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Ecological Economics, Societal Transformation and Climate Change

by

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I. Introduction

This paper is a cautious first attempt to review the contributions of Ecological Economics (EE) to research on 'transformation' and 'transition' towards a more sustainable future. The approach is cautious, because the field of EE is very diverse and non-homogeneous, a fact highlighted by the divergence of material in available collective works (Costanza et al., 1997b; Martinez-Alier and Røpke, 2008; Perrings, 2008; Spash, 2009a). The journal *Ecological Economics* is also contentious because it's Editors have chosen to include a broader field of research in environmental studies, sustainability, and mainstream resource and environmental economics rather than specifically being focussed upon defining a subject area called EE (Spash, 2012c; Spash, 2013b, a). In a series of recent articles (Spash, 2011; Spash, 2013b; Spash and Ryan, 2012), the divisions have been explained as consisting of three main camps: new resource economists (orthodox neoclassical), new environmental pragmatists (atheoretical), and social ecological economists (vanguard).

Despite this EE is founded on the principle of interdisciplinary cooperation and endeavour. That is a fundamental position is taken that environmental problems can only satisfactorily be addressed through a combined understanding of the natural and social sciences and that policy implementation requires engagement with non-scientists and lay knowledge. Many researchers on human induced climate change have slowly come to the same realisation (Driessen et al., forthcoming). Both interdisciplinary and transdisciplinary means to inclusion and integration of knowledge have been deemed important in EE. However, both have proven challenging and have often been absent from published work in the journal *Ecological Economics*, which has increasingly favoured papers dominated by a mono-disciplinary mainstream economics approach (Anderson and M'Gonigle, 2012; Plumecocq, forthcoming). Claims of transdisciplinarity have often been superficial rather than substantive (Spash, 2012c; Spash, 2013b).[1]

This review is part of the project called "TRAFOREVIEW" funded under the 2011 Joint Programming Initiative in the area of climate change research (JPI Climate, 2011). The task set for the authors was twofold.

1. Review the social-scientific literature of their specific field in terms of approaches to and research perspectives on the concept of social transformation/transition. We take the terms transition and transformation as synonymous.[2]

[1] Transdisciplinary research is taken to involve scientific expert collaboration with non-scientific stakeholders, lay-public and others in civil society in the joint creation of knowledge. Spash (2013b) differentiates this strong transdisciplinary approach based upon interdisciplinary scientific expert knowledge from a weak approach which uses the concept to avoid engagement in disciplinary understanding.

[2] A clear formal distinction is hard to draw between the concepts of transition and transformation. A dictionary definition of transition is "*the process or a period of changing from one state or condition to another*", while transformation is a "*marked change in form, nature, or appearance*" (Oxford Dictionaries, 2013). Transition management has been the centre of attention in a dominantly Dutch approach (Feiner and Wesely, 2013). This literature defines sustainability transitions as "*long-term, multi-dimensional, and fundamental transformation processes through which established socio-technical systems shift to more sustainable modes of production and*

2. Relate this to how that field deals with the issue of climate change.

In order to address the first objective we arrange the paper according to a set of TRAFOREVIEW pre-defined subject areas: Ontology, Epistemology, Drivers (What is driving the system?), Objects (What needs to change?) Subjects (Who needs to take action?) and Means (How can change be achieved?). This approach aims to provide comparability across the project's reports. In order to address the second objective, the main discussion is kept separate as a distinct review section that calls upon the preceding review.

II. What is ecological economics?

In the book that came out of the first conference of the newly founded International Society for Ecological Economics (ISEE),[3] EE was defined as '*the science and management of sustainability*' (Costanza, 1991). A key concern was the relevance of biophysical limits to economic systems and the failure of orthodox economics to address these. EE aims to address the interdependencies between human and natural systems. This recognises the negative impacts and value conflicts arising from human society and its economy through the exploitation of the natural and physical environment. From the very beginning the field was based on the grounds that environmental problems were real social issues requiring political and economic action or in other words on ideological motivations (Spash, 2013b).

At the same time as the founding conference, Joan Martinez Alier (1990), an economic historian, traced the antecedents of the new EE endeavour back into the 1800s. His book explained the relevance and importance of contributions for EE made in the past by political economists such as Thomas Malthus and John Stuart Mill, biologist and urban planner Patrick Geddes, physician Sergei Podolinksi, engineer and social reformer Josef Popper-Lynkeus, biologist and systems ecologist Alfred Lotka and chemist Frederick Soddy. This showed how the central concerns of the emerging EE field about biophysical limits had strong links to ideas in energy analysis, systems thinking and political economy.

EE is an interdisciplinary field of academic research (Spash, 2013b), which "… *sees the economy as a subsystem of a larger finite global ecosystem*" (Martinez-Alier, 2001, p. 4016). In fact, the way in which it attempts to combine knowledge from different disciplines means it could be described as a *"movement"* for *"...expressing concern over environment-economy interactions with the potential for common cause to be expressed through shared concepts."* (Spash, 2013b, p. 6).

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consumption" (Markard et al., 2012, p. 956). However, Rotmans (2001) describes transitions as "*the result of developments in different domains. In other words, a transition can be described as a set of connected changes, which reinforce each other but take place in several different areas, such as technology, the economy, institutions, behaviour, culture, ecology and belief systems*". This is closer to common understanding of transformation (i.e. not dependent on a specific preferred outcome), whereas Markard's (2012) definition actually contains the word "transformation". These differing interpretations suggest that, at this stage, there is a lack of conceptual clarity distinguishing the terms.

[3] Hosted by the World Bank, Washington D.C., 1990

Divergence from Orthodox Economics

The modern movement was created as a platform for all those discontent with the state of affairs or lack of arenas for engaging with the human-society-nature nexus in their original disciplines (e.g., environmental and resource economics, ecology and physics). Founding members, actual or conceptual, have been clear about their rejection of the orthodox economic mainstream traits including its:

- affinity with mathematical formalism and abstraction (e.g. Daly and Cobb Jr, 1989; Georgescu-Roegen, 1979), which it appears to equate to rigor (Spash, 2013b);
- value *concept* adopted from mechanical physics (Georgescu-Roegen, 1971; Kapp and Kapp, 1963; Norgaard, 1987; Söllner, 1997);
- definition of humans as rational, utility maximising individuals (homo-economicus) (Daly and Cobb Jr, 1989; Gintis, 2000; Max-Neef, 1992);
- "ideology of efficiency" (Bromley, 1990);
- ignorance of biophysical limits, including the carrying capacity of ecosystems (Ehrlich, 1968) and the laws of thermodynamics (e.g. Ayres, 1998; Daly, 1992a; Georgescu-Roegen, 1971; Georgescu-Roegen, 1975);
- unquestioned technological optimism (Costanza, 1989; Røpke, 1996);
- belief in relative scarcity and unlimited substitutability of resources (Ayres, 2007; Daly, 1992b);
- failure to recognise refusals to trade (Spash, 1998a, 2000; Spash and Hanley, 1995; Spash et al., 2000), and general commensuration of the incommensurable (O'Neill, 1993, 1997b, a);
- substitution of natural with man-made capital (Holland, 1997).[4]

Directly related to this are critiques of the orthodoxy's unconditional dedication to economic growth (e.g. Daly, 1992b; Hirsch, 1977; Max-Neef, 1995; Meadows et al., 1972; Mishan, 1969). Economic growth, typically measured as Gross Domestic Product (GDP), is mistakenly interpreted as an indicator for welfare (Easterlin, 1995; Milbrath, 1993) and progress (Common, 1988; Norgaard, 1994a). Attempts to make such economic growth compatible with sustainability have been attempted via the empirically untenable concept of **absolute decoupling** of resource and energy use from GDP (Alcantara and Roca, 1995; de Bruyn and Opschoor, 1997; Dittrich et al., 2012; Krausmann et al., 2008; Max-Neef, 1995; Schandl and Schulz, 2002). This faith in the potential of a dematerialised economy is often connected to a belief that a service or knowledge economy can replace the traditional energy and material intensive industrial economy.

Integration Across Disciplinary Boundaries

The anti-growth element in EE is strongly linked to understanding of entropy and traces back to the work of Georgescu-Roegen (1971). Physics and the laws of thermodynamics also inspired Georgescu-Roegen (1971) to develop his flow-fund model and Ayres (1996) to the development of the 'materials balance principle', 'industrial metabolism' and the closely

[4] Extending the use of the concept of capital to the natural and social realm has been both advocated by some in EE and also been regarded as highly problematic by others (e.g. Spash and Clayton, 1997).

related field of Industrial Ecology.[5] EE also embraced the work of energy analysts and their research interests, such as the **Jevons Paradox** (Alcott, 2005; Giampietro and Mayumi, 2008; Jevons, 1965 [1865]), the 'maximum power principle'[6], 'emergy[7]' and 'net energy'[8] (Odum, 1971) and the energy return on energy invested (EROI) (Hall et al., 1986). For some time there was also lobbying in favour of reviving energy as a monistic unit of value to challenge money and cost-benefit analysis due to their lack of a link to physical reality. This however, for good reasons (Söllner, 1997) was fiercely opposed by important figures of the movement (e.g.Georgescu-Roegen, 1975). Embedded in energy studies and biophysics is the more recently defined concept of resource peaks e.g. Peak-Oil (e.g. Kerschner, 2012).

The other major area of natural science integration in EE has been with the biological sciences and of course ecology. Ecologist Ann Mari Jansson initiated collaborative international research workshops for the integration of concepts from ecology with those from economics, such as complex adaptive systems theory applied to social ecological systems (Røpke 2004). EE has pursued this via linking ecological and economic models, but also via evolutionary theories (Gowdy and Ferreri Carbonell, 1999). In EE one thread of thought has developed the socio-economic relevance of the ecological concept of co-evolutionary development[9] (Common, 1988; Gowdy, 1994; Norgaard, 1984). A distinction needs to be drawn from the approach here and the attempts by the Chicago School economists to integrate neoclassical economic models and biology via theories of selfish behaviour and competitive survival. This in effect amounted to a form of evolutionary determinism and social Darwinism (Gowdy, 1987).

Indicators, Values and Multiple Criteria

In an attempt to provide data for the material and energetic costs of the expanding human economy there have been ambitions to develop indicators of physical flows including: material and energy flow analysis (Fischer-Kowalski and Hüttler, 1998; Haberl et al., 2004), the human appropriation of net primary production (Haberl et al., 2007; Vitousek et al., 1986) and the more controversial ecological footprint (Wackernagel and Rees, 1997)[10]. Moreover a number of EE scholars rediscovered Leontief's (1936) input-output analysis for environmental studies (Alcántara and Padilla, 2009; Hubacek and Sun, 2001) and combined the model with the ecological footprint (e.g. Hubacek and Giljum, 2003), physical data (e.g. Giljum and Hubacek, 2004), material and energy flow analysis studies (e.g. Muñoz et al., 2009) and resource peaks (Kerschner and Hubacek, 2009).

[5] Later also social metabolism and social ecology (Hausknost, 2013).
[6] Every system exploits the available energy flow around it to a maximum (nothing goes to waist and nothing is saved for later).
[7] Embodied energy in organisms, products, services and so on.
[8] Energy remaining from a primary source after discounting the energy necessary to make it useable by the human economy.
[9] Different interdependent systems evolve together i.e. influencing each other's development e.g. economy and society.
[10] For a critique of the ecological footprint that is widely acknowledged in the EE movement see Fiala (2008).

The supposed power and political impact achieved by a monistic measure has remained attractive for some EE researchers, while also being highly problematic. Indeed despite a pluralist value theory many pursue such measures (e.g. Kubiszewski et al., 2013; Lawn, 2003; Stockhammer et al., 1997). For example, the Index of Sustainable Economic Welfare (ISEW) first put forward by Daly and Cobb (Daly and Cobb Jr, 1989) has been challenged as inconsistent with the authors own value positions (Ziegler, 2007). This is now explicitly recognised by Daly and Cobb as having been a political manoeuvre to challenge GDP and that a multi-criteria approach would be theoretically more appropriate (Daly and Cobb Jr, 2007). Similar endeavours, such as the Genuine Progress Indicator (Hamilton, 1999) are also inconsistent with value incommensurability and remain at the margins of the movement, despite ambitions to revive these indexes (e.g. Lawn, 2003). This pursuit of indicators and single numbers for supposed political impact has recently been criticised as a form of naïve environmental pragmatism because the numbers produced lack a theoretical basis and are being advocated purely as rhetorical tools within a political structure which goes unexplained by the advocates (Spash, 2009b).

In response to arguments claiming the superior public impact of a single (often monetary) number, Martinez-Alier et al. (1998) argue that human intelligence is perfectly capable of processing more than one indicator for different, only weakly comparable, phenomena. Hence those aiming to broaden understanding of environmental values have advocated forms of multi-criteria assessment (Faucheux and O'Connor, 1998; O'Neill and Spash, 2000; Stagl et al., 2001). Proposals in that direction have been brought forward under the name of social multi-criteria-analysis (SMC) (Munda, 2008), multi-criteria mapping (Stirling, 1997) and multi-scale integrated analysis of societal and ecosystem metabolism (MuSIASEM) (Giampietro et al., 2009).

Environmental Values and Value Articulating Institutions

A central controversial question in EE has been how environmental change and entities should be valued. In accord with the pragmatic drive high profile attempts have been made to produce single monetary numbers meant to represent the value of the world's ecosystems and all remaining wild nature (Costanza et al., 1997a). More generally there has been a thrust of work in the direction of commodification of nature into goods and services. This monetisation work goes against the existence of value and ethical pluralism. Indeed the basic value theory behind such work is either totally absent or identical to that from orthodox environmental economics with its foundation in **microeconomic welfare theory**.

In EE there has been a long standing awareness of the problems embedded in both welfare economics and environmental economics (Gowdy, 2004, 2005; Gowdy and Olsen, 1994). The problems inherent in the **commodification of Nature** have been explored and explained (O'Neill, 1993; Vatn, 2000). There has been open criticism of the inadequacies with the benefit and value transfer work behind the ecosystems valuation work, and indication of better alternatives (Spash, 2005, 2006b; Spash et al., 2005). The use of preferences as the basis for valuation has been shown to be highly problematic (Spash, 2008a; Spash and Hanley, 1995).

In addition, there has been a range of work pointing out the failures of the economic approach to the behaviour and psychology of the individual including the assumptions encapsulated on the economic definition of rationality (Vatn, 2004). This has serious implications for the way in which stated preference work (e.g., using contingent valuation and choice experiments) is conducted and interpreted (Spash, 2008c). Interdisciplinary work on **economics and social psychology** has expanded the limited mainstream economic model to include attitudes and norms, and further beyond this ethics (Spash, 1997). In so doing research has revealed the inadequacies of the economic concept of value for interpreting public responses to environmental change such as biodiversity loss and ecosystem degradation (Spash, 2006b; Spash et al., 2009).

A related issue is the meaning and relevance of refusals to trade. [11] This literature covers the intrinsic value of nature (O'Neill, 1992), the incommensurability of values (Aldred, 2006), the weak comparability of values (Martinez-Alier et al., 1998; O'Neill, 1993) and the presence of **lexicographic preferences** and rights based thinking (Spash, 1998a; Spash and Hanley, 1995). This shows the widespread basis for defence of Nature on grounds which do not fall within the economic preference utilitarian calculus.

A result of recognising the impossibility of reducing environmental values to a single metric is to open up the question as to how incommensurable values can be taken into account. The critical institutionalist and ecological economist, Arild Vatn has pointed towards the need for developing '**value articulating institutions**'(Vatn, 2005). This links to calls for approaches that allow public participation (Kallis et al., 2006), representation (O'Neill, 2001) and deliberation (Spash, 2008b) rather than the expert led cost-benefit analysis and ecosystem services valuation approach.

A related concern is how to represent different values and interests. There is a particular problem in the environmental area with the inclusion of **silent voices**. That is how voice can be given to those who are silent or not present such as non-human animals and future generations (Norton, 2003; Spash, 2002c). Similarly there is the issue of how the poor can be given representation and how they are excluded by an approach oriented towards an ability to pay. In this area the work of Martinez-Alier is relevant. His concepts include 'ecological debt' (Martinez-Alier, 1993; Martínez-Alier, 2002) and the 'environmentalism of the poor' combined with the study of 'environmental conflicts' and 'commodity frontiers' (Martinez-Alier, 2002).

Strong Uncertainty and the Science-Policy Interface

The treatment of uncertainty and role of expert, science-led decision making processes is partially related to the concerns over environmental valuation but also goes well beyond this specific issue. An initial seminal article in EE that introduced the topic of **post-normal**

[11] Individuals may refuse to trade or be compensated for the loss of environmental attributes or entities. This may be seen as maintaining principles such as protecting rights for animals. For example, defending whales at the risk of loss of life by the person involved as found in environmental activist organisations such as Sea Shepherd.

science was directly related to the use of monetary valuation and cost-benefit analysis for addressing climate change (Funtowicz and Ravetz, 1994a). The ideas can be seen as relating to the earlier criticisms of treating all uncertainty as risk (Keynes, 1988 [1921]). Public decision processes can be seen as involving the bounding of knowledge in a way that creates **partial ignorance** (Stirling, 1997). They also involve social indeterminacy (Wynne, 1994). The conceptualisation of uncertainty then requires recognising **strong uncertainty** and how this differs from the weak uncertainty that is typically discussed in risk assessment (Spash, 2002a).

The theoretical critique involves a broader deconstruction of the role of expert knowledge and statistics in public policy. This is then an issue both relating to values and valuation as well as the role of public participation and lay knowledge in general. The implication of partial ignorance and strong uncertainty are that greater precaution is needed about new technologies and clearer approaches are necessary for mapping out value positions and identifying areas of ignorance (Stirling, 1999, 2007; Stirling and Mayer, 2005). A related concept addressing elements of strong uncertainty is Ciracy-Wantrup's '**safe minimum standard**' (Ciriacy-Wantrup, 1952; Seidl and Tisdell, 2001). Opening-up public decision processes to alternative means for addressing strong uncertainty requires using alternative methods, such as scenario analysis, without attempting to associate future states to either objective or subjective probabilities. Attempts to make this kind of understanding operational have involved a strong transdisciplinary approach (van der Sluijs et al., 2005) and openness regarding the interconnected fact-value relationship (see for example the work of Martinez-Alier et al., 2011 who instigated a fruitful dialoge between activists and scientists).

III. Philosophy of Science in EE

Numerous calls have been made for developing a unifying ontology and epistemology for the EE movement (Costanza, 1996; Costanza et al., 1998; Daly, 1991; Daly and Farley, 2004; Munda, 1997; Spash, 2012b; Özkaynak et al., 2002). This may be understood as answering a series of questions: what do we understand as being the reality with which we are engaging, what are its key features, how do the various elements then fit together and what are their properties?

This need for a unifying approach based upon a common understanding of reality has very often been framed using Schumpeter's (1994 [1954]) concept of a preanalytic vision (e.g. by Anderson and M'Gonigle, 2012; Costanza, 1996; Daly, 1991; Daly and Farley, 2004; Munda, 1997; Özkaynak et al., 2012; Spash, 2012b). This also involves commitment to ideological positions. Spash (2012b) argues that insufficient progress has been made in the endeavour of creating a unifying preanalytic vision for EE so far – a fact he attributes to the implications of methodological pluralism in the movement. In his 'tentative vision for EE' he offers a set of suggestions for the foundation of EE in terms of ontology, epistemology, methodology and ideology (as will be presented below).

Schumpeter's (1994 [1954]) preanalytic vision is ideological by definition. Ideology is a starting point which he believed could be (at least partially) removed and challenged over

time by scientific understanding. The claim that fact and values can be separated and ideology is value laden and unscientific is then challenged. Neoclassical economics, for example, claims ideological neutrality but actually has an implicit ideological bias towards the present capitalist system (Söderbaum, 2011). Box 1 reproduces Spash's (2012b) list of ideological beliefs in EE (without claiming comprehensiveness or definitiveness).

Box 1: Ideological Beliefs in Ecological Economics

- Ethical neutrality should be rejected and ethical positions made explicit;
- Both human and non-human inhabitants of Earth are morally considerable;
- Action is required to address gender inequity and inequity between, within and across social groups, time periods and spatial dimensions;
- There are more meaningful aspirations for human existence than hedonism (e.g. invoking philosophical concepts such as flourishing, a 'worthwhile life', the 'good-life');
- Restrictions are necessary on population growth and the scale of human activity;
- Levels of material and energy consumption per capita prevalent in the industrialised world are excessive and its social and environmental consequences unacceptable;
- Opposition is required to the wanton destruction of war and the military-industrial complex;
- We should uphold democratic principles of fairness and justice, including international human rights and protection of the innocent from harm;
- Ecological economics can change the world by creating better understanding of the structure of the social and environmental reality in which we live and communicating its findings to help achieve that change.
- Ecological economists should act personally in ways consistent with their environmental and social values.

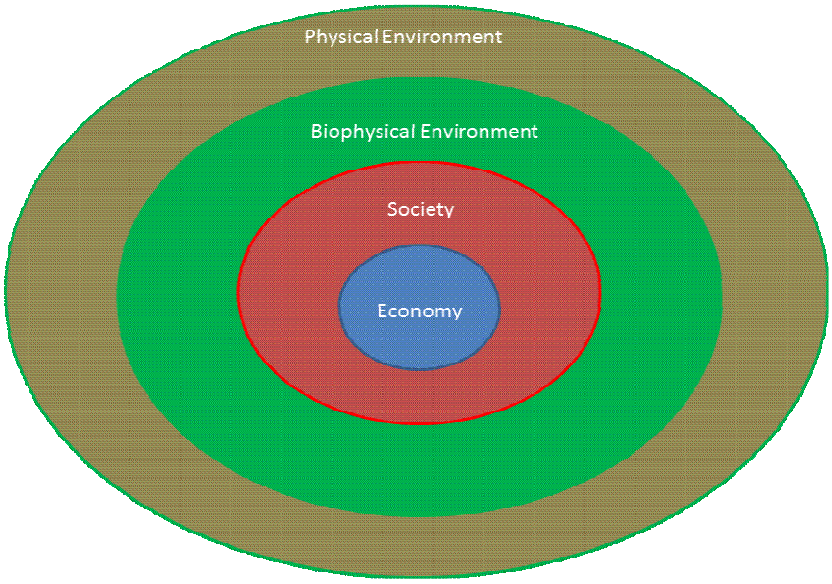
Source: Spash (2012b) p. 45

Ontological assumptions

Figure 1 below illustrates the **hierarchical systems level ontology** of EE. The economy is embedded in society, which in turn is embedded in the biophysical environment, which yet again is embedded in the physical environment. This means economic systems, as the lowest level, are subject to all the higher level systems including such things as the laws of thermodynamics. The economy is therefore seen as an open (exchanging materials and energy) subsystem of a materially finite planet. This contrasts with the typical approach in economics that treats the system as isolated, i.e. having no external energy or material flows.

This embedded structure should not be understood as reductionist. That is, even though humans are composed of atoms and chemical substances this does not mean that their composition as entities can be understood from a close study of these components, any more so than behaviours could be determined by studying genetic codes. Such reductionism has been reject by EE (Georgescu-Roegen, 2009 [1979]; Norgaard, 1994b). Neither can the human society be fully understood studying the behaviour of individuals and simply aggregating this. The concept of **emergent properties** then becomes highly relevant for understanding social reality (Lawson, 2012).

Figure 1: Hierarchical systems level ontology of Ecological Economics



While the biophysical ontology described above is well founded and elaborated within the movement the **social ontology** is still rather weak. This can be seen as a failure to address the social and political aspects of economic systems and resource use. Anderson and M'Gonigle (2012, p. 42) regard this as evident in the half-embrace of the anomaly of economic growth i.e., recognising its entropic effect but not its capitalist cause. Environmental problems framed as a purely scale issues creates a focus on there being "too much economic activity" (e.g. Daly, 1977, 2010) rather than qualitative aspects of the economy. This has allowed some in EE to avoid clarifying and conceptualising social reality and detailing how economic systems create relationships of exploitation, accumulation and inequity. However, the social ecological economics camp explicitly counters this in research addressing institutions (Vatn, 2005), the market (O'Neill, 1998) and poverty (Martinez-Alier, 2002).

Box 2: Ontological Presuppositions in Ecological Economics

- An objective reality exists independent of humans;
- Humans create social reality;
- Facts about social reality are inseparable from values;
- Biophysical and social reality are distinct but are interconnected;
- A hierarchical ontology is accepted in which there is an ordered structure (e.g. biophysical, social, economic);
- Society and the individual are distinct in that the former cannot be reduced to the latter nor the latter merely aggregate to create the former;
- Complex systems and their interactions create emergent properties and are inherently unpredictable;
- Systems are continually subject to change and interaction.

Source: Spash (2012b) p. 45

That EE has a strong biophysical ontology and has taken as a core teaching the importance of the laws of thermodynamics means it has a realist element and accepts an objective external

reality. This has not always been given prominence because of the popularity of a **sociology of science**, post-normal science and social constructivism. The obvious way forward is to recognise that **realism** does not require denying a weak form of social construction of knowledge and can accept **fallibalism** and deny a strict and universal fact-value dichotomy in accord with the EE understanding of the science policy interface and strong uncertainty. Such an approach is found, for example, in critical realism. These positions are summarised in Box 2.

Epistemic Framework

The epistemological position of EE has been described as weak (Røpke, 2005), ill-defined (Faber, 2008), in need of structuring (Baumgartner et al., 2008) and precariously confused (Spash, 2012b). A key challenge for EE from the beginning was how to combine the social and natural sciences. This problem of unity of science and integrating knowledge was address by Kapp (1961) but his book has been given relatively little attention. One reason is the disfavour towards all positivist approaches and a failure to distinguish the characteristics of logical empiricism that are valid for an EE epistemology. Unity of science is too readily associated with a single truth, a narrow dogmatic positivism and exclusion of alternative viewpoints. The collaboration between different disciplines can rather be seen as an 'orchestration of the sciences' in terms of logical empiricist Otto Neurath (Martinez-Alier, 2001). A fresh look at unity and integration of knowledge is then required (Spash, 2012a).

Early on ecological economists rejected a prevalent mainstream economic approach that combines a form of 19th century scientific positivism with 17th century mechanism (Georgescu-Roegen, 1979). This has been described by Norgaard (1987, 1994b) as also entailing the rejection of universalism, atomism and monism. Yet, despite the fact that he is highly critical of logical positivism, Norgaard argues that the adoption of an alternative would exclude nearly "all of economics". He then strongly advocates a form of methodological pluralism for EE which has left it open to eclecticism. This pragmatic approach to philosophy of science, in particular with respect to methodological pluralism has recently been subject to strong criticism (Anderson and M'Gonigle, 2012; Özkaynak et al., 2012; Spash, 2012b)

Actually worse than eclecticism the openness has meant domination by the hegemonic power in the field, namely mainstream neoclassical economic approaches and methods (e.g., mathematical formalism, optimisation, preference utilitarianism, market valuation). Mainstream economics is of no great help in terms of finding a coherent epistemological position as it mixes 19th century positivism, hypothetico deduction, empiricism, rhetoric and much else. In addition, as Lawson (1997) has noted, the discipline suffers from the epistemic fallacy whereby ontology is ignored and beliefs about reality left implicit.

In EE one area where there has been some discussion about knowledge creation is post-normal science. According to post-normal science there is a physical reality (i.e. not everything is socially constructed), which can be brought to light by experimentation in certain (laboratory) conditions. However the areas where such knowledge creation is fruitful are limited and increasingly so. Outside of controlled laboratory conditions, when studying

complex interactive global systems and environmental problems, different approaches for knowledge creation are needed. Hence in cases of strong uncertainty and high decision stakes, Funtowicz and Ravetz (1991; 1994a) postulate broad participation of an '**extended peer community**', i.e. members of the lay public, in the decision making process. The problem with PNS is that in its current formulation it does not provide a clear theory of science, but is rather an attack of modern science and its practice and rhetoric. The role of this normal or traditional science, whose existence it implicitly legitimizes, remains however unclear i.e. is research in a physics laboratory valid, or is all science really post-normal (Spash, 2012b)? Moreover the implied ontology of PNS - evolving round complex systems theory - is still rather ambiguous (Kay et al., 1999) and its methodology underdeveloped (Tacconi, 1998) except for some recent progress (e.g. van der Sluijs et al., 2005). With respect to EE it could be said that PNS finds itself in a similar self-defining struggle (Turnpenny et al., 2011), "*…trying to steer a course between the postmodern temptation to be nihilistic, while avoiding the modernist temptation to claim a single optimal answer or truth*" (Spash, 2002a, p. 144).

Box 3: Epistemology for Ecological Economics

- Our scientific knowledge is always subject to strong uncertainty (i.e., partial ignorance, social indeterminacy);
- We can never prove that we have discovered the truth in our scientific understanding;
- Understanding and interpreting reality is in part a social process in which knowledge is often contested;
- Knowledge comes in different forms and is not the exclusive domain of the expert; indigenous and lay knowledge may challenge or complement expert knowledge;
- Knowledge is subject to reasoned critique and empirical investigation;
- Critique can take a variety of forms leading to the need for plural methods;
- Advancing knowledge requires accepting and rejecting information and being open to revising beliefs.

Source: Spash (2012b) p. 45

This then is the crux of the matter for EE, how to steer a way through acceptance of an objective reality while accepting a sociology of science position. The problem is that strong social constructivism is incompatible with the biophysical ontology of EE. Rather than independent constrains on human society biophysical limits might then be argued by strong constructivists to depend on personal perspective and group choice (Spash, 2012b). The accepted role of the laws of thermodynamics in EE (Daly and Farley, 2004; Georgescu-Roegen, 1971; Martinez-Alier, 1990; Munda, 1997) suggest that members of the movement do believe in some independent reality, even if the truth about this reality is unknowable, i.e. fallibilism is accepted as encapsulate in strong uncertainty (Spash, 2002a). In this regard **'**critical realism**'** appears more likely to provide answers than other approaches and has already been advocated to reform the failings of mainstream economics (Archer et al., 1998; Fleetwood, 1999; Lawson, 1997). An overall epistemological approach consistent with this and the literature in EE is summarised in Box 3 and a related set of methodological positions is described in Box 4.

Box 4: Methodology for Ecological Economics

- EE is an interdisciplinary approach to understanding;
- Successful interdisciplinarity requires integration having understood the ontological and epistemological basis for cooperation between different bodies of knowledge;
- Unstructured methodological pluralism is the antithesis of creating knowledge and understanding;
- Structured methodological pluralism requires working across fields of knowledge with those who share a common ontology and epistemology;
- Creation of mutually understood concepts is necessary for interdisciplinary understanding;
- Methods of evaluation must match the requirements of value pluralism.

Source: Spash (2012b) p. 45

IV. Transformation: Drivers, Objects, Subjects, Means

The basic position of EE is that the current social and economic system is based on the combustion of fossil fuels to drive economic growth tied to the throughput of materials. The prevalent model of development then involves massive scale interventions into the environment both to extract resources and dump waste. The result is to push well beyond the natural capacities of systems to handle waste and throughput without substantive change in functioning. Hence human induced climate change is one of many social and environmental problems arising from the systems of the modern industrial economy whether run by East-West, North-South, capitalism or communism. Others include: loss of biodiversity, toxic chemical waste, acidification of oceans, acidic deposition from the atmosphere, spread of heavy metals, hormones in water, depletion of the ozone layer. As Kapp (1978b) recognised long ago the problems are pervasive and fundamental to the system of economic exploitation regardless of political or cultural differences.

The basic answer as to why we need to change is that the systems within which we live have biophysical boundaries and if we fail to respect them then the systems will either collapse or change in ways which no longer support a humane society. Before this stage of collapse much would be lost in terms of the civilisation taken for granted today in Western culture (e.g. freedom, stability, cooperation, social norms). Much richness in the natural world is already disappearing (e.g. species, habitats, landscapes).

Change in ecological social and economic systems and their interactions is now ongoing. Environmental research indicates that for many areas we have actually crossed safe boundaries already (Rockström et al., 2009). The questions are how far humanity can avoid worst case scenarios, redirect the already irreversible and prevent future harm (to human and non-human). Lock-in is by the resource crisis, e.g., wars over petroleum access and supply. Peak Oil (the maximum rate of oil extraction per unit of time) (Kerschner, forthcoming) is either already past, or close, according to a growing number of researchers (Aleklett, 2012; Kerr, 2011; Sorrell et al., 2010). This may accelerate the rate of extraction of other resources, as substitution occurs, and bring forward their expected maximum use rate, e.g., coal (Hughes, 2008; Kerr, 2009; Zittel and Schindler, 2007), phosphorus (Cordell et al., 2009; Déry and Anderson, 2007), uranium (Dittmar, 2012; Wynne, 1994) and other minerals (Bardi

and Pagani, 2007; Mason et al., 2011; O'Neill, 1998). The impacts and implications of such phenomena are uncertain and have been contested since Jevons (1865) raised concerns over UK coal depletion, and in more recent times the limits to growth work of Meadows et al. (Meadows et al., 2005; Meadows et al., 1992; Meadows et al., 1972). Due to the specific properties of oil, and the quantities going through the current system, substitution threatens to be weak at best with the result of economic and societal collapse (Ehrlich and Club, 1971; Hall and Klitgaard, 2011; Kerschner, 2012; Tainter and Patzek, 2012). Work in the area of social metabolism has then highlighted the vulnerability of current systems and how industrialization has been built upon fossil fuels (Krausmann et al., 2008; Sieferle, 2001).

These supply side issues (i.e. how to maintain production) are complemented by a set of concerns over the demand side (i.e. what we want produced and for what reasons). The myth of traditional economic growth is that it will alleviate world poverty and remove social inequity, even though this is not part of economic growth theory and trickle down is discredited (Stiglitz, 2009). After over 70 years since Keynes managed to salvage the growth economy from collapse, world poverty and national inequity remain or are getting worse (OECD, 2011). Thus another reason for change is to move to a system which directly addresses the needs of all people for a humane life as opposed to fulfilling the wants of an elite. A related criticism is that the growth oriented economic system quickly stops increasing welfare or happiness. The position finds a range of support including that from the ISEW indicator (e.g. Stockhammer et al., 1997) and studies on self-reported happiness (e.g. Easterlin, 1974, 1995; Easterlin, 2003). There are problems with such measures (e.g., implicit hedonism, utilitarianism, individualism and reductionism). However, the basic point is a philosophical one about the meaning of well-being and the limited ability of materialism to contribute to a good life (O'Neill, 2008). This in turn raises the role of needs and satisfiers as explored by Max-Neef (2009).

In summary, the EE critique points towards the failures of the current system and the impossibility of spreading it to the world population. It borrows from many different discourses and in many ways remains fragmented (Spash, 2011, 2012b; Spash, 2013b, a). However in the following we attempt to draw out the key features that relate to what is driving the system, what needs to change, who needs to make the change, and how change can be achieved.

Drivers: What is driving the system?

EE describes a multitude of systemic drivers that make change inevitable and directing that change desirable. As set out in the 1972 limits to growth scenario analysis, a combination of factors drive exponential growth leading to a critical failure and collapse of the current system (Meadows et al., 1972). Today the main drivers typically cited are: population growth, resource peaks, resource extraction beyond renewal rates and pollution. EE has focussed largely on material and energy use as drivers of change and related these to intensive consumerism, the spread of hedonism as the ultimate lifestyle and the role of market institutions in spreading and maintaining such values (Spash, 2009a).

Population as a driver of crisis was popularised by ecologist Paul Ehrlich in the late 1960s and early 1970s (Ehrlich, 1968; Ehrlich and Club, 1971). However, the topic has not featured strongly as a research area in EE and for some this is seen as a serious failing (Alcott, 2012). The counter to regarding population as a serious driver is that technology can supply all that humans require and the world population can keep expanding as it has in the past. In EE, new technologies and artificial or synthetic creations are seen as drivers of unwanted outcomes due to the potential for surprise events and systems change outside historical experience. Thus, some criticise mainstream economics as being far too committed to technological optimism (Costanza, 1989; Ehlers and Kerschner, 2010). In this respect EE questions the common faith in solving problems via innovative highly advanced technological solutions, e.g. the Green economy.

A specific thread of criticism comes from post-normal science (Funtowicz and Ravetz, 1990; Funtowicz and Ravetz, 1992, 1993, 1994a; Funtowicz and Ravetz, 1994b; Muller, 2003; Ravetz, 1995). Faith in technology as advanced by experts has been questioned in favour of including a critical perspective from extended peer communities. This scepticism over technology is also evident from work on multi-criteria mapping (Stirling, 2007) and the need for ‘opening up’ of the decision space (Stirling, 2008). Yet the issue is not simply one of being against technology but rather concerns the use of ‘appropriate technology’, as described by (Schumacher, 1973). So the driver of concern is then invasive technology and rapid technological change.

The qualitative role of technology in the system raises concerns over the social and political structures that support and drive innovation and the institutions promoting the use of specific technological 'solutions'. This has been given some attention in a variety of contexts concerning how specific institutions act as drivers. EE work in this area covers institutional analysis of water resource use (Aguilera-Klink et al., 2000; Aguilera-Klink and Sánchez García, 2002), the spread of genetically modified crops (Aasen and Vatn, 2013; Kvakkestad et al., 2007; Kvakkestad and Vatn, 2011; Kvakkestad et al., 2008; Stirling and Mayer, 2001) and carbon trading (Coelho, 2012; Spash, 2010). This type of work points towards the role of powerful vested interest groups, and specifically those supporting, owning and benefiting directly from multi-national corporations.

In fact, social and political institutions could be added as a separate driver of change. This means turning attention to the underlying system which drives accumulation and throughput as the primary human activity in modern society. While so far largely implicit in EE, we would summarise the critical position as follows. Production systems built around rent extraction and cost shifting create a crisis due to inequity and over accumulation by a minority which threatens instability. The system must counter balance this threat and aims to do so via the promise of growth achieving gains for all. Exploitation, inequity and cost shifting as a means for capital accumulation and rent capture lay the seeds for moral outrage and social instability. Another way in which this can be framed is in terms of value conflicts in society with a struggle between alternative institutions for the conduct of human affairs (e.g. markets vs. community planning) and responding to the interests of different groups.

Objects: What needs to change?

The biophysical ontology of EE explains why the current system cannot persist and sustained economic growth, as encapsulated in economic theory, is an unattainable utopian vision. Addressing the divorce between economic systems and the reality of biophysical constraints requires a radical transformation of the present social and economic system. The basic critique from EE is at the systems level. Thus what needs to change is the structure of interactions between the economy and the environment. However, there is not an exclusive focus on structure as opposed to agency (Vatn, 2005).

Individual actors, as part of the system, also need to change their behaviour. Thus the mass consumption lifestyle that has been advocated in Western style democracies, and has now spread to other countries, is regarded as highly problematic. This lifestyle needs to change in order to address the energy and material throughput of the system as well as the obsession with hedonism as opposed to other human goals. The critique here has been developing strongly within the degrowth community which is closely associated with EE in Europe (see special issue in Ecological Economics edited by Kallis et al., 2012). For example, this has raised ideas of sufficiency and frugality (not austerity) (Alexander, 2013; Latouche, 2009), which could be linked to EE concerns over needs (Max-Neef, 1992; Rauschmayer et al., 2011).

A step further down this line of reasoning questions why people engage in the mass consumption lifestyle, fashion and the general hedonism it encourages (Røpke, 1999). This points towards corporations and marketing as manipulation (Kapp, 1978a), but also the collusion of governments in terms of maintaining and often promoting the system (e.g., the role of the technostructure in the writings of Galbraith, 1979). The latter may occur due to fears of instability under alternative structures, ideological commitment to the current system or capture by powerful interests. This implies social and political reform is also necessary to achieve change.

That issues of political economy and power relations urgently need addressing, and are integrally related with environmental and social degradation, has long been recognised (Galbraith, 1979; Kapp, 1950; Polanyi, 1944). However, a core recommendation from the EE literature, based on taking biophysical reality seriously, has been a dynamic equilibrium stead-state (capitalist) economy that avoids growth in material and energy throughput (Daly, 1977; Kerschner, 2010). This aims to stay within the carrying capacity of natural systems, emphasising a level of throughput low enough in terms of material and energy needs to rebalance natural capacities with economic and social demands. The frame is one of biophysical stabilisation which leaves the structure of social and economic systems basically unquestioned. Daly's steady state economy was harshly criticised on the grounds of thermodynamics by his former tutor Georgescu-Roegen (1977). However, Georgescu-Roegen himself offered little guidance as to the future beyond some general policy recommendations,

as shown in Box 4.[12] This "minimal bioeconomic programme" appears more as a personal wish list than a set of conclusions based upon his analytical work. While there is much with which one might agree here, the list of points appears more as an ideological statement and only very loosely related to his actual research (i.e., entropy and the economic process). Indeed a fully explored and explicit utopian vision might have been more valuable as a source of inspiration.

Box 4: Georgescu-Roegen's Bioeconomic Programme

1. the complete prohibition of weapons production, thereby releasing productive forces for more constructive purposes;
2. immediate aid to underdeveloped nations;
3. gradual decrease in population to a level that could be maintained only by organic agriculture;
4. avoidance, and strict regulation if necessary, of wasteful energy use;
5. abandon our attachment to "extravagant gadgetry";
6. "get rid of fashion";
7. make goods more durable and repairable; and
8. cure ourselves of workaholic habits by rebalancing the time spent on work and leisure, a shift that will become incumbent as the effects of the other changes make themselves felt.

Source: Goergescu-Roegen (1976 pp. 33-34)

In EE there are then different perceptions as to the degree to which the basic biophysical constraints imply social and economic, let alone political, reform. Indeed the main American textbook in EE, by Daly and Farley (2004), advocates a set of constraints to address the scale of the economy and distributional issues, but sees no fundamental problems with the social and economic system of American capitalism itself. As Daly (2010) has stated, this position is based upon a belief that market capitalism is the best system for resource allocation and the maintenance of human society. Similarly Lawn (2011) believes a steady-state economy is compatible with capitalism. However, others argue that capitalism will neither accept nor survive a steady-state economy (Anderson and M'Gonigle, 2012; Blauwhof, 2012; Trainer, 2010). The systemic argument operating at ecological, social and economic levels clearly would challenge a more narrow focus e.g., a high tech Green Economy, efficiency increases such as the Factor 10 debate, or ecological modernization. However, much remains vague in terms of what exactly needs to change according to EE.

Typically the steady-state literature fails to address qualitative issues in the production and consumption process. Logically a concern for balance with biophysical constraints does need to address the qualities of what is being produced and not just the quantity. On a quality level hazardous materials and interventionist technologies threaten to destroy, disrupt or transform

[12] Gowdy and Mesner (1998) criticise this as being half-hearted, because in reality Georgescu-Roegen, seemed convinced that humanity cannot be saved. As he stated: "Perhaps, the destiny of man is to have a short, but fiery, exciting and extravagant life rather than a long, uneventful and vegetative existence"(Georgescu-Roegen, 1976, p. 35).

systems in surprising and potentially threatening ways (e.g. nuclear waste, nano-particles, genetically modified organisms and a range of synthetic innovations). The argument developing within EE then appears to be that a sufficiency approach with systems operating in harmony with natural systems, not trying to dominate them, is appropriate. So this implies the type of products and technology need to change.

Another object of change is the way in which we measure societal well-being. Single number indicators have been proposed in EE to replace GDP (e.g. ISEW, GPI); although GDP was never meant to be a measure of well-being it seems to have been popularly interpreted as one. As with GDP, these Green GDP measures also suffer from reductionism and ignoring incommensurability. The rise of self-reported happiness measures has not helped address such basic measurement problems. One response in EE has been to turn away from such indicators and focus instead on the identification and satisfaction of human needs (Max-Neef, 1992, 1995; Rauschmayer et al., 2011). Moreover the indicator debate risks paralyzing efforts to instigate change, because action becomes tied to awaiting the impossibility of an objective indicator that will show what should be done next. Searching for sustainability indicators is then implicated in distracting from the need for judgment and responsibility in the decision process.

Subjects: Who needs to make the change?

The question of who needs to make the change can be taken from two perspectives: (i) the initiators of change, (ii) the people who are targets of change. On the basis of the fundamental restructuring of society and economy implied by the EE critique the answer to the later can be simplistically summarised as everybody engaged in mass energy and materials production and consumption. The answer to the former is more difficult. The broad EE literature includes a variety of discussions covering both the role of agency at all levels (individual, institutional, political, systemic) and the need for structural change. Determining whom EE sees as needing to make the necessary changes occur can depend upon who you ask. Some, such as those in social ecology, may regard systemic change as too difficult for actors in the system to intiate (Hausknost, 2013), while others see the role for new institutional arrangements both from bottom-up and top-down initiatives (Vatn, 2005).

In the early thermodynamic/limits to growth literature (e.g. Kneese et al., 1970), there was no particular reference as to whom should instigate change (Georgescu-Roegen, 1971). Perhaps in the 1970s there was an implicit acceptance of the role for government and a strong state intervention, e.g., building on the theories of externalities and public goods. Certainly Daly (1977) focused on top-down policies by the nation state to create his steady state economy. Daly argued that, if the time was ripe, moral growth among people would make them vote for such a system. Yet, rather typically in EE, this approach ignores political and economic structures and power relations and neglects what (or who?) would make 'the time right' or motivate 'moral growth'.

In some parts of the EE community there is still a widespread, if implicit, adoption of the orthodox idea of a fully-informed, rational, atomistic agent, despite recognising failings of

this as a representation of reality (Gintis, 2000; Sen, 1977). Using this as a model for policy analysis creates a series of failings e.g., crowding out intrinsic motivation. Reliance on the concept of 'homo economicus' has persisted despite the difficulty this poses for the inclusion of concepts arising from a broader understanding of human behaviour and motivation e.g. social altruism, refusal to trade and lexicographic preferences (Spash, 1998b, 2006b). The assumption is that a fully informed consumer is sovereign in the market place and can merely change their consumption patterns and the whole economic system will respond. Hence Green product labelling and information campaigns are seen as the best means to get the consumer, as key agent of change, to respond. Firms here are passive actors without any market power.

This opens a rather different avenue of thought in terms of who needs to change. In as far as an academic discipline, its practitioners and their rhetoric in society are important, economists need to fundamentally change their approach to economics. This would change the academic explanation of world affairs and undermine the justifications used by business and politicians for continuing policies as usual. Thus, EE has focussed much criticism at the conduct of economics and the associated market instruments recommended by mainstream economists (e.g., O'Neill, 1997a, 1998; Spash, 2010; Vatn, 2010; Vatn and Bromley, 1994). A crucial aspect of this criticism is the lack of realism and failure to address institutional structures and power relations as they are in the world and not as they should be according to idealised mathematical models in economics textbooks.

Vatn (2006) introduced the concept of value articulating institutions into EE. He argues that, in core societal issues (such as a major transformation), choices should be evaluated on the basis of what is best for society rather than on personal preferences, willingness to pay or auctioning rights. In order to create a society which recognises and empowers different values we need to create institutions that articulate these values. Preferences of individuals in decision making processes will vary according to which value articulating institutions are operational. This goes against the common argument that market mechanisms are 'value free' or in fact match the requirements of human nature (i.e. psychological egoism).

Such propositions automatically raise questions of power, i.e. who controls the processes to determine what's best for society. The change Vatn (2005) is requesting involves a move towards greater recognition of community over the individual (or what he refers to as the we vs. I problem). This also means developing the role of public participation and deliberation, if the collective is to be beneficial and avoid becoming oppressive.

However, even participatory processes can be framed, influenced or captured by those in power. So the change needed is one which changes the power relationships in society. The concept of power is perhaps rather underdeveloped in EE, but has been the subject of work by Joan Martinez-Alier. He has focussed on how to give voice to the poor (and powerless) of the global south, highlighting distributional conflicts and ecological debts (Martinez-Alier, 2002) and more recently integrating civil societies in the knowledge creation process (Martinez-Alier et al., 2011; Martinez-Alier et al., 2013). In these regards what needs to change is the structure of the political and economic system and the institutions creating disempowerment

and preventing participation. This also appears to be a call to those who are disempowered, disillusioned or disengaged (for whatever reasons) to engage in a new political process to create change.

Means: How can change be achieved?

In principle, change in the direction humanity is heading requires controlling, or at least substantively influencing, the drivers of the system outlined above. Anything that impedes that control needs to be addressed. Just as there are differences as to what different people in EE regard as drivers so there are difference as to what might be the impediments to control.

As mentioned, Daly (1973) seems to have a strong belief in national government as being able to overcome any obstacles if it has been given a popular mandate. His approach is for this government to implement policies which amount to side constraints on economic activity, which can otherwise continue as normal. He recommends three top-down institutions for his steady state economy. One addresses population control and a second material and energy throughput. Both involve regulation via market based mechanisms (i.e., cap and trade). A third addresses income inequity by imposing a maximum and a minimum earning constraint. The international dimension is not addressed by this proposal, nor is there any analysis of what might advance or what might block the proposal.

In fact Daly maintains considerable faith in the market and its supposed efficiency in resource allocation (despite his entire analysis of the growth economy being a critique of capital accumulating institutions). For example, Daly (1974 p.19; 1992b) has proposed that population could be controlled by transferable birth licences, following a suggestion by Kenneth Boulding (1964). Such markets are inherently biased towards the relatively best-off in society. More generally they can be regarded as inappropriate institutions for making such decisions i.e., the idea of placing rights to human babies in the financial markets as a traded commodity.

Others have suggested looking back a century to the Euro-American, neo-malthusian, bottom-up, women's freedom movement of Emma Goldman (Martínez Alier and Masjuan, 2009). This involves the concept of "conscious procreation" control to prevent low wages and pressure on natural resources. So the mobilisation of bottom-up movements can be seen as another approach to achieve change. This could be seen as also relating to more radical proposals from the degrowth community such as 'activist opposition', 'nowtopias' or 'revolutionary reformism'(Petridis, 2013).

What the population control example reveals is the need for new institutional designs to change human behaviour. Some favour market mechanisms for everything but EE has been strongly critical of markets as broadly defined and has raised concerns over expression (or rather suppression) of plural values in society. Vatn's call for value articulating institutions is an instance of this. Any market, as an institution, involves conventions, norms and rules which exclude community and emphasise the role of individual choice (as a selection amongst

commodities). Vatn has been concerned that a social element and idea of community cooperation via alternative institutions is being omitted or actively suppressed.

One hope for achieving change has then been to appeal to forms of participatory (Arzt, 2005; De Marchi and Ravetz, 2001; Kallis et al., 2006) and/or deliberative institutions (Niemeyer, 2005; Niemeyer and Spash, 2001; Zografos and Howarth, 2008). These have tended to be discussed in terms of taking better local decisions or encouraging small group processes for input into policy or project evaluation. The topic has been particularly taken-up in the area of environmental valuation (Aldred, 2005; O'Hara, 1996; Sagoff, 1998; Spash, 2007c, 2008b; Spash et al., 2005). There are different aims within this literature from merely wishing to improve existing methods to changing the whole way in which the societal decision process is being undertaken (Lo and Spash, 2013). The latter has been linked into the writings of Habermass and a debate over the need to reform democratic processes. This engagement with a wider public in decision making is also found in the promotion of strong transdisciplinarity in the Germanic tradition (Luks and Siebenhuner, 2007), and the application of the principles of post-normal science (van der Sluijs et al., 2005).

Yet how new institutions could be created remains unclear. In EE the means for addressing poverty, inequality, environmental degradation and so on, have yet to be seriously considered in relation to the power structures in society. There is then possibly a split between the new environmental pragmatists promoting exiting approaches within the system (e.g. emissions trading) and others, such as the social ecological economists, looking for more radical change from the grass roots movements and a politically revitalised general public.

The ability of society to respond appropriately will depend upon the rate, extent and type of surprise events that result from the on-going changes in social ecological economic system interactions. In this respect a more resilient human system is merely able to delay the inevitable adjustment longer. For example, the ability to adapt to climate change delays action on greenhouse gas mitigation. This would mean change can be achieved only after seriously exceeding natural systems limits. Achieving change as a conscious policy initiative often seems highly unlikely. This means EE scholars are left with the alternative of concluding that nothing will change until too late. Still the hope remains that transformation to an alternative socio-economic system can be achieved by volition not contrition, design not disaster.

V. EE and Climate Change

For a long time Climate Change research has been a project of the natural sciences. Module 3 of the JPI Climate's Strategic Research Agenda (2011) "*Societal transformations in the face of climate change*" however emphasises the need to strengthen the role of the social sciences in climate research (i.e. Climate social science). It calls for intensified research into the social dimension of climate change and "*… a need to move beyond the notion that the role of social science is that of removing institutional and cultural barriers to the implementation of infrastructural and technological solutions or providing input to socio-economic scenarios*" (Driessen et al., forthcoming, p. 9) The goal is a sustainable transformation towards both

climate friendly (through mitigation) i.e. "carbon neutral" and climate-proof (through adaptation) European Societies. "JPI Climate facilitates the coordination, collaboration and exploitation of synergies while working against fragmentation and duplication of efforts" (JPI Climate, 2011, p. 7) in three domains: (1) geographic i.e. among its 13 European member countries[13]; (2) societal – in the name of *transdisciplinarity*, connecting scientists with policy/decision makers and other stakeholders and (3) scientific *interdisciplinarity* – establishing strong links between the natural and the social sciences (JPI Climate, 2011, p. 12). EE could be regarded as the research field with the longest history in trying to establish these type of links in the context of sustainability. Below we describe the movements contributions to research on human induced climate change according to: (i) the scale of change needed, (ii) uncertainty, (iii) evaluation methods, (iv) ethics and (v) policy responses.

Scale of change needed

The Kyoto Protocol, ratified in 2001 to control the human induced enhanced Greenhouse Effect, required signing countries to reduce their CO_2 emissions by 5% relative to 1990 levels until 2008-2012. This was already a rather modest goal compared to the 80% reductions that will be needed in order to have a good chance to avoid temperature rises above 2 °C (Parry et al., 2008). Various options and variable targets however meant that even high per capita emitters did not need to reduce their emissions e.g. Australia, the largest per capita source of CO_2, could increase its emission by 8% relative to 1990 levels (Spash, 2010) and has actually failed to stay even within this limit. The initiative has failed as a means of achieving any substantive emissions reduction; CO_2 emissions only notably decreased during the 2008 due to the economic downturn not the policy initiative. The emissions of European plants and factories participating in the EU emissions trading scheme (see below for details), increased 0.4% in 2006 and 0.7% in 2007 (Kantner, 2008).

Jackson (2009) has emphasised the sheer magnitude of reductions in carbon intensity necessary. In order to meet IPCC targets a more than 20 fold improvement in technical resource efficiency would be necessary in the next 40 years, everything else (e.g. consumption) remaining constant. So for now at least it seems that Peak Oil and other resource peak scenarios, which tend to be referred to as pessimistic, are actually the only hope for stopping the increases of CO_2 emissions[14]. However, the possibility of switching to coal as a major backstop resource and the potential of other heavily polluting sources (e.g. fracking) means even this seems unlikely to help.

Uncertainty in climate change

Global climatic systems are inherently complex, for which climate change research inevitably has to deal with uncertainty. For example, small changes in the regional transportation of heat by oceans can have large, unpredictable and unprecedented impacts on local climate. As already outlined in section II (see page 8), post normal science has been introduced in EE, to

[13] http://jpi.ipsum35.emmaportal.nl/programme/membercountries

[14] Petroleum geologists (e.g. Aleklett, 2007) have expressed their surprise over the assumptions of the IPCC. 17 of its 40 scenarios allow fossil fuel consumption in 2100 to be higher than today.

address uncertainty (Funtowicz and Ravetz, 1994a). Both natural as well as social scientists tend to assume that uncertainty can be reduced or eradicated with more research. This positions is particularly problematic in the context of human induced climate change, where weak uncertainty persists due to measurement errors and strong uncertainty due partial ignorance and social indeterminacy. Moreover there is the methodological problem that evidence can only at best hope disprove or falsify, but not prove, a theory, and perhaps even this form of validity is impossible leaving us with merely being able to confirm our warranted beliefs. Human induced climate change forces us to accept that irreducible ignorance exists and that unknown cause-effect relationships persist regardless of how much research effort is spent on attempting to perfect predictive models (Spash, 2002a). In this context, Spash (2002a) provides a classification of uncertainty, risk and ignorance as shown in Table 1.

Table 1: Classification of uncertainty, risk and ignorance

	Sub-categories	*Explanation*
Weak uncertainty	Objective risk	Known outcomes and their probabilities; termed 'risk' by mainstream economists; probabilities given by natural world
	Subjective risk	Known outcomes only; termed 'uncertainty' by mainstream economists; probabilities assessed from human preferences
Strong uncertainty	Partial ignorance	Unknown outcomes
	Indeterminacy	Unpredictable outcomes

Source: (Spash, 2002a, p. 122)

Evaluation methods employed

The threat of human induced climate change has led to the evaluation of potential impacts as a means to inform the public policy response and the design of possible countermeasures. A popular choice of method for this purpose is global cost-benefit analysis as employed in the highly publicised UK Treasury Department commissioned report by Stern (2006). In section II we have outlined the concepts that have been brought forward in criticism of this approach (see page 7 & 8). Cost-benefit analysis assumes the objectivity of monetary evaluation of nature (Spash, 2008a), human rationality and the model of homo economicus based on preference utilitarianism (Vatn, 2004), fairness and objectivity of Pareto efficiency (Spash, 2002c), strong comparability of values (Martinez-Alier et al., 1998; O'Neill, 1993) and the implicit inclusion of future generations via discounting damages and optimism about future wealth (see below) (Hampicke, 2011; Spash, 1993, 1994a, b; Spash and d'Arge, 1989). Cost-benefit analysis, for environmental evaluation has therefore been strongly criticised, using the concepts introduced in section II (i.e. intrinsic value of nature, incommensurability and weak comparability of values; lexicographic preferences and rights based thinking) (Ackerman and Heinzerling, 2001; Funtowicz and Ravetz, 1994a; Spash, 1994b, 1996, 2002d, 2007a). Considering its complexity, scale and potential impacts for all human beings, climate change

is one of the worst possible areas for the application of cost-benefit analysis, which explains the strong critiques of the 2006 Stern review and its mainstream economic assumptions (Gowdy, 2008; Spash, 2006a, 2007b)[15].The point here is that just because the conclusion is more amenable to an environmentally concerned audience does not make the method any more valid. This is why EE needs to maintain a firm theoretical foundation.

Ethical concerns (current & future generations), alternative ethical approaches

One of the many problematic issues with cost-benefit analysis, is the use of discounting methods to reduce the concerns of future generations down to something that can be handled in an economic approach based upon accounting for financial flows (Azar and Sterner, 1996; Hampicke, 2011; Padilla, 2002; Rabl, 1996). Future control costs for greenhouse gas mitigation and the benefits from the reduction of future damages to humans, non-humans and the environment are discounted to derive their present value. Standard public sector discount rates (which are lower than market rates) are sufficiently high for the future after a few decades to have little, or almost no, weight in current decisions, suggesting no action is needed today to address future harms. Arrow et al. (1996) follow the confused and muddled approach of orthodox economic thinking in trying to claim this is a matter of positive economics and appropriate discount rates can be empirically observed in the market place. They advocate discounting as an efficiency goal and dismiss explicit ethical judgments, while failing to accept that they are making their own implicitly (Spash, 2002b).

A related problem is that mainstream economic approaches, and those advocating them, assume that future generations will automatically be better off than present ones, because of continuous economic growth. Even if this were the case, the basic argument is flawed as it confuses the right to a standard of living over time with the liability to compensation for damages (Spash, 1994a, 2002c). Hence different types of intergenerational transfers may be justified (DeCanio, 2009; O'Hara, 2009; Spash and d'Arge, 1989).

Under economic discounting today's preferences are arbitrarily extended beyond the existence of present generations and therefore imply their quasi immortality (Padilla, 2002). In other words discounting is not based on equity criteria at all and lacks any ethical underpinnings. One major alternative approach to such issues is right based, or deontolgical, ethics. Where there are long-term impacts and/or strong uncertain, as in the case of human induced climate change, thinking in these terms has been argued to be highly relevant(Spash, 1993, 1994b, 2002c; Spash and d'Arge, 1989; Spash and Hanley, 1995). This means that the rights of future generations should be recognised and respected as basic aspects of a humane society, e.g. a life without suffering due to environmental degradation requiring current generations to avoid deliberate creation of harm to the innocent.

[15] Having said that, there were also rather praising words for the "Stern approach" to climate change by important figures in EE (e.g. Costanza, 2009), largely based on pragmatist arguments.

The same is true also with respect to the rights of poor and disadvantaged of the present generation, even though these communities have at least in theory the possibility to fight for being taken into account. That is, the issues of representation between current and future generations differ with the former being able to argue their own case. In practice the poorest are politically weak and lack voice in ways which are similar to actually not even being present (as is the case for future generations). There is in fact no conflict between concerns for future and present poor as they are united in the mechanism by which they are and will be oppressed or suffer.

In terms of justice human induced climate change raises issues of inequity in ability to respond to change. The poor (whether individuals, groups or nations) are least able to defend themselves against the negative effects of climate change. For example, if someone's home in an affluent country gets flooded that person can rely on emergency services, considerable infrastructure making a may move elsewhere easy and possibly get compensated for damages by insurance and/or state. In contrast, for many or most in poor nations such events quickly become a matter of life and death with the loss of home, livelihood, sources of food and water and the spread of disease. This emphasises the need for connection social and environmental issues together and is the aim of social ecological economics (Spash, 2011).

Policy response and criticism of emissions trading

Greenhouse gas emission trading schemes are largely based on efficiency arguments and on the spread of abatement technology. The goal is a 'painless' (i.e. without a major restructuring of the present economic structure) decoupling of emissions from economic activity via efficiency improvements and ecological modernization. The theory behind such proposals is the Environmental Kutznets curve, which may hold for particular pollutants but certainly not for CO2 emissions. Arguing against the feasibility of such plans the Jevons Paradox (Alcott, 2005) or rebound effect (Binswanger, 2001) have been evoked, to show that efficiency improvements, if not accompanied with price increases, tend to increase (not decrease) consumption.

In terms of criticising this approach to climate change policies, there is a general concern expressed by some members of the EE community about the domination by market-based approaches as an inappropriate institution. Thus Söderbaum (2013 (forthcoming)) criticises climate related initiatives, that are clearly based on such approaches such as reducing emissions from deforestation and forest degradation (REDD+). Norgaard (2010) concurs and calls for an end of decades of "free market fundamentalism" (p.1225) and a reduction of the reach of capitalist markets, rather than its extension. However, these calls go against the thrust of current international political thinking.

Instead emissions trading, with its 'win-win rhetoric', continues to be the most popular climate change policy. This remains the cases, despite the obvious ineffectiveness European Union's emissions trading scheme, by far the largest of its kind in the world (80% of global carbon allowances) (European Commission, 2008 p.21). Corporate lobbying power is seen of the source of this persistence and why this option prevailed in 'competition' with plans for a

carbon tax (Spash, 2010; Spash and Lo, 2012). The profit making ethos behind the carbon markets creation of ever more exchange value (Anderson and M'Gonigle, 2012), directly contradicts the need for an absolute reduction of CO_2 emissions (Lohmann, 2010). Socially problematic is also the fact that 'good intentions' and voluntary action are crowded out, when market logic is expanded to inappropriate domains (Spash, 2010); see also Vatn's value articulating institutions mentioned in Section II.

So called 'carbon offset' schemes (i.e. the clean development mechanism), apart from their questionable effectiveness, have been criticised as new forms of neo-colonial oppression (cited in Anderson and M'Gonigle, 2012; Bachram, 2004; Lohmann, 2010; Paterson, 2000; Smith, 2007). Very often 'efficiency' is claimed for such projects, while in reality they are just more cost-effective because "*the poor sell cheap*" (Martinez-Alier, 2002). They are in principle payments for ecosystem services, for which the 'commodification of nature' criticism in EE is also of relevance here (Bumpus and Liverman, 2008; Kosoy and Corbera, 2010). Ethically problematic are also payments for 'not doing something' (e.g. exploitation of a carbon resource), because of the 'bribery effect' (others may follow to ask for money in order not to damage the environment).

A carbon tax on the other hand would me much better on political economy grounds, but does not guarantee an absolute reduction of emissions. This is especially true as energy analysts emphasise the fact that fossil fuels, with their high energy return on investment, are the engine of our modern economies and there are no real substitutes. A consequence is economic downturn, whenever fossil fuels become more expensive, wherever due to limited supplies or a carbon tax. The dynamics of this situation are then important and specifically the substitution of labour for both capital and energy. However for the political reality of today even a carbon tax seems too radical (Spash, 2010) and the imposition of absolute limits to resource extraction (and therefore emissions) via tradable quotas as proposed by Daly (1992b) appears simply impossible[16].

As already mentioned earlier, the journal *Ecological Economics* is not representative for the work of those involved in the EE movement. This has been made very clear with respect to research on human induced climate change. A survey by Anderson and M'Gonigle (2012) found that from all 147 climate change related articles, published in the last 5 years, 50 did not question the mainstream economic approach (e.g. remaining 'neutral' such as using input-output analysis). Of the remaining 97 only 11 of were located outside the dominant neoclassical paradigm. In other words the majority of contributions did not question market mechanisms per se. Among the 11% of climate-change related articles classified as 'critical' there were some calls for an altogether new economic paradigm (e.g., Buddhist economics (Daniels, 2010b, a), co-evolutionary economics (Foxon, 2011) or a social justice paradigm (Bina and La Camera, 2011)).

[16] In later publications Daly adapted his proposal more towards a "cap and trade" i.e. an emissions trading approach (Daly and Farley, 2004), rather than resource quotas and auctions as before.

VI. Conclusion

An open question remains as to what type of society humanity desires? The answer is often implicit in how economic, social and ecological changes are critically evaluated in terms of the causal powers creating undesirable futures.

> "Modern economic growth has been locked-in to dependence upon fossil fuels and these are the historical source of the majority of GHG emissions. Humanity is facing the transformation of the economy away from this dependence; that transformation will come whether humanity chooses to plan for it or not. A permanently smaller material economy has been positively advocated, by literature on steady-state economics, as something for which we should be planning. Smaller by design, rather than smaller by disaster." (Spash, 2007b p.712)

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