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Incorporating Human Dimensions of Land and Seascapes into Spatial Planning

A dissertation submitted in partial satisfaction of the

requirements for the degree Doctor of Philosophy

in Geography

by

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Education

2016 Ph.D. in Geography
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2004 B.A. in Political Economy with Honors
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2003 Education Abroad Program
University of California and Pontifical Catholic University of Chile

Appointments

2013-2014 Lead Author and Co-Principal Investigator
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"InVEST Chiloé: Communicating the Value of the Archipelago's Natural and Cultural Heritage to Generate Alternative Development Scenarios"

Wrote grant, co-designed pilot program, and led collaboration between resident and nonresident scientists from the NGO in Chile and the Natural Capital Project (NatCap) at Stanford University. The applied research program consolidated spatial planning as a new line of work for the NGO, and established a new partnership to apply and improve NatCap's modeling tools that can inform environmental decision-making.

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Publications

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Publications in Preparation

Elwell, T.L., López-Carr, D., Gelcich S., Gaines, S. "Deciphering the Importance of Cultural Ecosystem Services in Natural Resource-Dependent Communities: Methods Matter"; article in preparation for *Journal of Environmental Management*.

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Elwell, T.L., Gelcich S., Gaines, S., López-Carr, D. "What Matters Most? A Methodological Framework to Prioritize Ecosystem Services for Human Wellbeing"; article in preparation for *Science of the Total Environment*.

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2015 "Getting Cultural Ecosystem Services onto Decision-Making Tables." Panelist. Discussion Track: *Pathways to Impact: Ecosystem-Based Management*. The Natural Capital Project Symposium. Woods Institute for the Environment, Stanford University. 23 March 2015.

2014 "Interdisciplinary Research: Challenges and Opportunities." Invited Panelist. Graduate Seminar: Interdepartmental PhD Emphasis in Environment & Society, UC Santa Barbara. 3 November 2014.

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Teaching

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Environmental Ethics
Introduction to Environmental Studies
Population Geography
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2015 Alumna Leadership Scholar Volunteer
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Evaluated applications and interviewed candidates for merit-diversity scholarships.

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Wrote and translated text on coastal conservation for the general public. Assisted with environmental science education in local schools.

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Haas Scholars Undergraduate Research Program, UC Berkeley

Provided professional development and guidance for a current Haas Scholar. The Haas Scholars Program, a merit-diversity award, grants a capstone research experience for community-oriented leaders.

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ABSTRACT

Incorporating Human Dimensions of Land and Seascapes into Spatial Planning

by

Tammy Lynn Elwell

Despite advances in global ecosystem management, natural resource planning still often fails to incorporate cultural preferences and values. Spatial planning methods, particularly in coastal and marine contexts, tend to rely on data that relate biophysical processes and economic sector revenue. Consequently, a 'missing layer' of data that captures the people and communities involved prevents spatial planning from achieving its full potential (St. Martin and Hall-Arber, 2008). A critical question is therefore: how is decision-making within spatial planning affected by considering people's ecosystem-related values and management preferences—the human dimensions of land and seascapes, in addition to layers of biophysical and economic sector data?

To address this over-arching question, this study employed integrated qualitative and quantitative research methods to examine (1) how mixed field research methods can shed light on which management paths to pursue when faced with tradeoffs among the various benefits provided by nature, (2) how people in developing world contexts who depend more directly on nature's tangible benefits (e.g., livelihood sources) value intangible cultural benefits provided by ecosystems, and (3) how information on the cultural benefits of nature can inform environmental decision-making processes. In so doing, this study presents a methodological framework to elicit people's ecosystem-related values and management preferences, shows how to decipher the importance of nature's intangible benefits to natural-

resource dependent communities, and shares lessons learned from integrating the cultural benefits of nature into decisions concerning rural, undeveloped coastline in the Chiloé Archipelago, Chile.

I. Introduction

On May 2, 2016, life in the Chiloé Archipelago, a usually quiet corner of southern Chile, came to a halt, literally. Barricades of all kinds prevented movement across the Pan-American Highway: tires set aflame, fishing boats, lines of fed up small-scale fishers and supporters. Nothing via land—neither people, fuel, food, nor salmon destined for export—could enter or leave. Never had the Archipelago experienced a cut-off for such a length of time and over such an extent of territory. The province-wide blockade lasted 18 days.

Why were fishers and supporters so irate? Months prior, the sea surrounding the Archipelago, which serves as sustenance for most residents and the bastion of local economy and culture, had begun showing serious signs of distress. The microalgae *Alexandrium catenella* had taken over not only the inland sea, but also the coastal waters along the open ocean. Salmon farmed in pens began suffocating from a lack of oxygen: salmon companies had no salmon to harvest. Shellfish by the thousands washed ashore dead: small-scale fishers had no catch to sell. Rotting seabirds and marine fauna, poisoned from eating toxic shellfish, added to the stench of beaches. And, authorities from Chile's National Fishing Service dumped 4,655 tons of dead salmon into the sea 140 kilometers west of the Archipelago. When remnants of the tossed salmon appeared ashore, hell broke loose. No longer would people believe that El Niño Southern Oscillation (ENSO), rising sea temperatures, or global environmental change alone caused this unprecedented algal bloom. The sea had become so sick because it had been treated like a toilet bowl.[1]

[1] Months later, Greenpeace Chile would announce that, indeed, test results of sea water revealed a relationship between the dumped salmon and the algal bloom. Chile's Subsecretary of Fisheries, along with several Chilean scientists who appeared on television at the onset of the environmental and social disaster in May, had attributed the algal bloom to ENSO and had diminished any role played by the dumped salmon.

Such discontent encompasses more than pollution and poor judgement. Rather, the discontent stems from a history of coastal and marine spatial planning (or lack thereof) through which Chile's salmon aquaculture industry began to transform the Archipelago in the 1980s, for better or worse. In decades, most of Chiloé's inlets along its inner sea turned into farms of non-native salmonids. The salmon industry brought employment (mainly for manual laborers, especially women) and economic development to the Archipelago.

The salmon industry also brought pollution, eutrophication, and a new conception of coastal and marine space. The sea could now be divvied up into private property, like land. For ownership of a parceled piece of the sea, albeit with rights ultimately held by the state, might encourage stewardship, as people tend to care more for what belongs to them.

A Google Earth image shows this parceled Pacific surrounding the Chiloé Archipelago (Figure 1). As a participant in a 1989 conference on the status of marine resources in southern Chile, Oscar Gacitúa, put it:

> *If one looks at the real map of Chiloé … in reality, it's not an island surrounded by water but an island surrounded by marine concessions.'*[2]

In a race for sea space, a largely transnational salmon industry clearly took the lead. State authorities granted marine concessions in areas deemed apt for aquaculture to individuals or companies to cultivate specific species almost exclusively destined for export, from salmonids to shellfish to algae. Small-scale fishers, organized and registered as such, could also apply for space to harvest natural shellfish banks, a type of marine tenure called

[2] Bussenius, Carlos (editor). Chiloé bajo el agua. Primer seminario internacional sobre la situación de los recursos del mar en el sur chileno. Oficina Promotora del Desarrollo Chilote. Grafica Nueva, Santiago, 1989. p. 67.

territorial user rights fisheries.[3] In this race for space, the astute and connected did well. Those who remained behind were to fish areas that remained open to all. While a strip of coastline in Chile technically remains public, or open access, spillover effects of industrial-scale aquaculture in Chiloé (e.g., private property signs, pollution) often deter physical access. In this way, a new system of marine tenure, as well as the salmon industry, transformed the Archipelago. Fishers who traditionally rotated fishing areas could no longer do so. Gatherers of shellfish and algae from intertidal areas were also limited to certain spaces. Everyone began dealing with heightened pollution of sea water and coasts.

And yet, could a more comprehensive type of spatial planning have prevented the severe algal bloom of 2016 and its concomitant series of events? Probably not. However, as evident from protests, many residents believe that thirty plus years of a salmon industry saturating the inner sea plays a role. Perhaps spatial planning that included residents' ecosystem-related values (i.e. how ecosystems underpin livelihoods, ways of life, and other benefits that contribute to human health and wellbeing), as well as residents' management preferences, might have allowed for a different map of marine tenure in Chiloé.

I do not tell this story to paint the salmon aquaculture industry in a sweepingly negative light, nor to gloss over a diversity of fishers and residents of Chiloé who hold widely divergent views on this history and its legacy. I tell this story to allude to an underlying theme of each chapter that is largely left implicit in this dissertation, as its analysis extended beyond the scope of the study: power. Political economic power played a key role in transforming who had access to which space. In Chiloé, this meant that while some uses

[3] Ley de Pesca y Acuacultura, Pub. L. No. Ley 18892 (1991). Retrieved from https://www.leychile.cl/Navegar?idNorma=30265

were granted formal map space (e.g., productive uses such as marine species cultivation or territorial user rights fisheries; conservation), others (e.g., space for families to practice traditional activities such as gathering edible algae; ancestral claims to space) remained off the map. In response to this new system of marine tenure, people from coastal indigenous communities began organizing to see that the state would recognize ancestral claims to space. Years later, in 2008, Chile ratified Law 20.249, which created Coastal Marine Space for Native Peoples and allowed registered indigenous communities to solicit sea space based on ancestral uses[4].

While Chile's Law 20.249 recognizes other uses of sea space beyond productive or profit-driven uses, it often proves difficult to successfully obtain such a space. Communities must solicit space currently available. That is, space already divvied up for productive purposes stands as such. Other bureaucratic obstacles exist. For example, when the Newen Mapu indigenous community in Chiloé voiced interest in soliciting space in the Pudeto estuary—the site of this study—state authorities discouraged them from doing so, because a clause added to Law 20.249 in 2010 excluded rivers and lakes navigable by 100-ton ships[5]. So, although the Pudeto estuary, locally known as the Pudeto river, is in fact an estuary fueled by the Humboldt Current, maritime authorities have it (incorrectly) registered as a river. Interestingly, the same geographic definition of the Pudeto river-estuary did not prevent the state from granting several marine concessions to cultivate algae. Authorities

[4] Crea el Espacio Costero Marino de los Pueblos Originarios, Pub. L. No. 20.249 (2008). Retrieved from https://www.leychile.cl/Navegar?idNorma=269291

[5] Jefe de División Jurídica, Gobierno de Chile. (2010, April 20). Memorándum 114.

even granted a concession to cultivate salmonids, though the concession owner never made use of the concession.

This situation experienced at locality manifests at a broader spatial scale. Despite advances in global ecosystem management, natural resource planning still often fails to incorporate cultural preferences and values. Spatial planning methods, particularly in coastal and marine contexts, tend to rely on data that relate biophysical processes and economic sector revenue (Hall-Arber et al., 2009). Consequently, as St. Martin and Hall-Arber (2008) argue, a 'missing layer' of data that captures the people and communities involved prevents spatial planning from achieving its full potential. While economic sector data may constitute a "human" layer, such data describes aggregate economic sectors rather than individual people who use coastal and marine space for both economic and non-economic purposes. A critical question is therefore: how is decision-making within spatial planning affected by considering people's ecosystem-related values and management preferences, or *human dimensions of land and seascapes*, in addition to layers of biophysical and economic sector data? Figure 2 conveys how these layers would contribute toward more comprehensive spatial planning.

Here, I address this over-arching question through three studies driven by their respective sub-questions. Chapter II presents an empirically tested methodological framework and addresses the question: how might mixed qualitative and quantitative field research methods shed light on which of nature's benefits, or ecosystem services, to maximize and which management pathways to pursue when faced with tradeoffs among services? Chapter III focuses on an unexpected result and addresses the question: how do natural-resource dependent communities perceive the importance of nature's intangible

benefits, called cultural ecosystem services, to wellbeing? Chapter IV focuses on lessons learned in getting cultural ecosystem services onto decision-making tables. This chapter addresses the question: how might decision makers integrate the cultural benefits of nature into spatial plans, and consider cultural concerns of new development, while undergoing rapid sea- and land-use change.

Each of these three chapters stand alone as research articles aimed for publication in peer-reviewed journals. Thus, some language may repeat. While I led research and writing of this dissertation, collaborators on the three main chapters, noted in footnotes, contributed to research design, analysis, and manuscript preparation. Hence, I use the pronoun "we."

Each manuscript targets a diverse audience of interdisciplinary scholars and practitioners concerned with the sustainability of ecosystems that underpin people's lives and livelihoods. We aim the manuscript "What matters most? A methodological framework to prioritize ecosystem service for human wellbeing," (Chapter II) toward *Science of the Total Environment – An International Journal for Scientific Research into the Environment and its Relationship with Humankind*. The manuscript, "Deciphering the importance of cultural ecosystem services in natural resource-dependent communities: Methods matter" (Chapter III) targets *Journal of Environmental Management*. Finally, the manuscript, "From science to policy outcomes: How a cultural ecosystem service approach informed planning decisions in Chile," (Chapter IV) targets *Environmental Science & Policy*.

II. What matters most? A methodological framework to identify ecosystem service priorities for human wellbeing[6]

1. Introduction

To meet the sustainability challenges of the 21st century, practitioners and researchers are piloting interdisciplinary approaches, methods, and tools to move environmental decision-making processes toward better outcomes for ecosystems and people (Daily, 2000; Clark and Dickson, 2003; Ostrom, 2007; Halpern et al., 2013). Ecosystem service (ES) approaches—based on an understanding that ecosystems provide myriad benefits called ecosystem services (ESs) to people—are increasingly showing promise in this regard (McKenzie et al., 2014; Arkema et al., 2015; Ruckelshaus et al., 2015). On one hand, spatially explicit models that incorporate biophysical and economic sector data allow users to identify tradeoffs and synergies among ESs (White et al., 2012; Lester et al., 2013) and to predict the provision of services under different management scenarios (e.g., business as usual; development; conservation) (Polasky et al., 2008; Guerry et al., 2012). On another hand, a range of qualitative, quantitative, and spatial valuation methods help managers elicit what matters to people (Klain and Chan, 2012; Marín et al., 2014, Hicks and Cinner, 2014; Gould et al., 2015). However, despite rapid advances in ES modeling and valuation methods, these two lines of research largely remain disconnected, preventing them from reaching full potential to improve decision-making. The disjuncture has resulted in failed management and clashes among stakeholders, managers, and state authorities.

[6] Co-authors on this manuscript include Stefan Gelcich, David López-Carr, and Steven D. Gaines.

Whereas studies on tradeoffs among ESs often take societal preferences for services as a given or something left separate to decipher, ES valuations tend to focus on eliciting what people value and why, rather than show how to proceed when faced with tradeoffs. Notable exceptions include studies by Mastrangelo and Laterra (2015) and Cavender-Bares et al. (2015), which integrated tradeoff analyses with societal preferences. Both studies examined farmers' preferences through the lens of tradeoffs between agricultural productivity and biodiversity. While these studies begin to link supply of ESs (i.e., what combinations of benefits are possible given biophysical constraints) with demand for services (i.e., which benefits people prefer), methods to build the latter remain implicit.

Our study takes a next step and presents a methodological framework to (1) identify ES priorities for wellbeing, which would comprise the axes of a tradeoff analysis when faced with tradeoffs among services; (2) assess the perceived states of ESs (e.g., doing well, needs improvement); and, (3) understand which management interventions ecosystem service users prefer, so as to safeguard services perceived as priorities. In so doing, we address a critical question: how might mixed qualitative and quantitative field research methods shed light on which of nature's benefits, or ecosystem services, to maximize and which management pathways to pursue when faced with tradeoffs among services? Insights into societal preferences inform discussions on how to proceed when faced with tradeoffs among priorities. Furthermore, managers would benefit from knowing what matters most to people so as to anticipate potential support or conflict surrounding decisions influencing services.

2. Insights from economic theory on multiple attribute decision-making

Not all ESs can be maximized simultaneously. Constraints result from complex interactions among services that occur across time and space and following management

choices (Rodríguez et al., 2015). The biophysical side of a tradeoff analysis allow modelers to estimate which combinations of ESs are possible given such constraints. These possible combinations form what economists call an efficiency or production frontier, as points along this curve denote optimal solutions (Mas-Colell et al., 1995). In cases where maximizing one service (e.g., timber) trades off with, or reduces, the provision of another service (e.g., trees' role in carbon sequestration), preferences for what to prioritize. To estimate where along the efficiency frontier an individual or society prefers to be when faced with such a tradeoff (i.e., which possible combination of ESs is preferred), economists generate what is called an indifference curve (Figure 3). An indifference curve shows how a person (or society, by means of aggregate individual curves) values two attributes in comparison with one another (Keeny and Raiffa, 1976). To build an indifference curve, economists use a variety of techniques to identify a person's points of indifference between attributes (e.g., successive choices with incremental changes in attributes, direct questioning) (MacCrimmon and Wehrung, 1977). Here, we present field-tested methods that would allow practitioners and researchers to estimate indifferences curves and to identify perceived ES priorities.

3. Methods

3.1. Research setting

We developed the methodological framework through examining the ES priorities and management preferences of people living along the Pudeto estuary and its coastal zone (ca. 843 km^2), a social-ecological system located on the northern portion of Chiloé (41°-43°S), an archipelago in southern Chile known for its cultural heritage of small-scale farmer-fishers. The urban sector of Pudeto is mainly comprised of government housing for families displaced by a 1960 earthquake and tidal wave—the same event that formed the estuary. Its

brackish waters house farms of the red algae *Gracilaria sp.*, grown to produce agar, as well as natural shellfish banks of mussels, clams, and oysters. Processing plants for farmed salmon, shellfish, and algae line part of the estuary zoned for industrial use (Ilustre Municipalidad de Ancud, 2013), while patches of native forest give way to coastal wetlands, critical habitat for migratory birds (Andres et al., 2009). Like other rural regions of the developing world, Chiloé is experiencing rapid sea- and land-use change (e.g., introduction of industrial-scale wind farms; loss of native forest and peat lands to monoculture tree farms; unregulated extraction of kelp from sea and *Sphagnum* moss from forests), combined with unprecedented global environmental change (e.g., droughts; algal blooms).

3.2. Field research methods

We applied integrated qualitative and quantitative methods in order to understand the context in which people with varying degrees of dependency on ESs perceived the importance of ESs to wellbeing (Singleton et al., 1988; Poteete et al., 2010; Cheong et al., 2012). Semistructured interviews with key informants informed the design of a survey questionnaire that included closed and open-ended questions. Qualitative data—collected through both interviews with small-scale fishers and a survey of estuary residents—allowed us to interpret patterns observed through the analysis of quantitative data (Sayer, 1992; Carr, 2003; Creswell, 2009).

3.2.1. Identifying benefits associated with the estuary and its coastal zone

To identify potential ES priorities, we interviewed 41 small-scale fishers between June and December 2013. This series of interviews followed several months of fieldwork to conduct interviews with 12 key informants, analyze coastal policy documents, and observe and participate in harvest activities (e.g., cleaning algae). The initial months of fieldwork

helped us gain access into communities. Interviews were conducted in Spanish at the informants' worksite (shoreline) or home. We first contacted fishing organizations to request participation and lists of members. From these lists, we purposefully sampled at least two members of the organization and one leader from the directorate board in order to capture a potential diversity of perceptions based on factors that are thought to influence what people value and prioritize. Factors that drove this purposeful sampling technique included: rural versus urban place of residence, years of schooling, age, and gender (Martín-López et al., 2014); ethnicity and ancestral ties to place (Gould et al., 2014; Winthrop, 2014); livelihood sources (Gelcich et al., 2009; Marín et al., 2014); membership in livelihood-related organizations (Gelcich et al., 2005); and, ability to access ESs (Leach et al., 1999; Daw et al., 2011; Hicks and Cinner, 2014; Wieland et al., 2016). To capture the latter factor in the sample, we interviewed people who accessed the estuary via territorial user rights (i.e., access gained through membership in a fishing organization), or open access areas. Fishers not in organizations were approached at the shoreline, an area of open access.

3.2.1.1. Sample of key informants interviewed

The sample consisted of 19 female and 22 male fishers, ranging in age from 21 to 82, with an average age of 51. Informants had lived along the estuary from less than a year to 82 years, with an average duration of 29 years. 78% of the informants (32 people) belonged to a small-scale fishing organization, 5 informants belonged to a registered indigenous community, and two belonged to both. Four informants did not belong to either. Of those who belonged to a fishing organization, 12% (5 people) drew their household income from sources other than marine resource extraction (e.g., sale of locally-caught seafood, commercial truck transport, boat rental), yet maintained membership to obtain other

benefits. More than half of the informants (22 people) depended solely on marine resource extraction for livelihood. 32% of informants (13 people) depended on the extraction of only one marine species, most often the commercial red algae *Gracilaria sp.* 17% (7 people) depended on the combination of marine resource extraction and small-scale farming or timber extraction. An additional 17% (7 people) depended on marine resource extraction and another off-sector livelihood source (e.g., handcrafts, boat mechanic).

3.2.1.2. Design of semi-structured interview

Interviews followed a semistructured format of open ended questions that allowed interviewees to respond using their own words. First, we collected background information to better understand the informant's history in the social-ecological system, including degree and type of reliance on ecosystems for subsistence and income, harvests per unit effort, and access to natural resources (Ostrom, 1990). We then asked informants what coastal and marine ecosystems provided them, using follow-up questions such as, "Anything beyond immediate sources of livelihood or food?" We also asked if they perceived any tradeoffs among existing or projected uses of the ecosystems, opinions on current management, and how they envisioned the estuary's future. For instance, we asked what they would like to see changed or remain the same, and what other potential uses or changes, if any, they thought would add to their wellbeing.

3.2.1.3. Interview data analysis

We transcribed interviews and compiled responses to each question according to the interview structure (Kitchin and Tate, 2000). Responses were coded to compose main categories of answers to each question (Saldaña, 2013). Main categories per question were

then tabulated in Microsoft Excel to assess response frequency. Quotations that captured common responses or presented different ideas included in this paper were selected and translated to English in order to convey findings.

3.2.2. Prioritizing benefits associated with the estuary and its coastal zone

Based on responses to the open-ended questions we asked informants (Section 3.2.1.2.), we compiled a list of 17 benefits, or ESs, granted by the estuary, and a list of 10 projected management interventions. We corroborated these lists with officials at the local office of Chile's National Fishing Service to ensure interventions would be plausible. Between 26 February and 3 March 2014, we used territorial coverage to survey residents who lived in the three main sectors that border the estuary: urban Pudeto; peri-urban La Pasarela, and rural Pupelde. The lead author and a trained team surveyed participants with a questionnaire (in Spanish), either in individuals' homes or at their workplace (e.g., fishing organization headquarters, shoreline).

3.2.2.1. Sample of estuary residents surveyed

We surveyed 168 residents (71 women and 97 men) ranging in age from 16 to 82 years, with an average age of 48. Survey participants had lived along the estuary from less than a year to 82 years, with an average duration of 20 years. The sample covered the range of ES use types, or livelihoods, representative of the study area. *Marine:* 51% of those surveyed (86 people) directly depended on shellfish, *Gracilaria sp.* algae, fish, or a combination of coastal and marine provisioning services for a main source of income. *Off-sector:* 35% of those surveyed (58 people) included wage workers (e.g., fish processing plant workers, people with work contracts); pension earners; and, freelance taxi drivers, electricians, and mechanics who depended indirectly on provisioning, regulating, and supporting ESs. *Other:*

14% of those surveyed (24 people) included artisans, carpenters, farmers, gardeners, forest natural resource users, people who sold locally extracted seafood, and one tourism operator. Nearly all in the *Other* ES use category worked independently without a work contract. Overall, participants grouped as *Other* depended more directly on terrestrial supporting, regulating, and provisioning services.

3.2.2.2. Design of survey questionnaire

We included the 17 ESs and 10 interventions identified through key informant interviews in a survey questionnaire. To improve question wording and ensure fluidity, we piloted the questionnaire with a similar population of ES users in a different part of the municipality. As opposed to open-ended questions that had allowed informants to respond in own words, the survey questionnaire mainly included closed questions where participants moved a scale to reflect importance.

The questionnaire included:

- A Google Earth image that defined the estuary and its coastal zone.
- Closed questions to assess the perceived importance of each service to personal and familial wellbeing, and the perceived state of each service in terms of provision (Table 1). We asked participants to indicate how important each of the 17 aspects of the Pudeto estuary proved for their own wellbeing and that of their family. To mark responses, we used a continuous scale with two anchor points, “very important” and “not important”, and a clear “indifference” line in the middle. We then asked participants to express the current state of each ES on the continuous scale, with two anchor points, “excellent” and “terrible”, and a clear “indifference” or “unsure” line in the middle.

- Closed questions to assess users' preferences for 10 potential interventions in the estuary (Table 2). We asked participants to indicate how each intervention would impact the wellbeing and that of their family, and how the intervention would impact the environment. We marked responses using a continuous scale with two anchor points, "excellent" and "terrible", and a clear "indifference" or "unsure" line in the middle.
- Open-ended questions that followed up on responses marked between +7 and +10 or -7 and -10 on the continuous scale. For instance, we asked, "What do you think would change?" to record reasons behind impact on wellbeing or impact on the environment.

3.2.2.3. Survey data analysis

We analyzed survey data using Microsoft Excel, R, and SPSS. We grouped individuals into ES use categories based on their main source of livelihood: *marine* (51%, 86 people), *off-sector* (35%, 58 people), and *other* (14%, 24 people). To compare scores among different ES user groups, we used a Kruskal-Wallis H test with Dunn's posteriori tests (IBM SPSS 24). Written-in reasons behind scores between +7 and +10 or -7 and -10 for interventions were coded to compose main categories of responses. Main categories per intervention were then tabulated to assess response frequency.

4. Results

4.1. Ecosystem services and potential interventions identified

Interviewees in the qualitative research phase identified a range of benefits granted by the estuary. While interviewees mainly spoke of provisioning services such as livelihood

sources and food, the 17 benefits identified and included in the survey questionnaire represented each of the four ES categories outlined in the Millennium Ecosystem Assessment: provisioning, cultural, regulating, and supporting. Additionally, interviewees conveyed several potential interventions for the estuary's future that ranged from expanding (e.g., more *Gracilaria* algal farms) or renewing (e.g., reseeding natural shellfish banks) existing uses of the estuary to introducing new uses (e.g., small-scale tourism, mussel farming), and from conservation to development.

4.2. Ecosystem service users grouped according to livelihoods

The sample population surveyed comprised of three main types of ES users: people who depended directly on marine and coastal provisioning ES ("marine"), people who depended indirectly on ES ("off-sector"), and people who depended more directly on regulating and supporting ES ("other"). Marine users (n = 86) included individuals whose main source of income came from shellfish, *Gracilaria* algae, fish, or a combination of ocean resources. These users represented a range of livelihoods within small-scale fishing: coastal gleaners, algae harvesters, hookah divers, diving assistants, and fishers. Given the seasonal and unstable nature of their work, some applied strategies to ride out resource variability (e.g., switching between different ocean resources, adding value to a resource, supplementing household income with another activity).

Off-sector users, in contrast, earned more stable income. Off-sector (n = 58) included salary or wage earners (e.g., processing plant employees); retirees who drew pensions; and, self-employed taxi drivers, electricians, and mechanics. Off-sector ES users depended indirectly on marine and coastal provisioning services like seafood and regulating and supporting services such as tidal flow. While off-sector ES users' livelihoods did not depend

directly on marine and coastal ES, some off-sector users fished or gathered edible algae and shellfish for subsistence—a common practice in Chiloé.

Lastly, other users (n = 24) included artisans, carpenters, farmers, vegetable gardeners, people who extracted natural resources from forests (e.g., *Sphagnum* moss, firewood), one person who sold locally extracted seafood, and one tourism operator. People in other ES group depended more directly on terrestrial and coastal regulating and supporting services, such as the estuary's support in the growth of native forest from which carpenters build, or vegetable fibers from which artisans make crafts. In the same way, those who worked in agriculture depended on wetlands and peatlands that serve as freshwater reservoirs. Nearly all users in the other ES group worked independently without a work contract, much like the marine users.

4.3. Perceived importance of ecosystem services to wellbeing

Mean scores for importance ranged from near zero (unsure or indifferent) to near ten (very important) (Table 1). The ES perceived as most important to wellbeing, by far, was scenic beauty. This result was consistent across user groups. Users shared similar perceptions on importance to wellbeing for 9 ESs, listed in order of greatest to least importance according to mean scores of the total sample population: scenic beauty, variety and number of birds (a proxy value for biodiversity), support for the growth of native forest, presence of edible algae, tidal flow of salt water, wetlands and peat lands that serve as freshwater reservoirs, vegetable fibers to make crafts, the estuary's ability to eliminate drainage and greywater from houses, and presence of other commercial algae.

For 8 ESs, users' perceptions of the importance of ESs to wellbeing differed significantly (Table 1). In order of greatest to least importance according to mean scores of

the total sample population, these differences were: space to recreate and practice sports, space to develop tourism, presence of shellfish, spiritual space, space to practice traditional activities with family, ability to navigate the estuary, and quantity and quality of the commercial algae *Gracilaria*. For these differences, marine users' scores for importance were significantly higher than those of off-sector users. In the case of the commercial algae *Gracilaria*, marine users' mean score for importance was significantly higher than both off-sector and other users' scores. In the case of spiritual space, both marine and other users' scores for importance were higher than off-sector users' score.

4.4. Perceived states of ecosystem services

Users shared similar perceptions of the states of 13 of 17 ESs (Table 1). Overall, users perceived most ESs in a somewhat positive state. Scenic beauty again stood out as being in an excellent state. Users perceived tidal flow of salt water, ability to navigate the estuary, and variety and number of birds in good states. Overall, the estuary's ability to eliminate greywater and drainage from houses was the only ES perceived in a poor state (negative mean score). Mean scores were near zero for the states of other commercial algae, which most users marked as zero (unsure), and wetlands and peatlands that serve as freshwater reservoirs, where users' scores appeared across the spectrum.

Perceptions regarding the state of ESs differed significantly among groups in four cases. Other ES users perceived the state of the estuary as a spiritual space in a significantly better state than did off-sector users. Other ES users also perceived the state of the estuary's support in the growth of native forest significantly better than did marine users. Marine users perceived the presence of fish and vegetable fibers in significantly better states than did off-sector users.

4.5. Perceived impacts of interventions on wellbeing

Interventions, based on users' perceived impacts on wellbeing, fell into three categories: strong support, intermediate support, and neutral (mean scores near zero) (Table 2). Overall, users showed strong support for tourism and conservation as well as for expanding *Gracilaria* algal farms and reseeding shellfish banks. For the latter two interventions, marine users' mean scores were significantly higher than off-sector and other users' scores. Users showed intermediate support for introducing a mussel farm and installing another shellfish processing plant. Interventions with overall mean scores near zero included establishing a salmon farm, filling wetlands to build roads and houses, and establishing territorial user rights to restrict access to the estuary's natural shellfish banks.

Strong support: Users strongly supported developing small scale tourism, creating a protected area for nature, and installing a lookout point for birds. Mean scores greater than 7.5 across groups indicate that nearly all users perceived tourism and conservation interventions would have very positive impacts on wellbeing. As expected, marine users showed significantly strong support for expanding *Gracilaria* algal farms and reseeding natural shellfish banks—resources on which they depend directly for income. Interestingly, both off-sector and other users perceived these marine-specific interventions as having positive impacts on their wellbeing, though not as much as the positive gains marine users thought they would experience.

Intermediate support: Users across groups shared intermediate support for introducing a mussel seed farm. Overall, users also showed intermediate support for installing another shellfish processing plant near the estuary, though other users' mean score is lower than

those of marine and off-sector users. Larger standard errors for both of these interventions indicate greater variation of perceived benefits within user groups.

Neutral yet controversial: For the interventions of territorial user rights, a salmon farm, and filling wetlands, users' mean scores for perceived impacts on wellbeing were near zero, or neutral. However, users were hardly neutral on these interventions. While several individual users marked wellbeing impacts at zero (unsure or indifferent), overall, users' scores appeared polarized—either negative or positive, thus averaging to zero.

Establishing territorial user rights in the estuary's shellfish banks garnered the most divergent scores among user groups. Off-sector users perceived significantly more positive wellbeing impacts from restricting access to shellfisheries than did marine users. Roughly half of marine users perceived positive impacts from restricting access, while half perceived extremely negative impacts. Similarly, introducing a salmon smolt farm into the estuary incited polarized scores within groups; users were split on whether a salmon farm would have negative or positive impacts on wellbeing. Only one intervention garnered negative wellbeing scores from all ES user groups: filling wetlands to build infrastructure. However, larger standard errors point to greater variation within groups. Indeed, several users perceived positive impacts on wellbeing from filling wetlands to build infrastructure; hence, mean scores were near zero.

4.6. Perceived impacts of interventions on the environment

Users across groups shared similar perceptions of how all 10 interventions would affect the environment. Users similarly perceived positive environmental impacts from creating a protected area for nature, developing small-scale tourism, installing a lookout point to observe birds, reseeding shellfish banks, expanding *Gracilaria* algal farms, and introducing

a mussel farm. Mean scores for perceived environmental impacts were near zero for installing a new processing plant and establishing territorial user rights for shellfisheries. For both interventions, responses clustered at zero. That is, users were unsure or did not know how a processing plant or territorial user rights would impact the environment.

5. Discussion

5.1. Identifying which ecosystem service priorities can be improved

In identifying both ES priorities and perceived states of services, the methodological framework allowed us to highlight which highly valued services could be improved. (Figure 6). Such snapshots can help managers and community actors assess where to focus efforts. Alternatively, managers and actors could apply the framework after an intervention to evaluate any changes in the perceived states of targeted ES priorities. In this study, the framework showed that residents across ES use types highly valued space to develop small-scale tourism (and favored doing so), yet perceived the state of this ES as mediocre. This strong support for developing small-scale tourism contrasts with the fact that only one of the 168 residents surveyed earned income as a tourism operator. Despite the potential for ecotourism in the estuary (Nahuelhual et al. 2013), households lack infrastructure, resources, and capacity to realize such ventures. Such insights can help community members and leaders target efforts toward interventions with wide support. The pattern described in the aforementioned example of small-scale tourism, an ES (and proposed intervention) highly valued by users yet lacking in quality or access—extends to 10 of the 17 ESs (Figure 6).

5.2. Identifying potential win-win interventions across ecosystem service use types

While tradeoffs can occur because of people's differing abilities to access ESs (Leach et al., 1999; Daw et al., 2011; Vira et al., 2012; Hicks and Cinner, 2014; Wieland et al., 2016), our results suggest that, at a spatial scale of locality, win-win interventions inclusive of users with different types of dependency on ESs, can occur. Interestingly, both off-sector and other users supported expanding *Gracilaria* algal farms—an intervention specific to marine users who harvest and sell the red algae for a living. An understanding of the dynamics of the Pudeto estuary social-ecological system, obtained through qualitative field research methods, shed light on why non-marine users would strongly support this marine-specific intervention. When the marine resource *Gracilaria* booms, people enter the harvest, regardless of livelihood source. These boom and bust cycles make for a variable population of harvesters. Indeed, the history of Chiloe, like many natural resource-dependent places, developed around booms and busts (Grenier, 1984). Based on this history, it is likely that off-sector and other users perceive expanding algal farms as a potential opportunity to supplement household income. Users' interpretations of personal and familial wellbeing also played a role in reasoning. In written responses, some users explained that expanding algal farms would mean more work for more people, which would increase wellbeing for the community. Users also reasoned that more algae would increase habitat for shellfish and fish, provisioning ESs linked with local culture. As this example shows, the framework can highlight interventions with potential support across users with varying degrees of dependence on certain ESs.

5.3. Clarifying details: people need specifics of interventions to form opinions

Although results showed a common perception among users regarding the states of ESs (Table 1), users held significantly different opinions on how to best manage marine ESs—

namely, *Gracilaria* algae and shellfish (Table 2). The interventions that garnered statistically significant differences among users' perceived wellbeing impacts—expanding algal farms, reseeding natural shellfish banks, and establishing territorial user rights shellfisheries (TURF)—involve a key issue: access. By their *de jure* definition, territorial rights allocate uses of farming algae or harvesting shellfish, and, in so doing, include some people and exclude others.

Based on the questionnaire wording of these interventions, survey participants did not know whether they would win or lose. Would they be in a group that would benefit from an algal farm? That would depend on whether or not they belonged to an organization that obtained *de jure* rights to carry out said activity in the designated space. Thus, as expected, marine users were polarized on the TURF intervention. Indeed, individual marine users held contradictory views. In interviews, informants reasoned the benefits of territorial user rights: people tended to take better care of what was "theirs" (i.e., stewardship), organizations allowed fishers to pool together for resources and projects (i.e., collective action), they had legal backing against poachers, and there was, at least in theory, a more widespread incentive to let species grow and re-populate.

Yet, even while acknowledging benefits, informants reasoned the downsides, either based on personal experience or from observing local dynamics of existing TURFs. Major downsides included the tendency for open access areas to experience over-fishing; loss of historical customary rights inextricably linked with local culture (e.g., gathering shellfish from open access areas for subsistence, rotating harvest areas); fishing organizations and people pitted against each other, and some people, particularly those who are slower to join organizations and solicit space, are left out as "losers" in a race to get TURF. Therefore,

while the methodological framework can highlight interventions that incite potential conflict, follow-up methods that specify details of interventions are needed so that ES users can judge whether they would gain or lose following an intervention that restrict access to ESs.

6. Conclusion

The methodological framework presented here allows practitioners to interpret which ESs matter most to people in terms of wellbeing, and which interventions different people prefer so as to promote and ensure the continued provision of priority services. In so doing, the framework bridges tradeoff analysis (supply of ESs) with ecosystem service valuation (demand for ESs)—two lines of research poised to improve environmental decision-making, yet hitherto largely disconnected. Future research would integrate the literature on environmental politics into ecosystem service frameworks. For example, who are winners and losers of different interventions, and at which spatial and temporal scales? When faced with such tradeoffs among users at different spatial and temporal scales, how might we as society make those tough decisions? How might insights from environmental and social justice shed light on such situations?

III. The importance of cultural ecosystem services in natural resource-dependent communities[7]

1. Introduction

In environmental decision-making processes, ecosystem service frameworks have proven to be one useful way to convey how ecosystems underpin human wellbeing, and, in so doing, identify pathways toward sustainability (McKenzie et al., 2014; Arkema et al., 2015; Ruckelshaus et al., 2015). Ecosystem processes contribute benefits that people value (Chan et al., 2011), in ways that can be articulated, projected, and considered when deciding among courses of action (Daily, 2000; Daily et al., 2009). Some ecosystem services (ESs), termed *provisioning* services, translate directly into what people would obviously value for wellbeing, as they meet basic, material needs (e.g., water, food, fuel) (Maslow, 1943; MA, 2005). Others, including *supporting* and *regulating* (e.g., soil formation; water purification) and *cultural* services (e.g., spirituality, educational opportunities), capture subtler ways in which ecosystems foster human wellbeing. Of these categories, cultural ecosystem services (CES) have proven the most complex for people to articulate and researchers to elicit (Klain and Chan, 2012; Satz et al., 2013; Gould et al., 2015). This complexity presents challenges for effectively including CES in decision-making processes (de Groot et al., 2005; Chan et al., 2012*a*; Chan et al., 2012*b*).

The Millennium Ecosystem Assessment (MA), which established a framework from which to begin to trace consequences of ecosystem change to human wellbeing outcomes, defined CES as those that provide recreational, aesthetic, educational, and spiritual benefits

[7] Co-authors on this manuscript include David López-Carr, Stefan Gelcich, and Steven D. Gaines.

(MA, 2005). Some scholars have criticized the MA's emphasis of CES on non-material benefits like recreation and aesthetics as seemingly more relevant to people who can afford to value them (Satterfield et al., 2013). These critiques relate to notions of aesthetic landscape consumption, in which affluent urbanites seek natural beauty in rural areas that are often inhabited by families who often depend on natural-resource production (Walker and Fortmann, 2003). The MA's CES definition may support developed world contexts where, generally speaking, more people have basic material needs met, and thus more privilege to recreate in nature and admire, or consume, scenic beauty. Following this logic, people who depend more directly on provisioning services, such as natural resources, for livelihoods and ways of life (as is often the case in the developing world) would more likely perceive such services as more important to wellbeing. Indeed, Cinner and Pollnac (2004) and Hicks et al. (2014) found that people who relied more on natural resources for livelihood tended to prioritize meeting basic needs through provisioning services, rather than pursuing other more abstract benefits (e.g., aesthetic needs) as outlined in Maslow's hierarchy (Maslow, 1943).

Empirical tests of this hypothetical dichotomy between the value of non-material CES in developed versus developing world contexts are relatively rare but are inconsistent with posited outcomes. Vilardy et al. (2011) found that farmers and fishers in the Ciénaga Grande of Santa Marta, Colombia, perceived CES, including aesthetic values and sense of place, as important to wellbeing. Marín et al. (2014) found that farmers and fishers in a coastal wetland in Chile highly valued birds, a proxy for terrestrial biodiversity, closely followed by provisioning ESs. Hicks et al. (2014) found that fishers in Seychelles prioritized a non-material CES: bequest, or knowing future generations would be able to enjoy benefits

from ecosystems enjoyed today. These results suggest far more positive connections with CES such as scenic beauty, recreation, and biodiversity even in poorer developing world settings, as these elements contribute to an ability to maintain livelihoods and ways of life that directly depend on natural resources (e.g., forest forager, coastal gleaner). But if so, the connection remains implicit only. It also remains unclear as to how people's preferences for ESs relate to their preferences for management interventions, which might decrease some ESs in the short term at the expense of other services in the long term, or vice versa. Such unresolved questions constitute much needed steps to appropriately value and thus ensure the continued provision of services that underpin human wellbeing, especially in places undergoing economic development and concomitant ecosystem change (Guerry et al., 2015).

Critical unanswered questions thus remain: how do people in developing world contexts who depend directly or indirectly on provisioning, regulating, and supporting ecosystem services value CES in terms of wellbeing? And, how do said values relate to perceived changes in wellbeing following plausible development and conservation interventions? Here, we begin to fill some of these critical gaps in the literature by employing integrated qualitative and quantitative methods to examine which ecosystem services mattered most to people with varying degrees of dependence on ESs in a natural-resource dependent community, which management interventions they preferred, and why.

2. Methods

2.1. Research setting

Our study examined the social-ecological system of Pudeto estuary and its coastal zone (ca. 843 km^2), located on the northern portion of Chiloé (41°-43°S), an archipelago in southern Chile known for its cultural heritage of small-scale farmer-fishers. The urban sector

of Pudeto is mainly comprised of government housing for families displaced by a 1960 earthquake and tidal wave—the same event that formed the estuary. Its brackish waters house farms of the red algae *Gracilaria sp.*, grown to produce agar, as well as natural shellfish banks of mussels, clams, and oysters. Processing plants for farmed salmon, shellfish, and algae line part of the estuary zoned for industrial use (Ilustre Municipalidad de Ancud, 2013), while patches of native forest give way to coastal wetlands, critical habitat for migratory birds (Andres et al., 2009). Like other rural regions of the developing world, Chiloé is experiencing rapid sea- and land-use change (e.g., introduction of industrial-scale wind farms; loss of native forest and peat lands to monoculture tree farms; unregulated extraction of kelp from sea and *Sphagnum* moss from forests), combined with unprecedented global environmental change (e.g., droughts; algal blooms). The rural-urban contrasts of Chiloé, along with the environmental, economic, and social changes representative of the Global South, make for a compelling place to examine how people with varying degrees of dependence on different types of ESs perceive the importance of CES.

2.2. Field research methods

We applied integrated qualitative and quantitative methods in order to understand the context in which people with varying degrees of dependency on ESs perceived the importance of ESs to wellbeing (Singleton et al., 1988; Poteete et al., 2010; Cheong et al., 2012). Semistructured interviews with key informants informed the design of a survey questionnaire that included closed and open-ended questions. Qualitative data—collected through both interviews with small-scale fishers and a survey of estuary residents—allowed us to interpret patterns observed through the analysis of quantitative data (Sayer, 1992; Carr, 2003; Creswell, 2009).

2.2.1. Identifying benefits associated with the estuary and its coastal zone

To identify potential ecosystem service priorities, we interviewed 41 small-scale fishers between June and December 2013. This series of interviews followed several months of fieldwork to conduct interviews with 12 key informants, analyze coastal policy documents, and observe and participate in harvest activities (e.g., cleaning algae). The initial months of fieldwork helped us gain access into communities. Interviews were conducted in Spanish at the informants' worksite (shoreline) or home. We first contacted fishing organizations to request participation and lists of members. From these lists, we purposefully sampled at least two members of the organization and one leader from the directorate board in order to capture a potential diversity of perceptions based on factors that are thought to influence what people value and prioritize. Factors that drove this purposeful sampling technique included: rural versus urban place of residence, years of schooling, age, and gender (Martín-López et al., 2014); ethnicity and ancestral ties to place (Gould et al., 2014; Winthrop, 2014); livelihood sources (Gelcich et al., 2009; Marín et al., 2014); membership in livelihood-related organizations (Gelcich et al., 2005); and, ability to access ESs (Leach et al., 1999; Daw et al., 2011; Hicks and Cinner, 2014; Wieland et al., 2016). To capture the latter factor in the sample, we interviewed people who accessed the estuary via territorial user rights (i.e., access gained through membership in a fishing organization), or open access areas. Fishers not in organizations were approached at the shoreline, an area of open access.

2.2.1.1. Sample of key informants interviewed

The sample consisted of 19 female and 22 male fishers, ranging in age from 21 to 82, with an average age of 51. Informants had lived along the estuary from less than a year to 82

years, with an average duration of 29 years. 78% of the informants (32 people) belonged to a small-scale fishing organization, 5 informants belonged to a registered indigenous community, and two belonged to both. Four informants did not belong to either. Of those who belonged to a fishing organization, 12% (5 people) drew their household income from sources other than marine resource extraction (e.g., sale of locally-caught seafood, commercial truck transport, boat rental), yet maintained membership to obtain other benefits. More than half of the informants (22 people) depended solely on marine resource extraction for livelihood. 32% of informants (13 people) depended on the extraction of only one marine species, most often the commercial red algae *Gracilaria sp.* 17% (7 people) depended on the combination of marine resource extraction and small-scale farming or timber extraction. An additional 17% (7 people) depended on marine resource extraction and another off-sector livelihood source (e.g., handcrafts, boat mechanic).

2.1.1.2. Design of semi-structured interview

Interviews followed a semistructured format of open ended questions that allowed interviewees to respond using their own words. First, we collected background information to better understand the informant's history in the social-ecological system, including degree and type of reliance on ecosystems for subsistence and income, harvests per unit effort, and access to natural resources (Ostrom, 1990). We then asked informants what coastal and marine ecosystems provided them, using follow-up questions such as, "Anything beyond immediate sources of livelihood or food?" We also asked if they perceived any tradeoffs among existing or projected uses of the ecosystems, opinions on current management, and how they envisioned the estuary's future. For instance, we asked what they would like to see

changed or remain the same, and what other potential uses or changes, if any, they thought would add to their wellbeing.

2.2.1.3. Interview data analysis

We transcribed interviews and compiled responses to each question according to the interview structure (Kitchin and Tate, 2000). Responses were coded to compose main categories of answers to each question (Saldaña, 2013). Main categories per question were then tabulated in Microsoft Excel to assess response frequency. Quotations that captured common responses or presented different ideas included in this paper were selected and translated to English in order to convey findings.

2.2.2. Prioritizing benefits associated with the estuary and its coastal zone

Based on responses to the open-ended questions we asked informants (Section 2.1.2.), we compiled a list of 17 benefits, or ESs, granted by the estuary, and a list of 10 projected management interventions. We corroborated these lists with officials at the local office of Chile's National Fishing Service to ensure interventions would be plausible. Between 26 February and 3 March 2014, we went house to house to survey residents who lived in the three main sectors that border the estuary: urban Pudeto; peri-urban La Pasarela, and rural Pupelde. The lead author and a trained team surveyed participants with a questionnaire (in Spanish), either in individuals' homes or at their workplace (e.g., fishing organization headquarters, shoreline).

2.2.2.1. Sample of estuary residents surveyed

We surveyed 168 residents (71 women and 97 men) ranging in age from 16 to 82 years, with an average age of 48. Survey participants had lived along the estuary from less than a

year to 82 years, with an average duration of 20 years. The sample covered the range of ecosystem service use types, or livelihoods, representative of the study area. *Marine:* 51% of those surveyed (86 people) directly depended on shellfish, *Gracilaria sp.* algae, fish, or a combination of coastal and marine provisioning services for a main source of income. *Off-sector:* 35% of those surveyed (58 people) included wage workers (e.g., fish processing plant workers, people with work contracts); pension earners; and, freelance taxi drivers, electricians, and mechanics who depended indirectly on provisioning, regulating, and supporting ESs. *Other:* 14% of those surveyed (24 people) included artisans, carpenters, farmers, gardeners, forest natural resource users, people who sold locally extracted seafood, and one tourism operator. Nearly all in the *Other* ecosystem service use category worked independently without a work contract. Overall, participants grouped as *Other* depended more directly on terrestrial supporting, regulating, and provisioning services.

2.2.2.2. Design of survey questionnaire

We included the 17 ESs and 10 interventions identified through key informant interviews in a survey questionnaire. To improve question wording and ensure fluidity, we piloted the questionnaire with a similar population of ecosystem service users in a different part of the municipality. As opposed to open-ended questions that had allowed informants to respond in own words, the survey questionnaire mainly included closed questions where participants moved a scale to reflect importance.

The questionnaire included:

- A Google Earth image that defined the estuary and its coastal zone.
- Closed questions to assess the perceived importance of each service to personal and familial wellbeing and the perceived state of each service. We asked participants to

indicate how important each of the 17 aspects of the Pudeto estuary proved for their own wellbeing and that of their family. To mark responses, we used a continuous scale with two anchor points, "very important" and "not important", and a clear "indifference" line in the middle.

- Closed questions to assess users' preferences for 10 potential interventions in the estuary. We asked participants to indicate how each intervention would impact their wellbeing and that of their family. We marked responses using a continuous scale with two anchor points, "excellent" and "terrible", and a clear "indifference" or "unsure" line in the middle.
- Open-ended questions that followed up on responses marked between +7 and +10 or -7 and -10 on the continuous scale. For instance, we asked, "What do you think would change?" to record reasons behind impact on wellbeing.

2.2.2.3. Survey data analysis

We analyzed survey data using Microsoft Excel, R, and SPSS. We grouped individuals into ecosystem service use categories based on their main source of livelihood: *marine* (51%, 86 people), *off-sector* (35%, 58 people), and *other* (14%, 24 people). To compare mean scores among the three ecosystem service user groups, we used a Kruskal-Wallis H test, a non-parametric one-way analysis of variance, with Dunn's posteriori tests (Rice, 1989; Elliott & Woodward, 2007; IBM SPSS 24). Written-in reasons behind scores between +7 and +10 or -7 and -10 for interventions were coded to compose main categories of responses. Main categories per intervention were then tabulated to assess response frequency.

3. Results

3.1. Ecosystem services identified through interviews with key informants

Most responses to the question, *"What does the estuary, sea, and coastal zone give you?"*, focused on provisioning ecosystem services, some mentioned cultural ecosystem services, and only one interviewee cited supporting and regulating ecosystem services (Figure 6). All interviewees (41 people) mentioned livelihood. 44% (18 interviewees) cited food for people and farm animals (e.g., shellfish, fish, algae). 12% (5 people) mentioned cultural identity and ways of life (e.g., ancestral tradition of gathering shellfish for subsistence). Each of the following benefits were mentioned twice by different people: recreation and family outings (e.g., walking the shoreline), independence and the ability to work for self, firewood from nearshore forests, and algae as fertilizer for vegetable gardens. One interviewee listed benefits we do not yet know of or understand (e.g., that which scientists can explore), as well as algae's role in oxygen production and habitat for aquatic life—supporting and regulating ecosystem services.

3.1.1. Mention of an ability to enjoy nature as a family

While no one invoked scenic beauty in response to the open-ended question of what the estuary provided, two interviewees cited recreation. Although the responses did not explicitly reference scenic beauty, they highlighted being outside and enjoying nature:

> *Apart from work, the sea provides food, medicine, a recreational use, and what's familiar. As a family, we take a day to visit the shoreline, to walk, collect stones, and create memories.*

What does the sea give me? Nothing. [10-year-old son, interjects, "*Swimming!"*] [Laughter] *True. In summer, we go out on the boat. Yes, recreation as a family.*

These two interviewees—both mothers and founding members of small-scale fishing organizations and indigenous communities, respectively—emphasized family when citing the sea's recreational use. In the latter response, the interviewee's child interjected, reminding his mother of the family outings they enjoy in nature. Yet, overall, and unsurprisingly, most interviewees spoke of the provisioning ecosystem services that allowed them to make a living.

3.1.2. Scenic beauty referenced in regard to future opportunities in tourism

Scenic beauty appeared explicitly in response to questions in a final interview segment focused on future projections. Questions here included, *"What opportunities, if any, do you envision for this place?"* and *"How do you imagine this place for your children, nieces and nephews, and grandchildren*?" The two aforementioned interviewees who cited recreation as a family used the same wording to describe the area's scenic beauty: "beautiful vistas".

What's lacking is to foment nature and maximize the beautiful vistas.

[I imagine this place] with a coastal boardwalk. The Municipality practically treats this place as a dump. [The estuary and coastal zone] can be improved so that people can enjoy and admire the beautiful vistas.

Both interviewees mention beautiful vistas in concert with tourism. The latter discussed building a lookout point and improving the dock's infrastructure as a means to

attract tourism, while the former spoke of natural beauty as greater than that of the provincial capital, a neighboring municipality that draws more tourists. Thus, at least for these two interviewees, beautiful vistas are associated with tourism.

While most interviewees did not mention scenic beauty explicitly, either as a benefit or as an opportunity, several spoke of tourism. 44% of interviewees (18 people) cited tourism in response to the question, "*"What opportunities, if any, do you envision for this place?"* Of these, most (11 people) emphasized potential barriers to achieving these potential benefits. Most frequently, interviewees cited opportunities for small-scale, niche tourism (e.g., nature- and culture-based, adventure, gastronomic), and then said, "but" followed by an existing obstacle: a lack of cooperation and commitment among residents; financial and social capital; government support; and, infrastructure.

3.2. Ecosystem service prioritized through a survey of estuary residents

3.2.1. Scenic beauty prioritized as most important and perceived in best state

The 168 residents surveyed overwhelmingly perceived scenic beauty as the most important ecosystem service for wellbeing. This result held across groups based on type of ecosystem service use—marine, off-sector, and other (Figure 4). Although each sub-sample user group prioritized ecosystem services differently after scenic beauty (e.g., off-sector users prioritized variety and number of birds, marine users prioritized the ability to navigate the estuary, and other users prioritized space to recreate), all groups perceived scenic beauty as most important to wellbeing, by far. Participants also perceived scenic beauty as in the best current state (mean score of 8.166, out of 10, for total sample population), compared with the other 16 ecosystem services listed. User groups' mean scores for the importance of scenic beauty and its perceived state did not differ significantly (Table 1).

3.2.2. Scenic beauty in regard to potential synergies and tradeoffs from interventions

In addition to highly valuing scenic beauty for wellbeing, participants strongly supported developing small-scale tourism, creating a protected area for nature, and installing a lookout point for birds (Tables 1, 2, and 3). For these three interventions, user groups' mean scores did not differ significantly (Table 2). Over half of participants surveyed reasoned that the development of small-scale tourism would bring economic opportunities, and, in so doing, positively impact wellbeing. A minority (15 people) cited non-economic reasons for gains in wellbeing, most often reasoning that small-scale tourism would incentivize people to keep areas clean and trash-free, which in turn would make areas more beautiful. A few participants cited opportunities for cultural exchange. Only two marked very negative scores for small-scale tourism, specifying that tourism development should be large-scale.

Estuary residents also perceived gains in wellbeing from conservation interventions. Nearly half of participants explained their very positive rating for a protected area by citing the benefits for nature. Reasons of this type ranged from preserving terrestrial and marine species, to encouraging stewardship, to safeguarding scenic beauty. Several (23 people) cited tourism as a reason for strong support of a protected area. Only one person, who builds boats for a living, marked a very negative score, explaining that a protected area would result in a loss of work. Nearly 38% of participants who strongly supported installing a lookout point for birds cited reasons other than tourism. Reasons mostly included CES, such as opportunities to relax, admire scenic beauty, recreate as a family, learn more about local species, and educate younger generations. 26% of participants rated a lookout point highly because they thought it would draw tourists and, in turn, more economic resources and opportunities to the community.

Interventions that might potentially trade off with scenic beauty—i.e., filling wetlands to build infrastructure and introducing a salmon farm to the estuary—garnered mixed opinions, although user groups' mean scores did not differ significantly. For these development interventions, participants' mean scores for perceived impacts on wellbeing were near zero. However, individuals were hardly neutral on these interventions. While several participants marked wellbeing impacts at zero (unsure or indifferent), overall, scores appeared polarized—either negative or positive, thus averaging to zero.

Nearly half of participants marked neither strongly negative nor strongly positive impacts on wellbeing from filling wetlands (Table 4). Approximately 20% of participants strongly supported filling wetlands, most often reasoning that doing so signified progress or that people needed houses and roads. Several people thought this intervention would make the area appear cleaner (people often use wetlands here as a place to dispose refuse) and eliminate odors from stagnant water. For the 27% of residents who strongly opposed filling wetlands, most reasoned that doing so would result in flooding as well as a loss of life and habitat (birds would disappear). A few strong opponents reasoned that filling wetlands would negatively alter scenic beauty.

Introducing a salmon farm proved just as controversial. While half of participants marked neither strongly negative nor strongly positive impacts on wellbeing, approximately 29% strongly opposed and 22% strongly supported this development intervention. Most opponents reasoned that a salmon farm would pollute the estuary, sea, and coastal zone. Some spoke from experience as divers who have observed how salmon farms "kill everything underneath," including the algae *Gracilaria sp.*, shellfish, and native fish.

Conversely, supporters most often reasoned that a salmon farm would bring much needed employment opportunities.

4. Discussion

4.1. Practitioners and researchers best keep an open mind as to what people value

Rather than presume what people might value, we (researchers and practitioners) can ask. As this study has shown, any ecosystem service user, regardless of living in the developing or developed world and regardless of dependency on certain types of ESs, may in fact perceive CES, such as scenic beauty, as most important to wellbeing. We assert this with care, as we are sensitive to the fact that many people in both developing and developed world contexts struggle to meet the basic necessities of life.

As a corollary to this finding, we cannot overstate a need to employ mixed methods (e.g., qualitative, quantitative, spatial) to identify priority ecosystem services for wellbeing, although the use of such approaches is widely regarded among scholars (Creswell and Plano Clark, 2007) and increasingly commonplace in sustainability science and its on-the-ground efforts. In our case, we attribute the differences among results from key informant interviews and survey of estuary residents (i.e., 2 of 41 key informants explicitly spoke of scenic beauty, while the 168 survey participants overwhelmingly perceived scenic beauty as the most important of 17 aspects of the estuary for wellbeing) to differences in method, including a purposive versus territorial coverage sample design and question wording. Environmental values, and highly valued ESs, may be so entrenched in a society or culture that they go unarticulated, unless they are threatened, become scarce, or perhaps unless they appear on a list. This is the logic behind ecosystem service frameworks: to bring to the

forefront and to more explicitly convey the importance of that which sustains human life, so as to safeguard that which is often taken for granted.

For example, Warren-Rhodes et al. (2011) found that villagers who depended on mangroves for subsistence did not regard the cultural importance of mangroves separately, likely because mangroves served as the center of their lives and livelihoods. Similarly, informants may have taken scenic beauty as a given, and may not have recalled it as a benefit provided by the estuary until prompted with a list. Hence, this study further adds to a recognition that mixed methods prove to be a wise approach to elicit ESs, particularly, CES (Hernández-Morcillo et al., 2013).

At the same time, much work remains to better address diverse worldviews into ecosystem service frameworks that guide valuations. Existing ecosystem service frameworks may clash with worldviews in which people perceive nature as a holistic and inextricable unit, humans included (Satterfield et al., 2013; Winthrop 2014; Barnaud and Antona, 2014). Within such worldviews, the logic and exercise of identifying ESs as separate aspects of an ecosystem to prioritize seems to break down. Recent research is beginning to address such concerns through bridging cultural psychology with ecosystem service approaches to decision-making (Hicks et al., 2015).

4.2. Ecosystem service most valued also perceived as in the best state

Perhaps in efforts to acknowledge a diversity of ecosystem service users with varying types and degrees of dependency on ESs, we have implicitly assumed that certain types of people prefer certain ESs without fully acknowledging the cultural norms in which people's perceptions are embedded. In this study, residents most valued an ecosystem service—scenic beauty—that they also perceived as in the best state. Scenic beauty of land- and

seascapes of the south of Chile—and one of its gems, Chiloé—occupies a cornerstone of local culture. This culture traces back to a time when explorers like Darwin noted its rugged beauty, a recognition that developed into a national pride of place (Schell, 2013; Schaeffer and Smits, 2015). Thus, we would add local culture to a list of factors that influence perceptions of ecosystem service priorities and management interventions.

4.3. Ecosystem service priorities in regard to potential tradeoffs and synergies

Admittedly, scenic beauty involves terrestrial and marine ecosystems viewed above water, whereas the 10 interventions listed on the survey questionnaire mainly involved marine ecosystems underwater. We chose to include interventions considered by key informants in interviews, rather than our own ideas, so as to make the study more relevant to actors within the social-ecological system (Lele et al., 2013). Livelihood sources (in this case, marine resource extraction) might not directly trade off with scenic beauty and other CES (e.g., birds, space to recreate) enjoyed above water, though, depending on the degree of resource extraction, the number of birds that eat fish might decrease or the ability to navigate a boat freely might be impeded. Regardless, this leads to the question of how people would appreciate beauty and biodiversity underwater, where marine resource extraction would more directly trade off with these CES.

Yet, as some survey participants noted, filling wetlands to build infrastructure or introducing a salmon farm might negatively impact scenic beauty. Here, potential tradeoffs become clear: more job opportunities versus loss or compromised quality of ESs (Table 4). Future research could examine such perceived tradeoffs between CES and other ESs, such as provisioning services, so as to better understand how people make decisions when faced with tradeoffs among ecosystem service priorities.

Perhaps more interestingly, several participants perceived synergies through small-scale tourism and conservation interventions, which they reasoned might incentivize people to keep areas trash-free and maintain scenic beauty (Table 3). Thus, a priority ecosystem service, considered through the lens of plausible management interventions, spurs potential dialogue on how to safeguard what is perceived as most important for wellbeing. While such information can help managers develop strategies to promote ecosystem service priorities, understand how people perceive those priorities, ascertain why people prioritize certain ESs, and determine which situations constitute critical next steps. Such insights can help managers promote stewardship and foster more equitable access to ESs (Winthrop, 2014).

5. Conclusion

Practitioners and researchers should ask, rather than presume, what matters most to people in terms of wellbeing. In this empirical study, we have shown that any ecosystem service user, regardless of the degree of dependence on natural resources, may in fact perceive non-material CES, such as scenic beauty, as most important to wellbeing. Furthermore, exploring ecosystem service priorities vis-à-vis projected development and conservation initiatives yields insights into not only what people value, but also when, where, and why (Walker et al., 2014). Further probing into the reasoning behind perceived priorities would help practitioners and researchers develop more effective strategies to safeguard what matters most. Key questions for future research, then, include: How do people perceive ecosystem service priorities (i.e., as all-encompassing or as separate aspects that sum to a whole)? To what degree are perceptions of priorities for wellbeing amenable to ecosystem service frameworks? When faced with tradeoffs among priority ESs, how might people choose which to safeguard?

IV. From science to policy outcomes: How a cultural ecosystem service approach informed planning decisions in Chile[8]

1. Introduction

Ecosystem service approaches to decision-making, based on an understanding that ecosystems provide myriad benefits for people, have proven to be one way to make more explicit considerations that often go overlooked when allocating uses of land- or seascapes (Guerry et al. 2015; Halpern et al., 2013; Daily et al 2009; Daily 2000). While such approaches to decision-making are beginning to take hold, the services accounted for in these analyses tend to focus on the more tangible benefits (e.g., provisioning of food and freshwater), leaving out critical intangibles that are equally important to people (e.g., recreational, aesthetic, psychological, and spiritual benefits) (Chan et al., 2011; Chan et al., 2012*a*; Satz et al., 2013). These less tangible services are often grouped as "cultural ecosystem services" (CES) (MA, 2005; Russell et al., 2013). CES encompass both tangible cultural phenomena (e.g. sacred places), as well as intangible cultural traits or processes (e.g. worldviews) (Satterfield et al., 2013). Methods to understand CES include map-based, semi-structured interviews that elicit the meanings people attach to places (Raymond et al., 2009; Klain & Chan, 2012; Gould et al., 2015), spatial analyses that map CES using attribute values (Nahuelhual et al., 2013) or social media data (Wood et al., 2013; Richards & Friess, 2015), as well as techniques from cultural heritage conservation that capture the time-depth of CES (Tengberg et al., 2012). Including CES as explicit components of decision-making processes can lead to outcomes that better reflect local values. For

[8] Co-authors on this manuscript include Alvaro G. Montaña Soto, Robert Griffin, Anne D. Guerry, Jessica M. Silver, Jorge Valenzuela, and Spencer A. Wood.

example, on the West Coast of Vancouver Island, British Columbia, access to traditional fishing grounds and ceremonial areas guided spatial planning efforts (McKenzie et al., 2014).

Although decision-making processes guided by ecosystem service approaches emphasize the importance of CES, few processes explicitly incorporate CES into planning or policy and speak from experience in sharing lessons learned (Chan et al., 2012*b*; Martinez-Harms et al., 2015). Here, we begin to fill critical gaps in the literature by showing how spatial analyses of recreational opportunities and scenic quality informed land-use decisions concerning rural, undeveloped coastline in the Chiloé Archipelago (41°-43°S), Chile. Our efforts targeted two distinct types of decision-making processes. In a case at a local spatial scale with dialogue, we used maps of recreation to work with municipal stakeholders to zone parts of the municipality for small-scale nature- and culture-based recreation and tourism. In a second case at a national spatial scale without dialogue, we included maps in observations submitted to national government authorities during the public participation phase of an environmental impact assessment that showed how a projected industrial-scale wind farm would affect the scenic quality of undeveloped coastline. In both decision-making contexts, maps of CES contributed information previously absent from decision-making tables. Based on our experience, we share lessons learned in working at these interfaces of science and policy across municipal, regional, and national spatial scales. Indeed, more comprehensive spatial planning can result from including CES information in environmental decision-making. We found that relaying information through maps, connecting information to lives and livelihoods, and engaging

with decision-makers early in a process—essential steps to see any science into policy—allowed us to explicitly incorporate CES into decision-making processes.

2. Background of decision-making contexts

As developing countries turn to small-scale tourism as an alternative to resource-dependency, and look to renewables for energy security amid climate change, collective decisions that designate terrestrial and marine space to new, emerging uses are becoming commonplace. Like other rural regions of the developing world, Chiloé is experiencing rapid industrialization. Offshore salmon aquaculture transformed the eastern fjords of Chiloé in the 1980s and 90s during a marked absence of planning to manage environmental and socio-cultural impacts (Barton & Floysand, 2010). Consequences of such include an inland sea saturated by salmon farming infrastructure (Outeiro & Villasante, 2013) as well as eutrophication that likely plays a role in more frequent and severe algal blooms. Today, Chiloé's undeveloped, exposed coast is slated for the development of industrial-scale wind energy (Ministry of Energy, 2014). Transnational developers own these projects, which address increased demand for renewable energy on mainland Chile (Ministry of Energy, 2012). This emerging land-use presents potential tradeoffs and synergies that warrant consideration in siting decisions. Yet, the ability to assess how this emerging land-use impacts local lives and livelihoods exceeds the scope of local authorities' capacity.

While decision makers are working to clarify types of development desired (e.g., endogenous versus exogenous), planning efforts continue to be piecemeal at municipal scales. More and more, citizens are defining long-term visions for the province, with directives that challenge exogenous models of development. Statements from indigenous

communities and youth, in particular, call for development in accordance with, and respectful of, the cultural and natural heritage of the Archipelago (Comité Pensar Chiloé, 2013; Tercer Congreso Williche, 2014). These concerns stem from histories of a region and peoples disenfranchised in decision-making processes (Grenier, 1984). The case of Chiloé echoes many others around the world, which prompt the question: How can decision makers integrate the cultural benefits of nature into spatial plans, and consider cultural concerns of new development, while undergoing rapid sea- and land-use change?

2.1. Using maps of recreational opportunities to zone small-scale tourism

The ten municipalities that comprise the province of Chiloé, part of Chile's Lakes Region, market themselves as destinations for nature- and culture-based tourism. However, the National Chilean Tourism Service (SERNATUR) promotes a different vision for the province. SERNATUR (2011) includes only the World Heritage Churches of Chiloé, clustered along the inland coast, as sites of interest to foreigners (Figure 7). Yet the recreational opportunities on Chiloé are much broader with both foreigners and locals frequenting the exposed Pacific coast, which is home to largely unexplored sites of historical importance (e.g., middens), sandy beaches, penguin colonies, and world-class birding (SERNATUR, 2008). This mismatch between municipal and state visions of tourism—and the potential for improved tourism development strategies —offered an opportunity to show the breadth of recreation across Chiloé. Here, we used modeling efforts to demonstrate a broader base for tourism beyond Chiloé's churches. In working with municipal decision makers, we made visible the multi-attribute nature of recreation, underscored the potential of a broader territory that encompassed multiple attributes of recreation, and proposed zoning for tourism as a means to leverage recreational opportunities while conserving emblematic

land and seascapes. As a result, a process is underway to declare a section of the municipality a zone of tourist interest.

2.2. Accounting for scenic quality tradeoffs in an environmental impact assessment

Large, industrial-scale energy projects, like those proposed in Chiloé, undergo processes of environmental impact assessment, which environmental authorities from the national government evaluate on a case-by-case basis. While environmental impact assessments in Chile meet regulatory requirements, the role of science—and what constitutes credible science—in such decision-making processes remains questionable (Barandiarian, 2015). The process we targeted allowed for one opportunity to convey CES information. In a written report submitted during a phase of public participation, we showed how proposed development would affect views of undeveloped exposed coast valued for its recreational and tourism opportunities, cultural heritage and identity, scenic beauty, and open space. If tradeoffs in scenic quality were made visible and put forth, then Chile's Regional Impact Assessment Service could take into account considerations absent from environmental impact reports submitted by the bidding developer. This decision-making context proved to be much more difficult to influence, as national government authorities seem to rubberstamp most energy development projects in order to meet the needs for renewable energy outlined in legislature (Ministry of Energy, 2012).

3. Methods

3.1. Study area

We applied a cultural ecosystem service approach to inform land-use decisions in Lacuy Peninsula (ca. 339 km^2) the northwestern extremity of the main island of Chiloé, which

corresponds to the Municipality of Ancud. Lacuy is one of Chiloé's most important hubs for nature-based recreation, an activity sought by nearly every visitor (SERNATUR, 2008). Lacuy is also a proposed site for the development of wind energy facilities at an industrial scale. This emerging land-use in the Chiloé Archipelago potentially trades off a local sense of place to benefit the national energy grid. If built, the project would supply 100.8 MW of renewable energy to mainland Chile, at the cost of industrializing undeveloped coast.

Lacuy's 181 km coastline encompasses sandy beaches, dunes, and rocky islets, three of which—Puñihuil Islets National Monument (DS 130/1999)—house Humboldt and Magellanic penguins, the largest of a few known places where both species nest (Simeone et al., 1998). Southern right and blue whales feed and nurse in surrounding waters, and inspire initiatives to conserve marine habitat through ecotourism (Galletti et al., 2012). In this rural area, households of indigenous Williche Mapuche and mixed Chilote ancestry, totaling 3,600 people, make livings as shellfish divers, coastal gatherers, and farmers. Several households have small adventure-, ethno-, and agritourism businesses. Infrastructure for recreationalists includes hiking trails, campsites, and newly paved roads—a USD $15 million investment (MOP, 2013). According to the latest record made by ecotourism operators, 19,765 people took a boat tour in 2011. Thus, estimated visitation to Lacuy compares to Chiloé National Park, which drew 20,950 visitors in 2011 (CONAF, 2011).

3.2. Modeling cultural ecosystem services

We used models from the Integrated Valuation of Ecosystem Services and Tradeoffs (InVEST) toolbox to map current recreational opportunities in Lacuy and project how proposed wind energy development would affect the Peninsula's scenic quality. InVEST is open source software that allows users to explore changes in ecosystem services across

different potential futures, and assess tradeoffs among these scenarios. Designed for iterative use in decision-making processes, InVEST tools yield spatially explicit information that can broaden discussions (Kareiva et al., 2011; Guerry et al., 2012).

3.2.1. Recreational opportunities

To map current visitation to Lacuy, we applied the InVEST Recreation model, which estimates the spread of person-days of recreational use in space based on the locations of geotagged photographs posted to the social media website Flickr (Wood et al., 2013; Sharp et al., 2015; Keeler et al., 2015). Several recent studies comparing methods for measuring visitation rates have shown that the density of photographs is positively correlated with visitor counts using traditional survey methods (Wood et al. 2013; Keeler et al., 2015). Although this method does not capture visitors without cameras or those who do not upload images to Flickr, it presents a quicker and more cost effective method compared to *in situ* surveys (Wood et al., 2013). And this approach can be used to successfully model which areas attract relatively more visitors and why (e.g., Arkema et al. 2015). We defined the area of interest as Lacuy Peninsula, based on administrative boundaries used by the Statistics Institute of Chile.

3.2.2. Scenic quality

To assess the visibility of 42 proposed turbines on Lacuy's coast, we used the InVEST Scenic Quality model, a raster-based viewshed tool that measures the visibility of features on the landscape given the local topography. The model classifies impacts as low, medium, high, and very high, according to quartiles based on the percentage of area visually affected by turbines (Sharp et al., 2015; Griffin et al., 2015). We obtained turbine locations from a

report submitted by the bidding company (Ecopower S.A.C., 2013), and took a turbine height of 120 meters, from the same report. We considered a circumference of 20 kilometers around each turbine, a range where turbines appear less distinct yet rotor movement appears visible (Sullivan et al., 2013). We defined the area of interest as Lacuy, based on the aforementioned boundaries used by the Statistics Institute of Chile. Cables from the wind farm to the mainland presented additional visual impacts; yet, due to their height at tree line, we could not discern cables and thus did not assess their impacts. To evaluate where views of proposed turbines overlapped with areas of import for recreation and tourism, we overlaid the map of visual impacts on the map of visitation to Lacuy (Figure 8).

3.3. Engaging decision makers

We targeted these spatial assessments of CES toward two opportunities to inform coastal land-use planning: one that allowed for iterative dialogue and one that allowed for one-way written communication. In the former, we discussed with municipal officials and local small-scale tourism operators how maps of recreational opportunities could help design zoning for nature- and culture-based recreation and tourism. In the latter process of environmental impact assessment, we used maps of scenic quality to report the proposed wind farm's visual impacts. In both processes, we adapted communication of CES assessments to target audiences.

3.3.1. Iterative dialogue with municipal stakeholders

Between September 2013 and June 2014, authors AGMS and TLE met with local tourism operators, regional SERNATUR officials, and municipal officials to discuss maps of recreational opportunities. We first met individually with a few officials, and then with local

tourism operators. In these meetings, we listened carefully and recorded how people interpreted maps and how they thought the information could benefit the Municipality. We then used this feedback to hone communication with larger audiences that included decision makers with more authority. Upon meeting with the mayor of Ancud, we proposed that the Municipality solicit Lacuy as a Zone of Tourist Interest, a designation that recognizes the special conditions of a determined area that attract visitors, and requires integrated planning to conserve what makes that area special (Law 20.243, 2010).

3.3.2. One-way communication with regional environmental assessment service

The decision-making process for the proposed wind farm did not allow for iterative feedback. Rather, we had one opportunity to communicate findings to the Environmental Assessment Service of Chile's Lakes Region, decision makers who review projects and either grant or reject permission to proceed with proposed development. Thus, we shared maps of visual impacts on scenic quality in a written report submitted during the public participation phase of the environmental impact assessment process (CECPAN, 2014).

4. Results

4.1. Spatial analysis of recreational opportunities

The resulting map of visitation to Lacuy showed, as anticipated, a more extensive zone of touristic interest than that identified by SERNATUR. The InVEST Recreation model results suggest that visitors recreate along the entire perimeter of Lacuy, with a well-defined corridor along the exposed Pacific coast (Figure 8). Whereas the map made by SERNATUR (Figure 7) displayed ten points in Lacuy defined as tourist attractions, results from the

InVEST Recreation model showed clusters of visitation, which underscored the multi-attribute nature of recreational opportunities across a broader territory.

4.2. Spatial overlap analysis of wind energy development in recreational areas

The map of spatial overlap made visible the impact of turbines on views from areas deemed important to recreation and tourism (Figure 9). We found that proposed turbines appeared visible from nearly everywhere, including the city of Ancud and the perimeter of Lacuy Peninsula—the same areas frequented by recreationalists. Furthermore, the analysis showed that rural households on the western coast of Lacuy would be most impacted, measured in terms of households' proximity to turbines and views affected by turbines.

4.3. Outcomes from decision maker engagement

In the meetings we convened with municipal stakeholders, maps contributed new information to decision makers on the locations of popular recreation areas and how proposed wind energy developments will impacts views of and from these locations. Meeting participants discussed the maps of recreational opportunities and what the information implied for the Municipality. Local tourism operators joined municipal officials in planning how to better leverage recreational opportunities and capture benefits for the local economy. Municipal stakeholders considered giving Lacuy Peninsula a special designation, zoning it a priority area for tourism.

Maps of visual impacts and spatial overlap, submitted as observations to the Regional Environmental Assessment Service, conveyed information that did not appear in reports of environmental impacts completed by the bidding company (CECPAN, 2014). Ecopower S.A.C. responded to observations from the public in their third and final report of impacts

(Ecopower S.A.C., 2015). The decision-making process did not allow for further public participation.

5. Discussion

5.1. Reflections on outcomes from decision maker engagement

Zoning and more comprehensive planning resulted from explicitly incorporating CES into the decision-making processes we described. In the process with dialogue, maps that showed the multi-attribute nature of recreational opportunities across a broader territory allowed us to discuss with municipal stakeholders the opportunity to zone areas for nature- and culture-based tourism. In the process without dialogue, CES information contributed to a more extensive review of environmental impacts posed by the industrial-scale wind farm proposed for Lacuy's undeveloped coast.

5.1.1. Zoning for recreation and tourism in progress

Nine months after our first meetings with officials, the mayor declared zoning for tourism a municipal priority (Municipality of Ancud, 2014). In considering this first step of success, we cannot overstate the value of engaging decision makers early. Initial meetings with municipal officials yielded valuable feedback that was used to hone communication with decision makers of more authority as the process grew from just mapping recreation to discussing strategies for encouraging nature- and culture-based tourism. For example, local municipal officials mentioned that zoning for tourism would coincide with current efforts to develop a Plan for Communal Development, a process to prioritize municipal projects. Then, when we presented the initiative to the mayor, we emphasized this timeliness: zoning for tourism complimented planning underway.

Iterative feedback also helped build a broader base of support for the zoning initiative. In effect, maps brought up new discussions with a wider range of stakeholders. The meetings we convened brought local tourism operators into dialogue with municipal officials about the future of Lacuy. While everyone already knew Lacuy attracted visitors, the maps served as powerful visuals that highlighted the area's import for the local economy. While the low-density, widespread visitation seen in Lacuy (Fig. 2) potentially benefits more local vendors, existing infrastructure did not match this spatial distribution. Zoning offered a useful means to manage visitation that spilled over official infrastructure, as well as a way to attract national funds to promote nature- and culture-based tourism.

5.1.2. Scenic quality tradeoffs reviewed by environmental assessment service

A year and a half after we submitted observations of visual impacts, the Regional Environmental Assessment Service approved the project's development. That said, we emphasize the value of putting information on the table. Decision makers' actions depend on many factors at play when science interfaces with policy (Section 4.2.).

The report we submitted to environmental authorities communicated two new considerations: (1) how turbines visually impacted areas deemed important for recreation and tourism, and (2) how turbines visually impacted rural households (CECPAN, 2014). While visual *impact* connotes a negative perception of viewing wind farms, some would argue that wind farms could draw more tourism, and that residents might enjoy living close to turbines, or find them innocuous.[9] Regardless, it is important that impact assessments

[9] The literature supports different conclusions across a range of geographies. Land-based studies on wind farms using hedonic analysis of real estate values have found that property values remained the same after the introduction of visible turbines (Heintzelman and Tuttle, 2012; Lang et al, 2014; Vyn and McCullough, 2013). However, Ladenburg and

consider people and views exposed. Our analysis highlighted potential tradeoffs in scenic quality—aspects to consider in relation to current visitation as well as future visitation, particularly if tourism matures into a source of livelihood for more residents. The analysis also conveyed a count of households within 500 meters of turbines—key information to evaluate impacts on human wellbeing. Tracing consequences of turbine visibility to metrics of human wellbeing, such as changes in property value or effects of sound on health, went beyond the scope of the study. However, our analysis provided a baseline assessment of exposure: where turbines would be visible, and which households and areas would be most visually impacted, considerations hitherto absent from the decision-making table.

5.2. Insights from interfaces of science and policy

Science-policy interfaces present complex terrain. Pathways to impact vary across places and cultures, change over time, and involve politics. Nonetheless, decisions continue to be made. Ideally, decisions will be based on the best knowledge available, and yield better outcomes for ecosystems that sustain people (Daily et al., 2009). In applying a CES approach to the decision contexts described here, we learned that steps to get CES onto decision-making tables involve similar steps to see any science inform policy: relate

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Duubgard (2007) and Krueger et al (2011) found a positive willingness to pay for moving offshore wind turbines farther out to sea and, hence, an aversion to locating them close to people. In terms of public opinion, there is negative perceived association of wind farms and visibility based on research in the U.S. (Firestone and Kempton, 2007), Denmark (Ladenburg, 2008), U.K. (Jones and Eiser, 2010), and the Netherlands (Wolsink, 2010). Molnarova et al (2012) found a similar result in the Czech Republic. Their survey results indicate that people who live farther away from on-shore turbines (beyond 6km) showed more sensitivity to siting turbines in an attractive landscape versus those who live closer than 6km. This sensitivity seems to stem from peoples' inexperience with turbines, though there could be unexplored endogeneity—(1) geographic sorting after siting, or (2) turbines are installed where people favor wind farms versus where people resist wind farms.

information through effective visuals, connect information back to people and their wellbeing, and engage early with decision makers.

5.2.1. Maps open discussion with a range of audiences

Maps—whether snapshots of the spatial distribution of recreationalists, or projections of visual impacts based on an assumed scenario—allowed us to communicate information of CES to a range of audiences, including municipal officials navigating development directions, regional authorities assessing impacts of proposed development, and local residents forming opinions about types of development desired. With the maps, we were able to communicate cultural benefits of nature, as well as cultural considerations related to proposed development, in more concrete terms with audiences. In working with municipal stakeholders on zoning for recreation and tourism, maps elicited feedback, a key part of the iterations involved in seeing science inform policy. For example, we used feedback from one-on-one meetings with officials to pitch the zoning initiative to a larger audience, and, eventually, the mayor (Section 4.1.1.). Thus, maps can spark ideas for how to frame communication toward target audiences, steps that save time.

5.2.2. People listen when information connects to livelihoods and ways of life

Just as maps facilitated communication, information relevant to livelihoods and ways of life captured the attention of government officials and local residents. When we shared maps of CES, officials voiced concerns based on the interests of their constituents, and residents cared about how proposed land- and sea-use changes would affect everyday life. Therefore, to increase the likelihood that science inform policy, researchers and practitioners can continue to assess links between ecosystems and human wellbeing, while taking care to report uncertainty (Ruckelshaus et al., 2015). Links need not trace consequences of change

in ecosystem services to livelihood outcomes. Baseline assessments of people and places exposed to visual impacts, for example, communicate tradeoffs to consider when deciding if and where to site development (Section 4.1.2).

5.2.3. Decision-making processes take time and trust—start early

The aforementioned insights hinge on time and space dedicated to dialogue. In our experience, windows of policy opportunity drew from working relationships between NGO resident scientists and government officials that had developed over years. To solidify these ongoing conversations, resident scientists held a series of meetings with officials and local tourism operators to discuss how information of ecosystem services could inform planning decisions (Section 2.3.1). The meetings fostered mutual trust, which in turn contributed to collaboration toward the policy outcome of municipal zoning. In decision contexts that do not allow for dialogue, namely environmental impact assessments, an early start proves even more critical because, often, there is only one opportunity to communicate considerations. Preparing communication that targets such opportunities requires lead-time, as well as familiarity with protocol (e.g., when and how to submit observations).

6. Conclusion

In sum, while it seems difficult to integrate CES information into decision-making processes, doing so can result in more comprehensive planning. We found that explicitly incorporating cultural benefits of nature into spatial plans involves the same fundamentals to incorporate other ecosystem services, or any knowledge, into policy. Once CES enter into the discussion, questions then come down to what matters most to the people doing the deciding. Regardless of whether or not CES dictate decisions, their inclusion in deliberation

can only benefit decision-making processes. Discussions become that much more informed because a wider range of considerations can be taken into account.

CES that remain off of decision-making tables may be interpreted through, or bundled with, CES or other ecosystem services that lend more readily to measurement. Particularly for CES that do not lend to quantitative measurement, such as a sense of place or cultural heritage and identity, there is a need to continue developing tools that capture the diversity of CES and the worldviews from which they extend (Chan et al. 2012*b*; Milcu et al. 2013; Gould et al., 2015). At the same time, and perhaps more importantly, there is a need to put CES onto decision-making tables and reflect on lessons learned from doing so.

V. Conclusion

This dissertation presented a methodological framework to elicit people's ecosystem-related values and management preferences, showed how to decipher the importance of nature's intangible benefits to the wellbeing of natural-resource dependent communities, and shared lessons learned from integrating the cultural benefits of nature into decisions concerning rural, undeveloped coastline. Then, how is decision-making within spatial planning affected by considering the human dimensions of land and seascapes, in addition to layers of biophysical and economic sector data?

Each of the three chapter-manuscripts has demonstrated ways to create data inputs that relay human dimensions of land and seascapes, including people's ecosystem-related values and management preferences, as well as the meanings people attach to places that develop over time and, consequently, involve high stakes. Chapters II and III discussed how insights might assist managers and community actors. First, keeping an open mind as to what people value can help ensure that ecosystem service priorities are accurately identified, a key step in efforts to safeguard what matters most to people. Second, applying a methodological framework to assess ecosystem service priorities and perceived states of services can help target efforts and identify interventions that garner potential community-wide support or conflict. Finally, Chapter IV, in more explicitly addressing the over-arching question, showed how information on the cultural benefits of nature, put forth on decision-making tables, benefitted decision-making processes by including considerations hitherto absent.

Thus, decision-making within spatial planning clearly benefits from integrating social layers of data in addition to biophysical and economic sector data. At the same time, as Chapter IV discusses, decision-making processes are affected by a number of other factors

beyond data availability, access, and analysis. Speaking from my personal experience in completing this research, I have gained an appreciation for critical additional factors that can influence environmental decision-making. These include politics and agendas at play across different spatial scales, formal and informal rules and norms, and broader systemic context such as climate change and global capitalism. I am convinced that communicating effectively to the right people at the right time is as important as the science itself (or the conceptual framework, policy implications, etc.) in order to effectively bridge science into policy. That, and patience and persistence.

In looking forward, future research could usefully address a main concern that arose from this dissertation: to what extent can ecosystem service frameworks do justice to differing worldviews? How might we make such frameworks more inclusive of different worldviews? Tradeoff analyses and indifference curves (and ecosystem service valuations, implicitly) rest on the logic that nature's benefits may be divided into individual benefits that are comparable amongst each other. Yet, this logic seems incompatible with worldviews that perceive nature as a whole comprehensive unit. One way to chip away at this concern is to follow up on the importance of scenic beauty in order to understand how different people perceive an intangible cultural benefit of nature as so critical to wellbeing. Another approach would involve examining access to ecosystem services across spatial and temporal scales, for ecosystem service priorities can differ widely according to *whose* wellbeing is of concern (e.g., does national and global wellbeing from clean energy trump local wellbeing from undeveloped coastline being preserved?). Key to either of these future directions will be an ability to move beyond criticizing or identifying flaws to contributing toward improved

outcomes and solutions. To accomplish the latter, working with a team of committed and diverse yet like-minded people may be a fruitful way forward.

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Table 1. Similarities and differences in user groups' mean perceptions of the importance of ecosystem services to wellbeing (left columns) and current state of each service (right columns).

			Perceived importance to wellbeing						Perceived state of ecosystem service					
	Category of Ecosystem Service	Ecosystem Service	Total *n* (*SE*)	Marine (*SE*)	Off-sector (*SE*)	Other (*SE*)	*P*		Total *n* (*SE*)	Marine (*SE*)	Off-sector (*SE*)	Other (*SE*)	*P*	
Similarities														
	Cultural	Scenic beauty	9.2 (0.132)	9.3 (0.166)	8.9 (0.266)	9.2 (0.307)	0.771		8.2 (0.281)	7.8 (0.435)	8.7 (0.313)	8.3 (0.935)	0.548	
	Cultural	Variety and number of birds	6.5 (0.319)	6.8 (0.448)	6.0 (0.583)	6.6 (0.666)	0.357		4.8 (0.375)	5.1 (0.576)	4.3 (0.618)	5.3 (0.658)	0.298	
	Provisioning	Presence of edible algae (luche, cochayuyo)	5.7 (0.387)	5.9 (0.567)	5.5 (0.656)	5.5 (0.871)	0.544		2.6 (0.478)	2.0 (0.719)	2.9 (0.778)	4.1 (0.997)	0.515	
	Regulating	Tidal flow of salt water in the river	5.6 (0.386)	6.5 (0.485)	5.0 (0.732)	4.0 (0.987)	0.055		5.1 (0.407)	5.7 (0.530)	4.3 (0.797)	5.0 (0.868)	0.417	
	Provisioning, Regulating, Supporting	Wetlands and peat lands that serve as reservoirs of freshwater	5.1 (0.415)	5.7 (0.578)	4.7 (0.747)	4.0 (0.918)	0.075		0.4 (0.456)	0.4 (0.638)	0.0 (0.774)	1.6 (1.228)	0.56	
	Regulating	Ability to eliminate greywater and drainage from houses	2.1 (0.597)	2.8 (0.839)	2.7 (0.956)	-1.8 (1.592)	0.051		-0.7 (0.583)	-0.5 (0.859)	0.2 (0.951)	-3.2 (1.309)	0.159	
	Provisioning	Presence of other commercial algae (luga)	1.8 (0.532)	2.7 (0.755)	0.6 (0.864)	1.2 (1.437)	0.088		0.4 (0.438)	0.1 (0.669)	0.1 (0.666)	2.2 (0.998)	0.188	
Differences														
	Cultural	Space to recreate and practice sports	6.3 (0.418)	6.9a (0.545)	4.8b (0.842)	7.6 (0.557)	0.043	**	3.2 (0.526)	2.7 (0.769)	2.8 (0.906)	6.2 (0.931)	0.088	
	Provisioning, Regulating, Supporting	Support for the growth of native forest	6.2 (0.376)	6.4 (0.570)	6.0 (0.559)	6.1 (1.006)	0.423		2.6 (0.434)	1.7b (0.665)	3.1 (0.584)	4.9a (1.14)	0.033	**
	Cultural, potentially Provisioning	Space to develop tourism	6.1 (0.460)	7.1a (0.557)	4.9b (0.875)	5.5 (1.323)	0.046	**	2.3 (0.530)	1.3 (0.771)	2.6 (0.874)	5.2 (1.127)	0.095	
	Provisioning	Presence of natural shellfish banks (mussels, clams, oysters)	5.9 (0.378)	6.9a (0.456)	4.3b (0.734)	5.9 (0.902)	0.001	***	3.5 (0.378)	3.7 (0.544)	2.5 (0.659)	5.2 (0.704)	0.082	
	Cultural	Spiritual space	5.7 (0.413)	6.3a (0.561)	4.1b (0.731)	7.4a (0.936)	≤ 0.033	**	3.5 (0.498)	3.7 (0.704)	2.1b (0.836)	6.4a (1.130)	0.006	***
	Cultural	Space to practice traditional activities with family	5.5 (0.419)	6.8a (0.448)	3.7b (0.869)	5.4 (1.074)	0.011	***	3.2 (0.479)	3.1 (0.703)	2.4 (0.816)	5.2 (0.954)	0.224	
	Provisioning	Ability to navigate the estuary	5.5 (0.440)	7.4a (0.444)	2.7b (0.872)	5.4 (1.139)	0.000	***	5.0 (0.433)	5.4 (0.629)	4.4 (0.727)	5.3 (1.040)	0.347	
	Provisioning	Presence of fish (robalo, pejerrey)	5.2 (0.410)	6.1a (0.520)	3.9b (0.765)	4.8 (1.076)	0.022	**	3.4 (0.399)	3.88a (0.577)	2.16b (0.673)	4.6 (0.833)	0.038	**
	Provisioning	Quantity and quality of commercial algae *Gracilaria*(pelillo)	3.7 (0.494)	6.2a (0.573)	1.0b (0.843)	1.5b (1.373)	≤ 0.002	***	1.5 (0.408)	1.3 (0.574)	1.4 (0.679)	2.9 (1.102)	0.37	
	Provisioning, Cultural	Presence of vegetable fibers (junquillo, quilineja) to make crafts	3.1 (0.475)	2.6 (0.707)	2.8 (0.796)	5.6 (0.870)	0.149		4.1 (0.398)	4.6a (0.596)	2.9b (0.650)	5.2 (0.759)	0.037	**

Symbols show significant differences among group perceptions based on Kruskal-Wallis and Dunn's posteriori tests. User groups that are not statistically significant share the same letter.

Size of user groups: Total n = 168. Marine*n* = 86, Off-sector*n* = 58, and Other *n* = 24. Interviewees marked responses on a continuous line with two anchor points "very important" or "very good" (= +10) and "not important at all" or "not good at all" (= -10), and a clear "indifference" or "I don't know" line in the middle (= 0). Responses were thus recorded as positive or negative distances from the central zero point.

Table 2. Similarities and differences in user groups' mean perceptions of how potential interventions would impact personal and familial wellbeing (left columns), as well as the environment (right column).

			Perceived impact on wellbeing					Perceived impact on the environment				
	Typology	Intervention	Total *n* (*SE*)	Marine (*SE*)	Off-sector (*SE*)	Other (*SE*)	*P*	Total *n* (*SE*)	Marine (*SE*)	Off-sector (*SE*)	Other (*SE*)	*P*
Similarities												
	New use	Development of small scale tourism	7.6 (0.263)	7.5 (0.365)	7.7 (0.400)	7.4 (0.893)	0.926	4.8 (0.332)	5.0 (0.464)	4.4 (0.569)	5.1 (0.885)	0.547
	Conservation	Creation of a protected area for nature	7.5 (0.271)	7.3 (0.414)	7.8 (0.334)	7.7 (0.881)	0.722	5.0 (0.344)	5.2 (0.481)	4.7 (0.546)	4.5 (1.065)	0.632
	Conservation	Installation of a lookout point to observe birds	7.5 (0.228)	7.6 (0.315)	7.2 (0.425)	8.3 (0.461)	0.331	4.8 (0.329)	5.0 (0.450)	4.2 (0.581)	5.4 (0.866)	0.431
	New use	Establishment of a mussel farm (seed)	4.8 (0.448)	5.4 (0.644)	4.3 (0.730)	4.0 (1.193)	0.102	2.3 (0.359)	2.9 (0.534)	1.6 (0.549)	2.0 (0.923)	0.344
	Expand use	Installation of a new shellfish processing plant	4.2 (0.499)	4.5 (0.695)	5.0 (0.705)	1.3 (1.683)	0.261	0.3 (0.460)	0.1 (0.623)	1.0 (0.783)	-0.7 (1.350)	0.389
	New use	Establishment of a salmon farm (smolt)	0.2 (0.575)	-0.9 (0.829)	2.0 (0.899)	0.1 (1.537)	0.192	-2.2 (0.494)	-3.4 (0.692)	-0.8 (0.793)	-1.2 (1.353)	0.078
	Development	Filling wetlands to build roads and houses	-0.7 (0.546)	-0.2 (0.736)	-1.6 (0.993)	-0.1 (1.391)	0.465	-3.6 (0.493)	-3.1 (0.715)	-4.4 (0.795)	-3.8 (1.305)	0.469
Differences												
	Expand use	More *Gracilaria* algal farms	7.0 (0.334)	8.7a (0.197)	5.5b (0.651)	4.3b (1.267)	≤ 0.001 ***	3.3 (0.337)	4.0 (0.518)	2.3 (0.460)	3.2 (0.878)	0.082
	Renew use	Reseeding natural shellfish banks	7.0 (0.319)	8.0a (0.358)	5.8b (0.629)	6.1b (0.885)	≤ 0.014 ***	3.9 (0.350)	4.6 (0.498)	3.1 (0.594)	3.7 (0.840)	0.180
	Restrict use	Establishment of territorial user rights fishery	1.9 (0.549)	0.5b (0.837)	4.1a (0.717)	1.5 (1.456)	0.028 **	0.8 (0.406)	0.3 (0.624)	1.2 (0.588)	1.3 (1.044)	0.576

Symbols show significant differences among group perceptions based on Kruskal-Wallis and Dunn's posteriori tests. User groups that are not statistically significant share the same letter.

Size of user groups: Total n = 168. Marine n = 86, Off-sector n = 58, and Other n = 24. Interviewees marked responses on a continuous line with two anchor points "very important" or "very good" (= +10) and "not important at all" or "not good at all" (= -10), and a clear "indifference" or "I don't know" line in the middle (= 0). Responses were thus recorded as positive or negative distances from the central zero point.

Table 3. Participants' reasoning behind scores for perceived impact of on wellbeing for interventions with the greatest support, interpreted as potential synergies to promote and safeguard scenic beauty.

Typology	Intervention	Mean score *(SE)*	Percent of *n*	Number of participants
New use	Development of small scale tourism	7.6 (0.263)		
	Did not mark score between +/-7 and +/-10		32.1	54
	Economic reasons		53.6	90
	Other reasons, not economic		8.9	15
	Vague "good"		4.2	7
	Bad: tourism should be large scale		1.2	2
Conservation	Creation of a protected area for nature	7.5 (0.271)		
	Did not mark score between +/-7 and +/-10		32.7	55
	Good for nature		45.8	77
	Good for tourism		13.7	23
	Vague "good"		7.1	12
	Bad: results in loss of work		0.6	1
Conservation	Installation of a lookout point to observe birds	7.5 (0.228)		
	Did not mark score between +/-7 and +/-10		36.3	61
	Good for other reasons besides tourism		37.5	63
	Good for tourism		26.2	44

Survey sample population n = 168. Participants marked responses on a continuous line with two anchor points "very good" (= +10) and "not good at all" (= -10), and a clear "indifference" or "I don't know" line in the middle (= 0). Responses were thus recorded as positive or negative distances from the central zero point. Reasoning behind score was recorded for any scores marked between +/-7 and +/-10.

Table 4. Participants' reasoning behind scores for perceived impact of on wellbeing for interventions with mixed reviews, interpreted as potential tradeoffs that might diminish scenic beauty.

Typology	Intervention	Mean score *(SE)*	Percent of *n*	Number of participants
Development	Filling wetlands to build roads and houses	-0.7 (0.546)		
	Did not mark score between +/-7 and +/-10		53.0	89
	Bad to fill for various reasons		27.4	46
	Good to fill for various reasons		19.6	33
New use	Establishment of a salmon farm (smolt)	0.2 (0.575)		
	Did not mark score between +/-7 and +/-10		50.0	84
	Bad, for various reasons, mainly pollution		28.6	48
	Good, for various reasons, mainly more work opportunties		21.4	36

Survey sample population n = 168. Participants marked responses on a continuous line with two anchor points "very good" (= +10) and "not good at all" (= -10), and a clear "indifference" or "I don't know" line in the middle (= 0). Responses were thus recorded as positive or negative distances from the central zero point. Reasoning behind score was recorded for any scores marked between +/-7 and +/-10.

Figure 1. A 2016 Google Earth image of the Chiloé Archipelago, Reloncaví Sound, and Chiloé Continental (mainland Chile) that depicts active marine concessions as of July 2013, delineated in orange. Marine concessions include state-granted territorial rights to cultivate species of salmonids, algae, and shellfish.

Figure 2. A diagram that conveys the purpose of the research: to contribute toward more comprehensive spatial planning based on layers of human dimensions—defined as people's ecosystem-related values and management preferences, in addition to economic sector and biophysical data.

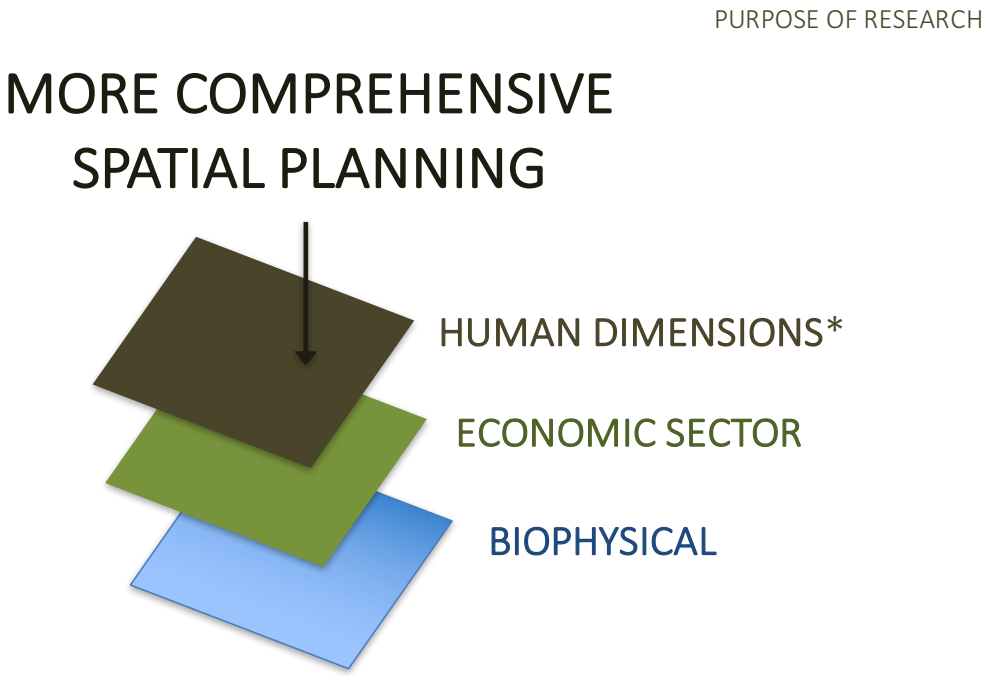


Figure 3. Indifference curves show preferences for ecosystem services 1 and 2, whose possible combinations appear along an efficiency frontier. In this example, the decision maker is indifferent between the combinations of services represented by x' and x'' and prefers x'''. Figure adapted from Keeny & Raiffa (1976) and Lester et al. (2013).

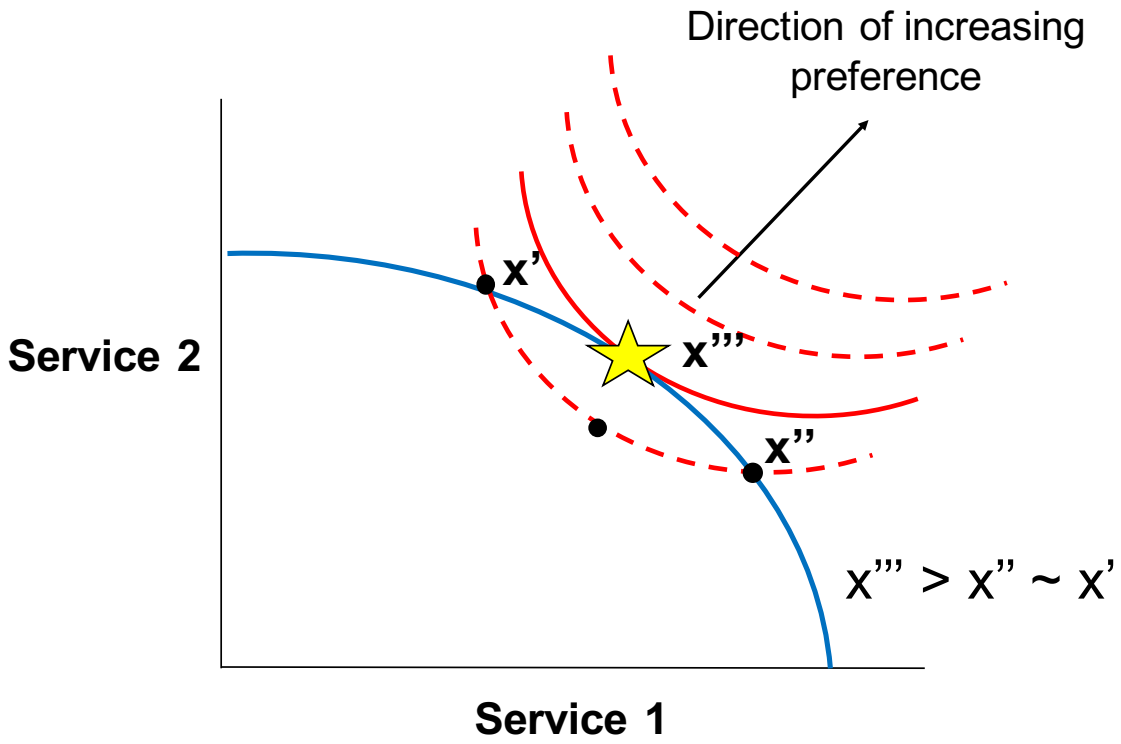
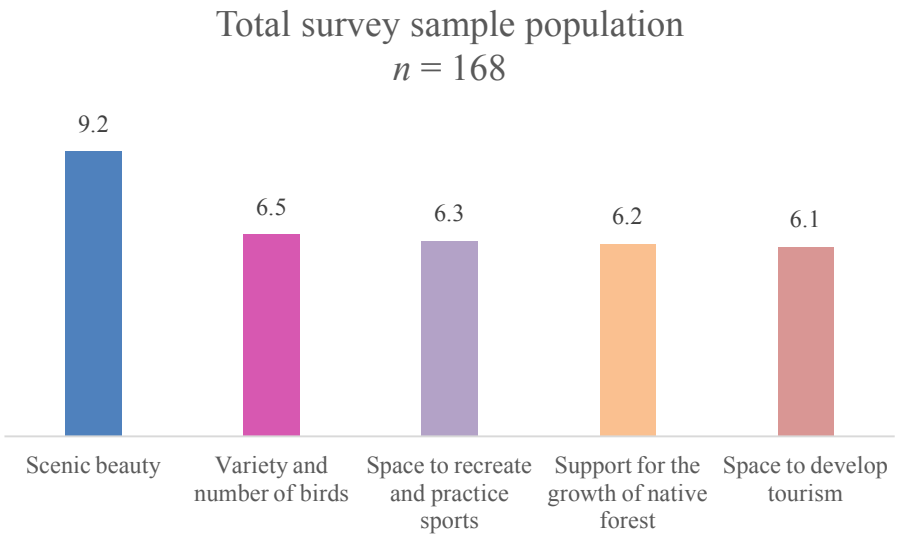


Figure 4. The top five most important ecosystem services provided by the Pudeto estuary and coastal zone in terms of perceived importance to wellbeing, per total survey sample population and sub-sample groups based on type of ecosystem service use.



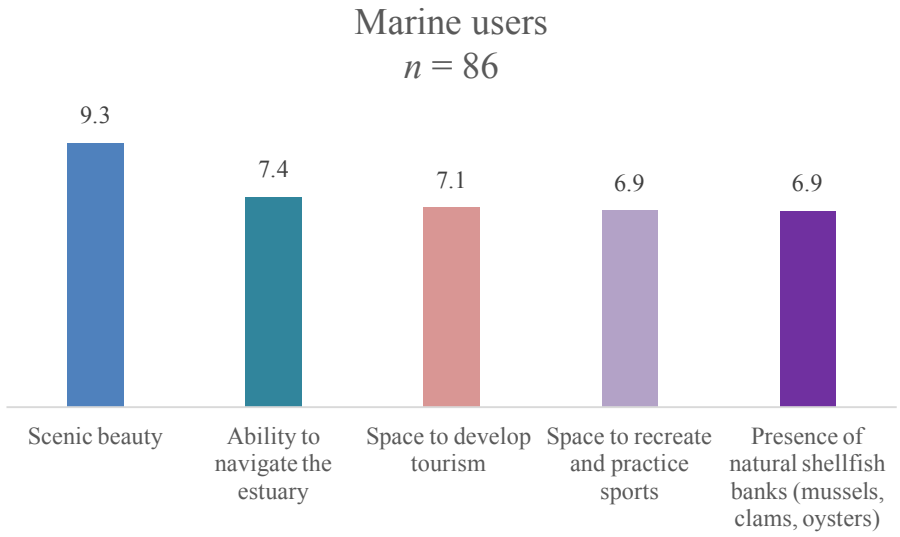
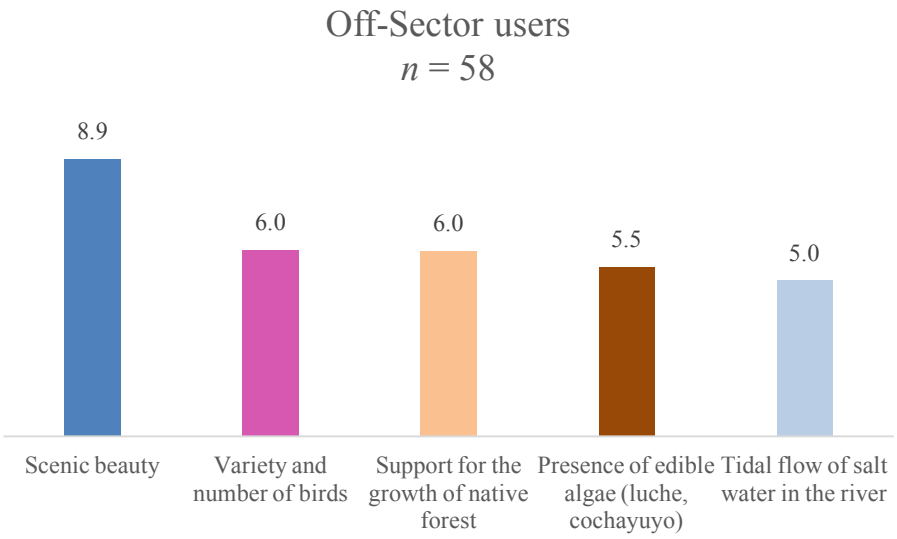


Figure 4 (cont'd). The top five most important ecosystem services provided by the Pudeto estuary and coastal zone in terms of perceived importance to wellbeing, per total survey sample population and sub-sample groups based on type of ecosystem service use.



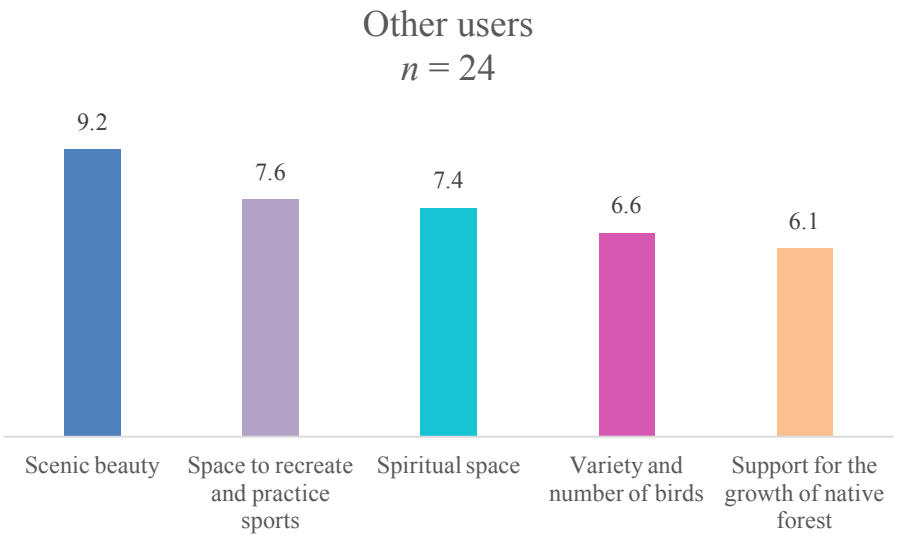


Figure 5. Mean scores of perceived importance and state of ecosystem services (continuous scale from -10 to +10) for the total sample population (n = 168). Quadrants indicate ecosystem services perceived as (a) somewhat important, in good state; (b) very important, in good state; (c) somewhat important, in mediocre state; and, (d) very important, in mediocre state.

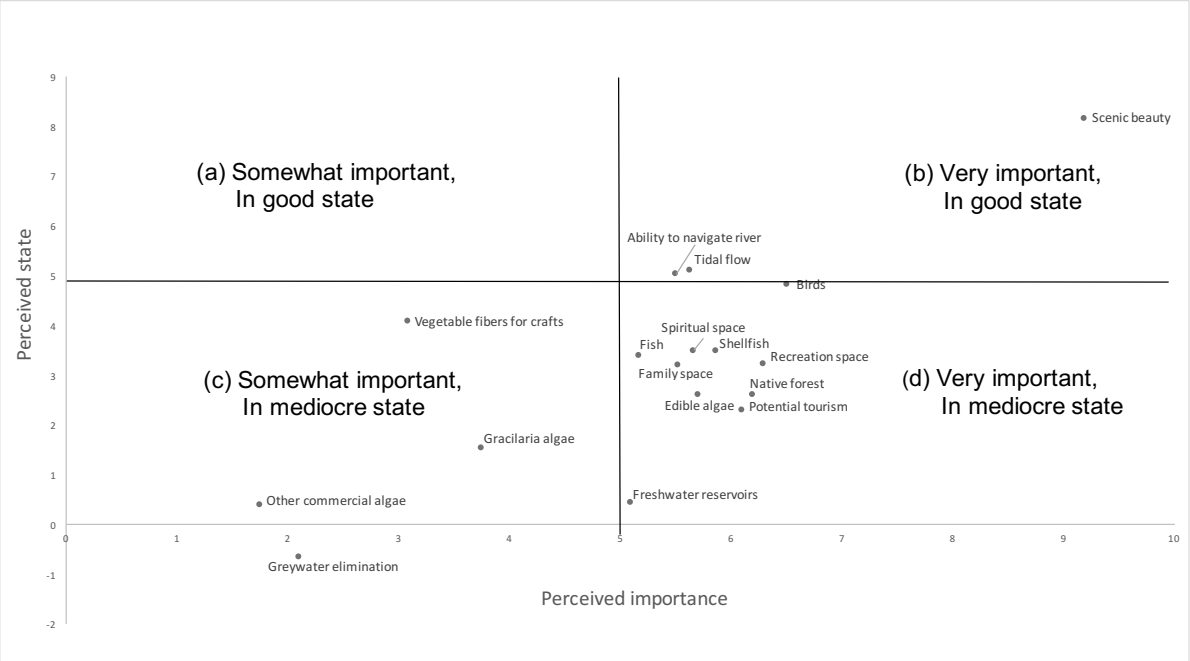


Figure 6. Number of mentions by interviewees (n = 41) of benefits provided by the sea, Pudeto estuary, and coastal zone.

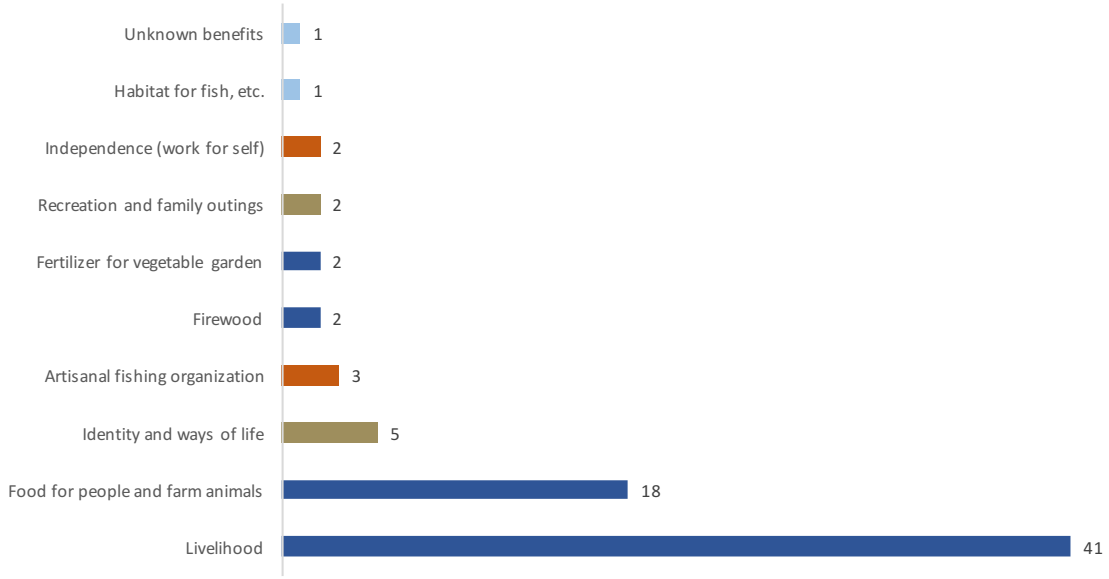


Figure 7. Map prepared by the National Chilean Tourism Service that shows points of tourist attraction categorized as foreign, national, regional, and local interests.

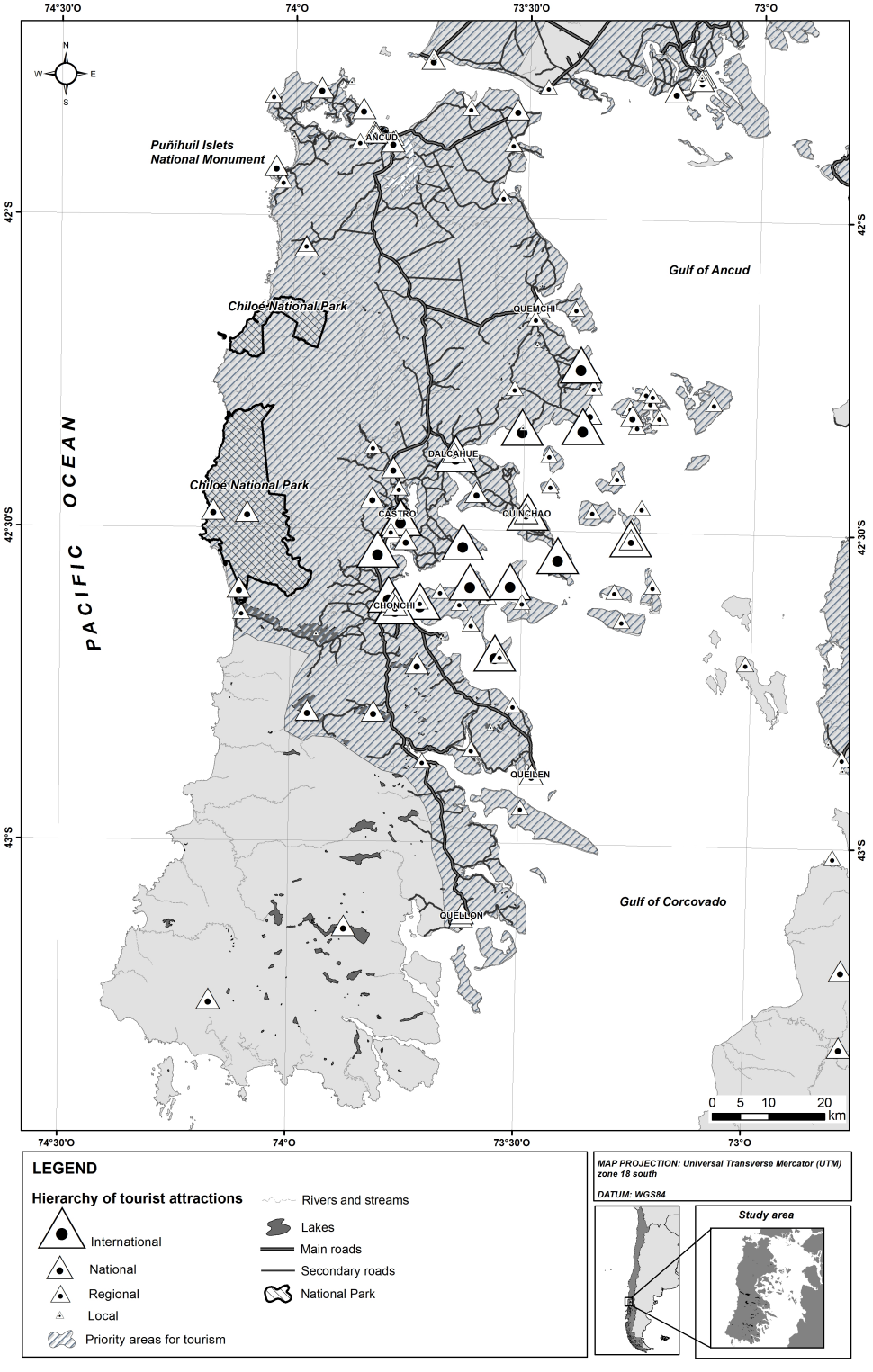


Figure 8. Map of visitation to Lacuy based on flickr data that shows clusters of recreational opportunities, including a corridor along the exposed coast.

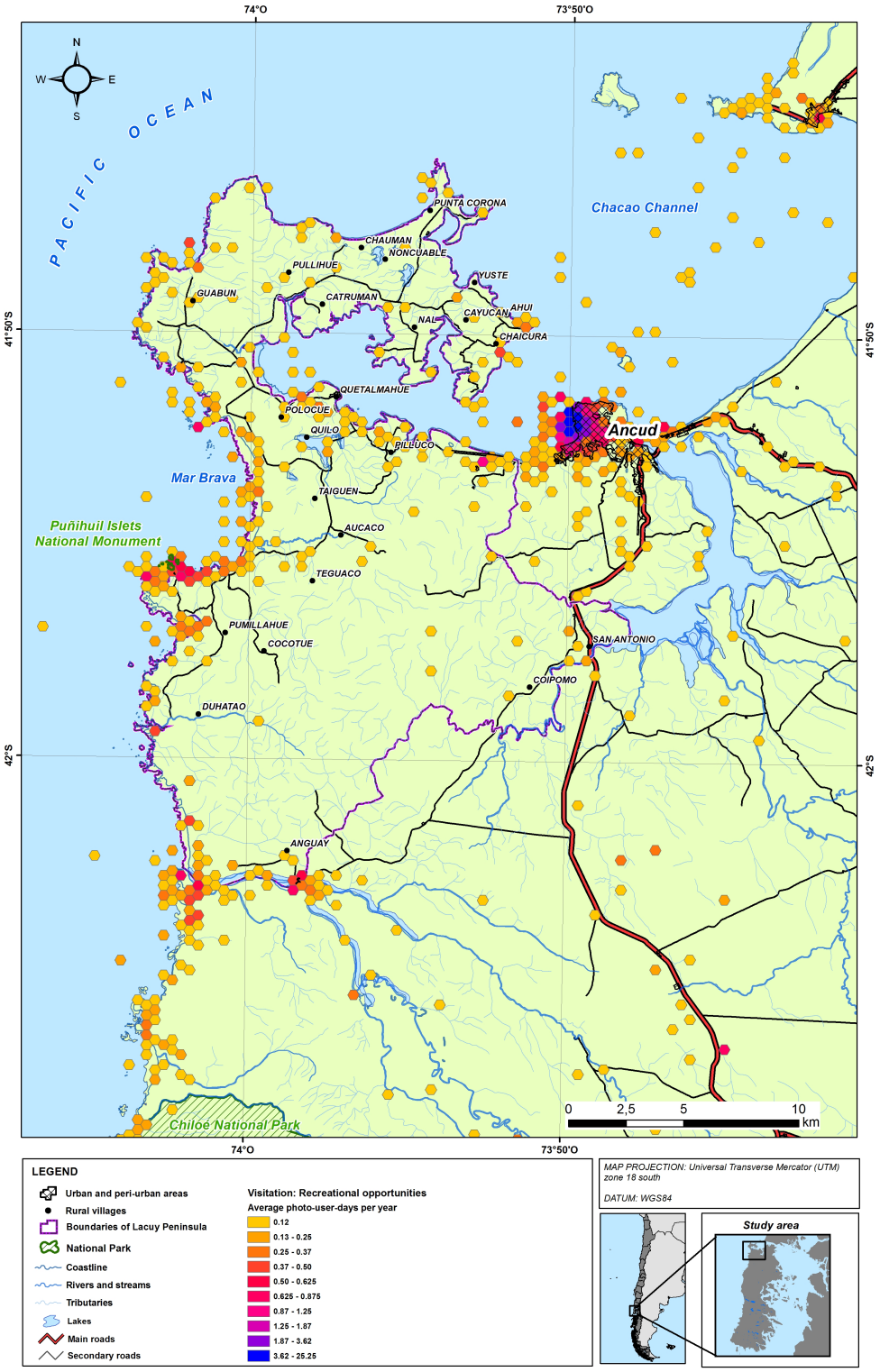
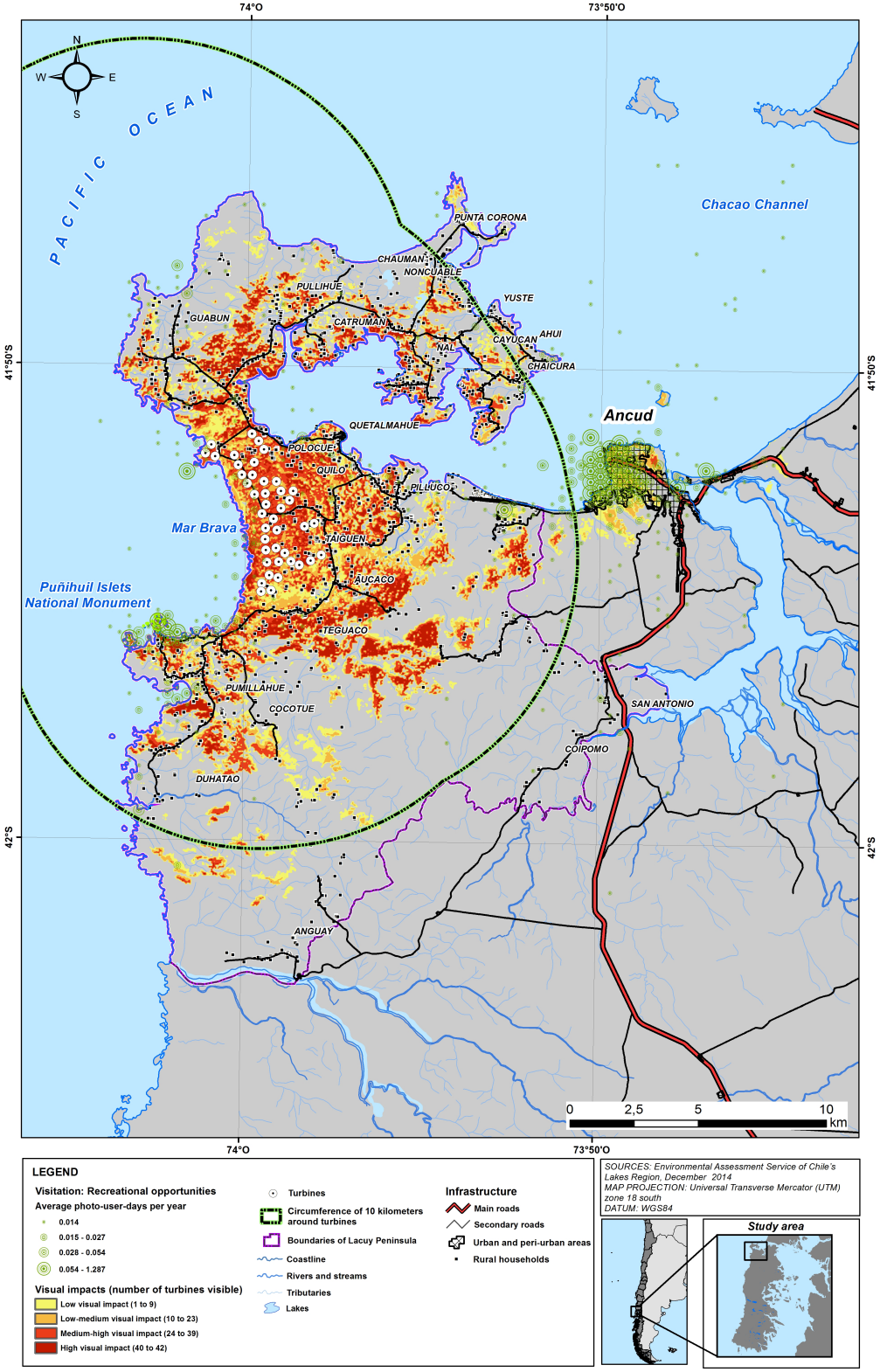


Figure 9. Map that shows how visual impacts from a proposed wind farm overlap spatially with areas deemed important to recreation and tourism.



Appendix A. Map of Pudeto estuary and coastal zone showed to survey participants.

Appendix B. Survey questionnaire (translated to English).

USES OF THE PUDETO RIVER & COASTAL ZONE QUESTIONNAIRE

INITIALS:
FOLIO #:

Date: _____/_____/2014 Sector: _____ Start time: ____:____hrs.

Name (Optional)**:** _____ *If lives in same house already surveyed, see folio #_____*

1. Please list the following about the people that lived in your household during this past year, including yourself. For each person, indicate age and last year of schooling completed or passed.

N°	Relation	Gender	Age	Year schooling	N°	Relation	Gender	Age	Year schooling
(1)	Surveyed				(5)				
(2)					(6)				
(3)					(7)				
(4)					(8)				

+Add and note the number of persons that comprise the household. Household total: _____ persons

2. *(*If respondent did not complete elementary, ask)* **Do you know how to read and write?** YES NO

3. What are the first three words that come to your mind when you think of the Pudeto River and its coastal zone?

4. What are three benefits that the Pudeto River and its coastal zone provide you?

5. Now I'm going to name some aspects of the Pudeto River and its coastal zone, and I'm going to ask you two questions about this. To mark your responses, we'll use this instrument that you move to indicate your response along the scale. There are two extremes, on one side, ☺, and on the other side, ☹. The line in the middle marks zero, or indifference. For example, if I were asked how happy I'd like to feel tomorrow, I would mark the maximum. If I were asked how many problems I'd like, I'd mark the minimum. <u>So, thinking about the Pudeto River and its coastal zone, how important is each aspect for the wellbeing of you and your family?</u> We'll use a scale of VERY IMPORTANT and ☹ NOT IMPORTANT.

6. From your point of view<u>, in what situation or state is each of the aspects today?</u> We'll use the scale of ☺ EXCELLENT and ☹ TERRIBLE.

ID	Aspect of the Pudeto River and its coastal zone	5. Wellbeing	6. Situation
a.	Quantity and quality of algae *pelillo*		
b.	Presence of other commercial algae (*luga*)		
c.	Presence of natural shellfish banks (mussels, clams, oysters)		
d.	Presence of fish (*robalo, pejerrey*)		
e.	Possibility to navigate along the river		
f.	Support for the growth of native forest		
g.	Ability to eliminate greywater and drainage from houses		
h.	Tidal flow of salt water in the river		
i.	Wetlands and peat lands that serve as reservoirs of freshwater		
j.	Variety and number of birds		
k.	Presence of vegetable fibers (*junquillo, quilineja*) to make crafts		
l.	Space to practice traditional activities with family		
m.	Presence of edible algae (*luche, cochayuyo*)		
n.	Scenic beauty		
ñ.	Spiritual space		
o.	Space to recreate and practice sports		
p.	Space to develop tourism		

Appendix B (cont'd). Survey questionnaire (translated to English).

7. Now I'm going to list ten changes that could occur in the Pudeto River and coastal zone in the future. We're going to imagine that each change occurs. <u>What would be the impact on the wellbeing of you and your family as a result of each change?</u> We'll use the scale of ☺ EXCELLENT and ☹ TERRIBLE.

8. <u>What would be the environmental impact on the Pudeto River and coastal zone as a result of each change?</u> We'll use the scale of ☺ EXCELLENT and ☹ TERRIBLE.

ID	Future change assumed for the Pudeto river and its coastal zone	7.Wellbeing*	8.Environment*
q.	Filling wetlands to build roads and houses		
r.	More algal farms (*pelillo*)		
s.	Reseeding natural shellfish banks		
t.	Establishment of a management area		
u.	Establishment of a mussel farm (seed)		
v.	Establishment of a salmon farm (smolt)		
w.	Installation of a new shellfish processing plant		
x.	Installation of a lookout point to observe birds		
y.	Development of small scale tourism		
z.	Creation of a protected area for nature		

9. **(For each response between +10 y +7 or -7 y -10)* **What do you think would change?**

Change	Reasons behind impact on wellbeing	Reasons behind environmental impact
(q.) Filling wetlands to build roads and houses		
(r.) More algal farms (*pelillo*)		
(s.) Reseeding natural shellfish banks		
(t.) Establishment of a management area		
(u.) Establishment of a mussel farm (seed)		
(v.) Establishment of a salmon farm (smolt)		
(w.) Installation of a new shellfish processing plant		
(x.) Installation of a lookout point to observe birds		
(y.) Development of small scale tourism		
(z.) Creation of a protected area for nature		

10. Are you originally from the *comuna* of Ancud? YES NO*

11. **(If no)* **Which *comuna* are you from originally and in what year did you move here?**
Comuna _____ Year _____

Appendix B (cont'd). Survey questionnaire (translated to English).

12. In what sector do you live? And, in what sector do you work?

Sector	Lives	Works
Pudeto		
La Pasarela		
Another ***urban*** sector in Ancud. *Specify.*		
Pupelde		
Another ***rural*** sector in Ancud. *Specify.*		
Other outside of the *comuna* of Ancud. *Specify.*		

13. Since what year have you lived in your current residence? Since the year _____

14. Does anyone in your home have a work contract? YES NO

15. In the last twelve months, in which activities did you participate during each season of the year? Please indicate how much each of these activities contributed to your household income: Everything, most, half, a little, or nothing.

Activity	Summer	Autumn	Winter	Spring
Algae *pelillo**				
Shellfish				
Fish				
Farm work				
Vegetable garden				
Firewood				
Handcrafts				
Factory work				
Other(s) *Specify.*				

16. **(If pelillo, ask)* **Which pelillo-related activities do you realize?** *Can mark more than 1.*

Gather *pelillo* along the shoreline of the river	
Gather *pelillo* via wooden stakes or sticks in the water	
Gather *pelillo* from the open access areas in the river	
Cultivate and harvest *pelillo* from a concession that belongs to me as an associate of an organization	
Cultivate and harvest *pelillo* from a concession that does not belong to me but that I work	
Guard a concession of *pelillo* that does not belong to me	
Lend my associate privileges to another person that works the concession in my place	
Other(s) *Specify.*	

17. Considering *all* activities that generate income for your household, in the last twelve months, what has been the average total income per season?

SUMMER Dec., Jan., Feb.	**AUTUMN** Mar., Apr., May	**WINTER** June, Jul., Aug.	**SPRING** Sept., Oct., Nov.	**= TOTAL ANNUAL** *Add and note*

18. Do you have your own house?
YES* NO ***How many?** _____

19. Do you have titles to your own land?
YES* NO ***How many?** _____

Appendix B (cont'd). Survey questionnaire (translated to English).

20. Do you own a boat that currently functions? YES* NO

↓

21. *(If YES) **How many of the following?** *Indicate number.*

____Rowboat(s)
____Wooden boat(s) with a motor
____Fiberglass boat(s) with a motor
____Boat with cabin

22. Do you own a vehicle that currently functions? YES* NO

↓

23. *(If YES) **How many of the following?** *Indicate number.*

____Auto(s)
____Truck (s)
____Small cargo truck(s)

24. Do you belong to any of the following organizations? And do you hold any leadership position? *Can mark more than one.*

Organization	Member	Leader
Residents Association		
Syndicate of Independent Workers		
Indigenous Community		
Cooperative of Artisanal Fishers		
Other *Specify.*		
I don't belong to any organization		

25. Do you self-identify with any of the following cultural identities?

Chilote Williche | Mapuche Williche | Chileno | Other *Specify.* _____ | None

26. Is there anything else that you would like to mention regarding the present and future wellbeing associated with the Pudeto River and its coastal zone that we have not asked in this survey?

End time: ___:___hrs. **Thank you for your participation. If you would like to access the results, a summary of this study will be available in the Office of Fisheries in the Municipality of Ancud in March 2015. Should you have any questions, you may contact the researcher by email: elwell@geog.ucsb.edu**

OBSERVATIONS: