1. Taking stock: the keystones of ecological economics

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1. TAKING STOCK

After some decades of existence, ecological economics is a thriving field of knowledge. Our purpose here is not to engage in the normative debate about what it should be, but rather to introduce the *Handbook* we have edited, while also trying to provide some insight into what constitutes the ontological foundations of ecological economics. In the concluding chapter we shall elaborate on the most salient current concerns of the field, as well as on its future. This compilation of chapters aims, on the one hand, to present and stimulate the debate on the scope and methods of the multifaceted transdisciplinary field that was baptized as ecological economics in the late 1980s and, on the other, to comprehensively review the 'state of the art' in several exciting, relevant and rather new subjects dealing with the fluid interface between economic and ecological systems.

The *Handbook* covers a wide range of appealing topics but it would be too ambitious to attempt to review the vast history and current production of ecological economics in a single volume. Moreover, this compendium is the result of combining the tastes of the editors with the generous availability of the invited authors. Therefore, we do not pretend to have made a full overview of all major trends and issues of ecological economics. Our goal is more modest. We have invited some of the leading authors in the field to reflect on the most important developments in the subjects in which they are experts, and in doing so to contribute to disseminate within the ecological economics and other communities what they consider to be the most significant achievements and challenges in specific areas of knowledge. The outcome is stimulating and we hope enjoyable both for junior and experienced readers.

The rest of section 1 contains a historical account of ecological economics, while also describing what we consider to be its foundations. The review is not done in a chronological order, but along main foundational propositions. It is meant to be particularly useful for readers not yet familiar with the field. Section 2 briefly summarizes major organizational

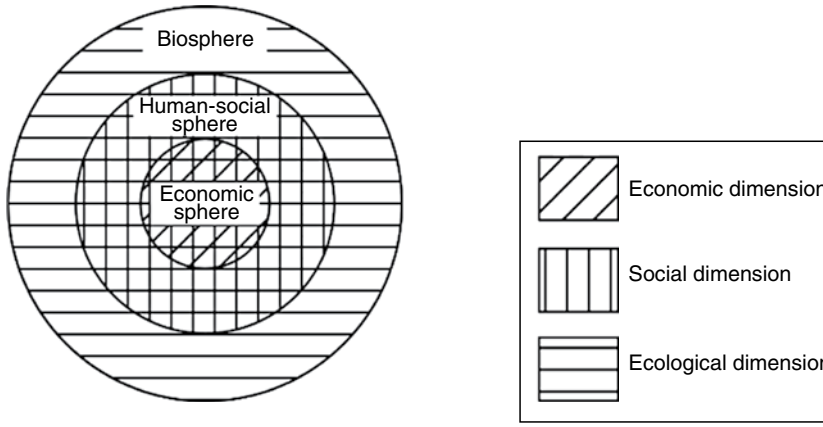

Figure 1.1 The economy embedded in the institutions of human society and in the biosphere

achievements of ecological economics as a community of scholars and introduces the contributions composing this volume.

1.1 The Analytical Lenses of Ecological Economics

René Passet in 1979 in *L'Économique et le Vivant* drew an image of the relations between nature, human society and the human economy (Figure 1.1) that has become a symbol for ecological economics. The drawing shows the obvious reality that there was nature before human society, and human society preceded the generalized market system by many generations. This vision has implications for economics. The teaching of the theory of externalities (that is, the impacts of the economy on the environment which are not measured by market prices) should not wait for the time when students have already grasped the analysis of general market equilibrium. On the contrary, the study of the market (the chrematistics) should come after the study of ecology and social institutions. The 'externalities' come before the 'internalities'. The market economy could not exist without social institutions, and without the unpaid services of ecosystems.

Ecological economists see the economy as an open system. In thermodynamics, systems are classified as 'open' to the entry and exit of energy and materials, 'closed' to the entry and exit of materials though open to the entry and exit of energy, such as the Earth, and 'isolated' systems (without entry or exit of energy and materials). The availability of free energy and the cycling of materials allow life forms to become ever more organized

and complex; the same applies to the economy. Dissipated energy and waste are produced in the process. If the scale of the economy is too large and its growth is too rapid, then the natural cycles cannot sustainably produce the resources or absorb or assimilate the waste such as, for instance, heavy metals or carbon dioxide. The economy bumps into 'limits to growth' or 'planetary boundaries'.

In ecological economics the economy is seen as embedded in the ecosystem (or, more accurately, in the historically changing social perception of the ecosystem). The economy is also embedded in a structure of property rights on environmental resources and services, in a social distribution of power and income, in social structures of gender, social class or caste. Instead, in mainstream economics the economy is seen as a self-sufficient system where prices for consumer goods and services, and prices for the services of production factors, are formed.

Ecological economists (Norgaard, 1990) disputed the view expressed in the 1960s by Barnett, Krutilla and other mainstream resource economists, that since natural resources were cheap, they must be abundant. Markets are myopic, they discount the future, and they cannot see future uncertain scarcities of sources or sinks. Ecological economists understand and even sympathize with attempts at 'internalizing' externalities into the price system, they readily concur with proposals to correct prices by taxes (such as 'natural capital depletion taxes' or taxes on pollution) but they deny that there exists a set of 'ecologically correct prices'.

In the late nineteenth and early twentieth centuries the biologist and urban planner Patrick Geddes, the chemist Frederick Soddy and the engineer and social reformer Josef Popper-Lynkeus had unsuccessfully tried to promote a biophysical view of the economy as a subsystem embedded in a larger system subject to the laws of thermodynamics (Martínez-Alier and Schlüpmann, 1987). By 1850 or 1860 the carbon cycle and the cycles of plant nutrients had been discovered, while the first and second laws of thermodynamics (conservation and transformation of energy, but also dissipation of energy and increase in entropy) had been established.

The contrived conflict between the 'optimistic' theory of evolution which explained the diversity of life and the 'pessimistic' second law of thermodynamics was a staple of the cultural diet of the early 1900s. Praising the energy accounts of agricultural systems published in 1880 by the 'narodnik' revolutionary and physician S.A. Podolinsky, the ecologist Vernadsky wrote in 1924 (Vernadsky, 1924, pp. 334–5) that Podolinsky had analysed the energetics of life (life systems being open to the entry of energy), and had applied these ideas to the analysis of the economy. Podolinsky wrote that, for an economy to be sustainable, the energy productivity of human work (that is, how much energy is made available by

one day of human work) must be higher (or equal, if everybody is working) than the efficiency of the transformation of the energy intake into human work. The energy productivity of a coal miner (wrote Podolinsky) was much larger than an agriculturalist could attain but this energy surplus from fossil fuels was transitory (Podolinsky, 1880, 1883).

Therefore, the main ingredients for an ecological view of the economy were present much before the birth of a self-conscious ecological economics in the 1980s, which was delayed by the strict boundaries between the natural and the social sciences. The biologist and systems ecologist Alfred Lotka, born in 1880, had introduced in the 1910s and early 1920s the fundamental distinction between the endosomatic use and the exosomatic use of energy by humans. While we have genetic instructions on the amount of food energy to be consumed (about 7 to 10 MJ per day for an adult), our exosomatic use of energy depends on culture and income, and reaches 1 GJ or more per day for rich people.

Much later, four well-known economists, who did not yet form a school, are seen in retrospect as ecological economists: Nicholas Georgescu-Roegen (1906–94), the author of *The Entropy Law and the Economic Process* (1971) (where Lotka was often quoted), Kenneth Boulding (1910–93), who worked mainly on general systems analysis, K.W. Kapp (1910–76) and S. von Ciriacy-Wantrup (1906–80), who were both institutionalist economists. The systems ecologist H.T. Odum (1924–2002) studied the use of energy in the economy and some of his former students were among the first ecological economists in the 1980s. Other sources of ecological economics are in Environmental and Resource Economics (microeconomics applied to environmental pollution and the depletion of natural resources), in Human Ecology, Ecological Anthropology, Agroecology and Urban Ecology, and in the study of 'industrial metabolism' as developed by Robert Ayres (born in 1932), now known as Industrial Ecology.

The first books or special issues of journals with the title 'Ecological Economics' appeared in 1987. After meetings in Stockholm and Barcelona, Robert Costanza and Herman Daly set up the International Society for Ecological Economics (ISEE) and convened the first world conference in Washington DC in 1990. The book that came out of this first conference (Costanza, 1991) ambitiously defined the field as 'the science and management of sustainability'. The successful academic journal *Ecological Economics* started in 1989, edited first by Robert Costanza, and later by Cutler Cleveland (who also edits the Encyclopedia of the Earth) and by Richard Howarth.

Some environmental economists of neoclassical persuasion were also present in those early efforts. David Pearce became one of the main editors

of the new journal, *Ecological Economics*, but he left the journal after 1994 because of internal disputes on what is now called 'weak sustainability vs. strong sustainability'. Pearce had influenced the World Bank to do macroeconomic accounts in which 'human-made capital' could in theory be a substitute for so-called 'natural capital'. This was 'weak sustainability', that is, sustainability in the weak sense of the term. Herman Daly, Peter Victor and other ecological economists objected to 'weak sustainability'. One could not sustainably substitute the increased horsepower of the fishing fleet for a declining availability of fish. Moreover, measurement of stocks of capital depended on the rate of profit (as discussed in the controversies on capital theory of the 1970s) (Victor, 1991).

However, the International Society for Ecologial Economics (ISEE) is a scientific society encouraging internal controversy and also a product of the environmental movement of the 1960s and 1970s in its different varieties. Internal pluralism and perhaps some confusion of ideas were present in the volume produced after a second ISEE conference in Stockholm in 1992, 'Investing in natural capital: the ecological economics approach to sustainability'. While some ecological economists even today feel that the metaphor of 'natural capital' is useful, others strongly reject it because it suggests that we can use 'units of capital' as a common measuring rod that would make commensurable the losses of biodiversity and the increases in manufactured capital stocks. The notion of 'natural capital' supports policies such as 'habitat trading' (one habitat is destroyed and another one, far away, is effectively protected) or the Rio Tinto mining company's doctrine of 'net positive impact' (a new location is destroyed while another is preserved and enhanced, going round the world until no natural spaces will be left).

While H.T. Odum (and his disciples working on human ecological energetics: A.M. Jansson, Robert Costanza, Charles Hall and Cutler Cleveland), David Pimentel (agricultural energetics) and C.S. Holling ('resilience') were the ecologist grandfathers, mothers and fathers of ecological economics, Boulding and Georgescu-Roegen were the economist grandfathers. (K.W. Kapp had died early, missing the birth of ecological economics.) Herman Daly's influence was also decisive. Daly (born in 1938) published his first article in what we now call ecological economics in 1968 in *The Journal of Political Ecology*. In the early 1990s (Daly and Cobb, 1989) Daly promoted an index of sustainable economic welfare (ISEW) expressed in money terms that showed results very different from GDP (because of the different assumptions in the calculations). It seemed at the time that ISEW was a good way to attack GDP accounting but an index in money terms was not congruent with the critique against 'weak sustainability'. Daly maintained his stature in the field and recently increased it as his early defence of a Steady State economy (Daly, 1973)

is now seen as having announced the new ecological macroeconomics without growth (Victor, 2008; Jackson, 2009).

Daly was explicitly inspired in his work by Boulding and Georgescu-Roegen. Boulding had published a famous article on *The Economics of the Coming Spaceship Earth* (a spaceship where materials would have to be recycled) (Boulding, 1966). He became a card-carrying member of the ISEE and an author in the collective book edited by Costanza (1991). Georgescu-Roegen refused to be drawn into the ISEE; he preferred to call the field 'Bioeconomics' (Mayumi, 2001; Bonaiuti, 2011) and announced the publication of a book with this title that never appeared. He disliked Costanza's article in *Science* in 1980 (Costanza, 1980) proposing an energy theory of value, he disliked also H.T. Odum's 'emergy' (embodied energy) accounts to which he answered with an irritated reply: 'matter matters too' (Georgescu-Roegen, 1977), against what he called the 'energetic dogma'. On the other hand, Boulding, more concerned with scarcity of materials than with energy dissipation, wrote a less than enthusiastic review of Georgescu-Roegen's magnum opus. In due course the edition of the collected works and correspondence of such major intellectual figures and pioneers of ecological economics will clarify the real substance, if any, in such disagreements and quarrels.

Georgescu-Roegen's point on the importance of entropy for the economy is as follows. Life is 'negentropic': Georgescu very often cited Schrödinger's *What is Life* (1944). The evolution of species, the complexity of living structures, was achieved by 'capturing' energy through photosynthesis, and by dissipating energy to outside systems. The industrial economy, however, after the thermo-industrial revolution (Grinevald, 1976) did not work only by using current photosynthesis or hydraulic energy. It was burning stocks of fossil fuels. Even a non-growing industrial economy would not be sustainable because energy cannot be used twice (except in minor cases of 'co-generation'). In any day in 2014 we take 90 million of barrels of oil from the 'subterranean forest' (Sieferle, 2001), and tomorrow we have to do the same again, a little more or a little less, whether from the bottom of the sea or from fields in Iraq or Saudi Arabia, the rainforest of Ecuador or the Orinoco Delta in Venezuela. Perhaps the EROI is declining (the energy return on the energy input) or perhaps not yet. Georgescu was also aware of Hubbert's approaching 'peak oil'.

Although we could claim that Darwin won against Sadi Carnot (Prigogine and Stengers, 1984), in the industrial economy the sources of low-entropy become scarcer. Moreover, materials cannot (in practice) be recycled to the full extent (an observation that Georgescu tried to glorify into a Fourth Law of Thermodynamics, without success; Mayumi, 2001). Georgescu saw the economy as a system open not only to the entry of

energy and materials but also to the unavoidable exit of inconvenient and unrecyclable 'garbojunk' (a word formed by garbage + junk).

Georgescu's fundamental contribution to ecological economics was then that, because of the Second Law of Thermodynamics or Entropy Law, even a non-growing industrial economy is not sustainable. Therefore, in the rich economies, a steady state (as proposed by Daly, drawing on Stuart Mill) would not be enough. A steady state economy aims for mildly fluctuating levels in population and consumption of energy and materials. Birth rates equal death rates, and (in economic terms) saving/investment equals depreciation. Georgescu said that in rich countries a degrowth in the inputs of fossil fuels and other materials was required. Hence Georgescu's agreement to the French title to a selection of his articles edited by Grinevald in 1979, *Demain la Décroissance*. In retrospect, this book became 25 years later one main inspiration for the European 'degrowth' movement (Martínez-Alier et al., 2010). Nobody ever preached a 100 per cent degrowth of the economy. Georgescu's lower limit would be that of an economy fuelled by the current inflow of solar power. There is therefore a confluence of ideas between Georgescu's degrowth, Daly's steady-state (Kerschner, 2010) and the new ecological macroeconomics without growth which is presented in this volume.

The winner of the Nobel Prize in Chemistry and expert on radioactivity, Frederick Soddy, had written on energy and the economy from 1910 onwards. He compared 'real wealth', which grows at the rhythms of nature and which, if turned into manufactured capital, is worn down, with 'virtual wealth' in the form of debts that apparently could grow forever. Private property in a capitalist system guarantees (for a while) the increasing private debt while the public debt could apparently grow based on the guarantees provided by the State. But this was a flimsy building. Soddy has been quoted by Daly and other ecological economists since the 1980s, much before the financial crisis of 2008. Debt-fuelled growth was not viable. The real fuel of economic growth was coal, oil and gas. The amount of real wealth that an economy could create is limited by the amount of low-entropy energy and materials that it can sustainably take from the external environment, and by the amount of effluents such as greenhouse gases that the environment could sustainably absorb. Soddy's book of 1926 was called *Debt, Wealth and Virtual Wealth*. He drew on John Ruskin. He meant that debt was not real wealth, it was virtual wealth. Real wealth was the current inputs of solar energy. Although ecological economists have not developed a consensual monetary reform plan, they follow Soddy on the need for 'financial prudence' against increasing indebtedness and recommending for instance a large increase in the cash reserve requirements of banks (Daly and Cobb, 1989).

Soddy approvingly quoted Aristotle's distinction between *oikonomia* and *chrematistika*, as Marx had done and Karl Polanyi (1957) was to do later. Ecological economists are fond of this distinction. *Oikonomia* meant the material provisioning of the *oikos* (the extended family), while chrematistics was the art of studying market prices to make money, for instance by becoming a monopolist (a word used by Aristotle). What Aristotle called *oikonomia* would now be called human ecology and economic anthropology, while chrematistics is what students of microeconomics learn.

Apart from the United States and Europe, the Japanese 'entropy school' of economic analysis (Tamanoi et al., 1984) studied the environmental services provided by the water cycle, and also the ancient urban ecosystems of Japan. In India, there was much work after the 1970s by economists but also by ecologists (Madhav Gadgil) on the links between forest or water management and common property rights, nowadays one main focus of interest in ecological economics (Berkes and Folke, 1998; Agarwal, 2010). Other early ecological economists (whose major works were not in English) are, in France, René Passet (1979), and Ignacy Sachs, who proposed in the early 1970s the notion of 'eco-development'; Roefie Hueting (1980) in the Netherlands and Christian Leipert in Germany; Jose-Manuel Naredo in Spain (Naredo, 1987). (For general introductions to the field, see: Costanza et al., 1997; Cleveland et al., 2001; Martínez-Alier and Røpke, 2008; Spash, 2009.)

According to Georgescu-Roegen (1971), economics should see the economy as an open system (and not as a self-sustaining system, a 'merry-go-round' between consumer and producers, as in the textbooks). Economics should study the 'metabolic flows' in the economy. This is today linked to two research schools. The first one centres on Marina Fischer-Kowalski and collaborators at the Institute of Social Ecology in Vienna, drawing on work by Robert Ayres, R.P. Sieferle and other authors.

The second school would be Marxist ecological economics. It has much less influence. It claims with reason that Marx already wrote in the 1860s that the capitalist economy was causing a 'metabolic rift' (Foster, 1999). Marx took the word 'metabolism' (*Stoffwechsel*) from Moleschott and Liebig, pointing to the export of nutrients in the soil by commercial agriculture. Capitalism not only exploited workers, it also exploited the soil. The soil was no longer a 'fund' able to supply crops continuously; it became an exhaustible stock in terms of its fertility and texture. Marx quoted Liebig who feared the day when guano imports would diminish. Marx, as Liebig, hoped for factory-made chemical fertilizers (in a sort of 'weak sustainability' approach) to escape the Malthusian trap of 'diminishing returns'. Despite such intellectual traces, a Marxist ecological

economics or environmental history has not existed until the contributions at the end of the twentieth century from Altvater (2007), Bellamy Foster, Hornborg (in his theory of ecologically unequal trade, Hornborg, 1998), and O'Connor's 'second contradiction' (O'Connor, 1988).

1.2 Keystone Concepts: Irreducibility of Needs and Incommensurability of Values

In economic theories of production and consumption, compensation and substitution reign supreme. Not so in ecological economics, where diverse standards of value are deployed 'to take Nature into account' (O'Connor and Spash, 1999). In the ecological economics theory of consumption, some goods are more important and cannot be substituted by other goods (economists call this a 'lexicographic' order of preferences). Thus, sacredness cannot be traded off. And no other good can substitute or compensate for the minimum amount of endosomatic energy or for water necessary for human life. To call the endosomatic consumption or the exosomatic use of energy a 'socially constructed need or want' would ignore the ecological explanations and/or implications of such use of energy, while to call the daily endosomatic consumption a revealed preference would betray the conventional economist's metaphysical viewpoint.

There is another approach which, as pointed out by John Gowdy and Susan Mesner (1998), builds upon the 'principle of irreducibility of needs' (proclaimed by Georgescu-Roegen in the 1968 edition of the *Encyclopedia of the Social Sciences*, article on 'Utility'). According to Max-Neef (1992), all humans have the same needs, described as 'subsistence', 'affection', 'protection', 'understanding', 'participation', 'leisure', 'creation', 'identity', 'freedom' . . . and there is no generalized principle of substitution among them. Such needs can be satisfied by a variety of 'satisfactors'. Instead of taking the economic production as given, we may ask (as in the steady-state and *décroissance* perspectives) why there is so much travel, and why there is so much building of houses with new materials instead of restoration of old ones. Is there a trend to use 'satisfactors' increasingly intensive in energy and materials in order to satisfy predominantly non-material needs?

In part due to the existence of a 'lexicographic' order of preferences, there are also limits to the degree of substitution between different types of values (economic and non-economic). Stressing these constraints, one of the foundations of ecological economics is thus the incommensurability of values. Ecological economics is not committed to a unique type of value expressed in a single numeraire or unit of account. 'The issue is not whether it is only the market place that can determine value,

for economists have long debated other means of valuation; our concern is with the assumption that in any dialogue, all valuations or "numeraires" should be reducible to a single one-dimension standard' (Funtowicz and Ravetz, 1994, p. 198). Ecological economics encompasses money-valuation, and also physical appraisals of the environmental impacts of the human economy measured in their own physical numeraires. It also gives importance to social indicators.

However, ecological economists understand and have pushed sometimes for the economic valuation of ecosystem services, with the avowed intention of making them more visible to the general public and to policy makers who are assumed to think mainly in money terms. Nevertheless, the insistence on money valuation clearly makes less visible the biological and ecological importance of Nature, and also livelihood and cultural values. The beauty and sacredness of mountains such as the Niyamgiri Hills in Odisha might seem negligible when compared to the very large money value of their bauxite deposits. The mountains are better defended outside money valuation (Temper and Martínez-Alier, 2013). The debates on when money valuation is appropriate continue in ecological economics (Kumar, 2010). A consensus is perhaps being reached that money valuation is appropriate when trying to make companies accountable in civil litigation for their past environmental liabilities (as in the British Petroleum case in the Gulf of Mexico, Chevron-Texaco in Ecuador or Shell in the Niger Delta) but it is not appropriate when taking decisions for the future (whether on climate change or biodiversity policies or on building an open cast mine or a dam) when money valuation becomes only one of several relevant valuation languages (Rodriguez-Labajos and Martínez-Alier, 2013).

As John O'Neill and Thomas Uebel show in their contribution to this *Handbook*, the current debate on incommensurability of values in an intergenerational context goes back to the 'socialist calculation debate' started by Otto Neurath and Ludwig von Mises in Vienna in the early 1920s. Otto Neurath (1882–1945) favoured a *Naturalrechnung*, accounting in physical terms, while Von Mises wrote that without prices there could not be a rational economy. Max Weber agreed with Von Mises. Otto Neurath disagreed, and asked how we should decide whether to use more coal now and less human labour, or keep coal for the future and use more human labour now. In today's terms, should we use more fossil fuels now, enjoy economic growth and produce more GHG, rely on technological change and invest in new renewable technologies and geoengineering, or should we go into a steady-state economy after a period of slight degrowth in the rich economies? Collectively, these are technical-ethical questions, they are not decisions that real or fictitious market prices can solve. We cannot

enter into market-like negotiations with future generations of humans; the methodological individualism of orthodox economic theory breaks down here. Nevertheless, instead of engaging with such arguments, Hayek (1952) in *The Counter-Revolution of Science*, pursuing his thirty-year-old disagreement with Neurath, lumped him and other authors (Soddy, Geddes, Mumford) who supported physical accounting together into the category of 'social engineers', would-be dictators.

1.3 The Institutional Dimension

Many years later, one article by Vatn and Bromley (1994) titled 'Choices without prices without apologies' explained why money valuation is only optional. Choices depend on socially moulded preferences that depend on institutions, that is, the social rules and norms. As Veblen famously put it, the individual consumption of the rich is guided by the social rule of showing off. Bromley and Vatn are institutionalist economists, in Veblen and Kapp's tradition. (Kapp himself was influenced by Otto Neurath's economics.) They see economic behaviour not as being determined by inscrutable individual preferences but as influenced and explained by social rules and norms. Institutions articulate a diversity of values (Vatn, 2005).

In this context, Coase's approach to the internalization of negative externalities or positive environmental services into the price system relies on market transactions between partners. So, if an agent (a peasant community, a factory) pollutes the water in a river, the downstream aggrieved agents may get together either to ask for an indemnity equivalent to the damage suffered or to bribe the polluters to stop the pollution, depending on the property rights on the river. This might work without need for government intervention. However, getting the downstream people together to start a court case implies 'transaction costs' (lawyers' fees, time for meetings) which prevent the simple Coasean solution from operating. Also, when those being polluted are future generations and other species, the market solution does not operate. Regulation (physical norms and fines) or Pigovian taxation are preferable.

Regarding the empirical study of a very popular policy instrument such as Payment for Environmental Services, one main contribution from ecological economists has been to criticize the simple Coasean, market approach, and introduce complexities related to uncertainty, distributional issues, social embeddedness and power relations, acknowledging the variety of contexts and institutional settings in which PES operate (Muradian et al., 2010).

The institutionalist perspective (economic actions are explained by

social rules more than by inscrutable individual preferences) is also very relevant for the study of the relation between property rights or property regimes and the management of natural resources. We go back here to the much quoted article by Garrett Hardin (1968), 'The tragedy of the commons', which should have been titled 'The tragedy of open access'. In fact, Hardin attended the inaugural conference of the ISEE in Washington DC and he had a chapter in the seminal book edited by Costanza (1991). One paragraph in Hardin's article starts like this: 'Picture a pasture open to all. . .', and describes how a tragedy of overgrazing will occur because individuals will put more and more sheep or cows on it provided that the marginal benefit (a few litres of milk, a few pounds of wool, a sack full of dung) are larger, individually, than the private marginal cost, disregarding the collective marginal costs in terms of soil degradation.

To the old liberal critique of 'common' property ('the magic of private property (and enclosures) would turn sand into gold' had written Arthur Young) was now added a trendy environmental critique, the Tragedy of the Commons. However, was Hardin not aware of the rules that in the past (brought from England to New England) presumably regulated the amount of horses or cows that a citizen could put to pasture in the Boston Commons? Or in any other commons, whether a Mexican *ejido* or a New Mexican common pasture? Why was the confusion between 'commons' and 'open access' not spotted by the reviewers of Hardin's article in *Science*? There were many well regulated communal systems of management for coastal fisheries or irrigation water, as Bromley and others soon retorted and as Elinor Ostrom was to study in detail (Ostrom, 1990).

Hardin's 1968 article mistook commons for open access. It preached privatization (or State property) against the misnamed 'commons'. It took some time until the confusion was cleared up, provoking much research on the practical functioning of common property regimes, and also on the relations between forms of property and resource management. There are certainly open access resources, for instance some fisheries in the open seas. The atmosphere was also treated as being in open access to dump polluting substances such as CFC that damage the ozone layer until an international treaty banned this practice. The atmosphere is still a dumping ground in open access as regards GHG. Other examples abound. Some scholars did research on the trend to turn natural resources held in common and subject to traditional management rules (like coastal mangroves and fisheries in India or Latin America) into de facto private property, for example for growing shrimp or for fishing for export. This was described not only as a social but also an environmental 'tragedy of enclosures'.

Compared to open access, private property is in principle more

conducive to conservation because the costs of today's actions will be felt by the owner or his/her immediate kin. This has been discussed in resource economics at least since Faustmann's rule (1849). The private owner of a forest (or rather, of a tree plantation) will decide to cut the trees not as soon as possible, but when the rate of growth of the trees (net of harvesting costs and multiplied by the market price of wood) falls below the rate of interest in the bank plus the rent to be obtained from the land now empty of trees (potentially used for crops or pastures while the new stand of plantation trees is starting to grow again). Notice here that a high interest rate (or discount rate) will lead to cutting the trees very soon, while payment for ecosystems products or services (like hunting rights, mushroom collection, recreation under the trees, carbon capture) will slow down the rotation period and could even persuade the owner not to cut the trees at all and eventually turn back the plantation into a true forest.

In the case not of trees in a plantation but of metal mining or extraction of fossil fuels, private property linked to the profit motive is certainly not conducive to conservation, nor to the avoidance of negative environmental impacts during operation or after the exhaustion of the resource such as acid drainage from mines. New institutions, that is, rules articulating new values (for instance, civil or criminal legislation on socio-environmental liabilities) would perhaps modify such behaviour.

1.4 The Contested Issue of Population Growth

Ecological economists emphasize both the pressure of population and the pressure of production (and consumption) on resources. How large is humankind's ecological footprint? Has humankind exceeded 'carrying capacity'? This is defined in ecology as the maximum population of a given species, such as frogs in a lake, which can be supported sustainably in a given territory without spoiling its resource base. However, the large differences internal to the human species in the exosomatic use of energy and materials mean that the first question is, maximum population at which level of consumption? Second, human technologies change at a quick pace. Already Boserup's thesis (1965) of endogenous technical change according to which pre-industrial agricultural systems had intensified in response to increases in population density, turned the tables on the Malthusian argument. Third, the territories occupied by humans are not 'given', other species are pushed into corners or into oblivion (as the index Human Net Primary Productivity (HANPP) implies), and, internal to the human species, territoriality is politically constructed through state borders. Fourth, international trade (similar to horizontal transport in ecology, but

which humans can regulate consciously) may imply 'ecologically unequal exchange', though if one territory lacks a very necessary item which is abundantly present in another territory, Liebig's law of the minimum would recommend exchange. Then, the joint carrying capacity would be larger than the sum of the carrying capacities of all autarchic territories.

Because of the shortcomings of 'carrying capacity' as an index of (un) sustainability for humans, and because of Barry Commoner's arguments against Paul Ehrlich's fixation on population growth (Ehrlich, 1968) forgetting that overconsumption was the main environmental threat, the formula I = PAT was proposed by Ehrlich himself, where I is environmental impact, P is population, A is affluence per capita, and T stands for the environmental effects of technology. Efforts are being made to operationalize I = PAT. True, population remains one important variable. True also, the demographic transitions are not mere automatic responses to urbanization and education, and their timing does not depend only on social institutions, such as inheritance patterns and family forms. Human demography is anticipatory and self-conscious. Though it also follows Verhulst's curve, it is different from the ecology of a population of frogs in a lake.

There have been three different varieties of Malthusianism. First, Malthus' own view in 1798 that human populations would grow exponentially unless checked by war and pestilence, or by the unlikely restraint of chastity and late marriages. Food would grow less than proportionately to the growth of the labour input, because of decreasing returns. Hence, subsistence crises.

Then there was the Neo-Malthusianism of 1900, with radical activists such as Emma Goldman, Paul Robin (Ronsin, 1980). Human populations could regulate their own growth through contraception. Women's freedom was required for this, and it was desirable for its own sake. This was a feminist Neo-Malthusianism, insisting on what is called today 'reproductive rights'. Abortion and vasectomies should not be criminalized. 'Conscious procreation' was required in order to prevent low wages and pressure on natural resources but the main cause of poverty was social inequality. This was a successful bottom-up movement only in some parts of the world, particularly in Europe and America against states (which wanted more soldiers) and against the Catholic Church.

There is finally top-down Neo-Malthusianism after 1970, reaching extremes like Hardin's 'lifeboat ethics' (Hardin, 1974) against freedom of migration with racist overtones. This top-down doctrine and practice is sponsored by international organizations and some governments. Population growth is seen as one main cause of poverty and environmental degradation. Therefore states must introduce contraceptive methods,

even sometimes without the population's (particularly women's) prior consent.

Ecological economists have been divided into top-down and bottom-up Neo-Malthusians with lack of dialogue between them, although they all refuse the doctrines of the anti-Malthusians, who assume that human population growth is no threat to the natural environment, and that it is conducive to desirable economic growth. The divide has been expressed in more recent debates about the relationship between migration and the environment (Muradian et al., 2006). Ecological economists believe that growth of world population (four times in the twentieth century) is certainly a very major issue, but differ in their visions about policies to deal with population growth and migratory flows. It now seems that population might be stabilized and even go into a slow decline after 2050, perhaps at 9 billion people. Fertility is going down in many regions and countries. The demographic transition is being completed. This is a good thing, although local depopulation (not only rural, also urban) may create new social and environmental problems.

2. THE SOCIETY FOR ECOLOGICAL ECONOMICS

Could the ISEE (born in the late 1980s) be seen in future as remotely similar in influence (though very different in intention) to the Mont Pelerin Society founded by Hayek in 1947 to defend the market economy and Karl Popper's 'open society' against Marxist doctrines and Keynesian social-democratic planning? Should we have a political objective, are we already politically motivated? Is the pluralism in ecological economics undermining such a prospect, or rather, is the radicalism of ecological economics preventing or delaying its social acceptance? Should we relent a bit and accept 'weak sustainability' and the promises of ecological modernization, or should we denounce UNEP's 'green growth' of 2013 as an oxymoron even more blatant than Brundtland's 'sustainable development' of 1987? In fact, should 'we' (ecological economists) have any collective position at all?

The ISEE has lived up to its promise of promoting a transdisciplinary academic field at the intersection of ecology and economics. Both economists and ecologists coming from different schools have been active in the field. This chapter has briefly explained the origins of ecological economics going back to the late nineteenth century. Therefore it is not true that 'ecological economics is simply what ecological economists do'. They do many different things but within a common tradition which is a bit shaky and not clearly delimited because it is at the interface of related fields.

While the journal *Ecological Economics* and the biennial conferences are the main focus of activities of the ISEE, there are active regional societies in the United States, Europe, India, Latin America and Russia. The European Society for Ecological Economics edits a journal, *Environmental Policy and Governance*. The Latin American ecological economists publish the journal *Revibec*. Other well-known ISEE members have edited related journals: Charles Perrings, *Environment and Development*; Clive Spash edits *Environmental Values*; Robert Costanza, *Solutions*; Jeroen van den Bergh, *Environmental Innovation and Societal Transitions*. The Indian Society (INSEE) regularly publishes proceedings of well attended conferences. Its past-president, Kanchan Chopra, gave her name to a famous committee named in 2002 by the Supreme Court, giving Net Present Values to non-market forest products and services that companies have to pay for when carrying out mining or hydroelectric projects.

Among all this variety, there is a common thread. A sample of first university degrees and main scientific interests of the (older) ecological economists can easily be constructed by listing the names of the ISEE presidents since 1989, as follows.

- Robert Costanza, ecologist and landscape architect, energy in the economy, valuation of ecosystem services;
- R.B. Norgaard, economist, post-development studies, co-evolution, biodiversity conservation;
- John Proops, physicist, energy and the economy, capital theory, economic-ecological modelling;
- Charles Perrings, economist, development studies, economics of biodiversity;
- Joan Martínez-Alier, economist, energy and society, environmental history, political ecology;
- Peter May, resource and environmental economist, development, Amazon deforestation;
- John Gowdy, economist, economic anthropology, economics of consumption;
- Bina Agarwal, economist, development and feminist economics, common property, India;
- Marina Fischer-Kowalski, sociologist, industrial ecology, social metabolism, transition societies.

This list can be complemented by the list of recipients of the ISEE Boulding Award: Herman Daly (economist); Robert Goodland (biologist); A.M. Jansson (ecologist); Robert Costanza (ecologist); C.S. Holling (ecologist); Robert U. Ayres (physicist, industrial ecologist); Partha

Dasgupta (economist); K.G. Mäler (economist); R.B. Norgaard (economist); Charles Perrings (economist); Manfred Max-Neef (economist); Ignacy Sachs (economist); Joan Martínez-Alier (economist); Bill Rees (ecologist); Mathis Wackernagel (ecologist); and Peter Victor (economist), roughly divided as half ecologists (biologists, physicists) and half economists in their original training. Their names often appear in the present *Handbook*.

Ecological economics is then a new transdisciplinary field which develops topics and methods such as:

- new indicators and indices of (un)sustainability of the economy;
- ecological macroeconomics without growth, the debate between 'weak' and 'strong' notions of sustainability;
- the application of ecological notions of carrying capacity and resilience to human ecosystems;
- the valuation and payment for environmental services, monetary valuation of externalities but also the discussion on incommensurability of values;
- risk assessment, uncertainty, complexity and 'post-normal' science; integrated environmental assessment, including building of scenarios, dynamic modelling, participatory multi-criteria methods of decision making;
- the allocation of property rights and its relation to natural resource management, old and new communal institutions for environmental management;
- environmental causes and consequences of technological change, relations between ecological economics and evolutionary economics;
- theories of consumption (needs, satisfactors), as they relate to environmental impacts;
- relations to industrial ecology; applications to business administration; corporate liability and accountability;
- relations to fields such as industrial ecology, urban ecology, feminist economics; environmental and economic history; political ecology, peasant studies;
- instruments of environmental policy, often centred on the 'precautionary principle' (or 'safe minimum standards', as introduced by Ciriacy-Wantrup).

As stated above, in this *Handbook*, however, we do not attempt to cover all these issues. The book cannot therefore be considered as a comprehensive map of all the topics addressed by ecological economists. It should rather be seen as a stimulating exploration of some of the most critical

contemporary matters in the field. After this introduction, the chapter written by Clive Spash tackles one of the recurrent and fundamental subjects in the modern history of ecological economics. Namely, what ecological economics is or should be, and how it could be differentiated from other fields of knowledge. This constitutes the topic of an ongoing debate. The frontiers of ecological economics are by definition difficult to set, and its call for pluralism often falls in contradiction to some core tenets of the field, including a critical vision about the assumptions and methods of mainstream neoclassical economics. Furthermore, some of the internal contradictions of ecological economics arise from 'epistemological tensions'. For example, between the need of pragmatism (to have influence on contemporary policy making) and the aim of conceptual rigour, or between the adoption of the notion of biophysical constraints to the economy (implying a sort of 'objective' vision on human societies) and acknowledging that reality is socially constructed (social constructivism), which implies adopting the vision that biophysical limits are dependent on social preferences.

The emphasis on incommensurability of values is one of the main issues of dispute between ecological economics and mainstream economics, and John O'Neill and Thomas Uebel's contribution traces the roots of such discussion to the 1920s and 1930s. The search for alternative methods to conventional monetary valuation of environmental assets (and ability to acknowledge the plurality of human values) has been a recurrent concern in ecological economics. In his chapter, Christos Zografos draws the state of the art of deliberative methods for policy design in the field of the socio-environmental evaluation. Deliberative methods assume legitimacy as a key element of social decision making. A motivation for the adoption of deliberative methods in ecological economics is the concern for improving the quality of policy assessment and design.

One of the distinctive features of ecological economics has been a shared vision of the economic system as embedded in a biophysical base, which calls for looking at economic processes from a biophysical perspective (instead of solely from a monetary point of view) and thus invoking the notion of metabolism. The chapter written by Fischer-Kowalski and Haberl outlines the concept of social metabolism, and discusses how it has evolved across time. The chapter addresses some key conceptual and methodological issues when studying the socio-metabolic profile of economic processes, as well as showing some empirical findings and patterns, stylized through several decades of research. This contribution constitutes an excellent state of the art of the study of the material and energetic metabolism of human societies.

The relationship between macroeconomic policies and the condition of

the environment is a subject that has been often neglected. The chapter by Nadal tackles this complex issue from a post-Keynesian perspective. He argues that sustainability objectives involve the whole economy, and therefore environmental policies cannot be disentangled from macroeconomic policies. Environmental sustainability is hence essentially a macroeconomic problem. In practice, this means that monetary and fiscal policies, for example, must be redesigned and redefined in order to be instrumental in achieving sustainability objectives. This chapter discusses extensively how the priorities of macroeconomic policies (which are assumed to be politically determined and not the result of technical considerations) can be redefined in order to achieve a better environmental performance in contemporary capitalist economies.

Also making use of Keynesian insights, the contribution from Peter Victor deals with a subject studied so far by only a few scholars, namely, the 'macroeconomics of non-growth'. The goal of this approach is to test whether social, economic and environmental goals can be met in a non-growing economy, so less emphasis could be put on economic growth as a societal goal. A model is used to discuss how different components of the economy, such as consumption, investment, employment, technological change, public expenditure and trade, would look in a non-growth advanced economy. The chapter also outlines a possible research agenda around these issues.

The chapter by Petridis, Muraca and Kallis also deals with the current discussion around the concept of 'degrowth'. Activists and scholars gathered in the contemporary 'degrowth' movement criticize the adoption of economic growth as the ultimate goal of human societies since they point out that, after a certain threshold, growth intensifies social inequalities and exacerbates environmental problems. The chapter traces the history of critical ideas composing the core of the degrowth movement, and the parallelism with other contemporary initiatives. It also discusses the links between academia and activist groups around this issue. Ecological economics, as a broad field of knowledge creation and exchange, has traditionally been closer to social bottom-up movements, as compared to other more mainstream approaches in economics. The authors also delineate a research agenda and propose some key lines of action for strengthening a fruitful exchange between academicians and activists over societal goals, particularly in advanced economies. The tenets of the contemporary degrowth movement are not shared by the whole community of ecological economists. However, what is a common concern is the biophysical limits to the economy.

The flow of resources into the economy is not only a relevant issue because of the threats of depletion or over-exploitation, but it is also

relevant due to the multiple conflicts that arise between social groups about access and the distribution of benefits and costs derived from the use of natural resources. Ecological economics has always had a fluid exchange with political ecology, the field that studies socio-environmental conflicts. The contribution of Rodríguez-Labajos and Martínez-Alier discusses the relationship between water social metabolism ('the hydro-social cycle') and water conflicts. The authors outline a classification of contemporary conflicts over water resources and elaborate on what type of responses from social movements and new management institutions have emerged from conflicts, showing that disputes over water can also be a creative source of institutional changes.

The contribution by De Groot and Braat deals with one of the currently most influential concepts in the environmental field, namely the notion of ecosystem services. This approach is based on the proposition that lack of information about the benefits humans derive from ecosystems and wrong incentives remain as the key sources of the persistent degradation of the natural environment. The authors give an overview of the history of the ecosystem services paradigm and elaborate on the typology of those services. They also discuss the ongoing debate and existing methods to estimate the values (quantify the importance) of ecosystem services. Furthermore, the chapter addresses a critical issue, namely how to incorporate the notion of ecosystem services into decision making in order to improve socio-environmental governance. In this field, they pinpoint three key issues currently hotly debated: how to estimate and aggregate monetary values; how to undertake trade-off analysis and to incorporate it into decision processes; and how to raise awareness and create positive incentives to change practices.

In their chapter, Gómez-Baggethun and Martín-López also tackle the issue of how to incorporate the benefits humans derive from the natural environment into decision making by means of allocating values to ecosystem services. Instead of taking a monist (monetary) approach for value assessment, they plead for 'value pluralism'. That is, they consider different social values allocated to the natural environment, and they assess them by using a broad set of units and scales. This calls for integrated valuation and methodological pluralism, which can, however, be very challenging (due to the problem of aggregation and a higher complexity of communication). Such an approach would need openness to different knowledge systems and the will to negotiate values along different social groups and organizations. This constitutes an appealing research and policy agenda, which is still under construction among ecological economists, despite the progress made during past decades, particularly in the development of integrated methodologies for socio-environmental valuation.

Adopting a plural vision about knowledge systems involves, among other things, taking into consideration traditional environmental knowledge. In her chapter, bridging a gap between anthropology and ecological economics, Reyes-Garcia describes how the relative importance allocated to traditional ecological knowledge has been reconsidered and revalued in recent times in academic and policy arenas. Despite being threatened by modernity, this knowledge system, which is embedded in local institutions, organizations and culture, has shown a remarkable capacity for dynamism and adaptation, as well as contributing to local livelihoods, the conservation of biodiversity and ecosystem functions, and the resilience of social-ecological systems. The chapter includes a comprehensive literature review about the relationship between traditional environmental knowledge and these three dimensions, and discusses how the dynamism of these knowledge systems can contribute to enhancing the contemporary 'knowledge society'.

One of the exciting areas of recent innovation in economics has been the growing field of experimental economics. Empirical results have been noteworthy since many of them have challenged basic assumption of mainstream neoclassical models. The contribution of J.C. Cardenas analyses how the progress made by behavioural sciences over the last decades and the tools provided by experimental economics have helped to enhance our understanding of the decision-making process of individuals in collective action situations, including the management of common pool resources. These methodological approaches have been able to simulate some of the complexities involved in the management of common pool resources in real-life situations. The chapter identifies some behavioural patterns in such situations, and it delineates a possible future research agenda.

Another behavioural concern in ecological economics has been the issue of consumption. The chapter by Røpke outlines trends in consumption patterns during the past twenty years. She also discusses major trends in consumption patterns among affluent and middle-class citizens of rich countries, a key matter since these patterns reflect the aspiration of billions of people in less wealthy parts of the world. In this chapter, the phenomenon of consumption is understood from a comprehensive perspective, taking into consideration not only behavioural aspects (such as practices and habits), but also the role of economic cycles, and the structure of socio-technical systems of provision. The author conceives consumption as a key element in enabling a sustainability transition towards lifestyles more compatible with the existence of planetary biophysical constraints.

Complementing the previous chapter, the contribution of Guarín and Scholz deals with the environmental and social consequences of the consumptions patterns of the emerging middle classes at the global

level. It addresses the interesting issue of whether consumer behaviour is converging or diverging among the new middle class in emerging countries. Generalizations around this topic are difficult to elaborate, since the relationship between culture, income and consumption patterns is very complex. The authors acknowledge cognitive biases and the variety of values and motivations underlying consumption, which creates flexibility and diversity among consumers from different cultural and social backgrounds. Four broad emerging trends are identified, and their implications for environmental sustainability discussed. The authors point out that there is scope for being both pessimist and optimist about the prospects for sustainable lifestyles in the future, depending on the aspects considered.

The chapter written by Vatn is based on two basic premises: environmental problems increasingly have a global scope, with regard to both causes and solutions; and in general there is a misfit between the governance systems and the type of problems faced, which creates a 'governance gap'. From an institutional perspective, first the chapter clarifies what governance is about. Then it characterizes the main global governance challenges and discusses the variety of governance structures, as well as the configuration of the most important international agreements. The chapter ends pleading for a look beyond technological fixes (which have dominated the search for solutions to environmental problems) and necessary attention to be paid to changing the multi-level institutions governing economic and political processes.

The contribution of Ring and Barton also addresses governance issues, and more specifically it analyses the challenges involved in disentangling the role of economic instruments in policy mixes for biodiversity conservation and the provision of ecosystem services. A policy mix is understood as a particular combination of policy instruments with a common goal. After systematizing evaluation criteria for evaluating policy instruments, the authors elaborate on the possible frameworks for the analysis of policy mixes and the types of policy interactions. The chapter ends taking examples of policy mixes from two relatively novel governance approaches: payments for ecosystem services and ecological fiscal transfers.

In their contribution to this book, Coudel and co-authors examine the evolution of a novel environmental policy instrument (again, payments for ecosystem services) in one of the countries where it has been adopted swiftly and at different scales: Brazil. The authors describe the ongoing process of policy experimentation and how payments schemes have been inserted in policy mixes. They show that the success of payments for ecosystem services in Brazil has been driven by diverse policy agendas. These schemes have raised the interest of different social groups about how to

reward efforts to protect natural ecosystems and thus create incentives to adopt more environmentally-friendly practices and prevent deforestation. The authors conclude that there is yet insufficient empirical evidence about the impacts of these schemes. Much additional research is therefore needed in order to feed future decision-making processes.

In the last chapter of the book we, the editors, delineate what we consider to be the most salient concerns in contemporary ecological economics and discuss possible ways forward, while also recapitulating the main contributions made in this comprehensive volume. Overall, the contributions composing this book show a very complete picture not only of the foundation of the field but also of some of the most appealing areas of knowledge where ecological economists work nowadays.

REFERENCES

Agarwal, B. 2010. *Gender and Green Governance: The Political Economy of Women's Presence Within and Beyond Community Forestry*, Oxford: Oxford University Press.

Altvater, E. 2007. Marxism and ecological economics: toward a red and green political economy, *Monthly Review*, 58(8): 55–64.

Berkes, F. and C. Folke (eds). 1998. *Linking Social and Ecological Systems: Management Practices and Social Mechanisms for Building Resilience*, Cambridge: Cambridge University Press.

Bonaiuti, M. (ed.). 2011. *From Bioeconomics to Degrowth. Georgescu-Roegen's 'New Economics' in Eight Essays*, London: Routledge.

Boulding, K. 1966. The economics of the coming spaceship Earth, in: H. Jarrett (ed.), *Environmental Quality in a Growing Economy*, Baltimore, MD: Resources for the Future/ Johns Hopkins University Press, pp. 3–14.

Cleveland, C., D.I. Stern and R. Costanza (eds). 2001. *The Economics of Nature and the Nature of Economics*, Cheltenham, UK and Northampton, MA, USA: Edward Elgar Publishing.

Costanza, R. 1980. Embodied energy and economic valuation, *Science*, 210: 1219–24.

Costanza, R. (ed.). 1991. *Ecological Economics: The Science and Management of Sustainability*, New York: Columbia University Press.

Costanza, R., C. Cleveland and C. Perrings (eds). 1997. *The Development of Ecological Economics*, Cheltenham, UK and Northampton, MA, USA: Edward Elgar Publishing.

Daly, H. (ed.). 1973. *Toward a Steady-State Economy*, San Francisco, CA: W.H. Freeman.

Daly, H. and J. Cobb. 1989. *For the Common Good: Redirecting the Economy Toward Community, the Environment and a Sustainable Future* (2nd edn 1994), Boston, MA: Beacon Press.

Ehrlich, P.R. 1968. *The Population Bomb*, New York: Sierra Club/Ballantine Books.

Foster, J.B. 1999. Marx's theory of metabolic rift: classical foundations for environmental sociology, *The American Journal of Sociology*, 105(2): 366–405.

Funtowicz, S. and J. Ravetz. 1994. The worth of a songbird: ecological economics as a post-normal science, *Ecological Economics*, 10: 189–96.

Georgescu-Roegen, N. 1971. *The Entropy Law and the Economic Process*, Cambridge, MA: Harvard University Press.

Georgescu-Roegen, N. 1977. Matter matters too, in: K.D. Wilson (ed.), *Prospect for Growth: Changing Expectations for the Future*, New York: Praeger.

Gowdy, J. and S. Mesner. 1998. The evolution of Georgescu-Roegen's bioeconomics, *Review of Social Economy*, 56(2): 136–56.
Grinevald, J. 1976. La révolution carnotienne: thermodynamique, économie et idéologie, *Revue Européenne des Sciences Sociales et Cahiers Vilfredo Pareto*, 36: 39–79.
Hardin, G. 1968. The tragedy of the commons, *Science*, 162: 1243–8.
Hardin, G. 1974. Lifeboat ethics: the case against helping the poor, *Psychology Today*, 8(4).
Hayek, F.A. 1952. *The Counter-Revolution of Science: Studies of the Abuse of Reason*, Glencoe, IL: The Free Press.
Hornborg, A. 1998. Towards an ecological theory of unequal exchange: articulating world system theory and ecological economics, *Ecological Economics*, 25: 127–36.
Hueting, R. 1980. *New Scarcity and Economic Growth: More Welfare Through Less Production?* Amsterdam: North Holland.
Jackson, T. 2009. *Prosperity without Growth: Economics for a Finite Planet*, London: Routledge.
Kerschner, C. 2010. Economic de-growth vs. steady-state economy, *Journal of Cleaner Production*, 18(6): 544–51.
Kumar, P. (ed.). 2010. *The Economics of Ecosystems and Biodiversity: Ecological Economics Foundations*, London and Washington, DC: Earthscan.
Martínez-Alier, J. and I. Røpke (eds). 2008. *Recent Developments in Ecological Economics*, Cheltenham, UK and Northampton, MA, USA: Edward Elgar Publishing.
Martínez-Alier, J. with K. Schlüpmann. 1987. *Ecological Economics: Energy, Environment and Society*, Oxford: Blackwell.
Martínez-Alier, J., U. Pascual, F. Vivien and E. Zaccai. 2010. Sustainable de-growth: mapping the context, criticisms and future prospects of an emergent paradigm, *Ecological Economics*, 69(9): 1741–7.
Max-Neef, M. 1992. *From the Outside Looking in: Experiences in Barefoot Economics*, London: Zed Press.
Mayumi, K. 2001. *The Origins of Ecological Economics: The Bioeconomics of Georgescu-Roegen*, London: Routledge.
Muradian, R., E. Neumayer and I. Røpke. 2006. Introduction to the special issue on migration, globalization and the environment, *Ecological Economics*, 59(2): 185–6.
Muradian, R., E. Corbera, U. Pascual, N. Kosoy and P. May. 2010. Reconciling theory and practice: an alternative conceptual framework for understanding payments for environmental services, *Ecological Economics*, 69: 1202–8.
Naredo, J.M. 1987. *La Economía en Evolución. Historia y Perspectivas de las Categorías Básicas del Pensamiento Económico*, Madrid: Siglo XXI.
Norgaard, R.B. 1990. Economic indicators of resource scarcity: a critical essay, *Journal of Environmental Economics and Management*, 19(1): 19–25.
O'Connor, J. 1988. Capitalism, nature, socialism: a theoretical introduction, *Capitalism Nature Socialism*, 1: 11–39.
O'Connor, M. and C. Spash (eds). 1999. *Valuation and the Environment*, Cheltenham, UK and Northampton, MA, USA: Edward Elgar Publishing.
Ostrom, E. 1990. *Governing the Commons: The Evolution of Institutions for Collective Action*, Cambridge: Cambridge: University Press.
Passet, R. 1979. *L'Économique et le Vivant*, 2nd edn 1996, Paris: Economica.
Podolinsky, S. 1880. Le socialisme et l'unité des forces physiques, *La Revue Socialiste*, 8: 353–65.
Podolinsky, S. 1883. Menschliche Arbeit und Einheit der Kraft, *Die Neue Zeit*, 1(9): 413–24 and 1(10): 449–57.
Polanyi, K. 1957. Aristotle discovers the economy, in: K. Polanyi, C.M. Arensberg and H.W. Pearson (eds), *Trade and Markets in the Early Empires: Economies in History and Theory*, Glencoe, IL: The Free Press.
Prigogine, I. and I. Stengers. 1984. *Order Out of Chaos: Man's New Dialogue with Nature*, New York: Bantam Books.
Rodriguez-Labajos, B. and J. Martínez-Alier. 2013. The economics of ecosystems and biodiversity: recent instances for debate, *Conservation and Society*, 4(11): 326–42.

Ronsin, F. 1980. *La Grève des Ventres: Propagande Malthusienne et Baisse de la Natalité en France, XIXe–XXe siècles*, Paris: Aubier-Montaigne.
Schrödinger, E. 1944. *What is Life: The Physical Aspect of the Living Cell*, Cambridge: Cambridge University Press.
Sieferle, R.P. 2001. *The Subterranean Forest: Energy Systems and the Industrial Revolution*, Cambridge: The White Horse Press.
Soddy, F. 1926[1987]. *Wealth, Virtual Wealth and Debt*, California, USA: Noontide Press.
Spash, C. (ed.). 2009. *Ecological Economics*, London: Routledge.
Tamanoi, Y., A. Tsuchida and T. Murota. 1984. Towards an entropic theory of economy and ecology: beyond the mechanistic equilibrium approach, *Economie Appliquée*, 37: 279–94.
Temper, L. and J. Martínez-Alier. 2013. The god of the mountain and Godavarman: Net Present Value, indigenous territorial rights and sacredness in a bauxite mining conflict in India, *Ecological Economics*, 96: 79–87.
Vatn, A. 2005. *Institutions and the Environment*, Cheltenham, UK and Northampton, MA, USA: Edward Elgar Publishing.
Vatn, A. and D. Bromley. 1994. Choices without prices without apologies, *Journal of Environmental Economics and Management*, 26: 129–48.
Vernadsky, V. 1924. *La Géochimie*, Paris: Alcan.
Victor, P. 1991. Indicators of sustainable development: some lessons from capital theory, *Ecological Economics*, 4(3): 191–213.
Victor, P. 2008. *Managing without Growth: Slower by Design, not Disaster*, Cheltenham, UK and Northampton, MA, USA: Edward Elgar Publishing.