SOCIOLOGY

Why resilience is unappealing to social science: Theoretical and empirical investigations of the scientific use of resilience

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Resilience is often promoted as a boundary concept to integrate the social and natural dimensions of sustainability. However, it is a troubled dialogue from which social scientists may feel detached. To explain this, we first scrutinize the meanings, attributes, and uses of resilience in ecology and elsewhere to construct a typology of definitions. Second, we analyze core concepts and principles in resilience theory that cause disciplinary tensions between the social and natural sciences (system ontology, system boundary, equilibria and thresholds, feedback mechanisms, self-organization, and function). Third, we provide empirical evidence of the asymmetry in the use of resilience theory in ecology and environmental sciences compared to five relevant social science disciplines. Fourth, we contrast the unification ambition in resilience theory with methodological pluralism. Throughout, we develop the argument that in-commensurability and unification constrain the interdisciplinary dialogue, whereas pluralism drawing on core social scientific concepts would better facilitate integrated sustainability research.

INTRODUCTION

In search of resilience

Climate change is a reason to engage in sustainability research and to clarify the scientific foundation of, and conditions for, doing integrated research. As a contribution to this, we analyze why interdisciplinary communication between the social and the natural sciences is difficult and divisive, here exemplified by the ambition in resilience theory to make resilience a boundary concept in sustainability research. To that end, we critically explore four questions:

(i) What does resilience actually mean and how can it be defined?

(ii) Why is resilience problematic in social science and for understanding society?

(iii) To what extent does resilience theory close the disciplinary gap that it aspires to?

(iv) Is there an alternative way forward to conduct integrated research on sustainability?

In search of explanations for the troubled dialogue internal to the sciences themselves, we first trace different disciplinary uses of resilience. From this, we generate a typology of the four most salient types of definition of the concept in resilience theory and social-ecological thinking, some of which stand in the way of a constructive dialogue between disciplines. In the identifying incommensurability with social science section, and as the bulk of our argument, we illustrate how incommensurability and miscommunication are rooted in ontological and epistemological differences between the social and the natural sciences. As an aspect of this, we discuss why society and social relations cannot be readily cast in the ecological terms that resilience researchers use to describe interaction in natural systems such as dynamic equilibria, feedbacks, thresholds, and self-organization. In the in search of resilience in scientific journals section, we present the results from our bibliometric analysis of natural and social science journals showing strong asymmetry in the presence of resilience. In the Discussion section, we discuss how the ambition in resilience thinking to overcome the dis-

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ciplinary divide through unification is counterproductive from a social science perspective; it would more likely be achieved through methodological pluralism. On the basis of our findings, we argue that there are reasons to favor pluralism over unification as a methodological approach to integrated research on social and natural dimensions of sustainability. In the Conclusions section, we conclude with five key messages.

RESULTS

On the meanings and attributes of resilience

The use of the word resilience has a long history replete with diverse meanings ranging from bouncing, leaping, and rebounding, to human resourcefulness, to elasticity and resistance properties in materials including steel, yarn, and woven fabrics (1). In contemporary debates, it is a commonly held view that resilience is concerned with the ability to cope with stress or, more precisely, to return to some form of normal condition after a period of stress.

Early on, ecological theory was associated with the equilibrium and stability of ecosystems. In his seminal paper in 1973, Holling questioned the notion of a single equilibrium and stability and started promoting resilience that he defined in a rather precise way: "Resilience determines the persistence of relationships within a system and is a measure of the ability of these systems to absorb change of state variable, driving variables, and parameters, and still persist" (2). In 1998, Perrings offered a more open definition of resilience: "in its broadest sense, resilience is a measure of the ability of a system to withstand stresses and shocks—its ability to persist in an uncertain world" (3).

Resilience has longer roots in psychology than in ecology (4). In psychology, some scholars argue that resilience is a personal trait (5), although it is most commonly understood as a process (6)—a dynamic process of positive adaptation within the context of significant adversity, trauma, tragedy, threats, or significant sources of stress (7). In the case of chronic adversity, it refers to long-term outcomes, such as children eventually achieving a normal adulthood (8). This meaning has been called emergent resilience (9). More recently, resilience has been used by psychologists to describe an individual's reactions to potentially

traumatic events (*10*). In some circles, this change shifted the focus from individual resilience to include the role of social capital in communities in which individuals are embedded (*11*). Research on community resilience includes insights on health and human development, and can potentially be seen as an example of co-development with resilience theory in the context of socio-ecological systems (SESs) (*12*–*14*).

With regard to the wider spread of resilience thinking, interdisciplinary scientists interested in SESs have incorporated resilience into their thinking and define it as follows: "The ability of human communities to withstand external shocks or perturbations to their infrastructure, such as environmental variability or social, economic or political upheaval, and to recover from such perturbations" (*15*). The tendency to understand resilience as resistance to change is ubiquitous in the literature, as exemplified by the following quotation from leading resilience theorists: "The more resilient a system, the larger the disturbance it can absorb without shifting into an alternate regime" (*16*). In disaster management, it refers to multiple aspects ranging from absorbing and recovering from, to resisting, the effects of a hazard, as well as preserving and restoring "essential basic structures and functions" [(*17*), p. 24]. Such wide meanings may end up being contradictory as in the notion of "restoring equilibrium and getting away from it by moving to a new system state" [(*1*), p. 2710].

It is clear that resilience thinking describes important attributes of ecosystems, of materials, and of human beings, that is, the ability to cope with, and recover after, disturbance, shocks, and stress. However, with popularity comes the risk of blurring and diluting the meaning (*18*). From a scientific point of view, one might think that scientists rooted in resilience research would try to safeguard the concept from inconsistency and ambiguity because conceptual accuracy and precision are of fundamental importance and often considered a prerequisite in science (*19*). Conversely, the Resilience Alliance contributes to ambiguity, as exemplified in the following quotation where transformation is pointed out as crucial to maintain resilience: "the very dynamics between periods of abrupt and gradual change and the capacity to adapt and transform for persistence are at the core of the resilience of social-ecological systems (SESs)" (*20*). However, we take transformation, which seems to be contrary to what Walker *et al.* see as the necessity to avoid "shifting into an alternate regime" (*16*), to be in contrast to resilience (*21*, *22*). Recently, resilience thinkers address this ambiguity in the meaning of resilience, which seems to include both change and resistance to change, by arguing that it is the critics who misinterpret or misunderstand the notion of transformation (*23*).

A major point of that discussion in resilience circles is whether resilience is a normative concept or not; that is, is resilience "good" or "bad," or neither? The policy use of resilience is almost exclusively normative (*24*), and proponents of resilience theory have recently acknowledged that "we agree that the resilience literature often treats resilience as something good" (*23*). However, the tendency to see resilience and all that it entails as desirable is an important reason, we argue, why social science focusing on social change over stability has difficulties accepting the resilience concept. Given the controversy around the normativity of resilience, the notions of "good" and "bad" resilience need to be studied more (*25*). In addition, resilience aspires to be an integrated framework to be used across the boundaries of the natural and social sciences [(*3*), p. 511, (*26*), p. xxi], but that causes tension especially in relation to agency, conflict, knowledge, and power, which are core social science concepts. Social scientists have

therefore argued that the application of resilience to social systems requires more solid theoretical grounding (*27*).

A typology on resilience

At this point, we acknowledge the long history of the concept of resilience with its many articulations, iterations, and positive attributes. However, it is an elusive concept in need of structuring, so we suggest a typology organized around two conceptual meanings on one axis, and two attributes on the other, describing the four main types of definition frequently used in the scientific literature (Table 1). The first conceptual meaning refers to the ability of a system to cope with stress and "bounce back" (BB); the second refers to the ability of the system to "bounce back" and "transform" (BB-T). The first attribute is descriptive implying that resilience is "neutral" (N), that is, neither good nor bad, contrasted by a prescriptive attribute implying that resilience is desirable and "good" (G). Each of the four distinct types is exemplified by one representative article.

Identifying incommensurability with social science

In the following five subsections, we identify core concepts and principles in resilience theory that create theoretical tensions and methodological barriers between the natural and social sciences and thus stand in the way of a constructive dialogue on knowledge integration between disciplines. To evaluate the ontological commensurability of resilience theory with social science, we examine the concepts and principles deployed in resilience research in terms of their assumptions about society and the standing of these assumptions in social science.

First: System ontology. In ecology, the concept of resilience is associated with a system ontology and ecosystems as the target domain. Whereas some ecologists study ecosystems for the interactions between predators and their prey, others see ecosystems as flows of energy. Neither of these "constructed systems" is intended as a complete account of ecosystems. In the literature on SESs, the system under study commonly has a prominent ecosystem component such as a coral reef (*28*), fisheries (*29*), forests (*30*), grasslands (*31*), or wetlands

Table 1. Typology of resilience definitions in ecology and social-ecological systems thinking.

Meanings	Attributes	
	Descriptive— neutral (N)	Prescriptive— good (G)
Bounce back	**BB-N**	**BB-G**
	(*2*) Holling, 1973. Resilience and stability of ecological systems.	(*3*) Perrings, 1998. Introduction: Resilience and sustainable development.
Bounce back and transform	**BB-T-N**	**BB-T-G**
	(*16*) Walker *et al.*, 2006. A handful of heuristics and some propositions for understanding resilience in social-ecological systems.	(*20*) Folke *et al.*, 2010. Resilience thinking: Integrating resilience, adaptability and transformability.

(*32*). The notion of system is indispensable to resilience, and having decided on the phenomenon to be explained, the system boundaries need to be defined. Beyond that, resilience is sometimes used to describe and analyze social entities such as institutions, organizations, cities, or states (*33*). To take it even further, ecologists sometimes claim that "ecological and social domains of social-ecological systems can be addressed in a common conceptual, theoretical, and modelling framework" (*16*). Even if the system ontology is essential in resilience thinking, there are surprisingly few studies addressing resilience at the system level. In a recent quantitative meta-analysis of 197 published articles on resilience, Downes *et al.* (*34*) found an overwhelming focus on the species or community level in ecological studies and on the individual level in social science studies.

In the social sciences, system ontology is not new or unknown. Although researchers studying social phenomena based on social theory are reluctant to use systems as an ontological description of society, they may use "system" analytically to study a specific aspect of society, polity, or the economy such as the energy system, the party system, or the tax system. To be noted here, some early social system theories emanated from physics and biology. In 1935, in his book *The Mind and Society*, the renowned economist Vilfredo Pareto formulated one of the first social system theories in the form of "General Sociology." Here he claimed that: "My wish is to construct a system of sociology on the model of celestial mechanics, physics [and] chemistry" [(*35*), p. 16]. In sociology, Talcott Parsons, another proponent of system theory, was inspired by Pareto and the emerging system science in biology (*36*). Intentionally or unintentionally, the current discourse on SESs borrows many of its ideas about society from this early view of social systems inspired by the natural sciences, which is now highly controversial in contemporary social sciences (*37*).

The most prominent modern system theory in the social sciences, especially in sociology, is without doubt Niklas Luhmann's general system theory rooted in functionalism (*38*). However, Luhmann's notion of system is very different from that of Parsons and also quite different from the meaning of system in resilience theory. According to Luhmann, a social system consists of nothing but communication; neither material conditions nor human beings are part of it (*39*). Luhmann's systems are characterized by autopoiesis, meaning that the system creates its own basic elements that make up the system. For example, the economic system as we know it is based on money, and money is created by the economic system. Without an economic system that defines the value of money, it would simply be pieces of paper, and without money, there would be no economic system. This is very different from how we understand ecosystems.

Another characteristic of an autopoietic system is that its boundaries are determined by the system itself. In the economic system, anything that is scarce and in demand has a price and is internal to the system, whereas goods and services that are either ubiquitous or not in demand have no price and are external to the system. Hence, an autopoietic system has no direct links to its environment; it is closed. However, under pressure from its environment, the system may change by shrinking or extending its boundaries. In Luhmann's system theory, the environment (ecosystems for example) can never become part of society, and society can never become part of the environment—the notion of SESs is therefore incompatible with Luhmann's systems theory (*40*).

Although Luhmann's attempt to reconceptualize modern society is "attractive, comprehensive and theoretically consistent," it is, for several reasons, highly controversial in social theory, and critics have pointed out that not all systems are as (functionally) autonomous or closed as Luhmann described them (*39*). As a whole, the critique points at the problem of using functional systems thinking to describe and explain relations between entities and systems (*41*). This takes us to the next point: the problem of defining system boundaries.

Before that, we should briefly mention World System Theory (WST) as yet another well-known system theory in the social sciences, with the sociologist Immanuel Wallerstein as its most prominent theorist. It developed in the 1970s out of Marxist thought and builds on dependency theory emerging in the late 1960s as a critique of functionalist modernization theory in development (*42*). WST is an important source of inspiration to many environmental social scientists (*43*)—and development thinkers alike—but it is hardly compatible with resilience theory. From the following discussion on the similarity between resilience theory's assumptions about society and those of functionalism, it should be clear why WST and resilience seem incompatible, especially because WST is fundamentally informed by a radical rather than a conservative political agenda (*44*).

Second: System boundary. The ability to define boundaries is an important prerequisite in "system ontology"; however, at times, this can be a challenge. Not even planet Earth is an example of a system with clear boundaries owing to its layered atmosphere. In some cases, it is easier to define the system because it may have clear boundaries, or the research focus may allow boundaries to be clearly stipulated. In psychology, the system ontology is well established, and the most fundamental systems under study are (fairly) well defined such as the individual, the family, the local community, the school, and so forth. In many instances, it is more difficult to settle the boundaries—in both the natural and the social sciences. A forest, for instance, may have no boundaries that can be unambiguously determined. It may be more or less well connected with other forests, lakes, and rivers in such a way that any suggested boundary will be arbitrary or artificial. At first blush, a lake ecosystem is clearly separate from the surrounding terrestrial environment. However, some plants along the shoreline may be either partially submerged or rooted in the surrounding land; amphibians move between the shoreline and the water; surrounding trees drop leaves into the water, etc. [(*45*), chap. 6]. To take a further but different example of the delineation problem, cognitive processes draw on the external world to such an extent that an individual's skin can obviously not be taken to approximate the boundaries of an individual's cognitive system (*46*). The delineation of a system is not just a matter of social or spatial location, and depending on the choice of theory, boundaries will vary. Hence, we must rely on other properties and recognize how scales and social relations are interconnected with actors, institutions, and structures beyond the "system."

Generally, we seem to understand a system as an entity of a given phenomenon that we want to describe, explain, or interact with—and this has consequences for how we understand the system. Herbert Simon (*47*) argued that the strength of connections between variables can be used to decompose systems into distinct subsystems. Moreover, it is often claimed (*48*) that a system is a set of elements standing in reciprocal interrelation. However, even such systems depend to some extent on pragmatic considerations (*49*). As an illustration, Collier and Cumming [(*50*), p. 203] claim that "the difficulty of defining an ecosystem is complicated by the fact that any description of an ecosystem is from the perspective of an observer." This resonates with the social science perspective arguing that boundaries, like theories, are constructed by someone for some purpose (*51*). In case study design, researchers

set boundaries on the basis of research questions, propositions generated from theory, meta-theoretical assumptions, etc.

With regard to boundaries, there is no sharp line of demarcation in reality to explain perceived differences between natural or social systems. Neither in nature nor in society are boundaries fixed unless we first decide on the phenomenon to be described or explained. Pragmatic considerations imply some degree of construction—in both social and natural contexts. There is thus a certain degree of reflexivity among researchers who recognize that system boundaries are constructed, and that sometimes, for various reasons, resilience is contested.

In theory and practice, systems and system boundaries are essential components of resilience, although there are many obstacles to systems thinking inherent in contemporary social science. In particular, system boundaries depend on the assumption that there is a given set of entities and that these are universally recognized across disciplines. However, in the natural sciences, a given set of entities is more accepted than in the social sciences. It is tempting to downplay the conceptual requirements of systems to make resilience applicable to social phenomena, but that would be a clear example of blurring the concept of resilience, which should be avoided because it would result in a less scientific concept.

Whereas system is almost a universal concept in the natural sciences, institutions are axiomatic, although interpreted variously, to social science and core to understanding social continuity and change (52, 53). The use of an institutional lens on the integration of social and natural dimensions could become a methodological linchpin to connect the social and the natural sciences for the sake of sustainability. This would require not only the use of rational choice institutionalism, as represented by Ostrom (54) and often associated with SESs (55), but also the involvement of historical, sociological, and discursive institutionalism, which stress the material as well as ideational aspects of society and nature and their dynamics (56). Different institutional theories would treat the idea of system and system boundaries differently.

Third: Equilibria, thresholds, and feedback mechanisms. The idea of multiple equilibria and thresholds is central to resilience theory as seen in this quotation: "Social-ecological systems exhibit thresholds that, when exceeded, result in changed system feedbacks that lead to changes in function and structure" (16). This dynamic is often visualized by a ball on an undulating surface with multiple concave shapes. If pushed too hard, or if the walls are lowered, the ball may move into another concave shape, illustrating that the system has exceeded some critical threshold(s) and shifted into a new equilibrium. An example could be a lake shifting from a vegetation-dominated clear state into a turbid plankton-dominated state (33). The interesting question is whether the lake has shifted into a new system, thus a system transformation, or whether the system is basically the same but with an altered function. Using this as an analogy to social systems is problematic because here we take transformation to mean a process in which society changes not only in function but more profoundly in terms of structures, institutions, or social relations: "after a transition, the society, or a subsystem, operates according to new assumptions and rules, thus indicating a range of new practices and not just an altered function" [(21), p. 176].

The analogy of the ball and the undulating surface is problematic in relation to social phenomena because of competing explanations and paradigms in the social sciences. In ecological resilience, the undulating surface reflects the current scientific understanding, whereas in the social sciences there may be no consensus on the "shape" of that "surface."

Feedback is another central component of the "system ontology" that is problematic in the study of society and social relations. In cybernetics, there are two types of feedback mechanisms: negative feedback, which stabilizes the system (homeostasis), and positive feedback, which causes exponential change. Applied to social phenomena, this notion of negative and positive feedback is overly simple. Social entities interact back and forth in norm-based processes of continuously interpreted (and reinterpreted) communication and interaction that may or may not affect behavior—thus indicating less predictability and greater complexity than simple positive or negative feedback (27, 57). The structural complexity of ecological and social systems can partly be conceived of in similar terms, but the feedback processes associated with each are incomparable because feedback mechanisms in social systems are primarily determined by agency, or structured agency, rather than by structural forces (27). This is especially so because norms influencing agency are dynamic constructs subject to continuous change rather than to static structures (56).

Fourth: Self-organization. The principle of self-organization is a further cornerstone of the resilience discourse (58). In ecology, self-organizing systems are common and perceived as unproblematic because there is often an overarching driver, the attractor, providing the logic of self-organization. To exemplify this, all leaves in a deciduous boreal forest orient themselves toward the sun to optimize the amount of sunlight that they can capture, thus maximizing the uptake of solar energy, which is an attractor of that system.

With regard to society, the most obvious example of self-organization would be the "invisible hand," which was first described in 1776 by Adam Smith, stating that capitalist markets would self-regulate if left on their own (59). According to Smith, the natural propensity of humans to "truck, barter and exchange" leads to a situation where every man is a merchant and "the society itself grows to be what is properly a commercial society" [(60), p. 22]. Even if Smith did not use the term self-organization, what he depicts is almost a perfect illustration of such a system. The outcome (= the market) is the result of a decentralized and nonintentional process where the role of government is to guarantee freedom, property rights, and security in a process that should work even if participants are unaware and have no knowledge of it (61).

Much later, in an argument in favor of market forces and against radical (state-oriented) reformists, the economist Friedrich Hayek (62) developed the idea of self-organization even further. However, such views of society are contested by scholars outside the neoclassical paradigm. When Polanyi (63) speaks of the emergence of a self-regulating market, he stresses that it relies on strong state interventions, primarily the commodification of land, labor, and money (63). He also argues that Smith's claim on man's natural propensity to "truck, barter and exchange" is a myth created during industrialization. What appears to be self-regulating by some is thus considered the result of political forces and institutional change by others. As a further illustration, social science offers a vast literature on power as a fundamental and omnipresent force shaping and reshaping interactions, relations, and social (not self-) organizations, implying various degrees and types of continuity or change (64). In addition, the literature on agency, conflict, institutionalism, structuralism, and other middle-range theories is rich, varied, and frequently used.

Self-organization is aligned with rational choice theory as seen in the works of Elinor Ostrom (54, 55, 65), who was a strong supporter of and contributor to resilience thinking. However, rational choice is

often criticized for leaning heavily on the two principles of methodo-logical individualism: of seeing macro patterns as resulting from the aggregation of decentralized choices and of seeing economic change as determined by factor costs (land, labor, capital).

Resilience theory is rooted in complexity theory, wherein self-organization is seen as the overriding organizing principle (58, 66). A conspicuous example is given by Walker *et al.* (31) claiming that "a characteristic feature of complex adaptive systems is self-organization without intent … and although the dynamics of SESs are dominated by individual human actors who do exhibit intent, the system as a whole does not (as in the case of a market)." Proponents of complexity theory argue that complex systems (for example, business systems and social networks) can be understood by emergence—in terms of new config-urations resulting from self-organization (67), whereas others say that emergence refers to new patterns and properties resulting from itera-tive human interaction (68). When self-organization is used in the social sciences, it is mainly understood as a reaction to power asymmetries and structural inequality such as in the formation of social movements (69–71).

Fifth: The notion of function and functionalism. The under-standing of function is a major source of divergence between the natural sciences and contemporary social sciences, but this was not always the case. In ecological sciences, function is a central theme of-ten defined as the ecological mechanism that maintains the structure and services produced by ecosystems, such as primary production, decomposition, and trophic (food chain) interactions (72). The early functionalists in the social sciences, such as the sociologist Durkheim and the anthropologist Radcliffe-Brown, argued that the concept of function, when applied to society, can be seen as an analogy between social life and organic life (73). A meaning similar to that used by the early functionalists is found in resilience theory where ecosystems have four main functions (exploitation, conservation, release, and re-organization), which according to certain dynamics are responsible for the succession and transformation of ecosystems from one state to another (74).

In the seminal book *Panarchy* [(74), p. 107], the definition of a social system is taken from "The Social System" by Talcott Parsons (75), a structural functionalist in sociology who argued that his principles could be applied to many systems, not just social systems. Resilience thinking resembles Parsons' general theory wherein intra- and inter-systemic relations are defined by cohesion, consensus, and order (41). In particular, there are obvious similarities between the SES discourse and Parsons' AGIL scheme describing four core functions—or func-tional imperatives—that serve to maintain stability and secure survival of the social system [(41), pp. 241–242]: (i) adaptation (A)—a system must adapt to the physical and social environment as well as adapt the environment to its needs; (ii) goal attainment (G)—a system must de-fine and achieve its primary goals; (iii) integration (I)—a system must coordinate and regulate interrelationships of its components and strive toward a cohesive whole; (iv) latency (L)—a system must furnish, maintain, and renew itself and its individuals to perform their roles according to social and cultural expectations.

As a further description and explanation of the AGIL model, mod-ern societies have acted on all four components according to Parsons: for adaptation, societies developed industries and markets as well as science and technology; for goal attainment, societies developed polit-ical institutions; for integration, societies developed civil society and religion; and for latency, societies developed families and schools. Parson

was later criticized for overemphasizing consensus, conformity, stability, and reification. To address this critique, neofunctionalists incorpo-rated more agency, dynamics, and conflict into this thinking (76).

A recent quotation from *Ecology and Society* may serve as an ex-ample of the resemblance between resilience theory and Parsons' func-tionalism: "The crux of the problem of fostering sustainable, resilient landscapes is thus the problem of designing or developing appropriate institutions that will act flexibly, proactively, and at appropriate scales to strengthen feedbacks that modify and moderate demand for eco-system services and incorporate the trade-offs between human well-being, profit, and the exploitation of ecosystems" [(77), p. 1143]. However, the crux of the matter is not only to create functional institutions but also, as known from institutional theory, that inefficient or ineffective norms, rules, and values often persist because institutions are "sticky" and not easily replaced nor designed, developed, or changed (78). There are further concerns with functional definitions of institutions. First, the emphasis on the functionality of institutions implies a conservative ap-proach to social change (79). Second, the existence of malfunctioning institutions is difficult to explain if their role is to perform the very function that defines them (27). Third, the equilibrium tendencies in struc-tural functionalism may not be helpful in a social science analysis (1).

As a reaction to the incapacity of functionalism, such as the in-ability to explain rapid social change, various conflict theories rooted in the ideas of Karl Marx, Max Weber, and George Simmel emerged in the 1960s and asked other questions about society (80). According to conflict theory, institutions are shaped by existing conflicts, power (im)balances, and social stratifications in society, which in itself is seen as highly dynamic rather than static as in functionalism (81). On the basis of a wealth of empirical data, the further development of socio-logical conflict theories has since then emphasized the importance of detailed study of processes in society, thus moving away from the pro-duction of grand theory and what was perceived as ideologically based conflict theory (82). Similarly, the influence of functionalism waned substantially in the 1960s (80) and some even declare it to be "dead as a dodo" [(83), p. 37]. Notably, and as a peculiarity, functionalism builds on a nondynamic consensus perspective of society, which echoes the state of a steady equilibrium that resilience theory reacted against and rejected in its own analysis of ecosystems (84).

The most fundamental obstacle here, we argue, is the difference in how resilience theory and the social sciences understand society—in terms of social systems, social relations, and social change. In essence, resilience theory is implicitly based on an understanding of society that resembles consensus theories in sociology, according to which shared norms and values are the foundation of a stable harmonious society in which social change is slow and orderly—and where, in an-alog, resilience thus becomes the equivalent of stability and harmony or the good norm. However, while previously seen as dominant in sociological theory—though strongly contested, for example, by the critical theory of the Frankfurt School—consensus theories have de-clined dramatically since the 1960s (41), giving more space to conflict theory and issues of diversity, inequality, and power. Conflict theories emphasize conflicting interests between groups in society, meaning that social order is maintained by (material or discursive) manipula-tion and control by dominant and powerful groups, and that transfor-mational change can develop from the tensions between these groups and the redistribution of power. In functional approaches, the conserv-atism is clear: change is understood as coming about due to continuous progressive processes such as the division of labor or differentiation;

conflict arises in reaction to these, and a stable society must contain the unrest. This must be taken into consideration in any serious attempt to bridge the social with the natural sciences, be it via resilience theory and thinking or via other less unifying and thus more methodologically and theoretically pluralist approaches.

Whereas most disciplines seek to avoid teleological explanations, biology, and evolutionary biology in particular, is rife with functional claims (85). The striking similarities between resilience theory and rightly abandoned theories of functionalism (and structural functionalism) in the social sciences, as also noted by others (1, 79), are one reason why the resilience discourse does not fit the social sciences. Resilience theory rests on functionalism as a theoretically superseded understanding of society; furthermore, owing to its emphasis on self-organization, it appears to be aligned with the contemporary neoliberal economics paradigm (86, 87). This entails a proliferation of market-based instruments for ecosystem management (88) as epitomized by The Economics of Ecosystems and Biodiversity initiative (TEEB) aiming to help decision-makers recognize, demonstrate, and capture the values of ecosystem services and biodiversity (89 [see also Brown (90)].

A preliminary conclusion

To summarize the argument so far, we conclude that despite its compelling attractiveness in terms of its original coherence, simplicity, and apparent completeness, there are problems in using resilience as a universal concept. Admittedly, it has analytical potential, especially in the serious effort to promote integrated approaches across scales, sectors, and spaces (25), but not everyone finds it helpful that resilience thinking seeks to combine adaptation (dynamic) with resistance (static) in one framing concept (1). Moreover, whereas resilience theory aims to prevent transitions—or rather, hinder the collapse of a productive system—social theory commonly used in sustainability studies—from transition theory to political ecology—aims to locate and analyze multilevel or multiscalar resistance against change while seeking to stimulate social transformation (91). This incommensurability is problematic for at least two reasons. First, sustainability research needs to consider both continuity and change while also distinguishing between them (76). Second, transformation for the sake of persistence of the system—rather than transformation for profound change—appears counterintuitive to social science thinking. Whereas studies building on rational choice, as found in the literature on SESs, have difficulties in identifying and explaining change, studies drawing on, for instance, transition theory and discursive institutional theory seek specifically to identify initial change by studying agency, or the thinking and speaking that precedes agency (56). Agency, in turn, can be interpreted differently depending on the use of analytical perspective, be it cultural, discursive, power-based, or a rational choice (91). Furthermore, structures serve as both outcome of and context for agency (76).

On the basis of the analysis thus far, we offer three main synthesized reasons for why resilience is not attractive to nor easily integrated with social science thinking: (i) the ontological presupposition to see reality as a system with equilibria, feedbacks, and thresholds; (ii) the principle of self-organization overshadowing agency, conflict, and power; and (iii) the notion of function as foundational to resilience theory while having lost its centrality in the social sciences.

A cautionary remark on the politics and metaphor of resilience

As resilience travels from being a descriptive—and initially a rather precise—concept in ecology to become a normative notion in society

(and policy), it becomes increasingly vague and wooly, whereas the descriptive origin somehow gets lost (18). Further, in the attempt "to make resilience a full-scale paradigm or even a science," its explanatory power gets "pushed to represent more than it can deliver" [(1), p. 2713]. Owing to its malleability in science combined with its popularity among powerful private or public actors, there is a risk of (un)intentional scientific justification of particular policies, projects, and practices. This creates a tendency in resilience theory to depoliticize social change (92) as in a recent example where poverty is seen as a stochastic dynamic process (93) rather than the outcome of political and structural processes.

To exemplify this, resilience is increasingly adopted by influential global organizations such as the United Nations Development Program (24) and funding institutions such as the Rockefeller Foundation (94) as a basis for policy-making and deployment of funds. Because of the difficulties of incommensurability synthesized above: system ontology, and that assumptions of self-organization and function tend to hide power, ignore the dynamics of conflict, and bracket agency. The use and promotion of the resilience concept in policy making and funding regimes concerned with development and sustainability transitions, where issues of power, conflict, and agency are generally considered central, is at best inappropriate. If oppressive power or a denial of agency cannot be questioned, it is unlikely that they can be understood, no less changed.

For these reasons and the fact that resilience appears conservative when extended to social change and social relations (95), we need to acknowledge "the politics of resilience" [(25), p. 48]. This can be done by asking specific questions on resilience "of what" and resilience "for whom" as explicitly expressed by Cote and Nightingale [(79), p. 479]. One person's resilience may be another person's vulnerability (1). This becomes particularly problematic in the context of poverty, where resilience has serious limitations: it is not a pro-poor concept; there is no automatic connection between resilience building and poverty reduction; efforts to reduce poverty cannot simply be replaced by building resilience that does not offer any direct road out of poverty; and finally, emphasis on system-level resilience may work against the interest of people who are poor (25).

Larson (96), himself an ecologist, argues that the integration of ecology with ethics and society is facilitated by the presence of metaphors in ecology—such as competition, invasion, and resilience—that originated in society. These metaphors are frequently used by ecologists to describe and explain complex processes and systems dynamics including their expected, or even desired, outcomes (96). They operate as "feedback metaphors," which come from everyday parlance, are applied in science, and then feed back into society again. However, there are both philosophical problems and social challenges associated with this. The choice of metaphors is not only epistemological but also ethical and performative, resulting in actions and real social consequences (96). Metaphors highlight some aspects while hiding others, thus blurring the line between fact and value. Because of the way metaphors operate, they create a "tension between neutrality and advocacy" [(96), p. 142]; facts and values as well as science and society are intertwined. When resilience as a metaphor becomes widespread, this has implications for social science and society as we argue herein.

In search of resilience in scientific journals

Having shown theoretically why it is unlikely that resilience would appeal to contemporary social science, we will now demonstrate empirically

that it has not appealed. The evidence that resilience does not at present close the gap between the natural and social sciences emerged from our bibliometric analysis of the use of "resilience" AND "ecology" as well as "resilience" AND "system" in the 10 highest-ranked journals in seven fields: ecology and environmental studies, plus five social science disciplines all addressing sustainability and engaging with integrated or interdisciplinary approaches. According to the emerging pattern, the resilience discourse is asymmetrically present in ecology and environmental studies as compared with the other five disciplines (Fig. 1).

This means that despite the potential utility of resilience theory to grapple with sustainability challenges and despite its rapid spread from systems ecology to wider debates on SESs and sustainability, it is not widely taken up by the 10 most influential journals in each of the five selected social sciences (see the Supplementary Materials).

From the bibliometric analysis, we draw four conclusions. First, the concept of resilience is commonly used in the entire field of ecology as illustrated by the large number of references to resilience in most of the 10 most highly ranked journals in the field (Table 2). This supports the idea that the concept of resilience has helped to unify ecology as a discipline. Second, outside ecology, we see that the vast majority of articles on resilience appear in environmental studies and, to some extent, also in geography. Here, and as shown in Table 2, two journals dominate the resilience debate completely—*Ecology and Society*, which has published on resilience since its inception in 2003, and Global Environmental Change (GEC), which started to publish widely on social-ecological resilience in connection with a special issue in 2006 on resilience, vulnerability, and adaptation (*97*). Third, the promotion of resilience theory is closely related to one particular organization, the Resilience Alliance, whose official journal is *Ecology and Society*. In addition, the Editor-in-Chief of GEC for the period July 2004 to December 2013 is a member of the Resilience Alliance. And fourth, resilience theory and thinking is not common in the main social science journals. Hence, it is safe to argue that resilience does not currently engage the core of social sciences. Despite increasing popularity, we conclude here that resilience theory is a unifying concept in ecological and environmental sciences but not across the social and natural science divide.

DISCUSSION

Scope for a better dialogue: Using pluralism instead of unification

Integrated research may offer (better) understandings of and responses to complex demands of the contemporary world such as climate change. To understand the conditions for how to build integrated knowledge across disciplinary domains, such as the natural and social sciences, we make a distinction between two distinct types of scientific knowledge integration—pluralism and unification—and then show how pluralism allows problem feeding as
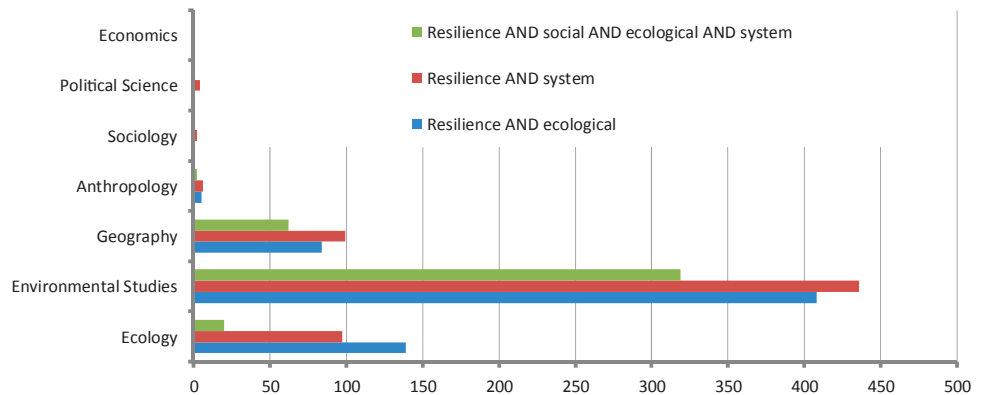

Fig. 1. Number of articles, 2001–2013, containing "resilience" and (Boolean "AND") combinations of "ecological" and "system" in the 10 highest-ranked journals (ISI) in seven relevant scientific disciplines or fields. Data file S1 contains a complete list of data.

a fruitful strategy in interdisciplinary research, whereas unification can easily slip into not-so-useful scientific imperialism. Problem feeding occurs when a problem arises or is discovered in a discipline that cannot solve it but can import the necessary tools to solve it or export it to another discipline that may find a solution. In the natural sciences, there are many examples of such interaction, one of which is the recent construction of the nanoscope (awarded the 2014 Nobel Prize in chemistry). It was developed when chemists and physicists worked together to help physiologists study processes inside individual cells, such as pathogens, or interaction between individual molecules. Scientific pluralism thus appears when several disciplines contribute particular theories, methods, and/or questions to solve problems.

According to scientific pluralism, the ultimate goal of scientific inquiry is not (necessarily) to establish a single theory (*98*). Pluralism is useful in situations where no unified theories are available to explain a phenomenon or where the phenomenon can only be explained by multiple theories (*99, 100*). Also, to be noted here, problem feeding does not necessitate broad unification—not even in its most powerful bilateral form where both problems and solutions are transferred between disciplines (*101–103*).

Disciplinary imperialism is usually thought of as an illicit infringement, such as when one discipline attempts to explain phenomena or solve problems in a domain belonging to or associated with another discipline (*104–106*). As an example, the economist G. S. Becker argues that the decision to have children can be expressed as a utility maximization function with three variables: the number of children, their quality, and the rate of consumption of all other commodities (*107*). As another example, sociobiologists (*108*) sought to explain social behavior in terms of natural selection and thus believed that they could replace social science theories (*109*).

Serious cases of scientific imperialism are reductive in the sense that they tend or aim to exclude alternative (even compatible) explanations and solutions (*110–112*). Here, inferior explanations or problem solutions outcompete superior ones (*112*). All kinds of unification are not necessarily imperialist (in this negative sense), but there is always reason to worry about imperialism in situations where a single theory is claimed to account for persistent social problems such as poverty or complex phenomena such as the impacts of climate change and the responses in society.

Table 2. Articles, since 2001, containing the term "resilience" AND (Boolean) various related terms in the 10 highest-ranked journals (ISI) in each of the three scientific disciplines/fields where resilience appears most frequently. Source: ISI Web of Science: 1 May 2014.

Ecology	Resilience, ecological (%)	Resilience, system (%)	Resilience, social, ecological, system (%)	Environmental studies	Resilience, ecological (%)	Resilience, system (%)	Resilience, social, ecological, system (%)	Geography	Resilience, ecological (%)	Resilience, system (%)	Resilience, social, ecological, system (%)
Ecology Letters	16	12	15	Nature Climate Change	1	1	0	Global Environmental Change	80	83	82
Annual Review of Ecology, Evolution, and Systematics	1	1	0	Annual Review of Environmental Resources	1	2	2	Progress in Human Geography	5	4	5
Trends in Ecology and Evolution	10	10	25	Review of Environmental Economics and Policy	0	0	0	Transactions of the Institute of British Geographers	4	2	3
Frontiers in Ecology and the Environment	22	24	55	Global Environmental Change	16	19	16	Economic Geography	0	0	0
Ecological Monographs	4	5	0	Journal of Environmental Economics and Management	1	1	0	Journal of Economic Geography	0	1	0
The ISME Journal	2	2	0	Energy Journal	0	0	0	Antipode	1	0	0
Global Ecology and Biogeography	1	2	0	Wiley Interdisciplinary Reviews: Climate Change	1	1	1	Political Geography	0	0	0
Global Change Biology	17	15	0	Global Environmental Politics	1	0	1	Global Networks	0	0	0
Ecology	21	20	0	Ecology and Society	68	66	74	Environmental and Planning D: Society and Space	0	0	0
American Naturalist	6	8	5	Ecological Economics	11	95	7	Geoforum	11	10	10
Total no.	139	97	20		408	436	319		84	99	62

The claims made in resilience theory (to close the gap to the social sciences) can be classified as an attempt of unification via disciplinary imperialism. To substantiate this, we refer to the fact that resilience often appears in contexts where discipline-bridging and integration is sought. In the influential book *Panarchy*, Holling and Gunderson (*113*) seek to develop a general theory of change, and while doing so, they express concerns that "approaches" in which resilience has no role are partial in the sense that "[t]hey are too simple and lack an integrative framework that bridges disciplines and scales" [(*113*), p. 8]. Similarly, resilience theory suggests that "critical changes in social-ecological systems are determined by a small set of three to five key variables, i.e., the 'rule of hand'" (*16*). Further, they claim that one way

to put in place "robust foundations for sustainable decision-making" is through the "search for integrative theories that combine disciplinary strengths while filling disciplinary gaps" (*16*). Other authors are more explicit. Charles Perrings, for instance, notes that the concept has broad appeal for both natural and social sciences: "while the notion of system resilience has its roots in ecology, it is concerned with something that is common to any stochastic evolutionary system" [(*114*), p. 511]. In another influential volume, Gunderson and Pritchard treat resilience as a "unifying concept in both ecological and social systems" [(*26*), p. xxi].

Together, these examples may illustrate the integrative potential but more so the unification ambition in resilience theory. Here, we

propose that it is partly this ambition in combination with the incommensurability that has given rise to the problems that constitute our central argument. First, many of these difficulties arise from the inappropriate extension of concepts from the natural sciences to society. These concepts entail similar assumptions to both functionalism and neoclassical economics, which have been found to be highly problematic by social science as seen already from the 1950s when development economics (and other development theories) emerged in reaction to, and as an alternative to, neoclassical economics. Second, given the dominance of economics, and particularly neoclassical theory, in the social sciences, it is likely that associated concepts appear as given for ecologists unfamiliar with the diversity within social science.

In contrast to unification, we advocate pluralism. Rather than seeing resilience as a grand or unifying theory, it should be seen (and used) as a middle-range theory compatible with some, but not all, ontologies (*91*). In essence, we argue that there are two main barriers for resilience thinking to bridge the natural and social sciences, as it aspires to do. First, the aspiration of a "unifying theory" is contested because the idea of the unity of science has long been controversial—especially after the postmodern turn, which advocated diversity and criticized grand theory for suppressing alternative views and voices originating in less influential parts of society. Second, the combination of unificationist ambitions and issues of incommensurability is particularly problematic. Incommensurability of the ontological type that we have focused on here effectively blocks unification. This is best represented by how resilience thinking recreates functionalism, which is now rightly outdated in contemporary social sciences (*41*).

CONCLUSIONS

Our analysis has illustrated the problems of using resilience as a universal and unifying concept, and it has explained why social scientists lack research-strategic incentives to use and fully engage with resilience theory and thinking. In sum, we contribute five conclusions to the debate on resilience:

(i) Definitions of resilience vary from concise to comprehensive, from coherent to internally contradictory, from precise to vague, and from descriptive to normative to predictive—but after scrutiny can be categorized into a typology of four distinct types (see Table 1).

(ii) The incommensurability between the natural and social sciences constrains the dialogue in two ways: the resilience vocabulary does not fit into the social sciences, whereas core concepts and theories in social science—such as agency, conflict, knowledge, and power—are absent from resilience theory.

(iii) Given its insensitivity to theoretical development of the social sciences and lack of attention to agency, conflict, knowledge, and power, resilience can become a powerful depoliticizing or naturalizing scientific concept and metaphor when used by political actors.

(iv) Resilience is a unifying concept within ecology and environmental studies but not in the social sciences (see Fig. 1 and Table 2).

(v) The unifying ambition in resilience theory and thinking to go beyond natural science is counterproductive to successful interdisciplinary and integrated research.

Finally, we underline that far-reaching unification as an approach to integrated research can easily result in scientific imperialism—which is arguably how resilience theory has been perceived from the perspective of the social sciences. To establish fruitful interdis-

ciplinary collaboration, such as problem feeding, pluralism is quite sufficient and perhaps preferable (*103*), especially in integrated research on complex sustainability challenges in times dominated by neoliberal ideology.

MATERIALS AND METHODS

The article is based on two kinds of data related to two types of investigation. Our theoretical investigations are based on a systematic analysis of how resilience is used, in ecology and beyond, in attempts to bridge the natural and social sciences, as well as a critical scrutiny of core concepts and principles in resilience theory.

For the bibliometric analysis, we used the ISI Web of Knowledge/ Science. As a first step, we identified the 10 most influential journals (as measured by the Article Influence Score) in each of seven scientific categories: Ecology, Environmental Studies (social science), Geography (social science), Anthropology (social science), Sociology, Political Science, and Economics.

We then searched these journals for articles published between 1 January 2001 and 30 April 2014 with the following Boolean combinations: (i) resilience AND ecological; (ii) resilience AND system; (iii) resilience AND social AND ecological AND system.

We searched for these words in the title, key words, and abstract. The full data set is available as data file S1 (MS Excel).

SUPPLEMENTARY MATERIALS

Supplementary material for this article is available at http://advances.sciencemag.org/cgi/content/full/1/4/e1400217/DC1
Data file S1. Complete list of journals used in the bibliometric analysis including the number of articles for each combination of search terms.

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