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A mapping approach to assess intangible cultural ecosystem services: The case of agriculture heritage in Southern Chile

L. Nahuelhual[a,b,c,*], A. Carmona[a,c], P. Laterra[d], J. Barrena[a,c], M. Aguayo[e]

[a] Instituto de Economía Agraria, Universidad Austral de Chile, Chile
[b] Fundación Centro de los Bosques Nativos FORECOS, Chile
[c] Center for Climate and Resilience Research (CR^2), Chile
[d] Consejo Nacional de Investigaciones Científicas y Técnicas (CONICET) – Unidad Integrada Balcarce: EEA Balcarce, Instituto Nacional de Tecnología Agropecuaria – Facultad de Ciencias Agrarias, Universidad Nacional de Mar del Plata, Balcarce, Argentina
[e] Centro EULA, Universidad de Concepción, Concepción, Chile

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ABSTRACT

Modeling and mapping of cultural ecosystem services (CES) represents a significant gap in ecosystem service research. A GIS-based methodological framework was developed and applied to map agricultural heritage (AH), understood as a non-divisible combination of three cultural services (dimensions, D): the heritage value associated to a *culturally significant species* (i.e. Chiloé native potato) (D1); the traditional *systems of knowledge* of AH keepers (D2); and the social relations among them (D3). The final aim of the study was to provide indicators of the "final" service (AH_i, measured in a 0–100 point scale) and its benefits (AH_B, measured in US$/ha), capable to display areas where high value farmland was located. In essence, AH_i comprised a set of biocultural variables validated and weighted by expert opinion. The experts gave the maximum importance to 5 variables: number of native potato varieties cultivated (D1), use of own seed (D1), form in which cultivation knowledge was acquired by the keeper (D2), exchange of own seed (D3), and number of other potato keepers known (D3). In turn, AH_B reflected society's willingness to pay for the nonmaterial benefits of AH conservation. Since these benefits "propagate" across space extending from local to unknown and distant beneficiaries, and the aim was to identify the most valuable areas for their capacity to satisfy a potential demand, AH_B was spatialized following the approach of "ascribing" the potential benefits to their "point of provision". Thus the highest values of AH_i coincided with the highest values of AH_B (US$10.64–8.64 ha^{-1}) a comprised 5608 ha of the landscape, and similarly the lowest values of AH_i matched the lowest values of AH_B (US$1.69–0.18 ha^{-1}) comprising 13,070 ha of the landscape.
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1. Introduction

The Millennium Ecosystem Assessment (MEA) defined CES as "the nonmaterial benefits people obtain from ecosystems through spiritual enrichment, cognitive development, reflection, recreation, and esthetic experience, including knowledge systems, social relations, and esthetic values" (MEA, 2005: p. 40). Expressed alternately to differentiate explicitly among services, benefits, and values, CES have also been defined as "ecosystems' contribution to the nonmaterial benefits (e.g. experiences, capabilities) that people derive from human–ecological relations" (Chan et al., 2012).

Although one broadly agreed upon characteristic of CES is their intangibility, they nonetheless create robust ties between humans and their natural environment and represent one of the strongest incentives for people to engage in natural capital conservation (Angulo-Valdes and Hatcher, 2009; Schaich et al., 2010; Daniel et al., 2012; Milcu et al., 2013). Cultural ecosystem services are important in a wide range of situations and industrialized societies frequently value them ahead of other services (Quétier et al., 2010; Tielbörger et al., 2010; Palomo and Montes, 2011).

However, despite this recognized importance, the incorporation of CES into decision-making remains far behind that associated with more tangible services (Daniel et al., 2012; Milcu et al., 2013). This is largely due to the many difficulties associated with measuring and mapping CES (Ambrose-Oji and Pagella, 2012). In fact, CES generally defy quantitative characterization and modeling (MEA, 2005; Daniel et al., 2012), recreation and esthetics being few exceptions to this (Chan et al., 2006; Raymond et al., 2009; Sherrouse et al., 2011; van Riper et al., 2012), since that contrary to other services which can be quantified independently from the presence of humans (i.e. water supply and regulation) – as they mostly depend on natural attributes – CES are closely linked to personal and local value systems (Pejchar and Mooney, 2009).

* Corresponding author at: Instituto de Economía Agraria, Universidad Austral de Chile, Casilla #567, Valdivia, Chile.
E-mail address: lauranahuel@uach.cl (L. Nahuelhual).

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Cultural ecosystem services are frequently dependent on intermediate ecosystem services (Fisher et al., 2009; Johnston and Russell, 2011), and cultural benefits arise from final CES combined with other forms of capital (Chan et al., 2011). Yet, the spatial representation of these different components presents many challenges. As a result, most studies have focused on mapping benefits rather than the CES itself. These benefits are obtained using economic valuation methods (Costanza et al., 1997; Angulo-Valdes and Hatcher, 2009; Martín-López et al., 2009; Zhang et al., 2010) and are usually ascribed to specific zones (e.g. protected areas in the case of recreation), excluding from the maps those areas of potential benefits for which indicators cannot be obtained (Anderson et al., 2009; Eigenbrod et al., 2010).

Further attempts have been made to quantify and map CES on the basis of proxies that describe societal interest for these services in specific landscape types (Maes et al., 2011; Daniel et al., 2012). Thus, for cultural values and inspirational services, maps have been based on specific classes of objects (i.e. land use, natural monuments) (Maes et al., 2011; Plieninger et al., 2013; van Berkel and Verburg, 2014). But the object classes usually executed in GIS may be insufficient to describe all connections between ecosystems and social systems that define CES (Daniel et al., 2012). In many studies the methods incorporate informants who are given a preliminary list of services and then asked to associate these with areas of the landscape. An important issue that emerges from these studies is the potential effect of "super-mappers" (Ambrose-Oji and Pagella, 2012) since "when no limits are placed on the number of ecosystem service markers that can be placed on maps, some participants tend to place many more markers than others" (Ambrose-Oji and Pagella, 2012). This has noticeable implications in terms of the representativeness of the maps produced using these techniques (Ambrose-Oji and Pagella, 2012). Examples of this approach can be found in Raymond et al. (2009), Brown and Weber (2012) and Fagerholm et al. (2012).

In this context, the goal of this study was to develop a methodological framework capable of spatially representing both the final service and the benefits from intangible CES, which was applied to mapping agricultural heritage (AH). The final aim was to provide spatial indicators, at municipality scale, capable of displaying areas where high AH value farmland is located, which can support several purposes from raising awareness of the presence and importance of AH, to the design of conservation instruments for specific farmers.

Agricultural heritage was defined here as "a specific type of inheritance composed of the farmers' way of life, production and agricultural activities" (Casanelles, 1994). Other authors have identified AH with the "cultural heritage of rural lifestyles" (Swinton et al., 2007). These definitions suggest that AH can be considered a non-divisible combination of three cultural services: the heritage value associated to a *culturally significant species* (i.e. Chiloé native potato); the traditional *systems of knowledge* of the heritage keepers; and the *social relations* established by them. Hence, mapping the final service and the benefits requires the spatial representation of the biocultural components of heritage, represented by the natural features (e.g. soil and climate) that allow the cultivation of the species as well as farmers' systems of knowledge and the values attached to AH by users. Other biophysical attributes of the ecosystem were not considered here because of their relative uniformity for this specific type of heritage along the study area.

2. Study case

The study area was the municipality of Ancud (73°15′ and 74°15′ W and 41°50′ and 42°15′), which is located in the northern portion of Chiloé Island (Fig. 1) in the Chiloé Archipelago in southern Chile. It is also part of the Valdivian Temperate Rainforest Ecoregion (35° S–48° S) (Di Castri and Hajek, 1976).

The municipality covers a territory of 172,400 ha, of which less than 1% is classified as urban. Of this total area 11,776 ha are protected by Chiloé National Park. The remainder of the rural territory is comprised of 2770 farms (INE, 2007), with an area that ranges between 0.03 ha and 4658 ha (CIREN-CORFO 1999). A large proportion of these farms (94%) correspond to peasant agricultural systems (Carmona et al., 2010).

Due to the restrictive agro-ecological conditions, Ancud can be considered marginal in terms of agricultural production, although agriculture continues to be a relevant source of rural income. These natural conditions have led to farming systems and rural livelihoods mostly oriented around self-sufficiency (Barret et al., 2002).

Within the agricultural activity, native potato (*Solanum tuberosum*) cultivation is a vital part of the food security and sovereignty of the inhabitants (CET, 2011). In fact Chiloé Island is considered one of the Vavílov centers of origin of potato, and traditionally the indigenous communities and farmers of Chiloé cultivated about 800–1000 native varieties of potatoes before the onset of agricultural modernization. The conservation of this species in small farms is closely related to the oral transmission of traditional knowledge, and the existence of a network of social relationships among the generations of peasant families (CET, 2011; FAO, 2012).

All these features have granted Chiloé the designation as a GIAHS (Global Importance Agricultural Heritage Systems) pilot site. GIAHS are defined as "remarkable land use systems and landscapes, which are rich in globally significant biological diversity evolving from the co-adaptation of a community with their environment and their needs and aspirations for sustainable development" (FAO, 2003). GIAHS are selected based on their importance for the provision of local food security, high levels of agro-biodiversity and associated biological diversity, store of indigenous knowledge and ingenuity of management systems. The principal objectives of the GIAHS program in Chiloé Island are to encourage its recognition as a source of culture, tradition, and genetic biodiversity; to stimulate sustainable development, and to alert society about the importance of protection and conservation of biodiversity (FAO, 2012).

However, in the last decades, the influx of new economic activities (forestry and fish-farming), urban expansion, migration of young people and the increasing use of commercial potato varieties have threatened the conservation of this patrimonial agriculture, and have produced deep changes in the socio-economic structure of the Island (Salières et al., 2005; CET, 2011; FAO, 2012). Recent studies show the abandonment of agricultural land, previously dedicated to crops and pastures (Díaz et al., 2011; Carmona and Nahuelhual, 2012). Whether landscape and agricultural policy interventions are undertaken to prevent the abandonment of traditional agriculture will depend on the choices and priorities of policy makers and on which development strategy is judged as preferable, i.e. exogenous modernization versus endogenous development based on the natural and cultural heritage. At present there is a clear misalignment among these strategies which menaces the in situ conservation of AH in Chiloé.

3. Methods and data

This study is part of a larger research project aimed at assessing the magnitude and spatial distribution of economic benefits of ecosystem services provided by rural landscapes in southern Chile, and therefore relied on information previously gathered by the research team. The mapping framework comprised two major stages which were the spatial representation of AH as a "final" ecosystem service (steps 1–5) and the spatial representation of the economic benefits that people derived from AH (step 6), each of

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