Chapter 5

Applying Ecosystem Services to Support Planning Decisions: A Case Study

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5.1 Introduction

Although several authors acknowledge the potential of ecosystem service (ES) assessments to increase the quality of planning processes and decisions (Geneletti 2011; McKenzie et al. 2014; Rall et al. 2015), most urban ES studies are still far from real-life application. While urban ES research demonstrates continuous methodological advancements, scientific works often lack the identification of specific policy questions and stakeholders to which they might be relevant (Haase et al. 2014), thus resulting in generic and abstract recommendations with no direct applicability to the planning and management of green infrastructure (Luederitz et al. 2015). The aim of this chapter is to show how ES knowledge, i.e. information produced by ES assessments (see Chap. 4), can be used to support decision-making in a real-life urban planning context.

ES knowledge can enter policy- and decision-making processes through multiple pathways associated to different potential impacts, from raising stakeholder awareness to shaping specific decisions. (Posner et al. 2016). Among the pathways described by Posner and colleagues, we refer here to the use of ES knowledge to *generate actions* and *produce outcomes*. The expected result is the establishment of new or updated plans and policies that consider impacts on ES and promote their balanced provision, ultimately improving human health and wellbeing along with biodiversity and nature conservation (Posner et al. 2016).

Drawing from a set of case studies, Barton et al. (2018) provide some examples of the tasks that ES assessments can perform in these contexts. ES knowledge can assume a *decisive* role, when it is used to support the formulation and structuring of

the decision problem; to identify criteria for screening, ranking, and spatial-targeting of the alternatives; or to provide arguments for negotiations, shared norms, and conflict resolution. It can also assume a *design* role, when it is used to set the basis for implementation tools, including the definition of standards and policy targets; the design of regulations, certifications, pricing, and incentives; or the establishment of damage compensations (Barton et al. 2018).

The *decisive* role encompasses the use of ES knowledge in the specific phase of urban planning processes when alternative scenarios must be assessed and compared (e.g., Kain et al. 2016). This use poses specific requirements to ES assessments. First, it entails identifying appropriate indicators that measure the expected outcomes of planning actions in terms of changes in human wellbeing, coherently with planning objectives (Ruckelshaus et al. 2015). Second, it requires assessing the consequences of planning interventions on multiple ES, explicitly addressing the potential trade-offs between different ES and competing land uses that characterize the alternative planning scenarios (Sanon et al. 2012; Woodruff and BenDor 2016; Kain et al. 2016).

This chapter presents an application in which ES assessments are used to support a real-life planning decision about the regeneration of brownfields in the city of Trento (Italy). Potential re-greening interventions are prioritized according to their expected consequences on two illustrative, though relevant ES for the city. The performance of the different alternatives in relation to the two ES is assessed by comparing current conditions and future planning scenarios. Then, the results are combined through a multi-criteria analysis where criteria correspond to a set of defined planning objectives that may assume different weights according to different stakeholder perspectives.

5.2 Case Study: Brownfield Regeneration in Trento

Trento is an alpine city of around 120,000 inhabitants in northeastern Italy, located along the valley of the river Adige, roughly half-way between the Brenner Pass and the Adriatic Sea. The main settlement originated from the concentration of urban areas and infrastructures in the valley floor and hosts around 70% of the population. The remaining 30% lives in small villages spread across the surrounding hills and mountains. Agricultural areas, predominantly vineyards and apple orchards, occupy the few non-urbanized patches on the valley floor and the sunny hillsides. Forests cover almost half of the large municipal territory, which spreads over more than 150 km² and up to an elevation of 2180 m. Of this, more than 10 km² are designated as natural protected areas, including eight Natura 2000 sites and four local reserves (Fig. 5.1).

The presence of brownfields is one of the main planning issues in Trento. The current urban plan identifies thirteen ‘urban redevelopment areas’, mostly former industrial sites or partially-abandoned residential blocks, ranging in size from 0.5 to 9.9 ha and covering a total area of around 44 ha. With few exceptions, they are close to the most dense and populated parts of the city, where their presence exacerbates

Fig. 5.1 Main land uses in Trento and the 13 brownfields identified by the urban plan as ‘urban redevelopment areas’

social, economic, and environmental problems, but at the same time is an opportunity to benefit through regeneration interventions a large part of the population. Until now, the costs, especially for contaminated sites, and the bureaucratic burden associated to intervention, as well as the sometimes-contrasting interests of public administration and private owners, have hindered their transformation.

Considering the existing situation, it is reasonable to assume that only some of the brownfields will be converted to new industrial or residential areas in the next years. A greening intervention can thus be advanced as a possible, perhaps temporary, solution. Accordingly, the study hypothesizes a possible conversion of the thirteen urban redevelopment areas into new public parks, with the aim of identifying which intervention should be prioritized to maximise the benefits for the surrounding population. Benefits are measured in terms of increased provision of two key urban ES for Trento, namely micro-climate regulation and nature-based recreation.

The selection of micro-climate regulation responds to the growing concerns for summer heat waves, particularly intense in the city due to its low altitude and to the narrowness of the valley. During the 2003 event, Trento proved to be more vulnerable to heat waves than other Italian cities (Conti et al. 2005). The combined effect of heat waves and of the intense urban heat island in the most urbanized part of the city causes peaks in energy demand and threatens citizens' health and wellbeing (Giovannini et al. 2011). Considering the increased frequency and intensity of heat waves expected in the coming decades (Fischer and Schär 2010), effective solutions to control the urban micro-climate and to provide cool areas for heat relief during the hot season are seen as one of the most pressing needs by citizens and administration.

The selection of recreation responds to the specific planning goal of the city administration: to provide equal opportunities for nature-based recreation and relaxation to all citizens. During the last years, new public parks have been realized in peri-urban areas to gain a more balanced distribution over the city. However, understanding if opportunities for nature-based recreation are equally distributed is not an easy task. In Trento, besides urban parks, citizens also benefit from the proximity to other typologies of green areas where they conduct a wide range of day-to-day recreational activities, including hiking, mountain-biking, trail running, and climbing. Indicators based on the availability of and accessibility to public urban parks, though common in urban planning applications, are not enough to capture this variety and to support planning decisions (Cortinovis et al. 2018). Assessing recreation as an ES, considering different providing units and different levels of demand, could provide planners with useful information for achieving an equal distribution of recreational opportunities over the city (Kabisch and Haase 2014).

5.3 Producing ES Knowledge to Evaluate Planning Scenarios

5.3.1 Mapping and Assessing ES

The cooling effect of urban green infrastructure was assessed by applying the method described in Chap. 4 (see also Zardo et al. 2017 for further details), specifically designed to support planning and management decisions at the urban and sub-urban scale. Green infrastructure in Trento were classified according to their size, soil cover, and percentage of canopy coverage, and assigned a cooling capacity

score and the respective class based on Fig. 4.2. Then, the cooling effect produced on the surroundings was mapped by approximating the effect of evapotranspiration through linear decay functions that vary depending on the size of the area, and the effect of shading through local buffers around canopies (Geneletti et al. 2016). The final map of the cooling effect is divided into six classes, from A+ (maximum cooling effect) to E (minimum or no cooling effect). The difference between two successive classes corresponds approximately to 1 °C.

Opportunities for nature-based recreation in the city were assessed through a locally-adjusted version of ESTIMAP-recreation, a model originally developed for mapping ES across Europe (Zulian et al. 2013; Paracchini et al. 2014) and later adjusted for the application to different contexts and scales (Baró et al. 2016; Liqueste et al. 2016; Vallecillo et al. 2018; Zulian et al. 2018). The model is composed of two modules. The first module assesses the Recreation Potential (RP), i.e. the suitability of different areas to support nature-based recreational activities based on their intrinsic characteristics. Elements that contribute to define the RP are identified in the three categories of natural features, urban green infrastructure components, and land uses. The map of RP is a raster with values ranging from 0 (no RP) to 1 (maximum RP in the analysed area). The second module assesses the Recreation Opportunity Spectrum (ROS), i.e., the actual opportunities for nature-based recreation offered to the citizens. The value of ROS is obtained by combining RP with information about proximity, here defined as the availability of infrastructures and facilities to access (e.g., cycle paths, bus routes, parking areas) and to use (e.g. playgrounds, sport fields, park furniture) the areas. The map of ROS is classified into nine categories resulting from the cross-tabulation of high/medium/low RP and high/medium/low availability of infrastructure and facilities.

To produce the maps of RP and ROS, the elements considered in each module are spatially combined according to scores assigned by the user. In the described application, scores were elicited from a pool of seventeen local experts, including key personnel of different provincial and municipal departments, researchers from different institutions, and local practitioners. The experts were asked to fill-in an online questionnaire and then invited to discuss the preliminary results in a follow-up focus group. A detailed list of the data used for the analysis and the description of the involvement process, including the final scores used to run the model, can be found in Cortinovis et al. (2018).

5.3.2 Comparing Scenarios Based on ES Beneficiaries

The results of the analysis at the city scale were used as a baseline to assess the potential benefits produced by brownfield regeneration. The conversion of each of the thirteen brownfields into a new green area was considered as an alternative planning scenario and analysed independently. The outcome of the transformation was assumed to be, for each brownfield, a new urban park, intensely planted and open to public use. Accordingly, to assess their expected cooling effect, new urban parks were modelled as areas covered by grass with canopy coverage ranging from 80%

to 100%. To assess opportunities for nature-based recreation, brownfields were assigned to the land use class ‘green urban areas’, assuming the same presence of infrastructures and facilities as in other parks of comparable size.

Similar indicators, based on the number of people affected by the transformation, were used to assess the two ES. For each ES, vulnerable people, defined as citizens’ groups with a higher-than-average need for the specific service, were identified and quantified as a sub-group of the total beneficiaries. In the case of cooling, beneficiaries were defined as citizens that experienced a positive change in the class of cooling effect of their living place. Young children (< 5 years old) and the elderly (> 65 year old) were selected as vulnerable groups, based on their higher sensitivity to heat stress (Basu and Samet 2002; Kenny et al. 2010; Kabisch et al. 2017). In the case of recreation, people living within 300 m from the new parks were considered as beneficiaries (Kabisch et al. 2016; Stessens et al. 2017). Children and teenagers (< 20 years old) and the elderly (> 65 year old) were identified as vulnerable groups, based on the higher demand for close-to-home recreation and relaxation areas (Kabisch and Haase 2014). Furthermore, those beneficiaries already served by high-level opportunities for nature- based recreation in the current condition (i.e., living within 300 m from areas classified in the highest class of ROS), were counted separately.

The results of the two ES assessments were combined through a multi-criteria analysis, using the thirteen scenarios as alternatives and the two ES and corresponding categories of beneficiaries as criteria and sub-criteria, respectively (Table 5.1). Weights were assigned according to three illustrative policy perspectives and related objectives. The ‘cool air for the elderly’ perspective prioritizes the improvement of the cooling effect in areas with a high share of older population. The ‘every child needs a park’ perspective favours opportunities for recreation to people, especially

Table 5.1 The three policy perspectives and respective combinations of weights considered in the multi-criteria analysis to prioritize brownfield regeneration scenarios

	Perspective 1 “balanced”			Perspective 2 “cool air for the elderly”			Perspective 3 “every child needs a park”		
Cooling	0.50			0.80			0.20		
Non-vulnerable		0.20			0.14			0.20	
< 5 years old		0.40			0.29			0.40	
> 65 years old		0.40			0.57			0.40	
Recreation	0.50			0.20			0.80		
Non-vulnerable		0.20			0.20			0.14	
Served			–			–			0.20
Not served			–			–			0.80
< 20 years old		0.40			0.40			0.57	
Served			–			–			0.20
Not served			–			–			0.80
> 65 years old		0.40			0.40			0.29	
Served			–			–			0.20
Not served			–			–			0.80

children and teenagers, who are not served in the present condition. The ‘balanced’ perspective promotes both ES equally but assigns a higher weight to vulnerable groups. Values for each criterion and sub-criterion were normalised according to the maximum and a ‘weighted summation’ approach was used to calculate the overall score for each alternative, hence defining the final rankings for the three perspectives. Finally, a sensitivity analysis was conducted to explore the robustness of the rankings to variations in the weights assigned to criteria and sub-criteria. Further details on the methodology adopted to compare the brownfield regeneration scenarios can be found in Cortinovis and Geneletti (2018a).

5.4 Planning Scenarios Evaluated Through ES

5.4.1 *Current ES Provision Across the City*

The current provision of the two analysed ES (Figs. 5.2-5.3) is used as baseline to measure the benefits of brownfield regeneration scenarios. The map of the cooling effect produced by green infrastructure in the valley floor, i.e., the most urbanised area of the city, shows a prevalence of the highest classes of cooling effect (Fig. 5.2). The presence of close-by forests and of the river Adige and its tributaries contributes to lower the temperature of their surroundings. Disadvantaged areas can be observed in the dense neighbourhoods close to the city centre and in the northern suburbs. Here, the mix of residential and industrial areas with little green infrastructure, as well as the high rate of soil sealing produced by the concentration of urban activities and major transport infrastructures, have a negative impact on the cooling performance of the city. Most of the brownfields are strategically located close to areas that scarcely benefit from the cooling effect of green infrastructure.

The map of ROS shows a clear difference in the recreation opportunities between the main urban settlement in the valley floor and its surroundings (Fig. 5.3). The main urban settlement is mostly characterized by low values of RP, but large urban parks and the riverbanks provide good opportunities for nature-based recreation thanks to their high accessibility. The surroundings are mostly characterised by high values of RP, but the availability of infrastructures and facilities is not homogeneous. Forests characterised by the presence of forest tracks, hiking trails, and facilities dedicated to specific activities such as climbing routes and MTB trails are mainly located close to the villages. Areas in the highest class of ROS prevail on the east side of the valley, whilst on the west side, where the settlements are sparser and the connections with the valley floor are more difficult, many areas are characterised by high RP but low proximity. The analysis suggests different directions for interventions. While infrastructures and facilities could be strengthened in natural and semi-natural areas, interventions in the main urban settlement should focus on achieving a more equal distribution of urban green areas. The location of some of the brownfields represents an opportunity to act in this direction, thus enhancing the condition of people that currently have no or very few close-to-home opportunities for nature-based recreation.

Fig. 5.2 Map of the cooling effect of urban green infrastructure in the most urbanized part of the city of Trento

5.4.2 Potential Benefits of Brownfield Regeneration

An example of how the conversion of brownfields into new urban parks would affect the two analysed ES is provided in Fig. 5.4. Due to the change in the soil cover from partly sealed to grass and to the intense plantation, the site would reach the highest class of cooling effect, thus also positively affecting the micro-climate of the immediate areas. While in the present condition, most of the

Fig. 5.3 Map of the Recreation Opportunity Spectrum (ROS) in Trento calculated through the locally- adjusted version of the ESTIMAP-recreation model

surrounding residents gain very little or no thermal benefit at all from the presence of green infrastructure, almost exclusively limited to single shading trees, in the regeneration scenario the major part of the area is affected by a noticeable improvement. In the neighbourhood to the North, some households would shift from the lowest to the highest class of cooling effect. The conversion to a new urban park would also be an opportunity to increase the availability of public green areas by connecting the converted brownfield to the adjacent open-air

Fig. 5.4 An example of comparison between baseline condition and planning scenario for brown-field 11. Maps of the cooling effect considering the maximum distance potentially reached by the cooling effect produced by the brownfield (left) and maps of the Recreation Opportunity Spectrum showing the 300-m buffer used to identify potential beneficiaries (right)

soccer field. In the regeneration scenario, all the households included in the map would benefit from an additional space for recreation within walking distance from their location.

The different scenarios are assessed and compared based on the number of people that would benefit from brownfield regeneration (Fig. 5.5). In terms of cooling effect, scenario 11, involving the conversion of a large brownfield inside a densely

Fig. 5.5 Expected benefits produced by the different scenarios in terms of enhanced cooling effect by urban green infrastructure (left) and enhanced opportunities for nature-based recreation (right): number of beneficiaries broken down into different vulnerability classes

built-up and populated part of the city, is by far the best performing one: more than 2000 citizens would benefit from the enhanced cooling effect produced by the new green area. The other scenarios are expected to affect from some decades to few hundreds of people. Overall, the number of people that would benefit from increased opportunities for nature-based recreation is much higher. Scenarios 07 and 08 produce the highest absolute number of beneficiaries. However, only the regeneration of brownfields 01, 02 and 03 would serve people that, at present, have no access to close-to-home nature-based recreational opportunities. The ratio between total beneficiaries and specific vulnerable groups is not the same across scenarios, due to the uneven distribution of population groups across the city. For example, the share of children and teenagers is higher for scenarios 01 and 02 compared to the others, while the share of people aged more than 65 is the highest for scenario 11.

The information about the number of beneficiaries of the two ES in the different scenarios was combined through a multi-criteria analysis according to the three perspectives described in Table 5.1 (Fig. 5.6). When assuming a ‘balanced’ perspective, with the same weight assigned to the two ES and a double weight assigned to vulnerable compared to non-vulnerable groups, scenario 11 ranks first. The second perspective, consistent with the objective of improving the cooling effect in areas with a high share of older population, leads to the same first-ranking scenario. Although the other positions change between the two perspectives, all scenarios gain a very low score compared to scenario 11. Under the third perspective, the final ranking changes significantly and the first positions are occupied by the three scenarios (01, 02 and 03) involving the regeneration of brownfields located in the northern part of the city, where the population is comparatively younger and existing opportunities for recreation are scarcer.

Fig. 5.6 Map of the priority level of brownfield regeneration scenarios according to three perspectives considered in the multi-criteria analysis

5.5 Lesson Learned and Conclusions

The case study showed a possible use of ES knowledge to support urban planning in the stage of the planning process when decisions amongst alternative scenarios are to be made. Specifically, it addressed the issue of brownfield regeneration in the city of Trento, where the presence of thirteen sites that could be converted to new public green areas determines the need for a rational approach to select and prioritise interventions. The presence of brownfields is a key issue for today's cities, with strong economic and social implications (Nassauer and Raskin 2014). Recent studies have highlighted how brownfields can be turned into sources of ES for the urban population (McPhearson et al. 2013; Collier 2014; Mathey et al. 2015; Geneletti et al. 2016; Beames et al. 2018), thus contributing to a more sustainable urban development (European Commission 2016).

Our analysis focused on the expected benefits of brownfield regeneration scenarios in terms of improved cooling effect by vegetation and enhanced opportunities for nature-based recreation: two of the most critical issues for citizens' wellbeing in Trento. The results of the two ES assessments were expressed through beneficiary-based indicators. Several authors have highlighted limitations and potential drawbacks associated to the use of both biophysical measures and monetary valuations of ES in real-life decision-making contexts (Bagstad et al. 2014; Ruckelshaus et al. 2015; Saarikoski et al. 2016; Olander et al. 2018). To this respect, beneficiary-based indicators that explicitly link the provision of ES with changes in human wellbeing are considered a promising way to integrate ES knowledge into decision-making processes (Geneletti et al. 2016; Olander et al. 2018) and to communicate ecological knowledge to planners and politicians primarily focused on social and economic objectives (von Haaren and Albert 2011; Schleyer et al. 2015), as is often the case in urban planning.

Multi-criteria analysis proved to be an effective tool to make the results of multiple ES assessments usable by decision-makers. On the one hand, it allows multiple sources of information and value dimensions to be combined, disregarding the indicators that are used to express them (Saarikoski et al. 2016). On the other hand, it offers a structured way to explore different stakeholder perspectives and related objectives, balancing diverse and sometimes competing interests in a rational and transparent way (Adem Esmail and Geneletti 2018). In the analysed case, all scenarios had a positive effect on the provision of both ES, but potential trade-offs could be related to competing uses of the brownfields (Kain et al. 2016) or to the costs of intervention (Koschke et al. 2012). Starting from the described multi-criteria analysis, a more complete decision support system could be built by integrating other relevant criteria about costs and benefits of planning scenarios.

As already demonstrated in other applications (Sanon et al. 2012; Grêt-Regamey et al. 2013; Kremer and Hamstead 2016), the results of the analysis show how priorities may shift with changing policy goals. The ranking is sensitive to the relative weights assigned to the two ES and related categories of beneficiaries and, eventually, the best scenario depends on decision-makers' orientations about specific planning objectives. This highlights the need for a strategic approach to ES, still mostly lacking in current planning documents (Cortinovis and Geneletti 2018b). Clear objectives and targets for ES provision would help to identify the values against which the effectiveness of planning actions should be measured, and to highlight the relevance of ES knowledge within the planning process. Information about ES beneficiaries allows understanding the social implications of planning decisions, particularly in terms of equity and environmental justice, as discussed in the next chapter.

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