

Review

The Economic Valuation of Ecosystem Services of Biodiversity Components in Protected Areas: A Review for a Framework of Analysis for the Gargano National Park

Domenico Pisani ^{1,*}, Pasquale Paziienza ¹, Enrico Vito Perrino ², Diana Caporale ³ and Caterina De Lucia ¹

¹ Department of Economics, Management and Territory, University of Foggia, 71121 Foggia, Italy; pasquale.paziienza@unifg.it (P.P.); caterina.delucia@unifg.it (C.D.L.)

² CIHEAM, Mediterranean Agronomic Institute of Bari, 70010 Valenzano, Italy; perrino@iamb.it

³ Department of Environmental Science and Policy (ESP), University of Milan, 20133 Milano, Italy; diana.caporale@unimi.it

* Correspondence: domenico.pisani@unifg.it

Abstract: Protected areas play an important role in the conservation and protection of biodiversity of particular territories, especially of ecosystems that provide resources for living organisms, including human beings. Different studies highlight the importance of biodiversity and its associated benefits in terms of ecosystem services of protected areas. The economic assessment of ecosystem services and biodiversity becomes a viable solution to help the policy maker to make decisions on the environmental preservation of these areas according to the Agenda 2030 for Sustainable Development. Nonetheless, very few studies provide an economic evaluation of the benefits of protected areas. To advance the current debate on the economic evaluation of the benefits provided by protected areas, the present paper purposes an integrated approach. It presents an overview of main ecosystem services' mapping techniques currently available to researchers and policy makers and offers a systematic review carried out for the period 2015–2020 at an international level. The main findings are particularly attractive for the Gargano National Park (GNP) in the south of Italy, which is recognised as being a biodiversity hot spot at global level. The current study provides useful guidance for the assessment of trade-offs, the support to policy makers, and the provision of efficient allocation of public resources for protected areas.

Keywords: ecosystem services; environmental valuation; biodiversity conservation; Gargano National Park



Citation: Pisani, D.; Paziienza, P.; Perrino, E.V.; Caporale, D.; De Lucia, C. The Economic Valuation of Ecosystem Services of Biodiversity Components in Protected Areas: A Review for a Framework of Analysis for the Gargano National Park. *Sustainability* **2021**, *13*, 11726. <https://doi.org/10.3390/su132111726>

Academic Editors: Pietro Santamaria, Antonio Elia, Giulia Conversa and Massimiliano Renna

Received: 29 July 2021

Accepted: 15 October 2021

Published: 23 October 2021

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1. Introduction

Protected areas play an important role in the conservation and/or protection of the biodiversity of particular territories and ecosystems that provide resources for living organisms, including human beings.

The International Union for Conservation of Nature and Natural Resources [1] defines a protected area as 'a geographical space, recognised, dedicated and managed, through legal or other effective means, to achieve the long-term conservation of nature with associated ecosystem services and cultural values'.

More recently, the Resolution A/RES/73/284 adopted by the General Assembly of the United Nations on 1 March 2019 argues that the period 2021–2030 is declared as Decade of Ecosystem Restoration [2]. This decade aims at 'supporting and scaling up efforts to prevent, halt and reverse the degradation of ecosystems worldwide and raise awareness of the importance of successful ecosystem restoration' [2].

The above actions underline the existence, at international level, of a widely acknowledged intrinsic value and related benefits, such as biodiversity and ecosystem services, provided by protected areas. Nonetheless, the actual international guidelines seem not

enough to prevent the degradation and downsizing of these areas and the consequent imbalance between the ecosystem and the services they provide. This inefficiency is proven by the rate of decline and/or extinction of species, which occurs at about 100 times higher than the background extinction rate that existed before the arrival of the *Homo sapiens* 150,000 years ago. The decline or extinction of the species rate is caused by population pressure, habitat destruction, alien species, pollution, the excessive exploitation of resources and the combination of these factors [3]. Natural systems and the services they offer to human development are the essential bases of the economic processes, development and well-being of human societies [4].

The actual economic models pursued by human societies cannot continue to operate outside the biophysical limits of the natural systems [5].

It is necessary to ensure that the value of the natural capital significantly affects the decision-making process.

The Italian National Strategy for Biodiversity [6], prepared by the Ministry of the Environment, Land and Sea Protection to comply with the indications of the United Nations Convention on Biological Diversity and approved in 2010, indicates that *'The biodiversity and ecosystem services, our natural capital, are preserved, valued and, as far as possible, restored, for their intrinsic value and so that they can continue to sustainably support economic prosperity and human well-being despite profound changes in place globally and locally'*.

To meet the requirements of the United Nations, different studies focused on the valuation of biodiversity conservation and ecosystem services with different approaches [7–15], including urban aspects [16]. Nonetheless, there exists a gap in the context of protected areas and in particular of National Parks, except those for marine aspects [17,18] or in countries outside the Mediterranean Basin [19,20].

This lack of attention is unwarranted considering the key role that these areas play in biodiversity and ecosystem service conservation. The present study aims to close the above gap and provides a useful guidance for the assessment of these benefits in the complex context of protected areas.

The present work is structured as follows: Section 1 illustrates a definition of biodiversity and ecosystem services and their relationship; Section 2 describes the main ecosystem service mapping techniques; Section 3 shows theoretical and empirical approaches to evaluate ecosystem services in the current debate; Section 4 offers an overview of the current (2015–2020) international literature on ecosystem service and biodiversity conservation; Section 5 illustrates the particular case of valuing ecosystem services and biodiversity in the protected area of the Gargano National Park, in the south of Italy; and finally, Section 6 concludes the work.

ES, Biodiversity Definition and Their Relationship

The world's protected areas, which currently cover more than 15% of the Earth's surface in the form of national parks and nature reserves, provide the largest single source of safe ES along with their most recognized roles in the conservation and recreation of biodiversity [21,22].

Before examining the definitions of ecosystem services and biodiversity, we firstly introduce the concept of ecosystem. According to The Economics of Ecosystems and Biodiversity [23], an ecosystem is *'a dynamic complex of plant, animal and micro-organism communities and their non-living environment interacting as a functional unit'*. These systems provide a set of benefits or services to human beings that are named ecosystem services (ES). The TEEB defines them as *'the benefits that people obtain from ecosystems. Examples include food, freshwater, timber, climate regulation, protection from natural hazards, erosion control, pharmaceutical ingredients and recreation'*. Meanwhile, the Millennial Ecosystems Assessment (MA) [24] defines ES as the multiple benefits provided, directly and indirectly, by the ecosystems to the human being.

After the pioneering work of Costanza et al. [4], which listed ES and introduced ES valuation at global level, different ES classifications have followed. The three main interna-

tional classification systems are: the Millennium Ecosystem Assessment (MA, 2005) [24], the Economics of Ecosystems and Biodiversity (TEEB, 2010) [23] and the Common International Classification of Ecosystem Services (CICES) [25]. Although these works differ in terms of classification's characteristics, they are based on previous studies. The MA was the first global study on ES. It provided an innovative scientific valuation about the ecosystems' condition and the provided ES.

The MA considers ES under four groups:

- *Provisioning services*: which represent the contribution of the ecosystem to goods extracted or collected from the ecosystem (e.g., genetic resources, food, fresh water, etc.);
- *Regulating services*: which represent ES ability to regulate biological processes, influencing climatic and hydrological cycles and maintaining the environmental conditions benefited by the society and individuals (e.g., air quality regulation, erosion regulation, climate regulation, etc.);
- *Cultural services*: which include non-tangible services. They refer to the experiences that human beings could benefit from ecosystems (e.g., cultural, spiritual, recreation, etc.).
- *Supporting services*: which are the services necessary for the production of other ES (nutrient cycling and primary production).

The CICES is the most recent among the three international classifications described above. It supports the work of the European Environment Agency (EEA) on environmental accounting.

The TEEB represents a milestone in the ecosystem assessment studies. It highlights the economic benefits provided by biodiversity and underlines the social cost of biodiversity loss in the presence of ecosystem degradation.

The official biodiversity concept was conceived during the Rio Conference, in 1992 [26]. Prior to 1992, the international literature considered biodiversity in terms of species and plant community richness to reflect the relative abundance, and ecological or evolutionary relationships between species or community of species [27–30]. An inclusive definition of biodiversity was needed because, during the Convention on Biological Diversity (CBD) [31], the biodiversity concept was defined as '*the variability among living organisms from all sources, including, inter alia, terrestrial, marine and other aquatic ecosystems and the ecological complexes of which they are part; this includes diversity within species, between species and of ecosystems*'.

The existence of a link between biodiversity and ES was recognised by the Millennium Ecosystem Assessment in 2005 [24]. According to the MA, "*biodiversity loss and the resulting deterioration of ecosystem services contribute—directly or indirectly—to worsening health, higher food insecurity, increasing vulnerability, lower material wealth, worsening social relations, and less freedom of choice and action*".

Nonetheless, it is not an easy task to demonstrate the direct relationship between biodiversity and ES. The ability of ES to provide benefits is not only affected by biological diversity per se, and vice versa; but it is mostly influenced by the functional diversity. The functional diversity is referred to as the diverse capacity to influence the ecosystem stability, productivity, nutrient balance and other ecosystem functioning aspects [32]. In the last 20 years, the international debate evolved and provided the existence of a positive relationship between biodiversity and ES. [11,33–37].

In their pioneering study, Naeem et al. [33] underline that ecosystems are complex systems which are based on diversity. The lack of biodiversity negatively influences the quality of the services offered by these systems, such as plant productivity, soil fertility and water quality. In addition, the work by Isbell et al. [36] offers interesting empirical evidence about the existence of linkages between biodiversity and ES. In particular, it shows that different plant species support the ecosystem functioning under different environmental scenarios. More recently, Harrison et al. [37] investigate, with the use of a systematic literature review, the existence of a positive relationship between biodiversity and ES.

To address the importance of ES, biodiversity and the link between them, Costanza et al. [38] estimate their economic value at global level. This is in the figure of USD 125–140 trillion

and appears far greater (1.5 times) than that of the gross domestic product (GDP) in the same year. This means that biodiversity worldwide is significantly much more important than the production of goods and services.

2. ES Mapping Techniques

The establishment of protected areas represents one of the main pillars for the protection of biodiversity and ES [24]. Nevertheless, examples of management strategies and decision support in land use planning for ES are scarce in comparison to those tackling biodiversity or landscape conservation [39,40]. Despite the increase in the number of studies proposing indicators and methods for quantifying and assessing ES on different scales [41], few methods and tools allowing a systematic qualitative and quantitative evaluation of ES for protected areas are generally implemented [42]. Below, a brief description of these techniques is presented.

- (1) WebGIS. With a WebGIS, traditional DesktopGIS applications can be implemented on a web server (also called map server) allowing the interaction between the cartography and the associated data. The data processing offered by web interfaces are nowadays still limited compared to DesktopGIS software, but it is still possible to carry out targeted queries and analyses. The strength of WebGIS is the availability of information regardless of the platform, installation and location. In addition, WebGIS can be consulted through Client-type applications, which can be generic (web browser) or specific (GIS software). Several types of WebGIS applications are available according to the degree of complexity [43], provided by the following services: viewing, associated info (attributes), processing queries/tools, data and mapping download and upload and instructions. The following WebGIS sites are used for biodiversity and ESs mapping: SoilConsWeb (Multifunctional Soil Conservation and Land Management through the Development of a Web-Based Spatial Decision Supporting System) [44], Rewetland (widespread introduction of constructed wetlands for a wastewater treatment of Agro Pontino) [45], FaceCoast (FACE i.e. the challenge of climate change in the med COASTal zones) [46], HABEaS (Hotspot Areas for Biodiversity and Ecosystem Services) [47] and Lakes ES (Lakes Ecosystem Service) [48].

There are also several tools and software such as ARIES (ARTificial Intelligence for Ecosystem Services) [49], InVEST (INtegrated Valuation of Enviromental Services and Tradeoffs) [50] and SolVES (Social Values for Ecosystem Services) [51].

In particular, the InVEST software defines the quality of habitats and combines information on land cover and threats for biodiversity to provide habitat quality maps. Changes in the quality and quantity of habitats can be considered only partially representative of the genetic biodiversity content and the number of species. The impact of each threat on habitats is mediated according to two factors: degree and distance. The model approach only partially allows users to quantify the ecosystem service of biodiversity, as it lacks the detailed field data on populations and species. Another weakness is the relationship between threats and biodiversity, which is generally considered a linear relationship rather than a non-linear dynamic.

- (2) The assessment of supply and demand of ES in protected areas, applied to potable water and protection from hydrological instability and aesthetic value [42]; crops for farmers, natural fodder for breeders, wood and fibres for processing and fuel use; and mushroom and truffle harvesting [52]. This method allows users to take into account the peculiarity of the territorial context under study.
- (3) GIS techniques. It provides attractive valuations through photointerpretation in terms of used surface through digital imaging and vegetation/habitat coverage change. On the other hand, the qualitative aspect is generally retrieved by means of phytosociological surveys (e.g., tree coverage, shrub and herbaceous layer, number of species surveyed and their relative coverage) and forestry data (e.g., presence of dead wood,

pathogens) which provide further information on biodiversity, the conservation of the tree components and the sources of disturbance such as overgrazing, tourism, etc. The above queries and surveys should be repeated over time as suggested by the habitat monitoring manual for each habitat. Subsequently, for each recorded data (from forestry, vegetation, fauna and soil surveys) a value (to be defined) is generally attached. This value can be referred to, for example, the plant biodiversity index (ipb) (for phytosociological data), forest biodiversity index (ifod) (for forest data), fauna biodiversity index (ifab) and soil biodiversity index (isb) (on sampling and subsequent laboratory analysis). Other indicators may also apply such as an index of climatic biodiversity (icb) (temperature, precipitation, wind) and an index of insect biodiversity (iib) (detection of insects and small organisms at litter level). Finally, a specific algorithm is specified to provide a full value of biodiversity, useful for evaluating ES. The above multidisciplinary approach generally involves nine professional figures (a botanist, forest expert, fauna expert, soil scientist, climatologist, entomologist, economist, mathematician and GIS expert) leading to reliable data used as an estimated value for ES.

3. Total Economic Value and the Valuation Methods

3.1. Total Economic Value (TEV)

Although the international scientific debate and policy guidelines recognise the relevance of ecosystems for the human and natural well-being, practical applications are still limited or, in some cases, lacking. This causes the exclusion of ecosystems health from the political debate and a consequent degradation of the natural environment, thus worsening the services provided to the society. The assessment of an economic value to ES may be a viable solution to stimulate the public debate and provide useful insights for the policy maker.

The Total Economic Value (TEV) is the result of the continuing scientific debate to integrate, into the decision process, the monetary assessment of the ecological benefits or costs, due to the application of a policy or implementation of a project.

One of the pioneering works to assess ecological benefits and costs is the use of the Total Economic Value (TEV) [53,54]. In addition, a key aspect of the natural capital or ES assessment is its marginal value. This is the estimate of a change in human welfare due to a change occurred in the supply or flow of ES [4].

The TEV is the net sum of the aggregate willingness to pay (WTP) and willingness to accept (WTA), as a result of any policy or project that causes a change in human well-being [55].

According to the anthropocentric view [56,57], the TEV is the result of two value components, as showed in Figure 1.

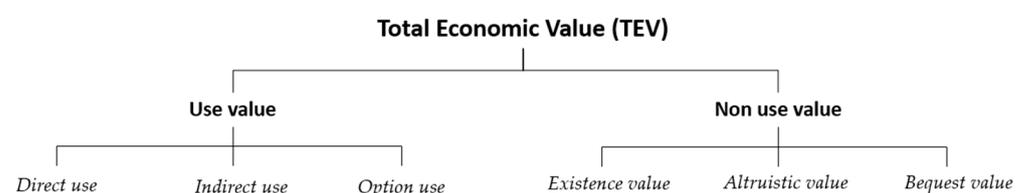


Figure 1. Total Economic Value (TEV) components.

The *use value* is the WTP associated with the use of the good. It could be *direct use*, which is the WTP for the direct use of the natural resource such as, for example, the visit to a forest or a park; *indirect use*, which is the WTP for the indirect use of the natural resource such as, for example, the benefit of clean air due to the proximity to a park; and *option use*, which is the WTP for the conservation of a natural resource to use it (optionally) in the future. The *non-use value* is the WTP to preserve an environmental good. It could be *existence (non-use) value*, which is the WTP to know that a natural resource continues to

exist (e.g., WTP to preserve the Amazon Forest or the polar bears); *altruistic (non-use) value*, which is the WTP for someone of the present generation to benefit of the environmental good (e.g., the Amazon Forest preservation guarantees the isolation of the local indigenous tribes); *bequest (non-use) value*, which is similar to the altruistic value although the associated WTP refers to the benefit for the future generation (e.g., the protection of the Amazon Forest guarantees clean air for future generations).

3.2. Valuation Methods

The international literature on environmental valuation recognises two main estimation techniques such as *price estimation methods*, also known as *market price methods*, and *value estimation methods*, or *non-market valuation methods* [55,58]. The core hypothesis behind both market and non-market price models is that the benefit or the cost associated to a change in the availability of a good is the result of the preference of the individual stakeholder interested in that change [59,60].

As for the market price methods, the economic valuation is derived from market prices. It is based on the exchange value of goods in the real market. Examples of these techniques are the *market analysis*, which is the value of the good that is selling on the market; the *restoration cost*, which is the cost to compensate for the absence of the environmental good; and the *damage cost avoided*, which is the damage cost (avoided) in the absence of a certain environmental good.

Non-market price techniques are generally state preference methods and revealed preference methods.

State preference methods or direct techniques offer a direct way of estimating the changes in the supply of (non-market) goods. Direct methods are the *contingent valuation* (CV) to evaluate 'ex ante' and 'ex post' changes occurring in the environmental good [61–65] and the *choice experiment technique* (CE) to estimate the value of the environmental change in a multidimensional way [66–71].

Revealed preference methods or indirect techniques offer an indirect way to assess the value of environmental goods. Indirect methods are the *hedonic price method* (HPM), generally used with reference to the real estate market to estimate the preference for an environmental good [72–76], the *travel cost method* (TCM) is mostly used to estimate the value of recreational resources [77–80] and the *defensive expenditure* method refers to the social expenses to avoid an environmental damage [81–83].

Market price methods generally estimate use values, while non-use values are estimated with stated preference techniques [55].

Finally, the *benefit transfer method* is a process to estimate the economic value of ES using estimated results from other studies [84–86].

4. Literature Review

4.1. Methods and Data

This section deals with the recent empirical literature review analysing a monetary assessment of ES and biodiversity in protected areas. We consider the timespan 2015–2020 (in line with the Strategic Plan for Biodiversity 2011–2020 (<https://www.cbd.int/sp/>) (access on 11 October 2021) a 10-year timespan could also be considered. Nonetheless, this Strategic Plan identified a set of indicators (among which ES play a relevant role) used to monitor the progress of the 20 goals known as the Aichi Biodiversity Targets (ABTs). Since the goals of biodiversity are related to the ability to link with the 2015 SDGs, we argue that the timespan 2015–2020 can be considered as a reasonable time interval for our investigation). Specifically, it is possible to frame the research question that leads the current review as “the economic assessment of ES and biodiversity provided by protected areas”.

The review considers the peer-reviewed journal papers published in English on the Scopus database.

The query includes a combination of the following terms searched in the title, abstract and keywords: ‘economic valuation’ or ‘monetary valuation’; and ‘ecosystem service*’ or ‘ES’;

and 'protected area*' or 'national park*' or 'natural park*'; 'provisioning' or 'regulating' or 'cultural' or 'biodiversity'.

The literature lacking any of the following characteristics were excluded: (i) an economic valuation of ES; (ii) the valuation methods specified in Section 3.2; (iii) geographic information about the study area; and (iv) presence of protected areas or national parks.

In the first instance, 33 articles appeared in line with the above query, while the final dataset is provided by 11 studies.

Figure 2 shows the flow chart according to the PRISMA guidelines.

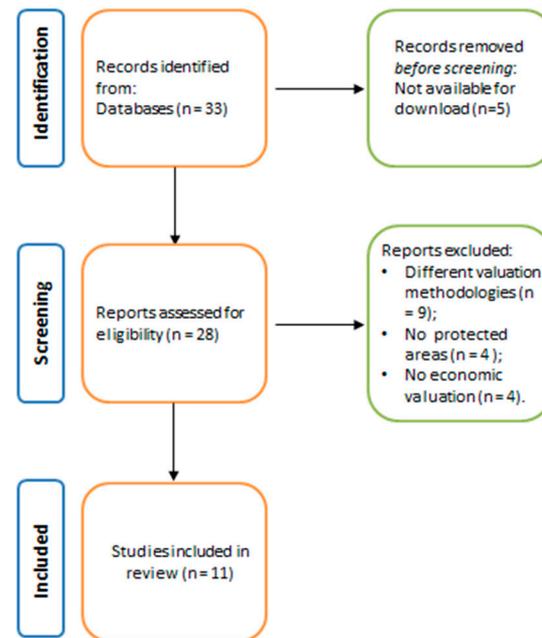


Figure 2. Flow chart used in the present review.

Of the initial 33 articles, 5 were not available to download, 9 presented different valuation methodologies from those analysed in Section 3.2, 4 did not consider protected areas and 4 did not present an economic valuation of either national parks or protected areas. Conversely, the latter presented a qualitative valuation based on people's perceptions.

This literature reports the existence of a gap on the economic valuation of ES and biodiversity in protected areas.

The key information retrieved from the above literature was coded according to the following classes: type of assessed ecosystem service; presence of biodiversity valuation; type of valuation method; geographical and protected area. The classification follows the Millennium Ecosystem Assessment [24] described above.

Table 1 shows the list of reviewed articles and their information.

Table 1. List of articles used in the present review and type of ES ecosystem services or/and biodiversity.

Author	Geographical Information	Provisioning	Regulating	Cultural	Supporting	Biodiversity
Považan et al., 2015 [87]	Muránska Planina National Park (Slovakia)	x	x	x		
Gandarillas et al., 2016 [88]	Sajama National Park (Bolivia)	x		x		x
Ninan et al., 2016 [89]	Nagarhole National Park (India)	x	x	x	x	x

Table 1. Cont.

Author	Geographical Information	Provisioning	Regulating	Cultural	Supporting	Biodiversity
Torres-Miralles et al., 2017 [90]	Cazorla, Segura y Las Villa National Park (Spain)	x	x	x		x
Schirpke et al., 2017 [91]	Alto Garda Bresciano Park and Val Grigna Park (Italy)	x	x	x		
Ferreira et al., 2017 [92]	Biophysical Interest Zone of Avenças, ZIBA (Portugal)					x
Marta-Pedroso et al., 2018 [93]	Natural Park of Serra de São Mamede (Portugal)	x	x			x
Valasiuk et al., 2018 [94]	Fulufjället National Park Area (Sweden-Norway)			x		
Molina et al., 2019 [95]	Cazorla, Segura y Las Villa National Park and Doñana National Park (Spain)					x
Chi-Ok Oh et al., 2019 [96]	Jiri Mountains National Park (Korea)			x		
Ramel C et al., 2020 [97]	Western Swiss Alps (Switzerland)	x	x	x		

4.2. Results

Figure 3 shows the type of ES and biodiversity which have been assessed in protected areas according to the MA classification [24].

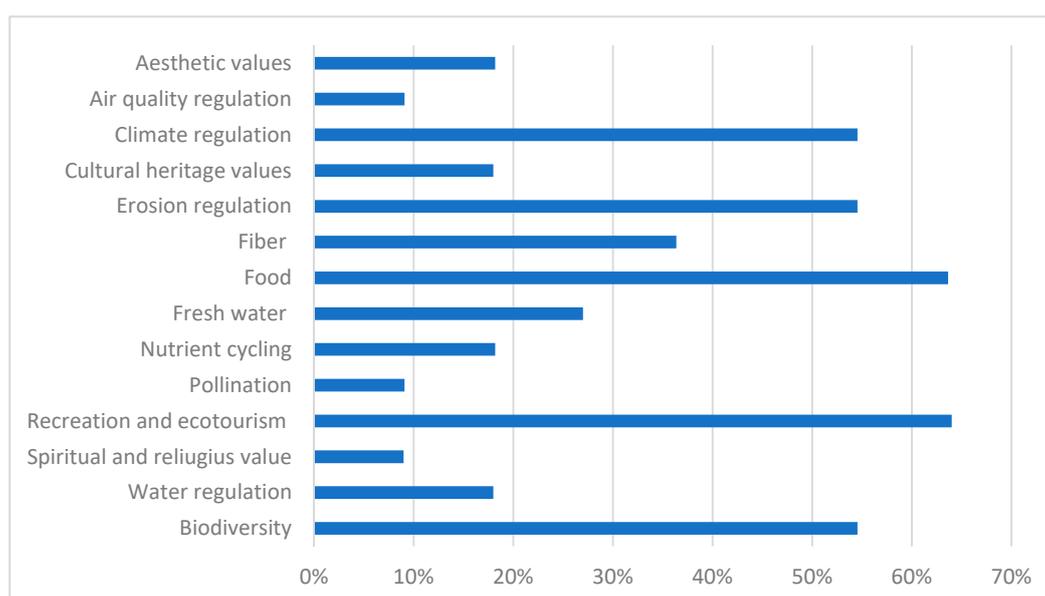


Figure 3. Ecosystem services and biodiversity considered in the present work according to the MA classification in protected areas.

We notice the investigation of the following ES: provisioning service (*food*, 64%), regulation services (*climate regulation*, 55%; *erosion regulation*, 55%), cultural service (*recreation and ecotourism*, 64%) and *biodiversity* (55%).

Below, we present a detailed description of the above results.

4.2.1. Provisioning

This group represents the contribution of the ecosystem to goods that could be physically extracted or collected from the ecosystem. This category considers services such as food, fibre and fresh water. These are goods which are directly used by humans, generally estimated with a market price method, as shown in Table 2.

Table 2. List of articles assessing provisioning services in protected areas and valuation methods used.

Author	Type of ES	Sub-Category	Estimation Driver	Valuation Method	
Považan et al., 2015 [87]	Provisioning	Food	Honey	Market price	
			Seed	Market price	
			Crop	Market price	
			Livestock	Market price	
			Timber	Market price	
Gandarillas et al., 2016 [88]	Provisioning	Fresh water	Water supply	Market price	
				Replacement cost	
Ninan et al., 2016 [89]	Provisioning	Food	Livestock	Benefit transfer	
			Food	Market price	
Torres-Miralles et al., 2017 [90]	Provisioning	Food	Olive groves	Contingent valuation	
Schirpke et al., 2017 [91]	Provisioning	Food	Crop	Market price	
			Mushrooms	Market price	
			Timber	Market price	
			Fibre	Market price	
Marta-Pedroso et al., 2018 [93]	Provisioning	Fresh water	Water supply	Market price	
			Food	Crop	Market price
				Livestock	Market price
Ramel C et al., 2020 [97]	Provisioning	Fibre	Timber	Market price	
			Food	Milk	Market price
				Meal	Market price
				Cheese	Market price
		Timber	Market price		

Food and Fibre. According to the market price method, it is possible to assess these services by multiplying the physical quantity provided by the investigated area with the market price of the specific good. There are different methods to identify the production of goods.

Some authors have computed the amount of the asset production by simply observing the market. Based on the local or regional annual production of the good under study, a quantity of the ecosystem service provided by that area is obtained [87,93]. Other scholars consider the productivity of the good from national datasets or official statistics multiplied by the surface used (in ha) to produce that good [91,93,97]. The above method is often used for crop goods or pasture. In case of a lack of productivity data, information is retrieved from surveys to local inhabitants, stakeholders and experts [87–89]. Other methods are also considered, such as the benefit transfer [89] and CV [90].

Water supply. Považan et al. [87] use national or local data on the average number of people using water from protected areas. In particular, the authors estimate the economic value of the water supply by multiplying the above data with the average water consumption per person per year. Schirpke et al. [91] point out the estimated monetary value of

the potential water supply of the studied area based on spatial regional data and water selling price.

In the economic valuation suggested by the study of Gandarillas et al. [88], the monetary value is obtained following the retention cost method. The value is estimated as the cost of building and operating a water supply facility as alternative to the service provided by the wet forest.

4.2.2. Regulating

This group of benefits represents the ability of ES to rule the biological processes, influencing climatic and hydrological cycles and maintaining environmental conditions. Table 3 shows the valuation technique used and the estimation driver.

Table 3. List of articles assessing regulating services in protected areas and valuation methods used.

Author	Type of ES	Sub-Category	Estimation Driver	Valuation Method
Považan et al., 2015 [87]	Regulating	Climate regulation	Carbon sequestration	Benefit transfer
		Erosion regulation	Flood control and erosion control	Benefit transfer
		Water purification	Water retention	Benefit transfer
Ninan et al., 2016 [89]	Regulating	Water purification	Water retention	Alternate cost
		Climate regulation	Carbon sequestration	Market price and damage cost
		Erosion regulation	Soil erosion control	Hedonic pricing and opportunity cost
		Air quality regulation Pollination	Air purification Pollination	Alternate cost Benefit transfer
Torres-Miralles et al., 2017 [90]	Regulating	Air quality regulation Water purification Erosion regulation	WTP for ecosystem conservation	Contingent valuation
Schirpke et al., 2017 [91]	Regulating	Climate regulation Water purification Erosion regulation	Carbon sequestration Water retention Soil erosion control	Market price Restoration cost Replacement cost
Marta-Pedroso et al., 2018 [93]	Regulating	Climate regulation Erosion regulation	Carbon sequestration Soil erosion control	Benefit transfer Benefit transfer
Ramel C et al., 2020 [97]	Regulating	Climate regulation Erosion regulation	Carbon sequestration Soil erosion control	Market price Avoided damage cost

Climate regulation. This service is identified as the volume of carbon and oxygen captured by the vegetation (e.g., forest, grass and seagrass).

The computation of the carbon content is based on increases of aboveground biomass for the biophysical context provided by similar areas. The amount of biomass is converted into carbon content according to the International Panel of Climate Change (IPCC) [98]. This latter is then multiplied by the carbon market price [97], the social value [91] or both [89] to obtain an estimate of the economic value. In the case of lack of data, a benefit transfer method is used [87,93].

Erosion regulation. Schirpke et al. [91] based the evaluation of this ecosystem service on the potential amount of eroded soil thanks to data obtained by the Revised Universal Soil Loss Equation (RUSLE) [99] and other variables according to previous studies [99–102]. The authors applied the replacement cost method to the amount of potential soil loss and the local market price.

Alternatively, Ramel et al. [97] employ the avoided damage cost method on existing infrastructures in the protected area under study.

A further work adopts hedonic price and opportunity cost methods to the soil protection function. The latter is obtained using changes in the land price as variations of the soil quality [89].

Torres-Miralles et al. [90] obtain the economic value of ES using the CV method. Through the creation of alternative conservation policies, it is possible to obtain the respondents' WTP for each ecosystem service included in the hypothetical scenario.

In the absence of data, some authors use the benefit transfer method [87,93].

Water regulation. It is the water conservation capacity of the area. Its value is the result of the alternative cost method. It is computed using the amount of water conserved in the area with the economic storing cost of 1m³ of water in a reservoir [90,91]. Other authors compute the value of ES using the CV [90] or benefit transfer method [87].

Air quality regulation. Ninan et al. [89] used the alternate cost and estimated the economic value of the service by multiplying the quantity of SO₂ and NO₂ absorbed by the forest by their marginal abatement costs.

4.2.3. Cultural

This group of ES includes all non-tangible services. They refer to experiences and activities that human beings benefit from ecosystems (e.g., cultural, spiritual, recreation, etc.). Table 4 shows, for each study, the estimation driver and the valuation technique used.

Table 4. List of articles assessing cultural services in protected areas and valuation methods used.

Author	Type of ES	Sub-Category	Estimation Driver	Valuation Method
Považan et al., 2015 [87]	Cultural	Recreation and ecotourism	Hunting Tourism	Market price Travel cost
Gandarillas et al., 2016 [88]	Cultural	Recreation and ecotourism Cultural heritage values	Ecotourism Heritage value	Market price Contingent valuation
Ninan et al., 2016 [89]	Cultural	Recreation and ecotourism	Tourism	Travel cost and Benefit transfer
Torres-Miralles et al., 2017 [90]	Cultural	Recreation and ecotourism Cultural heritage values Aesthetic value	WTP to ecosystem conservation	Contingent valuation
Schirpke et al., 2017 [91]	Cultural	Recreation and ecotourism	Tourism	Travel cost
Valasiuk et al., 2018 [94]	Cultural	Recreation and ecotourism	Recreational area	Choice Experiment
Chi-Ok Oh et al., 2019 [96]	Cultural	Spiritual and religious value	Heritage value	Contingent valuation
Ramel C et al., 2020 [97]	Cultural	Recreation and ecotourism	Hunting Recreational activity	Market price Benefit transfer

Recreational and ecotourism. These ES identify the demand for recreational uses of natural areas. Generally, these services refer to recreational aspects such as, for example, hunting or fishing, and personal experiences by visiting the territory under study such as eco-tourism activities. As for hunting, several studies compute the economic value using the market cost of the hunting license [87,97]. Similarly, the above method is also used to estimate tourism values (i.e., the revenue that the local community receives from an ecotourism enterprise) [88]. Other authors use the travel cost method. It estimates the value of a tourism or ecotourism service of a particular recreational site by considering an aggregate cost paid by the tourist [87–89,91].

Cultural ES, such as *cultural and heritage values*, *landscape values* and *spiritual and religious values*, are generally estimated using alternative methods than market prices.

Few authors use CV methods [88,96], while others use choice experiments to estimate the economic value [94]. When data is lacking, the benefit transfer method is applied [97].

4.2.4. Supporting

Supporting services are a particular group needed for the production of other ES (nutrient cycling and primary production). The supporting class is a debated group of ES. Often, supporting services are integrated into other groups [23]. Table 5 shows the papers which have used this particular ecosystem service.

Table 5. Literature assessing supporting services in protected areas and valuation methods used.

Author	Type of ES	Sub-Category	Estimation Driver	Valuation Method
Ninan et al., 2016 [89]	Supporting	Nutrient cycling	Accumulating nutrients	Alternate cost and market price

Nutrient cycling. The mineral nutrients of trees facilitate the nutrient cycle in the soil [103]. The economic valuation of this ecosystem service assesses the aboveground biomass that is present in the considered protected area. Subsequently, it is important to compute the nutrient value of the forest biomass and retrieve economic data to obtain a monetary value of the nutrient cycling.

According to Ninan et al. [89] the first step is obtained through the use of a biophysical formula in order to provide a unit value generally expressed in tonnes/year. The absorbing biomass capacity is retrieved from previous studies in similar areas. The above two values are then multiplied to obtain the amount of nutrient accumulation services. Finally, to determine the economic value, the authors consider the (market) price of green fertilizers or the average price of mixed chemical fertilizers (alternate cost).

4.2.5. Biodiversity

Table 6 shows, for each paper, the estimation driver and the valuation technique used for biodiversity in protected areas.

Table 6. Articles that valued the biodiversity and valuation methods used.

Author	Type of ES	Estimation Driver	Valuation Method
Gandarillas et al., 2016 [88]	Biodiversity	-	Benefit transfer
Ninan et al., 2016 [89]	Biodiversity	WTP for elephant conservation	Contingent valuation
Torres-Miralles et al., 2017 [90]	Biodiversity	WTP for ecosystem conservation	Contingent valuation
Ferreira et al., 2017 [92]	Biodiversity	WTP for the ecosystem conservation	Contingent valuation
Marta-Pedroso et al., 2018 [93]	Biodiversity	Payment to ecosystem conservation	Contingent valuation
Molina et al., 2019 [95]	Biodiversity	WTP for three flagship species	Contingent valuation

In the selected literature, the economic valuation of biodiversity is obtained through non-market methods. The majority of studies use the CV method. Few authors obtain the economic value through the WTP from respondents for the implementation of protection policies [90,92,93]. Other studies use the individual WTP for the protection of selected flagship species, such as elephants or other mammals [89,95].

5. Mapping of Ecosystem Service and Biodiversity of the Gargano National Park

The GNP was founded in 1991 and covers an area of 1181.4 hectares. It is ranked fourth in the list of Italian National Parks (IMELS) in terms of land extension and is considered a biodiversity hot spot at global level [104], with a high density of rare, endemic and phytogeographic interest species [105–110] and habitat 92/43 EEC [111–118].

The flora of the Gargano presents about 2100 species [119], 24 of which are endemic (11 exclusive to the Puglia Region) [120]. This latter can be considered a high value if we take into account the limited area of the Promontory of the Italian peninsula, which reports 8195 plant species [121]. The data can be partly explained by the considerable coverage of natural areas compared to cultivated areas and the presence of small municipalities with low population density. Below, we illustrate different types of services provided by native plants in the park.

- *Supporting services.* Soil-forming and nutrient cycling provide the foundation for all life on Earth. Plants form the critical basis of food chains in nearly all ecosystems. In general, native plants support other native species more effectively than non-native plants.
- *Provisioning services.* Supply services include food, fresh water, fuel, fibre and medicines collected from natural and managed ecosystems. Many native plants are harvested for food, animal feed and fibre. These are often referred to as wild harvested plants (WHP). In the GNP, many species of wild mushrooms, sweet chestnut (*Castanea sativa* Mill.), common hazel (*Corylus avellana* L.), wild strawberry (*Fragaria vesca* L. subsp. *vesca*), wild apple (*Malus sylvestris* (L.) Mill.), blackthorn (*Prunus spinosa* L. subsp. *spinosa*), bramble (*Rubus canescens* DC.), wild blackberry (*Rubus ulmifolius* Schott) and many edible herbaceous species that could be traded are simply harvested. Some people use native plants as medicines, such as rustyback (*Asplenium ceterach* L.), deadly nightshade (*Atropa bella-donna* L.), starflower (*Borago officinalis* L.), Saint John's wort (*Hypericum perforatum* L.), bay laurel (*Laurus nobilis* L.), common mallow (*Malva sylvestris* L.), Lemon balm (*Melissa officinalis* L.), mint (*Mentha* sp. pl.), dog rose (*Rosa canina* L.), dog figworts (*Scrophularia canina* L.) and Marian thistle (*Silybum marianum* (L.) Gaertn), while they have lost the use as dye plants, such as dyer's croton (*Chrozophora tinctoria* (L.) A. Juss.), dyer's alkanet (*Alkanna tinctoria* Tausch subsp. *tinctoria*), woad (*Isatis tinctoria* L. subsp. *tinctoria*) and golden marguerite (*Cota tinctoria* (L.) J. Gay). In addition, native trees and shrubs are mainly used for firewood and the production of wood for building purposes. Other potential wild-grown trees should also be evaluated [122], including prioritised ones [123].
- *Regulating services.* Native plants contribute to regulate ecosystem functions such as climate, flood, diseases, pests, the purification of water and pollination. For example: (1) The habitat functions are correlated with the diversity of ecosystem environments and processes that contribute to produce this diversity (e.g., the shelter and *nursery* functions of ecosystems support specific and genetic diversity, forming the basis for most of all other ecosystem functions); (2) several native plant communities along roadsides slow down water and can prevent flooding much more effectively than mowed lawns. Additionally, during photosynthesis, plants absorb carbon dioxide from the atmosphere, release oxygen for breathing and store carbon in their roots and stems, helping to regulate greenhouse gases.
- *Cultural services.* Native plants are valuable to human cultures for recreational and spiritual uses. Historically, shrub species such as olive (*Olea europaea* L.), blackthorn (*Prunus spinosa* L. subsp. *spinosa*) and rush broom (*Spartium junceum* L.) are used to make wicker baskets, or fruits of blackthorn or common centaury (*Centaureum erythraea* Rafn) for liqueur; blackberries (*Rubus* sp. pl.) and figs (*Ficus carica* L.) for jams; and wild oregano (*Origanum vulgare* L. subsp. *viridulum* (Martrin-Donos) Nyman) and Lesser calamint (*Clinopodium nepeta* (L.) Kuntze) for spices. As for recreational use, many people nowadays enjoy a wooded park-like setting for camping, picnics and other family gatherings [124]. Some make a special pilgrimage to their favorite

woodland each spring to view the wildflowers [125], or they grow particular native plants in their garden to support butterfly larvae or bees [126].

Agroecosystems in the Gargano area also play a relevant role, although they contain less plant and animal biodiversity compared to forests and natural environments, as well as less biomass content compared to forests. Generally, agroecosystems provide ES related to the production and sale of food such as citrus fruit (lemons and oranges), oil and wine. It is worth noting the presence of some interesting agroecosystems such as centuries-old olive groves [127], the historical *Citrus* L. which groves due to the presence of local varieties of oranges (such as "*Duretta del Gargano*", "*Biondo comune del Gargano*" and "*Melangolo*") and lemon ("*Femminello del Gargano*"). Lately, the above species have been suffering from competition with more industrial and commercial varieties. Marketing activities of the GNP, with the help of municipal institutions and producers of the "Consorzio Gargano Agrumi", have led to the Community recognition of protected geographical indication oranges such as the "*Biondo comune del Gargano*" (Arancia del Gargano IGP—EC regulation n. 1017/07) and the "*Femminello del Gargano*" (Limone Femminello del Gargano IGP—EC regulation n. 148/07).

6. Conclusions

Biodiversity has multiple roles in the delivery of ES. It can be considered a regulator of ecosystem processes, a service provider or a good. Effective ecosystem management will require identifying and analysing the above roles as a whole, both for the optimization of ecosystem service delivery and the conservation of species, habitats and landscapes.

New approaches underpinned by ecological and social sciences are needed for assessment purposes to mirror the different roles that biodiversity plays in the ecological process, in the delivery of ES and provision of goods. Over time, conservation and ecosystem management planning systems have largely developed independently from each other; although only recently they tend to operate side by side.

The conservation of biodiversity, plant species, woods and ecosystems in protected areas is a fundamental aspect for which it is worth to provide a methodological effort, mostly through an estimate of its economic value, to relate it to ES.

The present study shows a lack in the international literature about the economic valuation of ES and biodiversity in protected areas. Recently, the lack or limitation of empirical evidence may be caused by the relatively short period of time considered in the systematic review. Nonetheless, this result would contrast the increased international awareness for sustainability issues, including the management of ES and practices and green policy attitudes at global level. A further limitation may be provided by the particular aspect considered in this study related to protected areas. Being these areas under some forms of legal protection, the attention of the international debate can reasonably move towards the analysis and investigation of other areas lacking of any regulation.

Furthermore, the present study underlines the existence of an unbalance in the number of observed studies, occurring between and within ecosystem service groups. In particular, the supporting group appears insufficiently investigated, probably because it is provided by a complex set of ES that affect the services offered by other groups. In terms of 'within ecosystem service groups', the international literature seems to draw its attention on provisioning services such as food and timber services; on regulating services such as climate and water sanitation services; and on cultural services such as recreational activities and services.

Improving the quality of protected areas through an estimate of their monetary value may be a viable solution to guarantee an efficient management of ecosystems, ES and biodiversity. Recent international studies in protected areas show the adoption of both market and non-market valuation methods for biodiversity and ES classified according to the Millennium Ecosystem Assessment.

The above methods can also be considered a useful guide for future assessments of these benefits in a complex system such as that of the GNP in the south of Italy or other protected areas worldwide.

Author Contributions: Conceptualization, D.P., E.V.P. and P.P.; methodology, D.P.; software, D.P.; validation, D.P.; investigation, D.P. and E.V.P.; data curation, D.P.; writing—original draft preparation, D.P. and E.V.P.; writing—review and editing, C.D.L. and D.C.; visualization, D.P.; supervision, C.D.L. and P.P.; funding acquisition, P.P. All authors have read and agreed to the published version of the manuscript.

Funding: PhD program in Economics, Culture and Environmental, 36° cycle; funded by the Gargano National Park (protocol n.0017130—III/6 of 20.05.2020 and Rector’s Decree n. 631/2020) and awarded to Domenico Pisani.

Institutional Review Board Statement: Not applicable.

Informed Consent Statement: Not applicable.

Data Availability Statement: The data used in this study are available upon request from the corresponding author.

Acknowledgments: We are thankful to the participants of the 13th National Conference on Biodiversity, University of Foggia, 7–9 September 2021 for the feedback received; to the Gargano National Park for kindly providing funding for this research; and to the two anonymous referees who contributed to improve the original draft of this manuscript. Any remaining errors are the sole responsibility of the authors.

Conflicts of Interest: The authors declare no conflict of interest.

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