering conservative support and increasing liberal support for pro-environmental action. In the Portneuf watershed, we have identified a large political divide between experts and the public, with experts being far more liberal and the public far more conservative. As such, to limit political polarization, avoid traditional logical-scientific communication and engage non-expert audiences, we here propose a duty-based narrative of the findings of this study.

Below is a duty-based narrative, constructed from the findings of this study:

The Portneuf valley has faced, and continues to face, a large amount of land-use change, through developments, such as new residential housing. Such activities can negatively impact local water quality, particularly in the Portneuf River. These impacts limit the benefits our community can receive from the river and the wider environment. Our study has shown that the vast majority of the public perceive these threatened environments as valuable. Our local environment is important for many reasons, including providing habitat for native species, maintaining water resources, and sustaining agriculture.

When we as a community engage in projects like the Portneuf River Visioning Study, we exercise individual responsibly. By supporting these projects, we help protect our local environment, the local economy, and the long-term character and value of Idaho. Some people may be apprehensive to participate in community projects that involve both local people and experts. They may think that local people and experts will not have the same motivations, values, and goals.
However, our study has revealed that in the Portneuf valley, experts and public actually have very similar perceptions of what is important for our community. Idahoans have a strong sense of identity linked to place, and the Portneuf valley is a place to care for and be proud of. Coming together as a community to promote shared public and expert projects will help us ensure that we are protecting our land and our people. Without these projects, Idaho may lose the precious resources that make it so special.

Writing about communication between stakeholders and the public in the Portneuf watershed, McBeth et al (2016) described a key challenge in today’s environment as the need “to recognize that many people have different interests, and, particularly given today’s plethora of information, it is only a carefully crafted message that draws the attention and/or support of a variety of individuals”. The above duty-based narrative is an attempt at a “carefully crafted message”, supporting communication with an array of stakeholders in the Portneuf watershed, endeavoring to increase participation in local SES projects.

In addition to narrative creation and seeking positive local outcomes, it is important to contextualize the findings of this study within the PECS aim; to combine place-based SES research to generate scientific and policy-relevant knowledge of social ecological dynamics (Programme on Ecosystem Change and Society, 2020). To achieve this, it is necessary to consider the local particularities and complexities of the Portneuf watershed, and evaluate commonalities with other areas (particularly in the western US)
facing similar sustainability challenges (Balvanera et al, 2017, b). Subsequently, the scalability of our findings is proportional to the variability in social context and extent and severity of threats posed by sustainability challenges among locations.

Simplistically, many of the sustainability challenges faced by Portneuf watershed, including land-use change (Narducci et al, 2019) and issues of water quantity and quality (DEQ, 2020), are to be found throughout the western US (Sabo et al, 2010; Kueppers et al, 2008). However, sustainability challenges are complex and variable in extent and severity across locations. For instance, spatial and temporal patterns of urbanization in small and mid-sized cities in Idaho are correlated with proximity to large cities, with higher rates of urbanisation proximate to large cities (Felt et al, 2018). Therefore, the findings of our case study may be more applicable to locations that are also moderately distant to large cities, perhaps within 200 to 400 miles. Yet, the impacts of urbanization on ESS are difficult to predict. Landscape fragmentation associated with urbanization is not linear and may occur in accordance with the growth phases hypothesis of spatiotemporal urbanization (Dietzel et al, 2005). Correspondingly, fragmentation may reduce patch size and ecosystem biodiversity, complexity and connectivity, but actually connect areas of ES supply and demand (Fischer et al, 2007). The result is that urbanisation and associated landscape fragmentation can lead to trade-offs among ESS demand and supply (Mitchell et al, 2015).
Similarly, variability in social contexts and conditions should be considered when assessing the generality of SES research findings. Social concerns regarding water quality and quantity in the Portneuf watershed are multifaceted and may only be partially representative of the wider western US. For instance, in both the Portneuf watershed (Lybecker et al, 2016) and the western US (Gosnell et al, 2007; Buijs, 2009), stakeholders vested in agriculture and ranching are concerned that river habitat restoration may affect their livelihoods. However, social context in the Portneuf watershed may differ from the western US due to historical flooding in Pocatello (Portneuf River Visioning Study, 2020). Subsequently, many property owners near the Portneuf River are apprehensive of river restoration activity because they fear it would remove flood controls and leave the community vulnerable to flooding (McBeth et al, 2016). Similarly, historical degradation of the Portneuf River may have reduced river–community connections (Portneuf River Vision Study, 2015; Quintas-Soriano et al, 2018), potentially decreasing public recognition of ESS, thus reducing the engagement of local people with social-ecological projects relating to the Portneuf River. Additionally, unlike many small to medium sized watersheds in the western US, the Portneuf watershed encompasses a mid-sized University (Idaho State University), which is active in research pertinent to local and regional ecosystem management. Consequently, the proportion of academic to non-academic experts in the Portneuf Watershed is likely to be quite different to other similar watersheds that are without a university. In turn, this may influence the dynamics of
academic to non-academic expert interactions. For instance, in the Portneuf Watershed, many academic and non-academic experts reported they participated in collaborative projects between agencies and university researchers, often describing this as an important element of much of the local conservation and restoration activity.
5. Study Limitations and Future Directions

5.1 Study limitations

This study was limited by the lack of inclusion of the Shoshone-Bannock tribe and the traditional ecological knowledge that they hold. The Portneuf watershed begins and ends on the indigenous land of the Shoshone-Bannock tribe. The Shoshone-Bannock Tribes are a federally recognized sovereign nation located on the Fort Hall Reservation in Southeastern Idaho, between the cities of Pocatello, American Falls, and Blackfoot. The Reservation is separated into five districts: Fort Hall, Lincoln Creek, Ross Fork, Gibson, and Bannock Creek. Currently, 97% of the Reservation lands are owned by the Tribes and individual Indian ownership (Shoshone-Bannock Tribes, 2020). The total population of the Fort Hall Reservation was 5,762 at the 2000 census, however it is believed that the population has declined since. The Shoshone-Bannock Tribes has more than 5,300 enrolled members, and more than half reside on the Fort Hall Reservation.

The Indigenous populations in the United States continue to be disproportionately impacted by climate change in comparison to nonindigenous populations. Furthermore, they are often excluded in conversation surrounding environmental management and preservation, often negatively impacting their traditional homestead. As a result, many American Indian and Alaska Native tribes are identifying and implementing culturally appropriate strategies to assess climate impacts and adapt to projected changes.
Traditional ecological knowledge, as the indigenous knowledge system is called, has the potential to play a central role in both indigenous and nonindigenous climate change initiatives (Vinyeta and Lynn, 2013).

This study endeavoured to compare expert and public perceptions of ESS in the Portneuf watershed. However, the lack of tribal representation in the expert sample meant that a different, but equally valid and expert knowledge type, was not included. Due to the opportunistic sampling strategy, indigenous representation was present in the public sample. Similarly, due to the small sample of experts (n=28) within the study, there is the possibility that other types of experts from both the academic and management community were not represented.

5.2 Future directions

This study highlighted that for the land-use types of agricultural land and natural forest, experts reported a mismatch between ‘scientific certainty’ and ‘management’. This finding suggests that the flow and application of knowledge between academic and non-academic experts, in regard to how different land types produce ESS and how to best manage land-use types to maximize ESS provision, is imperfect. This suggests that in the land-use types of agricultural land and natural forest, optimal scientific knowledge is not being used to inform the best management practice for ESS. This is likely due to either a lack of communication between the two
types of experts (i.e. management agencies are unaware of the best practice that is informed by scientific understanding) or the management of a land-use type is not purely for ESS and rather has to appease multiple stakeholders. The latter is perhaps most likely when considering agricultural land, where management agencies must consider the socio-economic and political climate surrounding regulation. Additionally, within the context of agricultural land, many of the regulating agencies are subject to adhering to regulatory policies that do not align for management of ESS, or the broader mission of the management agency.

Similarly, when considering ESS categories, we identified a mismatch between expert perceptions of ‘scientific certainty’ and ‘management’, with respect to regulating services. This suggests that irrespective of land-use type, optimal scientific knowledge is not being used to inform the best management practice for regulating services. Whilst research and understanding of regulating services is strong in the Portneuf watershed, management of land for regulating services is complex (when compared to provisioning or cultural services). It was discussed during many expert interviews, that regulating services, such as climate, air, and water regulation, occur over large scales and their management requires a holistic and interagency approach, and that this can be a challenge when it comes to management. Although these topics were discussed with many academic and non-academic experts during the interview process, identifying and qualitatively assessing the cause of expert mismatches fell outside the
bounds of this study. Further study should continue to investigate the nature of the mismatch between ‘scientific certainty’ and ‘management’, particularly within agricultural and forest land-use types and across regulating services, to identify opportunities for experts to reduce this mismatch and improve ESS provision.
6. Citations


Future Earth, 2020. Available at https://futureearth.org/ Last Accessed 03/30/2020


7. Appendix

7.1 Figures

Figure 1 – Taken from Balvanera et al, (2017, A). Graphical abstract highlighting the key components, challenges, and opportunities to place-based sustainability research.
Figure 2 – Map of the Portneuf Watershed.
Figure 3 - Breakdown of expertise, self-reported by experts. A – Describes ecosystem service expertise, B – Describes land-use type expertise. Each expert could only select one ecosystem service and one land-use type.
Figure 4 – Percentage of respondents in each response category to the question ‘Do you think ecosystem services in the Portneuf River watershed provide contributions to human wellbeing in the region?’ in both the public and expert groups. Public sample n=451, Expert sample n=28.

Figure 5 - Mean number of free-listed ESS per respondent, categorized into provisioning, regulating and cultural services. Public n=1413 and expert n=84. Wilcoxon rank-sum test was used to calculate statistical significance levels * = P<0.05, ** = P<0.01, *** = P<0.001.
Figure 6 – Mean perceived ecosystem service importance ranking for both public and expert groups, where the highest possible ranking is 4.0 and the lowest is 0.0. Each individual only ranks four of the 11 ES; the remaining seven ES are then ranked as zero. Public n=1884, Expert n=112. Wilcoxon rank-sum test was used to calculate statistical significance levels * = P<0.05, ** = P<0.01, *** = P<0.001.
Figure 7 – Mean perceived change in the provision of each ES over the last ten years. Maximum possible increase = +1 and maximum possible decrease = -1. Public n=1308 and Expert n=105. Wilcoxon rank-sum test was used to calculate statistical significance levels * = P<0.05, **= P<0.01, ***= P<0.001.
Figure 8 – Mean perceived impacts on ES under four hypothetical land-use change scenarios, A Urban Development, B Agricultural Land, C Rangeland and D Natural Forest. Black solid line describes the public group and the solid orange line describes the expert group. Wilcoxon rank-sum test was used to calculate statistical significance levels * = P<0.05, **= P<0.01, ***= P<0.001.
Figure 9 – Mean scientific certainty (solid black bars) and mean management (solid white bars) across four land-use types. Lowest possible score, i.e. lowest scientific certainty and management = 0 and highest possible score = 3. Wilcoxon rank-sum test was used to calculate statistical significance levels * = P<0.05, ** = P<0.01, *** = P<0.001, # = P<0.1.
Figure 10 - Mean scientific certainty (solid black bars) and mean management (solid white bars) across ten ecosystem services. Ecosystem are categorised into provisioning, regulating and cultural services. Lowest possible score, i.e. lowest scientific certainty and management = 0 and highest possible score = 4. Wilcoxon rank-sum test was used to calculate statistical significance levels * = P<0.05, ** = P<0.01, *** = P<0.001.
Figure 11 – Count of expert free-listed responses to why, or why not, an ecosystem service based approach to management affect the people and ecosystems of the Portneuf Watershed. Black bars describe positive reasons to adopt an ES approach to management, red bars describe negative reasons not to adopt an ES approach to management.
**Figure 12** – Ecosystem services panel, categorized, and color coded into provisioning, regulating and cultural services.
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<th>Climate in the Treasure Valley</th>
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<td>Natural Wildfires</td>
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*Figure 13 – A resource panel highlighting local land-use types.*