SOCIETY–NATURE COEVOLUTION: INTERDISCIPLINARY CONCEPT FOR SUSTAINABILITY

by
Helga Weisz and Eric Clark

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ABSTRACT. A brief historical background to the currently ascending interest in evolutionary and coevolutionary theory is sketched, and the concept of society–nature coevolution is positioned in this broader field. The significance of society–nature coevolutionary pathways for transition to sustainability is highlighted with Schellnhuber's heuristic 'theater world' for representing paradigms of sustainable development. Geography's recent re-engagement in the geographical experiment of keeping society and nature under one conceptual umbrella is exemplified in the works of Hägerstrand and Harvey. This special issue's four contributions to developing society–nature coevolutionary theory are presented. The outlook these articles provide suggests that research into society–nature coevolution should play a key role in identifying physically, biologically and socially accessible pathways to sustainability. In order to keep the future accessible and navigable, we will need enhanced understanding of society–nature coevolution.

Keywords: coevolution, evolution, society–nature, sustainability

Introduction

The history of the notion of coevolution and its current use present a highly fragmented picture. The term coevolution goes back to Ehrlich and Raven (1964) who proposed it to describe a specific mutual relationship between plants and butterflies that shapes the evolution of both. Since then the term coevolution has been widely used in ecology, and has come into use in other fields that have developed theories based on generalized forms of Darwinian evolution. Originally used with reference to relations between species, it has come to include similar dynamics between complex units or systems that coevolve. In recent years the concept has been applied to such diverse fields as computer science, economics, organizational theory, anthropology, archaeology, geography, history, sociology, and earth system and environmental sciences. Two evolutionary processes and their mutual relations are at the core of the concept of society–nature coevolution: biological and cultural or socio-economic evolution.

Attempts to theorize society–nature coevolution work with different conceptions of culture and society, with different understandings of evolution and with different interpretations of biological evolution: hence the fragmented picture. Use of the term evolution in connection with processes of cultural and social change antedates the publication of Darwin's *The Origin of Species* (1968 [1859]). It was Darwin's contemporary Herbert Spencer who set the standard for an understanding of evolution in the humanities and social sciences for many decades. Interestingly, Spencer derived his understanding of evolution not from Darwinian phylogeny (ancestral descent), but from the biological concept of ontogeny (development through life stages of individual organisms) (Spencer 1876). The Spencerian notion of evolution is thus associated with progress, differentiation and directionality, not with variation and selection. Even today in disciplines such as history, anthropology or sociology the term evolution is commonly interpreted in the tradition of Herbert Spencer and what has later been called evolutionism in cultural anthropology. When the idea of social or cultural evolution is rejected, it is often in fact because of this connotation of intrinsic progress.

In biology, Darwin's theory of descent with modification did not become a unifying concept until the first half of the twentieth century with the so called synthetic theory of evolution by Dobshansky, Mayr and Fischer. Nonetheless, intensive debates and discussions about fundamental conceptual issues of Darwinian evolution continue (Sober 1994; Hull and Ruse 1998). Beyond biology, scholars from a variety of disciplines have applied Darwinian principles to aspects of social and cultural change in partly overlapping and partly incommensurable ways.[1]

This special issue addresses approaches that focus on the dynamic mutual interactions between human societies and their natural environment. Society–nature coevolution is the most general approach towards coevolution. As the articles in the issue demonstrate, it builds upon insights from a number of disciplines, including geography, history, sociology, psychology, ecology, socio-ecology, biology and economics, as well as many more specific

fields of inquiry such as human evolution, ecological anthropology and gene–culture coevolution, to mention just a few.

The relevance of studying society–nature interactions for identifying sustainable pathways for humanity's future is undisputed. The details and ramifications of this scientific enterprise, and the question of what value a coevolutionary framework can add, however, remain controversial. At a general level, abstracting from all details of the internal complexities of society, nature and history, Schellnhuber's '"theatre world" for representing paradigms of sustainable development' (Schellnhuber 1999, p. C22) can serve as a conceptual tool for identifying the ultimate goal of coevolutionary research. The "theatre world" is a heuristic presented as a two-dimensional space with a gradient of conceivable physical states of the planet Earth on the one axis and a gradient of conceivable socio-economic states of human civilization on the other axis. The area enclosed by the two axes comprises the space of all conceivable coevolutionary states between society and nature. At any given point in time global human society occupies a specific location in this two-dimensional coevolutionary space, from which a host of future pathways are accessible – or as Hägerstrand would have put it, within reach. The point is that the coevolutionary subsistence niche within which human society is sustainable is much smaller than the full space spanned out by the two axes. On the natural axis, extreme climate regimes such as a Martian or Venusian one (theoretically attainable by a runaway cooling chamber process or a greenhouse process) are clearly outside the subsistence niche for humans. There are also conceivable socio-economic regimes that move society outside the subsistence niche (a protracted global fertility rate of zero for example). Furthermore, within the two-dimensional subsistence niche there exist not only accessible but also catastrophic and inaccessible domains (Schellnhuber 1999). Catastrophic domains allow humans to survive as a species, but only in dramatically reduced numbers and under unpleasant conditions. Inaccessible domains are theoretically conceivable, but cannot be reached in practice. Schellnhuber's heuristic suggests that the ultimate goal of coevolutionary research could be to identify more precisely the subsistence niche for human civilization and to explore patterns and properties of accessible, inaccessible and catastrophic socio-ecological coevolutionary pathways.

This special issue brings together the work of scholars from different scientific communities who share an interest in fundamental aspects of the interaction between societies and their environments and apply a coevolutionary framework. We hope to foster cross-disciplinary exchange. Human geography with its traditional focus on studying interactions between humans and their natural environments is well suited to host such an ambitious theoretical endeavour.

Coevolution in geography

The development of evolutionary theory and the discipline of geography were tightly intertwined in the nineteenth and early twentieth centuries. The 'geographical experiment' was about 'keeping nature and culture under the one conceptual umbrella' (Livingstone 1992, p. 177). This experiment lost credibility in the wake of decades heavily influenced by forms of environmental determinism and Social Darwinism. The near silence in geography during the 150th anniversary of *The Origin of Species* (Darwin was, after all, Fellow of the Royal Geographical Society) in 2009 was a reminder of how the discipline disengaged with evolutionary theory after 'less than salutary uses were made of Darwin's ideas by many of the first university geographers. … not a past we'd wish to revisit' (Castree 2009b, p. 941). This disengagement was never total, however, and in recent decades we have seen renewed interest in evolutionary theory and participation in developing coevolutionary theory, reflected also in the pages of this journal (e.g. Funnell and Parish 1999; Tsai 2003; Hayter 2004).

The ongoing evolutionary turn in economic geography fills the pages of economic geography journals as evolutionary economic geography establishes itself as a leading school of thought. Evolutionary economic geography is, however, largely limited to 'applying models of evolutionary economics in a spatial setting' (Coe 2011, p. 88; cf. Hodgson 2009; MacKinnon *et al*. 2009), using evolutionary concepts of variety, selection, inheritance, retention and adaptation. Coevolution in evolutionary economic geography seldom extends beyond the social sphere. Coevolution unfolds between industrial sectors, institutional frameworks, networks and structures of agglomeration, or, more simply, between firms and dimensions of their social and economic environments. The new evolutionary economic geography may well contribute to research into society–nature coevolution,

but as yet remains directed towards understanding societal evolution more than society–nature coevolution.

Parallel with evolutionary economic geography – literally parallel, with little cross-fertilization – geographers have been busy on many focused fronts 'putting life back into the discipline' (Spencer and Whatmore 2001). There is much of relevance to society–nature coevolution in the diverse works of 'the new materialists', not least their refusal 'to acknowledge any Maginot Line (supposedly) separating' the natural and the social (Castree 2009b, p. 942). And yet, Castree's complaint over 'human geography's wider intellectual disconnection from the contemporary life sciences' (2009b, p. 944) is hard to refute. Indeed, few contemporary geographers have engaged in 'painting big (if crude) pictures on a very large intellectual canvas' (Castree 2009a, p. 2297). Two who have are Hägerstrand and Harvey. Both develop society–nature coevolutionary thought in different ways.

Most of Hägerstrand's nearly 300 publications (Lenntorp 2004b) are articles and essays (mostly in Swedish) seeking to formulate concepts based in elementary material events with which to grasp what he came to call '*all-ekologi*' in his posthumously published intellectual testament *Tillvarovären* (The weave of existence) (2009). Parts of *Tillvarovären* read like Heidegger, as Hägerstrand constructs an original vocabulary in an effort to fill the gap he repeatedly made note of: the need for a common language across the natural and social sciences and humanities in order to gain 'deeper understandings of fundamental ecological and social conditions and processes' (Lenntorp 2004a, p. 223; cf. Gren 2009). He variously formulated the task as developing a '*theory of diorama transformation*' (1984, p. 378, emphasis in original) or of 'topoecology' (2004, p. 323), or of '*förloppslandskap*' (process-landscape; 2009, p. 268). Geography he sees as 'the struggle for power over the entry of entities and events into space and time' (1986, p. 43, our translation). Hägerstrand's relevance for approaching society–nature coevolution can only be hinted at here by way of presenting passages in *Tillvarovären* where he formulates core hypotheses:

> As hypothesis, the conceptualization is introduced that the neighbourhood-configurations on the earth's surface (its next-to-each-othernesses) function as evolutionary filter.
>
> (Hägerstrand 2009, p. 76)

> *The study of steps into the future involves an effort to grasp everything's and everyone's passage through the present as one single question.* … The hypothesis is that the way space is acquired, held and used is the key to how the weave of existence is formed into the future.
>
> (Hägerstrand 2009, pp. 134–135, emphasis in original)

> In the living world, reach may be seen as a phenomenon of similar rank as gravity in physics.
>
> (Hägerstrand 2009, p. 163; all of the above are our translations)

Harvey shares Hägerstrand's concern that we 'badly need a much more unified language than we currently possess for exercising the joint responsibility towards nature that resides with the social and biological/physical sciences' (Harvey 1996, p. 190). Like Hägerstrand, Harvey seeks 'a way of depicting the fundamental physical and biological conditions and processes that work through all social, cultural, economic projects to create tangible historical geography and to do so in such a way as not to render those physical and biological elements as a banal and passive background to human historical geography' (1996, p. 192). Hägerstrand and Harvey are process-oriented materialists. But while Hägerstrand's purpose is to understand *limits* and *constraints* ('impeding contiguities are equally important objects of explanation on earth as the forces which initiate movement and change'; 2009, p. 120, our translation), Harvey's purpose is 'to specify these conditions and processes in such a way as to understand the *possibilities* for collective human activity in negotiating through these fundamental elements to generate significantly diverse outcomes' (1996, p. 192, emphasis added; cf. Harvey 2000). Harvey's view is dialectic, drawing on social scientists who recognize that agency is not confined within the human social sphere, and on life scientists who acknowledge 'the different ways in which all species (including human beings) can affect subsequent evolution through their behavior' (1996, p. 192; cf. Clark and Clark forthcoming). More recently, Harvey has elaborated an approach to coevolution (2009, Chapter 9; 2010a, Chapter 7; 2010b, Chapter 5) in which autonomous but dialectically interwoven elements, moments or spheres of activity constitute a socio-ecological totality of ensembles or assemblages in an open coevolutionary process. There are similarities with Norgaard's

work, Harvey's constellation of moments placing more emphasis on social relations, reproduction of daily life, production systems and labour processes (compare the figure in Harvey 2010a, p. 195, with the figure in Norgaard 1994 and Norgaard and Kallis 2011, p. 293).

'The danger for social theory', says Harvey (2010a, p. 196), 'is to see one of the elements as determinant of all the others'. No single sphere or moment generates the coevolutionary process. The 'geographical experiment' of keeping nature and culture and spheres of social activity under one conceptual umbrella remains an ongoing task, one that will require intensive engagement across disciplinary boundaries. We need a post-disciplinary geographical experiment.

The special issue

In the opening article, 'Coevolutionary contradictions: prospects for a research programme on social and environmental change', Richard Norgaard (a pioneer of coevolutionary thinking in ecological economics) and Giorgos Kallis address important epistemological aspects of coevolutionary research (Norgaard and Kallis 2011). They point out the inherent contradictions between society–environment coevolution as a real-world process, which is open-ended and non-deterministic, and various approaches to study the process. In particular they emphasize fundamental contradictions between what they call mental experiments and more formal empirical testing of specific hypotheses in analytical approaches. By mental experiments, a concept central to this article, the authors refer to the intensive cognitive engagement scholars entertain with a broadly defined framework, using it to reframe empirical phenomena, and ultimately enhance understanding. A broad and vaguely defined framework is seen as a prerequisite for gaining new and unexpected insights into the open-ended and complex nature of society–environment coevolution. To illustrate their point the authors reflect on their experiences with coevolutionary mental experiments, an unusual but insightful element in an academic article. Mental experiments are contrasted with analytical and mathematical approaches that are specifically designed to test empirical hypotheses. These require that the systems under consideration be defined *a priori*, including their key elements, their replication mechanism and their selective pressures. Norgaard and Kallis acknowledge that this programme has been applied successfully to related fields, such as gene–culture coevolution and has been instrumental in building an integrated school of thought, but they also question on what basis the characteristics of such systems are identified. Ultimately they argue that there 'are no "correct" analogies for thinking about the coevolution of social and environmental systems' (Norgaard and Kallis 2011, p. 296). The solution to the epistemological constraints, however, does not lie in abandoning analytical applications, but rather in their reflective use, maintaining consciousness of their limitations. For a possible future development of a coevolutionary community of scholars they propose in particular three lines of research that should be followed in parallel: (1) mental experiments applied through experiments on the ground, (2) the application of specific evolutionary concepts (such as variation, selection, path-dependency) as metaphors to frame historical narratives and hypotheses, and (3) the development of formal models.

In the following article, 'Towards unification of the socio-ecological sciences: the value of coupled models', Tim Waring and Peter Richerson present a thoughtful and thorough exploration of the third line of research suggested by Norgaard and Kallis. Drawing on Richerson's pioneering contributions to the dual inheritance model of cultural evolution, they propose a formal modelling strategy with the ultimate goal of achieving a unified theory of society–environment interaction (Waring and Richerson 2011). Their article is devoted to specifying the necessary and sufficient conditions of the possibility of such an endeavour and to demonstrating its practical feasibility. First, Waring and Richerson present and discuss three formal traditions, gene–culture coevolution, niche construction and the Lotka–Volterra ecological theory (the mathematical details and basic equations of these approaches are presented in appendices). Though capable of simulating cultural change, these models by themselves do not represent cultural complexity in sufficient detail. To this end Waring and Richerson employ mathematical models of cultural evolution originating in the work of Cavalli-Sforza and Feldman (1981), Boyd and Richerson (1985) and others. This body of research extends the formal characteristics of population genetics into the cultural realm, positioning cultural traits and various routines of social learning as dominant transmission processes. However, to approximate a theory of society–nature coevolution, such formal models must go beyond the representation of cultural phenomena by adequately taking into

account environmental influences on cultural evolution. Based on a wealth of cross-cultural empirical studies Waring and Richerson demonstrate how such models can help to interpret observed patterns in society–nature coevolution. Finally, they point out that some cultural phenomena are not adaptive, while others are even maladaptive in terms of biological evolution. A formal theory of society–nature coevolution would need to take those phenomena into account. For this purpose they propose development of coupled cultural–ecological models. To demonstrate the explanatory power and feasibility of such an approach, Waring and Richerson develop a simple model of a biological species that is affected by a habitat modification practice.

For environmental historian Rolf Peter Sieferle, recognized for his seminal socio-metabolic analyses of industrial transformation, socio-metabolic systems can be understood by a reconstruction of the coevolution between society and nature. The central hypothesis of Sieferle's article 'Cultural evolution and social metabolism' is that coevolution between natural ecosystems and human societies is mediated by human culture as an autopoietic[2] system. This conceptualization has important implications. One is to acknowledge that the autopoietic reach of culture, although limited by adaptive boundaries where the physical population serving as material information carrier for culture is endangered (a cultural system defining rules that undermine the existence of the population would disappear with the population), nevertheless has enormous degrees of freedom within this boundary condition. Therefore, a cultural system that is neutral or even maladaptive vis-à-vis the survival chances of the human population can emerge and propagate. Another implication is that nature (the entirety of the physical environment of the human population) and culture (a purely symbolic system of recursive communication) cannot interact directly, because nature's elements only interact physically, via flows of material and energy, while culture's elements only interact symbolically, via flows of information. Hence, nature and culture cannot possibly coevolve in any direct sense. The human population acts as physical agent towards nature (via social metabolism) and as information carrier towards culture (via communication), thereby constituting an interface with the effect of transforming cultural programmes into physical effects, but also of providing culture with signals gained from the physical environment. The main message therefore is that society–nature coevolution requires at least three elements (non-human nature, the human population and culture), and that the autopoietic character of culture as a recursive system of communication (a conceptualization largely derived from Luhmann's social systems) needs to be fully recognized in order to avoid both natural and cultural reductionism. The concept of social metabolism is credited a central role in this coevolutionary theory, in that it 'aims at the unity of "persons" in a physical-biological sense and "culture" in a symbolic sense, the decisive point being that culture must be understood as an autopoietic system *sui generis*' (Sieferle 2011, p. 322).

In the final article, 'The probability of the improbable: society–nature coevolution', Helga Weisz seeks synergetic potentials between Luhmann's social systems theory and social metabolism to develop a socio-ecological conceptualization of society–nature coevolution (Weisz 2011). Weisz argues for the value of such a concept in approaching issues concerning sustainability, and identifies pivotal points where greater precision can enhance the robustness of the concept, namely the sociological dimension of cultural evolution and the relations linking cultural evolution and environment. In seeking these, she calls for a fundamental shift in analytical focus, from populations to communication systems. The greatest sustainability challenge we face is transitioning from industrial metabolism, and to this end the concept of society–nature coevolution should prove very useful. Weisz offers a powerful enhancement of this invaluable concept.

Outlook

Niels Bohr observed that 'the practical use of every word stands in a complementary relation to its strict definition' (Bohr 1948, p. 318). The pursuit of precise definition of a concept can impede its assimilation by scholars from different disciplines. Lack of theoretical rigour, on the other hand, impedes innovative applications of theory to important societal and environmental problems. This dilemma characterizes interdisciplinary cooperation in addressing complex and pressing problems such as comprehending potential pathways for sustainability transition. The notion of coevolution between society and nature presents a conceptual framework with considerable promise for keeping nature and culture under one conceptual umbrella. Its history and current

applications and interpretations reveal a forceful framework capable of oscillating between generalization, dialectical openness and connectivity, theoretical rigour, formal mathematical representation and guidance in the formulation of new hypotheses, and the quest for adequate representation of social complexity. Following Schellnhuber, we suggest that continued research into society–nature coevolution – utilizing related formulations as geo-history meshes with theoretical refinement – can help us to identify physically, biologically and socially accessible pathways that stay clear of 'catastrophic domains' (1999, p. C22). Sustainability is 'the art of keeping the future navigable … of keeping the future accessible' (Hägerstrand 2009, pp. 187 and 264, our translation). For this, we will need enhanced understanding of society–nature coevolution.

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Notes

1. See Hodgson (1993), Nelson and Winter (2002), Fehr and Fischbacher (2003) and Hodgson and Knudsen (2006) on economic theory, the emergence and role of human cooperation, and the rise and fall of firms; Wilson (1998) and Richerson and Boyd (2005) on genetic constraints on cultural evolution and vice versa; Parsons (1964) and Luhmann (1997) on major social achievements and stages in societies; Cavalli-Sforza and Feldman (1981), Boyd and Richerson (1989) and Henrich (2001) on the transmission of cultural traits; and Kelly (1995) on complex systems theory and intervention into complex systems. Recent special issues of journals spanning society–nature coevolution include Rammel *et al*. (2007) and Kallis and Norgaard (2010).
2. The term autopoietic, a neologism created by Maturana and Varela (1975) from the Greek word αὖτο (self) and ποίησις (creation) to describe the self-producing properties of biological systems, was adopted by Luhmann (1984) to specify recursive systems of communication. It is in this latter sense that Sieferle uses the term to specify culture as a system *sui generis*.

Helga Weisz
Potsdam Institute for Climate Impact Research (PIK)
PO Box 60 12 03
D-14412 Potsdam
Germany
E-mail: weisz@pik-potsdam.de

Eric Clark
Department of Human Geography, and
Lund University Centre of Excellence for the Integration of Social and Natural Dimensions of Sustainability (LUCID)
Lund University
Sölvegatan 10
SE-223 62 Lund
Sweden
E-mail: eric.clark@keg.lu.se

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