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Ecosystem services value: a literature review

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Abstract
The paper aims to analyse the literature on ecosystem services and on payments for ecological services focusing on the pollination case study by highlighting the economic approaches most used in the evaluation of tangible and intangible environmental services. Agriculture guarantees food security and, to some extent, energy security, often at the expense of other ecosystem services. Remedying the negative consequences of intensive agriculture requires the identification of products and services deriving from eco-sustainable land management and their financial value (the so-called Payments for ecological systems). The literature agrees in recognizing a value to ecological services produced by sustainable agricultural management systems; however, different methods are applied.

Keywords
Ecosystem services, payments, agriculture, pollinators, sustainability

JEL Codes
Q57, Q24, Q18, R14, Q58

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1. Introduction

The ecosystem services (ES), emphasizing the interdependence between ecosystems and humans, are a rapidly institutionalizing concept concerned with the interaction between humans and nature. The recognition of human dependence on the environment goes back to the 1940s, but it was *The Study of Critical Environmental Problems* (1970) that first introduced the word 'ecosystem service' in the early 1970s. Then, in 2005, the Millennium Ecosystem Assessment (MEA)[1] defined ES as the benefits people obtain from ecosystems, commonly accepted definition.

In Zhang et al. (2006), the definition of ecosystem services, in agriculture, has often been used to refer to "input services" and "output services".

In 2011, Lamarque et al. (2011) classified ES in four categories:

- provisioning services (i.e., products obtained from ecosystems, such as food, fiber or timber),
- regulating services (i.e., flood or pest control and climate regulation),
- cultural services (i.e., non-material benefits such as aesthetic and recreational enjoyment),
- supporting services (i.e., those services that are necessary for the proper delivery of the other three types of services, such as nutrient cycling).

However, environmental services are not always easily identifiable. In some cases, goods and services have a clear value for the consumer, such as food; but, in the case of intangible services offered by ecosystems, difficulties can arise. The case of pollinators can be a good example. A landowner may have honeybees on his land and, in addition to the pollination service, may sell honey, providing an additional service. Apart from these “direct” services, honeybees and other pollinators, they do not offer easily detectable services beyond company boundaries. To overcome this problem and detect the services offered from a broader point of view, one method could be to interview local farmers about their needs and the use of the land. The amount of grass, texture and phenology of flowering can be converted into observable parameters such as annual green biomass production.

Biological and environmental evidence, however, are not sufficient to measure benefits. Any intervention / behavior can affect neighboring producers (e.g. livestock feed) or customers even outside the local region (Lamarque et al., 2011). Furthermore, the loss of pollinators can affect food production. While pollinator deaths have numerous and related causes, they are generally associated with land-use change, intensive crop management and pesticide use, environmental degradation and climate change. It is clear that, even if farmers or growers know that a given action is more environmentally friendly and safer, they may not have sufficient financial resources to adhere to more environmentally friendly behavior. This problem may be partially solved by shrinking the monetary gap through an exogenous intervention. In this regard, payments for ecosystem services (PES) are payments for environmental services (or benefits) awarded to farmers or landowners in exchange for voluntary sustainable land management, to promote the spread of ecological services. In other

[1] The Millennium Ecosystem Assessment is an international work initiative initialized by the U.N. and designed to meet the interests of decision-makers, public information on the impact of ecosystem changes on human well-being and options for adaptation to these changes. The MEA focuses on ecosystem services (the benefits people obtain from ecosystems). It also explores how improvements in ecosystem services have impacted human well-being. The assessment describes potential solution options that should be implemented to enhance ecosystem services. It looks at problems on a local, national, or global basis to help enhance the management of habitats and contribute to their well-being. For other information consult https://www.millenniumassessment.org/en/index.html

words, they represent the financial support to ES providers able to modify land management systems.

In creating the linkage between environmental services and payments, the MEA has played a decisive role. The MEA served as a kind of echo chamber and started the process of "mutual justification" between ES and PES, which began in 2005. Although the climate change impacts are measured, mainly in terms of tons of CO_2, the international community and policy makers, at different territorial levels, need a shared economic calculation method, to allow the adoption of an efficient and effective environmental policy capable of promoting and spread the production of environmental services and eco-sustainable behaviors (CBD 2003; Godard 2005).

The concept of the ES seems to provide suggestions on the subject. ES, largely independent from PES-type practical testing, is closely involved in the growing interest of decision makers, as well as in the definition of market-based ecosystem management tools. Actually, one of the most important achievements of the MEA was to propose a theoretical structure integrating ES, now part of the literature and public policy, and to draw the attention of the international community to the economic expense of doing little and the monetary importance of habitats. The key event highlighting this evolution has been the announcement of The Economics of Ecology and Biodiversity (TEEB) initiative. Building on the findings of the MEA, Sukhdev, the study leader, proposes to continue raising the alarm about the global lack of ES by measuring them in monetary terms. The first step (TEEB 2009) was to investigate the state of understanding of the monetary biodiversity value, to show how such policies run counter to the environmental management of the ES and to list economic instruments that are best suited to their protection. This list includes PES (Pesche et al., 2013).

Regarding the EU, the Common Agricultural Policy (CAP) introduced payment for environmental services (PES) at least two decades ago as agro-climatic-environmental measures (AECM), a sort of support for additional supply of ecosystem services through conditional payments to voluntary suppliers. In addition, cross compliance (aiming at contributing to the development of sustainable agriculture and making the CAP closer to expectations of society) was first introduced on a voluntary basis in Agenda 2000. It was further developed in the 2003 CAP reform, strengthening the link between the payment of additional income under the first pillar and certain rural development measures (CAP second pillar).

In the next programming period (2021-2027) among the nine objectives of the CAP, three of them refer to the environment, namely (European Commission, 2019a):

1. Contributing to climate change mitigation and adaptation, as well as sustainable energy.
2. Fostering sustainable development and efficient management of natural resources such as water, soil, and air.
3. Contributing to the protection of biodiversity, enhanced ecosystem services and preservation of our habitats and landscapes.

The AECMs of the next CAP are resumed. The purpose is to ensure best environmental and climate practices in the context of rural development. More specifically, they are aimed at restoring, preserving and improving ecosystems; promoting resource efficiency; achieving a low-carbon and climate-resilient economy. As previously, while mandatory for Member states, they are voluntary for farmers and other participating beneficiaries. Payments are granted to those who voluntarily go beyond basic mandatory standards to maximize actions for climate change and protect water quality and availability, air quality, soil health, biodiversity and ecosystem services (European Commission, 2019a). Member states will be required to commit at least 30% of their rural development budget to support action on environment and climate change. In 2019, the European Commission (2019b) adopted the European Green Deal a set of initiatives aimed at achieving climate neutrality in Europe by 2050. Starting from the assumption that ecosystems produce services essential for survival, it recognizes a progressive deterioration of biodiversity, caused by the excessive exploitation of not reproducible natural resources, by changes in land and seas uses and by climate change impact.

Starting from these premises, the paper aims at analysing the literature on the subject highlighting the economic approaches used in assessing the environmental services, a crucial stage in recognizing and quantifying payments for services produced. The adoption of sustainable behaviour, if public suppliers do not present particular criticalities, as in the case of private subjects, in the absence of support, the lack of economic convenience, leads to non-adhesion, compromising the path towards greater sustainability and enormously limiting the diffusion of sustainable business models.

The structure of the paper is the following. Section 1 provides an overview of ecosystem services. Section 2 briefly outlines the different definitions of payment for ecosystem services through a literature review and summarizes some important tools used in some countries, particularly OECD countries. Section 3 offers a literature review of some of the approaches taken to determine the values of ecosystem services. Section 4 describes the ecosystem services provided by insects. After identifying who are the pollinators, in particular bees, the paper focuses on some benefits in terms of recreational activities that the enhancement of pollinators can offer to a territory. Some concluding remarks are included in section 5.

2. Payments for environmental services in a nutshell

According to Engel et al. (2008), the PES, well defined by the MEA (2005) and by Wunder (2005), are "*a voluntary transaction where a well-defined ES (or a land-use likely to secure that service) is being 'brought' by a (minimum one) ES buyer from a (minimum one) ES provider, if and only if the ES provider secures ES provision (conditionability)".* This definition is the most cited and commonly accepted one and appears to be the most effective. The PES works as follows: ecosystem managers, for example farmers, tend to prefer observing the productivity of the land rather than its conservation level. This means that usually, these usages have negative consequences and externalities on other people (i.e., downstream water uses). For this purpose, the so-called ES buyers enter in play. ES buyers, such as governments, landowners, NGOs and other third parties, offer a cash payment or a series of financial incentives (for instance, the government could establish a tax discount) to the ES provider or seller (the farmer) to cover the costs or compensation for lost income of a (for instance, land) conservation behavior. Hence, they vary with both private and public goods. In the case of private goods or services traded on the market, the price is an indicator of marginal ability to pay, which can be used to quantify the economic worth of ecosystem services (Hufschmidt et al., 1983; Freeman, 1993). Moreover, in the case of public products or services, the marginal willingness to pay cannot be calculated by a straightforward measurement of revenue, and the demand curves are usually difficult to construct (Hueting, 1980). The above-mentioned definition and procedure, known as the *environmental economics perspective* (ENVEP), is strictly connected to the Coase theorem, even though Engel et al. (2008, pages 665, 666) allow us to consider *"PES programs as an environmental subsidy to ES providers combined, in some cases, with a user fee"*.

In contrast with the Coasean ENVEP vision of PES, the *Ecological Economic Perspective* (ECOLEP) focuses on the multiple priorities of ecological preservation, equal distribution and economic performance, and prefers a range of payment structures to achieve these objectives, both market and non-market. The ECOLEP criticized that only few cases are classified as true PES schemes because many real-world situations do not conform to ENVEP PES schemes. In order to broaden the PES schemes categorization, Muradian et al., 2010 proposed three criteria. The first is related to the importance of the economic incentive. This criterion refers to the role played by the incentives in the provision of the ES. There should be cases in which financial incentives are less effective than the intrinsic motivation. The second criterion is the directness of the transfer and refers to the passages from the ES buyers and the ES sellers. The third criterion regards the degree of commodification and so the possibility to find out the transferred quantities. Sometimes those quantities are measurable (i.e. tons of carbon sequestered per hectare) and sometimes not. Moreover, Muradian et al. (2010) redefined PES as "*a transfer of resources between social actors, which aims to create incentives to align individual and/or collective land use decisions with the social interest in the management of natural resources".*

Some of the main PES programs promoted in Organization for Economic Co-operation and Development (OECD) member countries (2018) could be divided in four categories:

Biodiversity-relevant taxes include taxes on pesticides, fertilizers, forest products and timber processing. Under the "polluter pays" principle, these instruments position indirect costs on the utilization of natural resources or on the emission of emissions to reflect the negative environmental externalities they generate. As such, they are motivated for both producers and consumers to behave in a more environmentally sustainable way. An example of tax allocation for biodiversity-relevant purposes is in Denmark, where 100% of the income from the pesticide tax is set aside for environmental purposes and to reward farmers.

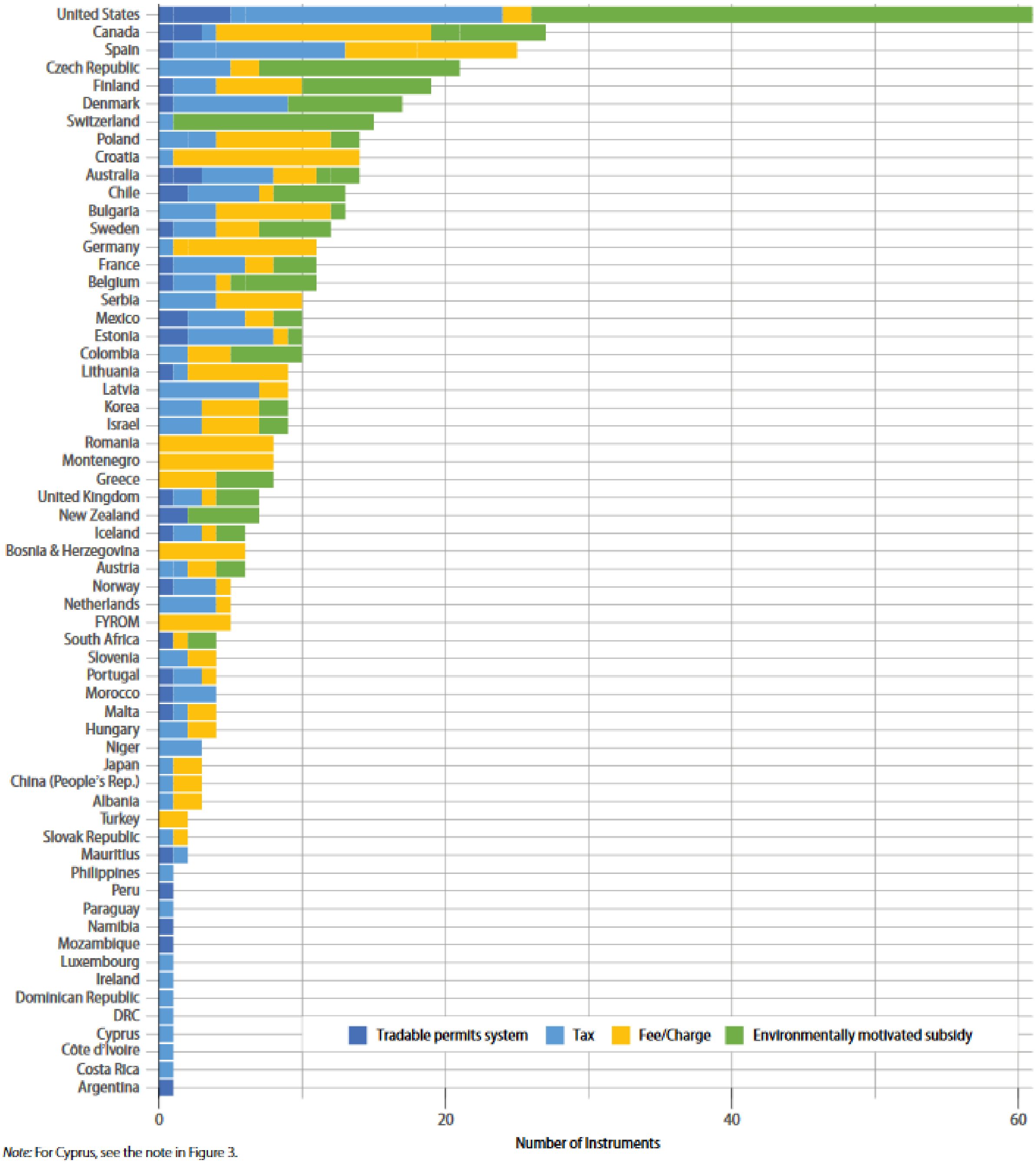
Biodiversity-relevant fees and charges include fees for visits to national parks, fees for hunting licenses, charges for land-based pollution discharges, such as for the Great Barrier Reef Area of Australia, charges for the disposal of groundwater and non-compliance with biodiversity-related fines.

Biodiversity-relevant tradable permits include individual transferable fishing quotas, tradeable construction and hunting rights. These policy instruments place a cap on the overall amount of natural resources that can be used, and then grant individual licenses to consumers who can also exchange. The distribution of these permits can be forfeited or auctioned. If auctioned, tradeable permits will also produce financing.

Biodiversity-relevant subsidies include subsidies for forest protection and reforestation, subsidies for sustainable or environmentally sustainable agriculture, subsidies for pesticide-free agriculture and soil restoration (OECD, 2018). Given the above-mentioned concepts, in Figure 1 is presented the overview of the PINE data on biodiversity-relevant economic instruments by country as in OECD (2018, page 14).

Figure 1 provides interesting information on the different types of PES used by OECD Member States. Disincentives, such as taxes and fines, for bad behavior, are the most widely used PES, whereas environmentally motivated subsidies are primarily used in developed countries. Furthermore, tradable permits are not widespread perhaps there are not many advantages in the exchange of privileges between individuals. Pollinators play a crucial role in ensuring that key crops supply us with sufficient, high-quality food supplies, a wide range of nutritional nutrients providing human health benefits and stability through crop production. In fact, pollinators not only increase the yield of several crops, but also increase their quality. This has been verified for a wide range of crops and plants, including apples, rapeseed, blueberries, cucumbers, leeks, kiwis, sunflowers and coffee (Perrot et al., 2019; Saez et al., 2019).

Figure 1 Number of biodiversity-relevant economic instruments by country and type (2018)



Note: For Cyprus, see the note in Figure 3.

Source: OECD PINE database, accessed 08 October 2018.

Despite the mentioned benefits, pollinators provide nutrition and human health, (section 4), and several studies have estimated the economic value of pollinators, but it is difficult to compare them as the results have been obtained using different hypotheses and techniques. Economic analyses are also restricted by variations in ecological and economic data. However, all recent results point to the economic importance of pollinators. Not only could the loss in pollinators lead to a reduction in crop production and productivity, but it could also cause massive costs if, for example, animal pollination was replaced with hand pollination. Table 1 summarizes some of these works highlighting the geographical spectrum, the methods, the variables considered, the assumptions taken into account and also the data base (European Commission, 2020b, pp. 20-21).

The approach followed by Gallai et al. (2009), the same as Bauer and Sue Wing (2016), is that of partial equilibrium, the first based on the contribution of pollinators, the second in terms of pollinator loss. The two studies also share the relationship of dependence to the market value. The JRC (2018) differs from the previous ones and makes use of an experimental ecosystem account of crop pollination, combining biophysical flows with monetary evaluation.

It should also be recalled that a 20% reduction in yield, for example, would not necessarily result in a 20% decline in sales. Farmers may respond by transferring production to another crop that is not dependent on animal pollination (IPBES, 2017), which may lead to shortages or price changes in some crops. However, for many farmers whose choices are restricted by economic or environmental constraints, what appears to be a relatively minor decrease in productivity may lead to the closure of their business.

Table 1 Comparison of estimates of economic value of pollination services for Europe.

Study	Gallai et al.,2009	Bauer and Sue Wing, 2016	JRC, 2018
Estimated value of insect pollination for Europe/year	€14 200 million (2005)	€17 700 million (2004)	€3 100 million (2006)
Geographical range	EU25	Europe	EU28
Approach	Partial equilibrium estimates, of contribution of insect pollination to the economic value of agricultural output. Applies a crop pollination dependency ratio to the market value	Partial equilibrium estimates of production loss in the event of complete pollinator loss. Applies a crop pollination dependency ratio to the market value.	Experimental ecosystem account of crop pollination, combining biophysical flows with monetary valuation, before presenting via accounting tables. Estimates contribution of pollination, using actual flow of met demand multiplied by dependency ratio
Factors considered	Considers crop quantity produced, quantity consumed dependence ration of crop on insect pollination, European price of crop per unit produced.	Considers the pollinator-dependent share of agricultural revenue as well as the loss of consumer surplus (CSL) in crop market	Considers actual production flows, records of pollinator presence, and agricultural economic accounts; uses constant monetary values rather than current prices; and c how much of the crop demand for pollination is actually met.
Assumptions/limitations	Focuses on individual markets without looking at potential linkages between them; ignores multi-market interactions. Assumes that the whole extent of crop demand is covered by the pollination potential. Only considered crops used directly for human consumption as reported by FAO and crops for which there were data available. Loss increases	Focuses on individual markets without looking at potential linkages between them; ignores multi-market interactions. Assumes that the whole extent of crop demand is covered by the pollination potential. Consider only losses that occur in pollinator-dependent crop sectors within the region experiencing the shock. Ignores potential increases in the prices of crop producers'	Only considers pollinator-dependent crop production covered by pollination service (met demand, which depends on the actions of wild pollinators).For pollinator-dependent crops, about 66% of production depends on the service of crop pollination. The actual flow is then only processed for the 66% of the production rather than the 100% of production. Lack of local data. Lack of

	with the size of the affected economy.	outputs and underestimates the total impact on the economy by not accounting for concomitant changes in the value of non-crop sectors' outputs. Opportunity cost increases with the size of the affected economy.	disaggregated data prevents integration of information on specific crops with costs incurred by farmers during production. Only considers simplified base prices rather than market prices.
Source data	2005 production data from FAOSTAT database; Klein et al., 2007	2004 production data from FAOSTAT database; Gallai et al. 2009; Kleinet al., 2007.	ESTAT; spatial data from CAPRI model; dependency ratios (Klein et al., 2007); economic account reported for agriculture within the SNA.

Sources: Gallai et al., 2009; Bauer and Sue Wing, 2016; JRC, 2018

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3. Methods: a literature review

In this section, we summarise some of the several techniques reported in the literature aimed at identifying methods for the qualitative and/or quantitative evaluation of PES. The comprehension of expertise in this work is not complete due to the diversity of literature and its ever-increasing interest. Following Mburu et al. (2006), the welfare or economic value of the ecosystem service is the weighted sum of the utility received by all individuals through the provision of ecosystem services. Eco systems service providers can benefit or lose their benefit from the provision. In the case of private ecosystem services and assuming optimum market conditions, costs reflect a marginal economic gain of the service. Customer surpluses and manufacturer surpluses are two key concepts for the identification of profits/benefits derived by consumers and producers from trading. The surplus of the producer is the amount of welfare the producer earns at a certain production volume and at a certain price.

In the case of agricultural production, the surplus of the producer is the net profit of adequate agricultural producers from earning a price higher than the cost of production, based on product differentiation. In addition, there may be positive externalities of sustainable processes. Based on the concept of the total economic value, there are several categories of economic value, and distinguish scholars have provided different classifications for these types of value. In this analysis, the following four types of valuation are reported:

1. The *direct value of use* comes from the direct use of ecosystems (Pearce and Turner, 1990), for example from the sale or use of a piece of fruit. Both manufacturing facilities and some cultural amenities (such as recreation) provide clear advantages for their use.
2. *Indirect use* arises from the indirect use of environments, in particular from the positive externalities of ecosystems (Munasinghe and Schwab, 1993). This reflects the kind of benefits offered to society by regulatory facilities.
3. *Option* value regards, in a certain way, the concept of risk. Since consumers are unsure of their potential need for a benefit, they are willing to pay to retain the chance of using a resource in the future.

4. *Non-use value* is extracted from properties that are implicit in the environment itself (Cummings and Harrison, 1995; Van Koppen, 2000). Hargrove (1989) points out that non-use ideals can be anthropocentric, as in the case of natural beauty, as well as ecocentric, based on the idea that animal and plant organisms have a "right to live."

These four benefit types need to be included in the estimation of the overall value of ecosystem resources. They can be summed up in order to achieve the overall amount of resources rendered by the ecosystem. A variety of economic valuation methods for ecosystem services has been developed.

In this sense, Hufnagel et al. (2018) provide a newer and wider collection of five methods to determine the value of ES enlarging the Mburu et al. (2006) one: *market price, production function, cost based, random utility and transportation costs, and hedonic pricing methods*. The following approaches are not meant to overwrite the previous one, but to provide a larger evaluation even due to shifts in resources and needs due to the passage of time.

Market price methods are mostly used when commodities are conveniently priced from their market value. This method has the benefit of cost and quantity knowledge, but only a limited number of resources are priced at reasonable and transparent prices (Koetse et al. 2015).

Production function methods are useful if a certain good is partly provided by human work and partly by the contribution of the environment (such as insect-pollinated crops). These tools were created to assess indirect use meanings, but the relationship between ES and human contribution is hardly determinable (Pascual et al. 2009).

Cost-based methods calculate the importance of an ecological service estimating the disruption incurred by the potential failure of the service and the potential cost of restoring the service. This approach has the benefit of following what the economy thinks of building a vault. However, the same costs do not represent the disadvantage they have suffered (Daly 2016)

Random utility and transformation costs are founded on the idea that people know their interests, but really researchers don't. These approaches are primarily used to determine ecosystem services values on the basis, for example, of activities and sports such as fishing, hunting and swimming. (National Research Council 2016).

Hedonic pricing approaches calculate the indirect value of ecosystem services, which are not marketable but can be calculated on the basis of the value of the product observed. This approach is also used to measure the gains or disadvantages of environmental quality. This is the case, by way of example, of two houses identical in almost everything, but the ambient air of the first house is more polluted than the second one, so the first is cheaper.

4. Pollination case study

4.1 Overview on insect pollination

Without pollinators, many of the micronutrients that are essential to health, like vitamins A and C, calcium and fluoride, will be short or missing from our diet. Animal-pollinated crops, such as fruit and nuts, are generally often richer in essential nutrients than staple crops, often wind- or self-pollinated (Della Penna, 1999). Insufficient consumption of primary foods pollinated by pollinator insects such as berries, vegetables, nuts and seeds increases the risk of multiple cancers, including coronary heart disease, asthma, oesophageal cancer and lung cancer. Globally, western honeybees are commonly found and used for their hive supplies. In fact, it is one of the very few species that produces honey and visits all the top 15 pollinator-dependent crops, including apples, cucumbers and pears (Klein et al., 2018). The work of Aizen and Harder (2009) shows that a wide range and a high number of pollinator species have a beneficial effect on crop production, and that managed bees are increasingly used to pollinate crops. Moreover, it is worth noting that managed honeybees, on their own, are not as successful and, as Garibaldi et al. (2013) point out, are not substitutes for wild pollinators, and they should "work" side to side with wild pollinators creating a mixed variety of pollinating wildlife. In particular, many species are also needed to ensure a high level of pollination throughout the region, ensuring difference between species and sites. Another advantage of a great biodiversity is that the loss in number of a specie due, for instance, to climate change may be compensated by the others (Sanaphati et al.,b2015). In addition, crop pollination species often require wild plants for breeding and food resources, and these wild plants also rely on a variety of other pollination species to help preserve healthy habitats and a broader biodiversity.

An extreme variety of insects, the benefits of which are known, such as pollinating crops and wild plants, exists worldwide. Pollinators visit flowers to drink nectar or to feed off pollen and to carry pollen while they fly from spot to spot. As is stated in Vanbergen et al. (2013), globally, insects provide pollination services, valued in the USA at $215 billion in 2005, provide about 75% of crop species and sustainable reproduction in up to 94% of wild plants. Even if these data are out of date, they reflect a consistent message true over the years. Winfree and Tarrant (2011) argue that between 75% and 90% of flowering plants need the assistance of pollinators. According to FAO (2020), "*pollinators affect 35 percent of the world's crop production, increasing outputs of 87 of the leading food crops worldwide, plus many plant-derived medicines. Three out of four crops across the globe producing fruits or seeds for human use as food depend, at least in part, on pollinators*". These data mean that food needs the help of pollinators (Vaissiere et al. 2007). Despite this awareness, pollinators such as bees, bats, butterflies, moths, insects, mice, wasps, tiny mammals and, most significant of all, bees are undergoing a dramatic reduction. Pollution, pesticide abuse, illness and increases in temperature levels are contributing to a reduction in feed and breeding habitats, leading to a drop in the populations of many pollinators. (Kremer et al. 2002).

Pollination, especially crop pollination, is perhaps the best-known ecosystem service performed by insects, involving a number of scholars over time. McGregor (1976) reports that between 15% and 30% of the US diet is the product, either directly or indirectly, of animal-mediated pollination. Although this number is likely to be high, it provides one of the better-published pollinator-dependent food measurements in the US diet. Losey et al. (2006) seek to measure the importance of the crop produced by wild (i.e., unmanaged) native insect pollination. According to the 2004 report of the National Agriculture Statistics Service (NASS, 2004), the US Government keeps records of crop production and, owing to its importance, some attention has been paid to insect pollinators, in particular pollination by managed insects such as European honeybee (*Apis mellifera*).

As said, pollinator populations are declining in many regions, threatening human food supplies and ecosystem functions. Several interactive pressures have an impact on pollinator health, abundance, and diversity. Land use intensification, such as over-urbanization and industrial intensification, has destroyed and fragmented much of the natural habitats that pollinators depend on for forage and nesting resources. In addition, while mass flowering crops can provide food for pollinators, they can affect plant biodiversity, causing changes in insect species and loss of biodiversity in animals as well. Intensive flower cultures also provide a quick, synchronous pulse of floral resources that do not provide enough food particularly for those species with longer periods of operation (Pleasant,1980). The use of systematic pesticides in intensive crop fields will then damage pollinators. Studies have found that there is a reduction in numbers and diversity of bees and butterflies in places where pesticides are used. Furthermore, climate change can change the synchrony between flowering and pollinators flight periods, by changing their diets and habits. Developing and regenerating pollinator populations will reduce the combined impacts of agriculture intensification, climate change, chemicals, and pathogens. The task, during strategic landscaping, would be to formulate sufficient incentives for land managers to communicate with each other to maintain an efficient spatial and temporal network of food and pollinator nests. Landscapers employed in urban areas can include projects to 're-wild' open spaces and encourage wildlife-friendly planting and apiculture to help benefit pollinators (Stelzer et al., 2010). That is why producers, states, scientists, and academics in several fields can work together to find a fundamental solution to the above-mentioned problem and to show that it is possible to get both a monetary and an environmental benefit from the solution to this problem.

4.2 Bees

Estimates do not always take into account the role that native bees may play in crops, that do not normally need insect pollinators to grow fruit, or in crops that could increase their productivity when both native bees and honeybees are visited (Losey et al., 2006). In the former case, tomatoes are self-fertile and only need their flowers to be whipped in the wind to release enough pollen to produce pollination. Furthermore, they have no interest in honeybees and their flowers produce nectar because, in order to expel pollen from the deep pores of their anthers, the flowers must be sonicated (i.e., buzz pollinated), a method in which the bee tightly grasps the flower and quickly burns its flight muscles to vibrate the anthers. Honeybees do not perform this activity and thus do not receive any reward from visiting these plants. Many native bees, such as bumblebees, make these flowers sound, and the subsequent cross-pollination can increase the fruit set by 45% and the fruit weight by four times (Greenleaf and Kremen, 2006). Native bees can also communicate with honeybees in a way that improves the efficiency of the pollination of honeybees. For example, in the production of sunflower hybrid seed, the pollen of the male row of sunflowers must be moved by the bees to the female (male-sterile) row. Growers usually use honeybees to accomplish this task. Most honey-bee workers, however, specialize as either nectar or pollen foragers. Nectar foragers tend to visit mainly female rows, while pollen foragers visit male rows.

4.3 Pollinators and free time activities

The relationship between pollinators and sporting activities is not always perceived as a source of income. There is little evidence of the added value deriving from a varied and diversified population in an area. Among these, it is worth remembering that the 2006 US census found that citizens spend more than $ 60 billion annually on hunting, fishing and wildlife observation. Insects are a critical food source for much of this wildlife, including many birds, fish, and small mammals. Saltwater fish, in contrast to recreational fishing, is the main target of commercial fishing. There are relatively few aquatic insect species, but many fish trapped in coastal systems spend a large part of their life cycle in fresh water, and insects are also essential sources of nutrients during these periods. Insectivore in migratory birds is not as prevalent as in the mainly terrestrial galliform birds referred to above. According to Ehrlich et al. (1988), 43% of migratory bird species are primarily insectivorous. Multiplying the total money spending on migratory bird hunting, around $1.3 billion, by 43% of the species that are primarily insectivorous, places the importance of insects as food for hunted migratory birds at $0.56 billion in hunting costs. Concluding, Losey et al. (2006), estimate the importance of those insect resources to be about $60 billion a year in the United States, which is just a portion of the value of all services rendered by insects. The consequence of this estimate is that an annual commitment of tens of billions of dollars would be warranted in sustaining those services, supplying insects where they are at risk. Indeed, these beneficial insects are under rising pressure from a variety of factors, including habitat loss, invasion of invasive animals, and overuse of toxic chemicals.

In this situation, the measurement is not as accurate due to a range of geographical regions, additives or even seed varieties. In order to carry out a genuinely accurate economic analysis of the role of native insects in crop pollination, Losey et al. (2006) propose that there is a need for a much better accounting of the current levels of pollination of different species of managed bees in crop pollination.

Kevan and Phillips (2001) suggested that there is also a need for researchers to acquire more knowledge of the unique pollination requirements of each crop and cultivar, including the best performing pollinators and the costs and effects of supplying these pollinators. . While much of this information is still missing, the calculation we give here for the value of crops produced as a result of wild native bee pollination is insightful.

5. Concluding remarks

The progressive contraction and deterioration of ecosystems and consequently of ecosystem services worries an important part of world public opinion. Human activities, driven by a constant growth of the world population and by the non-reproducibility of natural resources (water, land, above all) have compromised the natural ecosystems. Goods and services satisfy a need and, therefore, are useful as they increase the degree of satisfaction or well-being. Economic goods and services are useful and, at the same time, scarce. Ecosystems are useful for human survival and represent a declining and scarce resource, because they produce food and use scarce and non-reproducible inputs (land and water). Giving them an economic value is a necessary condition for the spread of eco-sustainable behaviour. The absence of a "price" or an economic value means recognize that a good or a service is neither useful nor limited in quantity and quality. Economic evaluation is needed and differs in the case of public or private goods or services (tangible and intangible. The behaviour of private operators follows the logic of profit maximization, which depends on the price of the product and/or service and on production costs. In the case of public goods and/or services, there is no market price available, but there is no doubt that these have an economic value.

The literature agrees on the importance of attributing a value to ecosystem services, but it is not uniform in defining the methods for their quantification. The market price is the shared method, not so in the attribution of a value especially to intangible ecosystem services. The case of pollinators is emblematic, often cited in the literature because its diffusion involves the production of tangible and intangible goods and services that are not always quantifiable in a univocal way. The implementation of economic evaluation methods allows both to modify the behaviour of economic actors, demonstrating that an enrichment of the environment in which pollinators reproduce more frequently allows obtaining qualitative and quantitative production increases (see the case of honey). This is the case of provisioning services. Moreover, pollinators provide essential services to humans, relationship not fully understood and properly evaluated. We refer, in particular, to the existing gap relating to the contribution of pollinators to the production of crops.

By transferring these concepts to public policies, how can a public payment or any other public policy intervene to change the state of the art? Which of the various measures adopted by the states worldwide has proven to be most effective? In the case of market failure, what is the amount of subsidy to be paid to the farmers to drive them to take measures to strengthen the pollinators? How economically measurable is a benefit that has characteristics essentially aimed at protecting and enhancing the environment? How much and how can other induced services be evaluated (niche tourism, by way of example). These are questions that the literature has asked and to which it has offered answers that are, however, fragmented and distant in time. The European Union, meanwhile, has been promoting for at least two decades agro-climatic-environmental measures (AECM), a sort of support for additional supply of ecosystem services through conditional payments to voluntary suppliers and is preparing to reconfirm them for the next programming period, strengthened by the Green Deal

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