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# Of Ecosystems and Economies: Re-connecting Economics with Reality

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**Of Ecosystems and Economies: Re-connecting Economics with Reality**[1]

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**Abstract**

This discussion paper looks at the connections between economies and ecosystems, or more generally biophysical reality. The term 'economies' is used, rather than 'the economy', because of the prevalent false claim that there is only one type of economic system that is possible. We outline how the ecological crises is linked to the dominant drive for economic growth and the tendency to equate growth with progress and development; common even amongst those apparently critical of the need for continued growth in the materially rich countries. The unreality of mainstream economics is epitomised by the accolades given to those justifying mild reformist policy in response to human induced climate change in order to continue the pursuit of economic growth. We emphasise the structural aspects of economies as emergent from and dependent upon the structure and functioning of both society and ecology (energy and material flows). Finally, that the structure of the global economy must change to avoid social ecological collapse, poses the questions of how that can be achieved and what sort of economics is necessary? We explain the need for: (i) a structural change that addresses the currently dysfunctional relationships between economic, social and ecological systems, and (ii) an economics that is interdisciplinary and realist about its social and natural science relations.

**Keywords:** growth, development, economics, ecosystems, thermodynamics, political economy, critical realism

[1]A version of this discussion paper will appear in the *Real World Economics Review*.

## I. Introduction

The state of planet Earth is widely recognised as in jeopardy due to a range of environmental problems relating to a dominant economic system that extracts resources and uses energy on an unprecedented scale in human history. A long-running claim amongst mainstream economists, defenders of unregulated capitalism and those favouring a regulated productivist economy has been that human ingenuity can find substitutes for all resources and technology can solve all problems allowing humanity to change and adapt to anything. These arguments are made in almost total ignorance of how the economy interacts with ecosystems and impacts their structure and functioning, how dependent economies are on the flow of low entropy materials and energy and what are the basic limits to humans as biological animals. Indeed even ignorance itself is ignored and reduced down to risk and probabilities.

Yet, that economies must change is no longer in question. That they will change is also no longer even an issue. The question is what responses materialise as resources, energy supplies and functioning of ecosystems do change? The options being put forward are numerous, but most aim to preserve some form of high-technology, capital accumulating, growth economy embedded in price-making markets, including: green economy, climate economy, low carbon economy, circular economy, knowledge economy, bioeconomy. Yet, none of these addresses the causal mechanisms of the current crises, or structural issues facing social ecological transformation; they are concerned only with controlling for impacts and adapting to consequences, not with the bio-physical relations of the economy with non-human nature.

This article provides an overview of the relationships between economic systems and the environment, human society and non-human nature, ecology and economy. It brings together various literatures with the aim of introducing the reader to the importance of biophysical reality for the operation of real economies, and therefore also for economics. In the next section, we explain the problems facing standard economic approaches if they are to

address environmental problems, but more generally their inability to even understand the social ecological crises due to a limited scope and direction. This is followed by outlining the place of economies in the context of their social and bio-physical structural relations, a basic general ontology. More specific detail is then added on the lessons that can be drawn from ecological understanding in terms of ecosystems, materials and energy. The final section draws out the implications of this understanding for social ecological transformation of the currently dominant economic systems and the type of economics required to help achieve that transformation.

## II. What ails economics? Growth, development and the environment

Economists hold that their concern is an object of study called "the economy". An object most economists assume can be treated meaningfully without any consideration of the social ecological context in which it operates, the society from which it emerges or the biophysical reality on which it depends. This positon is challenged by the, now common, realisation that there are serious environmental problems looming, including: mass extinction of species, biodiversity loss, destruction of ecosystems structure and functioning, and pollution of land, air and water on all scales from local to global. Talk of limits to economic growth by Meadows et al. (1972) was denigrated by economists (e.g., Beckerman 1974), but unfortunately their baseline scenario analysis has proven in line with real trends (Turner 2012). Limits have now returned to the political agenda, conceptualised as planetary boundaries (Rockström, et al. 2009).

However, few economists pay any attention to the ultimate failure of economic growth as their guiding principle. Even those, like Tim Jackson, who do claim prosperity is possible without growth still defend the need for economic growth for "poorer countries". As Jackson (2009: 41) makes clear, a "key message" of his book on the topic is that: "There is no case to abandon growth universally. […] It is in these poorer countries that growth really does make a

difference". This positon totally conflicts with the post-development school that documents how equating development with growth has been an imperialist post-World War II policy promoted by the USA and implemented through various captured organisations, such as the IMF and the World Bank (Sachs 2015 [1999]). Development policy has denigrated and destroyed the cultures of non-industrialised countries, livelihoods of the rural and materially poor and removed their autonomy. Sachs differentiates the materially poor into what can be described as living frugally, suffering deprivation and living under systems of economic scarcity. Traditional societies have economic systems of social provisioning that are structured on frugality and sufficiency. Interventions to "develop" their economic circumstances have typically resulted in expropriation and forms of primitive accumulation. Culture is destroyed along with sustainable livelihoods. Land is grabbed, resources exploited, agriculture is industrialised and the environment is polluted. The survivors add to the exponential growth in urban slum dwellers, more than a billion on conservative UN estimates a decade ago (Davis 2006: 23). A class of people ready for exploitation as commodified labour due to their newly-created wage dependency and their new lives as those saved from "poverty" to live in the economy of material scarcity measured by money.

Economists have continued to promote the "growth=development" ideology of progress even as the consequences (e.g., human induced climate change and biodiversity loss) are realised to be increasingly severe and threatening to all. The standard economic response has been to extend markets and private property rights including attempts to make ecosystems into goods and services (Spash 2015) and greenhouse gases into financially tradeable commodities (Spash 2010). Economic growth has remained the primary concern, with environmental issues considered only if investments give a positive financial rate of return, economic growth and jobs (GCEC 2014; Jaeger, et al. 2011). The problem is not seen as ecological crises, but how business can realise and capture the economic value that ecosystems produce. The opportunities for profiting from environmental problems are a

stimulating tonic for creators of new markets and financial instruments that "make Nature pay".

Despite their ever increasing type, number and scale, environmental problems are treated by most economists as isolated, individual instances of market failure. Their conceptualisation as "externalities" has been copied widely. The classic treatment, as in Coase and neoclassical environmental economics, is based on pollution being a minor problem between two contracting parties operating in an isolated system with no irreversibility, uncertainty, indeterminacy, unknowns, complexity or asymmetric information. Much is made of relaxing assumptions to take account of some of these things (one at a time *ceteris paribus*), but the basic "solutions" – unregulated markets and private property rights – remain, regardless of whether the simplest or most complex models are applied. This is a closed, self-referencing system of deductive thought. In short, it is a total fiction that bears no relationship to actual environmental problems operating in a complex open systems reality, and as a result it produces policies that fail. Neither is any attempt being made to identify real causal mechanisms. However, ideas have the power to motivate people and externality theory serves as a convenient fiction, suited to maintain economic theories of efficiency, the neoliberal ideology of "free" markets, and the supreme economic objective of technologically driven growth.

In reality, the creation of environmental degradation is nothing external to the economic system of industrial modernity, but rather an integral part of that system. In this system, success is the ability to pass on as many "costs" as possible to others, while exploiting all possibilities for gain at others' expense. As Kapp (1965; 1969; 1970; 1971; 1978 [1963]) pointed out long ago, this is an exercise in cost shifting,[2] and the output of a firm is dependent

[2] As Kapp (1965: 1) stated: "The concept of social costs refers to a wide variety of harmful effects of productive activities which are not reflected in entrepreneurial cost accounts and, hence, tend to be neglected in private decision making. That is to say, social costs may be identified as those harmful

on its ability to shift part of its costs to other sectors of the economy or individuals. Cost shifting can be identified within the structure of the economic system made operational through the mechanism of market competition. While unable to recognise structure, neoclassical economists might have recognised that investment for profit does not entail social efficiency, anymore than does the individual aiming to maximise their utility. Consistent with their neoclassically designated roles, both the primary mainstream economic actors – firms and consumers – can act "optimally" by shifting costs onto others. On this basis, mainstream economics should regard environmental degradation, as well as other social costs, as endemic to the system, and not some minor aberration or instance of market failure to be fixed by adjusting a price at the margin (i.e. internalising externalities). Yet, they persist in their ideological commitment to "getting the prices right" to empower economic actors with "information" about how to allocate resources efficiently.

Attempts, supposedly justified by "new" welfare economics, to convert environmental degradation into social costs, estimated as monetary values, require the application of heroic assumptions, e.g., a monistic value theory with total and universal commensurability, utilitarian ethics, absence of lexicographic preferences. The Pareto criterion, which economists seem to assume is some uncontestable moral ethic, justifies making the rich richer while doing nothing for anyone else. Its Kaldor-Hicks adjustment means deliberate harm – even to the already worst-off – can be justified without any actual compensation. The application of cost-benefit analysis to global environmental change (e.g. enhanced greenhouse effect causing climate change) violates even this neoclassically-based welfare theory, not least by ignoring the requirements for maintaining money as a measuring rod of value (i.e. no substantive income changes).

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effects of private action which, under given conditions and institutional arrangements, tend to be shifted to and borne by other sectors, third persons, or the economy as a whole."

After decades of criticism the arbitrary and unscientific economic analysis of environmental problems as "externalities" remains firmly in place. Worse still, the application of cost-benefit analysis to climate change due to greenhouse gas emissions has earned one economist, Stern, a place in the House of Lords, and another, Nordhaus, the highest international prize in economics. This despite Stern and his colleagues' work not addressing the basic issues they themselves identify (Spash 2007a; 2014). In the case of Nordhaus he has persisted in producing numbers which even *The Economist* admitted were "massively simplified" (Spash 2002a: 161), and he has always employed not only over-simplification but also numerous *ad hoc* assumptions and highly selective use of science, possible future impacts and economic scenarios (Spash 2002b; 2007b).

Beyond the basic failures of mainstream economists, even to stay within the strictures of their own theories, there is a much larger failure of the economics profession in general, and that is a lack of relation to the natural world. Most economists are trained to ignore the existence of anything outside "the economy", as if this were a self-sustaining and singular type of system. In what follows, we will explain why there is no such isolated system as "the economy", nor any such universal type as "the economy", but only varieties of economies.

## III. Relations between economy, society and nature: ontology

The basic relationship of an economy to the rest of reality is core to understanding the ecological crisis of modernity. Economics, in both orthodoxy and heterodoxy, largely fails to include the dependency of human society on nature. In the orthodoxy, resource and environmental economics uses neoclassical microeconomics and welfare theory, but is a marginalised and minor field within the economics profession. In the heterodoxy, outside of social ecological economics, there has been minimal attention to the environment: mainly amongst eco-socialists and eco-feminists, occasionally by institutionalists, and to a much lesser extent by a few post-Keynesians (Spash and Ryan 2012). In general, economists treat

the environment as an optional extra, an area for specialists, outside the central concerns of the profession, rather than of fundamental importance to understanding economic systems, their organisation, operation and reproduction.

The reality is that the modern economy is built on fossil fuels and mass throughput of low entropy resources. The standard picture of what constitutes “the economy” is narrowly framed around price-making markets and capital accumulation. There is no connection between the macroeconomic circular flow diagram, with its never ending cycle of goods and services flowing between firms and households, and the necessary resource inputs and waste outputs that make this system operative. If there were, the fallacy of such a model would be self-evident. As every military strategist knows, if you cut the resource supplies the economy soon collapses. Just as crucial, humans can die from accumulation of waste including their own excrement (a problem related to typhoid and hepatitis, documented for millions living in cities by Davis 2006 pp.137-142 in a section entitled ‘living in shit’ in a chapter on ‘Slum Ecology’). However, material provisioning and waste disposal have no place in modern economics where “the economy” is treated as a physically isolated system (i.e., with no material or energy exchange with any other system). Once this theoretical pretence is dropped, specifying the nature of the relationship of different types of economy to the environment becomes key.

That there are different types of economy is also something typically ignored by economists. Commonly the issue is to determine how “the economy” operates and what the relationships of “the economy” are that would maintain certain states (e.g. full employment, growth). That there are varieties of economic systems seems self-evident due to the potential variety of institutional arrangements for operating social provisioning systems, e.g. the extent of state planning, corporate control, ownership of the means of production, types of property rights, types of markets or no markets. Indeed, exactly what factors can vary across economies is contested. For example, a common neoliberal claim is that “free” market

capitalism is the ultimate form of economy and the only way in which human societies, on the scale of the current population, can operate. Others contest that government intervention is essential. That there might be varieties of capitalism is one issue (e.g., Hall and Gingerich 2009; Hall and Thelen 2008). That there might be alternatives to capitalism has seemingly been pushed off most economists' research agendas. Yet this is a basic historical fact. That is, before capitalism there were other types of economic systems, other economies. Once both the possibility of and need for alternatives are accepted then questions arise as to the varieties of social structure, means of social provisioning and waste disposal, and relationships with nature and biophysical reality.

In general, the conceptualisation of the place of economies in relation to other structures is a matter of ontology. Clarifying the structural relationships and dependency amongst different structures has then been a matter of some debate (e.g. the social 'embeddedness' of the economy, see Dale 2010; Gemici 2008). For those who have been attentive to the relationship between the economy and society, a popular interpretation of the rise of market capitalism is that "the economy" has taken over society. For example, Sachs (2015 [1999]: 17) states that "the economy overshadows every other reality; the laws of economy dominate society and not the rules of society the economy". This line of reasoning can be traced back to Karl Polanyi and his ideas of the economy being embedded in society prior to capitalism (Polanyi 1977b), and then the society becoming embedded in the market economy after its rise to power (e.g., Polanyi 1977a: 9). However, such reasoning is contradictory and problematic because, as Polanyi recognises, no economy can exist without society and the form of an economy is emergent from and dependent upon social relationships. There are then no pure economic entities that can dominate the social, but rather different types of social economic relations. Market economies are still "embedded" in social relations, but they rely on very specific institutionalised forms.

What the emergence of economies from society emphasises is the necessity of social theory. That is, economics always entails a set of social understandings whether they are explicit or not. Economic policy recommendations that fail to pay any attention to social aspects are like planning a transport system by designing a car engine (Spash 2017). Social relationships in the market economy are atomised to the individual, although this is contradicted by the necessity of non-market coordinating institutions (conventions, norms, rules and regulations, see Vatn 2005) that make the market operational. In addition, the undermining of social relationships in market-based economies results in the necessity of government intervention to restabilise the systems and save capitalism from itself. This is Polanyi's "double movement". The need to give back to the exploited before chaos ensues or democracy becomes authoritarian, dictatorial and fascist.

The tendency to undermine the social relationships upon which the system depends is matched by the impact on the environment. Ecosystems functions and structure are not optional extras to be added as an afterthought. The quality of the environment is essential to human flourishing and survival. Humans are biological entities and as such need to maintain their metabolism and are subject to the needs and conditions – climate, temperature, nutrients, water, oxygen – of being such entities. The ability to create interventions that change the actualised environmental circumstances to human advantage does not change these structural limits, but rather works within them, e.g. houses maintain a certain necessary temperature. This is a major distinction that needs to be made clear because of the techno-optimist rhetoric that claims human imagination can achieve anything it conceives; something prevalent amongst a class of technocratic advocates of the controversial Anthropocene conceptualisation of social ecological crises (Baskin 2015).

In this respect, a critical realist philosophy of science can help due to its depth ontology and understanding of stratification and emergence (see Collier 1994). The depth ontology differentiates between the empirical (things sensed by humans) and actual (things that happen,

not all which we sense), but also emphasises the role of an underlying structural aspect of reality. The relationship between, for example, the social, biological, chemical and physical is stratified and hierarchically ordered. Each stratum has its own causal mechanisms. What this philosophy of science explains is the asymmetric dependency of one set of mechanisms on another, but not in a reductionist or determinist sense. Higher strata have the properties of emergence, so they cannot be understood by reduction to the lower strata on which they depend, e.g. humans cannot be fully understood by reduction to the rules governing their biology. The structure of the natural world is slow to change or effectively (as far as humans are concerned) unchanging. Science has progressed by learning the rules, understanding the mechanisms of physics, chemistry and biology, and then technology has been developed by using these mechanisms for human ends.

The reason humanity faces limits is because it does not make the rules. However, in creating actual events and phenomena different mechanisms, from across the layers of nature, can be, and typically are, brought together. Thus, understanding concrete events and phenomena requires knowledge of the multiple mechanisms that cause them. Human economic and social systems impact on ecosystems, species, biological and physical entities, not by changing the mechanisms, but by using them, either intentionally or unintentionally. Of course, a class of humans now have the ability to destroy entire systems on Earth, which completely removes mechanisms and their potential.

So how should something like human induced climate change be understood from this perspective? The greenhouse effect is a phenomenon established by a set of physical and chemical mechanisms. A select minority of humanity have unintentionally used these mechanisms to such an extent that they are responsible for enhancing the greenhouse effect, leading to global warming in the absence of any counter-mechanisms. Geoengineering promises to develop the use of such counter-mechanisms, rather than stop using those of the greenhouse effect. However, why does this minority of humans use the greenhouse

mechanisms on such a scale in the first place? This is because they live within fossil fuel based economies, and to stop using them would require changing the economic system. There has never been an industrial economy that was not based on fossil fuels. So a totally new type of economy is necessary, and because economies are dependent on social structure that would imply new social arrangements and new means of social provisioning. Thus, recognising human induced climate change as a serious structural problem, the preference of policy makers, corporations, industrialists, financiers, bankers and all those invested heavily in the fossil fuel economy is to maintain the system and hope for a technology that could provide a physical-chemical counter-mechanism. Yet, the enhancement of the greenhouse effect is just one of many ecological problems created by modern economies.

## IV. Linking economics to biophysical reality: ecosystems, entropy and values

In the 1970s, fundamental insights arose from ecology about modern human society and the operations of its economy under capital accumulation and mass consumerism. At the core of concerns was the disruption of ecosystems' structure and functions impacting on human and non-human life. Impacts were related to the expanding scale of human activity due to economic and population growth (e.g. land use change, appropriation of natural functions), technologically driven qualities of those activities (e.g., emissions from fossil fuels, radioactive waste from nuclear power, toxic waste from the creation of synthetic chemical substances), and their combined impact.

The interconnectivity of things was a major new understanding coming from ecology, based upon the developing concept of ecosystems. Nutrients, as essential to life, were linked to chemical cycles – carbon, hydrogen, nitrogen, oxygen, phosphorus and Sulphur – operating through ecosystems. As systems composed of physical-chemical-biological processes, ecosystems were recognised to provide a concept of the functioning of nature that combined the biotic and abiotic. The importance of the conversion of biomass into energy laid the

foundations for studying ecosystems through energy flow analysis. For example, ecologists traced energy through agro-ecosystems to question the sustainability of the Green revolution in agriculture (Biswas and Biswas 1976; Pimentel, et al. 1973). Pollution had been treated as a local problem or something solved by dilution of matter into a large and accepting environment. Now the long range transport of air pollutants creating acidic deposition became a recognised phenomenon, as did the potential for bioaccumulation of chemicals (e.g. DDT, heavy metals). In all this new understanding, the centrality of ecosystems structure and functioning to life on planet Earth became evident, but also that the characteristics of ecosystems were not those of mechanistic science, i.e. stable, static, equilibrating, reversible.

*Ecosystems Change, Irreversibility and Strong Uncertainty*

For a long time ecologists assumed ecosystems were largely closed systems dominated by internal recycling of elements, self-regulating and deterministic, and stable with end points (e.g., climax communities). They also neglected human influence, externalised it and separated it off, as something outside their concerns. Holling (2009 [1986]: 87; 1995) reinterpreted disturbance as part of ecosystem dynamics and described this as a cycle in four phases: (i) exploitation, where species get established; (ii) conservation, where a climax community is achieved and consolidated; (iii) release / creative destruction, where a disturbance destroys the structure; and (iv) reorganisation / renewal, where order and structure starts to reform incorporating released materials and energy. An ecosystem might dramatically change at stage (iii), thereby preventing reorganisation along the same path as before. That is, there is no guarantee that a system will keep going through the same cycle of succession and recreating the same structure and functions (e.g. an old growth forest might never reappear after a devastating forest fire, and instead might become a desert ecosystem). The resilience of a system is then defined in terms of maintaining certain structures and functions through change. This emphasises the boundary of stability, events far from

equilibrium, high variability and adaptation to change (Holling 2009 [1986]: 71-71). Economic growth emphasises "operational efficiency" and demands more from all systems leading to impacts on biophysical evolution (Holling 2009 [1986]: 92).

These developments in ecosystem theory led to awareness that the changing dynamic of systems may result in surprise as systems flip due to different attractors becoming dominant. Kay et al. (1999) developed the concept of a self-organising holarchic open system. Such a system shows spontaneous coherent behaviour but can suddenly change (i.e., show discontinuity) when reaching a "catastrophic" threshold. Learning from ecosystems dynamics is combined with thermodynamic theory and linked into the need for a new approach to science. The scientist is seen as providing narrative descriptions, based upon quantitative and qualitative understanding, rather than making deterministic predictions. Kay et al. (1994: 737-740) recommend a process of management where science informs but decisions involve ethics, values and concerns, visions of the future and socio-political context.

Continuous human intervention creating disturbance to ecosystems structure and functioning is not some mechanistic engineering problem to be solved through controlled experimentation. Standard scientific epistemology is challenged due to complexity precluding reductionism, lack of control and inability to replicate relationships in open systems. "Not only is the science incomplete, the system itself is a moving target, evolving because of the impacts of management and the progressive expansion of the scale of human influences on the planet" (Walters and Holling 2009 [1990]: 117-118). Ludwig, Hilborn and Walters (1993) note the failure of science to prevent resource overexploitation, collapse and extinction and see this as due to a lack of scientific consensus as to the causes. The recommendation is caution and, more specifically, attention to: human motivation, acting before scientific consensus, recognising scientists and their judgements are subject to political pressure, distrusting claims of sustainability (especially where problems of population growth and excessive resource use are ignored), and confronting uncertainty. Similar concerns lay behind

the development of post-normal science and its recommendation to involve an extended peer community in science-policy, including laypersons (Funtowicz and Ravetz, 1991).

As can be seen from this brief overview, the literature on ecosystem dynamics emphasises surprise and strong uncertainty (i.e., ignorance and indeterminacy, see Spash 2002c). However, economics remains mechanistic, quantitative, equilibrium seeking and so totally incompatible with understanding the reality of the ecosystems in which economies are embedded. As Holling et al. (1995) recognise, the result is that economists generally ignore ecological information, despite the accumulated body of evidence from natural, disturbed and managed ecosystems.

Rather than a more humble approach in human non-human relationships, the co-option of selected ecological concepts has been employed to support the opposite conclusion, that humans can create and control everything. For example, the idea that resilience is something mechanistic to be built into all systems as an inherently good quality, despite there being nothing that necessitates resilience in itself leading to sustainability, and it may even do the opposite, e.g. a resilient fossil fuel economy hurtling us headlong towards climatic disaster. Similarly, the use made of the ecological concept of adaptation can be seen as having undermined greenhouse gas mitigation especially once combined with economistic arguments about adaptation being more "cost-effective". The inappropriateness of such human hubris is further reinforced by the laws of physics.

*Thermodynamics, Entropy and Economics*

The marginalist revolution in economics during the 1870s, which led to the rise of neoclassical economics, borrowed heavily from mechanistic physics in terms of mathematical formalism and models (Mirowski 1989). However, economics has managed to totally ignore the relevance of actual laws of physics, despite their importance for the social provisioning and reproduction of society. Economic growth predicated on material throughput creates vast

amounts of waste. These wastes go into the environment and ecosystems with the implicit expectation of their harmless assimilation. The amount of energy remains the same from extraction to waste, as a direct consequence of the First Law of Thermodynamics, i.e. energy can neither be created nor destroyed. A similar law relates to matter and led to the idea of materials balance theory, that was briefly a topic of research in environmental economics (Kneese, et al. 1970), that later developed into the field of industrial ecology. This means material that does not go into embodied capital will become waste and all the materials extracted from the environment will go back into the environment in equal mass.

Economic growth is dependent upon a specific form of energy, that is energy available for performing mechanical, chemical or thermal work. This useful energy is termed "exergy" to differentiate it from energy, which is neither created nor destroyed, because exergy is used up in all transformation processes (Ayres and Warr 2009). Modern industrial society makes use of stored exergy in ores and fossil fuels. These sources are depleted and while the energy remains in the system it is no longer useful and so the exergy is reduced. The Second Law of Thermodynamics, or Entropy Law, in its classic form, states that energy changes quality from useful (low entropy) to less useful (high entropy) heading towards an equilibrium where all is evenly distributed (heat death of the universe). This process is irreversible and therefore associated with the phrase "times arrow". Creating concentrated forms of matter and energy (i.e., low entropy) is possible within a system, but only with energy added from another system; that is, overall in the combined system energy is still degraded, the Entropy Law remains in force. Georgescu-Roegen's (1971) major thesis, "*The Entropy Law and the Economic Process*", basically concluded that economic growth was infeasible over the long run and economic policy needed fundamental reform. His reasoning led to questioning human society from the size of population and the pressure placed upon systems, to the time allowed for change and the rate at which human systems impose change. Economic systems are then inseparable from ethical judgments both concerning others currently living and future

generations. Herman Daly (1977a; 1977b) came to the conclusion that the best option in the face of the Entropy Law and critiques of growth was to aim for a steady-state economy.

The Entropy Law has been taken to imply absolute constraints on economic systems (Daly 1977a; 1977b; Georgescu-Roegen 2009 [1975]). That is, energy use depletes stored exergy and dissipates minerals into "devil's dust" which can never be recovered (Marx cited by Daly 1968). However, in theory the large amounts of energy input to the Earth system from the Sun can be used to create order and reverse dispersal. If human society relied upon solar energy and conserved the required amounts of ores to maintain man-made capital then a different type of economic system could be sustained over a long time horizon (Ayres 1998). In fact, humans are not anywhere near meeting such requirements for a physically-sustainable system. We have no machines for filtering atomic particles from the atmosphere or oceans for reconstruction to replace essential ores, let alone ones which can do so while replacing all the materials they dissipate in the process and as they themselves decay. So in practice dissipation of ores and running down of useful energy sources (exergy), while creating all-pervasive pollution, are major problems posing ultimate limits. Indeed the rush to use these sources means the transition to a world which is of the physically sustainable type will be thrust upon future generations rather than achieved via a planned process. The great hope of the mainstream economic tradition is that prices will send signals to which producers will respond with substitution away from the increasingly unavailable resources. Yet, such economics is based on mechanistic equilibrium theories which bare little relationship to reality and cannot explain the evolution of technological change. Why mainstream economists, who have no theory to address past transitions, should predict a smooth future transition in the face of resource and exergy depletion, appears explicable more as a matter of blind faith than economic science.

In the absence of the means to re-concentrate dispersed ores a prudent approach would be to avoid their frivolous use. Of course what is frivolous, and whether a minority of humans

should have a big all-consuming party while others starve, are value judgments of a most fundamental kind, not dictates from physical laws. Georgescu-Roegen (2009 [1975]) extrapolated from his interpretation of classical entropy as to the desirability of degrowth and avoiding luxury items constituted of metals which future generations would need for basic food production. Clearly physical laws only point to implications, they do not make ethical choices for us. Similarly the size of human population, type and scale of pressures placed upon systems, time allowed for change and rate of imposed change, are all matters for human judgment (if those responsible were able to stand back and use some).

One caveat to classical entropy is the neglect of self-organising systems arising to make use of available energy, i.e. organisation from disorder (Schneider and Kay 1994). These systems include ecosystem functions but also geo-physical systems, such as climate regulation and ocean current circulation. Unfortunately some humans are destroying the ability of existing self-organising systems to operate. In addition, these systems fall outside the economic model of what is valued because they are not exchanged in market transactions. Ayres (1998; 2004) proposes starting to take account of what we are doing using measures of exergy, and others have suggested similar energy based approaches to measuring ecosystem health (Schneider and Kay 1994).

*Ecosystems' Function, Structure and Value*

The idea of stable equilibria is a fallacy. At the ecosystem level change is an ongoing reality and always has been, but human induced change is qualitatively and quantitatively different. Landscape modification, climate change and/or social developments all disturb ecosystem structure and function. The five main direct causes of biodiversity loss and degradation of ecosystems are: land use change, pollution, climate change, resource depletion and invasive alien species. All these factors are structurally part of current industrial economic systems

with their focus on capital accumulation, appropriation of resources, global trade and innovative technology.

That humans are changing ecosystems is not in question, contestation is over the extent of human control, potential irreversibility and surprise, and consequences both bio-physically and in social, psychological and value terms. The idea that humans can recreate and restore ecosystems to their historical form (e.g. by invasive species removal) is popular enough. However, human inability and ignorance, plus the characteristics of the Holling cycle, imply that the outcomes are more likely to be novel ecosystems that are different from and cannot be restored to historic ones. Novel ecosystems may also arise from planned creation which can take on a variety of forms. For example, farming involves controlling non-human nature to establish specific ecological functions for human productivist ends. More recently the idea of promoting specific, typically singular, functions has moved to the planetary level as a means for survival e.g., carbon sequestration. Novel ecosystems may also arise from maintaining specific species or aesthetics because other aspects are simply ignored, and hence a new structure results. Then there is the whole area of compensation for loss, where totally different ecosystems, often in different locations, are created to justify destruction elsewhere.

How ecosystems functions are conceptualised and valued becomes a core concern. Regarding ecosystems as service providers facilitates regarding all change as good, because novelty can be described as supplying new ecosystem services. The central issue is how commensurable are new and old. The use of arguments to justify ecosystem destruction and re-creation is pervasive in the development of economic instruments for offsetting deliberately created damages, such as emissions trading (Spash 2010), biodiversity offsetting (Spash 2015), and species and ecosystem banking (Spash 2011). Corporations and their financial backers, engaged internationally in resource extraction, have been particularly keen on seeing an “anything goes” policy, justified by commensuration of loss and gain. This has

been supported by arguments that the worth of ecosystems can be converted into monetary values based on individual preferences (Spash 2008).

An alternative is to focus explicitly on ecosystems functions, but this does not avoid commensuration and value judgements. A particular problem is where functional goals take priority over historical and compositional ones in ecosystem management. The contention is that ecosystem functions should be changed in novel ways to meet ecological crises, and traditional preservation goals should be dropped because they will prevent adaptation. Such logic is found in promotion of the bioeconomy, mainstream climate change mitigation and geoengineering. Desjardins, Donhauser and Barker (2019) identify a mechanistic approach to natural processes in such policy proposals, which also adopt a central aim of maintaining economic growth and industrial "development". Instead they argue for ecological integrity and value of place assessed through complex, multi-dimensional indices, rather than simple proxies. Such complex multidimensional evaluation severely restricts commensurability and means directly opposing economic and business logic based on bulldozing biodiversity and erasing ecosystems for monetary gain.

What cannot be avoided is the role of values and judgement. The aims of maintaining historical continuity, social-ecological relationships and a place for non-human autonomy sit uneasily with the values and institutions of price-making markets, love of money and capital accumulation. Contention over the values of modernity have always been evident when it comes to environmental concerns, and attempts to remove values for hegemonic conformity merely create the contradictions of new environmental pragmatism in the modern environmental movement (Spash 2009). A place for "other values" is evident in the "rewilding" movement that includes a radical non-anthropocentric stance aimed at giving back autonomy to non-human nature (Gammon 2018). This demands a reinterpretation of landscape and history, as well as the relations between humans and their environment, and thus challenges identities that are historically based (Drenthen 2018).

Values are constitutive of human identity and reproduced (or not) through human practice. There are then real conflicts between the values of modernity promoted by industrialised technologically driven economies and other types of economies. Technology has become a force in itself that forecloses any notion of ends that would challenge what technology itself favours. As a hegemonic discourse it has real impacts on the world, motivating practices that eradicate human-independent entities from the surface of the Earth (Vetlesen, 2015, pp. 161–162).

Humans hold plural values that are in regular conflict. If economist wish to have any scientific credibility they can no longer continue the pretence that humans are preference utilitarians, or even purely consequentialists. In addition, the pretence that their work and its conceptualisations have no value implications and are merely factual, in some naïve objectivist sense, needs to be dropped as equally fallacious.

**V. What type of economics and what type of economy?**

That the global economy needs to change to avoid social ecological collapse, poses the problem of how and what sort of economics might help? There are three interrelated research questions. First, what is understood as being the current social ecological and economic reality and the causal mechanisms creating crises? Second, how can the current system be transformed, i.e. what are the barriers and enablers? Third, what is the goal of transformation, i.e. what kind of society is desirable?

What then is the point of the growth economy that modern economics tries so hard to sustain? Keynes advocated growth to avoid imminent social and economic collapse leading to international instability and war due to high unemployment (Spash and Schandl 2009). Keynes (1930) outlined his vision in an article entitled “Economic possibilities for our grandchildren”. He defined the economic problem as removing the struggle for meeting subsistence needs, a definable goal with an endpoint. His means of transformation was 100

years of economic growth (not an end in itself). Keynesians remain apologists for capitalism and the growth economy, although often growth for them this seems to have become an objective not a means. The ecological economist Tim Jackson (2009), as noted earlier, argues in line with Keynes, requiring the growth economy to transform society *before* there can be "prosperity without growth".

For Keynes the future goal was a leisure society sustained by the accumulated capital (ignoring maintenance requirements). Although he had doubts about this utopia when looking at the leisure class of his contemporaries. Worse, he recognised his transformative economic growth society would require empowering the worst of human values (i.e., greed, avarice, usury, the desire for ever more money) and people (i.e., those with "semi-criminal, semi-pathological propensities"). He had absolutely no answer as to what could be done after 100 years had been spent pretending "that fair is foul and foul is fair; for foul is useful and fair is not" (Keynes 1930: 97). Under neoliberalism, the values Keynes apparently despised so much have been made into norms, supported by the institutions of private and public enterprise.

Concepts of "sufficiency" and "the good life for all" are challenges to how economic systems have been developing under Keynes growth imperative. Keynes recognised that affluence would not inform how "the art of life itself" should be conducted. Productivism makes life into labouring for a wage to survive and love of money into a virtue. While love of money results in people "which one hands over with a shudder to the specialists of mental disease" (Keynes, 1930, p. 97). Today, these are some of the most powerful people in the world.

The Polanyian double movement summarises the same tension between protecting and reacting against market capitalism (Polanyi 1944 e.g., Chapter 11). Keynesian policy faces the dilemma of promoting this system, while also requiring major government intervention to control boom-bust cycles, and criticising and removing "market incentives" in the form of unemployment and bankruptcy. The welfare state was a necessary reaction to the social

effects of unregulated market capitalism of the 19th Century and, more generally, the commodification of labour (Burawoy, 2015). Its gradual deconstruction by neoliberalism has led to a situation similar to the social and economic crises of the 1920s and 1930s, including the political encouragement of nationalism and fascism. So unsurprisingly, returns to the Keynesian policies of the "golden age" (1950 to 1973) are back on the agenda, but with the additional aim of trying to address the ecological crises. A currently prominent example is the Green New Deal. Principally the target is carbon emissions and the concern is how to finance policy initiatives while creating growth, jobs and more equality. Changing the conditions under which capitalism operates is what has made it resilient in the face of change, and this may be part of developing a future regulatory regime (Dannreuther and Petit 2012). However, this plan for a new, Green, fully employed, productivist, capitalist, growth economy considers none of the causal mechanism that generate lifestyles of unsustainable consumption and involves no analysis of the structure of material and energy throughput of the existing or revamped capitalist system. Rather than the necessary radical change, a Gramscian "passive revolution" is offered, which reinforces and facilities the preservation of the hegemonic system.

Even those who strongly criticise growth can be found defending market capitalism. A prime example is the steady-state economy promoted by Herman Daly (1973; 1992). This recommends a monetary, price-making market, capitalist economy that operates in equilibrium at an "optimal" scale to stay within limits to avoid ecological disaster. Scale, while important, fails to address the issues highlighted in our coverage of ecosystems or the qualitative properties of pollutants (e.g. toxic waste, radiation, plastics, hormones). Social problems are limited to inequitable income distribution which fails to get to the heart of the social organisation of production. Most fundamentally there remains the contradiction of maintaining the social economic institutions of capital-accumulation while deconstructing economic growth. Indeed, in reply to the criticisms of Smith (2010), Daly (2010) has

confirmed his preference for constrained markets over centralised planning with the aim of achieving allocative efficiency. He has long been an advocate for tradable permits markets, even for the allocation of rights to give birth (Daly 1974). His apologia for capitalism is why some see the steady state as a Trojan horse for neoclassical economic thinking (Pirgmaier 2017). Others believe they can adopt Daly as a mainstream economist (Auffhammer 2009), which would clearly be difficult (Spash 2013). However, there is much confusion as to what an alternative economics is all about with the two main ecological economics textbooks – (Common and Stagl 2005; Daly and Farley 2004) – both strongly supporting the basic validity of neoclassical economics.

The point of these critical reflections is that the structural and multiple causal mechanisms creating social ecological crises are not being addressed and cannot be addressed by neoclassical economics anymore than maintaining market capitalism will solve our problems. The major contribution of Daly, like his teacher Georgescu-Roegen, has been to emphasise the importance of biophysical reality for the operations of any economy. However, the move away from "growth=development", "growth removes poverty", "growth is necessary", and towards an economy without growth, requires more than income redistribution and limits on scale. Neither is this a simple matter of implementing market based policies or subsidising corporate development of Green technology. The core is how social provisioning is undertaken, within which institutional arrangements and for what ends.

In order to answer these questions, requires a research agenda that understands the social metabolism of an economy (see Gerber and Scheidel 2018; Giampietro, et al. 2009; Krausmann 2017). That is, in the same way that the biological metabolism of a human necessarily needs inputs and outputs to maintain itself, so does society. Yet, society can be structured in different ways with different material and energy requirements. Prioritising reductions in material and energy throughput to sustain systems over a long time period means using simpler technologies and less automatised production systems that can be

maintained by the users with readily available materials and without complex technical knowledge, i.e., appropriate technologies. The problem with Green economies, Green New Deals and Green revolutions is that they pay no attention to the structural relationships nor the requirements of the associated technologies, let alone the military interventions that maintain their supply chains. However, there is more to the structure of society than materials and energy. There are the values a society upholds and, through its practices, reproduces.

This is why there is no such thing as a value-neutral technology. The transformation of social practices by technology is clear to anyone who looks around them, from modes of transport to means of communication to work life. Technology additionally brings with it strong uncertainty (ignorance and indeterminacy), surprise, lock-in and social change. The values it entails relate not just to human relationships but also human to non-human and, in modernity the most neglected of all, non-human to non-human relationships. Technology is inherently anthropocentric and typically about human dominance over nature. Yet the rhetoric surrounding technology, innovation and growth is a better world for all.

The "Green revolution" in the 1960s, and the later push to use biotechnology and genetically modified organisms in food production, were undertaken in the name of "feeding the world". Yet, as Sen (1986) explained, famines have not occurred due to lack of food but due to lack of ability to pay, or actually pay high enough, in a monetary system of profit making. More commodification of nature, price-making markets, technology and capitalist growth do nothing to address this systemic problem, rather the exact opposite. A basic fact is that the number of undernourished people has remained at approximately 800 million since the mid-1990s (FAO 1996; FIAN 2018), although food production has been high enough to feed the whole world. The aim of *sufficient* food to feed the world is fundamentally at odds with the current systems that create excess and waste for profit, while others starve. From Western obesity to third world starvation, no one gets a good life.

Economics, to be of use for the future, must address how to meet basic needs through social provisioning, not how to create markets for profit making. Billions suffer deprivation of food, water, shelter and sanitation. The variety of economies that might operate to address these issues is not even on the research agenda. Instead a one-size-fits-all approach is backed by simple quantitative minimum standards that reduce the human condition to a common metric that ignores culture and meaning (Sachs 2015 [1999]: 9-10). In contrast, needs can be associated with contextual satisfiers that are culturally specific and signify the diversity and difference that gives meaning to people's lives (Rauschmayer and Omann 2017). At the same time, that needs can be met by different satisfiers allows analysis and creation of alternative economies for social provisioning.

## VI. Concluding remarks

To suggest ways out of the current social ecological crisis, we need an economics that can lead us away from catastrophe rather than towards it. Such an economics needs to understand both how the current economy is working and impacting on ecosystems, how ecosystems work and the basic structural mechanisms of the natural world, as well as understanding potentials that could be built on to create new and different kinds of economic systems. Current projects of Green growth or a Green New Deal, unfortunately, do not live up to these criteria because they fail to conceptualise nature and environmental problems in their own terms.

John Stuart Mill believed that economics, as political economy, needed to be more than abstract theory and should be practical. In order to achieve that end, and contrary to the later development of economics, his *Principles*

> "treated Political Economy not as a thing by itself, but as a fragment of a greater whole; a branch of Social Philosophy, so interlinked with all the other branches, that its conclusions, even in its own peculiar province, are only true

> conditionally, subject to interference and counteraction from causes not directly within its scope: while to the character of a practical guide it has no pretension, apart from other classes of considerations" (Mill 1874: 236).

More than being this sort of interdisciplinary social science, we argue for economics to also connect to the natural sciences in order to understand the basic requirements for social provisioning and the reproduction of society.

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