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Recreation potential assessment at large spatial scales: A method based in the ecosystem services approach and landscape metrics

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ABSTRACT

Ecosystem services (ES) is a useful framework for land-use decision making oriented to, ensure human well-being. Outdoor recreation potential, as a cultural ecosystem service, pose, particular challenges to its evaluation and mapping: it depends to a greater extent that other ES on, stakeholders′ perception and values, it has lower generalization capacity, the delimitation of, provisioning areas is not straightforward and it should be evaluated at different spatial scales. In this, study, we propose a conceptual framework and method that is intended to cope with these challenges. Our method is based on landscape metrics measured at coarse scale, and campsite density as an, indicator of ecosystem service supply and benefit capture. We applied this method to a case study in, Argentina. We estimated outdoor recreation potential level using a quantile multiple regression, analysis of the 0.9 quantile of campsite density with nine landscape metrics determinants of ecosystem, service supply. We also explored two determinants of benefit capture with a linear stepwise regression, analysis of differences between the predicted recreation potential and actual use. We stratified the, analysis by ecoregion to distinguish the different weight of determinants of ecosystem service supply, and benefit capture.

The examined landscape determinants showed differences in their explicative capacity of outdoor, recreation potential across ecoregions, showing that their generalization capacity is limited. For, example, and contrary to our expectations, crop area did not have a negative effect for any of the 15, analyzed ecoregions. In fact, significant correlations are positive for three cases. Forest cover, on the, other hand, had a positive effect only in the Pampas ecoregion, originally dominated by grasslands and, where current forests consist in plantations of exotic trees. Results also showed that, in general, unrealized benefit increases with road and population density.

Our method makes a contribution to the study of recreation potential under the framework of ES by, taking into account important aspects that are sometimes overlooked. It considers the differences with, other ecosystem services in terms of the underlying processes that control ecosystem service supply, and benefit capture and it can be applied at a very wide spatial extent, at which approaches with other, methods that are more information demanding is difficult. Yet complementary methods at more, detailed spatial scales would provide additional information for a comprehensive estimation of, outdoor recreation potential.

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1. Introduction

The concept of ecosystem services (ES) is being increasingly adopted as a framework for guiding decision making in land use. ES are defined as the contributions that ecosystems make to human well-being, including biotic and abiotic outputs (Haines-Young and Potschin, 2010). ES are classified as provisioning, regulating and maintenance, and cultural services.

Cultural services include “all non-material ecosystem outputs that have symbolic, cultural or intellectual significance” (Haines-Young and Potschin, 2011). Their special importance for human well-being relies in the fact that these services are irreplaceable by technological means (Hernández-Morcillo et al., 2013). Among cultural services, the recreation and community activities services group is associated to aesthetic experiences and symbolic values of ecosystems (Gobster et al., 2007; Hunziker, 1995) as well as conditions that facilitate recreational and touristic activities[1] (Daniel et al., 2012).

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[1] Tourism is distinguished from recreation as the first involves an overnight stay in the site, while recreation is a diary activity that normally takes place near the recreationist's residence. Given that the indicator we use for this work does not allow us to distinguish between tourism and recreation, we will use the term recreation in a broad sense to refer to both concepts indistinctly.

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Nature-based recreation value is thought to be dependent upon environmental conditions and landscape attributes such as climate (Gül et al., 2006), type of vegetation (Edwards et al., 2012), slope (Roovers et al., 2002; Colson et al., 2010), presence of water bodies (Faggi et al., 2011) and number of cultural attractions (Nahuelhual et al., 2013). Facilities (campsites, services, roads, etc.) and accessibility are also important factors that influence recreationist' experience (Goossen and Langers, 2000; Gursoy and Chen, 2012). Although, the importance of these factors for distinct recreational activities varies across different types of landscapes (Goossen and Langers, 2000).

Despite these general patterns, the study of recreation potential under the framework of ES is relatively recent and needs further development. In fact, most cultural ES are relegated in the research and policy agenda due to the inherent conceptual and methodological difficulties in their evaluation (Daniel et al., 2012). Even when recreation potential is among the most studied cultural ecosystem service, there are still lacking proper conceptual frameworks and methods to cope with the particular challenges of this ES (Hernández-Morcillo et al., 2013).

In this work, we aim at developing a conceptual framework to describe recreation potential at a landscape scale and a method to quantify its supply level. We first discuss the relevant aspects that should be taken into account for the study of recreation potential under the framework of ES. Then, we make a brief review of the most common methodological approaches that have been used to date. Finally, we present our proposed conceptual framework and we test its validity and utility with a case study in Argentina.

1.1. Recreation as an ES

The study of any ES involves different aspects like the definition of the ES, its generalization possibilities, the delimitation of the provisioning areas, and the spatial scale of analysis. Each ES presents peculiarities in these aspects that should be taken into account for evaluation, mapping, trade-off analysis and management.

An accurate definition of an ES is important for identification of the underlying ecosystem processes and the stakeholders involved, as well as for comparison of studies (Nahlik et al., 2012). In the case of recreation, as well as other cultural services, explicit definitions are normally absent within the natural sciences bibliography (Daniel et al., 2012). The most common way to define recreation is through the measured indicators or the particular recreation activities studied (fishing, hiking, cycling, etc.). We define landscape recreation potential based in Chan et al. (2006), as the provision of outdoor recreation opportunities by natural and semi natural landscapes. The recreation potential differs from the realized service (the recreation benefit), which is a result from the combination of natural and social assets that directly contribute to human well-being through the actual capture of the recreation ES. Therefore, landscapes with a high provision level for this ES are those that offer the optimal conditions given by its biophysical attributes and cultural elements for use in recreation activities, regardless of these being actually carried out. The level of use, measured as recreationists flow, is one of the possible proxies of the benefit delivered by the service.

The second aspect of relevance is the capacity of generalization of the underlying processes that determine the ES for comparing studies and extrapolating results (ecological production functions). ES supply depends on biophysical processes interlinked with cultural factors associated to human values. Biophysical processes influence provisioning and regulation services to a great extent, although cultural factors play an important role as well. This makes the generalization to different regions relatively straightforward (Fisher et al., 2009). Cultural services have a more indirect relation (Daniel et al., 2012). In the case of recreation potential, landscape attributes (landforms, vegetation, climate, etc.) are differently perceived by people depending on their cultural context (Buijs et al., 2006). As a consequence, there is a great heterogeneity in the appreciation of the same landscape settings by different social groups and individuals of the same group given by factors such as age, economic condition and education (Faggi et al., 2011; Gobster, 2001; Lindborg et al., 2009). Although, some general environmental attributes consistently affect recreation potential across ecological and socio-cultural contexts. Generalization of underlying factors can be made based on these attributes taking into account the peculiarities of the case study under analysis.

A third aspect involves the delimitation of the ES provisioning areas. An adequate delimitation allows calculating the provision as a flow (level of provision by unit of area and time), evaluating benefit propagation and determining the appropriate institutional level for management policies (Hein et al., 2006; Syrbe and Walz, 2012). The delimitation of provisioning areas of cultural services is not as straight forward as other ES. The limits of a recreation area are fuzzy, depending on different factors such as terrain topography or type of activity. If recreation is associated to landscape visual appreciation, the view shed from a panoramic point is a provisioning area (Baerenklau et al., 2010; Gimona and Horst, 2007; Reyers et al., 2009). The extent of this area is highly variable depending on the terrain topography. For other recreational activities, such as angling, it can be assumed that the provisioning area is the water body and its recreational value is influenced only by local factors. Nonetheless, management far away from the water body can have an indirect influence. For instance, nutrient or pesticide run-off from surrounding agricultural areas may affect water quality and fish availability (Carpenter et al., 1998). For these reasons, there is not any a priori ruling for the establishment of provisioning areas for recreation potential. The most common methods for delimitating a recreation provisioning area are the explicit identification of high recreation potential sites by stakeholders (Raymond et al., 2009), the delimitation of biomes with clear limits (valley, woodland, lake, etc.) or other managerial land units like parks and reserves (Colson et al., 2010; Larsen et al., 2008; Velazquez and Celemín, 2012).

The extent of the spatial scale at which ES operate is relevant for determining underlying ecosystem processes, extrapolation capacity, benefit propagation and capture, as well as for management at institutional level (Hein et al., 2006; Paruelo et al., 2011). Cultural services can be provided at very different spatial scales (Hernández-Morcillo et al., 2013). This sets some methodological challenges, as it implies a trade-off between extension and sampling effort (Eigenbrod et al., 2010). The recreation potential assessment demands a great effort in information collection about preferences that is usually gathered in situ or via telephone surveys (Eigenbrod et al., 2010; Goossen and Langers, 2000). This restricts the possibility of making large scale evaluations. On the other hand, the benefit of recreation is not propagated as a tangible good to other areas. Instead, recreation benefit is always captured in provisioning sites. Nonetheless, if we consider the recreationists' residence place we can think of a non-material propagation of the recreation benefit in terms of memories or stress level reduction (aspects of well-being associated to this ES). As recreationists' origin can be from nearby areas or as far as other continents the benefit of a recreational experience can have an effect at very distant areas. So it is important to define the scale at which benefit can be propagated to assess the importance of the recreation site for local or international recreationists.

1.2. Common methodological approaches to recreation potential evaluation

The goal of recreation potential assessment is to determine which landscape factors make a site more attractive for visual appreciation or for recreational activities. Broadly speaking, recreation potential can be assessed by two families of methods: recreationist's stated preference or revealed behavior. Stated preference methods are designed to elicit recreationist' preference towards landscape attributes to carry their recreation activity (Boxal et al., 1996). These methods involve the recreationists participation in different ways like choice experiments (Arriaza et al., 2004; Lange et al., 2008), participatory mapping (Plieninger et al., 2013) or contingent valuation (Penna et al., 2011).

Revealed behavior methods show what recreationists actually do. Travel Cost Method (TCM) is one of the most commonly used under this category (Spash, 2000; Vanslembrouck and Huylenbroeck, 2005; Gürlük and Rehber, 2008). This method considers that the travel costs to get to a destination can be used as an indicator of the site recreational value: the more valued is the site the more travel costs is a recreationist willing to pay. This method is especially useful for well delimited recreational locations, where information about recreationist origin can be gathered in situ (Bhat, 2003). Although, its application is less useful if the objective is to generate a provisioning function at broad scales and with more fuzzy limits. It is also not useful for extrapolating results to unused recreational sites (Penna et al., 2011).

A common characteristic of all recreation potential evaluation methods is the collection of information directly from the recreationist. In other ES, such as landslide protection or carbon sequestration, the assessment and valuation is made by "experts", who deal with technical information on ecosystem processes. In the case of recreation potential, experts (travel agencies, etc.) provide a more rigorous framework to the evaluation, generating and validating models (Colson et al., 2010; Daniel, 2001; Nahuelhual et al., 2013), but the participation of recreationists seems unavoidable (Fagerholm et al., 2012). This way the assessment is more robust but at the same time it demands a great sampling effort, thus it restricts the analysis mostly to local scale. When stakeholder's participation becomes a limitation for the assessment, like a study at a sub continent or a large country scale, a method based in indirect measures would be more practical. The assessment of recreation potential through landscape metrics is potentially useful and worthwhile exploring.

2. Materials and methods

2.1. Conceptual framework

The type of recreation that we approached in this study is the so-called nature-based recreation, outdoor recreation or soft eco-tourism (Deng et al., 2002). This kind of recreation is associated to activities such as angling, hiking, trekking, cycling, horse-back riding and bird-watching (Balmford et al., 2009). Landscape scenery quality is of fundamental importance for nature-based recreation (Boyd and Butler, 1996; Gobster et al., 2007).

Landscape recreation potential is determined by biophysical attributes including, among others, climatic conditions, landforms, hydrography and vegetation (Fig. 1) (Arriaza et al., 2004; Deng et al., 2002; Faggi et al., 2011; Goossen and Langers, 2000). Land use is also important for determining the scenic quality of the landscape. It is usually stated that intensive agriculture and urbanizations have a negative impact on recreation potential (Palomo et al., 2011; van Berkel and Verburg, 2014). The combination of these attributes with natural and cultural attractions (e.g. waterfalls, sight-viewing points, archaeological sites, etc.), as perceived by recreationists according to their values and preferences, determines the landscape recreation potential (Fig. 1). The recreation potential can be evaluated by the variety (spectrum) of possible activities, as well as by the quality for a particular activity (Boyd and Butler, 1996). The actual capture of the benefit is restricted by antrhopic intervention on the landscape by facilitating access to recreation sites (roads, access to mass transport), providing basic services (lodging, food, security, etc.) and by the population density in the vicinity, as service provider and source of recreationists. Human intervention has a feedback effect on the landscape attributes and attractions by altering environmental quality. This effect may be positive or negative, depending upon the kind and intensity of intervention as well as the ecosystem's sensibility to changes of their environmental conditions. In regions where the recreation potential relies on the natural undisturbed environments, human intervention should decrease recreation potential. There are also idiosyncratic factors that make a district base their economy and cultural identity on tourism. Prior experience by recreationists influences campsite choice as well (Gursoy and Chen, 2012). This also generates a positive feedback effect. Our method is not suited to evaluate these kinds of factors, thus they constitute a black box that we will not analyze. The benefit of the ES can be quantified as the number of visitors that make recreational use of the landscape. In this way, two landscape units with similar attributes should have the same recreation potential although the capture level may differ among them.

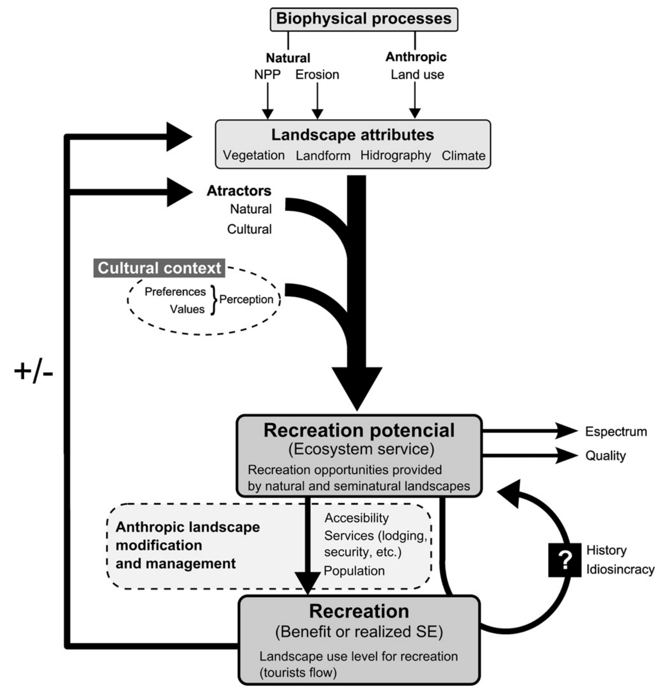

Fig. 1. Conceptual framework of recreation potential drivers. See explanation in the text.

2.2. Ecosystem service provision and benefit capture estimation

Under the framework described above, we estimated the recreation potential from the organized campsite density in landscape units. We consider that redundancy in the offer of this kind of accommodation is associated to the site attractiveness. Besides, campsites are strongly associated to the kind of recreation and activities that we focus in this evaluation.

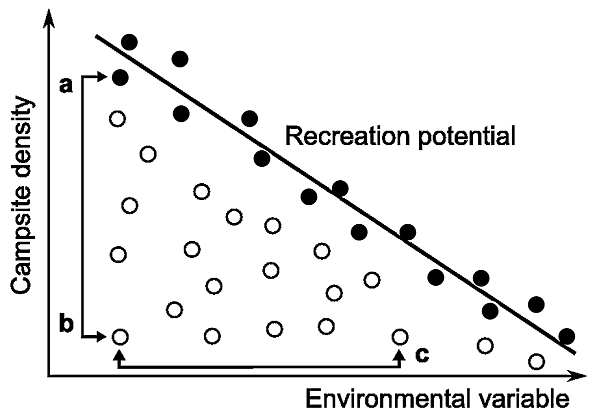

Fig. 2. Recreation potential and benefit capture model. Recreation potential is given by the maximum campsite density for a given environmental condition. Differences in benefit capture are given by the campsite density differences in landscape units with the same environmental conditions. In this way, points *a* and *b* have the same recreation potential, but they differ in their level of benefit capture. Point *c* has the same level of benefit capture as *b* but lower recreation potential. Filled dots illustrate for a hypothetical case the 0.9 quantile used for the calculation of recreation potential. Empty dots illustrate different campsite densities in land units with the same environmental conditions. These points were used to calculate unrealized benefit.

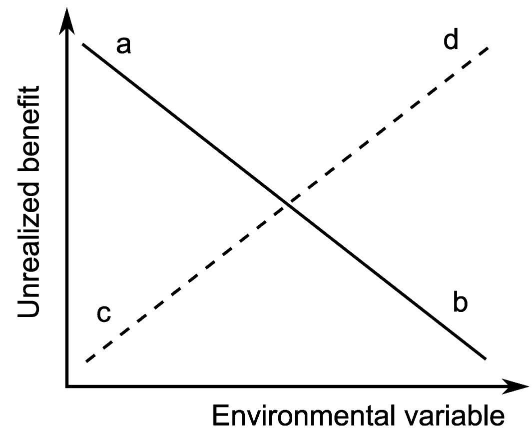

Fig. 3. Benefit capture model. Unrealized benefit is calculated as the model's positive obs–pred values. If antrhopic intervention on the landscape helps capturing this service, then the unrealized benefit should be lower. This way, benefit capture is higher in point *b* than in point *a*. On the contrary, if antrhopic interventions diminishes benefit capture, unrealized benefit should be higher, thus benefit capture is lower in point *d* than in point *c*.

Campsite density may be considered as a gross indicator of recreationists flow and benefit capture. Nonetheless, it can also provide useful information about ES supply. In a benefit production function of campsite density along some environmental gradient, recreation potential can be recognized as the maximum densities at each position in the gradient (Fig. 2). Assuming that this maximum represents a landscape functional capacity for recreational activities, differences in campsite density among landscape units with the same environmental conditions represent differences in the benefit capture.

Following this evaluation framework, recreation potential is calculated by a quantile multiple regression analysis with environmental variables as predictors and campsite density as response variable. In cases where the response variable cannot change by more than some upper limit set by the measured factors but may change by less when other unmeasured factors are limiting, quantile regression is an appropriate method for analysis (Cade and Noon, 2003). The predicted campsite density using the multiple regression equation can be considered as the recreation potential.

Differences in benefit capture are given by the predicted–observed number of campsites. These differences represent the unrealized benefit and could be explained by landscape attributes that facilitate access to provisioning sites, such as road density and urban centers. If that is true, then the unrealized benefit lower with higher road and population density (Fig. 3). Nonetheless, in landscapes where recreational value is associated to undisturbed environments the antrhopic intervention would have the opposite effect. Then high road and population densities would increase the unrealized benefit, expressed in this model by a positive slope in the regression (Fig. 3).

2.3. Case study application: Recreation potential and benefit capture in Argentina

We tested the framework described above estimating the recreation potential for the Argentinean territory as a case study. We georeferenciated a data base of campsites ($n = 1541$) based on a search in specialized web sites. To delimitate the areas over which we calculated campsite density we overlaid a grid 32 km × 32 km over the Argentinean territory. Each cell is a landscape unit on which we estimated nine biophysical attributes and campsite density (Table 1). We assumed that this area represents approximately the human perception of the landscape and is easily covered by a day trip, so it can be assumed to be the ES provisioning area for the campsites.

We estimated the recreation functional capacity in the environmental gradient as the 0.9 quantile of the corresponding campsite dot cloud. We chose the 0.9 quantile to build a regression function with the maximum campsite densities along the environmental gradient. We standardized the environmental variables in a 0–1 scale to make regression coefficients comparable. The response variable (campsite density in each cell) is not continuous, what generates many ties. To avoid the problems that this generates in quantile regressions, we added a random noise to the response variable ranging 0–0.2 (Cade, personal comm.). We standardized the response variable in a range 0-1 to interpret relative recreation potential values. We ran all analysis using package quantreg in the statistical software R (Koenker, 2006). We ran the analysis for the entire study area. Alongside, and in order to account for differences in the weight of landscape attributes in different environments for recreation potential we stratified the analysis using the 15 ecoregions comprised by the country (Morello et al., 2012) (Fig. 4, Table 2). Thus, we obtained one provision function for the entire study area and for each ecoregion.

We evaluated benefit capture determinants using a stepwise linear regression model with road and population density as explanatory variables and predicted–observed values of the previous model as response variable. We considered the varying effect of human intervention on unrealized benefit across ecoregions as proposed in the conceptual framework. We expected road and population density increase unrealized benefit in Yungas, Valdivian Forests, Atlantic Forest, Iberá Marshes and Campos and Malezales ecoregions, which recreation potential is believed to rely on natural environments (Velazquez and Celemín, 2012). This effect should be expressed by positive correlation coefficients in the regression model (Fig. 3). For the rest of the ecoregions, we expected road and population density to favor benefit capture, what should be expressed as negative regression coefficients.

3. Results and discussion

3.1. Recreation potential and drivers

We identified areas of high recreation potential within the Yungas, irrigation oasis in Hills and basins Monte, Sierras de Córdoba,

Table 1
Landscape metrics (variables) used as indicators of outdoor recreation potential.

Variable	Description	Source of information	Expected effect on recreation potential
Mean annual temperature	Mean annual temperature was calculated for each cell overlaying the isotherms map of Argentina	National Meteorological Service statistics for the period 1970–2000	Extreme temperatures restricts the camping activity (Booth et al., 2011; Cole and Hall, 2009)
Annual thermal amplitude	Annual thermal amplitude was calculated as mean temperature of warmest month minus mean temperature of coldest month. Thermal amplitude was calculated for each cell	National Meteorological Service statistics for the period 1970–2000	High annual thermal amplitudes may favor both summer and winter recreation activities (MINTUR, 2011; Velazquez and Celemín, 2012)
Roughness	Ruggedness index according to the method described in Beasom et al. (1983). Level curve density was calculated as km level curve/km^2	Digital Elevation Model (DEM) of Argentina	Rough reliefs generate heterogeneous landscapes with high visual attraction and possibility of recreational activities (hiking, climbing, etc.) (Roovers et al., 2002; Colson et al., 2010)
Coastline density	River, streams, lakes and shores coast density (km coastline/km^2)	Hydrographic layer of Soil Atlas of Argentina (INTA)	Coasts allow activities like fishing and swimming (Bhat et al., 1998; Faggi et al., 2011)
NDVI	Normalized Difference Vegetation Index as an indicator of lush vegetation	MODIS images mosaic 2011 and 2012 (source http://www.landcover.org/)	Landscapes with lush vegetation are preferred by recreationists (Velazquez and Celemín, 2012)
NDVI SD	Standard Deviation in NDVI as an indicator of vegetation heterogeneity	MODIS images mosaic 2011 and 2012 (source http://www.landcover.org/)	Landscapes with higher vegetation heterogeneity are preferred by recreationists (Hunziker, 1995; Roovers et al., 2002; Ode et al., 2008)
Tree cover	Percent tree cover	MODIS 2001 image (source http://www.landcover.org/)	Tree vegetation is preferred over other types of vegetation cover due to scenic value and shade provision (Sildoja and Eagles, 2004)
Bare soil cover	Percent bare soil	MODIS 2001 image (source http://www.landcover.org/)	High proportions of bare soil are not preferred for camping due to lack of shade and intensification of harsh climatic conditions (Gül et al., 2006)
Crop area	Percent herbaceous and shrub crops and forestations	Land Cover Map of Argentina (LCCS FAO), for the period 2006-2007	Agriculture diminishes scenic value and recreation activities (García-Llorente et al., 2012; Velazquez and Celemín, 2012)

Paraná River coast, Atlantic Forest, the Paraná River delta, Beaches in Buenos Aires Province and Valdivian Forests (Fig. 5). Results coincide with previous evaluation of nature-based recreation potential using different conceptual frameworks and methods (Velazquez and Celemín, 2012). Our results also show that landscape attributes relevant for determining the recreation potential differ across ecoregions of Argentina and what would be expected by an interpretation of the general pattern with no stratification (Table 3). In a

Table 2
Main characteristics of ecoregions of Argentina.

Ecoregion	Biome	Climate	Potential for agricultural production
High Andes	Grasslands steppe	Cold and dry with permanent snow	Barely none, only some camelid production
Valdivian temperate forest	Conifer forest	Temperate to cold humid	Timber extraction and production
Campos and Malezales	Grasslands and savannas	Subtropical humid	Extensive cattle grazing, mate, timber production, cattle grazing
Humid Chaco	Woodland, savannas and grasslands	Subtropical warm (1300 mm annual precipitation)	Extensive cattle grazing and agriculture (rice, tobacco, peanuts, sunflower, soybean), timber extraction
Dry Chaco	Xerophytic woodland, savannas and grasslands	Subtropical warm (600 mm annual precipitation)	Extensive cattle, sheep and goat grazing, recently agriculturization with soybean and cotton, timber extraction
Paraná flooded savannahs	Forests and scrublands	Temperate humid	Subsistence agriculture, commercial fishing, extensive cattle grazing
Espinal	Low xerophytic woodland, savannas and grasslands	Humid warm to dry temperate	Cattle grazing, rice, wheat, maize, citrus fruit, soybean, timber production
Patagonian steppe	Grass and shrub steppe	Dry cold	Sheep and goat extensive grazing
Iberá marshes	Wetlands and marshes	Subtropical Humid	Extensive cattle grazing, rice, timber production
Plains and plateaus Monte	Shrublands and grasslands	Temperate arid	Extensive cattle, sheep and goat grazing, fruit, vineyards, subsistence agriculture
Hills and bossoms Monte	Shrub steppe	Subtropical arid	Vineyards
Pampa	Grasslands	Temperate humid to sub humid	Cattle grazing, wheat, maize, soybean, sunflower
Puna	Shrub and grassland steppes	Cold, dry with high diary and seasonal thermal amplitude	Sheep, goat and camelid extensive grazing, subsistence agriculture
Paraná Atlantic forest	Humid subtropical forest	Warm humid	Subsistence agriculture, mate, timber extraction
Yungas	Transition from sub humid rain forest to grasslands in the highest areas	Warm humid to sub humid	Sugar cane, citrus fruit, timber extraction

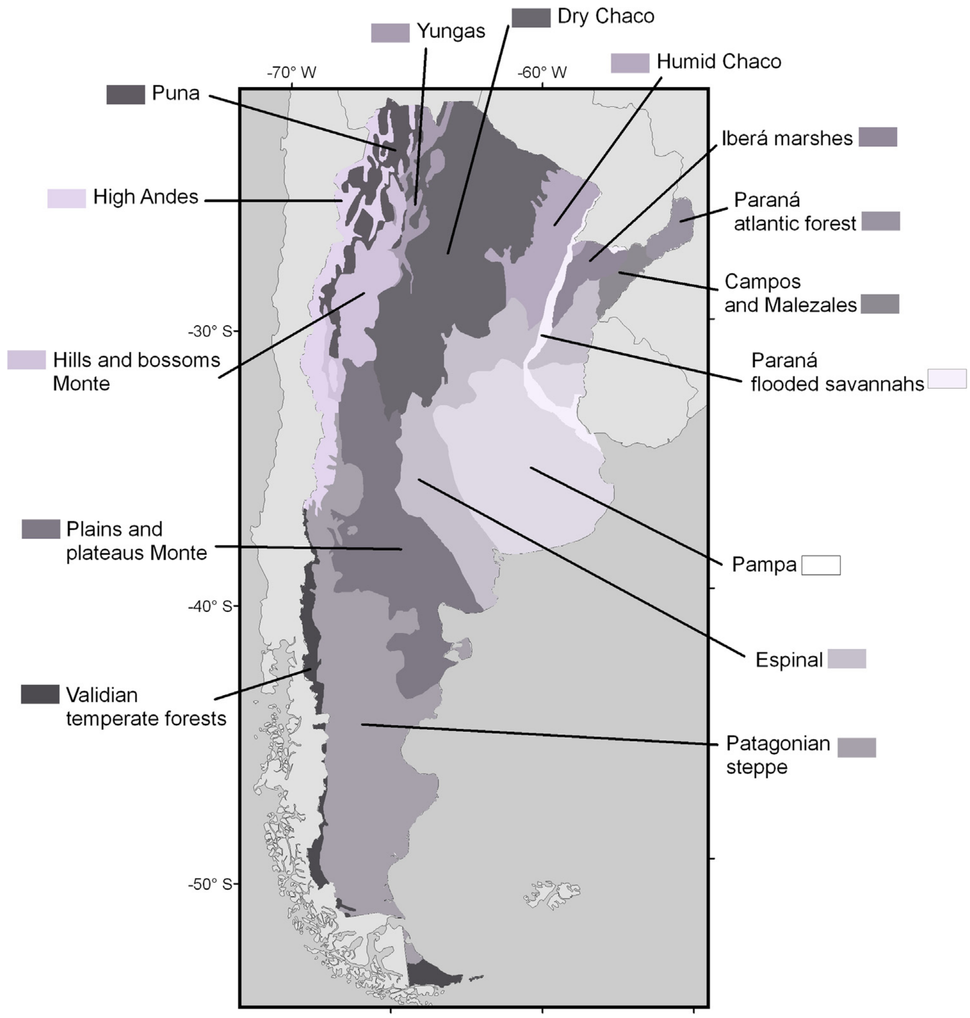

Fig. 4. Ecoregions of Argentina (see Table 2 for a detailed description).

very large study area, where environmental conditions vary across space, it was revealed the importance of stratification for a proper interpretation of results.

Variation in recreation potential is associated to temperate mean annual temperatures (Table 3). Extreme temperatures, low or high, have a limiting effect, as shown by regression coefficients for Patagonian steppe and Dry Chaco regions. The kind of lodgment we selected as indicator is probably particularly sensitive to harsh climatic conditions. Campers tend to consider bad weather conditions as important for their recreational experience (Booth et al., 2011; Cole and Hall, 2009). For this reason, in some cases like Tierra del Fuego province, a very important touristic area in Argentina, recreation potential may be underestimated (Fig. 5 area i). This may be caused by the cold weather that limits the possibility of camping tourism. In cases like this, other types of lodgment used by the same kind of recreationists, like cottages, would be more appropriate as indicators to reveal the real recreation potential.

Rough reliefs have generally a positive effect, especially in the ecoregions Dry Chaco and Espinal, where the regression coefficients are statistically significant. The Sierras de Córdoba region is a touristic area where hiking is one of the main recreational activities (Fig. 5 area c) (Velazquez and Celemín, 2012). River, lake and sea shores attract recreationists in Humid Chaco and Pampa. This is mainly associated to the Paraná River coast and ponds in Buenos Aires province (MINTUR, 2011). Fishing is a popular recreational activity in those areas. Likewise, beaches in Buenos Aires have a long tradition of tourism, and they constitute an important attractor at a national scale (Fig. 5 area h). Nonetheless, the importance of coastlines could have been underestimated in some cases, as we did not consider differences in coast types but only their density. It is probable though, that different types of coasts (creeks, rivers, lakes and sea) have a different potential for recreation depending on the kind of activity carried out (fishing, swimming, etc.) (Goossen and Langers, 2000; Velazquez and Celemín, 2012). More detailed studies should consider varying weights for different types of coasts.

Tree cover had a positive effect only in the Pampas, which is somewhat surprising as trees are exotic to this region (Ghersa and León, 2001). Pampas region has been intensively modified by agriculturization, urbanization and the introduction of trees (Soriano, 1991). Possibly, and contrary to other ecoregions, the physiognomy of the original vegetation of the Pampas (grassland) does not constitute the attractive characteristic for recreationists. This suggests that even for nature-based recreation it is not a requisite the presence of pristine environmental conditions, and cultural attachment to exotic elements of the landscape can have an important influence. It is also probable that shade provision by trees is a determining factor for campers' choice of camping sites, as it has been demonstrated in other case studies (Sildoja and Eagles, 2004).

Likewise, and contrary to our expectations, crop area did not have a negative effect for any of the 15 analyzed ecoregions. In fact, significant correlations are positive for the Monte, Valdivian Forests and Patagonian Steppe ecoregions (Table 3). There may be

Table 3
Regression coefficients of multivariate quantile regressions across ecoregions and for Argentina with no stratification. Highlighted coefficients are statistically significant at $p < 0.05$.

Ecoregion	Mean temperature	Thermal amplitude	Ruggedness	Coastline density	NDVI	NDVI SD	Tree cover	Bare soil cover	Crop cover	Origin	Total campsite number	Mean campsite number
High Andes	−0.006	−0.012	0.001	0.000	−0.007	−0.014	0.066	**−0.193**	1.246	**4.245**	20	0.135
Valdivian temperate forest	**2.398**	**−0.818**	0.035	0.084	0.469	0.036	−0.089	0.005	**12.182**	−10.082	130	1.398
Campos and Malezales	0.497	0.416	0.420	0.103	0.390	**0.547**	−0.009	3.104	0.030	−24.249	21	0.6
Humid Chaco	**0.087**	0.039	0.053	**0.235**	−0.005	−0.076	−0.068	−0.014	**0.006**	−1.280	22	0.19
Dry Chaco	**−0.365**	−0.094	**0.808**	0.005	**0.153**	−0.045	−0.057	0.032	−0.019	**6.786**	284	0.571
Paraná flooded savannas	−4.233	−3.739	4.110	1.371	−3.979	−1.172	1.130	−7.633	0.068	173.372	136	2.776
Espinal	0.195	0.325	**0.286**	0.124	0.005	**0.371**	−0.028	−0.164	0.018	−8.459	100	0.336
Patagonian steppe	**0.047**	**−0.030**	0.029	0.004	−0.001	**0.103**	0.160	−0.002	**0.997**	−0.029	102	0.176
Iberá marshes	0.497	0.416	0.420	0.103	0.390	**0.547**	−0.009	3.104	0.030	−24.249	20	0.476
Plains and plateaus Monte	0.011	**−0.034**	0.019	**0.012**	**−0.024**	0.036	−0.019	**−0.008**	**0.770**	**0.772**	114	0.318
Hills and basins Monte	−0.102	−0.184	−0.028	0.280	0.136	0.745	0.112	0.090	0.375	0.095	81	0.704
Pampas	−0.483	**−0.346**	−0.028	**0.493**	0.132	0.034	**0.798**	1.728	−0.071	8.666	377	0.922
Puna	0.019	−0.003	0.013	−0.014	−0.048	−0.011	−0.066	−0.186	−0.400	**3.937**	16	0.16
Paraná Atlantic forest			0.694	−0.140	0.225	0.264	−0.804	2.872	−0.012	8.809	68	1.889
Yungas	−0.003	**0.723**	−0.254	1.224	−0.978	0.277	−0.090	−1.526	−0.408	12.358	49	1.089
Argentina	**−0.072**	0.004	**0.113**	**0.160**	−0.013	**0.259**	0.033	**−0.028**	**0.045**	**0.832**	1541	0.526

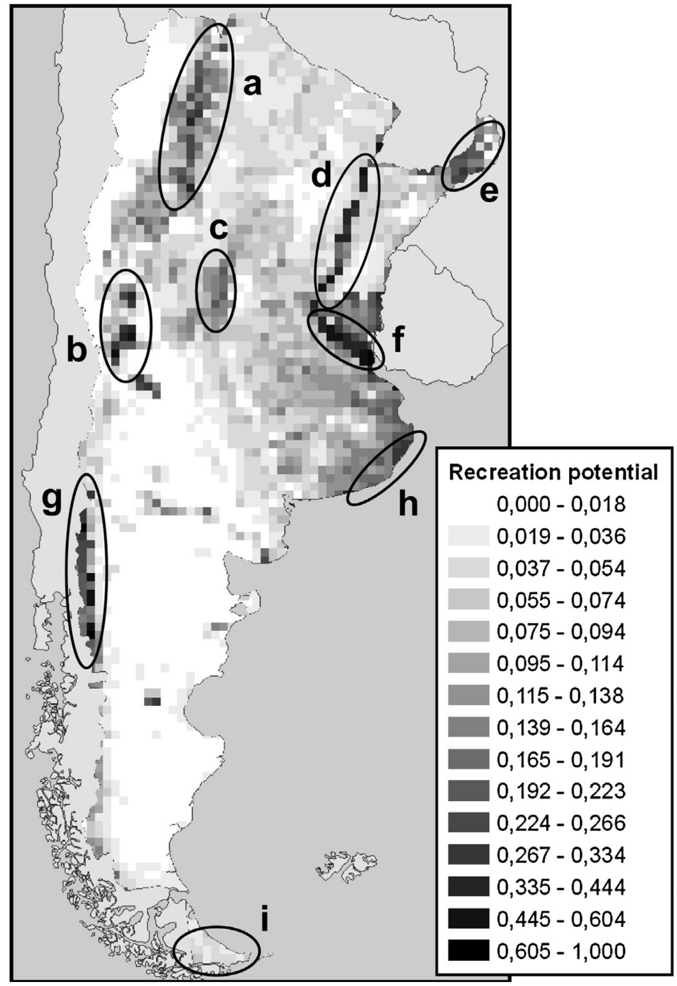

Fig. 5. Recreation potential calculated with provisioning functions. Recreation potential is expressed in a 0–1 scale where 0 is no recreation potential and 1 maximum recreation potential. Nine high recreation potential areas can be identified. (a) Northwest, associated to Yungas and Puna ecoregions, (b) Cuyo region, where recreation is concentrated in irrigation oasis, (c) Sierras de Córdoba, (d) Paraná River coast, (e) Atlantic forest, (f) Río de la Plata Delta, (g) Beaches in Buenos Aires province, (h) Valdivian woods, (i) Tierra del Fuego province.

two main reasons capable to explain this pattern. The first are the differences in agricultural practices among ecoregions. Agriculture of the Pampas region is intensive and expansion of soybean crop homogenized the landscape in the last decades (Aizen et al., 2009), what may diminish its scenic value and possibilities for recreational activities. In the Yungas and Paraná Atlantic forests, the natural biomes constitute the most valued characteristic, so agriculturization also diminishes its recreation attractiveness (Velazquez and Celemín, 2012). In the Monte and Valdivian Forests regions, on the contrary, agriculture is associated to irrigation oasis with vineyards and fruit production. This kind of agriculture is one of the attractors in these areas and there is a well established touristic industry associated to wineries (MINTUR, 2011). These results suggest that rural landscapes can have a high recreation value and even scenic quality under an Arcadian vision of nature, which associates landscape with a rural life in harmony with nature (Buijs et al., 2006; Daniel et al., 2012). In case studies in Europe, it has been demonstrated that heterogeneous landscapes with low intensive agriculture are most valued (García-Llorente et al., 2012; Pinto-Correia, 2000; van Berkel and Verburg, 2014). Another factor that could explain our results is that in arid regions climatic and topographic restrictions generate a concentration in space of all human activities. In these

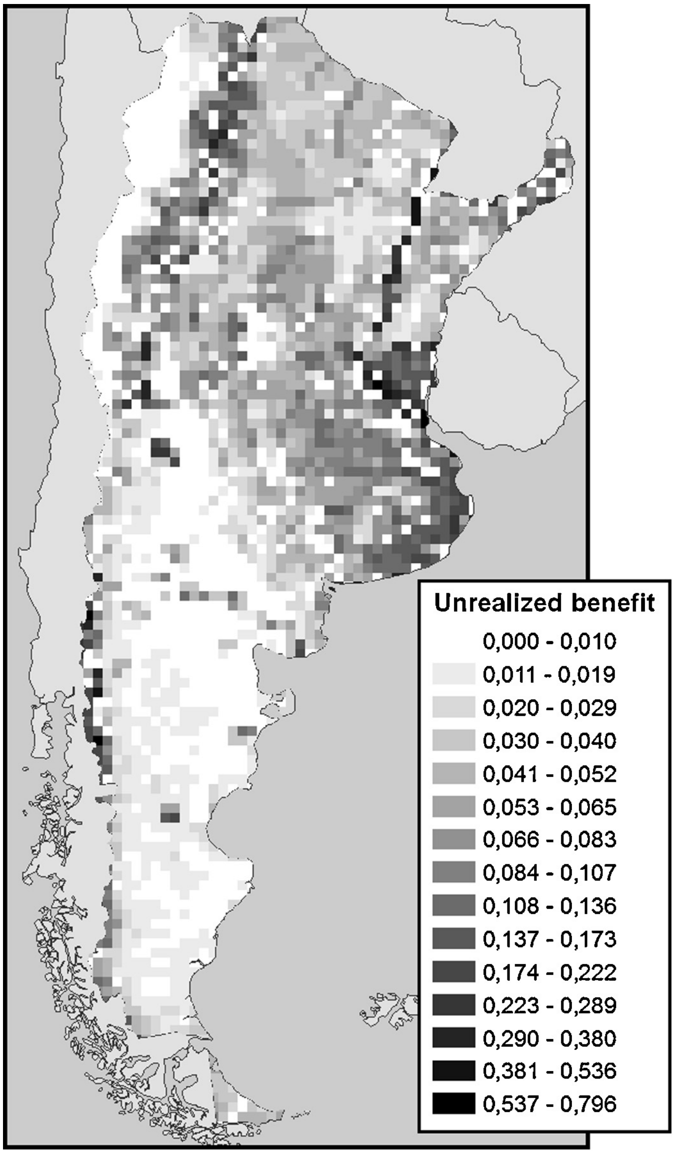

Fig. 6. Unrealized benefit of the ES. Values represent pred–obs values of the recreation potential model in a 0–1 scale. Darker gray cells are areas with high recreation potential that is not captured by recreationists.

cases recreation may take place far away from campsites so that a spatial congruence of campsite location with agriculture is a spurious relationship.

3.2. Benefit capture and drivers

Benefit capture is determined by different landscape attributes than those that determine service supply (Fisher et al., 2009). Among these factors are distance to cities (Chan et al., 2006), accessibility by roads (Hernández-Morcillo et al., 2013) or infrastructure that allows recreational activities (Colson et al., 2010). We considered road and population density to be relevant at our scale of analysis. These attributes showed no influence on unrealized benefit at the country scale, but they have different effects across ecoregions (Table 4) (Fig. 6). In Dry Chaco and Paraná flooded savannas road density reduces unrealized benefit as predicted. In the Pampas, where there is a non linear relationship, road density favors benefit capture but at higher densities unrealized benefit increases. In all other cases where there is a significant relationship higher road and population densities increase unrealized benefit (Table 4) (Fig. 6). It is possible that sensitivity to human intervention of the type of recreation we focused in our study explains these results. As we propose in our conceptual framework (Fig. 1), human intervention on the landscape may facilitate benefit capture but beyond certain threshold the negative incidence on scenic quality would reduce service provision. At certain scales, case studies demostrated that solitude is a prefered setting for campers (Goossen and Langers, 2000; Booth et al., 2011; Gursoy and Chen, 2012).

3.3. Conceptual framework for evaluation of recreation ES

Here we adopted a definition of recreation potential that allowed us to differentiate between ES provision and benefit capture. A vague definition would lead to incorrect methods or indicators, which will be translated in a poor quality of the studies for environmental management. As the general framework of ES is relatively recent, especial care should be put in the search of consensus in definitions (Nahlik et al., 2012).

Studies on recreation potential have normally a limited capacity of generalization and extrapolation. Nonetheless, some of the very broad landscape attributes we selected for our study coincide with previous findings and can be generalized across contexts. Good weather conditions, tree cover and presence of water are among the most important landscape attributes that improve camper's recreation experience (Cole and Hall, 2009; Faggi et al., 2011; Sildoja and Eagles, 2004). Velazquez and Celemín (2012) carried out

Table 4
Statistical models of stepwise multiple regression with pred–obs values of recreation potential model across ecoregions and Argentina with no stratification. RD: road density, PD: population density. Coefficient signs are expected to be negative or positive according to hypotheses formulated in the text.

Ecoregion	Statistical model	Expected coefficient sign (N = negative, P = positive)
High Andes	0.133(RD) + 8.208(PD)	N
Valdivian temperate forest	No relationship	P
Campos and Malezales	No relationship	P
Humid Chaco	1.384(PD) + 0.025	N
Dry Chaco	$-0.111^{*}\log(\text{RD}) + 4.87^{*}\log(\text{PD}) + 0.056$	N
Paraná flooded savannas	−0.643(RD) + 5.54(PD) + 0.295	N
Espinal	No relationship	N
Patagonian steppe	7.158(RD) + 0.016	N
Iberá marshes	No relationship	P
Plains and plateaus Monte	$0.613(\text{RD}) - 0.33(\text{RD})^{1/2} - 13.93(\text{PD}) + 1.18(\text{PD})^{1/2} + 0.04$	N
Hills and bossoms Monte	No relationship	N
Pampa	$-0.617^{*}(\text{RD}) + 0.76^{*}(\text{RD})^{2} + 0.197$	N
Puna	No relationship	N
Paraná Atlantic forest	No relationship	P
Yungas	No relationship	P
Argentina	No relationship	N

multi-criteria analysis in Argentina based on landscape metrics and derived an untested index of nature-based recreation resources. They considered seven types of resources: beaches, beach resorts, thermal bath resorts, snow/ice, relief, natural parks and green spaces, and water bodies. Even though they considered some different attributes the areas of high recreation potential in both studies tend to coincide.

Delimitation of provisioning areas was probably the most difficult challenge for our method. In previous studies, solution has been usually delimiting a view shed from panoramic points (Baerenklau et al., 2010; Gimona and Horst, 2007; Reyers et al., 2009) or evaluating the recreation value for protected areas (Colson et al., 2010; Larsen et al., 2008). We delimited provisioning areas with landscape units that we assumed close to the scale of human perception of the landscape. Still, we are not sure if this area corresponds to the extent where recreational activities take place. On the other hand, when campsites are located near the cell limits, it is probable that their area of influence is at least partly associated to neighbor cells. This neighbor effect was not taken into account and we could not predict its effect on the estimated recreation potential. For these reasons, it should be considered that cell size is a key variable affecting generalizability of our results. Still, the detection of high recreation potential areas is a first approach that will be useful for guiding more detailed delimitations in future studies.

We conducted our study at a very wide extent scale. As far as we know, there are few studies on recreation potential carried out at similar scales (see e.g. Edwards et al., 2012; Haines-Young et al., 2012). In some of these cases, simple indicators of recreation potential were selected, like number of visitors, but these usually confound ES provision with benefit capture (Eigenbrod et al., 2010; Hein et al., 2006). Our method had the strength of working with simple indicators at large scales (Haines-Young and Potschin, 2010). It is necessary to note though, that as we used the same indicator for ES supply and benefit capture measures, these are not completely independent. New studies at finer scales should reveal the influence of tourist attractor concentrations and local environmental conditions on both ES provision and benefit capture. In this work they are part of the unexplained variability.

In this work, we predicted recreation potential based in an indirect method using landscape metrics. It has the strength of being based in campsite locations, which resembles the approaches based in real tourist's behavior. At the same time, and contrary to TCM methods, it is capable of extrapolating results to unused landscape units, thus suggesting where potential for new recreation facilities could be developed. However, our approach neglects the variable distance from campsites at which recreation activities take place. This could be a source of bias of the expected recreation potential of sites where access limitations hamper the setting of campsites. This shortcoming could be overcome by studying recreation potential with complementary methods such as on site interviews to recreationists.

The general use of landscape metrics has also some limitations compared to methods based in interviews to stakeholders and experts (see e.g. Colson et al., 2010; Gül et al., 2006; Kliskey, 2000; Plieninger et al., 2013). It is known that the use of indicators may lead to incorrect estimations compared to the use of primary data (Eigenbrod et al., 2010). Some of the landscape attributes that were expected to be important in certain ecoregions, like woodland cover in Valdivian Forests (Velazquez and Celemín, 2012), turned out to be non significant. As this ecoregion has a homogeneous high woodland cover, the regression may have not detected significant differences in campsite density related to this attribute. Nonetheless, this attribute could be relevant for destination selection at a coarser scale, i.e., for selecting different ecoregions. The same is applicable to other landscape metrics. Thus, our results should be interpreted cautiously, avoiding their direct transference to different observation scales.

The study on recreation potential under the ES framework is less developed than other services (Daniel et al., 2012). As ES framework developed from ecological disciplines, cultural services are difficult to approach. Specific conceptual and methodological frameworks are urgently needed to take into account differences with other services based on biophysical processes. Human needs and well being cannot be fully attained without consideration to cultural values. Our work is a development that will allow the design of land-use plans with the objective of a balanced provision of ecosystems services taking into consideration these values alongside other human needs.

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Appendix A. Supplementary data

Supplementary material related to this article can be found, in the online version, at http://dx.doi.org/10.1016/j.ecolind.2013.11.023.

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