

Absolute and Relative Scarcity

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Abstract

Thomas Robert Malthus (1766 – 1834) introduced the notion of absolute scarcity of nature into classic economic thought. He maintained that a population grows faster than the food required to sustain the population, and that will eventually lead to a decline in the population.

In contrast, Mainstream Economics focuses on relative scarcity which defines a good as scarce in relation to other scarce goods. A scarce good carries opportunity costs, which in turn results in a positive price. Goods with no price are not scarce. However, many pollutants have no price, therefore they are not dealt with. In contrast, Ecological Economics focuses its analysis on the damage caused by these pollutants.

We show why the concept of relative scarcity is too narrow to secure the natural basis of life. For example, ground water is irreversibly lost, and climate change causes draught and flooding. In contrast, Ecological Economics is very much aware of the absolute scarcity of natural goods: A good which cannot be substituted with another is absolutely scarce. Ecological Economics focuses its analysis on non-priced goods.

This concept is necessary to recognise that many services provided by the environment become absolutely scarce in the long run, therefore we must take precautionary measures now.

To illustrate our critique, we examine the concept of relative scarcity in the context of the present loss of biodiversity.

Related concepts: HOMO OECONOMICUS & HOMO POLITICUS; RESPONSIBILITY; BASICS OF LIFE; BASICS OF TIME; IRREVERSIBILITY

1. History

The philosopher Aristotle (384/3 – 324/1 B.C.) postulated that the freedom of mankind was necessarily connected to the ability of human beings to understand their natural mean, the right proportion of necessities and desires that allowed them to live together peacefully with other people and nature.

In contrast to this anthropological concept, Mainstream Economics perceives the human being as *homo oeconomicus*, a concept whose roots go back to the political philosopher Thomas Hobbes (1588 – 1779) [see concept HOMO OECONOMICUS & HOMO POLITICUS; Faber et al. 1997, Manstetten 2000, Faber and Manstetten 2007: Chapter 4]. The homo oeconomicus does not have any understanding of a natural proportion of necessities and desires. Instead, the necessities and desires of a homo oeconomicus are postulated as infinite, and his nature is to try to fulfill as many of them as possible. This natural ambition leads to the experience of limits: Whatever the homo oeconomicus acquires or achieves, it will be less than he wishes to acquire or achieve. Nevertheless, the homo oeconomicus feels challenged by these limits. Thanks to technological progress and innovation, modern economies develop an intrinsic dynamic that allows them to go beyond some limits that were formerly known as ‘natural’ ones.

“For the discussion within Ecological Economics, the scarcity concepts of classical political economy have been of importance in particular. Thomas Robert Malthus (1766 – 1834) introduced the notion of a general scarcity of nature into classical economic thought. According to Malthus, natural laws specify that population growth is always substantially faster than the growth in agricultural output, which ‘implies a strong and constantly operating check on population from the difficulty of subsistence’ (Malthus [1798] 1976: 20; see also Becker et al. 2005). More generally, Malthusian scarcity denotes the idea that essential natural resources have a finite physical limit. This implies that, ultimately, there are limits to economic growth. [HISTORY OF THOUGHT] David Ricardo (1817 [1951]) gave a different economic interpretation of the scarcity of nature which refers to the decreasing quality of land: Land as a natural resource is readily available, but only in ever more declining quality.

Over time, the distinction between Malthusian and Ricardian scarcity, which is based on specific properties of natural resources, has lost more and more of its relevance. Mainstream Economics has adopted a more abstract notion of scarcity which does not refer specifically to natural resources anymore but is based more generally on human desires and preferences on the one hand and objective capabilities to fulfill them on the other. For example, Walras (1926 [1954]: 65; quoted after Montani 1987: 253) calls

economic goods scarce if they are ‘capable of satisfying a want’ and do not ‘exist in such quantities that each of us can find at hand enough, completely to satisfy his desires’. This reflects the shift in the research focus of Mainstream Economics which took place roughly in the second half of the nineteenth century, away from humans’ dependency on nature and toward exchange of produced commodities.

With the renewed interest in economy-environment interactions in the second half of the 20th century, there have been several attempts to revitalize the discussion about the economic scarcity concept by referring to classical economic considerations as well as to the natural sciences such as thermodynamics [THERMODYNAMICS] and ecology (Barbier 1989). Pioneering contributions have been made e.g. by Barnett and Morse (1963), Boulding (1966), Georgescu-Roegen (1971), Meadows et al. (1972) and Daly (1977). All of them refer in some sense to the Malthusian concept of a general inescapable scarcity of nature. Following Georgescu-Roegen (1971), the laws of thermodynamics in particular have been regarded as imposing such inescapable scarcity of nature. In this regard Daly (1977: 39) introduces the notion of ‘absolute scarcity’ which he distinguishes from ‘relative scarcity’. The distinction between ‘relative’ and ‘absolute’ scarcity has been taken up by a number of authors (e.g. Faber et al 1983/1990, Barbier 1989, Underwood and King 1989, Barbier et al. 1994, Sahu and Nayak 1994) and has been identified as one feature that distinguishes Mainstream Economics from Ecological Economics (e.g. Underwood and King 1989, Sahu and Nayak 1994): While Mainstream Economics is said to focus on issues of relative scarcity, Ecological Economics is primarily interested in issues of absolute scarcities” (Baumgärtner et al: 2006: 488-489).

Despite the appearance of many limits concerning the satisfaction of needs and wants as temporary ones, whoever deals with economic issues will have to admit the existence of limits that cannot be surpassed. These natural limits are studied by Ecological Economists [BASICS OF LIFE; THERMODYNAMICS; JOINT PRODUCTION; SUSTAINABILITY & JUSTICE]. In this context, a further neglected concept experiencing a renaissance is the notion of moderation [see Section 3.4 Biocoenosis and Faber and Manstetten 2007: Chapter 12].

2. The Concept of Scarcity

The objective of this chapter is to represent the roles of the concept of scarcity in Mainstream Economics on the hand and Ecological Economics and Ecology on the other (Section 2.1). To illustrate these concepts we will show, how it can be applied in order understand the role of biodiversity for ecosystem functioning and human well-being (Section 2.2). Due to the absolute dependence of human beings on the functioning of

nature and the lack of manmade substitutes to the services of nature we discuss the concept of absolute scarcity in Mainstream Economics and in Ecological Economics as well as in Ecology (Section 2.3.) The issue of biodiversity will be presented not only as one of relative scarcity (which would mean to postulate substitutability of natural services), but as one of absolute scarcity (Section 2.4). The relationship between relative and absolute scarcity is discussed in Section 2.5.

2.1 Relative scarcity in Mainstream Economics

Intuitive definition of scarcity

To understand scarcity, it is expedient to begin with a first definition of scarcity in economics: “Whenever goods and services are not available in a quantity that allows fulfilling completely the desires of all consumers, goods and services are, in economic terms, *scarce*.”

This concept is not necessarily connected to the shortage of something specific, it might not even be applicable to every situation of shortage; for in an economic sense, scarcity is applicable to anything that causes costs in order to be acquired. Costs, in this case, can be understood as money, work, stress or even costs of sheer time. Hence, scarcity of a good means: Whoever wants to acquire it needs to abstain from something else. On markets, suppliers and consumers compete in order to acquire scarce goods and services. The degree of a good’s scarcity is reflected in its price. The price expresses the amount that has to be paid in order to receive the scarce good. Every exchange reflects the particular scarcity of each good related to the quantity of the exchanged goods” (Faber and Manstetten 2007: 288f; our translation).

Scarce means of life

“The means acquired as the basis of life for an individual are scarce in relation to the needs and desires that distinguish this life. Hence, a person without needs would not experience scarcity, similarly to persons living their life in a world with an infinite amount of the means of life available” (Faber and Manstetten 2007: 285f; our translation).

In a similar vein Robbins (1932:15) writes: “We have been turned out of Paradise. We have neither eternal life nor unlimited means of gratification. Everywhere we turn, if we choose one thing we must relinquish others which, in different circumstances, we would wish not

to have relinquished. Scarcity of means to satisfy given ends is an almost ubiquitous condition of human behaviour” (Faber and Manstetten 2007: 286; our translation).

“Economic scarcity on a market requires the ability to choose. Only people who are able to choose, thus, free people, can experience the scarcity described by Robbins. Freedom therefore is understood as the possibility to choose between different alternatives. Scarcity shows us, that choosing is always an act of abstinence [HOMO OECONOMICUS & HOMO POLITICUS]. Since our means are scarce and the days of our lifetime are finite, a choice can imply that that which is not chosen might be something never to be chosen again. Hence, every factual satisfaction of one’s needs leads to not satisfying another, also urgent need. Such situations of choice and their analysis are, according to Robbins, the field of economic sciences [Homo Oeconomicus & Homo Politicus]. In his definition, Robbins defines economics as a theory of choice under the conditions of (relative) scarcity” (Faber and Manstetten 2007: 286f, our translation).

Economics as the study of relative scarcity: choice and substitution

“In Mainstream Economics, a means of production or consumption good is said to be *scarce* if it carries opportunity costs (Debreu 1959: 33, Eatwell et al. 1987). In order to obtain one additional unit of the good one must give up something else – some amount of another good or an opportunity to do something – or pay a monetary price. Thus, scarcity is defined in a relative way: A good is scarce in relation to other scarce goods. This definition is, once again, one of *relative scarcity*.

Such a relative notion of scarcity relies on one particular assumption about (a) the objective possibilities of consumption and (b) peoples’ subjective preferences over these options, namely *substitutability* [SUSTAINABILITY & JUSTICE]. First of all, the idea of relative scarcity presupposes the existence of alternative consumption bundles. Usually, there exists a wide spectrum of consumption possibilities which can all be produced from a number of elementary resources. Giving up one particular consumption bundle allows the production of a substitute consumption bundle from these resources if the resources can be used in alternative ways to produce different consumption bundles. Furthermore, the concept of relative scarcity presupposes that peoples’ preferences are characterized by substitutability. Saying that people are willing to give up something else in order to obtain one additional unit of a scarce good rests on the implicit assumption that people consider these two goods to be substitutes. Giving up one unit of good A and receiving in exchange a certain amount of good B will leave them equally well off in terms of utility. Only then does it make sense to say that one is willing to pay for one good by giving up another.

The concept of relative scarcity thus rests on the implicit assumption of substitutability, both on the production side and on the preference side. In economics, it is generally assumed that continuous substitution is always possible, at least on the margin. We shall deal with substitutability in more detail below.

An illustration: scarcity of bread

As an illustration consider the following example. Bread is a scarce good. Nonetheless, all of us have enough bread to eat. Scarcity of bread solely refers to the fact that obtaining bread carries opportunity costs. Obtaining one additional unit of bread implies that we have to give up something else. This is relative scarcity as defined above. Bread is scarce in relation to other goods, for instance other food, CDs, gasoline etc., which are relatively scarce as well. Furthermore, at the margin – and given the current average income level in developed countries – all these goods are substitutes for bread in satisfying preferences. At the same time, it is assumed that with increasing demand for bread it is possible to produce more bread by reallocating resources (flour, labour, electricity etc.) from other sectors of the economy to bread-production.

Based on this understanding of scarcity, Mainstream Economics has addressed environmental and resource issues which have been viewed as problems of relative scarcity with respect to the satisfaction of human needs (Baumgärtner 2005b). According to Fisher (2000), the aspect of scarcity allows one to define the field of environmental and resource economics as a sub-discipline of Mainstream Economics: for environmental and resource economics studies, those areas of optimizing human behavior subject to constraints imposed by the natural world. Examples include the limited stock, concentration and spatial distribution of mineral resources; the natural growth and mutual interaction of biological resources such as populations of different species; the diffusion, transformation and decay of a pollutant in an environmental medium; and so on” (Baumgärtner et al. 2006: 489).

2.2 The study of biodiversity in Mainstream Economics

Mainstream Economics has also addressed the issue of biodiversity loss and conservation. This includes, inter alia, the analysis of

- the measurement of biodiversity (e.g. Weitzman 1992, 1998, Solow et al. 1993, Nehring and Puppe 2002, 2004, see Baumgärtner 2005 for an overview),

- the valuation of biodiversity or individual components thereof (e.g. Randall 1988, Pearce and Moran 1994, Watson et al. 1995, Costanza et al. 1997, Goulder and Kennedy 1997),
- the optimal selection of specific plant genetic traits for the development of pharmaceutical substances (e.g. Polasky and Solow 1995, Simpson et al. 1996, Rausser and Small 2000),
- the use of biodiversity as an insurance of the provision with certain ecosystem services, for instance in agriculture or medicine (e.g. Perrings 1995, Weitzman 2000, Schläpfer et al. 2002, Swanson and Goeschl 2003; [IGNORANCE],
- different use and ownership regimes of biodiversity (e.g. Sedjo and Simpson 1995, Lerch 1998, Swanson and Goeschl 2000b),
- the relationship between biodiversity loss and poverty or, more generally, the distribution of wealth and income (e.g. Munasinghe 1992, Dasgupta 1995, Myers 1995, Swanson and Goeschl 2000a), and
- the design of cost-effective and efficient measures of nature conservation (e.g. Polasky et al. 1993, Solow et al. 1993, Weitzman 1993, Swanson 1994, Metrick and Weitzman 1996, 1998, Wu and Boggess 1999).

All these economic contributions are based on the idea of relative scarcity of biodiversity.

The Mainstream Economic view of the relationship between humans and nature

“Looking at biodiversity from the point of view of relative scarcity, economics features a specific, implicit understanding of humans, nature, and the relationship between them. In the view of economics, both human preferences and real production possibilities, including production by nature, are characterized by substitutability (Turner 1999). The human actor is seen as a rational decision-maker who makes choices based on his own preferences over goods [HOMO OECONOMICUS & HOMO POLITICUS]. Besides consumption goods, this also includes environmental goods and services. Thus, nature is seen as consisting of substitutable and reproducible environmental goods which serve the purpose of satisfying human preferences. The relationship between humans and nature in economics, therefore, appears as a relationship between homo oeconomicus and nature as a collection of goods and services which are, in principle, like any other economic goods and services. Other aspects of the relationship between humans and nature are outside the scope of economics (Becker 2005a)” (Baumgärtner et al. 2006: 490).

2.3 Absolute scarcity in Ecological Economics and ecology

Having dealt with relative scarcity, we now turn to absolute scarcity. “If a certain good is neither substitutable against others on the production side nor on the preference side, a relative notion of scarcity will not capture the scarce nature of this good. As an illustration, consider again the example of bread. As argued above, at the margin and at sufficiently high income levels bread is scarce only in a relative sense.

An illustration of absolute scarcity: a besieged town

Now imagine a besieged town. There is only a limited amount of flour, bread and other food available. This amount cannot be increased. What will happen? Bread and other food will become even scarcer as the siege continues, but the scarcity will be of a different kind than the relative scarcity discussed above. The scarcity of food will be of a fundamentally different kind than the also existent scarcity of CDs or gasoline because at some point in time it can no longer be put into a meaningful relation to other, less essential goods. Firstly, at a certain point – when the entire stock of flour has been depleted – it is not possible to produce more bread by reducing the output of other goods. Second, bread, like other food and water, is essential for survival, while gasoline and CDs are not. Therefore, at a certain level of consumption people are no longer willing to substitute bread with other goods. In such a case, when scarcity concerns a non-substitutable means for the satisfaction of an elementary need and cannot be levied by additional production, one may speak of absolute scarcity. This aspect of absolute scarcity is not within the scope of economics” (Baumgärtner et al. 2006: 490).

Three relations of scarcity: desires and needs, other goods, time and location

Up to now we have given rather broad definitions of scarcity. Now we want to go into more detail. To this end we note that “the economic term of scarcity describes the scarcity of a good within three relationships:

- (i) In relation to the choosing human being, his desires and needs.
- (ii) In relation to all the other goods that could be acquired with one’s income and therefore could be chosen as well.
- (iii) In relation to a certain point in time and a certain location.

A good is always scarce in relation to given needs (with regard to (i)); scarcity is always expressed in quantitative relations to other goods (with regard to (ii)). Considering a certain

good in relation to other goods enables us to choose between these goods. Furthermore, the conditions of scarcity can change depending on time and location (with regard to (iii)). This interrelation makes it necessary to underline the importance of technological progress: Thanks to technological progress, formerly scarce goods can be produced as bulk goods at a later point in time. For all the reasons mentioned above, scarcity in Mainstream Economics has to be understood as *relative scarcity*: Relative scarcity is the precondition that obliges people to choose between different goods.

Whenever the second relation, the relation between the different goods, ceases to exist, then people literally lose their ability to choose. This case is called a situation of *absolute scarcity*. The meaning of absolute scarcity is illustrated in a very figurative way by Robbins (1932:13): ‘The manna which fell from heaven may have been scarce, but, if it was impossible to exchange it for something else or to postpone its use, it was not the subject of any activity with an economic aspect.’ Trapped in the desert, the Israeli people did not have any choice in when manna would fall from heaven. Regarding the availability of food, they faced an absolute scarcity of it: Any kind of food that was available had to be consumed in order to survive” (Faber and Manstetten 2007: 288; our translation).

“The very definition of Mainstream Economics (Robbins 1932: 15), mentioned above, presupposes that scarce means have alternative ends, in other words that there is a possibility of substitution and that there is room for choice. Choice, therefore, is the true object of economic analysis. For this reason, absolute scarcity, which implies that there is no choice, is generally beyond the scope of economic analysis. Problems stemming from the possibility that there is no substitute for essential goods such as bread in a besieged town are typically not considered economic problems.

The example of bread in a besieged town may seem far-fetched and absolute scarcity hardly relevant for standard economic problems, but the idea of absolute scarcity is very relevant for the issue of nature conservation. From ecology it is well known that the extinction of one species can lead to the extinction of another species if the former is an essential resource for the latter and cannot be replaced (Begon et al. 1998, Ricklefs and Miller 1999). Thus, absolute scarcity is an essential characteristic of biological life [BASICS OF LIFE]. The questions are to what extent can humans be reduced to being a purely biological species and how relevant, as a result, is absolute scarcity for humans? In the following, we will discuss the meaning of absolute scarcity for the human being. We will first address non-substitutability on the preference side and then on the production side before we turn to a discussion of absolute scarcity of biodiversity.

Non-substitutability on the preference side: elementary and imaginary goods

In the history of economic thought, a distinction has been made between two classes of human needs which may be called *elementary needs* and *imaginary needs* following Schlosser (1784; cf. Binswanger 1991; see for an extensive analysis Faber and Manstetten: 2010: 135-138). This distinction goes back to the ancient Aristotelian distinction between the *natural economy* and the *artificial economy* (Roscher 1874: 529). This Aristotelian perspective shows up in various forms over time among various scholars; for example, Thoreau ([1854]1998) employs a similar distinction based on whether the satisfaction of needs is 'necessary for life' or not, when discussing man's relation to nature. And even today, the United Nations make a distinction between basic needs and non-basic needs when assessing progress in worldwide poverty alleviation (ILO 1976, Boltvinik 2001).

More specifically, we denote by *elementary needs* everything that is necessary to sustain human life and reproduction, such as eating, drinking, sleeping, shelter, heating and basic health care. They characterize the human existence as that of a biological animal. *Imaginary needs* extend to everything beyond that. If elementary needs are not satisfied, a human cannot survive. In contrast, if imaginary needs remain unsatisfied an individual may feel very much unsatisfied but will still be alive.

In Mainstream Economics it is presupposed that elementary needs can be satisfied and that they are, indeed, satisfied. This follows from the definition of Mainstream Economics as the study of choice among different alternatives. One may justly suppose that, as far as the satisfaction of elementary needs is concerned, there is no free choice. Someone on the verge of starving to death, when offered a choice between one slice of bread and a CD, is not free to make a choice. Such a person will take the slice of bread and not even consider the value of a CD. This means whether one satisfies basic needs or not, given the opportunity to do so or not, is not a matter of choice. Therefore, economics as an academic discipline has confined itself to the study of imaginary needs.

There is a correspondence between the distinction between elementary needs and imaginary needs on the one hand and the distinction between absolute scarcity and relative scarcity on the other. As far as elementary needs are concerned, absolute scarcity may arise since people are usually unwilling to trade off the means for their survival. And as far as imaginary needs are concerned, people will typically hold different goods to be substitutes. In this case, scarcity is a relative one. Since elementary needs refer to the biological condition of human existence, absolute scarcity may be dubbed *objective scarcity* and relative scarcity *subjective scarcity*.

There are other aspects of human being beyond elementary needs which might also be regarded as essential to human life and thus as absolutely scarce. Human life is not fulfilled by mere survival but by striving for aims beyond mere survival. In this regard some fundamental values might be regarded as absolutely scarce. For example, ethical laws in a Kantian sense can be regarded as universally and absolutely valid [RESPONSIBILITY].

As Kant noted in his *Groundwork of the Metaphysics of Morals* (*Grundlegung zur Metaphysik der Sitten*, [1785] 1996: 84): ‘In the kingdom of ends everything has either a price or dignity (German: ‘Würde’). What has a price can be replaced by something else as its equivalent; what on the other hand, is raised above all price and therefore admits of no equivalence has a dignity.’

The same holds for human rights, freedom or and justice [SUSTAINABILITY & JUSTICE]. Such values can be seen as absolutely scarce with regard to a fulfilled human existence. No substitution is conceivable without degrading a human being. In this perspective, ethical categories are not within the scope of economics, but they constitute a form of absolute scarcity which is not within the scope of ecology either.

Non-substitutability on the production side

When we want to know whether a certain bundle of goods and services can be replaced by another bundle, by reallocating resources from one production process to another, we have to make recourse to the objective natural and engineering sciences [JOINT PRODUCTION]. Resource availability and transformation (by production) has to obey the laws of nature [THERMODYNAMICS; IRREVERSIBILITY]. For that reason, geology, ecology, physics, chemistry, mechanical and chemical engineering, etc. tell us about the potential and limits of producing goods and services from primary resources [BASICS OF LIFE].

The natural and engineering sciences provide evidence that the potential for substitution between goods and services by reallocating resources in the economic transformation process is actually limited:

- The laws of thermodynamics [THERMODYNAMICS] specify the *minimal energy and material input required* to produce a certain product (Kondepudi and Prigogine 1998, Bejan 1997).
- Ecology tells us that in using a biological resource as a factor of production, e.g. a stock of fish, cattle, forest or rangeland, the dynamics of the respective ecological system is essentially governed by *different scale effects, discontinuities, thresholds, minimum viable population sizes, limited resilience intervals*, etc. (Begon et al. 1998, Ricklefs and Miller 1999).

- Both thermodynamics and ecology stress the importance of *irreversibility* [IRREVERSIBILITY] in a system's dynamics and evolution [EVOLUTION]. This means, it is not always possible to substitute one production result with another one by just undoing the former and starting anew. An extreme example is species extinction, which cannot be reversed.

From these arguments it becomes obvious that, in as far as production is governed by the laws of nature, the possibilities for substitution between producing alternative consumption bundles are generally limited. In particular, non-substitutability on the production side holds for the goods and services produced directly by nature, as the laws of ecology play a key role here. There are more or less restrictive limits to producing more or less natural goods and services in exchange for the production of manufactured goods and services. Nature provides a lot of factors for agricultural and industrial production, e.g. water, nutrients, sunlight, pollination and mineral as well as fossil resources [BASICS OF LIFE]. While some of these factors may be replaced by manufactured substitutes, this is not possible for all of them in their entire amount. As a consequence, these services of nature are indispensable – at least to a certain extent. Overall, nature has a number of characteristics which are systematically neglected when nature's goods and services are treated as ordinary economic goods, services or production factors" (Baumgärtner et al. 2006: 490-492).

"The research field of Ecological Economics, which 'addresses the relationship between ecosystems and economic system in the broadest sense' (Costanza 1989: 1), aims at incorporating the insights of the natural sciences into the study of the relationship between humans and nature. While Mainstream Economics, just like economics at large, focuses on relative scarcity of environmental goods and services; Ecological Economics, by taking into account the natural sciences, recognizes and emphasizes the relevant absolute scarcities as imposed by the biogeophysical environment (Underwood and King 1989)" (Baumgärtner et al. 2006: 490-492).

2.4 Absolute scarcity in ecology and Ecological Economics: the study of biodiversity

"In the view of Ecological Economists, many environmental goods and services are not only scarce in a relative sense but also in an absolute sense. This is part of the underlying 'vision' of Ecological Economics, where the term vision is used, following Schumpeter (1954: 41), to denote a 'preanalytic cognitive act'. As Herman Daly (1980: 8), one of the founders of Ecological Economics put it: '[N]ature really does impose an inescapable

general scarcity.’ Viewing environmental goods and services as absolutely or relatively scarce thus constitutes a basic difference in vision between Mainstream Economics and Ecological Economics” (Baumgärtner et al. 2006: 490-492).

“Ecologists and ecological economists have stressed that biodiversity has an important value in so far as it is instrumental for ecosystem functioning and ecosystems’ capability of providing essential life-supporting ecosystem services for humankind. In making this claim, the ‘division of labor’ between ecologists and Ecological Economists is the following. Ecology studies biodiversity and its role for ecosystem functioning and evolution in a descriptive way, independent of subjective human valuations. One result of this research is that biodiversity is essential for ecosystem functioning (e.g. Schulze and Mooney 1993, Holling et al. 1995, Kinzig et al. 2001, Loreau et al. 2001, 2002, Hooper et al. 2005) and for the provision of a number of ecosystem services (e.g. Perrings et al. 1995, Daily 1997, Millennium Ecosystem Assessment 2005). We note that these surveys also stress the large extent of uncertainty about the functioning of ecosystems [Ignorance]. Examples for ecosystem services include biomass production, nitrogen fixation, nutrient cycling, control of water runoff, purification of air and water, soil regeneration, pollination of crops and natural vegetation, and partial climate stabilization [BASICS OF LIFE].

Ecological Economists go on to argue that these ecosystem services are essential to support human existence on Earth. Until today, no man-made substitutes are known which could replace these ecosystem services – or even only some – at the scale at which we currently depend on them. Ecological Economists therefore argue that the ultimate value of biodiversity consists in safeguarding ecosystem functioning and the provision of a number of essential life-supporting ecosystem services for humankind (Perrings et al. 1995, Daily 1997, Mooney and Ehrlich 1997)” (Baumgärtner et al. 2006: 492-493).

As discussed in Section 2.3 above, Ecological Economists argue that nature too has a value in itself.

The ecological view of the relationship between humans and nature

“Ecologists, and not a few Ecological Economists, tend to regard humans mainly as a biological species like all others, i.e. the human being is regarded as a homo biologicus (Manstetten et al. 1998). In this view, and in contrast to the economic perspective, an elementary and absolute dependence of human beings on nature and its biodiversity becomes obvious. While humans are, to some extent, different from other animals, for instance in that they have a consciousness and free will, to a considerable extent they are just animals. That is, they are characterized by elementary biological dependencies (e.g. MacIntyre 1999). This insight refers to the perspective of absolute scarcity since it

presupposes that humans have elementary and non-substitutable needs (such as water, food, fresh air) which have to be satisfied for their mere survival (see Faber and Manstetten 2010: 135f). Thus, the relationship between humans and nature in Ecological Economics appears as a relation between homo biologicus and nature as an absolutely scarce entity, essential and necessary for survival. Thereby, Ecological Economics recognizes an aspect of the relationship between humankind and nature which cannot be regarded within economics (Becker 2003: 48-70)” (Baumgärtner et al. 2006: 490-492) [TELEOLOGICAL CONCEPT OF NATURE].

2.5 The relationship between relative and absolute scarcity

Having “introduced a categorical distinction between relative and absolute scarcity in the previous sections, we have to realize that this distinction is not as clear-cut as it seems. It depends on several qualifications and conditions. Whether there exist possibilities of substitution for a certain good or service depends on a number of factors, such as e.g. the time scale, the spatial scale, the institutional setting, the organization of interaction, and the hierarchical levels of analysis of the problem under study.

- *Time scale*: Technical progress may yield new technologies over time which allow the production of substitutes for previously absolutely scarce goods that then become scarce only in a relative sense [BASICS OF TIME]. For example, with progress in cardiac transplantation and the development of an artificial heart, the absolute scarcity of the life-supporting function of the natural heart has been transformed into a relative one. As an example of the reverse, in the besieged town considered above, bread may be relatively scarce at the beginning but may become absolutely scarce as the siege continues.
- *Spatial scale*: A good which is absolutely scarce on a given spatial scale may be relatively scarce on a larger spatial scale. In the example of the besieged town, bread is absolutely scarce only within the town, but it may be relatively scarce when considering the country at large.
- *Institutional settings*: Institutions, such as e.g. markets and mechanisms of (international) trade, which foster interaction and exchange between economic agents introduce or enlarge possibilities of substitution. For example, a subsistence farmer absolutely depends on his own food production. If this person has access to, say, markets for food and labour, he can transform the absolute scarcity of food into a relative one by trading his own labour for food.

- *Organization of interaction:* Interactions and exchange between individuals and the institutions which govern these interactions may be organized in an efficient or an inefficient way. Inefficiency means that resources or consumption goods are wasted, such that individuals and society at large fall short of reaping the maximum benefits from a given resource endowment. If social processes are organized in an inefficient manner, the full potential of substitution is not exhausted, and a certain good may be absolutely scarce which could be relatively scarce if the process were organized in a more efficient manner.
- *Hierarchical level:* An individual's possibilities of substitution are, in general, more limited than societies. As a consequence, what is absolutely scarce for an individual may be relatively scarce for society at large. As an extreme example, individual freedom and survival are non-substitutable for the individual. However, society at large may consider these as substitutable, for instance in times of war when the freedom and survival of military personnel are traded-off against the freedom and survival of other members of society and society at large.

As a consequence, the question of substitutability and the question of relative versus absolute scarcity cannot be answered in a general way, once and for all, but need to be addressed in a particular context. It requires detailed knowledge about ecosystem functioning, technological possibilities for substitution, human preferences, organization of interaction, institutional setting, etc. However, all these aspects are subject to dynamic change: evolution of nature, technology, preferences and institutions over time. These dynamic developments are uncertain and cannot be predicted in detail" (Baumgärtner et al. 2006: 493) [IGNORANCE].

3. Practice

In this Chapter we want to give a summary and present the conclusion of our findings. To this end we first focus on the role of economics in the study of relative and absolute scarcity in biodiversity (Section 3.1). We relate them to the subject of sustainability [SUSTAINABILITY & JUSTICE] since they have important implications for it (Section 3.2). This will show us that relative and absolute scarcity is grounded in a fundamental philosophical difference; hence we will turn to their philosophical dimension which is beyond Mainstream Economics on the one hand and Ecological Economics and ecology at the other (Section 3.3).

3.1 The roles of Mainstream Economics, Ecological Economics and ecology in the study of relative and absolute scarcity of Biodiversity

The merit and deficit of Mainstream Economics

“As we have seen in Section 2.1 above, Mainstream Economics deals with relative scarcity. Thus, Mainstream Economics is useful and important as far as the relative scarcity of biodiversity is concerned. The aspect of relative scarcity becomes apparent when considering the current situation of species extinction. As early as 1995, the *Global Biodiversity Assessment* (Watson et al. 1995: 2) made the following assessment:

‘Because of the world-wide loss or conversion of habitats that has already taken place, tens of thousands of species are already committed to extinction. It is not possible to take preventive action to save all of them.’

If it is true that it is not possible to save *all* species, then we face a problem of choice. We have to decide which species to save and which species to let go extinct. Put this way, biodiversity conservation is clearly an economic problem: how to use limited means, say, a given nature conservation budget, in an optimal way. Mainstream Economics as a discipline provides the methods and tools to solve this problem. Neglecting Mainstream Economics in the discussion of biodiversity conservation runs the risk of addressing this problem in an inefficient way. By suggesting efficient allocation rules and institutional designs, Mainstream Economic analysis can help promote efficient strategies for biodiversity conservation (see Section 2.4). Thus, Mainstream Economics can help to transform, to a certain extent, problems of absolute scarcity into problems of relative scarcity.

However, Mainstream Economics regards the problem of biodiversity loss *merely* under the aspect of relative scarcity. As argued above, the aspect of absolute scarcity cannot be within the scope of Mainstream Economics. Accordingly, Mainstream Economists tend to subsume absolute scarcity under relative scarcity. Typically, in the example of bread in a besieged town (see Section 2.4 above) Mainstream Economists would recommend an increase in the relative price of bread in order to achieve an efficient allocation of bread. As a consequence, demand for bread would drastically decline and everyone who could not afford bread anymore would have to look for substitutes for bread, existing and new ones. The possibility that all inhabitants of the town may starve to death is not a problem amenable to the methods of Mainstream Economics. Yet, as illustrated in Sections 2.4 and

2.5 above, absolute scarcity is an important aspect of biodiversity loss. In order to come to grips with this aspect, one needs a different approach.

The merit of ecology and Ecological Economics

Ecological Economics and ecology provide such an approach in that they stress the essential and non-substitutable role of biodiversity for human survival (see Section 2.4 above). Thus, they recognize one specific aspect of absolute scarcity of biodiversity. Recall from Section 2.1 that there could be further dimensions of absolute scarcity which are not based on biological reason, e.g. an ethical dimension. However, they regard the problem of biodiversity loss predominantly under this aspect of absolute scarcity” (Baumgärtner et al. 2006: 494) and do not give relative scarcity the importance it deserves.

Integrating the two perspectives

“The discussion so far has shown that both the Mainstream Economic perspective and the ecological or Ecological-Economic perspective yield important insights when applied to the scarcity of biodiversity. Each perspective highlights an aspect which the other one does not focus on, such that the two are complementary. As a consequence, a single-discipline approach to the analysis of biodiversity loss and protection is not sufficient, but ecology and economics (Mainstream as well as Ecological Economics) need to be combined for this purpose (Barbier et al. 1994). In a similar vein, Norgaard (1985, 1989, 2004) argues for methodological pluralism in Ecological Economics and discusses different modes of ‘learning and knowing collectively’ in order to better understand complex problems.

However, the integration of the two perspectives – in order to gain a full and comprehensive view of biodiversity and its role for human well-being – is difficult for two reasons:

- As discussed in Section 2.5, it is impossible to clearly distinguish, solely based on the objective knowledge of individual natural and social sciences, whether biodiversity is relatively or absolutely scarce. Therefore, on these grounds it is impossible to clearly assign roles for Mainstream Economics, Ecological Economics and Ecology in the study of biodiversity loss and conservation.
- As discussed in Section 2.3, the distinction between relative and absolute scarcity is essentially grounded in a difference in the underlying philosophical views on humans, nature and their interrelation.

Both of these reasons lead to the conclusion that assessing the roles of Mainstream Economics, Ecological Economics and ecology for biodiversity conservation is not possible merely on the level of Mainstream Economics, Ecological Economics or ecology. It requires

transcending the natural and social sciences and explicitly entering into a philosophical discussion” (Baumgärtner et al. 2006: 494).

3.2 Scarcity and sustainability

“Our discussion of the distinction between relative and absolute scarcity has immediate implications for the distinction between what has been called in the literature ‘weak’ and ‘strong’ sustainability (e.g. Neumayer 2003, Pearce and Barbier 2000: Chap. 2; [JUSTICE & SUSTAINABILITY]). In a sense, the two distinctions correspond to each other. While weak sustainability calls for the maintenance of the aggregate (i.e. natural plus human-made) stock of capital, strong sustainability calls for the separate maintenance of natural capital stock and human-made capital stock. The rationale between this distinction lies in different assumptions about the substitutability between natural and human-made capital: weak sustainability assumes that human-made capital is a perfect substitute for natural capital, i.e. natural capital is scarce only in a relative sense, while strong sustainability assumes that natural capital is essential and cannot be substituted by human-made capital, i.e. it is absolutely scarce (Barbier et al. 1994: 51-56).

With this correspondence in mind, our discussion has the following implication for the discussion of sustainability. As summarized in Section 4.1 above, the distinction between relative and absolute scarcity is essentially grounded in a fundamental philosophical difference and is therefore impossible to make solely on objective grounds. This carries over to the distinction between weak and strong sustainability. Whether sustainability should be weak or strong cannot be decided solely on objective grounds but ultimately depends on the philosophical view of humans, nature, and their interrelation” (Baumgärtner et al. 2006: 494-495).

3.3 Beyond Mainstream Economics and ecology: the philosophical dimension

Discussion of our images of humankind and nature

“In the end, a comprehensive discussion about biodiversity loss and protection comes down to a discussion of our images of humankind and nature, as well as their interrelationship. Mainstream Economics, Ecological Economics and Ecology provide us

with one particular dimension of this image. In Mainstream Economics, the relationship between humans and nature appears as a relationship between *homo oeconomicus* [HOMO OECONOMICUS & HOMO POLITICUS] and nature as a diverse bundle of substitutable consumption goods and production factors which are not essentially different from manufactured goods and factors. In ecology, this relation appears as a relationship between *homo biologicus* (i.e. man as purely biological being; Manstetten et al 1998) and nature as an entity which is essential and necessary for his survival. Mainstream Economics, Ecological Economics and Ecology address important dimensions of the human being and its relation to nature: The human being obviously shows both essential dimensions – *homo oeconomicus* and *homo biologicus* – and nature is both a set of objects that are subject to rational choice as well as an entity that is essential for human survival.

Discussion of the two perspectives is not sufficient

However, it is not sufficient to just consider these two perspectives. Even taken together, the perspective of Mainstream Economics, Ecological Economic and ecology do not give a full and comprehensive picture of the interrelation between humans and nature. Additional dimensions exist of the human being and its relation to nature (Becker and Manstetten 2004, Becker 2006). The difficult question regarding the meaning of nature for humankind beyond her economic function and beyond her necessity for biological survival cannot be fully discussed within economics or ecology. Human life is more than biological survival and rational economic choice. It also defines and fulfils itself essentially in an ethical dimension, for example, in the scope of what has been called a 'good life' (e.g. Aristotle 1925). In this sense, the relationship between humans and nature also has an ethical dimension which can only be discussed in philosophical terms (e.g. Sandler and Cafaro 2005, Spaemann 1989).

A plurality of perspectives

In order to fully cope with the complexity and multifariousness of the biodiversity issue, one needs to consider all of these dimensions. In other words, one needs a plurality of perspectives rather than a simple reduction to *the* appropriate perspective. Assessing the roles of economics and ecology for biodiversity conservation ultimately requires embedding the view of Mainstream Economics, Ecological Economics and ecology on humankind and nature into an encompassing philosophical understanding of the relationship between humans and nature. This should allow for an integrated view of the human being which solves the possible tension between the different human dimensions (Söderbaum 1999) and determines the meaning of each one as well as their relation. The

same holds for the different views of nature and for the relation of the human being with nature.

Conclusion: a philosophical approach is required

In conclusion, a philosophical approach can achieve at least four tasks:

- (i) clarify the preconditions, potential and limits of Mainstream Economics, Ecological Economics and ecology for the analysis of biodiversity protection;
- (ii) identify the dimensions of the problem that are beyond the scope of these two disciplines;
- (iii) formulate and analyse the ethical dimension of the problem;
- (iv) provide a philosophical framework in which the different underlying perspectives of disciplines such as Mainstream Economics, Ecological Economics, ecology and ethics [RESPONSIBILITY], as well as their relation can be identified and integrated. We note that this task is pursued in particular by Ecological Economics.

Biodiversity loss and conservation is a complex and multifarious problem. A large number of fruitful contributions have already been made to the analysis and solving of this problem by a large number of different academic disciplines. What is on the agenda now is an interdisciplinary integration along the lines of (i) through (iv). This goes beyond biodiversity research in the traditional, disciplinary sense and shows the need for a philosophy of science that deals with the foundations of interdisciplinary research” (Baumgärtner et al. 2006: 495).

4. Literature

The content of MINE originates from scientific work published in books and peer-reviewed journals. Quotes are indicated by a special typographic style.

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4.1 Recommended literature

Key literature

Baumgärtner, S., Becker, C., Faber, M., Manstetten, R. (2006) "Relative and absolute scarcity of nature. Assessing the roles of economics and ecology for biodiversity conservation." *Ecological Economics* 59: 487-498. [The concept RELATIVE & ABSOLUTE SCARCITY is mainly based on this paper.]

Daoud, Adel (2018) 'Unifying Studies of Scarcity, Abundance, and Sufficiency', *Ecological Economics* 147: 20-217. [Pioneering paper on scarcity, abundance and sufficiency. It is comprehensive concerning the literature and groundbreaking in its content.]

4.2 References

Scarcity

Barnett, H.J. and C. Morse (1963), *Scarcity and Growth. The Economics of Natural Resource Availability*, Baltimore: Johns Hopkins Press.

Barbier, E.B. (1989), *Economics, Natural Resource Scarcity and Development. Conventional and Alternative Views*, London: Earthscan.

Baumgärtner, S., Becker, C., Faber, M., Manstetten, R. (2006) “Relative and absolute scarcity of nature. Assessing the roles of economics and ecology for biodiversity conservation.” *Ecological Economics* 59: 487-498. [The concept RELATIVE & ABSOLUTE SCARCITY is mainly based on this paper.]

Daoud, A. (2018) Unifying Studies of Scarcity, Abundance, and Sufficiency’, *Ecological Economics* 147: 20-217. [Pioneering paper on scarcity, abundance and sufficiency. It is comprehensive concerning the literature and groundbreaking in its content. The author develops new and promising perspectives for further research.]

Faber, M., H. Niemes, and G. Stephan (1983/1987) *Entropie, Umweltschutz und Rohstoffverbrauch. Eine naturwissenschaftlich-ökonomische Untersuchung*; translated into English by Ingo Pellengahr. *Resources. An Essay in Physico-Economics*. Springer Verlag, Heidelberg etc. (translated into Chinese 1990; ISBN Y 80555-344-0/X.1.) [This book views absolute scarcity from an ecological economic and thermodynamic perspective.]

Faber, M., R. Manstetten (2007), *Was ist Wirtschaft? Von der Politischen Ökonomie zur Ökologischen Ökonomie*. Freiburg/München. [See in particular Chapter 12 which not only analyses scarcity in detail but also its relationship to the concept of moderation.]

Mankiw N.G. (2000), *Principles of Economics*, second ed., Harcourt Brace.

Manstetten, R. (2000) *Das Menschenbild der Ökonomie. Der homo oeconomicus und die Anthropologie von Adam Smith*, Alber, Freiburg, München.

Montani, G. (1987), Scarcity, in J. Eatwell, M. Milgate and P. Newman (eds.), *The New Palgrave. A Dictionary of Economics*, Vol. 4, Houndsmill and New York: Palgrave.

Robbins, L. (1932) *On the Nature and Significance of Economic Science*. London.

Schumpeter, J.A. (1954), *History of Economic Analysis*, New York: Oxford University Press.

Smith, V.K. (1979), *Scarcity and Growth Reconsidered*, Baltimore and London: Johns Hopkins University Press.

Mainstream Economics

Boltvinik, J. (2001), *Poverty measurement methods – an overview*, United Nations Development Programme (UNDP) Poverty Reduction Series Working Paper No. 3, available from: www.undp.org/poverty/publications/pov_red/.

Dasgupta, P. (1995), Population, poverty, and the local environment, *Scientific American*, 272(2), pp. 40ff.

Debreu, G. (1959), *Theory of Value. An Axiomatic Analysis of Economic Equilibrium*, New York: Wiley.

Eatwell, J., M. Milgate and R. Newman (eds.) (1987), *The New Palgrave. A Dictionary of Economics*, 4 vols, London: Maxmillan.

Fisher, A.C. (2000), Introduction to special issue on irreversibility, *Resource and Energy Economics*, 22, 189-196.

[ILO] International Labour Office (1976), *Employment, Growth and Basic Needs: A One-World Problem. Report of the Director-General of the International Labour Office*, Geneva.

Malthus, T.R. ([1798]1976), *An Essay on the Principle of Population*, ed. by P. Appleman New York and London: W.W. Norton and Company.

Mankiw, N.G. (2000), *Principles of Economics*, second ed., Harcourt Brace.

MasColell, A., M.D. Whinston and J.R. Green (1995), *Microeconomic Theory*, New York: Oxford University Press.

Polasky, S. and A. Solow (1995), On the value of a collection of species, *Journal of Environmental Economics and Management*, 29, 298-181.

Polasky, S., A. Solow and J. Broadus (1993), Searching for uncertain benefits and the conservation of biological diversity, *Environmental and Resource Economics*, 3, 171-181.

Ricardo, D. (1817[1951]), *On the Principles of Political Economy and Taxation*, ed. by P. Sraffa, Cambridge: Cambridge University Press.

Robbins, L. (1932), *An Essay on the Nature and Significance of Economic Science*, London: Macmillan.

Roscher, W. (1874), *Geschichte der National-Ökonomik in Deutschland*, München.

Schläpfer, F., M. Tucker and I. Seidl (2002), Returns from hay cultivation in fertilized low diversity and non-fertilized high diversity grassland, *Environmental and Resource Economics*, 21, 89-100.

Walras, L. (1926[1954]), *Elements of Pure Economics, or the theory of social wealth*, transl. by W. Jaffe, London, George Allen & Unwin.

Ecological Economics

- Baumgärtner, S. (2000), *Ambivalent Joint Production and the Natural Environment. An Economic and Thermodynamic Analysis*, Heidelberg and New York: Physica.
- Bejan, A. (1997), *Advanced Engineering Thermodynamics*, second ed., New York: Wiley.
- Boulding, K.E. (1966), *The economics of the coming spaceship Earth*, in H. Jarrett (ed.), *Environmental Quality in a Growing World*, Baltimore and London: Johns Hopkins University Press, pp. 3-14.
- Costanza, R. (1989), *What is Ecological Economics?* *Ecological Economics*, 1, 1-7.
- Costanza, R., R. d'Arge, R. de Groot, S. Farber, W. Grasso, B. Hannon, K. Limburg, S. Naeem, R.V. O'Neill, J. Paruelo, R.G. Raskin, P. Sutton and M. van den Belt (1997), *The value of the world's ecosystem services and natural capital*, *Nature*, 387, 253-260.
- Daily, G.C. (ed.) (1997), *Nature's Services. Societal Dependence on Natural Ecosystems*, Washington DC: Island Press.
- Daly, H.E. (1977): *Steady-state Economics*, San Francisco: W.H. Freeman and Company.
- Daly, H.E. (ed.) (1980), *Economics, Ecology, Ethics. Essays Toward a Steady-State Economy*, San Francisco: W.H. Freeman.
- Daly, H.E. (1990), *Toward some operational principles of sustainable development*, *Ecological Economics*, 2, 1-6.
- Ehrlich, P.R. and A.H. Ehrlich (1981), *Extinction: The Causes and Consequences of the Disappearance of Species*, New York: Random House.
- Faber, M., R. Manstetten and J. Proops (1996), *Ecological Economics. Concepts and Methods*, Cheltenham, UK and Northampton, MA, USA: Edward Elgar.
- Fisher, A.C. (2000), *Introduction to special issue on irreversibility*, *Resource and Energy Economics*, 22, 189-196.
- Kondepudi, D. and I. Prigogine (1998), *Modern Thermodynamics: From Heat Engines to Dissipative Structures*, New York: Wiley.
- Meadows, D.H., D.L. Meadows, J. Randers and W.W. Behrens (1972), *The Limits to Growth*, New York: Universe.
- Mooney, H.A. and P.R. Ehrlich (1997), *Ecosystem services: a fragmentary history*, in: G.C. Daily (ed.), *Nature's Services. Societal Dependence on Natural Ecosystems*, Washington DC: Island Press, pp. 11-19.

- Neumayer, E. (2003), *Weak Versus Strong Sustainability. Exploring the Limits of Two Opposing Paradigms*, Cheltenham, UK: Edward Elgar.
- Norgaard, R.B. (1985), Environmental economics: an evolutionary critique and a plea for pluralism, *Journal of Environmental Economics and Management*, 12, 382-394.
- Norgaard, R.B. (1989), The case for methodological pluralism, *Ecological Economics*, 1, 37-47.
- Norgaard, R.B. (1990), Economic indicators of resource scarcity: A critical essay, *Journal of Environmental Economics and Management*, 19(1), 19-25.
- Norgaard, R.B. (2004), Learning and knowing collectively, *Ecological Economics*, 49, 231-241.
- Norton, B.G. (1991), *Toward Unity Among Environmentalists*, New York: Oxford University Press.
- Norton, B.G. and M. Ruse (eds.) (2002), *Searching for Sustainability: Interdisciplinary Essays in the Philosophy of Conservation Biology*, New York: Cambridge University Press.
- Pearce, D.W. and E.B. Barbier (2000), *Blueprint for a Sustainable Economy*, London: Earthscan.
- Sayak, N.C. and B. Nayak (1994), Niche diversification in environmental/ecological economics, *Ecological Economics*, 11, 9-19.
- Schefold, B. (2001), Ökonomische Bewertung der Natur aus dogmengeschichtlicher Perspektive – eine Skizze, in F. Beckenbach et al. (eds.), *Jahrbuch Ökologische Ökonomik*, Bd. 2: Ökonomische Naturbewertung, Marburg: Metropolis, pp. 17-61.
- Schiller, J. (2002), *Umweltprobleme und Zeit. Bestände als konzeptionelle Grundlage ökologischer Ökonomik*, Marburg: Metropolis.
- Söderbaum, P. (1999), Values, ideology and politics in ecological economics, *Ecological Economics*, 28, 161-170.
- Underwood, D.A. and P.G. King (1989), On the ideological foundations of environmental policy, *Ecological Economics*, 1, 325-334.

Ecology

- Begon, M., C.R. Townsend and J.L. Harper (1998), *Ecology: Individuals, Populations and Communities*, third ed., Oxford: Blackwell.

Ricklefs, R.E. and G.L. Miller (1999), *Ecology*, fourth ed., San Francisco: W.H. Freeman.

Biodiversity

Barbier, E.B., J.C. Burgess and C. Folke (1994), *Paradise Lost? The Ecological Economics of Biodiversity*, London: Earthscan.

Baumgärtner, S. (2005a), *Measuring the diversity of what? And for what purpose? A conceptual comparison of ecological and economic biodiversity indices*, Mimeo, University of Heidelberg.

Baumgärtner, S. (2005b), *Natural Science Constraints in Environmental and Resource Economics. Problem and Method*, Habilitation Thesis, Faculty of Economics and Social Studies, University of Heidelberg.

Brown J.H. et al. (2001), *Complex species interactions and the dynamics of ecological systems: long-term experiments*, *Science*, 293 (27 July 2001), 643-650.

[CBD] *Convention on Biological Diversity*, United Nations Conference on Environment and Development, Rio de Janeiro, Brazil, 1992.

Daily, G.C. (ed.) (1997), *Nature's Services. Societal Dependence on Natural Ecosystems*, Washington DC: Island Press.

Holling, C.S., D.W. Schindler, B.W. Walker and J. Roughgarden (1995), *Biodiversity in the functioning of ecosystems: an ecological synthesis*, in C. Perrings, K.-G. Mäler, C. Folke, C.S. Holling and B.-O. Jansson (eds.), *Biodiversity Loss. Economic and Ecological Issues*, Cambridge: Cambridge University Press, pp. 44-83.

Kinzig, A.P., S.W. Pacala and D. Tilman (eds.) (2001), *The Functional Consequences of Biodiversity. Empirical Progress and Theoretical Extensions*, Princeton: Princeton University Press.

Loreau, M., S. Naeem, J. Bengtsson, J.P. Grime, A. Hector, D.U. Hooper, M.A. Huston, D. Raffaelli, B. Schmid, D. Tilman and D.A. Wardle (2001), *Biodiversity and ecosystem functioning: current knowledge and future challenges*, *Science*, 294 (26 October 2001), 804-808.

Loreau, M., S. Naeem and P. Ichausti (eds.) (2002), *Biodiversity and Ecosystem Functioning. Synthesis and Perspectives*, Oxford: Oxford University Press.

Perrings, C., K.-G. Mäler, C. Folke, C.S. Holling and B.-O. Jansson (1995), *Framing the problem of biodiversity loss*, in C. Perrings, K.-G. Mäler, C. Folke, C.S. Holling and B.-O.

- Jansson (eds.), *Biodiversity Loss. Economic and Ecological Issues*, Cambridge: Cambridge University Press, pp. 1-17.
- Schulze, E.-D. and H.A. Mooney (eds.) (1994), *Biodiversity and Ecosystem Functioning*, Berlin: Springer
- Tilman, D. (1997), Biodiversity and ecosystem functioning, in G.C. Daily (ed.), *Nature's Services. Societal Dependence on Natural Ecosystems*, Washington DC: Island Press, pp. 93-112.
- Kenzie, A.P., S.W. Pascale and D. Tilman (eds.) (2001), *the Functional Consequences of Biodiversity. Empirical Progress and Theoretical Extensions*, Princeton: Princeton University Press.
- Larch, A. (1998), Property rights and biodiversity, *European Journal of Law and Economics*, 6, 285-304.
- Loreau, M., S. Naeem, J. Bengtsson, J.P. Grime, A. Hector, D.U. Hooper, M.A. Huston, D. Raffaelli, B. Schmid, D. Tilman and D.A. Wardle (2001), Biodiversity and ecosystem functioning: current knowledge and future challenges, *Science*, 294, 804-808.
- Loreau, M., S. Naeem and P. Inchausti (eds.) (2002), *Biodiversity and Ecosystem Functioning. Synthesis and Perspectives*, Oxford: Oxford University Press.
- Metrick, A. and M.L. Weitzman (1996), Patterns of behavior in endangered species preservation, *Land Economics*, 72(1), 1-16.
- Metrick, A. and M.L. Weitzman (1998), Conflicts and choices in biodiversity preservation, *Journal of Economic Perspectives*, 12(3), 21-34.
- Millennium Ecosystem Assessment (2005), *Ecosystems and Human Well-Being: Synthesis Report*, Washington DC: Island Press.
- Munasinghe, M. (1992), Biodiversity protection policy: Environmental valuation and distribution issues, *Ambio*, 21, 227-236.
- Myers, N. (1995), Tropical deforestation: population, poverty and biodiversity, in T.M. Swanson (ed.), *The Economics and Ecology of Biodiversity Decline. The Forces Driving Global Change*, Cambridge: Cambridge University Press, pp. 111-122.
- Nehring, K. and C. Puppe (2002), A theory of diversity, *Econometrica*, 70, 1155-1198.
- Nehring, K. and C. Puppe (2004), Modelling phylogenetic diversity, *Resource and Energy Economics*, 26, 205-235.
- Pearce, D.W. and D. Moran (1994), *The Economic Value of Biodiversity*, London: Earthscan.

- Perrings, C. (1995), Biodiversity conservation as insurance, in T.M. Swanson (ed.), *The Economics and Ecology of Biodiversity Decline. The Forces Driving Global Change*, Cambridge: Cambridge University Press, pp. 69-77.
- Perrings, C., K.-G. Mäler, C. Folke, C.S. Holling and B.-O. Jansson (1995), Framing the problem of biodiversity loss, in C. Perrings, K.-G. Mäler, C. Folke, C.S. Holling and B.-O. Jansson (eds), *Biodiversity Loss. Economic and Ecological Issues*, Cambridge: Cambridge University Press, pp. 1-17.
- Proops, J. (1989), Ecological economics: rationale and problem areas, *Ecological Economics*, 1, 59-76.
- Randall, A. (1988), What mainstream economists have to say about the value of biodiversity, in E.O. Wilson (ed.), *BioDiversity*, Washington DC: National Academy Press, pp. 217-223.
- Rausser, G.C. and A.A. Small (2000), Valuing research leads: bioprospecting and the conservation of genetic resources, *Journal of Political Economy*, 108, 173-206.
- Schulze, E.-D. and H.A. Mooney (eds.) (1993), *Biodiversity and Ecosystem Functioning*, Berlin: Springer.
- Sedjo, R.A. and R.D. Simpson (1995), Property rights, externalities and biodiversity, in T.M. Swanson (ed.), *The Economics and Ecology of Biodiversity Decline. The Forces Driving Global Change*, Cambridge: Cambridge University Press, pp. 79-88.
- Simpson, R.D., R.A. Sedjo and J.W. Reid (1996), Valuing biodiversity for use in pharmaceutical research, *Journal of Political Economy*, 104, 163-185.
- Solow, A., S. Polasky and J. Broadus (1993), On the measurement of biological diversity, *Journal of Environmental Economics and Management*, 24, 60-68.
- Soulé, M.E. (ed.) (1986), *Conservation Biology: The Science of Scarcity and Diversity*, Sunderland, MA: Sinauer.
- Swanson, T.M. (1994), *The International Regulation of Extinction*, London: Macmillan.
- Swanson, T.M. (ed.) (1995), *The Economics and Ecology of Biodiversity Decline. The Forces Driving Global Change*, Cambridge: Cambridge University Press.
- Swanson, T.M. and T. Goeschl (2000a), Genetic use restriction technologies and the diffusion of yield gains to developing countries, *Journal of International Development*, 12(8), 1159-1178.

Swanson, T.M. and T. Goeschl (2000b), Property rights issues involving plant genetic resources: implications of ownership for economic efficiency, *Ecological Economics*, 32, 75-92.

Swanson, T.M. and T. Goeschl (2003), Pests, plagues, and patents, *Journal of the European Economic Association*, 1(2-3), 561-575.

Walras, L. (1926[1954]), *Elements of Pure Economics, or the Theory of Social Wealth*, transl. by W. Jaffé, London: George Allen & Unwin.

Watson, R.T., V.H. Heywood, I. Baste, B. Dias, R. Gámez, T. Janetos, W. Reid and G. Ruark (eds) (1995), *Global Biodiversity Assessment. Summary for Policy-Makers* (published for the United Nations Environment Programme), Cambridge: Cambridge University Press.

Weitzman, M.L. (1992), On diversity, *Quarterly Journal of Economics*, 107, 363-405.

Weitzman, M.L. (1993), What to preserve? An application of diversity theory to crane conservation, *Quarterly Journal of Economics*, 108, 157-183.

Weitzman, M.L. (1998), The Noah's ark problem, *Econometrica*, 66, 1279-1298.

Weitzman, M.L. (2000), Economic profitability versus ecological entropy, *Quarterly Journal of Economics*, 115, 237-263.

Wilson, E.O. (ed.) (1988), *BioDiversity*, Washington DC: National Academy Press.

Wu, J. and W.G. Boggess (1999), The optimal allocation of conservation funds, *Journal of Environmental Economics and Management*, 38, 302-321.

Philosophy and literature

Aristotle (1925), *The Nicomachean Ethics* (transl. by D. Ross), Oxford: Oxford University Press.

Baumgärtner, S. and C. Becker (eds.) (2005), *Wissenschaftsphilosophie interdisziplinärer Umweltforschung*, Marburg: Metropolis.

Becker, C. (2003), *Ökonomie und Natur in der Romantik. Das Denken von Novalis, Wordsworth und Thoreau als Grundlegung der Ökologischen Ökonomik*, Marburg: Metropolis.

Becker, C. (2005a), Wie Ökonomen über Natur denken, in: *Jahrbuch Ökologie 2006*, ed. by G.

- Becker, C. (2006), "The human actor in ecological economics. Philosophical approach and research perspectives," *Ecological Economics* 16: 17-23.
- Becker, C. and R. Manstetten (2004), Nature as a You: Novalis' philosophical thought and the modern ecological crisis, *Environmental Values*, 13, 101-118.
- Becker, C.; M. Faber; K. Hertel and R. Manstetten (2005), Malthus vs. Wordsworth: Perspectives on humankind, nature and economy. A contribution to the history and the foundations of ecological economics. *Ecological Economics* 53, 299-310.
- Biervert, B. and M. Held (eds) (1994), *Das Naturverständnis der Ökonomik. Beiträge zur Ethikdebatte in den Wirtschaftswissenschaften*, Frankfurt: Campus.
- Binswanger, H.C. (1991), Wachstum durch Imagination: J.G. Schlosers Theorie der imaginären Bedürfnisse, in *Geld und Natur. Das wirtschaftliche Wachstum im Spannungsfeld zwischen Ökonomie und Ökologie*, Stuttgart and Vienna, pp. 195-238.
- Faber, M. and R. Manstetten (1998), *Philosophische Grundlagen von Ökonomie und Ökologie*, Lecture Notes, Department of Economics, University of Heidelberg.
- Faber, M., R. Manstetten and G. Müller (1994), Interdisziplinäre Umweltforschung aus ökonomischer Sicht, *Naturwissenschaften*, 81, 193-199.
- Faber, M., R. Manstetten and T. Petersen, (1997) Homo Oeconomicus and homo politicus. Political economy, constitutional interest, *Kyklos* 5, Heft 4: 457-483.
- Kant, I. ([1785]1996), *Groundwork of the Metaphysics of Morals (Grundlegung zur Metaphysik der Sitten)*, in M.J. Gregor (transl. and ed.), *Practical Philosophy (The Cambridge Edition of the Works of Immanuel Kant)*, Cambridge: Cambridge University Press, pp. 37-108.
- MacIntyre, A. (1999), *Dependent Rational Animals. Why Human Beings Need the Virtues*, London: Duckworth.
- Manstetten, R., O. Hottinger and M. Faber (1998), Zur Aktualität von Adam Smith: Homo oeconomicus und ganzheitliches Menschenbild, *Homo oeconomicus*, XV (2), 127-168.
- Riedel, M. (1962), Aristoteles Tradition am Ausgang des 18. Jahrhunderts. Zur ersten deutschen Übersetzung der "Politik" durch Johann Georg Schlosser, in *Alteuropa und die moderne Gesellschaft. Festschrift für Otto Brunner*, Göttingen, pp. 278-315.
- Sandler, R. and P. Cafaro (eds.) (2005), *Environmental Virtue Ethics*, Lanham: Rowman & Littlefield.
- Schlosser, J.G. (1784), *Xenocrates oder Über die Abgaben*. An Göthe, Basel.

Spaemann, R. (1989), *Glück und Wohlwollen: Versuch über die Ethik*, Stuttgart: Klett-Cotta.

Thoreau, H.D. ([1854]1998), *Walden, or Life in the Woods*, first published 1854, reprinted in N. Baym et al. (eds.), *The Norton Anthology of American Literature*, Vol. 1, fifth ed., New York: W.W. Norton, pp. 1768-1942.

Turner, R.K. (1999), *Environmental and ecological economics perspectives*, in J.C.J.M. van den Bergh (ed.), *Handbook of Environmental and Resource Economics*, Cheltenham, UK and Northampton, MA, USA: Edward Elgar, pp. 1001-1033.

Underwood, D.A. and P.G. King (1989), *On the ideological foundations of environmental policy*, *Ecological Economics*, **1**, 315-334.