Ecological Economics xxx (2009) xxx–xxx

Contents lists available at ScienceDirect

Ecological Economics

journal homepage: www.elsevier.com/locate/ecolecon

Analysis

The history of ecosystem services in economic theory and practice: From early notions to markets and payment schemes

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ARTICLE INFO

Article history:
Received 14 May 2009
Received in revised form 30 October 2009
Accepted 3 November 2009
Available online xxxx

Keywords:
Economic history
Use value
Exchange value
Ecosystem services
Market based instruments
Commodification

ABSTRACT

This paper reviews the historic development of the conceptualization of ecosystem services and examines critical landmarks in economic theory and practice with regard to the incorporation of ecosystem services into markets and payment schemes. The review presented here suggests that the trend towards monetization and commodification of ecosystem services is partly the result of a slow move from the original economic conception of nature's benefits as use values in Classical economics to their conceptualization in terms of exchange values in Neoclassical economics. The theory and practice of current ecosystem services science are examined in the light of this historical development. From this review, we conclude that the focus on monetary valuation and payment schemes has contributed to attract political support for conservation, but also to commodify a growing number of ecosystem services and to reproduce the Neoclassical economics paradigm and the market logic to tackle environmental problems.

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1. Introduction

The concept of ecosystem services is attracting increased attention as a way to communicate societal dependence on ecological life support systems (Daily, 1997; de Groot et al., 2002).

The origins of the modern history of ecosystem services are to be found in the late 1970s. It starts with the utilitarian framing of beneficial ecosystem functions as services in order to increase public interest in biodiversity conservation (Westman, 1977; Ehrlich and Ehrlich, 1981; de Groot, 1987). It then continues in the 1990s with the mainstreaming of ecosystem services in the literature (Costanza and Daly, 1992; Perrings et al., 1992; Daily, 1997), and with increased interest on methods to estimate their economic value (Costanza et al., 1997). The Millennium Ecosystem Assessment (MA, 2003) contributed much to putting ecosystem services firmly on the policy agenda, and since its release the literature on ecosystem services has grown exponentially (Fisher et al., 2009). At present ecosystem services are increasingly reaching economic decision-making through the widespread promotion of Market Based Instruments for conservation such as Markets for Ecosystem Services (Bayon, 2004) and so-called Payments for Ecosystem Services schemes (Landell-Mills and Porras, 2002; Wunder, 2005; Pagiola and Platais, 2007; Engel et al., 2008; Pagiola, 2008).

In barely three decades a rapidly growing number of ecosystem functions have been characterized as services, valued in monetary terms and, to a lesser extent, incorporated into markets and payment mechanisms. As a part of this process, the use of the ecosystem services concept has transcended the academic arena to reach Governmental policy as well as the non profit, private and financial sectors (Bayon, 2004; EC, 2008). Mainstreaming of ecosystem services, however, has resulted as well in application of the concept in directions that diverge significantly from the original purpose with which the concept was introduced. For example, Peterson et al. (in press) notice a move from the original emphasis on ecosystem services as a pedagogical concept designed to raise public interest for biodiversity conservation, towards increased emphasis on how to cash ecosystem services as commodities on potential markets. In relation to Payments for Ecosystem Services, Redford and Adams (2009) note that such payment schemes are being adopted with great speed, and often without much critical discussion across the spectrum of conservation policy debate, developing a life of its own independent of its promulgators. These observations add to a growing body of literature that has raised questions on how utilitarian framing of ecological concerns and market strategies can modify the way humans perceive and relate to nature in a way that in the long run may be counterproductive for conservation purposes (Rees, 1998; Martínez-Alier, 2002; Robertson, 2004; McCauley, 2006; Soma, 2006; Spash, 2008a; Kosoy and Corbera, this issue).

Growing controversy around ongoing trends in the theory and practice of ecosystem services puts forward a call to analyze the origins

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doi:10.1016/j.ecolecon.2009.11.007

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Table 1

Period	Economic school	Conceptualization of nature	Value–environment relationship
19th C.	Classical economics	Land as production factor generating rent (income)	Labor theory of (exchange) value Nature's benefits as use values
20th C.	Neoclassical economics	Land removed from the production function	Land as substitutable/ producible by capital, and thus monetizable
Since 1960s	Environmental and Resource Economics Ecological Economics	Natural capital substitutable by manufactured capital Natural capital complements manufactured capital	Nature's benefits as monetizable and exchangeable services Controversies on monetization and commodification of nature's benefits

Based on Naredo, 2003; Hubacek and van der Bergh, 2006.

and evolution of the ecosystem services concept. This paper reviews the historic development of the conceptualization of ecosystem services, and examines critical landmarks in economic theory and practice with regard to the incorporation of ecosystem services into markets and payment schemes. The paper is structured in three main parts. Part one reviews the analytical treatment of nature's benefits throughout economic history. Our analysis covers from the Classical economics period to the consolidation of Neoclassical economics and the later emergence of economic sub-disciplines specialized in environmental issues during the second half of the 20th century. Part two proceeds by analyzing the modern history of ecosystem services. We show how theory and practice of ecosystem services since the 1990s have operated primarily within the exchange value framework settled by the Neoclassical economic paradigm. In the light of this historical review, part three discusses critically trends towards monetization and commodification of ecosystem functions taking place as ecosystem-service research unfolds.

2. Long Term Trends in the Economic Analysis of the Environment

Disruptions in the provision of nature's benefits caused by human action were already noticed by observers in ancient civilizations. Some examples are Plato's descriptions on the effects of deforestation on soil erosion and the drying of springs in 400 BC (Daily, 1997, pp. 5–6), and the observance by Pliny the Elder in the first century AD of the links between deforestation, rainfall, and the occurrence of torrents (Andréassian, 2004). Mooney and Ehrlich (1997) point to the publication of Marsh's 1864 book *Man and Nature* as the starting point of the history of modern concern for ecosystem services. Our review goes back even further and examines precursory notions of natural capital and ecosystem services from the Classical economic period to the emergence of the modern ecosystem services research field, identifying critical landmarks and long-term patterns of change (Table 1 and Fig. 1).

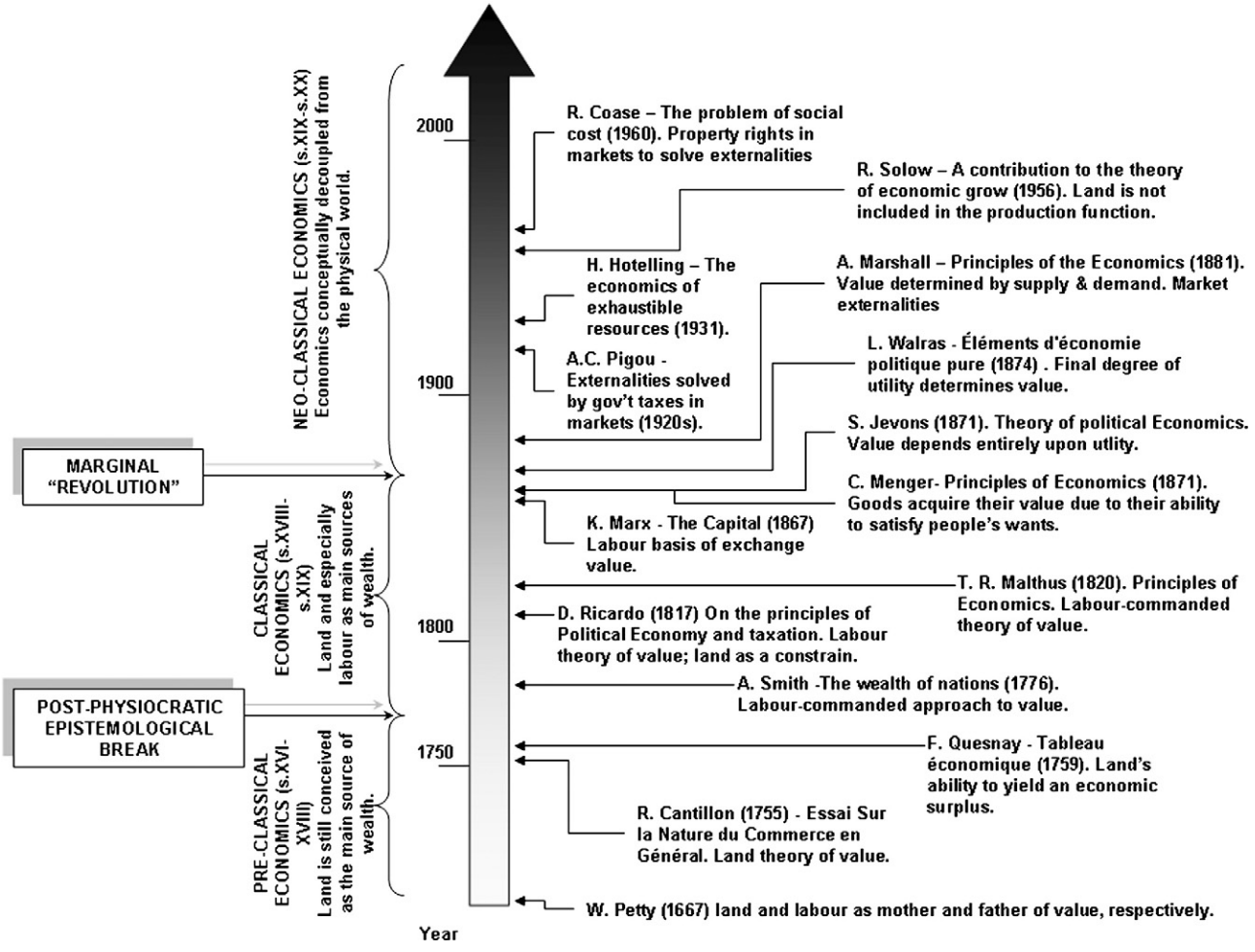

Fig. 1. Landmarks in the evolving conception of nature by economics.

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2.1. Classical Economics: Nature's Benefits as Use Values

Classical economists found natural resources worthy of distinct analytical treatment because the services they offer are free (Crocker, 1999). Besides labor (and later also capital), land remained as a separate factor in the production function. Its consideration as a non-substitutable production input explains to a degree the emphasis of some Classical economists on physical constraints to growth. This is reflected for instance in Ricardo's law on diminishing returns on land, in Malthus' concerns on population growth, and in Mill's forecast that the economy would eventually reach a steady state (Blaug, 1964; Costanza and Daly, 1992; Turner et al., 1994; Naredo, 2003).

Natural capital, in the form of land, which according to Malthus included "the soil, mines, and fisheries of the habitable globe" (Malthus, 1853, p. 9), thus maintained a core position in Classical economic analysis. However, the extent to which Classical economists acknowledged the economic role of nature's intangible benefits is unclear. In this respect, Crocker (1999, p. 33), states that "Other than Mill's brief remarks, no economists of stature deliberated upon the life support and the amenity services that natural environments offer". The present review partly challenges this statement. Since ecology did not yet exist as a discipline[1], the notion of ecosystem services as understood today could not appear in the economic literature of the time, but some Classical economists explicitly recognized the contribution of the "services" rendered by "natural agents" or "natural forces". They did so, however, only in relation to their value in use, while generally denied nature's services to play any role in the conformation of (exchange) value, as they were taken as free, non-appropriable gifts of nature.

In contrast to the Physiocrat belief that land was the primary source of value, Classical economists began to emphasize labor as the major force backing the production of wealth. This turning point in relation to pre-classical economic thinking is clearly reflected in Adam Smith's 1776 *Wealth of Nations*, whose introduction states that the wealth of a particular society is the result of the amount of labor it embodies (Smith (1976), 1909). Smith referred to the timber of the woods, the pastures from rangelands, and the yield of the soil as "natural production". Nevertheless, he did not consider value to stem from nature itself, but from the rent derived from its appropriation.

J. B. Say poses the idea of nature's services as costless, free gifts of nature as follows: "the wind which turns our mills, and even the heat of the sun, work for us; but happily no one has yet been able to say, the wind and the sun are mine, and the service which they render must be paid for" (Say, 1829, p. 250). In line with Say, Ricardo denied that nature's services contributed to the creation of exchange value. Natural agents, Ricardo wrote, "are serviceable to us […] by adding to value in use; but as they perform their work gratuitously, as nothing is paid for the use of the air, of heat, and of water, the assistance which they afford us, adds nothing to value in exchange" (Ricardo (1817), 2001, p. 208).

The work by Marx is rich in ecological hints (for comprehensive reviews see Schmidt, 1971; Bellamy-Foster, 2000). Inspired by Liebig's and Moleschott's analysis of the cycles of plant nutrients, Marx anticipated industrial ecology by a century using the concept of metabolism – *stoffwechsel* – to analyze human–nature interaction (Martínez-Alier, 2005). Marx considered value to emerge from the combination of labor and nature: "Labor is *not the source* of all wealth. *Nature* is just as much the source of use values (and it is surely of such that material wealth consists!) as labor, which itself is only the manifestation of a force of nature" (Marx (1891), 1970, p. 7; see also Marx (1867), 1887, p. 13; Marx (1859), 1989, pp. 22–23). But again, he attributed solely to labor the capacity to produce exchange value (Marx (1867), 1887, pp. 10–11), and consequently saw a waste of time in the "dull and tedious quarrel over the part played by Nature in the formation of exchange-value. Since exchange-value is a definite social manner of expressing the amount of labor bestowed upon an object, Nature has no more to do with it, than it has in fixing the course of exchange" (Marx (1867), 1887, p. 40).

In the 19th century, driving forces such as industrial growth, unprecedented technological development and the acceleration of capital accumulation triggered a series of changes in Classical economic thinking in a direction that progressively led nature to lose the distinct analytical treatment it had previously received. Three critical changes can be highlighted. First, a slow move of the primary focus on land and labor towards the factors labor and capital (Schumpeter, 1954; Daly and Cobb, 1989); second, a move from physical to monetary analysis (Hubacek and van der Bergh, 2006), and third, and most important for the sake of the discussion in this paper, a move in the focus from use values to exchange values (Naredo, 2003). Naredo refers to this set of slow but eventually ground-breaking changes as the "post-Physiocratic epistemological break" (2003, pp. 149 and 248). According to Naredo, this break involved a paradigm shift in economic thinking that would set the stage for the later analytical treatment of nature in terms of exchange values and to the theorization by Neoclassical economics on the substitutability of natural resources with human-made capital. By the fall of the Classical economics period (around 1870), the economic system had thus started its "temporary emancipation from land" (Mayumi, 1991).

2.2. Neoclassical Economics: The Dilution of Nature in Exchange Values

By the fall of the Classical economics period some authors kept paying substantial attention to natural resources in physical terms. For instance, in his 1865 book *The coal question*, Stanley Jevons raised concerns about the depletion of coal stocks. The so-called *Jevons paradox* (recently "rediscovered" as rebound effect) stated that gains in energy efficiency per unit of production could augment total energy consumption. However, as analyzed below, the marginalist revolution, started in the 1870s by authors like Menger, Walras and Jevons would have deep effects in the subsequent economic analysis of nature (Schumpeter, 1954) (Fig. 1).

Since the accomplishment of the marginalist revolution, Neoclassical economics gradually restricted its analysis to the sphere of exchange values. Quite explicitly in this respect, Pigou wrote: "The one obvious instrument of measurement available in social life is money. Hence, the range of our inquiry becomes restricted to that part of social welfare that can be put directly or indirectly into relation with the measuring rod of money" (Pigou (1920), 2006, p. 11). Monetary analysis was soon expanded beyond the limits of markets as a way to tackle economic externalities.

Between the 1910s and the 1930s, authors like Gray, Ramsey, Ise and Hotelling raised concerns on the external effects that resource depletion could have on future generations, and elaborated on the ethical and technical aspects involved in the application of discount rates (reviewed in Martínez-Alier, 1987). However, during the 1930s economist's interest in natural resource questions progressively languished (Crocker, 1999)[2], and the scope of conventional economic analysis became restricted to those goods and services that had been previously valued in monetary terms leaving outside the scope of analysis all those objects of the ecosphere bearing no exchange value (Naredo, 2003) – e.g., non marketed ecosystem services.

In the same period, Neoclassical economic theory started to elaborate on how technological innovation would allow for increased substitutability between production inputs such as land and capital,

[1] The term ecology was coined by the German biologist Ernst Haeckel in 1866. According to Mooney and Ehrlich (1997) the first papers including basic ecological foundations date from works published in the 1880s and 1890s. The concept of ecosystem is first used by Tansley in 1935.

[2] Crocker (1999) mentions as an exception the institutionalist school, which often elaborated on institutions for natural resource management to carry forward their arguments on the importance of norms and social commitments in economic decisions.

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eventually consigning concerns on physical scarcity to oblivion (Georgescu-Roegen, 1975). As stated by Hubacek and van der Bergh (2006, p. 15), "By the second half of the 20th century land or more generally environmental resources, completely disappeared from the production function and the shift from land and other natural inputs to capital and labor alone, and from physical to monetary and more aggregated measures of capital, was completed".

In Solow's contribution to the theory of economic growth (Solow, 1956), land had been removed from the production function under the implicit assumption that nature's input could be substituted by manufactured capital. In the context of the concerns on resource exhaustibility raised by the oil shock, Solow highlighted the self-regulatory capacity of markets, arguing that as a particular resource becomes scarce, rising prices encourage consumers to move to alternative consumption goods (Solow, 1973). Shortly after, Solow stated: "If it is very easy to substitute other factors for natural resources, then there is in principle no "problem." The world can, in effect, get along without natural resources, so exhaustion is just an event, not a catastrophe" (Solow, 1974, p. 11). As stated by Naredo (2003. p. 250): "the problem of [physical] scarcity was reduced to a problem of scarcity of capital, considered as an abstract category that could be expressed in homogeneous monetary units".

2.3. Environmental Economics: Expansion of Monetary Valuation Techniques

With the wave of modern environmentalism in the second half of the 20th century, specialized economic sub-disciplines started to address shortcomings in standard economic science to analyze environmental problems.

The first academic community that specialized in this field gathered around the Society of Environmental and Resource Economics, whose origins lie in the early 1960s (Turner et al., 1994). Broadly put, Environmental and Resource Economics (hereafter Environmental Economics) expands the scope of analysis of orthodox Neoclassical economics by developing methods to value and internalize economic impacts on the environment into decision making – e.g. through extended cost-benefit analysis. The basic argument underlying Environmental Economics can be summarized as follows: pure Neoclassical economics largely neglect the economic contribution of nature by restricting its scope of analysis to those ecosystem goods and services that bear a price. Hence, the systematic undervaluation of the ecological dimension in decision making would be partly explained by the fact that the services provided by natural capital are not adequately quantified in terms comparable with economic services and manufactured capital (Costanza et al., 1997). From this perspective, non marketed ecosystem services are viewed as positive externalities that, if valued in monetary terms, can be more explicitly incorporated in economic decision-making. With the aim to correct alleged market failures, the Environmental Economics literature has developed since the early 1960s a range of methods to value external environmental costs and benefits.

In order to capture a more comprehensive picture of the economic value of the environment, different types of economic value that are neglected by conventional markets are identified. For example, Krutilla's rule in the context of a cost-benefit analysis of dams, gave a high economic present value to the loss of landscape amenities, a service from nature (Krutilla, 1967). Since Krutilla's publication, economic value has generally been divided in use and non-use values, each subsequently disaggregated in different value components that are generally added up to the so-called Total Economic Value (e.g., Heal et al., 2005). For the elicitation of these different value types, a range of monetary valuation techniques have been developed and increasingly refined. Ecosystem-service valuation techniques typically rely on related marketed goods and services as proxies as in the case of the hedonic pricing method (Ridker and Henning, 1967), or on observed consumed behavior (revealed preferences) as in the travel cost methods (Clawson, 1959). In their absence, valuation studies have relied on expected consumer behavior in hypothetical markets simulated through surveys (stated preferences) as in the case of the contingent valuation method. Values from original valuation studies are sometimes applied to other sites through so-called "benefit transfer".

2.4. Ecological Economics: The Substitutability and Value Theory Controversy

A series of theoretical divergences within the society of Environmental and Resource Economics led to a split in the late 1980s. Influenced by the work of systems ecologists and heterodox economists concerned with human–nature interaction (von Bertalanffy, 1968; Georgescu-Roegen, 1971; Odum, 1971; Daly, 1977; Kapp, 1983), the spitted part of the society started to formalize the foundations of what we know today as modern[3] Ecological Economics (reviewed in Røpke, 2004).

How Environmental Economics and Ecological Economics exactly differ remains controversial (Turner, 1999). The two overlap in the use of specific techniques to measure sustainability, evaluate policies and assist decision-making, and in practice many scholars working in ecological economics exploit the tools of neoclassical microeconomics. It is patent, however, that both approaches differ significantly in the qualitative framework within which they operate (Costanza, 1991; Ozkaynak et al., 2002; Gowdy and Erickson, 2005). Environmental Economics operates mainly within the axiomatic framework of Neoclassical economics – e.g., theory of consumer choice, perfect information, and marginal productivity theory of distribution. Ecological Economics challenges some of these assumptions and conceptualizes the economic system as an open subsystem of the ecosphere exchanging energy, materials and waste flows with the social and ecological systems with which it co-evolves (Daly, 1977; Noorgard, 1994). The focus on market-driven efficiency in Neoclassical economics is expanded to the issues of equity and scale in relation to biophysical limits (Daly, 1992), and to the development of methods to account for the physical and social costs involved in economic performance using monetary along with biophysical accounts and other non-monetary valuation languages (Martínez-Alier, 2002).

For the sake of the discussion addressed in this paper there are worth noting two main areas of controversy. The first, often posed as the "strong versus weak sustainability debate", relates to the substitutability of natural capital (Neumayer, 1999). The Brundtland Report released in 1987 provided a broad definition of sustainable development based on an intergenerational equity principle,[4] leaving open the question on how it should be operationalized. In the debate on Neoclassical economic growth models started after the oil shock in the 1970s, Hartwick (1977) and Solow (1986) suggested that intergenerational equity could be achieved by maintaining a non-declining capital stock, which allegedly could be put into practice by investing in manufactured capital all the rents derived from the exploitation of non-renewable natural resources. This so-called "weak sustainability" approach, which assumes substitutability between natural and manufactured capital has been mostly embraced by Neoclassical environmental economists. Ecological Economics have generally advocated the so-called "strong sustainability" approach which maintains that natural capital and manufactured capital are in a relation of complementarity rather than of one of substitutability (Costanza and Daly, 1992). This perspective

[3] Martínez-Alier (1987) situate the origins of Ecological Economics *avant la lettre* in the late 19th century with the works of authors like S. Podolinsky and P. Geddes.

[4] Sustainable development is defined as a "development that meets the needs of the present without compromising the ability of future generations to meet their own needs" (WCED, 1987).

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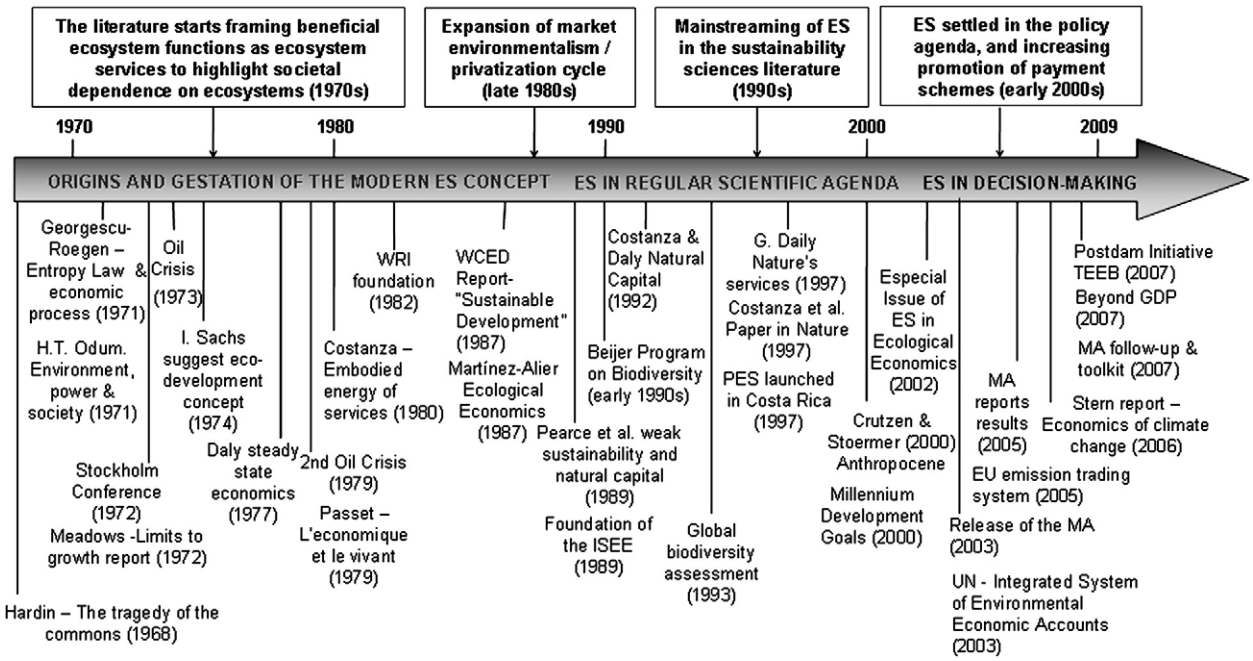

Fig. 2. Stages in the modern history of ecosystem services.

challenges economic growth models where natural resources are absent (Georgescu-Roegen, 1979; Daly, 1996, 1997)[5] on the basis that capital cannot be reproduced without inputs from natural resources: "every material process consists of the transformation of materials (flow elements) by specific agents (fond elements)" (Georgescu-Roegen, 1986, pp. 97–98).

A second area of controversy relates to ecosystem services valuation. Some ecological economists maintain critical standpoints towards cost-benefit analysis on the grounds that environmental decision-making is faced with conflicting valuation languages that may not be commensurable in monetary terms (Martínez-Alier, 2002). Incommensurability, i.e., the idea that different types of value may not be expressed in a common measurement unit (Neurath (1925), 2005; Kapp (1965), 1983; O'Neill, 1993) relies on the philosophical foundation of weak comparability of values (Martínez-Alier et al., 1998). From this perspective, environmental decision making tools reducing ecosystem-service values to a single measuring rod – e.g., extended cost-benefit analysis, tend to be critically appraised and predilection is shown to deliberative and multi-criteria based decision processes (Martínez-Alier, 1987, 2002; Munda, 2004; Spash, 2008b).

3. The New Economics of Ecosystems: From Functions to Services and Commodities

During the last three decades, sustainability sciences have witnessed the underpinning of a utilitarian line of argumentation that stress societal dependence on natural ecosystems, sometimes referred to as ecosystem services science (Armsworth et al., 2007). Herewith, we distinguish three stages in the history of modern ecosystem services science, which cover i) origins and gestation of the concept, ii) mainstreaming, and iii) emergence in markets (Fig. 2).

3.1. Origins and Gestation (1970–1980s)

The concept of ecosystem services, introduced in 1981 (Ehrlich and Ehrlich, 1981) builds on earlier literature highlighting the societal value of nature's functions. In ecology, the term ecosystem function has traditionally been used to refer to the set of ecosystem processes operating within an ecological system (Loreau et al., 2002; Hector et al., 2007), irrespective of whether or not such processes are useful for humans. However, in the late 1960s and 1970s,[6] a series of contributions started referring to the way particular "functions of nature" served human societies (King, 1966; Helliwell, 1969; Hueting, 1970; Odum and Odum, 1972; Braat et al., 1979).

In the 1970s and 1980s, a growing number of authors started to frame ecological concerns in economic terms in order to stress societal dependence on natural ecosystems and raise public interest on biodiversity conservation. Schumacher (1973) was probably the first author that used the concept of natural capital and shortly after several authors started referring to "ecosystem (or ecological, or environmental, or nature's) services". (Westman, 1977; Pimentel, 1980; Ehrlich and Ehrlich, 1981; Thibodeau and Ostro, 1981; Kellert, 1984; de Groot, 1987). The rationale behind the use of the ecosystem-service concept was mainly pedagogic, and it aimed to demonstrate how the disappearance of biodiversity directly affects ecosystem functions that underpin critical services for human well-being.

3.2. Mainstreaming (1990s)

The development of ecosystem services as a serious part of the research agenda was stimulated by the Beijer Institute's Biodiversity Program in the early 1990s (see Perrings et al., 1992; 1995). Research priorities indentified in this program were later addressed in a number of publications that appeared in the following years (e.g., Daily, 1997). The paper by Costanza et al. (1997) on the value of the

[5] Eventually, many scholars abandoned pure standpoints in this controversy to focus the debate on which components of natural capital are substitutable and which are not at a given historical moment, the latter receiving the name of critical natural capital (Brand, 2009).

[6] Isolated contributions had noticed the many ways nature's functions benefit humans several decades earlier. An early example can be found in Polanyi's writings: "The economic function is but one of many vital functions of land. It invests man's life with stability; it is the site of his habitation; it is a condition of his physical safety; it is the landscape" (Polanyi (1944), 1957, p. 178).

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global natural capital and ecosystem services was a milestone in the mainstreaming of ecosystem services. The monetary figures presented resulted in a high impact in both science and policy making, manifested both in terms of criticism and in the further increase in the development and use of monetary valuation studies.

In the late 1990s and early 2000s the concept of ecosystems services slowly found its way into the policy arena, e.g., through the "Ecosystem Approach" (adopted by the UNEP-CBD, 2000) and the Global Biodiversity Assessment (Heywood and Watson, 1995). The MA (MA, 2003) constitutes a critical landmark that firmly placed the ecosystem services concept in the policy agenda (Fig. 2). While emphasizing an anthropocentric approach, the MA framework stressed human dependency not only on ecosystem services, but also on the underlying ecosystem functioning, contributing to make visible the role of biodiversity and ecological processes in human well being. Since the MA, the literature on ecosystem services and international projects working with the concept have multiplied (Fisher et al., 2009). In the last few years several initiatives have framed global environmental problems in economic terms and conducted global cost-benefit analysis. Some relevant examples are the Stern Review on the Economics of Climate Change (Stern, 2006) and the Postdam Initiative – Biological Diversity 2010. The project Economics of Ecosystems and Biodiversity (www.teebweb.org), stemming from this initiative, aims to estimate the costs of ecosystem services-decline from inaction to halt global biodiversity loss (EC, 2008).

3.3. Articulation in Markets (1990s–2000s)

With increasing research on the monetary value of ecosystem services, interest has grown in the design of Market Based Instruments to create economic incentives for conservation (e.g. Daily and Matson, 2008; Jack et al., 2008). Leading instruments within this logic are Markets for Ecosystem Services (hereafter MES) (Bayon, 2004) and Payment for Ecosystem Services (hereafter PES) schemes (Landell-Mills and Porras, 2002; Wunder et al., 2008) (Table 2).

It should be noted that many ecosystem services have been bought and sold in markets for a long time although they were not called "ecosystem services" and the relation was often indirect. Examples are price-based incentives developed as part of agricultural policy in the European Community (to improve environmental quality and biodiversity) and energy taxes which have been applied for decades – although they had not been explicitly linked to carbon sequestration. Also PES like schemes for pollination services and for benign agricultural practices to protect water, soil and biodiversity have been in place for several decades in Europe and the United States (Claassen et al., 2008; Dobbs and Pretty, 2008). However, the formal framing of such Market Based Instruments as PES and MES and their widespread promotion as an integrated conservation tool mainly developed in the last two decades.

Table 2

Mechanism	Commodified ecosystem service	Sites of application	Reference
Markets for Ecosystem Services	Emission trading of greenhouse gases (atmospheric sink functions of CO_2)	European Union	Barker et al., 2001
		United Kingdom	Bayon, 2004
		Chicago	Bayon, 2004
	Sulphur dioxide emission trading (atmospheric sink functions of SO_2)	USA through the US Clean Air Act of 1990	Stavins, 1998
	Wetland mitigation baking	USA	Robertson, 2004
Payment for Ecosystem Services	Watershed protection	Central America	Corbera et al., 2007
		Ecuador	Wunder and Albán, 2008
		Bolivia	Asquith et al., 2008
	Carbon sequestration	Costa Rica	Pagiola, 2008
		Ecuador	Wunder and Albán, 2008
	Habitat conservation / wildlife services	Bolivia	Asquith et al., 2008;
		Zimbawe	Frost and Bond, 2008
	Bio prospecting	Costa Rica	Pagiola, 2008
	Agro environmental measures	European Union	Dobbs and Pretty, 2008
		US	Claassen et al., 2008

In 1990, with the amendment of the Clean Air Act, the United States Congress put limits to sulphur dioxide emissions and issued tradable permits to large scale emitters of SO_2 (Stavins, 1998). Another early experience is the Wetland Mitigation Banking in the US (Robertson, 2004). The Clean Water Act gave the Corps of Engineers the power to issue developers with permits to allow the damage of wetlands in exchange to their commitment to create or restore larger wetlands elsewhere. From the system it turned out that the average cost of wetland mitigation was approximately of $45,000 an acre, putting in practice a market price on preserved wetlands (Bayon, 2004). Carbon markets were born in the 2000s. The United Kingdom Emissions Trading Scheme (ETS) involved some companies in a Climate Change Agreement with the Government. Trading comes in because participants can use emission trading to meet the specific greenhouse gas emissions targets (Bayon, 2004). The Chicago Climate Exchange, launched in 2003 by a private company, created a trading scheme based on voluntary targets. Companies emitting more than their target could buy credits from those that emitted less. The first MES experience at the international scale is probably the EU emission trading system launched in 2005, which established a trading mechanism for the six major greenhouse gases (European Climate Exchange, 2008).

PES schemes have been defined as voluntary and conditional transactions over well-defined ecosystem services between at least one supplier and one user (Wunder, 2005). The basic idea behind these mechanisms is that the beneficiaries of service provision compensate the providers. Ecosystem services included most in market schemes so far include i) carbon sequestration in biomass or soils; ii) provision of habitat for endangered species; iii) protection of landscapes; and iv) various hydrological functions related to the quality, quantity, or timing of freshwater flows from upstream areas to downstream users. Costa Rica pioneered the use of formal PES mechanisms in developed countries by establishing a country-wide program called *Pago por Servicios Ambientales* (PSA) in 1997, which aimed to reverse the severe deforestation rates existing at that time (Pagiola, 2008). In the early 2000s a growing number of PES like mechanisms have spread throughout other Meso-American and South American countries (Corbera et al., 2007; Kosoy et al., 2007; Asquith et al., 2008; Pagiola, 2008; Wunder and Albán, 2008; reviewed in Wunder et al., 2008). For the post Kyoto protocol scenario, cap and trade programs such Reduced Emission from Deforestation and Degradation (REDD) are being discussed as a possible vehicle to articulate international PES schemes.

3.4. Ecosystem Services and the Commodification Process

Analyzed in perspective, the history of ecosystems services research reflects a parallel history of ecosystem function commodification. According to Kosoy and Corbera (this issue) the commodification process covers three main stages: i) framing an ecological function as a service, ii) assigning it a single exchange-value and, iii) linking providers and users of these services in a market exchange. For a number of ecosystem functions this process has been completed in barely three decades (Table 3).[7]

[7] It should be noted that whereas these stages are presented as a temporal sequence, all stages have partly overlapped in time. The indicative dates relates more to the period of mainstreaming than to the starting point of each stage.

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Table 3

Tentative period	Stage	Conceptualization	Action	Value	Influential publications
1960s–1990s	Utilitarian framing	Ecosystem functions as services	Ecosystem functions framed in utilitarian terms	Use value	Daily, 1997 De Groot et al. 2002 MA, 2003
Staring in 1960s, boosts in the 1990s	Monetization	Ecosystem services as valuable/ monetizable	Refinement of methods to value ecosystem services in monetary terms	Exchange value	Costanza et al., 1997 Stern, 2006 EC, 2007
Starting in 1970s, boosts in the 2000s	Appropriation	Ecosystem services as appropriable	Clear definition of ecosystem property rights (e.g. land titling)	Exchange value	Coase, 1960 Hardin, 1968
	Exchange	Ecosystem services as exchangeable	Institutional structures created for sale/exchange (PES and MES)	Exchange value	Wunder, 2005 Engel et al., 2008

The first stage, i.e., utilitarian framing of ecological functions as ecosystem services takes place in the 1970s and 1980s. By this time, a growing number natural scientists started adopting utilitarian arguments in a pragmatic attempt to reach economic decision-making circles (Armsworth et al., 2007). However, at this stage the ecosystem service concept was used mainly as a communication tool, remaining aside from economic processes of valuation, appropriation, and exchange.

A step further was the spreading of monetary valuation techniques. Although monetary valuation of ecosystems had been in use since the 1960s, this type of studies strongly increased in the 1990s as a growing number of natural scientists recognized the appeal that framing ecological concerns in economic terms could have for decision makers. Such valuation studies typically provided figures reflecting the economic importance of ecosystem services or the costs derived from their loss, highlighting how the conversion of natural ecosystems for development purposes could be counterproductive even from a monetary cost-benefit logic (e.g., Balmford et al., 2002).

The third stage in the commodification process correspond to the series of efforts devoted to cash ecosystem services in real markets through the design and implementation of institutional structures for the ecosystem services' appropriation and exchange. Although processes of appropriation of nature have been in place for centuries (Ingold, 1986), appropriation of intangible ecosystem services date mainly from the late 1980s, coinciding with the expansion of neoliberal economics (Smith, 1995; Robertson, 2004; Corbera et al., 2007; Peterson et al., in press; Kosoy and Corbera, this issue). The direct theoretical grounds backing this process are to be found in the literature of the 1960s arguing for the need to establish well-defined – generally private – property rights to facilitate efficient market regulation of environmental issues (Coase, 1960). In his *Tragedy of the commons,* Hardin (1968) warned that resource regimes lacking well-defined property rights were vulnerable to overexploitation. Despite Hardin confounded common property with open access regimes (Vatn, 2005), his famous article had great influence in subsequent environmental policy design. According to Bromley and Cernea (1989, p. 6), Hardin's scheme for natural resource management would become "the dominant paradigm within which social scientists assess natural resource issues". The commodification process is finally completed with the implementation of institutional structures allowing for transactions in market exchanges, as occurred with the establishment of MES and PES schemes.

4. Discussion

In western market economies, economic efficiency-based decision making transcend the pure economic sphere to reach most policy branches, and environmental decisions are often put within the framework of cost benefit-analysis (Salzman and Thompson, 2007). Since conventional cost-benefit analysis is largely blind to the value of ecological life-support systems, it seems logical that a growing number of conservationists have adopted utilitarian arguments to reflect the role that ecosystems play in human well-being (Armsworth et al., 2007). In this view, the concept of ecosystem services was originally conceived by most conservationists merely as a communication tool, and even some economic valuation exercises are to be interpreted in this context, i.e., as a tool to communicate the value of biodiversity and ecosystem functioning using a language that reflects dominant political and economic views. Therefore, several authors have posed the logic of valuation as a pragmatic short-term tool rather than as an end in itself (Daily et al., 2009). Natural scientists are increasingly embracing pragmatic valuation and market-based approaches (Spash, 2008a; Child, 2009). The reason for this is probably the search for short term policy action to halt ecosystem services loss where traditional narratives for conservation have failed to influence economic decision making. Because it fits in with the ideological and institutional economic structures in place, market-based policy design has been in an advantaged position to reach decision-making and to get policy proposals implemented.

However, the framing of ecological concerns in economic terms has involved important qualitative implications (Peterson et al. 2009). The spreading of the ecosystem service concept has in practice set the stage for the perception of ecosystem functions as exchange values that could be subject to monetization and sale (McCauley, 2006; Child, 2009). Hence, a controversial outcome of the economic framing of environmental concerns is the commodification of a growing number of ecosystems functions and the reproduction of market logics in the field of nature conservation (Vatn and Bromley, 1994; Martínez-Alier, 2002; Soma, 2006; Child, 2009; Kosoy et al., 2009–this issue). For instance, in a paper setting the stage for a previous special issue on PES in this journal, Engel et al. (2008), adopt an orthodox Neoclassical approach to provide guidelines for efficient PES design (Muradian et al., this issue). Coasean-based analysis is used to pose the logic of PES as mechanisms to translate non-market values of nature into real economic incentives, emphasizing the economic efficiency advantages of sheer market transactions, well-defined property rights and absence of intermediaries.

Economic values, valuation methods and market schemes are not ideologically neutral. As suggested by Vatn (2005) economic values and valuation processes are culturally constructed, and as such act as value articulating institutions, i.e., "constructed set of rules or typifications". It follows that valuation processes can act as vehicles that articulate particular notions of property and ownership, rationalities, and ways to relate with the environment that are specific to particular societies. In this sense, an important consequence of economic valuation and the establishment of market mechanisms for conservation is the way it may contribute to modify property systems applied to ecosystems. For example, Corbera et al. (2007) suggest that the assumed need of well defined land titling needed for the creation of markets can act as a driver of privatization of common property systems relying on customary rights.

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Regarding the issue of rationalities, institutional structures have the capacity to modify behavioural patterns and motivations (Vatn, 2005). For example, by creating economic incentives for conservation, market-based mechanisms can induce logics of individualism and competition in societies previously structured upon community and reciprocity values. As observed by Vatn (this issue), payments may change the logic from doing what is considered appropriate to start thinking what is individually best to do. Based on a review of empirical data from behavioural experiments, Bowles (2008) suggests that policy design based on economic incentives that signal self-regarding behaviour as an appropriate response can undermine the moral sentiments for conservation. As a consequence, a potential threat of market-based mechanisms relates to potential changes in the logic of conservation from ethical obligation or communal regulation to economic self-interest. If the money payment is perceived not to be large enough to compensate for the opportunity cost of conservation, then market mechanisms like PES might be counterproductive by achieving the opposite effect to that expected. When exporting market mechanisms for the protection of nature to developing countries and non-market societies, international organizations promoting market mechanisms for conservation can consciously or unconsciously contribute to manufacture the *homo economicus* in places where such logic was inexistent, or culturally discouraged by the existing institutional structures.

5. Conclusion

The review presented here on the historic development of the conceptualization of ecosystem services suggests that the trend towards monetization and commodification of ecosystem services is partly the result of a slow move from the original economic conception of nature's benefits as use values in Classical economics to their conceptualization in terms of exchange values in Neoclassical economics. We have argued that that the Neoclassical economic analysis of the environmental has been given continuity with the direction taken by ecosystem services research since the 1990s, characterized by increased efforts on the refinement of monetary valuation methods and research on how to cash ecosystem services on potential markets. Put it differently, we note that most ecosystem-service science is operating basically within the limits of the exchange value framework established after the marginalist revolution by Neoclassical economics for the economic analysis of the environment.

The focus on monetary valuation and market-based policy design has contributed much to mainstream ecosystem services science and attract political support for conservation. From the review, however, we conclude that this has taken place in parallel to a process of commodification of a growing number of ecosystem services, reproducing the market logic to tackle environmental problems, together with its underlying ideology and institutional structures. Finally, we have highlighted that uncertainties remain on which are the potential side effects that may result from mainstreaming of utilitarian market-based rationales for conservation, in terms of both possible changes in the motivational aspects for conservation, as well as in terms of exportation of particular worldviews in the understanding of the human–nature relation.

Acknowledgements

The authors thank Manuel Ruiz-Pérez for his valuable comments on an early draft of this paper. We also thank several anonymous reviewers for their insights on how to improve the original manuscript. This research was partially financed by the Biodiversity Foundation of the Spanish Ministry of the Environment and Rural and Marine Affairs, through the project Millennium Ecosystem Assessment of Spain (Evaluación de Ecosistemas del Milenio de España).

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Please cite this article as: Gómez-Baggethun, E., et al., The history of ecosystem services in economic theory and practice: from early notions to markets and payment schemes, Ecological Economics (2009), doi:10.1016/j.ecolecon.2009.11.007

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Please cite this article as: Gómez-Baggethun, E., et al., The history of ecosystem services in economic theory and practice: from early notions to markets and payment schemes, Ecological Economics (2009), doi:10.1016/j.ecolecon.2009.11.007