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Mapping beneficiaries of ecosystem services flows from Natura 2000 sites

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ABSTRACT

There is a growing need to integrate ecosystem services into management strategies of protected areas, and only a comprehensive ecosystem services assessment allows effective strategies for biodiversity conservation to be defined. Beneficiaries are largely disregarded or only mentioned in ecosystem services assessments related to protected areas. Thus, we propose indicators for identifying potential beneficiaries on the local and regional level, focusing on 16 relevant ecosystem services of Natura 2000 sites. For a case study in northern Italy, we used spatially-explicit modelling approaches to map and quantify the potential beneficiaries of multiple ecosystem services, including distance decay functions and basin catchment modelling. The resulting maps indicate that for provisioning and cultural services, the majority of the beneficiaries are located outside the protected area, whereas the beneficiaries of regulating services are mostly situated within or very close to it. The indicators and the beneficiary maps offer an important basis for an exhaustive assessment of ecosystem services flows from Natura 2000 sites and support the implementation of conservation policies by involving the local population and the community of users of protected areas.
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1. Introduction

In recent decades, there has been an increasing interest in the concept of ecosystem services (ES) for decision-making and ecosystem management, to discuss the role of biodiversity on the global (Millennium Ecosystem Assessment (MEA), 2005; TEEB, 2010), the regional (Egoh et al., 2009; Eigenbrod et al., 2009), or the landscape scales (Bastian, 2013; Tscharntke et al., 2005). The ES valuation of protected areas, which aims to preserve natural environments and thus biodiversity, has mostly concentrated on national or natural parks (Martín-López et al., 2011; Martínez-Harms and Gajardo, 2008). In Europe, conservation objectives of biodiversity are pursued through the establishment of the Natura 2000 network under the European Habitats Directive 92/43/EEC and the Birds Directive 79/409/EEC. Whereas conservation efforts in the past principally concentrated on preserving and restoring biodiversity, there is a growing need to integrate ES into management strategies, considering interactions between demand and supply of multiple ES and accounting for spatial and temporal scales (Anton et al., 2010; Naidoo et al., 2008). Based on the toolkit to assess the socio-economic benefits of Natura 2000 (Kettunen et al., 2009), initial ES assessments were carried out in different European regions (Bugalho, 2009; Cruz and Benedicto, 2009; Kazakova, 2009; Pabian and Bogdan, 2009; Tinch, 2009). Together with conserving biodiversity, the Natura 2000 network provides a wide range of provisioning, regulating and cultural ES (Brink et al., 2011). The socio-economic benefits of the Natura 2000 network have mostly been related to tourism and recreation, and their economic benefits are estimated to be between three and seven times their annual costs (Gantioler et al., 2010).

Especially in Europe, protected areas are placed within social contexts, where the interaction between natural processes and human activities has established social–ecological systems (Figueroa and Aronson, 2006). The ecological functioning of protected areas is affected by the landscape dynamics in the surrounding area (DeFries et al., 2007; Hansen and DeFries, 2007; Mcdonald et al., 2009; Wade et al., 2011) and by the attitude of users, such as visitors and local communities, or landowners (Allendorf et al., 2012; Jones et al., 2012; Vodouhê et al., 2010). Only a comprehensive ES analysis, including stakeholders and

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beneficiaries in their cultural, economic and policy context, allows effective management strategies to be defined (Anton et al., 2010), and in particular, beneficiaries outside the protected area play a crucial role in integrating the ES approach into conservation policies (Tallis et al., 2008). Although great progress has been made on mapping and quantifying ES in the last decade (Egoh et al., 2008, 2012; Raymond et al., 2009; Schägner et al., 2013; Troy and Wilson, 2006), to date, ES of Natura 2000 sites have only been assessed in terms of the potential of ES provision (Bastian, 2013; Kettunen et al., 2009), and most ES valuations consider ES beneficiaries only in qualitative terms or disregard them (Burkhard et al., 2012). Spatially explicit tools and methods that take into account the location and number of beneficiaries and their demands for ES, which might support the ES governance for protected areas in terms of both planning and public support, are still missing (Anton et al., 2010).

Therefore, this study focuses on the assessment of the beneficiaries related to the Natura 2000 network by:

- providing definitions of beneficiaries related to the Natura 2000 network;
- defining indicators for multiple ES to identify potential beneficiaries of Natura 2000 sites;
- using spatially explicit modelling approaches to map such indicators on the landscape scale; and
- mapping and quantifying potential beneficiaries for multiple ES for a case study in Italy.

2. Definitions of beneficiaries related to the Natura 2000 network

Natura 2000 sites and their beneficiaries have rarely been the focus of ES assessments (Bastian, 2013; Kettunen et al., 2009). Our literature review (Annex A) revealed that beneficiaries of ES from protected areas were largely disregarded (e.g., Armsworth et al., 2011; Bastian, 2013; Wade et al., 2011) or merely mentioned (e.g., Barton et al., 2009; Eigenbrod et al., 2009; Petrosillo et al., 2010; Rodríguez-Rodríguez and Martínez-Vega, 2012). Where identified (e.g. Juutinen et al., 2011; Palomo et al., 2013; Pietrzyk-Kaszyńska et al., 2012; van Riper et al., 2012), they were generally reported as interested categories such as private landowners, municipalities, local communities or visitors. In a few studies, beneficiaries were identified and specifically described, or in some cases also spatially recognised in the region and involved in the analysis or assessment (e.g., Brandon et al., 2005; Bernard et al., 2009; DeFries et al., 2010; Martín-López et al., 2011; Kari and Korhonen-Kurki, 2013; Mackenzie, 2012).

An ES beneficiary is defined as any group or individual that benefits from ecosystem goods and services, either through active or passive consumption of both, or through simple appreciation resulting from the awareness of these services (Nahlik et al., 2012). If there are no beneficiaries, the same ecosystem elements or processes cease to be ES (Boyd and Banzhaf, 2007). The ES benefits vary, depending on the type of service with its individual characteristics, in terms of the spatial extent and quality of the relationships between source areas and benefit areas (Bagstad et al., 2013; Costanza, 2008; Fisher et al., 2009). Each ES has a distinctive spatial range, related to specific ecological and economic processes, which can be local, regional/national or global (Hein et al., 2006). In the specific context of Natura 2000 sites, governance levels also distinguish between public and private sectors (Kettunen et al., 2009). The relationships between ES and beneficiaries can be described in terms of the intensity of the relationship, along a gradient of dependency and location (Table 1).

Among the several definitions of stakeholders in the literature, the most accepted is that of Freeman (Fassin, 2009): a stakeholder is “any group or individual who can affect or is affected by the achievement of the organisation's objective” (Freeman, 1984). This definition was adapted for ecosystem valuation into “any group or individual who can affect or is affected by the ecosystem's services” (Hein et al., 2006).

We propose a distinction between stakeholder and beneficiary in terms of the ability to influence ES provision (e.g., deciding policies) and the conditions of benefiting. The beneficiaries of ES from Natura 2000 sites can correspond to the stakeholders, which are subjects involved or interested in the management of the site, at different levels and through different perspectives (Hein et al., 2006). In general, each beneficiary should be considered as a stakeholder and involved in decision-making processes (Hein et al., 2006; Rastogi et al., 2010), but not vice versa: not all stakeholders are necessarily beneficiaries. Moreover, we can distinguish different degrees of dependency among the beneficiaries (Table 1). Fig. 1 schematises the relationship intensity in the ES in the protected area by concentric circles. This relationship is not permanent, even for the same subject and can vary in time, with changing variables and perspectives. For example, farmers strictly depend upon soil productivity (or primary productivity), whilst they are also indirect beneficiaries from the mitigation of natural extreme events (drought, floods); furthermore, farmers can enjoy recreational opportunities provided by the cultivated ecosystems (Swinton et al., 2007). Thus, a farmer can be simultaneously a dependent beneficiary, a direct and indirect beneficiary and a stakeholder, able to influence decisions in the area (A in Fig. 1) for different interests. In contrast, a public authority at the regional level (e.g., environmental authority) might be in charge of site management, but might not obtain any significant

Table 1
Intensity of relationship between beneficiaries and ES.

Beneficiary type	Substitution costs	Substitution opportunities	At site	Dependency	Ecosystem services[a] (examples)	Benefit domain (examples)	Examples of beneficiaries
A	High	Low	Yes	**Strong**: totally depending on ES	Provisioning (cultivated crops)	Agriculture Forestry	Farmers
B	High	Low	No	**Medium**: depending on ES from outside	Regulation & maintenance (water regulation)	Water retention Flood mitigation	Residents local administration
C	Low	High	Yes	**Low**: depending on ES, but with substitution opportunities	Provisioning (fibres and timber) cultural (experiential use of land)	Forestry Recreation	Farmers Residents[b]
D	Low	High	No	**No dependency:** easily substitutable with other source areas	Cultural (physical use of land)	Recreation	Visitors, hikers

[a] ES definitions were derived from CICES V4.3.
[b] Including local tourism actors, e.g., hotel owners who offers bikes to recreants.

benefit either direct or indirect (B in Fig. 1). Such a distinction between beneficiary groups helps to recognise the dependency of economic activity and well-being sources for local communities on Natura 2000 sites, and subsequently, to guide participatory approaches for their management and strategic planning: the group that is more dependent on ES and accordingly, more affected by losses or gains, should have the higher priority.

3. Mapping potential beneficiaries

3.1. Indicators

To identify the beneficiaries of protected areas in human-dominated landscapes, we propose indicators for different ES (Table 2). The selected ES are relevant on the local or regional level, whereas ES with a global relevance such as genetic resources or carbon sequestration were excluded from the analysis. To identify the beneficiaries not only in potential terms, all indicators should be derived directly from local or regional data, e.g., the number of persons gathering mushrooms can be obtained from the number of licences issued by the municipality and the number of visitors to protected areas can be obtained from automated visitor counters. In many cases, however, direct data are not available and only potential beneficiaries can be estimated by using spatial information and available statistical data on the municipality level such as a population or agricultural census. In our case study, we mapped and quantified the potential beneficiaries of the Natura 2000 site 'Alto Garda Bresciano', based on GIS-based modelling approaches as described in Section 3.2.2.

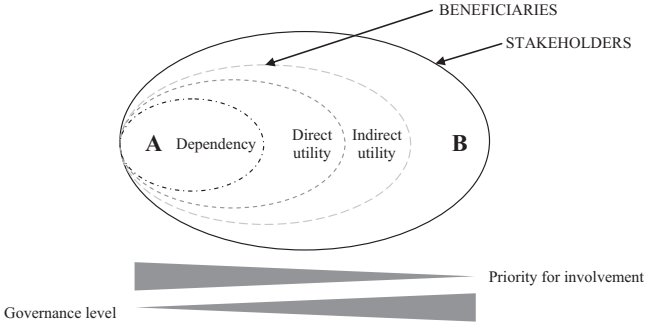

Fig. 1. Conceptual diagram of the categories of beneficiaries and stakeholders.

3.2. Case study

3.2.1. Alto Garda Bresciano

The Special Protection Area (SPA) Alto Garda Bresciano (IT2070402) is protected by the European Habitats Directive 92/43/EEC and the Birds Directive 79/409/EEC and is located in Lombardy (Italy) and covers an area of 21.526 ha. The SPA involves six municipalities with a total of 14,807 inhabitants (ISTAT, 2011a) with more than 1 million overnight stays per year (ISTAT, 2011b).

3.2.2. Spatial mapping

Based on spatial datasets and statistical information, potential beneficiaries were identified and mapped for different ES according to the indicators reported in Table 2. To exemplify the calculation of the indicators, spatial land cover information was derived from the CORINE land cover 2006 (CLC2006) seamless vector database consisting of 44 CLC-level-3 classes (EEA, 2013). Elevation was obtained from a digital elevation model (DEM) consisting of processed data from the ASTER Project (NASA, 2013). Local road networks were received from the geographical services of Lombardy, Veneto and Trentino. Statistical data

Table 2
Indicators for mapping potential beneficiaries.

ES	Indicator	Beneficiary type	Unit	Benefit area
P1 Agriculture	Farmer with crop cultivation	A	No farmers	Agricultural land with annual or permanent crops within protected area
P2 Forage, pasture	Farmer with livestock farming	A	No farmers	Meadows and pastures within protected area
P3 Game (wildlife)	Hunter and fisher	C	No hunters, No fishers	Hunting- and fishing-ground within protected area+5 km buffer
P4 Raw materials (timber and other wood fibre)	Owner (public and private) of (exploitable) forest	A	No owners	Forest within protected area
P5 Mushrooms and truffles	Persons gathering mushrooms and truffles	C	No persons	Forest and other apposite land cover within protected area
P6 Medical plants	Persons gathering medical plants	C	No persons	Selected land cover within protected area
P7 Fresh water	Residents within watershed	B	No residents	Watersheds intersecting the protected area
R1 Regulation of local air quality	Population benefiting from air purification	B	No residents	Buffer in relationship to extent of filtering land cover within the protected area
R2 Water purification	Population benefiting from water purification	B	No residents	Watersheds intersecting the protected area
R3 Erosion and landslide prevention	Population benefiting from erosion and landslide prevention	B	No residents	Watersheds intersecting the protected area
R4 Flood mitigation	Population benefiting from flood mitigation	B	No residents	Watersheds intersecting the protected area
R5 Pollination	Farmer with crop cultivation close to functional habitats for pollinators	B	No farmers	Agricultural land within protected area+2.5 km buffer
R6 Biological control	Farmer with crop cultivation close to functional habitats for beneficial species	B	No farmers	Agricultural land within protected area+2.5 km buffer
C1 Aesthetic value	Residents and tourists within visible area	D	No persons	Protected area+10 km buffer
C2 Recreational value (tourism, outdoor activities)	Visitors for recreational activities	D	No visitors	Urban areas with travel time <90 min from protected area
C3 Inspiration for arts and culture, spiritual and educational values, sense of place	People receiving inspiration, education, identity	B	No residents	Municipalities intersecting the protected area

concerning population (ISTAT, 2011a), tourism (ISTAT, 2011b), and agriculture (ISTAT, 2010) on the municipality level were used to quantify potential beneficiaries. As these data refer to administrative units, they were transferred to the landscape scale by intersecting the CORINE dataset with the municipality borders (ISTAT, 2013). Subsequently, the population density was calculated for urban areas and the density of different farm types was obtained for selected agricultural land cover types (annual and/or permanent crops, wine, woody agrarian cultivation, areas for forage production and grazing). Many ES refer to watersheds that were delimited based on the DEM and the existing river network (ISPRA, 2013), applying thresholds of 1, 5 and 10 km² for the minimum watershed size.

The GIS-based methods for estimating potential beneficiaries for each selected ES are hereafter described briefly. All calculations were automated by generating scripts in Python 2.7.2 (Python Software Foundation, NH, USA) and using standard routines provided with ArcGIS 10.1™ (ESRI, Redlands, CA, USA).

- *P*1 *Agriculture*: the number of farm sites growing annual and permanent crops within the study was obtained from the farm density in the used agricultural areas after intersecting the land cover data with the Natura 2000 site.
- *P*2 *Forage*, *pasture*: the number of farmers using the territory of the Natura 2000 site for forage production and grazing were derived from the farm density with animal farming in the used areas within the Natura 2000 site.
- *P*3 *Game* (*wildlife*): to assess the number of potential hunters, habitats for reproduction and suitable hunting-grounds, which are ecologically connected, were considered within the Natura 2000 site and its surrounding area up to 5 km. The fragmentation of elements such as main roads, urban areas, large rivers and very steep slopes $>80\%$ was used to define the ecologically connected natural areas. Due to the lack of statistical data, a mean density of 0.5 hunters per km² was assumed (considering local wildlife hunting plans, unpublished). For estimating the number of fishers, the minimum density of fishers was assumed, depending on the altitude, according to expert opinions and the following rules:
  (a) Altitude <600 m > river: four fishers/km; lake: 10 fishers/km
  (b) Altitude 600–1200 m > river: two fishers/km; lake: five fishers/km
  (c) Altitude >1200 m: river > one fishers/km; lake: three fishers/km
- *P*4 *Raw materials* (*timber and other wood fibre*): as no specific statistical data were available, the potential owners of exploitable forests were estimated based on the forest area within the Natura 2000 site and the population data of the intersecting municipalities.
- *P*5 *Mushrooms and truffles*: the potential beneficiaries were estimated based on the population of the intersecting municipalities with forest areas of the Natura 2000 site, which are suitable for mushrooming. Suitable areas were considered to be forests and open natural land with an elevation below 2000 m a.s.l. and a slope less than 80% (generally, areas in the region with this slope are cliffs).
- *P*6 *Medical plants*: the potential beneficiaries were estimated based on the population of the municipalities intersecting natural areas of the Natura 2000 site with a slope less than 80%.
- *P*7 *Fresh water*: the population within the watersheds, intersecting the Natura 2000 sites, was derived by the population density for urban areas.
- *R*1 *Regulation of local climate and air quality*: to identify urban areas that benefit from air purification, filtering land-cover types were determined within the Natura 2000 site. After applying a buffer in proportion to the extension of the filtering area, the size of the benefiting population was obtained from the population density of the urban areas within the buffer.
- *R*2 *Water purification*: this ES only exists if ecosystems with a capacity of water purification occur between polluting elements and potentially impacted areas with beneficiaries. To identify the urban areas benefitting from water purification, it was tested whether the Natura 2000 site can contribute to the ES by analysing polluting elements and the relative position of impacted areas. Finally, the number of residents was obtained from the population density of the urban areas.
- *R*3 *Erosion and landslide prevention*: to test whether the Natura 2000 site has the ability to prevent or moderate landslides, forested areas, which have a positive influence on soil stability (Scrinzi et al., 2006), with a slope greater than 10° (Trigila, 2007) were selected within the protected area and intersected with the watersheds. The whole municipality with all inhabitants was considered as a potential beneficiary.
- *R*4 *Flood mitigation*: for selecting urban areas that potentially benefit from flood mitigation of the Natura 2000 site, a riparian buffer of 100 m was used to identify the urban areas potentially prone to floods.
- *R*5 *Pollination*: farmers with cultivation that depends completely or partially on entomophilous pollination were determined by selecting the benefiting agricultural land within a buffer of 2.5 km from the potential habitats for pollinating insects included in the Natura 2000 site.
- *R*6 *Biological control*: farmers with cultivation benefit from biological control through beneficial species and the number was calculated based on the agricultural areas within a buffer of 2.5 km from habitats for beneficial species within the protected area.
- *C*1 *Aesthetic value*: the Natura 2000 site mainly consists of natural and semi-natural habitats with great aesthetic value. Residents and tourists in urban areas with a view of the protected area are potential beneficiaries. Their number was determined by identifying the visible area up to 10 km from the protected area and by intersecting it with the urban areas. The number of residents was calculated based on the population density and the number of tourists was expressed as the number of available beds. Furthermore, all visitors to the protected area benefit from the aesthetic value of the site. Their number was estimated for C2.
- *C*2 *Recreational value*: potential visitors, residents and tourists were mapped based on the travelling time to the protected area. By attributing mean velocities for different road types of the road network, the travelling time was calculated starting from the Natura 2000 site and all urban areas within 90 min were selected. The number of residents was calculated based on the population density and the number of tourists was expressed as the number of available beds.
- *C*3 *Inspiration for arts and culture, spiritual and educational values, sense of place*: beneficiaries on the global level were not included. On the local level, the residents of all municipalities intersecting the Natura 2000 site were selected as potential beneficiaries.

3.2.3. Potential beneficiaries maps

For each ES, the potential beneficiaries were mapped (Fig. 2), and their total numbers are reported in Table 3. Regarding the different beneficiary types, the total number of beneficiaries increased with decreasing dependency (Table 4).

For the ES P1, P2, R5 and R6, the number of farmers was quantified based on the mapping of the agricultural area, but it was not possible to locate the farmers by their place of residence.

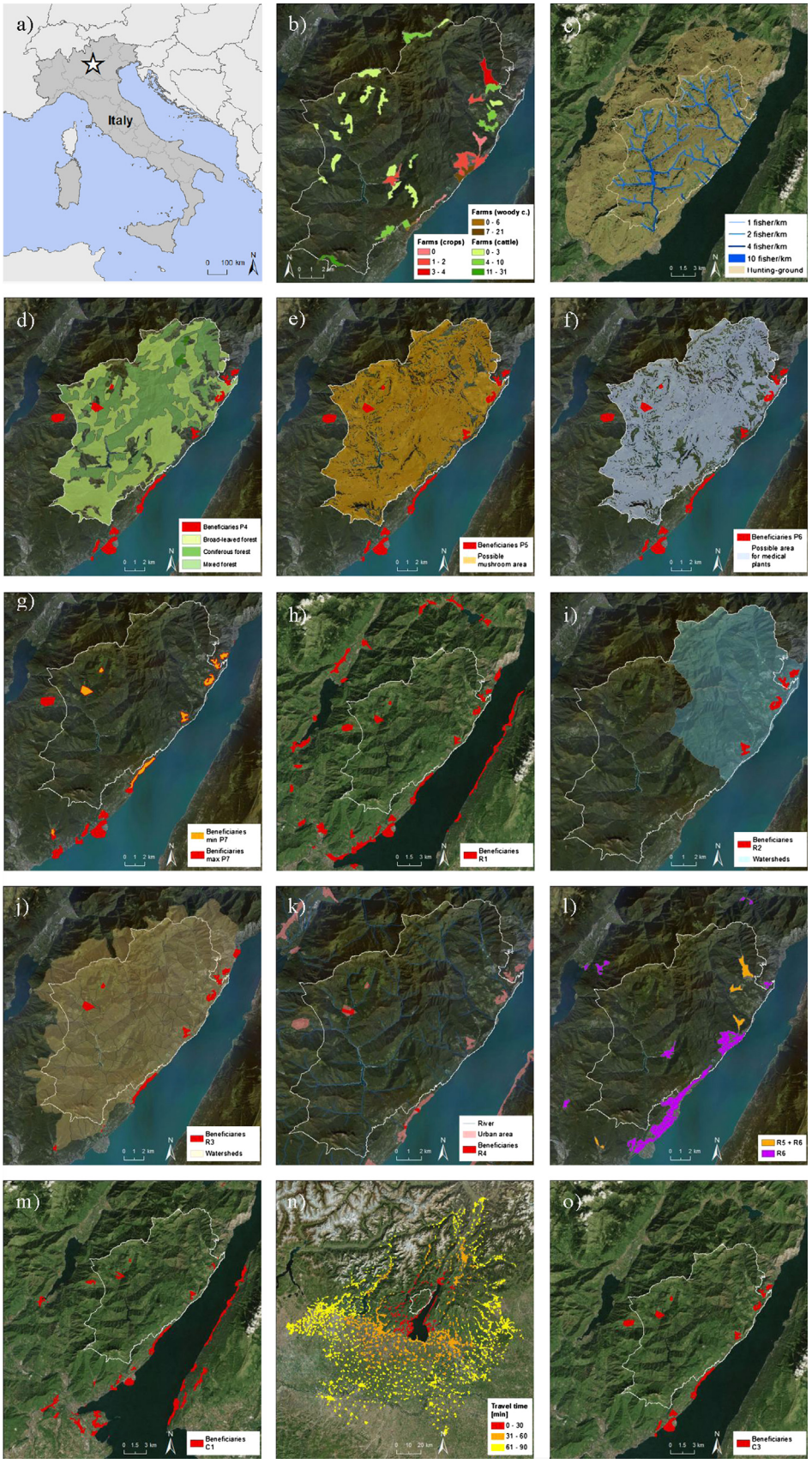

Fig. 2. (a) Location of study area (star). Maps of potential beneficiaries for (b) agriculture (P1) and forage, pasture (P2), (c) game (P3), (d) raw materials (P4), (e) mushrooms and truffles (P5), (f) medical plants (P6), (g) fresh water (P7), (h) regulation of local climate and air quality (R1), (i) water purification (R2), (j) erosion and landslide prevention (R3), (k) flood mitigation (R4), (l) pollination (R5) and biological control (R6), (m) aesthetic value (C1), (n) recreational value (C2), and (o) inspiration for arts and culture, spiritual and educational values, sense of place (C3).

Table 3
Potential beneficiaries of the study area 'Alto Garda Bresciano'.

ES		Beneficiaries	
P1	Agriculture	10	Farmers with annual and permanent crops
		27	Farmers with olive groves
P2	Forage, pasture	62	Farmers with cattle
		24	Farmers with sheep/goat
P3	Game (wildlife)	387	Hunters
		361	Fishers (min)
P4	Raw materials (timber and other wood fibre)	14,807	Residents
		6	Municipalities
P5	Mushrooms and truffles	14,807	Residents
P6	Medical plants	14,807	Residents
P7	Fresh water	6272	Residents (min)
		16,761	Residents (max)
R1	Regulation of local climate and air quality	55,516	Residents
R2	Water purification	3423	Residents
R3	Erosion and landslide prevention	7158	Residents
R4	Flood mitigation	803	Residents
R5	Pollination	7	Farmers with annual and permanent crops
R6	Biological control	32	Farmers with annual and permanent crops
		180	Farmers with olive groves
C1	Aesthetic value	30,401	Residents
		51,779	Tourists
C2	Recreational value (tourism, outdoor activities)	5,830,153	Residents
		427,798	Tourists
C3	Inspiration for arts and culture, spiritual and educational values, sense of place	14,807	Residents

Table 4
Total potential beneficiaries of the study area 'Alto Garda Bresciano' aggregated by beneficiary type (see Tables 1 and 2).

Beneficiary type	No. beneficiaries	Percentage of total (%)
A	14,930	0.2
B	88,198	1.4
C	30,159	0.5
D	6,340,131	97.9
Total	6,473,418	

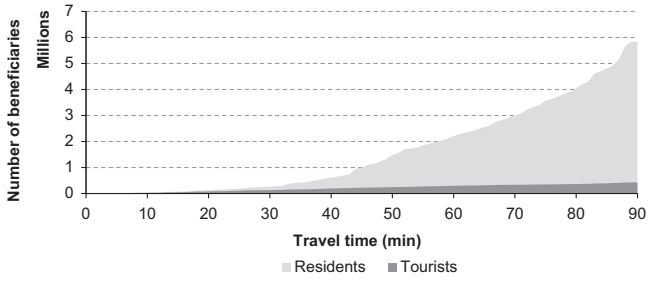

Fig. 3. Number of potential beneficiaries for recreation in relation to the travelling time.

Active hunters or fishers were associated with the hunting-ground and lakes or rivers, respectively. For all other ES, the beneficiaries were quantified based on their place of residence or tourist accommodation facilities. Agriculture plays a minor role within the study area (12% annual and permanent crops in the protected area). Nevertheless, 90% of the agricultural land that benefits from pollination (R5) is situated within the protected area, whereas 59% of agricultural land outside the protected area benefits from biological control (R6). The number of potential beneficiaries of the ES P4-6 and C2 corresponds to all residents of the municipalities intersecting the beneficial area (14,807 residents), of which 18% are located within the protected area. The ES P7 and R2-4 were mapped on the watershed level and include only residents of the benefiting area (P7: 6272–16,761 residents, R2: 3423 residents, R3: 7158 residents, R4: 803 residents). Although for R1 only 5% of the beneficiaries are within the protected area, for the other regulating services, up to 36% (R3) are located within the protected area or very close to it. The highest number of potential beneficiaries was mapped for the cultural services C1 and C2, and rose with increasing travelling time: 268,612 residents and 129,571 tourists can reach the protected area with a maximum travelling time of 30 min, and about 5.8 million residents and 0.4 million tourists are potential visitors if travelling up to 90 min (Fig. 3).

4. Discussion and conclusion

Integrating ES into conservation strategies requires a complete assessment of ES flows from protected areas, considering both the ES supply and demand, which varies with specific spatial and temporal conditions (Anton et al., 2010; Naidoo et al., 2008). The literature review, however, indicated that most studies disregarded or only mentioned the beneficiaries of ES from protected areas. Only in some cases were they also located and involved in the analysis, mainly by means of interviews or questionnaires (Martín-López et al., 2011; Vodouhê et al., 2010). The analysed studies confirm the importance of involving beneficiaries in ES assessments to identify ES flows, supported by an increasing demand in the surroundings of protected areas (Palomo et al.,

2013). Especially for the implementation of conservation actions, it is important to involve the local population and the community of users of protected areas located in a wider social–ecological system (DeFries et al., 2010). Whereas most studies have concentrated on ES supply (Burkhard et al., 2012), we focused on ES beneficiaries, proposing indicators to identify the beneficiaries of Natura 2000 sites on the local and regional level, and developing spatially-explicit modelling approaches to locate and estimate potential beneficiaries The various beneficiaries were related to the four categories of beneficiaries considering a dependency gradient and the distance from the site (Tables 1 and 2).

The application of these GIS-based models for a study site in Italy was based on CORINE land cover and national statistical datasets, because these datasets are generally available for most European countries, but finer land use/cover information and more detailed statistical data might produce more meaningful results. Using general rules for identifying potential beneficiaries allows the application to any protected area, although this might lead to an over- or underestimation of their number. For example, considering all residents of the interested municipalities for some ES (P4-6) might include people that are not beneficiaries because they do not own a forest or cannot access the area for gathering mushrooms or medical plants, but people might also come from the surrounding area, which were not included.

Methods such as interviews, questionnaires, conversations with people and participant observation have been applied in other studies (Bernard et al., 2009; Martín-López et al., 2011; Vodouhê et al., 2010), but are very time-consuming. With regard to the ES P1-2 and R5-6, the number of farmers was related to different farming types and represents the beneficiaries for that specific category, although the beneficiaries of provisioning services are in most cases not limited to the local or regional level. Goods and products can be consumed by international customers, affecting the local economy by an increasing or decreasing demand of certain products (Martín-López et al., 2011). In contrast, the beneficiaries of regulating services are mainly limited to the local and regional level (Fisher et al., 2009), and the maps indicate that beneficiaries of regulating services, with the exception of R1, are mainly located within or very close to the protected area. To identify these, it was tested whether the protected site has a positive influence on the provision of ES, but this was not intended to define the magnitude of influence, i.e., the assessment was limited to surface watersheds (P7, R2-4) or simple distance functions (R1 and R5-6). To quantify ES provision, complex ecological functions and processes should be considered and more sophisticated models should be applied.

With regard to the beneficiaries of cultural ES (C1 and C2), the potential beneficiaries do not represent the number of visitors, which can be obtained from automated visitor counters. The potential beneficiaries are mainly located outside the protected area and their number rises with increasing travelling time (Fig. 3), but environmental and socio-economic characteristics determine whether the protected area is capable of supporting a large number of persons without degradation of ecosystems and loss of recreational value (DeFries et al., 2010).

Although the spatially explicit modelling approaches to identify and quantify potential ES beneficiaries are based on general rules and approximations, they are easily applicable and can support a comprehensive assessment of ES flows from Natura 2000 sites, even at the regional scale. Furthermore, the scripts allow application to other study sites and calculations can be repeated rapidly for changed land-use information or updated statistical data, as well as for land-use scenarios. This methodological proposal, even though it has been shaped for European contexts, is appropriate to be applied to any protected area located within human-dominated landscapes.

Regarding the dependency and location of the beneficiaries, our results indicate that the number of beneficiaries increases when dependency decreases (Table 4); specifically, the local type A beneficiaries, are only a small proportion of the total number of the potential beneficiaries (0.2% of the total, and 11.2% of the A, B, C categories). These results can improve management and planning aspects of Natura 2000 sites or other protected areas. The local communities are considered for their capacity to manage reserves and support biodiversity through environmentally friendly economic activities within and around protected areas, and a solid understanding of the social context and the appropriate mechanisms for participation are claimed for natural reserve establishment and management (Brandon et al., 2005). However, management and planning generally consider only local beneficiaries and disregard those relatively distant to the site, but which have low opportunities or high costs for substitution (c.f. references in Annex A). DeFries et al. (2010) proposed the concept of a “zone of interaction” around protected areas that encompasses hydrological, ecological, and socioeconomic interactions between a protected area and the surrounding landscape. The designation of such zones of interaction improves the understanding of which activities (e.g., collection of forest products, grazing, road construction, tourism development) and which locations within the zone of interaction are most crucial to conservation goals and might enable improved land-use planning around protected areas in human-dominated landscapes. Our results provide a spatially-explicit quantification corresponding to site characteristics, such as distinctive ES and related beneficiaries, focusing on local and regional levels of both governance and ecological processes. Thanks to the distinction in different beneficiary groups, which were associated with a particular ES, especially the number of potential beneficiaries constitutes a valuable argument against the fact that Natura 2000 sites, as common for other protected areas, are often scrutinised as costing too much and delivering too little. This is important for an improved communication with, and involvement of, local communities, a better understanding and presentation of the benefits of protected areas, and especially for the communication with a wider audience (Brandon et al., 2005). Thus, the mapping of beneficiaries claims a wider public support.

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Annex A. Literature review

The literature review included studies related to terrestrial protected areas. The selection of relevant peer-reviewed paper was performed using different search engines (Google Scholar, ScienceDirect) and several combinations of the following key words: “ecosystem services”, “protected area”, “biodiversity conservation” or “park”, looking at the period from 1997 to May 2013. The selection resulted in 147 articles, of which only 60 specifically considered protected areas and terrestrial ecosystems. For this subset of articles, we analysed how beneficiaries were involved, using the following categories:

1. *Ignored*: no reference was made to beneficiaries of protected areas, only allusions to the general community of beneficiaries (e.g., the world human population or national population).
2. *Mentioned*: beneficiaries were simply mentioned as group/community or as users of protected areas.

Table A1
Studies considering beneficiaries.

How considered	Count	EU	Non-EU	Nd
Ignored	19	a, b, c, d, e, f, g	h, i, j, k, l, m, n, o, p, q	r, s
Mentioned	16	t, u, v, w, x	y, z, aa, ab, ac, ad, ae, af	ag, ah, ai
Identified	10	aj, ak, al, am, an, ao	ap, aq, ar, as	
Quantified	15	at, au, av, aw	ax, ay, az, ba, bb, bc, bd, be, bf, bg, bh	

(a) Gaston et al., 2006; (b) Hougner et al., 2006; (c) Petrosillo et al., 2009; (d) Liira et al., 2012; (e) Armsworth et al., 2011; (f) Kümmerling and Müller, 2012; (g) Bastian, 2013; (h) Gössling, 1999; (i) Velarde et al., 2005; (j) Roux et al., 2008; (k) Martínez-Harms and Gajardo, 2008; (l) Rayfield et al., 2008; (m) Wade et al., 2011; (n) Pettorelli et al., 2012; (o) Green et al., 2012; (p) Barber et al., 2012; (q) Payés et al., 2013; (r) Hansen and DeFries, 2007; (s) Abell et al., 2007; (t) Petrosillo et al., 2007; (u) Eigenbrod et al., 2009; (v) Petrosillo et al., 2010; (w) Jacobsen and Thorsen, 2010; (x) Padilla et al., 2010; (y) DeFries et al., 2007; (z) Barton et al., 2009; (aa) Strickland-Munro et al., 2010; (ab) Rogers et al., 2010; (ac) Almeida Cunha, 2010; (ad) Cline et al., 2011; (ae) Baumgardner et al., 2012; (af) Dewi et al., 2013; ag) Figueroa and Aronson, 2006; (ah) Mcdonald et al., 2009; (ai) Rodríguez-Rodríguez and Martínez-Vega, 2012; (aj) Carvalho-Ribeiro et al., 2010; (ak) Rescia et al., 2010; (al) Juutinen et al., 2011; (am) Palomo et al., 2013; (an) Jones et al., 2012; (ao) Pietrzyk-Kaszyńska et al., 2012; (ap) Shafer, 2004; (aq) Ring, 2008; (ar) Allendorf et al., 2012; (as) van Riper et al., 2012; (at) Brandon et al., 2005; (au) Martín-López et al., 2009; (av) Martín-López et al., 2011; (aw) Abelairas-Etxebarria and Astorkiza, 2012; (ax) Albers and Robinson, 2007; (ay) Corbera et al., 2007; (az) García-Frapolli et al., 2009; (ba) Bernard et al., 2009; (bb) DeFries et al., 2010; (bc) Sims, 2010; (bd) Vodouhê et al., 2010; (be) Granderson, 2011; (bf) Kovacs, 2012; (bg) Mackenzie, 2012; (bh) Kari and Korhonen-Kurki, 2013.

3. *Identified*: beneficiaries were distinguished or described by specific information.
4. *Quantified*: beneficiaries were identified and quantified or at least described by some quantitative attributes (including geographical characterisation).

Furthermore, since the Natura 2000 network is an European instrument, we distinguished European from non-European studies. The results of the literature review are summarised in Table A1.

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