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ABSTRACT

This editorial introduces a special section of the journal on *ecological economics: The next 30 years* consisting of 20 different articles from a broad range of contributors. It explores common themes from the articles including uncertainty, the normative goals of sustainable scale and just distribution, collective action, co-evolution, transdisciplinarity and the need for radical systemic change. Drawing on our own vision for the next 30 years of EE, we use multi-level selection theory (MLS) to help understand how these themes are connected, to offer insights into how we might promote collective action at the scale required to achieve a socially just sustainability transition, and to reassess the distinction between normative and positive science. We conclude that ecological economists are united primarily by the recognition that economics must be built from biophysical foundations and by our shared normative values that prioritize the common good over self-interested individual preferences

1. Introduction

This editorial introduces a special section (SS)[1] of this journal on *Ecological Economics: The Next 30 Years*. It has been just over 30 years since ecological economics (EE) coalesced into a distinct field, and nearly that long since two seminal publications laid out a visionary and influential research agenda (Costanza, 1991; Costanza et al., 1991). Thirty years later, it is time to both update that agenda and reassess our trajectory.

EE was developed to help understand and address emerging ecological and social crises driven by our current growth-obsessed economic systems, and many ecological economists hoped it would replace mainstream neoclassical economics[2] (NCE) altogether. As an intellectual and academic endeavor, EE has flourished. Defined by its worldview of the economy as a subsystem of a complex, finite planetary ecosystem characterized by profound uncertainty; the shared goals of ecological sustainability and just distribution; and methodological pluralism based in systems thinking, EE was among the first of many transdisciplinary fields focused on understanding and managing the interactions between humans and the rest of nature. As such, it has played a critical role in stimulating collaboration between disciplines and the true cross-fertilization of the natural and social sciences— a prerequisite for addressing the worsening ecological and social crises of the 21st century. Many important concepts developed within the EE community, including natural capital and ecosystem services, have become mainstream, albeit still controversial within EE.[3] The field boasts international and regional societies, annual conferences, and several excellent graduate programs (e.g. at Barcelona, Edinburgh, Leeds, Vienna, and the Leadership for the Ecozoic program (L4E.org)[4] co-hosted by McGill University and the University of Vermont). Its flagship journal is highly cited and widely respected.

While EE has made important contributions to understanding the causes of our myriad crises and proposing solutions, most of them have grown significantly worse. No country currently meets minimum thresholds for social development without exceeding planetary boundaries (O'Neill, 2015). From biodiversity loss and climate change to

[1] Articles from this special section have SS appended to the date.

[2] In the context of this article, we use NCE and neoclassical economics interchangeably to refer to the theory of self-organizing, competitive, price setting markets in which the single feedback loop of price, once corrected for market failures, can bring supply and demand into a utility maximizing equilibrium, as outlined in most introductory microeconomics textbooks.

[3] Some of the controversy arises from different definitions of capital and ecosystem services. Some ecological economists define capital as a stock that yields a flow benefits, such as a head (capita) of cattle capable of having offspring: stocks of biotic natural capital transform solar energy into a flow of benefits to humans and other species (Daly, 2014). This is primarily a biophysical concept. Others, following Marx, define capital as value in motion, where value is a social relation (Pirgmaier and Steinberger, 2019). Similarly, some define ecosystem services as nature's benefits to people, and among these, some believe they should be treated like market services, fitting the Marxist definition of capital in motion. Others define them in the Georgescu-Roegen (1971) sense of fund-services—ecosystems produce a flux of services at a rate over time without being physically transformed into those services. Market services benefit individuals, public services benefit human communities, and ecosystem services benefit the biotic community. Markets are generally ill-suited for the provision or protection of either public or ecosystem services (Farley, 2020).

[4] The L4E program is a continuation of the Economics for the Anthropocene program (E4A), which also included York University.

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growing inequality, EE has had less real-world impact than most hoped. NCE still dominates in academia and society.

Furthermore, though we believe the proliferation of related transdisciplines is among EE's greatest successes, some of these close kin broke away from the field due to internal disagreements. While disagreements are a prerequisite for scientific progress, they can metastasize into rending schisms affecting the field's vitality and influence. Rather than collaborating on broadly shared goals and worldviews, different factions spend significant time disputing relatively minor disagreements—the well-known problem of circular firing squads (Farley and Washington, 2018). We are weaker divided. The importance of multiple perspectives for holistic problem solving and for strengthening alternative systems for the future is a foundational philosophy of systems thinking (Gunderson and Holling, 2002). The division into homogenous subgroups reduces exposure to alternative views and awareness of internal weaknesses in theory and praxis. Narrow subgroups risk becoming echo chambers, as we have seen with political discourse in many countries. When groups identify in opposition to each other, debates often strengthen group identities and convictions, reducing the likelihood of either scientific progress or mutual collaboration (Björnberg et al., 2017; Lewandowsky et al., 2013; McCright and Dunlap, 2011). When individuals identify as members of the same group, they are more receptive to considering each other's views and modifying their own (Haidt, 2012; Moffett, 2018). It would be unscientific to believe ourselves immune to this behavior.

We believe EE will make more significant contributions to scientific progress and a socially just sustainability transition by collaborating with like-minded scientists and organizations than viewing research differences as irreconcilable divisions. We hope this special issue can help, however slightly, to reframe caustic debates as research questions, stimulate meaningful dialogue, attract and guide a new generation of ecological economists, stimulate collaboration with other like-minded transdisciplinary societies, and strengthen the EE community overall.

As a final justification for this special issue, Herman Daly wisely observed that humanity is "only one failed generational transfer of knowledge away from darkest ignorance" (Daly and Farley, 2011, p. 41). What knowledge gets transferred depends on what the older generation wishes to teach and the younger one wishes to learn (Daly, 2012). Inspired by this perspective, this special issue includes articles from the pioneers of EE (including Herman) describing what they wish to pass on to the next generations, their acolytes, and the next generation of ecological economists, including Ph.D. students and recent doctorates.

It would be remiss not to mention whose views this special issue represents. We issued a call for contributions to the International Society for Ecological Economics (ISEE) membership but biased the selection with some personal invitations to scholars we consider particularly influential or insightful. Despite our efforts at inclusion, most contributors are from WEIRD (western, educated, industrialized, rich, democratic) countries and male, representing neither humanity as a whole (Henrich et al., 2010) nor the demographics of emerging EE scholars (Kish and Bliss, 2020). This is problematic. WEIRD cultures and males have benefitted disproportionately from the existing system and might understandably desire to avoid radical changes that could erode their advantages. Furthermore, feminist economics focuses on reciprocity, care, emotion, and cooperation, rejects dualistic worldviews that artificially divide the world into superior and inferior categories (e.g. humans and nature, men and women, positive and normative), and embraces egalitarian and harmonistic worldviews (Ament, 2020; Plumwood, 1993; Ruder and Sanniti, 2019). These must also be foundational elements of any economics capable of solving the collective action problems that loom in our future.

This SS consists of 20 different articles from a broad range of contributors. Our editorial explores common themes from the articles, including uncertainty, the goals of sustainable scale and just distribution, collective action, co-evolution, transdisciplinarity and the need for radical systemic change. Drawing on our vision for the next 30 years of EE, we use multi-level selection theory (MLS) to help understand how these themes are connected, to offer insights into how we might promote collective action at the scale required to achieve a socially just sustainability transition, and to reassess the distinction between normative and positive science. We conclude that ecological economists are united primarily by our shared normative values that prioritize the common good over self-interested individual preferences.

2. The profound uncertainty of the next 30 years

Numerous studies in recent years claim that we must rapidly slash net carbon emissions to zero over the next 30 years or suffer from catastrophic climate change (Bush and Lemmen, 2019; IPCC, 2019; USGCRP, 2018). Either option will drive unprecedented, unpredictable, and nonlinear ecological, social, and/or technological changes. Even in less volatile times, Boulding (1969) observed that, "almost everything we [economists] do turns out different from what we expect because of our ignorance, so that both the bad and the good we do is all too often unintentional" (p.11). It is, therefore, hardly surprising that uncertainty is a central theme in this SS.

Daly's (2019) contribution, focused on unfinished business from the first 30 years of EE, addresses a core conundrum at EE's roots and any uncertainty analysis: the metaphysical assumption of determinism that permeates the natural sciences. Mainstream physics assumes we live in a deterministic albeit imperfectly predictable world (Prigogine, 1996), but belief in determinism would make EE pointless since all policy-oriented sciences "require the recognition of conscious purpose as causative in the world" (Daly, 2019, p. 7). EE is trying to change the world and, therefore must accept that complex thermodynamic systems are non-deterministic and evolutionary. The behavior of evolutionary systems cannot be fully captured by tautological mathematical equations in which all results are embedded in the premises (Georgescu-Roegen, 1971, 1979). When physicists assume that mathematics by itself can explain the universe, they predetermine their conclusion that the universe is deterministic, and when NCEs assume mathematics by itself can explain the economy, they assume away the evolutionary change on which EEs focus (Lozada, 1995).

Also important in EE is the distinction between risk, where we know possible future states and their probabilities; uncertainty, where we know possible states but not probabilities; and ignorance, where we know neither possible states nor probabilities (Faber et al., 1998; Knight, 1921). Rumsfeld (2002) famously rephrased these situations as known knowns, known unknowns, and unknown unknowns. The rate of novel economic, technological and ecological change—unknown unknowns—appears to be accelerating (Heilbroner, 1995; Muehlhauser and Salamon, 2012; World Meteorological Organization, 2020). However, Costanza (2020a), quoting himself from the first issue of this journal, warns that "the most insidious form of ignorance is misplaced certainty"(Costanza, 1989, p.3), or in Mark Twain's (purported) words, "what we know for sure that just ain't so." Numerous contributions to this SS warn that NCE is so rife with misplaced certainty—what Rees (2020a) calls "choreographed hallucination" (p. 9)—that it can have only a limited role in the future of EE, or none at all (Blignaut and Aronson, 2020; Goddard et al., 2019; Røpke, 2020; Spash, 2020), but we must also be wary of misplaced certainty in our theories.

Most of the articles in this special issue also call attention to the complexity of the ecological economy and the rapid rate of change, both sources of ignorance. It is a characteristic of complex systems that changing the value of a critical parameter beyond some critical point can flip the system into an unpredictable alternate state from which it can be difficult or impossible to return to the previous state (Gunderson and Holling, 2002; Hughes et al., 2013; Lenton and Williams, 2013; Pearce, 2007). Numerous contributions stress that we are simultaneously ramping up the value of innumerable critical parameters, both ecological and economic, threatening "monstrous upheaval in our

socioeconomic systems" (Stanley, 2020, p. 1) and that a focus on resilience is essential to confront such threats. Technological advance is another inherently unpredictable critical parameter undergoing super-exponential growth (Kurzweil, 2005). We are often uncertain precisely which parameters are critical, can only guess when they will reach critical thresholds, and remain profoundly ignorant about new regimes into which our system may flip. Time lags between crossing a threshold and irreversibly flipping to a new system may be decades or longer (Martin et al., 2020), but the possibility of irreversibly crossing a critical threshold or experiencing a major flip in the next 30 years is certainly non-trivial.[5] Echoing Nassim Taleb (2010), Stanley (2020) points out that the most consequential events in history have been Black Swans: extremely rare events with very high impacts that could not have been predicted ahead of time. Previous experience and existing data provide no guidance in predicting novel events (Faber et al., 1998). The very nature of EE as embedded in complex systems means that many scholars draw on the archetype and heuristic of resilience (Allen et al., 2014; Gunderson and Holling, 2002). Tools of resilience help navigate uncertainty through the principles of polycentric governance, encouraging learning, broad participation, and maintaining diversity and redundancy, all of which further amplifies the need to work as a united front – to strengthen our resilience to unknown futures and to help shape them (Kauffman, 2003; Westley et al., 2007).

Yet another source of uncertainty stressed by several articles in this SS is the reflexive and performative nature of social systems and social sciences (Costanza, 2020b; Goddard et al., 2019; Røpke, 2020; Spash, 2020; Vatn, 2020). Marx (1904) argued that "the mode of production of material life conditions the general process of social, political and intellectual life. It is not the consciousness of men that determines their existence, but their social existence that determines their consciousness". We, however, agree with Røpke (2020) that economic theories (consciousness) also help bring economic systems into existence, often intentionally (Røpke, 2020). For example, numerous studies find that studying NCE induces people to behave more like the self-interested *Homo economicus* (e.g. Bauman and Rose, 2011; Cipriani et al., 2009; Frank and Schulze, 2000; Kirchgässner, 2005). Theories can be self-fulfilling, such as predictions of an imminent recession that lead consumers to save more and producers to invest less in new productive capacity and job creation, which can reduce aggregate demand. Theories can also be self-negating, such as leading economists' claims that our economy had achieved a 'great moderation' and no longer had to fear financial crisis (Bernanke, 2004; Stock and Watson, 2002), likely exacerbating the excessive risk-taking that precipitated the 2008 financial crisis, as predicted by Minsky's Financial Instability Hypothesis (Minsky, 1977). Theories can be self-negating in another way as well: if world leaders in January of 2020 had immediately imposed a monthlong shutdown and stopped COVID-19 in its tracks, there would have been no evidence that the threat from the virus exceeded the economic pain caused by the shutdown, which many would claim falsified the theories backing the shutdown—the anti-Cassandra problem (see Taleb, 2010 for similar examples). If ecological economists' predictions of worsening ecological degradation and tipping points stimulated the societal changes required to prevent them from happening, some would interpret this as proof we were wrong.

In summary, this special issue asks ecological economists to suggest how our field should respond to unpredictable change. While physicists cannot yet model how three bodies interact in space (Marshal, 1990), ecological economists must strive to predict outcomes in a system with innumerable moving parts. We may get better at this someday, but right now should accept the possibility that social sciences are roughly analogous to 17th-century chemistry (a claim also made by Mandelbrot, 2006) when alchemists such as Isaac Newton presumably had heated arguments with their peers about the best way to transform lead into gold (Lewis, 2016). What we can say with some certainty, however, is that business as usual will result in unacceptable outcomes, especially for the world's poor, who have in general contributed the least to worsening ecological degradation. We can only hope we understand our complex system sufficiently to guide change towards more desirable outcomes.

3. Ethical values, social dilemmas, and collective action

The question of what outcomes are desirable is considered normative. Though many economists idealize objective, value-free science (Friedman, 1953; Gul and Pesendorfer, 2008; Stigler and Becker, 1977) and EE takes pride in its objective scientific foundations, EE also recognizes, in Spash's (2020) words, that "ethics and value theory are central to economic understanding, not a problematic normative add-on to a naïvely objective, positivistic science". Boulding (1969) points out the absurdity of calling for scientific objectivity when our investigations change the world we are investigating, and as Heilbroner (1973) acknowledges, "it is not one of their flaws, but one of their claims to greatness as economists that Smith, Ricardo, Mill, Marx, Marshall, and Keynes were explicit in their use of facts and theories as instruments of advocacy."(p. 139).

Many contributions to this SS focus on building stronger ethical foundations for EE over the next 30 years. Explicit examples include Washington and Maloney's (2020) call for extending moral (and legal) recognition to non-human life based on its intrinsic worth; Hanaček et al. (2020) call for greater inclusion of feminist perspectives and views from the global south explicitly to enrich EE's ethical values and normative vision; and Akbulut and Adaman (2020) and Muradian and Pascual (2020a) call for more research on how values evolve and are shaped.

In other articles, the call for stronger ethical foundations is implicit. Goddard et al. (2019) define *doxa* as the "unquestioned beliefs, opinions, and generally shared knowledge in society" (p. 3) which include "accepted group values" that are "immoral to oppose" (p. 3). Doxa shape both our ways of knowing (*episteme)* and social reality, which in turn influence doxa in a co-evolutionary process. They refer to the doxa underlying the modern economy and necessary for its function as *economism*, expressed in the episteme of NCE. The resulting social reality is characterized by the explosive, unequal growth of the human subsystem with resulting threats to global ecosystems they dub the Econocene. To change the system, EE must change the doxa, including normative values. Røpke (2020) makes similar arguments based on the notion of performativity—the idea that economic assumptions, theories and conceptual frameworks always have a normative dimension when applied to real-world situations and shape the world they purport to describe. Society requires a new economic paradigm primarily because the performativity of mainstream economics, including its normative agenda, "tends to be counterproductive in relation to just sustainability transitions" (Røpke, 2020, p. 3). Performativity and doxa are closely connected. Different schools of thought within the social sciences have different doxa, and performativity implies an effort to disseminate that doxa across society.

The normative goals of just distribution and ecological sustainability force EEs to focus on social dilemmas (SDs), situations "in which members of a group can gain by cooperating, but cooperation is costly, so each individual does better personally by not cooperating, no matter what the others do." (Gintis, 2011). Social dilemmas such as overpopulation (e.g. Melgar-Melgar and Hall, 2020a; O'Sullivan, 2020; Rees, 2020b; Washington and Maloney, 2020) or ecological degradation (nicely summarized by Hagens, 2020b; Rees, 2020b; Stanley, 2020) involve collective costs; others such as ecological restoration (Blignaut and Aronson, 2020) or efforts to control global pandemics and develop green technologies (Farley and Kubiszewski, 2015; Hensher et al., 2020) involve collective benefits. As Hardin (1968) noted, there are no

[5] See Muradian and Pascual (2020) for a discussion of how the uncertain reaction of policy makers and the public compounds this problem.

technical solutions to social dilemmas, which require instead "a fundamental extension in morality" (p. 1243) and collective action (Bowles and Gintis, 2004; Rapoport and Chammah, 1965). As befits the nature of the problems they address, most articles in this SS propose greater emphasis during the next 30 years of EE on collective action solutions and extensions of morality, not the competition, self-interest and individual choice of markets. Some examples illustrate our point.

Overpopulation was Hardin's poster child for a social dilemma requiring collective action, but in recent decades has become something of a taboo topic for some EEs in the belief that addressing the problem requires ""draconian" breaches of individual freedoms" (O'Sullivan, 2020, p. 2) or because it blames the poor for our ecological crises. O'Sullivan (2020) contribution dispels these myths and broadens the focus of the overpopulation debate to include justice and equity issues. In addition to being one of the main justifications for continued economic growth, population growth suppresses wages, increases rent (unearned income) by increasing demand for finite resources, contributes to resource conflicts and the rise of authoritarian regimes, and demands continuous and costly investments in new infrastructure. Historical evidence suggests that population decline contributes to the more equitable distribution of wealth and power (Scheidel, 2018), while population growth contributes to increasing poverty and inequality. O'Sullivan convincingly concludes that slowing or reversing population growth is required to achieve the central goals of EE, the primary beneficiaries would be the poor living in rapidly growing communities, and the problem, therefore, deserves renewed attention in EE.

Vatn's (2020) research tackles the social dilemma of ecological sustainability, though his emphasis on future generations unavoidably implies greater weight on moral principles and less on mutual benefits. He calls for institutional reforms to both political and economic systems to promote a sustainable future. On the political side, he proposes constitutional reforms that provide legal rights to a well-functioning environment for both the present and future, accompanied by an additional legislative chamber with a mandate to protect the rights of future generations. On the economic side, he proposes expanding the governance of firms to include workers and representatives of civil society, with a specific focus on the future.

Akbulut and Adaman (2020) similarly call for greater emphasis on collective decisions. Recognizing the failure of individual choice and markets to achieve the collective goals of EE, they propose instead "equitable and effective participation in decision-making in economic life by all concerned parties, with the proviso that power inequalities are properly addressed" (p. 2). Specifically, they call for greater attention to participatory planning processes informed by stakeholder councils to determine what society should produce collectively, and non-capitalist, cooperative enterprises to do the actual production. However, they remain open to market exchange for allocating commodities among consumers. Both contributions (Akbulut and Adaman, 2020; Vatn, 2020) suggest these alternative institutions can help shape human behavior to prioritize collective over individual interest and note that externalities and hence social dilemmas disappear when decisions are made at the appropriate group level.

Bliss and Egler (2020) further emphasis the need for research and development of non-market economic institutions. They explain why markets are ill-suited "for governing the production or distribution of entities that are non-rival, non-excludable, not produced for sale, essential need satisfiers, or culturally important" (p.1), call for mutual aid collectives and collective governance of our common inheritance from society and nature, and promote non-market allocation as a way to "strengthen relationships of care, love, solidarity, generosity, and reciprocity" (p. 7) undermined by market society. Modern society's obsession with markets and the association of non-market allocation with premodern economies convinces people that there is no alternative. Ecological economists can help correct this by studying non-market economic institutions as essential complements to markets in a pluralistic economy.

Finally, Ament (2020) focuses on an inherently collective institution: money. He dissects and rejects the mainstream view that money is neutral and serves merely to facilitate barter. Money instead is a social relation establishing claims on resources, and the right to create or destroy money confers considerable power on whoever obtains it. This power rightly belongs to the state and should be used to promote the goals of EE, including social equity and mutually beneficial relationships between humans and the rest of nature. Monetary and financial systems are continually evolving within the constraints imposed by rules and institutions that society creates, which are influenced by our theories about how money works. EE can build on Ament's theory to help direct this evolution towards the normative goals of justice and sustainability.

Mainstream economists frequently argue that developing economic institutions based on cooperation would be futile if people were inherently selfish and competitive. In contrast, we believe it is futile to pursue competitive, individualistic, market solutions to social dilemmas. Understanding how to solve the challenges we face requires a better understanding of the evolutionary origins of human behavior.

4. Evolution and human behavior

In capitalist countries, evolution is often portrayed as survival of the fittest in bloody competition—"nature red in tooth and claw" (1850, Tennyson), while in socialist countries, there has been a greater focus on mutual aid and cooperation (Kropotkin, 1902). The right has rejected evolution as anti-religious, and some on the left as biological determinism that justifies existing inequalities. Despite this intertwining of ideology and evolutionary theory, we agree with Rees (2020a) that "ecol-econ does not adequately reflect key aspects of human evolution and behavioral ecology." (p. 3) Several articles in this SS help address this deficit, but before turning to them we quickly introduce the theory of Multi-Level Selection (MLS,) which we believe helps tie together a variety of separate threads in the SS and has much to contribute to the future of EE.

Darwin (2004) famously argued that groups with more cooperative and altruistic members have distinct survival advantages over those with fewer, a once widely rejected theory known as group selection that has made a recent comeback as MLS. As Wilson and Wilson (2007) summarize MLS, "Selfishness beats altruism within groups. Altruistic groups beat selfish groups" (p. 345). Under rare circumstances, selection at the group level can dominate but not eliminate selection at the individual level. Humans, social insects and a handful of other species have achieved this leap (Wilson, 2012) to the extent that we are no longer capable of survival apart from the group (Henrich, 2016; Moffett, 2018), which defines a major evolutionary transition (Szathmáry, 2015). Importantly, altruistic behavior towards group members may not extend to other groups, especially those with whom the group competes (Moffett, 2018; Wilson, 2019). MLS theory does a far better job describing the variations in human behavior than the obsolete assumptions of Homo economicus (Gintis, 2000).

MLS theory is closely related to the theory of cultural evolution. Natural selection requires a struggle for existence, inheritance, variation, and time. When Darwin formulated the theory, genes had yet to be discovered and are now known to be only one of several inheritance mechanisms (Jablonka and Lamb, 2005). The most important of these mechanisms for group selection in humans is a culture based on symbolic thought—for example, language and abstract reasoning—which provides "a full-blown inheritance system with combinatorial possibilities to rival genetic inheritance" (Wilson et al., 2014, p. 10). Culture is learned information essential to our survival generated by innumerable individuals over innumerable generations and stored collectively in innumerable minds. Humans are not particularly brilliant as individuals, but we are as a collective. Without our collective culture, individuals have an identical fitness of zero (Henrich, 2016), highlighting the absurdity of social Darwinism. Cultures are highly variable and have enormous impacts on the human struggle for existence. The ability for

cultural elements to spread rapidly within and across cultures opens the door to the rapid cultural evolution necessary to address our current dire challenges (Hagens, 2020b). It is our ability to coordinate collective behavior in ever larger groups that has historically enhanced human fitness (Henrich, 2016; Moffett, 2018; Sloman and Fernbach, 2017; Wilson, 2012) and must again be harnessed to address our current challenges: we must develop cultural mechanisms for cooperating with other groups to solve global-scale prisoner's dilemmas.

Human cultures have evolved norms, morals, ethical values, institutions, social emotions such as shame and guilt that strengthen group cohesion and cooperation, and punishments for non-cooperators (Bowles and Gintis, 2004; Boyd et al., 2003; Tangney et al., 2007). In terms familiar to economists and foreshadowing MLS, Boulding defines ethics as group-level rank orderings of preferences among alternatives, in contrast to tastes, which are individual preference orderings. He argues that ethics evolved through a process of mutation and selection and shared ethical values define cultures. Similarly, MLS argues that morality is a culturally evolved trait to promote cooperation: moral individuals place the group ahead of individual self-interest, immoral individuals do the opposite. Morals, ethics, and values are required for humans to function as a society; there can be no society without social science. Just as an individual's genotype interacts with the environment to determine individual phenotypes, morals and ethics are critical elements of cultural symbotypes, and interact with environments to determine cultural phenotypes, our social reality. While religions claim divine origins for morality, their moral code is the same, as exemplified by Jesus Christ's sacrifice for the good of the group (Wilson, 2003; Wilson, 2007). Over time, those cultures that best promoted group coordination and suppressed self-interested behavior outcompeted other groups (Bowles and Gintis, 2004; Wilson, 2019; Wilson, 2012).

However, group coordination is also possible through coercion: cooperating groups of the elite and powerful can coerce weaker group members to contribute disproportionately to the larger group. Coercion has arguably played an increasingly dominant role since the advent of agriculture, the state, and capitalism (Gowdy and Krall, 2013, 2016; Scott, 2017), but cooperation is far more compatible with social justice.

MLS need not be limited to a single species: cooperation can evolve across different species within an ecosystem to the point of major evolutionary transition, meaning that the individual species cannot survive independent of the collective (Lovelock and Margulis, 1974; Margulis, 1970; Okasha, 2006). It is, of course, a basic tenet of EE that humans cannot survive independent of the complex global ecosystems of which they are part. Washington and Maloney (2020)argue that despite its wholistic worldview, EE nonetheless remains dominated by anthropocentric perspectives, focusing on nature's instrumental values and selfishly prioritizing humans over the group of species, the ecosystem, that sustains us. While humans dependent on well-functioning ecosystems should protect them from rational group interest, we do not. Washington and Maloney (2020) therefore, call for an ecocentric worldview that extends humanity's moral boundaries to include the ecosphere. People's contributions to nature must receive at least as much attention as nature's contribution to people. McGill and UVM's Leadership for the Ecozoic program, dedicated to training the next generation of ecological economists, adopts this same perspective.

This background can help us better understand several contributions to this SS that focus primarily on the dark sides of group cohesion and cooperation. Hagens (2020a) and (implicitly) Rees (2020a) suggest we are merging into a global superorganism united by growth-obsessed global capitalism but still subject to instincts, emotions, cognitive biases, and other behaviors that evolved during the Pleistocene. Rees (2020b) notes that K-adapted species, like humans, grow their populations until they reach ecological carrying capacity. Humans' accumulated cultural knowledge enables the invention of new resources and more rapid depletion of finite stocks, allowing us to increase our population, but only at the expense of future carrying capacity, which may be suicidal for the species. Concern for the distant future was unimportant when life expectancies were short, and our ability to affect the future limited, but myopia may prove catastrophically maladaptive when combined with advanced technologies.

Muradian and Pascual (2020b), as well as Hagens (2020b) and Rees (2020a), examine another dark side of cooperation: humans may be genetically and culturally wired to cooperate within a group, but often against other groups, particularly in times of rising insecurity, inequality, scarcity and threat. Muradian and Pascual (2020a) explore the origins and consequences of far-right, nationalistic authoritarianism that openly opposes many of EE's social and ecological goals and frequently rejects the underlying science. Group membership requires conformity with cultural norms, values, and beliefs. One cannot define group without the concept of non-group, and the morals that drive group cooperation rarely extend to non-group (Moffett, 2018). War and conflict with other groups, for example, over scarce resources, strengthens within-group cooperation(Turchin, 2016) and outgroup hostility, contributing to us-vs-them nationalism and sectarianism.[6] Successful cooperation at one scale can undermine cooperation at higher scales (Gintis, 2011; Turchin, 2016). Though we need cooperation between groups to solve global SDs and sustain civilization, in the short run, natural selection may favor those cultures that most rapidly burn through natural capital, especially fossil fuels (Hagens, 2020a; Melgar-Melgar and Hall, 2020b; Rees, 2020a). Solving global social dilemmas will require cooperation at unprecedented scales, likely requiring some form of polycentric governance (Ostrom, 2010), which in turn will require profound cultural change.

Furthermore, group bonds are based more on emotional and moral cues than rational analysis (Hagens, 2020a; Haidt, 2012; Muradian and Pascual, 2020b; Rees, 2020b). Many beliefs that bind us together, such as religion and nationality, are social constructs, neither scientific nor rational in the conventional sense (Stråth, 2000). However, from an evolutionary and sociological perspective, believing outlandishly unscientific ideas is rational if required for group membership. The more outlandish the beliefs, the more effective they may signal group membership (Harari, 2015; Moffett, 2018). In Steven Pinker's words, "any fair-weather friend can say that rocks fall down, but only a blood brother would be willing to say that rocks fall up" (as quoted by Edsall, 2020), or believe that "a group of Satan-worshipping elites who run a child sex ring are trying to control politics and media" (NPR/Ipsos Poll, 2020). Facts and empirical evidence are interpreted through the lens of group values and beliefs. Ideology is the best predictor of belief in climate change, and other environmental problems, and scientific evidence does little to change people's convictions (Hagens, 2020b; Melgar-Melgar and Hall, 2020a; Rees, 2020a). Evidence from neuroscience suggests that certainty, whether scientific, religious or otherwise, is an emotional state, not the product of rational analysis (Burton, 2008). Evolution selects for traits that allow us to survive and produce offspring, not traits that improve our perception of reality (Hoffman, 2019).

In the past, natural selection has been used to justify eugenics, slavery, inequality and other behaviors now widely considered to be immoral. Cultural evolution, in contrast, argues that behaviors are immoral if they undermine the cooperation required to solve social dilemmas, which disappear when decisions are made collectively at the scale of the problem. Cultural evolution suggests that society can intentionally evolve the moral values and intergroup cooperation required to address global SDs. We recognize that, at least to some degree, modern cooperative organizations emerged on the back of complexity and systems necessitated by growth economics (Elias, 2000; Pinker, 2012), which provides all the more reason for a sub-discipline, such as EE, to think of creative alternatives that allow for extended empathy (Rifkin, 2009), even in low-growth societies. The challenge for

[6] Strongly defined groups need not adopt an us-vs-them mentality. The Basques for example are known for strong nationalism while openly welcoming immigrants from other countries.

EE is to build and apply a body of knowledge that can contribute to that goal. With that in mind, we now turn to the ongoing debate over methodological pluralism in EE as viewed through an evolutionary lens.

5. Evolutionary change and methodological pluralism

Methodological pluralism has been a core tenet of ecological economics from the start (Costanza, 1989; Norgaard, 1989), yet precisely what that entails still generates heated discussions. Dube (2021) points out that methodological pluralism has multiple meanings in EE. Integrative interdisciplinarity seeks to build a scientifically rigorous theory of EE (e.g. social ecological economics). In contrast, action-oriented transdisciplinarity seeks to engage multiple stakeholder perspectives, acknowledges the politicization of knowledge, and questions the ability of objective science to provide definitive solutions to social problems (e.g. post normal science). Both approaches are useful but also quite distinct.

Focused on integrative interdisciplinarity, Spash's (2020) contribution continues his argument for a structured pluralism based on "a theoretically coherent and epistemically sound approach that rejects flawed economic concepts and theories on scientific grounds"(p. 2). He explicitly rejects mainstream economics and its assumption of market equilibrium, price-making markets, and deductive mathematical models of idealized competitive markets, encouraging the use of tools from heterodox economics instead. He concludes that the path forward requires social ecological transformation of the economy, which "means alteration of the current institutional and social relations of production. The change ahead is not a minor price adjustment, but a major transformation." (p. 10) Røpke (2020) rejects pluralism that simply supplements the NCE framework with theories and methods from other disciplines, proposing instead a new economics built on biophysical and heterodox economic foundations. NCE may provide some useful insights, but its performativity is incompatible with the goals of EE. Similarly, Goddard et al. (2019) agree that the economic system requires major transformation but argue that in a rapidly co-evolving system, the magnitude of the required transformation demands that we remain open to contributions from many fields of thought. They recognize the doxa underlying NCE can blind us to detrimental dynamics of the current system and call instead for developing a new doxa compatible with the pursuit of equity and sustainability in a changing world. Costanza (2020b) also defends methodological pluralism, recognizing that all of our theories are imperfect and we should therefore apply those that are most useful for solving a given problem. We should stop arguing over relatively minor differences and focus instead on collaborating with others pursuing broadly shared goals.

Blignaut and Aronson (2020), from the like-minded field of ecological restoration, bridge integrative theory and transdisciplinary practice. They acknowledge the failures of mainstream economic theory but also recognize that better theories alone cannot solve the problems we face. We must transition to a restoration-inspired culture and economic system, which requires engaging with myriad stakeholders to develop a restoration narrative integrating social injustice, ecological degradation, and multiple ways of knowing. Tools such as monetary valuation can contribute to this narrative if applied correctly. The authors provide a brief case study of Rwanda's *Umaganda* system, a"process of social healing including community-based activities" (p. 22) that resulted in a payment for ecosystem service scheme for ecological restoration designed to facilitate "behavioral and mental change" among all stakeholders.

As someone who has dedicated his career to using EE to solve real-life problems, Batker (2020a) contribution focuses entirely on action-oriented transdisciplinarity. Theories, no matter how scientifically rigorous or accurate, do not translate directly into policy; instead "all solutions must pass through the gauntlet of politics, society, and culture"(p. 6). Batker acknowledges the ethical and theoretical challenges to monetary valuation but notes that stakeholders ranging from indigenous tribes to the US government frequently request or demand valuation. Valuation proved essential in convincing policymakers to commit $50 billion to rebuild the Mississippi Delta. Leaders in the movement to massively reduce plastic waste, operating on the EE principle that "our lifestyles and economy fit within the environmental limits of the planet" want economic arguments to support their goals, whether neoclassical or ecological. Faced with innumerable, urgent, real-world challenges characterized by high stakes, uncertain facts, and stakeholders with various worldviews and values, practitioners "must act with the tools and research available when opportunities to implement ecological economics arise" (p. 6). Batker stresses that closer collaboration between academics and practitioners of EE over the next 30 years will benefit both sides: practitioners will be more effective, and academics will better understand how change is made.

Our previous discussions of uncertainty and MLS offer important insights into this pluralism debate. First, MLS sheds light on many EEs' aversion to NCE and capitalism. Social dilemmas result when decisions are made at a smaller scale than impacts are felt and, like so called externalities, are maximized by atomistic, self-interested individuals (Akbulut and Adaman, 2020; Vatn, 2020; Vatn and Bromley, 1997). Ecological sustainability and social justice are unavoidably group-level goals, requiring coordination of group activity at the scale of the problem, and cannot be achieved by self-interested competition. In contrast, the consumer choice theory at the heart of NCE focuses on the satisfaction of subjective individual preferences, while production theory focuses on profit maximization by private firms. NCE is "the discipline that most clearly satisfies the strictures of methodological individualism" (Heath, 2015), which means that "individuals are the only units of functional organization relevant for economic decisions" (Snower, 2020). Most definitions of capitalism emphasize private ownership of the means of production in pursuit of profit and individual choice. Thus, the theories of NCE and the practice of capitalism are both defined by their emphasis on decision-making by and for individuals. In short, from the perspective of MLS, EE is primarily focused on fitness at the group level and NCE at the individual level, a fundamental moral incompatibility. However, MLS also reminds us that evolution can select for selfishness or altruism under different circumstances, and humans are clearly capable of both. While we must forge an economic doxa compatible with cooperation and group level goals to solve the numerous social dilemmas we face, judicious use of the price mechanism can provide a powerful and useful feedback signal capable of contributing to group level goals even if we reject the belief it will result in some optimal equilibrium.

Second, MLS, we believe, forces us to reject the dualism between positive and normative, facts and values, "is" and "ought", and the widespread assertion that the latter cannot be derived from the former (Hume, 1739). MLS argues that more altruistic groups outcompete more selfish ones, so natural selection favors cultures with ethical values that promote social coordination and penalize self-interested behavior undermining it. We would not even have modern science dedicated to studying what "is" had we not previously evolved collective knowledge and culture, which in turn required the evolution of moral "oughts" facilitating social coordination. Developing institutions and norms for cooperation at the scale of our global social dilemmas requires an extension of our moral values to encompass a broader definition of group, perhaps even the entire biotic community. Ethics and value theory are not just central to economic understanding, they are also powerful tools for solving social dilemmas. The study of how ethical values shape a cultural phenotype is just as factual or objective as the study of how genes shape an individual phenotype. Efforts to promote societal values compatible with a socially just sustainability transition can be as scientific as gene therapies intended to mitigate a genetic disorder. Normative versus positive is a false dichotomy.

Furthermore, the existing system is on the cusp of radical change—social, ecological, or both—which could flip it into another regime in which many existing theories and policy prescriptions will no longer be

valid. Such periods of release and reorganization are conducive to evolutionary change to the social economic system (Stanley, 2020). EE's are trying to direct that change through a co-evolutionary process—a dynamic process of becoming rather than a static process of understanding what "is" (Whitehead, 1978)— with novel outcomes that cannot be predicted from past observations (Faber et al., 1998). From this perspective, EE's embrace of the normative goals of justice and sustainability is just as objective as its embrace of the law of entropy and complex systems theory and far more scientific than theories that reduce economics to mathematical equations.

On the other hand, MLS and cultural evolution caution against excessive certainty in our own convictions. The collective nature of human knowledge means that as individuals, none of us are very smart or influential (Henrich, 2016). EEs engage in years of specialized training just to partially understand some small facet of our field, and even that limited understanding is based on faith in the validity of the underlying paradigms from which it is built, despite recognizing that dramatic paradigm shifts are a basic feature of science. We interpret knowledge through the lens of our group doxa, and we would be foolish to believe we are any less susceptible to confirmation bias, motivated reasoning, or unwarranted certainty than other economists. We may understand the theories we critique even less well than we understand our own. Most importantly, people are more likely to listen to critiques from others they identify as part of their own group (Cialdini, 1993; Haidt, 2012). We do not need to agree with everything other groups believe to cooperate with them to achieve shared goals. The more we cooperate, the more likely we are to view each other as members of a group, and the more likely we are to listen open-mindedly to each other's theories and criticisms. We believe this will help us not only disseminate the EE doxa and episteme more broadly, but also improve it by helping us recognize flaws in our own understanding and exposing us to new insights that enrich our field.

The world of action-oriented EE is unavoidably far messier than the theoretical. The average citizen or decision-maker understands far less of the science underlying EE than the experts and largely accepts or rejects it based on how well it conforms to their doxa. Scientific evidence that conflicts with a person's worldviews may carry less weight than their social media feeds (Muradian and Pascual, 2020a). Policymakers assess policy options through the lens of their own strategic interests. More accurate public understanding and greater acceptance of EE require a change in the prevailing economic doxa (Goddard et al., 2019). Doxa is part of what binds people into groups, and groups are bound together by emotion and shared moral values, not rational argument (Haidt, 2012; Muradian and Pascual, 2020b). Furthermore, numerous studies have shown that different cultures respond very differently to identical economic cues (Henrich et al., 2005). As we seek to transform social reality, we are likely to find some cultures respond best to ethnocentric arguments and discussions of relational values (Chan et al., 2016; Chan et al., 2018), while others respond more forcefully to stories using market metaphors, such as monetary valuation and ecosystem services. From the perspective of integrative interdisciplinarity, we (the guest editors) are personally very skeptical of both the science and ethics of monetary valuation—not just for ecosystem services, but also for some essential market goods, such as food, as discussed by Bliss and Egler (2020). However, we simultaneously respect Batker, 2020a, Batker, 2020b) effectiveness at achieving real change, and are reluctant to criticize applied valuation work without objective evidence that other approaches work better.

We believe that over the coming thirty years, EE should integrate more basic principles from evolutionary theory. EE should have three complementary goals directed towards a socially just sustainability transition: to improve EE as a science, to push policies and other actions, and to strive to change economic doxa and other elements of culture. In all three cases, our approaches must account for uncertainty about how the current system functions, the unpredictable co-evolution of doxa, episteme and social reality, and our limited understanding of how to direct system changes towards more desirable ends.

As a science, EE weds the natural and social. Both generate innumerable false hypotheses, as found in many now rejected hypotheses put forward within the more than 74,000 research articles published on COVID 19 in the past year (Yong, 2021). Society appears to trust natural sciences more than social sciences not because the former are invariably right, but rather because the scientific method offers a reliable mechanism for rejecting false hypotheses, usually by conducting experiments in tightly controlled settings, and because welaws governing physics, chemistry, ecological and so on are unchanging, not affected by our theories. The normal scientific method therefore seems adequate for assessing the validity of the biophysical foundations of EE, though as several contributions point out (2020; Blignaut and Aronson, 2020; Hanaček et al., 2020; Muradian and Pascual, 2020b), traditional knowledge, often confirmed by millennia of experience, also deserves respect. Therefore, the social sciences must be consilient with the natural sciences (Farley, 2014; Gowdy and Carbonell, 1999; Wilson, 1998); for example, hypotheses and theories cannot contradict the laws of thermodynamics.

But social scientists cannot easily conduct tightly controlled experiments, especially since social behaviors are context-dependent. Furthermore, social sciences are performative, striving to change the system: Milton Friedman never claimed that the existing economic system generated a welfare-maximizing market equilibrium, but only that it would do so if we followed his advice. It is difficult to reject such a theory by proving it wrong, since it begins with a counterfactual, but we should reject a performative science if we disagree with its normative goals. The normative elements of EE theory are related to species survival, the driving force of evolution for the past four billion years, while the social reality that economic theories attempt to explain is continually evolving. Evolution works by trying innumerable variations, weeding out the failures through natural selection, then proceeding with innumerable new variations of those that survive. In terms of integrative interdisciplinarity, this calls for a structured multidisciplinarity that rejects theories and methods incompatible with the natural sciences or our normative goals while acknowledging that the explanatory power of many social science theories varies with culture and doxa, both of which themselves are evolving.

In terms of action-oriented transdisciplinarity, we should experiment with many policies, practices, and economic systems, recognizing that local culture will affect the effectiveness of each. When policies fail to promote sustainability and justice in a particular setting, or influence doxa in undesirable ways, for example by reinforcing self-interested behavior, they should be replaced with new combinations and variations of those that succeed, again recognizing that the very changes our experiments drive will also affect their future effectiveness.

Our most challenging task is to change doxa and cultures, including moral values, in ways that promote the EE agenda. EE's should recognize we are pursuing intentional cultural evolution (Wilson et al., 2014). We know little about how to direct evolution, especially in the face of other groups pushing society in entirely different directions, and the system is too complex to predict exactly how society will change in response to new doxa. Again, an evolutionary approach requires variety. Cultural pluralism is essential. However, we cannot rely on natural selection to achieve sustainability since -growth-obsessed cultures fundamentally alter the ecosphere and hence the fitness of cultures that might otherwise be sustainable. Instead, we should assess how particular elements of a given doxa or culture hinder or contribute to EE goals and strive to eliminate or stimulate them accordingly. Our theories of how the system works and evolves will always be flawed and incomplete, and their explanatory power will change as the system evolves.

All of this suggests that the validity of social science theories, our efforts to explain what is, may be far less important than EE's normative goals of what ought to be. For example, If NCEs could performatively forge institutions, policies and doxa that resulted in markets allocating resources to the producers willing to pay the most, apportioning the

commodities to the consumers willing to pay the most and thus maximizing net present monetary value for both producers and consumers, the theory would be superb at explaining what is. Nonetheless, most EEs would still reject the theory because they disagree with the goals. Laypeople who fail to understand the details of economic theories already accept or reject them based on the perceived desirability of their goals.

6. Summary and conclusions

Our central focus in this editorial is on the significance of important themes addressed by the articles in this SS: uncertainty, co-evolution, social dilemmas, the normative and performative nature of EE, methodological pluralism and the need for radical change. NCE and our STEM (Science, Technology, Engineering and Math)-obsessed society focus on technological change and simple behavioral nudges to solve our problems, and glorify objective, value-free science, but there are no purely technical solutions to social dilemmas. Achieving the goals of EE will require cooperation at unprecedented scales. Ethics and moral values evolved to facilitate cooperation and are as essential to achieving our goals as STEM is to technological progress. EE is a performative social science with biophysical foundations dedicated to the intentional evolution of a socially just and sustainable society. This will require cooperation at an unprecedented scale, which in turn will require changes to moral values, behavior, and institutions. Our approach should be informed by the evolutionary theories of MLS,[7] but in our highly complex, highly uncertain system, we can never be certain how specific policies or actions will affect the system and cannot rely on natural selection to weed out failed approaches. Instead, we must experiment with many policies, actions, and economic systems then actively select those that best achieve our normative goals. This means that social sciences should be judged by the ethics and doxa that guide them. However, we must also recognize that our field pursues many intermediate goals assuming they will allow us to achieve often ill-defined higher-order ends. Many well-meaning people continue to believe that economic growth is so effective at improving human well-being that it qualifies as an end in itself. We must therefore be willing to question and abandon intermediate goals if we learn they conflict with higher-order ends.

In conclusion, we believe that EE cannot possibly hope to promote the cooperation required to solve global-scale problems if we struggle to cooperate among ourselves and our natural allies. Over the next 30 years, we must prioritize building a major coalition of academic fields and social movements dedicated to shared normative goals (Muradian and Pascual, 2020a), such as the Well-Being Economics Alliance (Costanza, 2020b). We should still have vigorous dialogues and discussions about the validity of different theories and policies, essential for any dynamic transdiscipline. Perfect agreement would be the triumph of ideology over science. We (the guest-editors) consider all the authors in this issue part of our scientific community not because we fully understand or agree with every theory or method they propose, but rather because we share their moral values and normative goals of facilitating a socially just sustainability transition. While we might ignore critiques of our work from scholars with different moral values or who ignore the biophysical foundations of the economy, we welcome and learn from critiques from other researchers in the EE community—for example, Spash's (2020) and Røpke (2020) challenges to Farley's views in their contributions to this SS—because they are members of both our moral and collective knowledge communities.

We look forward to working together over the next 30 years to improve our science and build a better world.

[7] John Gowdy and Lisi Krall have been pioneers in integrating MLS theory into their EE work, while David Sloane Wilson has been a pioneer in applying MLS to economic problems (Wilson, 2019; Wilson and Gowdy, 2013; Wilson et al., 2014, Farley et al., 2020; Gowdy, 1994; Gowdy and Krall, 2013, 2016; Gowdy, 2004)). See also https://evonomics.com.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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