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Recognizing how ecosystem services of Mahuida Park (Santiago de Chile) benefit citizen: a strategy to link the protection of natural areas to urban settings[1]

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Abstract

Chilean Mediterranean ecosystems represent a hotspot of biodiversity; however, its biological importance has not been an enough argument to protect them. In this study, by using Mahuida Park as a model, we proposed a different approach based on the identification and maximization of ecosystem service to promote the conservation these well conserved ecosystems. We argued that its native vegetation structure in combination with other topography attributes can provide regulating ecosystem services to urban areas around it. This approach may be used as an argument to protect the Mediterranean vegetation within the park, and at the same time, increasing the economic resources given

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by local government. The approach is based on the inhabitants' daily well-being who live close to natural areas. We expect that this proposal be useful to incorporate this functional aspect in planning, management and decision-making related to urban and periurban parks.

Keywords: ecosystem services, landscape, periurban public parks, urban ecology

Resum: *Reconèixer com els serveis ecosistèmics del Parc Mahuida (Santiago de Xile) beneficien els ciutadans: una estratègia per vincular la protecció d'ecosistemes naturals a sistemes urbans*

Els ecosistemes mediterranis xilens representen un *hotspot* de biodiversitat, però, la seva importància biològica no ha estat un suficient argument per protegir-los. En aquest estudi, utilitzant el Parc Mahuida com a model, proposem un enfocament diferent basat en la identificació i maximització dels serveis ecosistèmics per promoure la conservació d'aquests. Hem argumentat que l'estructura de la vegetació nativa en combinació amb altres atributs de la topografia d'aquest parc pot proporcionar serveis ecosistèmics de regulació a les zones urbanes que l'envolten. Aquest enfocament pot ser utilitzat com un argument per donar protecció a la vegetació mediterrània dins del parc, i al mateix temps, augmentar els recursos econòmics donats pels governs locals. L'enfocament es basa en el benestar diari dels que viuen més a prop de zones naturals. Desitgem que aquestes proposta pugui ajudar a incorporar aquest aspecte funcional en la planificació, la gestió i la presa de decisions relacionades amb parcs urbans i periurbans.

Paraules clau: ecologia urbana, paisatge, parcs públics periurbans, serveis ecosistèmics.

Resumen: *Reconociendo cómo los servicios ecosistémicos del Parque Mahuida (Santiago de Chile) benefician a los ciudadanos: una estrategia para vincular la protección de ecosistemas naturales a sistemas urbanos*

Los ecosistemas chilenos mediterráneos representan un *hotspot* de biodiversidad; sin embargo su importancia biológica no ha sido un argumento suficiente para protegerlos. En este estudio, utilizando el Parque Mahuida como modelo, proponemos un enfoque diferente basado en la identificación y maximización de la producción de servicios ecosistémicos para promover la conservación de estos ecosistemas. Mostramos que la estructura de la vegetación nativa en combinación con otros atributos topográficos del parque puede proveer servicios ecosistémicos a áreas urbanas cercanas. Este enfoque puede ser usado como argumento para proteger la vegetación mediterránea dentro del parque, y al mismo tiempo, aumentar los recursos económicos entregados a esta. El enfoque se basa en el bienestar diario de quienes viven cerca de áreas naturales. Se espera que esta propuesta sirva para incorporar este aspecto funcional en la planificación, en la gestión y en la toma de decisiones asociada a parques urbanos y periubanos.

Palabras claves: ecología urbana, paisaje, parques públicos periurbanos, servicios ecosistémicos.

Introduction

Invoking ecosystem services has become a new tool conservationist to reduce the global loss of biodiversity in human-created ecosystems (Perrings *et al.,* 2010). Natural areas around urban and suburban areas may provide spaces where practicing sport and spiritual activities; also, depending on their level of disturbance, they can maintain a small sample of wildlife and lend more intangible services such as carbon sequestration and water supply (Bolund & Hunhammar, 1999). These areas are particularly important in South America countries since most of their cities are being quickly urbanized and most of them without urban planning for sustainable development (Barton, 2006).

What is the future of these areas next to growing cities? How can managers highlight the value of them? These surrounding areas are under pressure and we need innovative and robust arguments to protect them. Understanding which ecosystem services these natural area can provide (and planning its management), represents a conceptual and operative way to link efforts of quality life improvement and biodiversity conservation. Also it is required to innovate in governance aspects, recognizing socio-economic and institutional differences within cities.

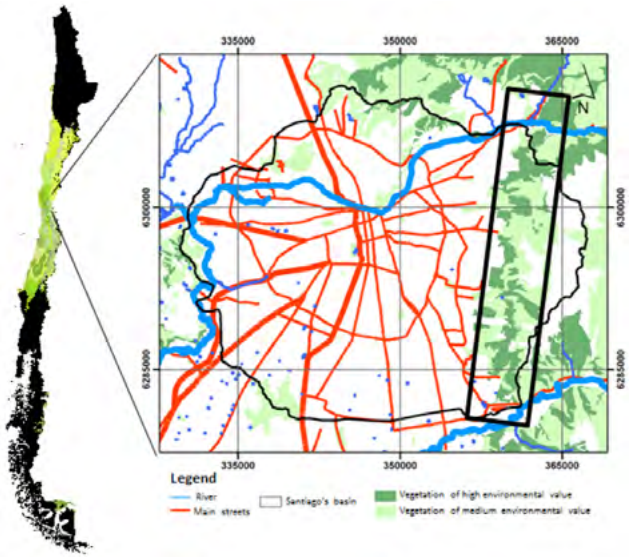
Geographical and ecological context

Chilean Mediterranean ecosystems are widespread recognized by their biological diversity and its high number of endemic species of plants and animals (Myers *et al.*, 2000). Despite this importance, farming and urbanization activities, which are increasing since the late 20th century, have reduced the natural land surface and the ecosystem services production, especially in Santiago city's watershed (Romero & Vasquez, 2005; Schulz *et al.*, 2010). As result, the Mediterranean vegetation is mainly represented by a single-vegetation layer composed of shrub and herbs, and controlled by anthropogenic agents (Holmgren, 2002).

Currently, these ecosystems represent small areas isolated within a human-dominated landscape at present. The Andean piedmont area, a pre-mountain formation between 800 and 1500 masl that includes many ravines, is one of the ecosystems that conserves native vegetation and that receives a higher urban pressure (Pavez *et al.*, 2010). This kind of ecosystem is located next Santiago city (33.5° S 70.6° W), which concentrates 6.8 million of inhabitants (projected at 2012), with higher population density and urbanized surface (around 700km^2) than other Chilean cities (fig. 1).

In comparison with other regions in Chile, the central region that includes Mediterranean ecosystems contains few officially protected areas within National System of Protected Areas (Luebert & Becerra, 1998). Because of most

Figure 1. Andean piedmont area (black rectangle) in Santiago de Chile. Chilean Mediterranean ecosystems are showed to the left.

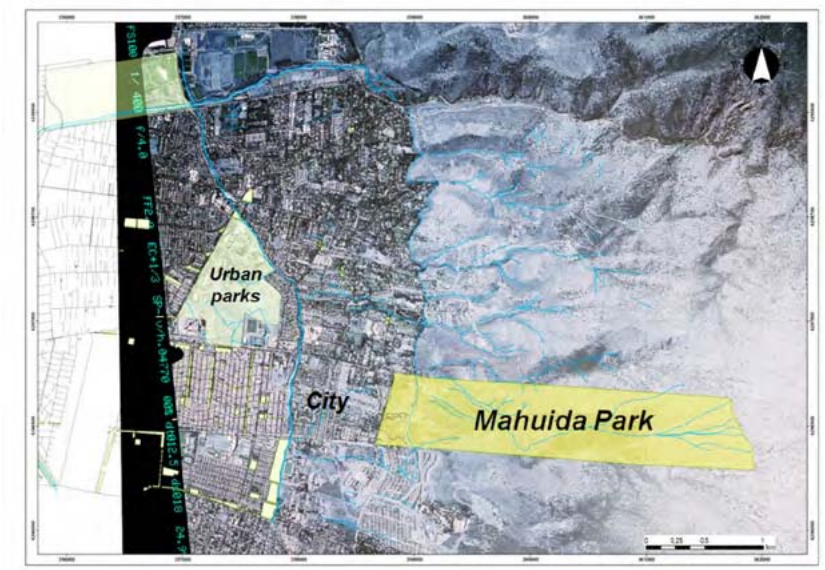


of the lands belong to private property within this region the scarce representation within this public system has not allowed an effective conservation of this type of ecosystems (Armesto *et al.*, 1998). Unfortunately, in order to increase the economic status, the Chilean State sold many natural areas to private landowners in the early 80s. Since then, these areas were used for farming and urbanization. So, other kind of protected natural areas are needed in order to protect the Mediterranean ecosystem.

Mahuida Park, a 112-hectare park placed in the Andean piedmont (fig. 2), represents our case of study. Although it is not part of this official system, plays an important function for Santiago's population. Mahuida Park was opened in the year 2000 using a municipal land and it is administered by a foundation, which has been created by the local government. This local foundation is composed by the major, two council members, three inhabitants (representatives) and three businessmen that offer services in the park.

Local municipalities next to Mahuida Park have a high socioeconomic status population and accelerated urbanization rates. Between 1975 and 2003 the urban surface in these districts showed an increase of 30% (Pavéz *et al.*, 2010). Currently, the urbanization process of this municipalities and non-controlled outdoor activities within the park have increased the pressure on it, promoting the degradation of vegetation cover in some areas and increasing the presence of exotic species as well (Romero & Vásquez, 2005; Becerra, 2006). As a result, an urgent regulation frame has been recognized by the local government to be incorporated. Due to Mahuida Park is close to main urban

Figure 2. Mahuida Park in the geographical context



areas (fig. 2) and it contains remnants of well conserved Mediterranean vegetation, including evergreen sclerophyllous shrubs and forest distributed mainly within ravines, we propose this Park have to be considered as a semi-natural ecological system able to generate ecosystem services for the inhabitants living nearby. Incorporating these aspects within the environmental planning of this municipality could allow managers to link natural conservation goals with social benefits for surrounding population.

The Mahuida Park environmental plan

We developed the Mahuida Park environmental plan based on land use and species-based criteria and included an innovative approach based on the assessment and protection of those areas able to produce ecosystem services that are consumed by local inhabitants. We used the *Millenium Ecosystem Assessment* classification that identifies four ecosystem services classes and its linkages with the constituents of human well-being (Alcamo *et al.*, 2003). We suggested that the mainly consumed ecosystem services in Santiago's periurban parks should be "cultural" and "regulating" services, more than "support" (related to essencial natural process) and "production" (extraction of resources). For the first services, people can access into these places in order to use and enjoy the nature, even from further districts. The second services have expression both at local scale (for example water regulation) and at global scale (for

example carbon sequestration). In other words, there are services that can be produced in one place of the Earth to be used by inhabitants of the whole world, but, other services can be enjoyed only by inhabitants that live near to the place where they are being produced. Regulation services are directly perceptible, quantifiable and inhabitants cannot decide if they will use them, so always are used. Urban areas that obtain benefits from these ecosystem services are spatially demarcated and are in function of its closeness to natural areas and the urban settings. Thus, these regulation services are consumed outside the park.

To infer regulating services provided for Mahuida Park, We first assessed the topography within the park. For that, we built a Digital Elevation Model (represented as a vector-based triangular irregular network, TIN) using contour lines and slope-exposition data. Then, we identified the topography features of the study area such as ravines and strong slopes. Then, we characterized the vegetation within the park by identifying the diversity of strata and cover of each vegetation class. For that, first, we used Google Earth imagery to get a general description for the vegetation (by using photointerpretation, fig. 3). Finally, we used field verification to describe the species composition and species dominants of each class.

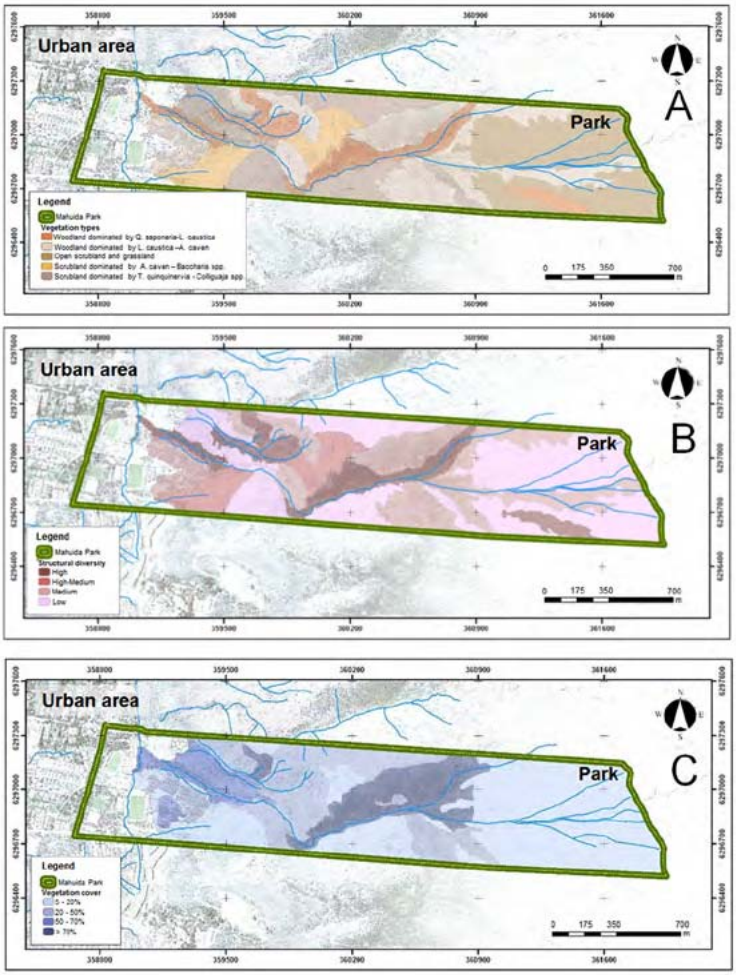
Because the park is functionally connected to the city, we recognized three of ecosystem services provided by Mahuida Park: (1) air quality maintenance, (2) local climate regulation and (3) water regulation. Interestingly, these services may help to solve partially three of the main environmental problems of those municipalities of Santiago city next to Mahuida Park: atmospheric pollution, energy spending in heating or cooling systems, and floods generated after intense rainfall.

To recognize the areas that may produce more ecosystem services within the park, we hypothesized that those areas with higher biomass and linked with slope classes (> 15%, in watershed oriented to urbanised areas), could indicate the higher potential of ecosystem services such as water regulation, especially in raining events (Reid *et al.,* 1999). Thus, in order to choose which areas to preserve, we prioritized those areas that produce these three mentioned ecosystem services. For water regulation we mapped the land vegetation cover located surrounding small sporadic basin within the park. These areas can enhance the rainwater infiltration and preventing faster and aggressive runoff. Thus, the rain water flows towards urban areas through the groundwater, reducing the volume of rainwater derived to the sewage system, and preventing catastrophic events like floods or landslides.

The vegetation of the Mahuida Park would have the capacity of removing airborne particulate matter and absorbing gases and aerosols pollutants. The areas that offer these services have higher biomass and photosynthetic activity, and are located against the direction of the wind charged with pollutants. Based on a general estimation, the park's vegetation land cover could remove

Figure 3. Vegetation park structure

A: dominant species association, B: structural strata diversity and C: land vegetation cover.



around 20 tons by year of Carbon and 1.2 of particulate matter, among other pollutants. We applied the general equation designed by Rowntree & Nowak (1991), and our land cover vegetation data, to estimate carbon sequestration of the Mahuida Park. Moreover, in order to get the extraction ability over other pollutants (O_3, SO_2, NO_2 and CO), we used other removing rates calculated for Santiago's urban trees (Hernandez, 2008).We notice that doubling the vegetation land cover would also duplicate its ability to extracting and/or absorbing pollutants.

Finally, since the areas that control the local temperature and the wind speed are defined by the flow of the same air mass, protecting the areas for air qual-

ity maintenance also would help to promote the maintenance of temperature and wind speed.

Environmental planning proposed included the production of ecosystem services taking into account these three different criteria. Also specific actions were designed to preserve and enhance the ecosystem services production. This environmental plan represents a scientific proposal that was explained to the park authorities.

Our current challenge is to explore the surface (extension and form) of urban areas that are favoured with these ecosystem services. This could be achieved by mapping these urban areas and identifying the amount of inhabitants favoured by these services. We suggest that a key factor to achieve this is by knowing how the ecosystem services are spread into the urban areas. These flows are conditioned by: (1) the maximum production of ecosystem service by the natural area, (2) physical variables that facilitate or constrain the flows inside the park (for example slope and wind), (3) the urban settings that could facilitate or constrain the flow outside the park and, (4) additional features of the urban area (for example urbanization process and population density) that could affect the ecosystem services supply in some areas with high consumption rates. For example, an assumption is that nowadays the runoff from park to city is around 0%, even in sporadic event of intense rainfalls, so, the water regulation service will be related with the watercourses and the main streets connected with the park, and the people that live near them will be the most benefited.

Reflections about this study and governance

Here we provided a conceptual framework based on the recognition of ecosystem services, to promote the conservation of parks around urban and suburban areas. By identifying vegetation and topography attributes within Mahuida Park and their link with different ecosystem services, we were able to highlight the conservation of this natural park by mean of the benefits this area can lend to districts around it. We considered that this approach may be used and improved to promote the conservation in other parks around urban zones.

Mahuida Park is part of a network of small natural areas surrounding Santiago city which are managed by public and private institutions. These organizations have increased their interest on the conservation of natural areas which are used by Santiago's inhabitants and inhabitants from other cities as well. These areas represent a new style of public parks with educational and conservation goals. Since they are near to the city, it is possible to access by using public transportation system, increasing the amount of visitors. Moreover, because the parks are bounded by urban and natural areas, its conservation

value is high. This represents an evolution in the relationship between citizen and nature.

Aguas de Ramón (3.624 ha with 200 ha at piedmont) and Cantalao (40 ha) parks are other natural areas placed close to Mahuida Park. The first one is located in a public property given in temporarily commodatum both the main private sanitary enterprise in Santiago and the association of districts near the Andean piedmont. The second one is located in an army land, also given in temporarily commodatum to a Chilean Non-Government Organization instead. Aguas de Ramón and Mahuida parks created new institutions to administrate them and both receive income from recreational activities inside the parks.

Traditionally, the main arguments to protect the natural areas are the endangered and uniqueness degree of biodiversity. This argument is strong to some environmentally conscious citizens and politicians. This ecosystem services approach is based on the inhabitants' daily well-being who are living close to these areas and is consistent with the essential roles of periurban parks (access to nature for urbanites, environmental education, etc.). Therefore, the strategy is to include a new argument able to seduce private companies, estate agencies, citizen organizations, and local governments to protect natural periurban areas. That, because the natural areas close to cities are functionally connected, and the protection of the linkages between Nature and human well-being could be a strong argument to be included in the environmental management of cities, local governments and natural periurban parks.

Because the importance of ecosystem services of this parks at global and local scale, who should plan, manage and finance them? On one hand, global ecosystem services have a worldwide interest and international organizations are protecting them, especially large natural areas. These institutions get and donate funds, make research, work with local communities and manage them through a great diversity of mechanisms. On the other hand, local ecosystem services may be protected by local government institutions and the private agencies (e.g. estate agencies). This is particularly important for small and periurban natural areas that are under urban pressure since landowners want to obtain direct and/or indirect economic benefits. Although the ecosystem services provided by the Mahuida Park are a reason to protect it, the park receives pressure from the city. The Santiago city consumes natural resources and produces air pollution. So, the relation must be bidirectional. The park must offer services and the city must offer protection to the park, especially for its vulnerable ecosystems and biodiversity.

Then, how do we integrate the protection of these areas in society? Although nature does not distinguish the socio-economic status of the populations favoured by ecosystem services in general terms, it has different impacts on poor and rich populations**.** On one hand, low-income segments

depend on the ecosystem services because they cannot substitute them for technologies. So, for poor populations, the lack of ecosystem services affects directly their well-being. On the other hand, the ecosystem services would have a less importance in higher socioeconomic status population because they can use human-made materials, heating or cooling systems and, water and air purifiers. However, the implementation of these "privileged services" can generate significant environmental impacts. Thus, the ecosystem service supply could be more appropriately managed by local governments through the management of periurban public parks, increasing its prioritization and influence in decision making process. In rich population, could be the private sector instead, specially the estate agencies, which are able to develop urbanization programs absorbing the adaptation costs and/or implementing actions in near public parks, as a result of the environmental impact assessment of new urban projects.

Quantifying the environmental impacts and preventing or mitigating them is not an easy task. We suggest that a worthwhile challenge for scientific in the field is to be able to identify who are being benefited by the ecosystem services of periurban parks, in order to know who should maintain them. On the other hand, urban projects located close to natural systems will affect the structure of these areas. As a consequence, the ecosystem services production capacity of these areas will also be modified, affecting the people who were previously benefited. Thus, the environmental damage must be repaired and those affected should be compensated. The protected area administrators could get resources from private sector (e.g. derived from urban projects close to periurban parks), or from public funds. These funds can be oriented to benefit directly and indirectly to citizens.

Finally, to sum up, we propose for periurban parks: (1) quantifiying the regulating ecosystem services production and the areas and inhabitants that are favoured with these services and; (2) the implementation, management and/or financing of periurban public parks must be shared between public and private institutions, according to the socio-economic population status. This, in order to protect and maximize the ecosystem services production in order to promote the inhabitants' well-being. These would have positive effects on the biodiversity conservation, representing an alternative way to protect natural areas near cities.

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