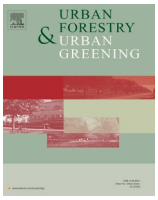
Urban Forestry & Urban Greening 66 (2021) 127390

Contents lists available at ScienceDirect

Urban Forestry & Urban Greening

journal homepage: www.elsevier.com/locate/ufug



Mapping the provision of cultural ecosystem services in large cities: The case of The Andean piedmont in Santiago, Chile

Soledad Alvarez-Codoceo [a], Claudia Cerda [b,*], Jorge F. Perez-Quezada [a,c]

[a] Department of Environmental Science and Renewable Natural Resources, Faculty of Agricultural Sciences, University of Chile, Santiago, Chile
[b] Department of Forest Management, Faculty of Forest Sciences and Conservation of Nature, University of Chile, Santiago, Chile
[c] Institute of Ecology and Biodiversity, Santiago, Chile

ARTICLE INFO

Handling Editor: Cynnamon Dobbs

Keywords:
Cultural ecosystem services
Large cities
Mapping
Mountain ecosystems

ABSTRACT

Large cities are both centers of demand for cultural ecosystem services (CES) and a source of environmental impacts. Assessing CES yields information to reduce the vulnerability of these services to such environmental impacts as well as to strengthen them in order to improve human well-being in cities. The Andean piedmont of Santiago is a natural mountainous area adjacent to the largest city in Chile and a source of CES, which are threatened as a result of the urbanization and weak territorial management instruments. A model was constructed to represent the provision of CES in the piedmont. The model integrated participatory techniques and geographic information analyses, making it possible to quantify and map the CES provision, which was represented by ecosystem attributes. CES are provided according to the weight that different stakeholders assign to these attributes. Attributes were characterized and then represented in space, resulting in a spatially explicit index constructed as the weighted sum of the previously established attributes. Our results show that the most relevant variables for the visitors when they come to enjoy the CES of the piedmont are accessibility and scenic beauty. In general terms, this means that the highest CES provision level is concentrated in the mid-altitude zone of the piedmont (away from the city but still accessible). We conclude that the piedmont areas close to large cities are relevant in terms of provision of CES and their protection is a priority to maintain the flow of CES towards the inhabitants of these cities.

1. Introduction

Ecosystem services (ES) are the direct contribution of ecosystems -whether natural, semi-natural or artificial- to the human well-being. In this respect, the ecosystem benefits are defined as products or experiences that derive from these ES (Haines and Potschin, 2013). It is broadly recognized that the ES approach is essential for making informed decisions about land use management (Jacobs et al., 2016; Menzel and Teng, 2010). This relevance is evident in the development of current conceptual frameworks such as the Intergovernmental Platform on Biodiversity and Ecosystem Services (IPBES, 2018), or the United Nations Agenda 2030 for Sustainable Development (United Nations, 2015), and in the exponential growth of ES scientific knowledge in the last decade (Delgado and Marín, 2015).

Natural and semi-natural areas near large cities are especially important to provide ES with a direct impact on human health and safety, such as air purification, noise reduction, urban cooling and runoff mitigation (Gómez-Baggethun et al., 2013; Zwierzchowska et al., 2018; Qizheng et al., 2020). Cultural ecosystem services (CES) (Haines and Potschin, 2013) are also provided by peri-urban natural ecosystems with an important and substantial contribution to well-being. The Millennium Ecosystem Assessment (MEA, 2003) defines CES as "non-material benefits that people obtain from ecosystems through spiritual enrichment, cognitive development, reflection, recreation and aesthetic experiences". CES can be experienced in remnants of forest, rivers and urban green areas (Elmqvist et al., 2015; Ko and Son, 2018), playing an important role in large cities (Riechers et al., 2016). Some of the benefits offered by CES are recreation, aesthetic inspiration, education, social interaction, attachment to the place, connection between residents and nature, and spiritual enrichment (TEEB, 2011).

Some authors have assessed the relation of access to natural areas with stress reduction and the improvement of physical and mental health (e.g. Ulrich, 1984; Alcock et al., 2014; Cole et al., 2019; Remme et al., 2021) and longevity (e.g. Takano et al., 2002). In addition, areas

* Corresponding author at: Santa Rosa 11315, Comuna La Pintana, Santiago, Chile.
E-mail addresses: sole.alvarez.codoceo@gmail.com (S. Alvarez-Codoceo), clcerdaj@uchile.cl (C. Cerda), jorgepq@uchile.cl (J.F. Perez-Quezada).

https://doi.org/10.1016/j.ufug.2021.127390
Received 17 May 2021; Received in revised form 27 August 2021; Accepted 19 October 2021
Available online 20 October 2021

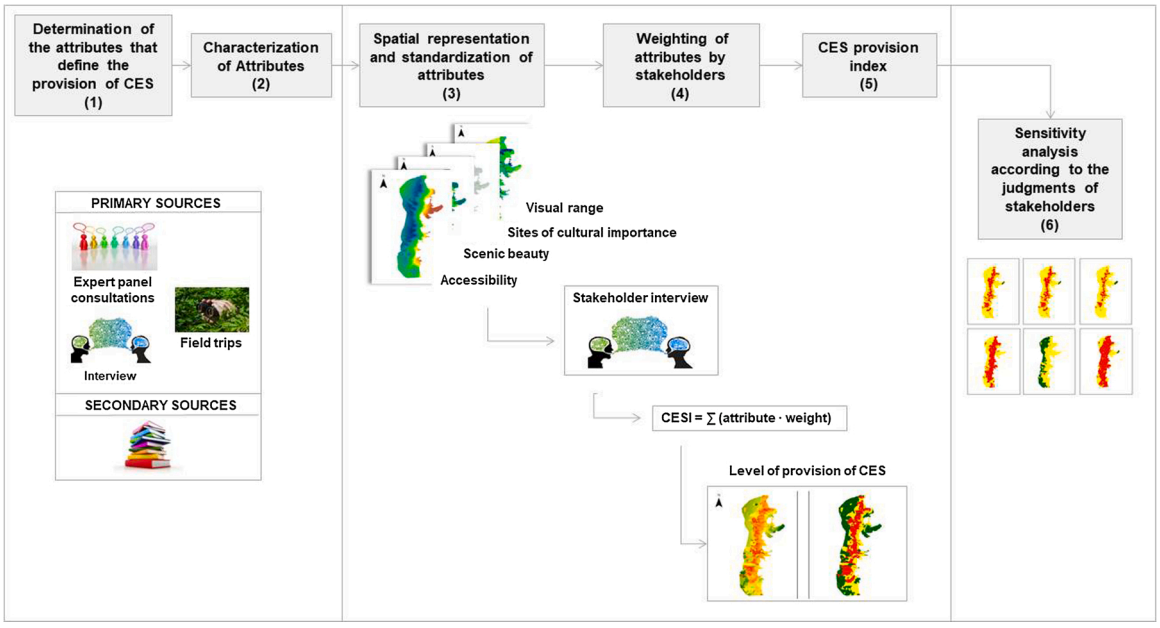


Fig. 1. Graphical representation of the methodological framework designed to evaluate the provision of ecosystem services.

with natural elements in cities are places where collective outdoor activities take place. These collective instances contribute to people creating and maintaining emotional bonds and social leadership, thus achieving cohesion among citizens (Kazmierczak, 2013; Enssle and Kabisch, 2020). Furthermore, children's cognitive processes have been reinforced by these natural areas (Groening, 1995; Dadvand et al., 2015). However, despite the recognized importance of CES for human well-being, significant conceptual and methodological gaps for their assessment still exist, especially for urban contexts (Hernández-Morcillo et al., 2013; Riechers et al., 2016). According to Chan et al. (2012a), these gaps persist because there is no commonly accepted framework for eliciting less tangible values. In this regard, the assessment of CES and their inclusion in policy agendas is a big challenge given the complex interactions of regional characteristics, different stakeholders and landscape settings that may influence the social perceptions of the immaterial benefits of the natural environment (Kabisch and Haase, 2014; Riechers et al., 2016). In addition, in large cities the generation of CES is affected by complex socio-environmental dynamics that are influenced by the historical, cultural and economic context of the territories (Ramos et al., 2018). Assessment of CES provides information to reduce the vulnerability of these services to adverse the effects of native vegetation areas being replaced for housing, and to strengthen them in order to guarantee specific standards to improve human well-being in cities (Maes et al., 2012; Cerda and Tironi, 2016; Enssle and Kabisch, 2020).

In many cases, piedmonts represent the interface between large urban centers and mountain ecosystems (Kulakowski et al., 2017), which makes piedmont regions sources of provisioning and regulating ES, such as prevention of natural disasters, food supply, water and raw materials, tourism, and CES related to recreational activities (cycling, bird watching and trekking) (Gret-Regameya et al., 2008). The Andean piedmont of Santiago is in central Chile, which has been classified as a biodiversity hotspot of global relevance due to the exceptional concentration of endemic species experiencing habitat loss (Myers et al., 2000). It is a transition zone between a mountain ecosystem and an urban ecosystem (Romero and Vásquez, 2005). The piedmont is visited by city residents for activities in contact with nature thanks to remnants of forests, rivers and mountain peaks (elements not present in the city) (De La Fuente De Val and Mühlhauser, 2014). However, there is a process of urban expansion towards the mountains not fully controlled by the authorities (Schiappacasse and Müller, 2012; Cox and Hurtubia, 2016) that poses a threat to mountain ecosystems that currently show low or no anthropogenic intervention and are a relevant source of CES. Therefore, information on CES provision can be useful for land use planning in the piedmont to prioritize areas that are relevant sources of CES for city residents and to prevent environmental conflicts (Almeida et al., 2007; Maes et al., 2012). In addition, the assessment of CES through spatial analyses that integrate participatory tools is suitable for involving the community in the analysis of the services and at present they are among the most used techniques to convey the social values of the territories to decision-makers (Cerda and Tironi, 2016).

In this vein, this study aimed to evaluate the provision of CES in the Andean piedmont of Santiago, Chile. In particular, our objectives were: a) define the attributes that determine the potential provision of CES, b) determine the importance that different stakeholders lend to the attributes, and c) estimate the actual provision of CES for the study area. The potential provision of CES is determined by attributes related to the biophysical, social and historical features of the ecosystems. The current CES provision is determined by the weight that different stakeholders give these attributes.

It is important to mention that this case study is a contribution to knowledge about CES in Latin America, one of the world's most urbanized regions (United Nations et al., 2014), but where the role of urban ecosystem services has been little studied in comparison with Europe and North America (Roy et al., 2012; Hernández-Morcillo et al., 2013; Milcu et al., 2013; Haase et al., 2014).

2. Materials and methods

To evaluate the performance of the CES, a model based on the multicriteria evaluation method (MCE) was proposed, specifically on the hierarchical analytical process developed by Saaty (2000). This method allows representing a complex problem or process that is composed of several attributes and criteria, developed hierarchically and at different levels. The attributes and criteria that explain the problem can be quantitative or qualitative and are represented in a common mathematical language to make them comparable (Pacheco and Contreras, 2008). The attributes must be evaluated and prioritized by the actors

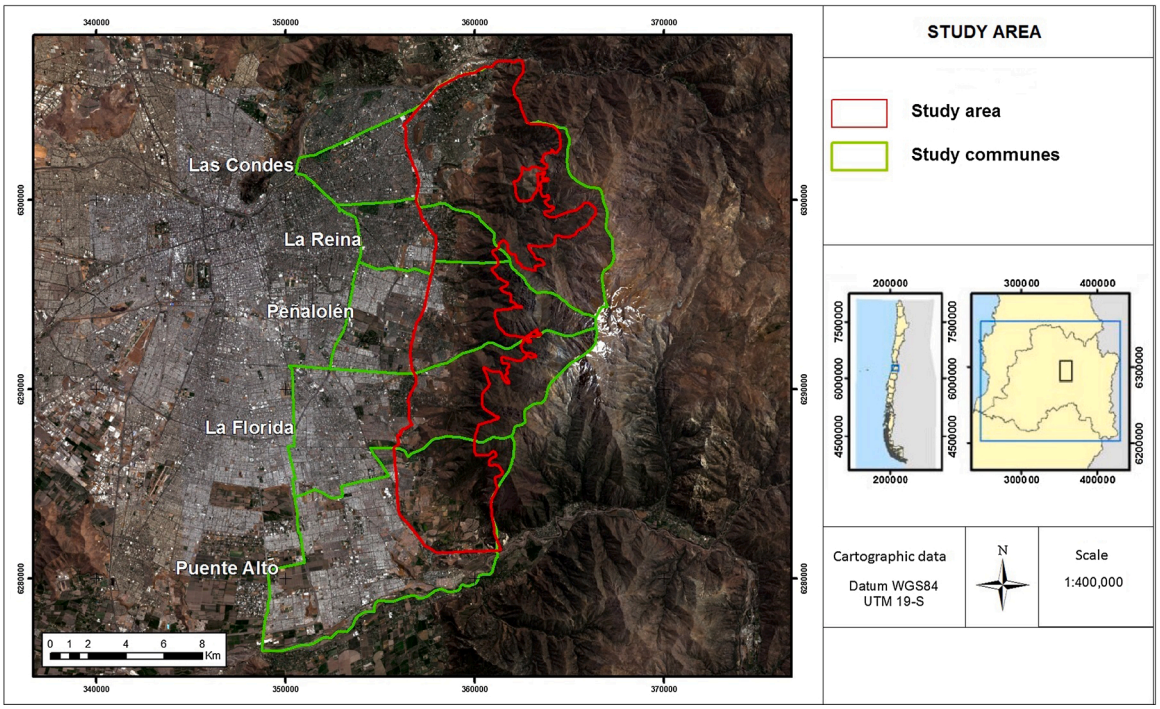


Fig. 2. Study area in the Andean piedmont of Santiago, Chile.

involved in the problem, resulting in different weighting of the attributes that represent their judgments, which is studied by performing a sensitivity analysis (Fig. 1).

2.1. Study area

The Andean piedmont of Santiago is located in the Metropolitan Region of Santiago (central Chile) and covers five communes from north to south: Las Condes, La Reina, Peñalolén, La Florida and Puente Alto (Fig. 2). It has an area of 146 km^2, with an approximate altitude between 700 and 1500 m a.s.l. It presents low density urban areas and ecosystems with plant communities of the sclerophyllous and the Andean sclerophyllous forests (Romero and Vásquez, 2005), which experience environmental pressures such as cutting and harvesting of woody material, extraction of non-wood products and loss of habitat caused by land use change (building space). In terms of fauna, there are 137 potential species, of which 16 % are endemic to Chile, 76 % are native and 22 % are threatened (Hernández et al., 2016).

Currently, the study area contains seven recreational parks used by Santiago residents and tourists. Six of these are under the administration of the Parque Cordillera Association, which is responsible for maintaining the trails, installing signage and providing park rangers. At present, the park network receives around 230000 visitors annually (data published at the Asociación Parque Cordillera, website http://asociacionparquecordillera.cl/quienes-somos/). Although most parks are managed by some institution, they are not legally protected or included in any territorial planning instrument. In fact, in most cases, the park lands belong to a private owner who has given over the responsibility for their management.

2.2. Determination of the attributes that define the provision of CES

The attributes which define the provision of CES are ecosystem elements relevant to the generation of these services, and are related to biophysical, social and historical ecosystem characteristics. Among the primary sources used to establish the attributes, there were field trips to recognize the study area, visits to recreational parks, interviews with park rangers and consultations with a panel of six environmental scientists. As a secondary source, literature was reviewed for similar experiences in other countries, previous studies in the Andean piedmont of Santiago (De la Fuente and Mühlhauser, 2006; Casado-Arzuaga et al., 2013; Nahuelhual et al., 2013; De la Fuente and Mühlhauser, 2014; Hernández et al., 2016) and applicable current legislation and official reports. Once the main dynamics associated with the provision of CES in the study area were understood, the following attributes were determined: accessibility, scenic beauty, sites of cultural importance and visual range, which are defined in Table 1.

The *accessibility* attribute was repeated as a key concept in the references consulted because it determines the enjoyment of CES users. During the field trips, it was verified that there are several sites in the piedmont that are difficult to access but are part of the landscape and offer impressive panoramic views. Thus, the *visual range* attribute was integrated to represent this characteristic and give value to hard-to-reach sites. On the other hand, the biota of the ecosystems also corresponds to a concept addressed in the literature (TEEB, 2011; Elmqvist et al., 2015; Riechers et al., 2016) and is relevant in the context of ES, particularly in an area such as the piedmont given that it differs from the city in that it contains patches of native forest. The latter was represented by the *scenic beauty* attribute, which deals with the subjective experience of different people visiting the piedmont. Finally, the cultural component contributed by the human being in the ecosystem was represented by the *sites of cultural importance*, since various constructions and representations that visitors currently use and value were identified during the field trips.

2.3. Characterization of attributes

Accessibility was characterized by the current density of paved roads in the urban area and the paths present in low density urban areas and areas with vegetation cover. The paths were classified into two types according to their altitude (1,000–1,250 m a.s.l. and 1,250−1,500 m a.s.l.). Only official spatial layers were used for plotting the road network, such as a street map of Santiago and the recreational paths in the parks. Tracks were made with GPS and visual interpretation from high-

Table 1
Description of the attributes used to construct the GIS on CES provision.

Attribute	Group of CES (CICES)	Definition	Representation	Characteristics/variables		Spatial representation
Accessibility	Physical and experiential interactions	Degree to which the piedmont, through the present roads, allows people to visit. It was selected as an attribute because it determines that piedmont visitors can access and enjoy the CES that the piedmont provides. Accessibility controls the provision of CES since it can satisfy the demand for these services.	Average between distance values of the layers associated with each type of road (paved and path). The layers are weighted differently according to their degree of accessibility considering the type of road.	Paved roads.		Distance (m) between a street and each pixel of the study area
				Authorized land paths connected to the street network.	Paths between 1000 m a.s.l.−1,250 m a.s.l.	˙1/2 distance (m) between a 1,000–1,250 m a.s.l. path and each pixel in the study area
					Paths between 1250 m a.s.l.−1,500 m a.s.l.	˙1/4 distance (m) between a 1,250−1,500 m a.s.l. path and each pixel in the study area
Sites of cultural importance	Physical and experiential interactions	Presence of sites, situations or structural configurations of ecosystems (e.g., a lagoon where people swim or a tree worshiped by indigenous people). They are linked to a specific site in the ecosystem with different spatial dimensions (it can be a landscape, a road or a rock) and allow access to the general public.	Score (0−6). Zero implies absence of a site of cultural importance, and the other values imply presence of one or more sites, with different levels of importance (see Table A3 in Appendix A).	Physical and intellectual interactions with biota, ecosystems and landscapes.	Type of Site	It can take 3 values: focal, complementary or support.
					Number of visitors	It can take 3 values: high, medium and low.
	Intellectual and representative interactions				Condition.	It can take 3 values: preserved, moderately deteriorated and deteriorated.
	Spiritual and/or emblematic			Spiritual, symbolic and other interactions with biota, ecosystems and landscapes.	Condition.	It can take 3 values: preserved, moderately deteriorated and deteriorated.
Scenic beauty	Physical and experiential interactions	Esthetic perception of territorial units (TU) in which they are inserted. TU were determined according to previously defined homogeneous TU, which are basic units of sampling and zoning plotted according to vegetation, slope, hydrological network, land use and other criteria.	Rating (1−7). 7 is the maximum value of scenic beauty.	Natural landscapes.		Rating (1−7). 7 is the maximum value of scenic beauty.
	Intellectual and representative interactions			Urban landscapes and crops.		Rating (1−7). 7 is the maximum value of scenic beauty.
Visual range	Physical and experiential interactions	Esthetic perception of a panoramic landscape. Evaluates the panoramic image observed from a certain point in space. It was determined relevant since it is possible to experience panoramic views from the high zones of piedmont with diverse landscapes.	Scale of value (high, medium, low).	Size of the visual field.		–
				Visible elements in the visual field.		–

resolution satellite images. In addition, spatial layers obtained from participatory websites (Web 2.0: Wikiexplora, Wikiloc, Andeshandbook and Openstreetmap) were reviewed to complement the road network.

The characterization of the attribute *sites of cultural importance* consisted of identifying and subsequently evaluating the sites. To identify the sites, we reviewed the official list of national monuments prepared by the National Council, the tourism and heritage guide of the commune of Peñalolén, official municipal websites and milestones marked on the Google Earth platform. In addition, the paths of the recreational parks were visited in search of relevant sites and the information obtained on the route was verified with the park rangers. The following characteristics of sites of cultural importance were evaluated: conservation status, number of visitors, timing of visits, type of protection and whether or not these were the main reason for the visit (e.g., waterfalls are generally the main reason for visiting tourists). The parameters evaluated are described in detail in Table A2 in Appendix A.

To verify which sites were the main reasons for tourist visits, 60 visitors were interviewed at the recreational parks present in the study area is September-October 2016. The survey allowed identifying their reason to visit the park, the relevant sites, the conservation status of the parks (vegetation and infrastructure), the frequency of visits, and determining if tourists were looking for specific elements of the park (e.g., viewpoint, waterfall, monument) or rather they preferred to walk the trails. In 2015, 190,000 people visited the piedmont recreational parks (estimated from data published at the Asociación Parque Cordillera website, http://asociacionparquecordillera.cl/). According to this, the results of the sample corresponding to the 60 surveys administered have an error of 12.65 % with a 95 % confidence level. The respondents were approached at the park exits to ask about their preferences.

In addition, the study area was divided into homogeneous territorial units (TU) to evaluate the attributes scenic beauty and visual range. To trace the TU, the following factors were considered: vegetational formations, slope of the terrain, aspect of slopes, watersheds, land use and elements constructed by humans. Homogeneity in the TU was sought to achieve representativeness; for example, a TU that had areas of two hillsides with different aspects would not be drawn, since this implies that there were two different vegetational formations in one TU. Water bodies and cultural monuments were not divided.

Scenic beauty of the landscapes present in the study area was characterized by the participatory works of Purcell et al. (1994) and De la Fuente and Mühlhauser (2006; 2014), made for the urban landscapes of Australia and landscapes of the Andean piedmont of Santiago, respectively. In those works, a group of people gave their preferences regarding the urban landscapes and piedmont landscapes through a survey, which consisted of a set of photos of different landscapes and a subsequent rating on their beauty (scale from 1 to 7) by each respondent. Landscape types and ratings are presented in Table A1 in Appendix A. Once the TU was defined, the works of Purcell et al. (1994) and De la Fuente and Mühlhauser (2006 and 2014) were used to assign a scenic beauty assessment to each TU in the study area. Each TU was homologated to a type of landscape and then the evaluation was assigned correspondingly, as was done in those studies.

Urban area and the areas with vegetation cover in the piedmont were characterized differently. For the area with vegetation cover, the type of landscape in each TU was classified directly during field trips according to the landscapes proposed by De la Fuente and Mühlhauser (2006 and 2014) (Table A1 in Appendix A). For the urban zone, the land cover data in each TU were associated with the landscape categories proposed by Purcell et al. (1994).

To evaluate the *visual range*, two criteria were established: (1) the size of the visual field that is perceived from a certain point of the landscape, and (2) the elements that are seen in that visual range. It was considered that the units with a "high visual range" were those with a wider visual field (either from the mountain range or the city) and with the possibility of appreciating natural sectors of scenic importance. On the contrary, those sectors with a narrow visual field and with natural sectors strongly intervened in a disjointed way within their visual field, were rated with "low visual range".

The visual range was characterized differently in the urban area than the areas with vegetation cover. The areas with vegetation cover were classified directly on the ground in the categories: high, medium and low visual range. The TUs of the urban area were classified according to their land cover and average altitude, because these two variables partially determine the size of the visual field perceived from a specific location of the TU and the elements that can be seen in that visual range.

2.4. Spatial representation and standardization of attributes

A geographic information system (GIS) was created to spatially represent CES provision in the piedmont, with a spatial resolution of 30 m (pixel size: 900 m^2). Table 1 shows the description of the attributes. These attributes can be linked to different CES groups presented in CICES (Haines and Potschin, 2013), which are: (1) physical and experiential interactions, (2) intellectual and representative interactions, spiritual and/or emblematic and other cultural outputs.

After the generation of the spatial layers, either qualitative or quantitative, they were standardized on a common ordinal scale of 0–100, according to the method proposed by Del Pilar Bautista et al. (2004):

$$Vn = \left[\frac{(V_0 - V_{\min})(Q_{max} - Q_{min})}{(V_{max} - V_{min})}\right] + (Q_{min}) \quad (1)$$

Where, : Normalized value, V_0 : Original value, $V_{\min}$: Minimum value of the original data range, V_{max} : Maximum value of the original data range, Q_{max} : Maximum value of the new data range, and Q_{min} : Minimum value of the new data range.

2.5. Weighting of attributes by stakeholders

Valuations of the attributes were obtained from a group of stakeholders to determine their relative importance using the Saaty matrix (1977). Stakeholders compared pairs of attributes to determine the relative importance of one attribute over another. Responses were on a scale of qualitative importance ranging from 1 to 9.

The stakeholders were represented by: (a) a professional related to the topic of the CES: a geographer and researcher. He has specialized in urban green infrastructure and has conducted CES studies in the context of urban planning and the piedmont of Santiago; (b) a manager of the CES provider-sites in the piedmont: current administrator of the Quebrada de Macul park (park belonging to the Cordillera Park Association) and a participant in various initiatives to protect the piedmont from urbanization processes; and a group of three beneficiaries (tourists) of these services. Each person represented one of the three tourist profiles identified in the 60 surveys, according to the main reasons they had to visit the study area: (c) *tourists interested in sports*, who do trekking, climbing or cycling, (d) *tourists interested in science and contemplation of nature*, and (e) *tourists interested in recreation*, seeking a natural space away from the city to enjoy with family or friends. People selected to value the attributes were searched within the networks of the research team.

All the actors were interviewed individually for one hour. The definitions of the attributes were explained to them in detail and an adapted questionnaire was applied to fill the Saaty matrix with their important judgments. Only one CES provider-site administrator was selected because there is a single entity responsible for the administration of recreational parks in the piedmont (Cordillera Park Association).

2.6. CES provision index

According to the MCE method, the actors' judgments were systematized using the Saaty (2000) matrix, a tool that compares pairs of attributes through the question: how much more important is the attribute in row *i* than the attribute in column *j*? This question is answered based on a qualitative scale of importance with values from 1 to 9. The value 1 implies that the attributes are equally important, while the value 9 implies that the attribute of row *i* is absolutely more important than the attribute of column *j*.

The Saaty Matrix was filled by the key stakeholders during individual meetings. Later, the geometric mean of the preference matrices of each actor was calculated. The result of the geometric mean was a common weighting vector (row matrix), which integrated the value judgments of all the selected actors for all the evaluated attributes. The weights took values between 0 and 1, and the sum of all of them added up to 1. Once this vector of weights was obtained, the cultural ecosystem services index (CESI) was calculated as:

$$CESI = \sum_{i=1}^{n} (weight_i \bullet \text{Attribute}_i) \quad (2)$$

Where $Weight_i$: attribute weighting $_i$, $Attribute_i$: attribute $_i$ of the evaluation model, and *n*: total number of attributes identified in the evaluation model.

The CESI represented the level of CES provision for each pixel in the study area with values between 0 and 100. Subsequently, values were categorized in three classes: high, medium and low, generating a map showing the level of CES provision in qualitative terms. The classes were determined using the natural breaks method (Jenks, 1963), which is widely used in GIS due to its ability to establish intervals with a clear spatial representation (García and Muñoz, 2008).

2.7. Sensitivity analysis according to the stakeholders' judgments

In order to analyze the sensitivity of the GIS model, the results obtained in Section 2.6 (original CESI) were compared with the results of the index constructed from the individual judgments of each of the five actors interviewed. These results were divided into three qualitative classes (high, medium and low) using the equal intervals method, so they would be comparable. The scale of possible results was from 0 to 100 and the intervals were: A: 0–33.33; B: 33.33–66.67; C: 66.67−100.

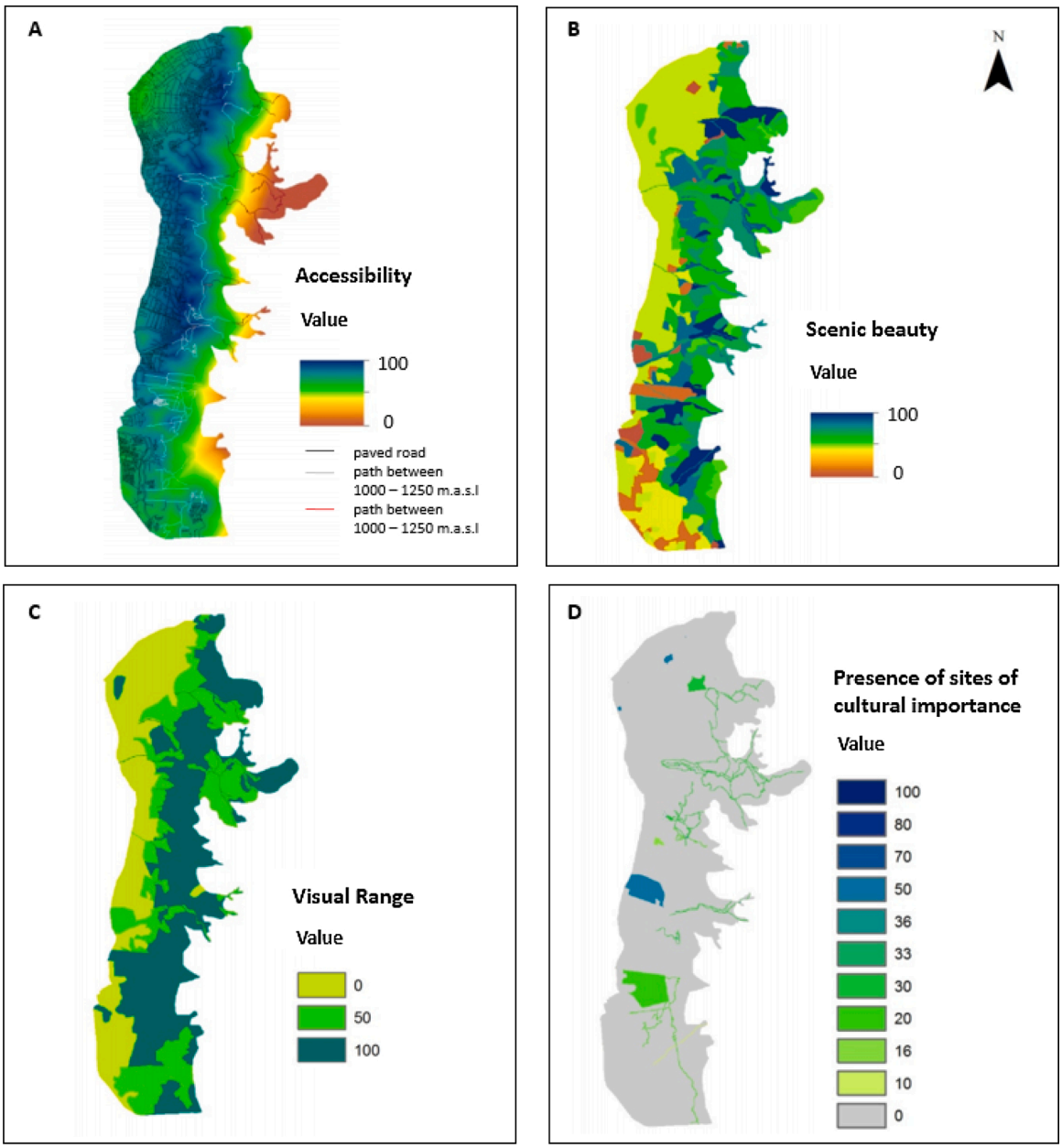


Fig. 3. Standardized attribute maps. A) Accessibility; B) Scenic beauty; C) Visual range; D) Presence of sites of cultural importance.

3. Results

3.1. Characterization of attributes

Accessibility: high accessibility values are tangential to the network of roads and paths traced, differentiated according to the type of road (paved or paths). The piedmont shows greater accessibility in the western area due to the higher density of roads in the urban area, decreasing to the east where low-density and non-urbanized urban sectors are more abundant (Fig. 3).

Scenic beauty: the natural spaces of the piedmont present greater scenic beauty than the spaces with anthropogenic impacts. Highlighted are forested landscapes, open spaces and the presence of water. Landscapes associated with mining and industrial areas, which do not have vegetation components, are the worst evaluated, so the values decrease according to human intervention (Fig. 3).

Sites of cultural importance: 93 sites of cultural importance were evaluated, from which 53 were classified as high, 33 as medium and 7 as low importance. The best evaluated sites of cultural importance are in the northern part of the study area, mainly due to the presence of established recreational parks that have good accessibility and an entity responsible for management. While in the southern part of the study area there are sites that are visited and considered important by tourists, they do not have adequate care or accessibility. Paths and rivers stand out among the sites classified with high importance. Some tourists appreciate walking the path *per se* and enjoy the surrounding landscape, while others seek out sites that the parks establish as goals on maps (usually mountain tops or viewpoints) (Fig. 3).

Visual range: higher visual range is related to higher altitude in the piedmont. The lower zones in the study area (west) have a limited visual range, caused in part by the smog layer present in Santiago. In high areas there is a wide visual range in all directions, with a view of natural areas

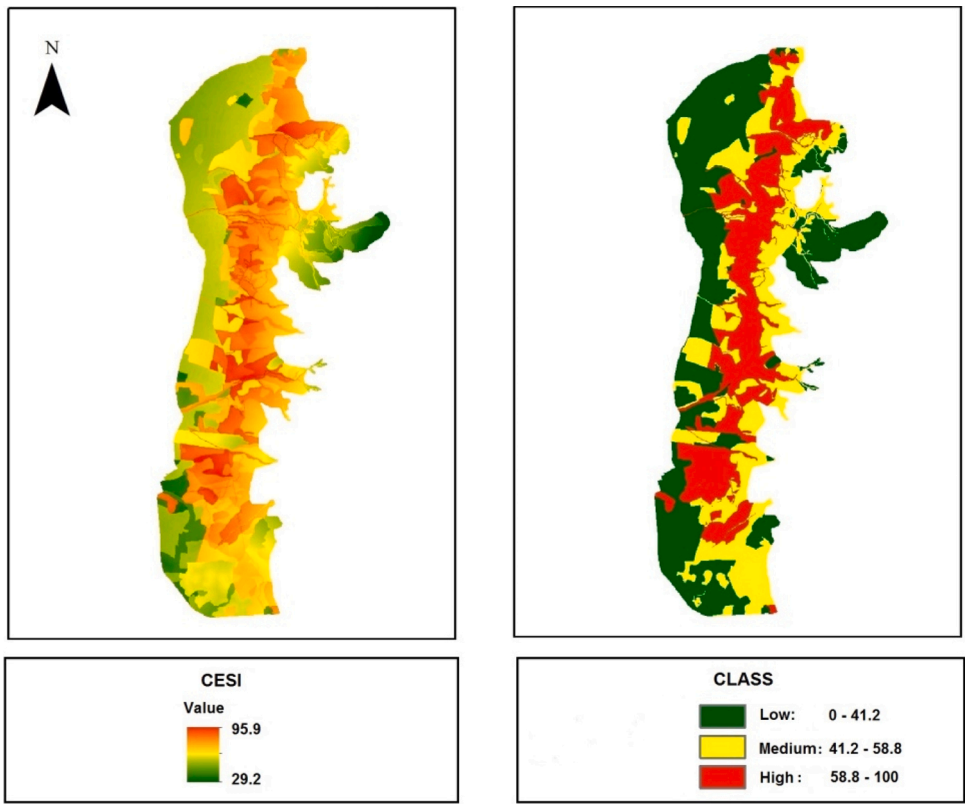


Fig. 4. CES provision level map. Left: CESI value. Right: qualitative classes of provision level.

of high scenic value and a panoramic view of the city (Fig. 3).

3.2. CES provision index

The CESI was estimated as follows:

$$CESI = (0.43 \cdot AC) + (0.27 \cdot SB) + (0.16 \cdot SCI) + (0.14 \cdot VR) \quad (3)$$

Where, *AC*: Accessibility, *SB*: Scenic beauty, *SCI:* Sites of cultural importance, and *VR*: Visual range. The set of relevant actors interviewed gave more importance to the accessibility attribute, which translated into the highest weighted value (0.43), followed by scenic beauty, sites of cultural importance and finally visual range.

Certain preferences associated with the actors' roles can be established. The park manager gave greater importance to accessibility, considering that it is a determining factor and the starting point for tourists to enjoy the services provided by the piedmont. The tourist with an interest in sports emphasized the visual range, preferring to contemplate the ecosystem in its fullness and liked to know the point where he was on the map to project his sporting goals. The tourist with interest in science and contemplation of nature gave greater importance to the scenic beauty than the other attributes, and was interested in having direct contact with nature. The less accessible a place is, the more pristine, and therefore more valued by him. The tourist with interest in recreation focused on accessibility. Similarly, the park manager considered accessibility a determining factor since children could become exhausted and prone to accidents in inaccessible places. Finally, the professional showed a balance in the preferences, probably associated to the academic role and knowledge of the study area and the dynamics associated with the CES, considering that all the attributes were equally relevant.

The CES provision level showed a pattern influenced by altitude (Fig. 4); the values of the CESI increased in the west-east direction as the height of the piedmont increases, reaching the maximum values in the middle-high part. This behavior is due mainly to two reasons related to scenic beauty and accessibility (attributes with greater weighting in the model): (1) accessibility values are higher in the west end (according to urbanization), and (2) the values of scenic beauty are concentrated in the middle and east end of the piedmont. As seen in Fig. 4, the highest CESI values are found in the upper-middle zone, according to surfaces with higher values of scenic beauty that present an acceptable degree of accessibility.

Table 2 shows that there is a greater area of the piedmont classified with a low level of provision (41.3 %), followed by the medium category (30.5 %), and finally the high level (28.2 %). The scale was constructed based on the values obtained in this study. This means that surfaces with a low level of CES provision are established with respect to the other surfaces of the piedmont.

The ravines are important sources of CES because they are evaluated with high scenic beauty and have sites of cultural importance, such as rivers, waterfalls, lookouts, trails and so forth, which are elements that contribute positively to the evaluation of the CES provision level. This also occurred with the established parks in the study area that have a relevant CES provision level, consistent with the current use and their offering. Parks are accessible places, with the presence of sites of cultural importance, beautiful in scenic terms and with sectors of high visual range. In other words, they are areas that meet all the evaluated attributes.

Another factor that determined the CES provision in the piedmont is

Table 2
Values of the CESI and area for each class obtained with the general model (Eq. (3)).

Class	CESI value	Area (km^2)	Area (%)
Low	0–41.2	60.3	41.3
Medium	41.2–58.8	44.6	30.5
High	58.8–100	41.1	28.2
Total		146	100

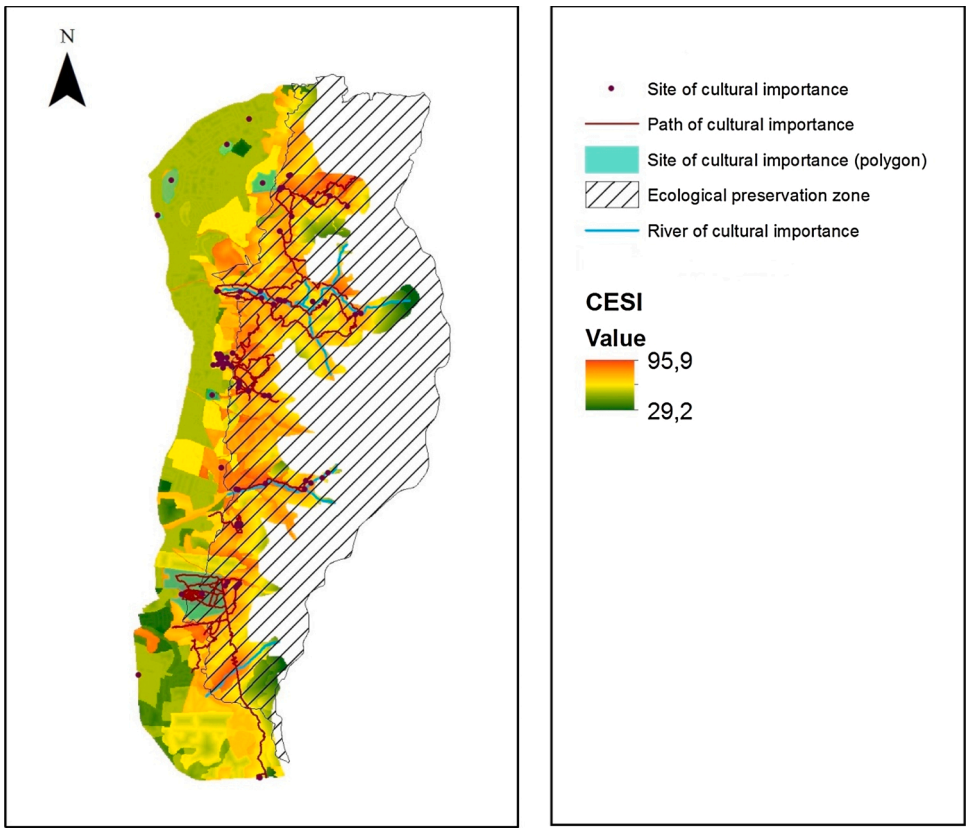


Fig. 5. Values of the Cultural Ecosystem Services Index (CESI).

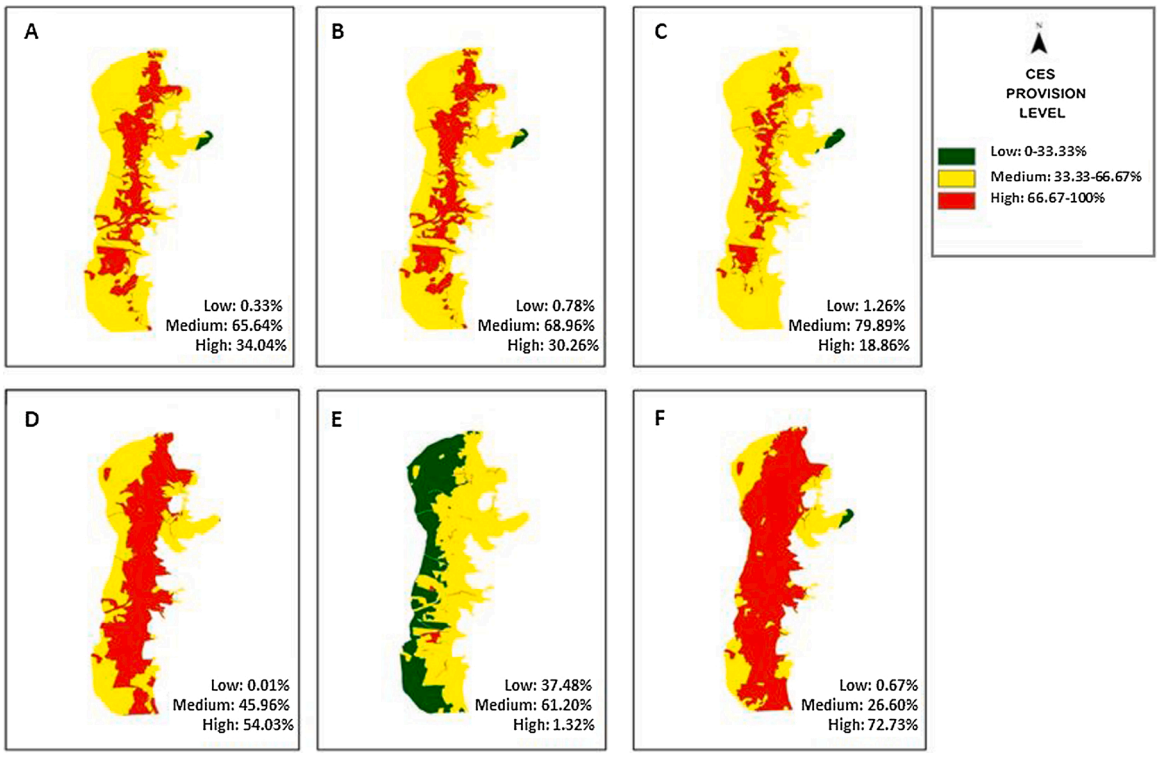


Fig. 6. Cultural ecosystem services provision level maps. A) Original model (CESI); B) Professional; C) Manager of CES sites; D) Tourist with an interest in sports; E) Tourist with an interest in science and F) Tourist with an interest in recreation.

the political delimitation of the Ecological Preservation Zone. As shown in Fig. 5, this zone protects much of the piedmont from urbanization processes by not allowing high-density construction, resulting in an area with features different from the city and with an important CES offering.

3.3. Sensitivity analysis

Fig. 6 shows that there are relevant differences between each actor's results. Some show a similar pattern, as in the case of the professional and the CES park manager, and the tourist interested in sports and the tourist interested in recreation. Although there are differences between the actors, all show a higher percentage of the area covered by high and medium CES provision level values vs. low values. Thus, there is a generalized positive assessment of the piedmont as a CES provider.

The model with the most surface area classified as high CES provision (72.7 % of the piedmont area) corresponds to the tourist with an interest in recreation. This person considered accessibility and scenic beauty as the most important attributes (weights equal to 0.64 and 0.19 respectively), two of which with a wide spatial distribution and representation. The model with the greatest area classified with a low level of CES provision (37.4 % of the piedmont area) corresponds to the tourist with an interest in science, who gave greater importance to scenic beauty and sites of cultural importance (0.49 and 0.36 respectively). This implies, on the one hand, that a large part of the urban area is classified as low because it is not positively qualified in terms of scenic beauty. On the other hand, the layer corresponding to sites of cultural importance is reduced in terms of its spatial distribution, because it gives value to specific pixels in the study area. This explains why a large part of the surface is classified as a medium provision of CES, and that a high level is assigned to gullies and specific sites in the piedmont. As explained before, the model most similar to the original model (CESI) was the one from the professional, which showed a similar proportion and pattern of spatial distribution in terms of the three qualitative classes.

4. Discussion and conclusions

4.1. CES provision of the piedmont

Context-specific information on urban ecosystem services is extremely relevant in the Latin American context and in other regions of the world where inequities and rapid urbanization place pressure on socio-political and ecological systems and their adaptive capacities (Dobbs et al., 2019). The fact that the effectiveness of the ES framework in decision-making depends on the recognition of the importance of different kinds of values, particularly with regard to CES, has been widely recognized (Chan et al., 2012a, b; Riechers et al., 2016). However, despite an increased interest in measuring ES for land use planning, significant information gaps on CES exist specially for urban systems (Rall et al., 2017). This study quantifies the provision of CES in the extent of a piedmont, a type of area that has not been sufficiently explored in the ecosystem services research despite the relevance it has for the well-being of inhabitants of large cities. Our results highlight the importance of the piedmont as a provider of CES and reveal areas that are more relevant to conservation and exposes the ecosystem attributes involved. This is the first step to subsequently developing territorial planning instruments consistent with the current territorial dynamics and that promote the conservation of the piedmont (De la Barrera and Moreira, 2013).

The most relevant variables for the stakeholders when they come to enjoy the CES of the piedmont are accessibility and scenic beauty. This result, together with the other ecosystem variables considered in the model, determines altitudinal variation of the CES provision. In the west-east direction, the levels of provision increase as the height of the piedmont increases, reaching its maximum values in the upper-middle part, and then decreasing its values in the eastern end of the study area, where the maximum heights are located. This behavior is because the accessibility values are higher on the west part (according to urbanization), and the values of scenic beauty are concentrated in the middle and eastern part of the piedmont. These results can be explained as the altitude gradient cause climatic differences affecting land cover and land use types (Shrestha and Zinck, 2001). The provision of CES shows higher levels in ravines and established recreational parks, which suggests that these areas should be protected and supported, respectively.

The results of the different models that represent each stakeholder show large differences in terms of the spatial distribution of the CESI. Understanding the spatial scale at which CES are provided is especially relevant when assessing which stakeholders are benefitting from each CES (Hazell, 2020), which may be related to the distances people are willing to travel to experience CES. The model that combines the judgments of importance of all the stakeholders integrated the diversity of their views according to the role they play in the study area. All the actors classified the piedmont between medium and high levels of CES provision. In this vein, the overlap of the areas classified as high by all the stakeholders covered 74 % of the piedmont.

4.2. Estimation of CES provision

To quantify CES provision in the piedmont we developed a method that integrated ecological variables, political administrative elements, and stakeholders' perceptions. The method developed is applicable to different territories by defining attributes with different types of variables (qualitative and/or quantitative) and selecting relevant actors for a specific area. In addition, it offers an easy result to apply for decision-makers through spatial visualization. The direct use of research on ecosystem services in policy-making and spatial planning remains challenging (Montoya-Tangarife et al., 2017). In this regard, our study contributes to existing processes of land use planning in urban areas. Although none of the instruments or information have explicitly incorporated the concept of CES nor the necessary conditions for ensuring their long-term supply, their use contributed to find that piedmont areas close to large cities are relevant in terms of provision of CES and their protection is a priority to maintain them.

Further, unlike previous studies in urban areas that for the evaluation of CES mostly use surveys outside the study site combined with the visual registration of the landscape in a GIS (e.g., Hegetschweiler et al., 2017), we conducted surveys at sites of cultural importance involving stakeholders that directly interact with the piedmont. In addition, we analyze attributes related to CES groups such as historical, educational heritage and feelings of attachment, which are generally not examined in CES research (Hegetschweiler et al., 2017). Urban planning confronts the challenge of securing the long-term quality of life for residents. Many studies on quality of life are based on provisioning ES with less attention paid to the non-material benefits gained from nature (Dou et al., 2017). These CES are often most important to urban residents (Dou et al., 2017; Chan et al., 2012a, b) and therefore understanding perceptions of CES is key for supporting urban planning and for the protection of spaces that provide such services as piedmonts.

4.3. Future perspectives and decision making

It would be interesting to complement this study with a more detailed evaluation of sites of cultural importance related to intellectual, representational, spiritual, and symbolic interactions from the point of view of demand. Only the state of conservation of these sites was evaluated, an aspect related to the offering. Another interesting line of research would be the study of the other categories of ES and how they relate to CES once the variables involved in each of these have been

affected.

Trade-offs between CES and regulating ES (e.g. pollination, climate regulation, flood control, prevention of landslide and erosion control) is a matter of concern, because regulating ES underlie the production of CES and are important for the resilience of social ecological systems (Raudsepp-Hearne et al., 2010). In this regard, flood control, prevention of landslide and erosion control have been studied in depth (Lara et al., 2018; Briones and Pilar, 2015; Lara, 2007), showing the contribution of the piedmont to prevent natural disasters in residential areas near the piedmont. Trade-offs between provisioning ES and CES have also been reported in China (e.g., Liu et al., 2019). In our study case, provisioning ES are fresh water, medicinal flora, genetic resources and wood. It is important to investigate the trades-off between CES and regulating and provisioning ES since there are areas in the Andean piedmont of Santiago that have uncontrolled tourism. This may represent a threat to the ES of all categories, since tourists who are unmonitored or have no environmental education can erode the soil, destroy plant resources and add litter to water sources, among other negative impacts. Previous research has already alerted the relevance of the piedmont to address sustainable tourism, environmental education and tourists' perceptions of piedmont landscapes (Hernández et al., 2016; De La Fuente De Val and Mühlhauser, 2006, 2014; Biskupovic, 2015; Rugiero and Wyndham, 2013; Romero and Vásquez, 2005; Montrasio et al., 2020).

From a management perspective, an in-depth analysis of the management and financing mechanisms of natural areas is required to guarantee the provision of ES. Additionally, the conservation of the piedmont should have positive effects on the conservation of biodiversity, representing an alternative way to protect natural areas surrounding large cities. However, in our case the current political-administrative status of the piedmont deserves attention. The piedmont is under the political-administrative protection of the Ecological Preservation Zone in the Santiago Metropolitan Regulatory Plan, where only low-density constructions are permitted. However, there is insufficient control of this rule and the city is currently expanding towards areas of the piedmont (Picón et al., 2017). Consequently, the city's expansion process constitutes a threat to the provision of the CES that the piedmont offers, and the land use instruments are not sufficient to protect this area.

In several large cities, urban development projects such as housing are usually designed to yield economic benefits rather than preserving green spaces (Aguayo et al., 2007), which threaten the provision of ES relevant to human well-being. Piedmonts may represent one of the few alternatives that people living in large urban areas have to connect with nature, so their consideration as part of urban management is relevant. The information generated in this study contributes to the understanding of supply and demand of CES in piedmonts. This information can be used as a source of reference values for similar assessments, for strengthening the cultural identity of piedmonts, for future territorial planning projects and for preventing environmental conflicts (Hernández and Sazo, 2015; Biskupovic, 2015; Schirpke et al., 2020).

In this sense, Chile can contribute to the discussion on how to implement socio-ecological planning in Latin America because it has made significant efforts to create new urban parks, form consolidated research groups and offer the new spatial planning perspectives under discussion in the country (Picón et al., 2017).

4.4. Conclusions

Our results show that the piedmont area close to Santiago is relevant in terms of provision of CES and its protection is a priority to maintain CES towards the inhabitants of this city. The conservation of piedmonts close to cities constitutes a strategy to safeguard the cultural heritage of the place from a touristic point of view, promoting its relevance for the wellbeing of inhabitants.

The most relevant variables for the stakeholders when they come to enjoy the CES of the piedmont are accessibility and scenic beauty. This implied that CES provision is determined by altitudinal variation, being the upper-middle part of the piedmont the most relevant CES provider. Particularly in ravines and established recreational parks, CES provision is higher because they are well-conserved places and have good accessibility. This result shows the importance of the coexistence of touristic activities and conservation to maximize the sustainability of the piedmont, which promotes the relevance of landscape traits for the valuation of CES.

Differences in the spatial distribution of CESI derived from models that represent each stakeholder reveal the necessity of understanding the spatial scale at which CES are provided, which would contribute to better connect the ecological and cultural networks. This is particularly relevant to identify which stakeholder benefits from each CES. For future research, a deeper exploration of knowledge and motivations of the different stakeholders is advisable, as these factors can affect the valuation of CES.

Research on CES in large cities should consider the existent instruments for land use planning to facilitate the exchange of results that support decision making process and the involvement of stakeholders responsible of achieving sustainable cities. Such instruments should promote the management of CES and consider their the relevance for well-being in these territories.

Models that integrate participatory techniques and geographic information analyses allow to quantify and map the CES provision, which contributes to visualize the role of piedmont areas to maintain CES in cities.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Acknowledgements

The authors wish to thank PNUD project N° 90298 "Implementation of a new national policy of urban development", particularly by funding the "Study for the definition of natural and patrimonial protected areas in the Andean piedmont of Santiago" (SCT-2015-019), the constructive comments made by two anonymous reviewers, and the funding from the Incentive Program for Institutional Excellence (University of Chile). Jorge F. Perez-Quezada also thanks the support of Grant ANID ACE 210006.

Appendix A

Table A1
Landscape types and ratings.

Landscape type	Density	Rating (1−7)
Sclerophyllous shrublands	Dense	6.20
	Very dense	4.67
	Sparse	5.16
	Very sparse	4.21
Acacia steppe	Dense	5.21
	Very dense	4.77
	Sparse	5.00
	Very sparse	5.63
Shrublands with succulent plants	Dense	5.15
	Very dense	4.94
	Sparse	4.62
	Very sparse	4.48
Ravine with shrublands	Dense	5.75
	Very dense	5.21
	Sparse	5.43
	Very sparse	4.73

Table A2
Parameters and criteria evaluated for each attribute.

Parameter	Criteria	Method for obtaining information
Type of Site	- Focal: Site that has intrinsic characteristics of uniqueness that best characterize a place and constitutes the fundamental reason why tourists will want to visit it. Ex: Waterfalls, Top of a hill, Forest, estuary, heritage site - Complementary: Site with lower importance than the focal one. It is not a fundamental reason for tourism, however, it also generates satisfaction in the tourist. Examples: qaterfalls, top of a hill, forest, estuary, heritage site (they can be the same elements as the focal attributes, but with lower importance). - Support: Site with artificial elements (facilities and services) that provide the visitor with different satisfactions. Examples: bathrooms, information centers, restaurants, viewpoints, bridges, picnic areas and trails.	60 surveys were applied to the visitors of the parks present in the study area, regarding the objectives and preferences of their visit
Type of CES	- According to the CICES (Haines and Potschin, 2013) classification of CES, there are two categories which have 2 and 9 classes, respectively	*In situ* classification (field trip)
Temporary visits	- Permanent: The site is visited every month of the year. - Seasonal: The site is visited only a few months of the Year. - Only a few days: The site is visited only some days of the year.	Conversations with park rangers and official data of the Network of Parks Cordillera (Association of Municipalities Parque Cordillera, 2014)
Number of visitors	- Low (<100 visitors per year) - Medium (Between 100 and 1000 visitors per year) - High (> 1000 visitors per year)	Conversations with park rangers and official data from the Parque Cordillera Network of Parks (Association of Municipalities Parque Cordillera, 2014)
Type of management	- Public: There is a public institution in charge of carrying out the administration and maintenance of the site. - Private: There is a private institution in charge of carrying out the administration and maintenance of the site. - Without management: The site is unprotected.	Conversations with park rangers and official data from the Network of Parks Cordillera (Association of Municipalities Parque Cordillera, 2014)
Type of protection	- Formal: There is a legal body or an institution in charge of protecting the site. - Informal: There is protection even though there is no associated legal body or responsible institution. - Without protection: The site is unprotected.	Conversations with park rangers and official data from the Network of Parks Cordillera (Association of Municipalities Parque Cordillera, 2014)
Condition	- Deteriorated: There is a clear deterioration of the site because of lack of maintenance or protection. Example: broken infrastructure. - Moderately deteriorated: There is evidence of a low deterioration of the site, because of maintenance without adequate periodicity. Example: presence of trash or graffiti. - Preserved: Properly preserved and well-maintained site.	In situ classification

Table A3
Scores used in the evaluation of the level of importance of the Sites of Cultural Importance, according to the criteria and variables of the model. The Final Importance Level was established with the following ranges of the Score obtained: high [7,9]; medium [5,7] and low [3,5].

Definition	Magnitude of visits	State of conservation	Score (∑scores for each cell)	Final Importance Level
Focal (3)	High (3)	Conserved (3)	9	High
		Slightly deteriorated (2)	8	High
		Deteriorated (1)	7	Medium
	Medium (2)	Conserved (3)	8	Hight
		Slightly deteriorated (2)	7	Medium
		Deteriorated (1)	6	Medium
	Low (1)	Conserved (3)	7	Medium
		Slightly deteriorated (2)	6	Medium
		Deteriorated (1)	5	Medium
Complementary (2)	High (3)	Conserved (3)	8	Hight
		Slightly deteriorated (2)	7	Medium
		Deteriorated (1)	6	Medium
	Medium (2)	Conserved (3)	7	Medium
		Slightly deteriorated (2)	6	Medium
		Deteriorated (1)	5	Medium
	Low (1)	Conserved (3)	6	Medium
		Slightly deteriorated (2)	5	Medium
		Deteriorated (1)	4	Low
Support (1)	High (3)	Conserved (3)	7	Medium
		Slightly deteriorated (2)	6	Medium
		Deteriorated (1)	5	Medium
	Medium (2)	Conserved (3)	6	Medium
		Slightly deteriorated (2)	5	Medium
		Deteriorated (1)	4	Low
	Low (1)	Conserved (3)	5	Medium
		Slightly deteriorated (2)	4	Low
		Deteriorated (1)	3	Low

References

Aguayo, M.I., Wiegand, T., Azócar, G.D., Wiegand, K., Vega, C.E., 2007. Revealing the driving forces of mid-cities urban growth patterns using spatial modeling: a case study of Los Ángeles, Chile. Ecol. Soc. 12 (1), 13.

Alcock, I., White, M., Wheeler, B., Fleming, L., Depledge, M., 2014. Longitudinal effects on mental health of moving to greener and less green urban areas. Environ. Sci. Technol. 48, 1247–1255.

Almeida, L., Nava, M., Ramos, A., Espinosa, M., Ordoñez, M., Juvnovsky, J., 2007. Servicios ecosistémicos en la cuenca del río Magdalena, Distrito Federal, México. Gaceta Ecológica 84 (85), 53–64.

Asociación de Municipalidades Parque. Cordillera, Chile, 2014. Memoria 2014: cuenta pública gestión 2014. Asociación de Municipalidades Parque, Cordillera. Santiago, Chile, p. 71.

Biskupovic, C., 2015. From rural haven to civil political project: utopian ideals and environmental protection in the Precordillera, Santiago, Chile. J. Political Ecol. 22, 183–198.

Briones, R., Pilar, V., 2015. Uso de un modelo lluvia escorrentía para la caracterización de crecidas rápidas en la precordillera andina. El caso de la Quebrada Ramón. Pontificia Universidad Católica de Chile, Santiago, Chile, p. 71.

Casado-Arzuaga, I., Onaindia, M., Madariaga, I., Verburg, P., 2013. Mapping recreation and aesthetic value of ecosystems in the Bilbao Metropolitan Greenbelt (northern Spain) to support landscape planning. Landsc. Ecol. 29 (8), 393–405.

Cerda, C., Tironi, A., 2016. La evaluación no monetaria de servicios ecosistémicos: perspectivas para la gestión sostenible de los territorios. Revista Luna Azul 45, 329–352.

Chan, K.M.A., Guerry, A.D., Balvanera, P., Klain, S., Satterfield, T., Basurto, X., Bostrom, A., Chuenpagdee, R., Gould, R., Halpern, B.S., Hannahs, N., Levine, J., Norton, B., Ruckelshaus, M., Russell, R., Tam, J., Woodside, U., 2012a. Where are cultural and social in ecosystem services? A framework for constructive engagement. Bioscience 62, 744–756.

Chan, K.M.A., Satterfield, T., Goldstein, J., 2012b. Rethinking ecosystem services to better address and navigate cultural values. Ecol. Econ. 74, 8–18.

Cole, H.V.S., Triguero-Mas, M., Connolly, J.J.T., Anguelovski, I., 2019. Determining the health benefits of green space: does gentrification matter? Health Place 57, 1–11.

Cox, T., Hurtubia, R., 2016. Vectores de expansión urbana y su interacción con los patrones socioeconómicos existentes en la ciudad de Santiago. EURE 42 (127).

Dadvand, P., Nieuwenhuijsen, M.J., Esnaola, M., Forns, J., Basagaña, X., Alvarez-Pedrerol, M., Rivas, I., López-Vicente, M., De Castro Pascual, M., Su, J., Jerrett, M., Querol, X., Sunyer, J., 2015. Green spaces and cognitive development in primary schoolchildren. Proc. Natl. Acad. Sci. U. S. A. 112 (26), 7937–7942.

De la Barrera, F., Moreira, D., 2013. Recognizing how ecosystems services of Mahuida Park (Santiago de Chile) benefit citizen: a strategy to link the protection of natural areas to urban settings. Treballs de la Societat Catalana de Geografia 75, 243–253.

De La Fuente De Val, G., Mühlhauser, H., 2006. Precordillera andina de Santiago: percepciones, actitudes y preferencias en visitantes urbanos. Urbano 9, 24–31.

De La Fuente De Val, G., Mühlhauser, H., 2014. Visual range: an examination of a South American Mediterranean landscape, Andean foothills east of Santiago (chile). Urban For. Urban Green. 13, 261–271.

Del Pilar Bautista, S., Reyes, M., Enrique, J., 2004. Prototipo de software para la agrupación de datos con una red neuronal artificial con topología de Kohonen UDCluster. Tecnura 8, 55–75.

Delgado, L., Marín, V., 2015. Ecosystem services: Where on earth? Ecosyst. Serv. 14, 24–26.

Dobbs, C., Escobedo, F.J., Clerici, N., De la Barrera, F., Eleuterio, A.A., MacGregor-For, I., Reyes-Paecke, S., Vásquez, A., Zea, J.D., Hernández, J., 2019. Urban ecosystem Services in Latin America: mismatch between global concepts and regional realities? Urban Ecosyst. 22, 173–187.

Dou, Y., Zhen, L., De Groot, R., Du, B., Yu, X., 2017. Assessing the importance of cultural ecosystem services in urban areas of Beijing municipality. Ecosyst. Serv. 24, 79–90.

Elmqvist, T., Seta, H., Handel, S., Van der Ploeg, S., Aronson, J., Blignaut, J.N., Gómez-Baggethun, E., Nowak, D.J., Kronenberg, J., Groot, R., 2015. Benefits of restoring ecosystem services in urban areas. ScienceDirect 14, 101–108.

Enssle, E., Kabisch, N., 2020. Urban green spaces for the social interaction, health and well-being of older people— an integrated view of urban ecosystem services and socio-environmental justice. Environ. Sci. Policy 109, 36–44.

García, V., Muñoz, M., 2008. Propuesta de nuevos espacios protegidos en la comunidad de Madrid a partir de metodologías multicriterio flexibles. Servicio de Publicaciones y Difusión Científica de la ULPGC, Madrid, España, p. 15.

Gómez-Baggethun, E., Gren, A., Barton, D.N., Langemeyer, J., McPhearson, T., O'Farrell, P., Andersson, E., Hamstead, Z., Peleg, K., 2013. Urban ecosystem services. In: Elmqvist, Th., Fragkias, M., Goodness, J., Güneralp, B., Marcotullio, P.J., McDonald, R.I., Parnell, S., Schewenius, M., Sendstad, M., Seto, K.C., Wilkinson, C. (Eds.), Urbanization, Biodiversity and Ecosystem Services: Challenges and oppOrtunities. A Global Assessment. Springer, Cham, pp. 175–251.

Gret-Regameya, A., Bebib, P., Bishopc, I., Schmida, W., 2008. Linking GIS-based models to value ecosystem services in an Alpine region. J. Environ. Manage. 89, 197–208.

Groening, G., 1995. School garden and kleingaerten: for education and enhancing life quality. Acta Hortic. 391, 53–64.

Haase, D., Larondelle, N., Andersson, E., Artmann, M., Borgström, S., Breuste, J., Gomez-Baggethun, E., Gren, A., Hamstead, Z., Hansen, R., Kabisch, N., Kremer, P., Langemeyer, J., Lorance, R.E., McPhearson, T., 2014. A quantitative review of urban ecosystem service assessments: concepts, models, and implementation. Ambio 43 (4), 413–433.

Haines-Yong, R., Potschin, M., 2013. Common International Classification of Ecosystem Services (CICES). London, UK, p. 34.

Hazell, E., 2020. Disaggregating ecosystem benefits: an integrated environmental-deprivation index. Sustainability 12 (18), 7589.

Hegetschweiler, T., Vries, S., Arnberger, A., Bell, S., Brennan, M., Siter, N., Olafsson, A., Voigt, A., Hunziker, M., 2017. Linking demand and supply factors in identifying cultural ecosystem services of urban green infrastructures: a review of European studies. Urban For. Urban Green. 21 (01), 48–59.

Hernández, C., Sazo, D., 2015. Movilización y resistencia verde: los conflictos socioambientales en Chile, 2003–2013. Revista de Gestión Pública 4 (2), 217–251.

Hernández, J., Acuña, M., Magni, C., 2016. El piedemonte de Santiago y sus servicios ecosistémicos. Maval SPA y Ministerio de Medio Ambiente, Chile, Santiago, Chile, p. 96.

Hernández-Morcillo, M., Plieninger, T., Bieling, T., 2013. An empirical review of cultural ecosystem service indicators. Ecol. Indic. 29, 434–444.

IPBES, 2018. Summary for Policymakers of the Assessment Report on the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services on Regional Assessment for the Americas. Secretariat of the Intergovernmental Science-Platform on Biodiversity and Ecosystem Services, Bonn, Germany.

Jacobs, S., Dendoncker, N., Martin-Lopez, B., Barton, D.N., Gomez-Baggethun, E., Boeraeve, F., McGrath, F., Vierikko, K., Geneletti, D., Sevecke, K., Pipart, N., Primmer, E., Mederly, P., Schmidt, S., Aragao, A., Baral, H., Bark, R., Briceno, T., Brogna, D., Cabral, P., De Vreese, R., Liquete, C., Mueller, H., Peh, K.S.H., Phelan, A., Rincon Ruiz, A., Rogers, S.H., Turkelboom, F., Van Reeth, W., van Zanten, B.T., Wam, H.K., Washbourne, C., 2016. A new valuation school: integrating diverse value of nature in resource and land use decisions. Ecosyst. Serv. 22, 213–220.

Jenks, G., 1963. Generalization in statistical mapping. Annals of the Association of American. Geographers 53, 15–26.

Kabisch, N., Haase, D., 2014. Green justice or just green? Provision of urban green spaces in Berlin, Germany. Landsc. Urban Plan. 122, 129–139.

Kazmierczak, A., 2013. The contribution of local parks to neighbourhood socialties. Landsc. Urban Plan. 109, 31–44.

Ko, H., Son, Y., 2018. Perceptions of cultural ecosystem services in urban green spaces: a case study in Gwacheon, Republic of Korea. Ecol. Indic. 91, 299–306.

Kulakowski, D., Seidl, R., Holeksa, J., Kuuluvainen, T., Nagel, T., Panayotov, M., Svoboda, M., Thorn, S., Vacchiano, G., Whitlock, C., Wohlgemuth, T., Bebi, P., 2017. A walk on the wild side: disturbance dynamics and the conservation and management of European mountain forest ecosystems. For. Ecol. Manage. 388, 120–131.

Lara, M., 2007. Metodología para la evaluación y zonificación de peligro de remociones en masa con aplicación en quebrada San Ramón, Santiago Oriente, Región Metropolitana. Santiago, Chile, p. 229.

Lara, S., Sepúlveda, A., Celis, C., Rebolledo, S., Ceballos, P., 2018. Landslide susceptibility maps of Santiago Andean foothills, Chile. Andean Geol. 45 (3), 433.

Liu, H., Wu, J., Liao, M., 2019. Ecosystem service trade-offs upstream and downstream of a dam: a case study of the Danjiangkou dam, China. Arab. J. Geosci. 12, 17.

Maes, J., Egoh, B., Willemen, L., Liquete, C., Vihervaara, P., Schagner, J., Grizzetti, B., Drakou, E., La Notte, A., Zulian, G., Bouraoui, F., Paracchini, M., Braat, L., Bidoglio, G., 2012. Mapping ecosystem services for policy support and decision making in the European Union. Ecosyst. Serv. 1, 31–39.

MEA (Millennium Ecosystem Assessment), USA, 2003. Ecosystem and Human Well-Being: A Framework for Assessment. MEA, Washington, USA, p. 22.

Menzel, S., Teng, J., 2010. Ecosystem services as a stakeholder-driven concept for conservation science. Conserv. Biol. 24, 907–909.

Milcu, A., Hanspach, J., Abson, D., Fischer, J., 2013. Cultural ecosystem services: a literature review and prospects for future research. Ecol. Soc. 18 (3), 44.

Montoya-Tangarife, C., Salazar, A., Inostroza, L., 2017. Monitoring the effects of land cover change on the supply of ecosystem services in an urban region: a study of Santiago-Valparaíso, Chile. PLoS One 12 (11), e0188117.

Montrasio, R., Mattiello, S., Zucaro, M., Genovese, D., Battaglini, L., 2020. The perception of ecosystem services of mountain farming and of a local cheese: an analysis for the touristic valorization of an inner alpine area. Sustainability 12 (19), 8017. https://doi.org/10.3390/su12198017.

Myers, N., Mittermeir, R., Mittermeir, C., Foncesa, G., Kent, J., 2000. Biodiversity hotspots for conservation priorities. Nature 403, 853–858.

Nahuelhual, L., Carmona, A., Lozada, P., Jaramillo, A., Aguayo, M., 2013. Mapping recreation and ecotourism as a cultural ecosystem service: an application at the local level in Southern Chile. Appl. Geogr. 40, 71–82.

Pacheco, J., Contreras, E., 2008. Manual metodológico de evaluación multicriterio para programas y proyectos. Instituto Latinoamericano y del Caribe de Planificación y Económica y Social (ILPES), CEPAL, Santiago, Chile, p. 111.

Picón, M.C., De la Barrera, F., Reyes, S., Forray, R., Berrizbeitia, A., 2017. Ecological planning in Santiago, Chile. How far are we? Classification of planning initiatives based on a brief literature review. Investigaciones Geográficas 54, 105–126.

Purcell, A., Lamb, R., Mainardi, E., Falcheros, S., 1994. Preference or preferences for landscape? J. Environ. Psychol. 14, 195–209.

Qizheng, M., Luyu, W., Qinghai, G., Yuanzheng, L., Min, L., Guanghua, X., 2020. Evaluating cultural ecosystem services of urban residential green spaces from the perspective of residents' satisfaction with green space. Front. Public Health 8, 226. https://doi.org/10.3389/fpubh.2020.0022.

Rall, E., Bieling, C., Zytynska, S., Hasse, D., 2017. Exploring city-wide patterns of cultural ecosystem service perceptions and use. Ecol. Indic. 77, 80–95.

Ramos, A., Jujnovskya, J., Almeida-Leñeroa, L., 2018. The relevance of stakeholders' perceptions of ecosystem services in a rural-urban watershed in Mexico city. Ecosyst. Serv. 34, 85–95.

Raudsepp-Hearne, C., Peterson, G.D., Bennett, E.M., 2010. Ecosystem service bundles for analyzing tradeoffs in diverse landscapes. Proc. Natl. Acad. Sci. 107 (11), 5242–5247.

Remme, R.P., Frumkin, H., Guerry, A.D., King, A.C., Mandle, L., Sarabu, C., Bratman, G. N., Giles-Corti, B., Hamel, P., Han, B., Hicks, J.L., James, P., Lawler, J.L., Lindahl, T., Liu, H., Lu, Y., Oosterbroek, B., Paudel, B., Sallis, J.F., Schipperijn, J., Sosič, R., de Vries, S., Wheeler, B.W., Wood, S.A., Wu, T., Daily, G.C., 2021. An ecosystem service perspective on urban nature, physical activity, and health. Proc. Natl. Acad. Sci. 118 (22), e2018472118.

Riechers, M., Barkmann, J., Tscharntke, T., 2016. Perceptions of cultural ecosystem services from urban green. Ecosyst. Serv. 17, 33–39.

Romero, H., Vásquez, A., 2005. Evaluación ambiental del proceso de urbanización de las cuencas del piedemonte andino de Santiago de Chile. EURE 21 (94), 97–118.

Roy, S., Byrne, J., Pickering, C., 2012. A systematic quantitative review of urban tree benefits, costs and assessment methods across cities in different climatic zones. Urban For. Urban Green. 11 (4), 351–363.

Rugiero, V., Wyndham, K., 2013. Identificación de capacidades para la reducción de riesgo de desastre: enfoque territorial de la participación ciudadana en la precordillera de comuna de La Florida, Santiago de Chile. Investigaciones Geográficas 46, 57–78.

Saaty, T., 1977. A scaling method for priorities in hierarchical structures. J. Math. Psychol. 15, 234–281.

Saaty, T., 2000. Fundamentals of Decision Making and Priority Theory with the Analytic Hierarchy Process. RWS Publications, University of Pittsburgh, USA, p. 478.

Schiappacasse, P., Müller, B., 2012. Metropolización y políticas de planificación: un desafío para Santiago de Chile. URBANO 25, 31–42.

Schirpke, U., Scolozzi, R., Dean, G., Haller, A., Jäger, H., Kister, J., Kovács, B., Sarmiento, F.O., Sattler, B., Schleyer, C., 2020. Cultural ecosystem services in mountain regions: conceptualising conflicts among users and limitations of use. Ecosyst. Serv. 46, 101210.

Shrestha, D.P., Zinck, J.A., 2001. Land use classification in mountainous areas: integration of image processing, digital elevation data and field knowledge (application to Nepal). Int. J. Appl. Earth Obs. Geoinf. 3 (1), 78–85.

Takano, T., Nakamura, K., Watanabe, M., 2002. Urban residential environments and senior citizens' longevity in megacity areas: the importance of walkable green spaces. J. Epidemiol. Community Health 56, 913–918.

TEEB (The Economics of Ecosystems and Biodiversity), 2011. Manual for Cities: Ecosystem Services in Urban Management, p. 48.

Ulrich, R., 1984. View through a window may influence recovery from surgery. Science 224, 420–421.

United Nations, Department of Economic and Social Affairs, Population Division, 2014. World Urbanization Prospects: The 2014 Revision, Highlights (ST/ESA/SER.A/352).

United Nations General Assembly (UN), 2015. Resolution 70/1. Accessed 26 Feb 2019. http://www.un.org/ga/search/view_doc.asp?symbol=A/RES/70/1&Lang=E.

Zwierzchowska, I., Hof, A., Iojă, I.C., Mueller, C., Ponizy, L., Breuste, J., et al., 2018. Multi-scale assessment of cultural ecosystem services of parks in Central European cities. Urban For. Urban Green. 30, 84–97. https://doi.org/10.1016/j.ufug.2017.12.017.