



Beyond Divides: Prospects for
synergy between resilience and
pathways approaches to sustainability

Simon West, Jamila Haider, Hanna Sinare and Tim Karpouzoglou

Resilience and Pathways

A large abstract graphic at the bottom of the cover, consisting of several thick, overlapping curved lines in various shades of green and grey, creating a sense of movement and interconnectedness.

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In the context of rapid social, ecological and technological change, there is rising global demand from private, public and civic interests for trans-disciplinary sustainability research. This demand is fuelled by an increasing recognition that transitions toward sustainability require new modes of knowledge production that incorporate social and natural sciences and the humanities. The STEPS Centre's 'pathways approach' and the Stockholm Resilience Centre's (SRC) 'resilience approach' are two distinct trans-disciplinary frameworks for understanding and responding to sustainability challenges. However, the varieties of trans-disciplinarity pursued by the SRC and STEPS each have distinct origins and implications. Therefore, by selecting either the 'resilience' or 'pathways' approach, or indeed any distinct approach to sustainability, the researcher must contend with a range of foundational ontological and epistemological commitments that profoundly affect the definition of problems, generation of knowledge and prescriptions for action. What does an (un)sustainable world look like? How might we 'know' and research (un)sustainability? How should sustainability researchers position themselves in relation to civil society, policy, business and academic communities? In this paper we explore how resilience and pathways address these questions, identifying points of overlap and friction with the aim of generating new research questions and illuminating areas of potential synergy.

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Acronymns

BIS	Department for Business, Innovation and Skills
ES	Ecosystems services
ESRC	Economic and Social Research Council
IDS	Institute for Development Studies
ISSC	International Social Science Council
LEK	Local ecological knowledge
MCM	Multi-criteria mapping
MEA	Millennium Ecosystem Assessment
MISTRA	Swedish Foundation for Strategic Environmental Research
PES	Payment for ecosystem service schemes
RRS	Resilience Research School
SEI	Stockholm Environment Institute
SES	Social-ecological systems
SNA	Social network analysis
SPRU	Science and Technology Policy Research
SRC	Stockholm Resilience Centre
STEPS	Social, Technological and Environmental Pathways to Sustainability
UNESCO	United Nations Educational, Scientific and Cultural Organization
WBCSD	World Business Council on Sustainable Development

Abstract

In the context of rapid social, ecological and technological change, there is rising global demand from private, public and civic interests for trans-disciplinary sustainability research. This demand is fuelled by an increasing recognition that transitions toward sustainability require new modes of knowledge production that incorporate social and natural sciences and the humanities. The Social, Technological and Environmental Pathways to Sustainability (STEPS) Centre's 'pathways approach' and the Stockholm Resilience Centre's (SRC) 'resilience approach' are two distinct trans-disciplinary frameworks for understanding and responding to sustainability challenges. However, the varieties of trans-disciplinarity pursued by the SRC and STEPS each have distinct origins and implications. Therefore, by selecting either the 'resilience' or 'pathways' approach, or indeed any distinct approach to sustainability, the researcher must contend with a range of foundational ontological and epistemological commitments that profoundly affect the definition of problems, generation of knowledge and prescriptions for action.

What does an (un)sustainable world look like? How might we 'know' and research (un)sustainability? How should sustainability researchers position themselves in relation to civil society, policy, business and academic communities? In this paper we explore how resilience and pathways address these questions, identifying points of overlap and friction with the aim of generating new research questions and illuminating areas of potential synergy. As a group of early-career trans-disciplinary researchers we think that exciting areas of sustainability research lie in the boundaries between emerging trans-disciplinary research communities such as the SRC and STEPS. We propose future research that draws energy from current tensions between, for instance, competing visions of reflexive and policy-relevant research, and between 'functional' and 'equity' perspectives on social-ecological change. More broadly, we aim to stimulate thinking and debate about possible research agendas for sustainability that are more reflexive about the boundaries of trans-disciplinary research and encourage greater collaboration across and between research with different ontological and epistemological starting points.

1. Introduction

We are living in times of rapid social, ecological and technological change. The increasing unpredictability of the climate is interacting with accelerated technological developments, changes in human mobility, biodiversity loss, urbanization and flows of capital, among others, to produce surprising and complex dynamics. At the same time these dynamics appear to be exacerbating unequal access to resources and fuelling inequities in the global distribution of vulnerabilities and opportunities. The feedbacks between complexity and inequity make it pertinent to understand how the connections between system qualities such as resilience, stability, robustness, durability and diversity can help ameliorate current inequities while increasing the adaptive capacity of our societies toward uncertainty, unpredictability and change.

We are also living in times of proliferating demand for new types of knowledge to address these changes. There has been a remarkable convergence and reorganisation of sustainability-related research in the last two decades. It has been broadly recognised in academic and policy circles that trans-, inter-, and multi- disciplinary work is necessary to integrate and link knowledge from the humanities, natural and social sciences (Gunderson and Holling 2002; Berkes *et al.* 2003; Leach *et al.* 2010). Increasingly, researchers are exploring what these knowledge structures might look like in practice (Palsson *et al.* 2013; Roy *et al.* 2013; Popa *et al.* 2014).

The resilience approach, predominantly developed by researchers associated with the Resilience Alliance and the Stockholm Resilience Centre (SRC), and the pathways approach, developed by the STEPS Centre (Social, Technological and Environmental Pathways to Sustainability) are emblematic of these new paradigms. The SRC emerged through extensive collaboration between ecologists and economists, while STEPS was born through the marriage of development studies and science and technology studies (see Text Box 1.1). Resilience research has consequently tended to progress according to positivist-oriented epistemologies, while pathways has been influenced to a greater extent by constructivist inquiry. Therefore, while the resilience approach is particularly adept at addressing the impacts of human management and exploitation on the functionality of social-ecological systems, pathways is suited to exploring issues of equity and distribution that arise from our discursive and contestable interpretations of system dynamics.

Both Research Centres seek to enhance connectivity and dialogue between policy-makers, academics and citizens through trans-disciplinary research on social, ecological and technological complexity. The funding received by both Institutions represents significant public investment in this agenda, mirrored by the substantial traction each Centre has received at a policy level and corresponding attention in national and international media. There has been some important academic cross-fertilization between STEPS and the SRC since their establishment in 2006-2007 (e.g. Leach 2008; Leach *et al.* 2012; Leach *et al.* 2013). As early career PhDs and Post-Docs closely involved with STEPS and SRC research groups, thematic activities (STEPS Summer School) and courses, we welcome this engagement and consider the STEPS and SRC cross-cutting research agendas as important nodes of research for sustainability.

At the same time, while promoting trans-disciplinary research, each Centre has its own research community (increasingly encompassing global research networks and associates) and, importantly for the argument of this paper, is embedded within its own distinct academic lineage. It is understandable that trans-disciplinary sustainability research has, so far, tended to coalesce around collaborations of least resistance where epistemologies and ontologies are at some level shared (although we recognise that these have been, in themselves, extremely hard-fought gains by pioneers). However, in our experience, these distinct histories, vocabularies and methodologies pose significant challenges in talking across resilience and pathways approaches in productive ways. While

beneficial in providing a 'safe space' for emerging frameworks, this 'clustering' of trans-disciplinary research may run the risk of neglecting the truly difficult questions that are produced through friction between substantially different ontologies and epistemologies.

What does an (un)sustainable world look like? How might we 'know' and research (un)sustainability? How should sustainability researchers position themselves in relation to civil society, policy, business and academic communities? Resilience and pathways address these questions in very different ways. We recognise the value and validity of both – for instance we consider questions of function as integrally interwoven with issues of equity and distribution – yet struggle to integrate these simultaneously in our research. In our view, the dissonance between resilience and pathways approaches lies primarily in the foundational ontological and epistemological commitments contained in the disciplinary heritage of each (e.g. Leach 2008). We think that a lack of reflexivity and awareness of the assumptions we make about reality, and a reticence to embrace the conditionality of these assumptions, are major hurdles for future collaboration.

This is not an argument for 'integration' of resilience and pathways research, nor are we implying that collaboration is only possible through convergence of ontologies or epistemologies. On the contrary, a diversity of approaches to sustainability is necessary and valuable, and fruitful research can come through friction between incommensurable perspectives. One practical example of how this friction can open up space for debate is the ongoing discussion between Melissa Leach (former STEPS Centre Director) and Johan Rockström (Director of the SRC) about the discursive and scientific roles played by planetary boundaries research.¹ Our point is that, in our experience, effective collaboration comes through recognition of the conditionality of our assumptions and a consequent willingness to accept the equal validity of others. This is not just an issue for resilience and pathways but for trans-disciplinary sustainability research more broadly, as the demand for transdisciplinary research becomes greater and distributed across a broader range of research institutions.

Nevertheless, a growing number of resilience and pathways researchers are willing to bridge these distinct research communities and tackle these uncomfortable questions. A key factor here is familiarity among young researchers with multiple disciplines and very different ontologies and epistemologies prior to, and including, their PhD studies. For example, the authorship of this paper has studied various combinations of ecology, political science, literature, international law, geography, environmental science, science and technology studies, biology, and soil science. This familiarity with multiple disciplines from the social sciences, natural sciences and humanities enables researchers to better identify synergies between them.

Of course, this diversity of roots is also challenging. While concepts and tools from any of these fields may be legitimately applied to problems broadly relating to 'sustainability,' it is often very difficult to reconcile them with each other, not least in a field where researchers face the dual pressure to be both policy-relevant and reflexive. Differences in training are further exacerbated by the varying standards expected by even inter-disciplinary academic journals (e.g. Rivera-Ferre *et al.* 2013). 'Best practice' in each of the disciplines listed above can in fact appear directly contradictory. However, if we are truly to take the interconnectedness suggested by 'wicked problems' and complexity

¹ Melissa Leach was STEPS Centre Director between 2006 and 2014. She is now Director of the Institute of Development Studies (IDS) at the University of Sussex. She and Johan Rockström presented their contrasting perspectives on planetary boundaries research in a plenary session at the 2014 conference, Resilience and Development: Mobilizing for Transformation. Accounts of this discussion can be found on Melissa Leach's blog: <http://www.transformingdevelopment.com/2014/05/limits-revisited-planetary-boundaries.html>, and Joern Fischer's blog: <http://ideas4sustainability.wordpress.com/2014/05/07/development-and-resilience-vs-development-or-resilience/>

seriously, we must also recognise that these apparent contradictions are products of our collective intellectual imagination, as much as they are indicative of different plains of reality. While comprehending Rittel and Webber (1973), if we are to find new ways of addressing and acting within complexity we need to recognise the contingency of these assemblages. That is to say that our very comprehension of wicked problems plays a constitutive role in the problems themselves; wicked problems are a product of the relations established between objective and subjective conditions. We therefore suggest that it is precisely in the exploration of these ‘contradictions’ between approaches that exciting sustainability research will emerge, providing the opportunity to re-define problems, to re-conceive attendant solutions and to ask new questions. The space for synergy and collaboration between resilience and pathways approaches has yet to realize its full potential and we look forward to finding ways of strengthening mutual learning and collaboration.

In this paper we attempt to expand this space for future collaboration between resilience and pathways by articulating some key ontological and epistemological differences and similarities. We then explore how these differences and similarities might influence the ways in which sustainability researchers position themselves in society, paying particular attention to ubiquitous calls for sustainability researchers to be ‘action-oriented’ and ‘solutions-based.’ We finish by identifying some specific thematic and methodological areas of synergy between resilience and pathways that we think will be especially fruitful for future sustainability research, and outline some practical activities we are involved with to address these issues. The paper aims to identify some of the basic challenges young trans-disciplinary researchers face when exploring multiple equally valid frameworks for sustainability, and adds our practical experience with pathways and resilience approaches to the more general literature on trans-disciplinary sustainability research (Turner and Robbins 2008; Turner 2010; Palsson *et al.* 2013; Popa *et al.* 2014).

Text Box 1.1: Institutional Histories

The STEPS Centre and the SRC have emerged as high-impact research centres in the context of increasing demand to understand global change. Their institutional history provides important background for understanding their academic orientation. The STEPS Centre is funded by the UK Economic and Social Research Council (ESRC), a non-departmental public body established by Royal Charter, receiving most of its funding from the Department for Business, Innovation and Skills (BIS). The STEPS Centre began as a collaboration between the Institute for Development Studies (IDS) and Science and Technology Policy Research (SPRU) at Sussex University in 2006 and was officially launched in 2007.

The SRC is funded by the Swedish Foundation for Strategic Environmental Research (MISTRA), a public foundation also closely linked to business and policy-makers. The SRC began as a joint response to a call for the establishment of an interdisciplinary research centre between Stockholm University, the Stockholm Environment Institute (SEI) and the Beijer International Institute of Ecological Economics at The Royal Swedish Academy of Sciences in 2006, and the SRC was officially launched in 2007. The emergence of the SRC was closely tied to the former Department of Systems Ecology at Stockholm University. Both STEPS and SRC have had their original grants extended for a second phase.

STEPS and the SRC have a comparable history and together represent significant investment in trans-disciplinary sustainability research. The core investment received by each Centre represents an opportunity to create creative and trusting spaces in which to explore new modes of knowledge production. Meanwhile, both Centres also respond to national and international funding calls, and therefore remain influenced to some extent by global demand for sustainability research. This balance has enabled each Centre to exert considerable influence on the trajectory of sustainability research and policy-making.

2. Ontological Foundations

Ontology refers to the kinds of entities that exist in the world. Resilience and pathways approaches to sustainability both generally adhere to realist ontologies, they take as given that a material world of some sort exists independently of our conceptions of it. Beyond this broad commonality, however, resilience and pathways tend to trace the relations between materiality and human conceptions very differently. In particular, the prominence of science and technology studies in the pathways approach ensures that knowledge is perceived as actively co-producing rather than merely representing realities. This ‘made’ aspect of reality is reflected in the STEPS Centre’s ‘social-ecological-technological systems,’ as opposed to the SRC’s ‘social-ecological systems.’ These ontological differences have a profound effect on the framing and boundary-setting of sustainability.

The resilience approach conceives of reality in terms of linked, coupled or nested social-ecological systems (SES) (Berkes and Folke 1998; Holling 2001; Folke 2006). These SES operate today in the context of a new geological epoch, the Anthropocene, where human actions are the fundamental drivers of changes in the earth system (or ‘life-support systems’) (Crutzen 2002). These changes are recognised by complexity, varying degrees of irreducible uncertainty and dynamic cross-scale interactions. The adaptive cycle is a common metaphor or heuristic used alongside the concept of ‘panarchy’ to describe dynamic change in SES, where collapse and renewal occur across multiple spatial and temporal scales. The adaptive cycle describes four sequential phases in system change, exploitation, conservation, release and reorganisation (Gunderson and Holling 2002). Fundamental or transformative change in SES happens when cycles trigger changes at different scales (the ‘revolt’ and ‘remember’ functions) prompting cascading interactions. The concept of panarchy is used to describe this interaction of adaptive cycles across scales, connected by ‘remember’ and ‘revolt’ processes (facilitating renewal and change respectively) (Gunderson and Holling 2002). Highly connected cascading effects can lead to non-linear change, the popularised concepts of ‘tipping points’ or ‘regime shifts’ (e.g. Scheffer 2009; Biggs *et al.* 2011).

This ontology lies behind the development of the ‘planetary boundaries’ concept (Rockström *et al.* 2009). Planetary boundaries aim to protect the ‘life-support systems’ of earth by establishing a range of biophysical variables necessary for ‘life as we know it’ to continue. This framework aims to establish a global agenda for action to decrease human impacts on the earth system, thus avoiding irreversible global tipping points and ensuring a ‘good anthropocene.’ It is proposed that exceeding these identified thresholds (established by syntheses of current research) will forever remove humanity from the benevolent conditions of the Holocene, and exert detrimental and potentially catastrophic effects on large parts of the world. While planetary boundaries research and resilience are not the same, and many resilience researchers do not work with planetary boundaries concepts, we include it here as a particularly influential extension of resilience-oriented ideas.

Where do human conceptions come into this picture? For resilience approaches, conceptions play a fundamental role in driving change in SES. Indeed, resilience thinking was born in part through recognition of the undesirable material changes in SES (such as shifts from clear to turbid lakes) caused by modernist managerial illusions of certainty and control. Nevertheless, a resilience approach embraces that we act upon what we know, and has consequently proposed management paradigms that prioritise ongoing learning and experimentation in the context of uncertainty. Resilience approaches tend to suggest that our representations of system dynamics, captured in the concept of ‘mental models,’ need to be improved while recognising that they will always be incomplete (Jones *et al.* 2011; Lynam *et al.* 2012; Rogers *et al.* 2013). This sense of ‘deficit’ or ‘separation’ becomes evident in calls to ‘reconnect to the Biosphere’ (Folke *et al.* 2011), implying

that ‘improving’ our mental models in order to reconnect to the Biosphere is part of the shift needed for humanity to remain within planetary boundaries.

In contrast, the pathways approach conceives of reality in terms of social-ecological-technological systems, tracing lineage to both social-ecological and socio-technical systems traditions. Socio-technical and social-ecological literatures both present systems as complex, multi-scale and adaptive (Smith and Stirling 2008). However, where social-ecological systems research is primarily concerned with maintaining a particular flow of services in a given context to achieve a desired outcome, and technology is seen to act on this process, a social-technical approach, in contrast, puts technology and social practices at the centre of the analysis, explicitly assuming the existence of interdependent heterogeneous power relationships. The socio-technical tradition questions the functionalism that social-ecological approaches necessarily prescribe in the measurement of desired outcomes, and rather focuses on the processes and structures that are thought to influence function. Therefore, while resilience research generally aims to maintain those desired functions, pathways approaches question the structures that create them (Smith and Stirling 2008).

This heritage situates pathways research within the systems tradition in some respects but the character of these systems, negotiated through practices of ‘framing’, ensures that it differs on key points from the social-ecological tradition. While the pathways approach considers it useful to think in terms of systems, it insists that these systems are not in themselves ontological entities but rather are particular framings of reality that include some things and leave others out (Leach *et al.* 2010). This is often also true for resilience research, but resilience approaches generally perceive the boundaries of social, ecological and technological systems to exist more clearly in an ‘objective’ sense. The rejection of these clear boundaries in the pathways approach leads to an emphasis on the articulation of systems trajectories or pathways through framing and narrative. It is important to emphasise that this difference in boundary-setting is not peripheral but has profound effects on how the core features of a system, including, for instance, its dimensions, relations, structures, processes and ends, are interpreted. As a consequence of the priority afforded to framing, differential power (co-produced by discursive and material elements) emerges in pathways research as the central force driving system change.

A good way to illustrate this alternate ontology, where conceptions do not merely represent systems but perform them (Callon 1998), is by tracing the STEPS critique of resilience approaches to the Anthropocene. In much resilience research the Anthropocene appears as an ontological reality that represents a shift from the relative stability of the Holocene towards unpredictability and potentially disastrous change, threatening ‘life as we know it.’ Many resilience-oriented papers begin by establishing this ontological ground, ‘Humanity has entered the Anthropocene era’ (Westley *et al.* 2011: 762) or, ‘the advent of the Anthropocene ... suggests that we need to fundamentally alter our relationship with the planet we inhabit’ (Steffen *et al.* 2011: 739). This ontology, once established, provides the basis for a range of actions geared towards maintaining a particular set of biogeophysical conditions.

When applying the pathways approach, the Anthropocene is not treated as a ‘neutral’ term to describe an objective ontological reality but as a particularly powerful or dominant framing. While pathways research might accept that human activities are having significant material impacts on the world, it also insists that characterizations of change are always selective and in this sense are always political projects (Stirling 2014a). For researchers applying a pathways approach, therefore, the ontological finality displayed by resilience approaches disguises a range of uncertainties and ambiguities, and power relationships between actors (Leach 2008; Stirling 2014b). For instance, the focus on ‘humanity’ in the Anthropocene might refer to the biological species, to a particular set of social formations or to a specific arrangement of geo-political hierarchies (Stirling *pers. comm.* 2013). More pertinently perhaps, pathways research points out that ‘life as we know it’ is not a unitary

concept and, pointing at the mass inequality in human conditions, prioritises questions such as 'whose life?' and 'as who knows it?' For pathways research, knowing and acting are irrevocably co-constituted.

These ontological differences have profound consequences for the positioning of sustainability research and the role of the researcher. In the resilience approach, the willingness to draw firmer boundaries between ecological, social and technological systems means that politics remain largely an epistemological practice. We need to learn how to *represent realities better* for policy-makers, whether that involves inclusion of indigenous knowledge in local resource management or construction of global scientific parameters for human action. Politics take place within the 'social' dimension of social-ecological systems; here the ontological 'ends' of the ecological system are already given. Therefore the way we research or measure properties of a system are often thought to exist in isolation from the complex system, instead of being part of it. In contrast, the pathways approach emphasises that the products of our research are part of the systems we study, and therefore also influence the system in question (Smith and Stirling 2008). This type of system level reflexivity is noted by Donella Meadows (1998:2): 'Indicators arise from values (we measure what we care about)'. Therefore, politics in the pathways approach tends towards an ontological practice. The political choices here do not lie in representing an objectively existing material world, but in producing particular futures. We need to increase participation in the *democratic production of realities* and accept that the needs and requirements of the poor may contradict scientific prescriptions for environmental protection; here the ends of social-ecological-technological systems are up for grabs.

3. Epistemological strategies

There are two interwoven dimensions to understanding epistemology in pathways and resilience. On the one hand each approach has something to say about the way that systems as a whole produce knowledge (including management and governance structures), and how this may be improved. On the other hand each approach itself has a particular approach to generating knowledge through research – these are questions of method and methodology. While these two dimensions are interwoven and mutually constitutive we deal in this section mainly with the former, how systems as a whole produce knowledge. This is because we address methodology implicitly in the sections on ‘ontological foundations’ and ‘epistemological strategies,’ and method in the ‘synergies’ section below.

Pathways and resilience approaches both work with ambivalence about the possibility of objectivity. Resilience research tends to work within a post-positivist epistemology that, while recognising that knowledge will forever be incomplete, holds out that approximations to a kind of objective truth may be obtained, and in fact *must* be obtained if decisive action is to take place on issues that threaten a sustainable Anthropocene. This emphasis on representation means that questions of validation become important, i.e. ‘are some claims truer than others?’ As mentioned above, pathways research generally works within a performative epistemology that maintains constitutive links between knowledge and action. The question of validation reduces in importance because the focus is on the contexts and perspectives under which contrasting (but potentially equally valid) truth claims emerge. Here, questions of legitimacy become increasingly pertinent. The epistemological strategies of pathways and resilience present a complex landscape that belies the caricatures sometimes drawn of each approach. Resilience does not advocate a simple ‘objectivity’ and pathways does not suggest ‘anything goes’. Nevertheless, these epistemologies do produce contrasting visions of the role of knowledge in system governance that differ in key respects, including the production of knowledge, the mobilization of knowledge in decision-making, and the relations between science, indigenous and local knowledge, and other ways of knowing.

For the resilience approach, accepting complexity entails recognising that the world is uncertain, nonlinear and surprising, and that our knowledge will be forever incomplete. As Evans (2011: 231) notes in relation to urban resilience thinking, ‘Epistemologically, it is possible to identify a shift from the dualistic tension between nomothetic (general) and ideographic (local) knowledge to a position that, while not going so far as to outright reject the possibility of ‘pure’ knowledge, certainly adopts a more circumscribed view of objectivity’. Acknowledging the contingency of knowledge has prompted innovation in two directions. Firstly, resilience approaches promote ongoing experimentation, systematic monitoring and feedback of information across scales of governance. These measures are designed to nurture learning-based approaches to management and governance (e.g. adaptive governance and adaptive management) that incrementally update and improve knowledge about social-ecological interactions (Olsson *et al.* 2004; Folke *et al.* 2005). Secondly, resilience thinking supports participatory and collaborative forms of environmental decision-making that seek to recognise, use and incorporate multiple types of knowledge, including local and indigenous knowledge (Berkes and Folke 2002; Tengö *et al.* 2014).

While this more ‘circumscribed view of objectivity’ has resulted in the development of management paradigms with greater acceptance of uncertainty and a more democratic attitude towards knowledge inputs, framing the problem in terms of ‘support for management of SES’ raises the issue of validation. As the ‘ends’ of useful knowledge have already been established by scientists validation is necessary to ensure that any knowledge introduced through participatory mechanisms supports these predetermined (functional) ends. This framing tends to mean that in the resilience approach, knowledge is validated in collaborative or experimental settings if it somehow ‘works’ to achieve

desired goals. Thus we see a heavy weighting in resilience research towards iconic examples of success, such as the use of Kristianstads Vattenrike Biosphere Reserve, in building the theory of adaptive co-management (Olsson *et al.* 2004). We might therefore characterise the resilience approach to validation as ‘truth = success.’

However, the difficulty here is that a functional approach to knowledge tends not to address construction of, and contestation over, ends which is essential to understand why and how certain kinds of knowledge ‘work’ in particular contexts (e.g. Cote and Nightingale 2012; Weichselgartner and Kelman 2014). This difficulty relates to the broader challenge in resilience research of giving meaning to the phrase ‘history matters’ while maintaining the hope that some types of local knowledge can in some sense be scaled up (Haider *et al.* forthcoming). As discussed more fully below, resilience research is increasingly addressing these challenges through, for instance, promoting parallel validation of local and traditional knowledge in ecosystem governance (Tengö *et al.* 2014).

The pathways approach also struggles with the implications of complexity for knowledge production. Like resilience, pathways suggests we embrace uncertainty and the inherent incompleteness of our knowledge. But while in resilience research declarations of incompleteness often predicate a representational approach to knowledge, where learning is assumed to be merely ‘equivalent to making a pictorial, linguistic, or mathematical image of the thing to know’ (Wagenaar 2011), and the end goal of all types of knowledge is assumed to be the same (this is why participation – as a way to ‘collate’ knowledge – is considered important), pathways research insists that a crucial extension of accepting incompleteness is recognising the constitutive force of power in establishing completeness in practice (by defining validity and ‘acceptable standards’ of knowledge). Pathways approaches therefore emphasise the multiple dimensions of incompleteness, ambiguity, ignorance, risk and uncertainty, and describe how power interests (often backed by scientific methods) work to reduce this diversity into narrow characterisations of risk (Stirling 2010a). Power closes down around particular interpretations, defining the ‘ends’ of knowledge by framing ‘problems’ and proposing ‘solutions.’ Here, certain interpretations become validated at the expense of others and ‘dominant pathways’ are created. We therefore characterize the pathways approach to validation as ‘truth = power.’

The attention to the links between power and knowledge found in the pathways approach is rooted in the sensitivity of development studies and science and technology studies to the imposition of ‘expert solutions’ on citizens who have had little role in designing them (Fisher 1993; Wynne 1996; Scott 1998). Therefore, while pathways recognises the importance of adaptive forms of governance and management, the emphasis is on ensuring that experimentation, monitoring and feedback – in other words, the mechanics of knowledge production – are placed within deliberative, reflexive and participatory frameworks (Stirling 2009). STEPS prescriptions for governance emphasise the importance of a plurality of understandings and interpretations that are not necessarily reconcilable. The challenge here is that dominant and powerful narratives can appear as unalterably ‘bad’ and the alternative or subaltern narratives of ‘the marginalised’ as unequivocally ‘good,’ when in fact power is a constitutive force behind all kinds of knowledge. The legitimacy of competing narratives therefore becomes a critical concern; which marginalised pathways should be articulated and provided a platform in governance? In practice this question may be decided by the ability of competing narratives to gain political support (subject to the same imbalances of power that a pathways approach identifies). The problem here is that empowering marginalised pathways may simply continue to empower some at the expense of others, challenging democratic principles in a parallel way to the support provided by resilience to ‘science as arbiter.’ Moreover, an acute sensitivity in pathways research to defining ‘ends’ leaves space open for those ends to be defined by others – most likely powerful interests. It is in this sense that the reluctance of pathways approaches to advocate on the basis of collective knowledge may itself be considered ‘elitist’, as Johan

Rockström argued in a plenary debate with Melissa Leach at the 2014 Resilience Conference (see above). Recognising these dilemmas openly and explicitly is essential if more productive collaboration is to be established between resilience and pathways (see Text Box 3.1). This debate, about the production of knowledge and the responsibilities and roles of experts, leads inevitably to the roles prescribed by pathways and resilience research for sustainability researchers in society, which we explore in the following section.

Text Box 3.1: Representing and performing planetary boundaries

There is a substantial risk that streams of trans-disciplinary research, operating under substantially different ontological and epistemological commitments, can talk past one another in unproductive ways. This risk is heightened if these commitments are not reflexively and openly discussed. A great example is the debate between Roger Pielke Jr. of the Breakthrough Institute (and a guest speaker at the 2013 STEPS Symposium: Credibility Across Cultures) and Victor Galaz of the Stockholm Resilience Centre.

In a widely read blog post posted in 2013, Pielke argues that the 'Planetary Boundaries' concept represents a 'power-grab,' reducing social and political choices to the technocratic maintenance of biogeophysical 'control variables.'² In response, Galaz argues that the concept of Planetary Boundaries does not specify any particular governance structure *per se*, and therefore works to inform rather than predetermine political choices.³

Regardless of the merits of each of these arguments (and we think there are merits on both sides), we see Pielke making his point in performative terms – that the production of planetary boundaries represents a powerful social imaginary and a source of discursive power – and Galaz responding in representational terms, that the accurate representation of biogeophysical dynamics sits outside of 'social' power dynamics. Each are arguing from within very different epistemological and ontological grounds, and consequently establishing very different connections between knowledge, power, reality and action. However, neither author makes these grounds explicit, and the reader is therefore left to choose sides – do planetary boundaries represent a power grab or not? This precludes a more productive discussion that might, for instance, trace the connections between biogeophysical, institutional and discursive dynamics, and explore how the concept of planetary boundaries may empower some actors while disempowering others.

² Roger Pielke Jr.'s original blog piece can be read in full here: <http://rogerpielkejr.blogspot.com.au/2013/04/planetary-boundries-as-power-grab.html>

³ Victor Galaz's response (and the accompanying debate in the comments section) can be found here: <http://rs.resalliance.org/2013/04/08/a-planetary-boundaries-straw-man/>

4. The role of the trans-disciplinary sustainability researcher in society

The ontological and epistemological positions staked out so far present very different options for the young sustainability researcher seeking to produce academically rigorous work while also making a positive difference to real-world sustainability issues. As young PhDs and Post-docs, we face these choices when writing articles, presenting at conferences, doing fieldwork and going about our daily lives. For instance, when working within a resilience framework we feel pressure to be policy-relevant and engaged, and when working with the pathways approach we feel we need to be reflexive and critical. With both we feel we are required to actively engage with society – to be, as the International Social Science Council (ISSC) put it in their 2013 report *Changing Global Environments*, ‘action-oriented’ and ‘solutions-based.’ Of course, policy-relevance and reflexive, critical research are not mutually exclusive, but interestingly they often appear to be framed as such. This is perhaps attributable to the power dynamics that shape the interaction between sustainability research and policy arenas; policy-makers (and fellow researchers) can disregard as ‘non-relevant’ research not compliant with, or simply not translatable into incumbent policies. These dynamics produce a fundamental tension in sustainability research (common to most knowledge demanding change), whether to affect change from ‘inside’ or ‘outside’ incumbent practices and structures. This tension is felt keenly by young trans-disciplinary researchers who feel compelled to work between academia and policy but are yet to establish themselves firmly in either. Therefore it is particularly important to be cognizant of the terms on which this engagement with society – including public, private and civil actors – is maintained, and to be aware of the risks and ambiguities involved.

The underlying normative goal of much resilience research is to ensure the perseverance of ecological and biophysical processes, from local to global scales, to a degree that enables ongoing social development (Raudsepp-Hearne *et al.* 2010). In other words, to maintain the earth system within ‘a safe operating space for humanity’ (Rockström *et al.* 2009). Accurate scientific information is prioritized as the most effective means of delineating this safe operating space. The use of social development and ‘humanity,’ particularly in the context of earth system governance, generally refers to abstract and aggregate measures of human wellbeing. Here, it is assumed that action to achieve environmental protection will tend to enhance human wellbeing and social equity. Given these assumptions, the task of resilience research considered as a collective whole is to empower system-level resilience. This does not mean focusing primarily on marginalised interests but on all potential pathways. Therefore it makes sense for resilience researchers to engage with powerful actors (e.g. big business, states) as they exercise large aggregate impacts on earth systems and are therefore key agents for change. At the same time, many resilience researchers are working at a local scale with individual villages and communities (e.g. Enfors *et al.* 2008; Berbés-Blázquez 2012; von Heland and Folke 2014). However, generally speaking the SRC has looked less at the distribution of this postulated increase in aggregate human wellbeing achieved by decreasing human impacts on the earth system (although this is changing, as further discussed below). This poses problems for sustainability researchers adopting the resilience approach: why should one empower pathways that are suppressing others? What is the use of empowering system-level resilience if system arrangements are themselves the problem?

For pathways research, the underlying presupposition is that the world is fundamentally unequal, both globally and locally, and that power inequalities are driving environmental degradation and injustice, producing increases in human wellbeing for some at the expense of others. Furthermore, pathways research holds that these inequalities are partially constituted by incumbent forms of knowledge production, including science. Given this starting point, there has been a greater focus in STEPS research practice on developing partnerships with marginalised groups across urban and rural

settings to understand how some of that 'lost' power can be re-instated in the domain of policy, innovation and earth system governance. While pathways research also seeks to engage with powerful interests, such as policy-makers, scientists or businesses, research action tends towards critically unpacking these interests, often by contrasting them with the counter narratives of marginalised citizens and civil society and articulating alternative possibilities. The pathways approach also poses dilemmas for sustainability researchers. How does the researcher choose marginalised pathways to highlight, when all pathways to some extent exclude and compete with others? What happens when a marginalised pathway 'catches on' in policy discourse and itself becomes dominant? When and on what criteria should the researcher 'let go' of such a pathway?

These differences affect the manner in which sustainability researchers orient themselves in society, including partnerships with non-academic actors, media engagements and so on. Here we briefly examine two contexts in which the dilemmas produced by both resilience and pathways approaches play out and are currently shaping the interaction between research and society. We have chosen examples of resilience concepts because, as current researchers in Stockholm, we are more familiar with these cases.

Firstly, planetary boundaries research has exerted significant influence on global policy-making by articulating a simple and compelling narrative in a form that chimes with the requirements of incumbent policy-makers (i.e. a reductive-aggregative 'dashboard'). Policy impacts include the Sustainable Development Goals, developed under the auspices of the United Nations (Leach 2013), and collaboration between the SRC and the World Business Council on Sustainable Development (WBCSD) (Bakker and Rockström 2012). As mentioned above, pathways approaches have offered a strident critique of the dominant narrative produced by this engagement, drawing heavily on the constitutive relations between knowledge and power. Indeed, concerns have also been raised within resilience circles that the planetary boundaries science has been misrepresented in the SRC's collaboration with the WBCSD, and perhaps used as a 'stamp of approval' to further private interests that run counter to the original normative stance of the research. From this perspective, the influence of planetary boundaries research has been achieved at the expense of diligence about how resilience science is presented and used in society, based on the assumption that as long as researchers do robust science on issues that they value (i.e. reconnection to the biosphere), it is only positive if this is picked up by policy-makers or business. While the pathways critique is valid according to the standards of socio-technical systems research, it becomes trickier when extended to trans-disciplinary sustainability research more broadly. If power is held to inherently constitute all knowledge, and science is therefore a form of politics, what are the consequences for scientists engaging with powerful actors? It is in this sense that pathways approaches, while not advocating 'anything goes', may reduce the ability of both scientists and policy-makers to situate action in the context of shared standards and norms, and paradoxically close down options to restrict powerful actors and exert influence on incumbent policies.

Secondly, the ascent of resilience research in the last decade has rapidly reframed the options available for projects that support marginalised, local-level pathways (such as local knowledge systems) seeking funding from international donors. In response, many international development organisations are helping communities to translate local interests into the (now dominant) language of resilience to attract financial support. This potentially empowering agenda has enabled some marginalised communities to pursue their agendas with previously unobtainable success. Here, pathways approaches might highlight the 'colonising' role that resilience as discourse can play, translating local needs into those which 'capital can see' (paraphrasing Robertson 2006). However, as with the planetary boundaries example above, this criticism itself produces a number of dilemmas for the researcher. While distinguishing between marginalised and dominant pathways may be a powerful analytical tool it is difficult empirically. In practice, narratives are not so easily delineated into 'dominant' and 'marginal', they are often messily entwined. Actors shift between dominant and

marginal perspectives when pursuing their interests, creating difficulties for the researcher seeking to empower weaker voices. Who is 'really' marginal?

This complexity points to the importance of a relational and reflexive role for sustainability research, where the researcher is prompted to continually balance competing and perhaps contradictory influences from society with self-assessment of his/her own normative assumptions. In the context of resilience and pathways approaches more generally, the existence of different normative starting points does not necessarily preclude opportunities for mutually supportive modes of action if they are openly acknowledged. Indeed, nurturing, protecting and encouraging diversity in all forms (social, ecological and technological) is a key synergy between resilience and pathways approaches. This diversity includes recognising the validity of different approaches to sustainability research itself (including different forms of social interaction) as part of the social, technological and ecological systems we study. But fostering diversity also entails reaching out across distinct traditions to discover potential areas of synergy. Below we identify areas where tensions produced by the clustering of particular streams of trans-disciplinary sustainability research may be mined for new research questions and areas of collaboration.

5. Synergies and ways forward

In this paper so far we have sought to outline some of the key differences between resilience and pathways approaches, in terms of epistemologies, ontologies, and the position of the sustainability researcher in society. We think this is important not because we think that one is better than the other, or to stake out particular intellectual ‘turf,’ but in fact precisely the opposite – because we think that each addresses different but equally valid aspects of sustainability. Putting these two approaches into dialogue is inspiring, and working with both simultaneously has helped us to improve our own work and our thinking around sustainability issues. In this section we outline thematic areas and methods of research that we are pursuing and that we think would benefit from collaboration and cross-fertilization between STEPS and the SRC. We also outline some current practical initiatives at the SRC that we feel provide exciting momentum to address areas of mutual interest in the coming years. While the authorship of this paper has experience with the research environments of both STEPS and the SRC, we currently reside primarily at the SRC – therefore, the section on practical activities is weighted towards our current activities in Stockholm. We hope that these specific points of action will stimulate and inspire collaboration.

5.1 Themes

Equity and Environmental Justice

One way of understanding human-environment interactions is through the concept of ecosystem services (ES), where the focus is on the importance of ecosystems for different aspects of human wellbeing (MEA 2005). The ES concept is widely used at the SRC to relate changes in ecosystem processes to changes in human wellbeing, but has been critiqued by STEPS-related research as one element of dominant narratives behind payment for ecosystem service schemes (PES) and large-scale ‘land-grabs’ (Fairhead *et al.* 2012; White *et al.* 2012). Here we want to highlight work by two SRC-affiliated researchers that offer interesting synergies between resilience and pathways approaches to ES: (1) analysing the differentiated effects of ES on communities using disaggregated measures of wellbeing, and (2) putting ES into dialogue with environmental justice perspectives to demonstrate the importance of the articulation and distribution of ES.

Daw *et al.* (2011) discuss four important aspects of interaction between ES and human wellbeing in the context of poverty alleviation: (1) different social groups benefit from different ES, which creates winners and losers when sets of ES in an area change; (2) access mechanisms decide who can benefit from a given ES; (3) the contribution of ES to wellbeing depends on context and individual needs; and (4) ES can contribute to wellbeing through different types of benefit, including cash through sale of ES. In a related study Abunge *et al.* (2013) used participatory and deliberative approaches to enable community members to articulate which aspects of wellbeing are important for particular community groups, and how ES can contribute to this wellbeing. This type of research helps to address the complex interactions between cultural dynamics (including issues of distribution, power and social capital) and ecological processes, and would be complemented by a STEPS focus on power relations between actors, framing of ecosystem services and resource ‘problems,’ and the playing out of global narratives of PES and ES in local places.

Work by SRC-affiliated researchers Ernstson (2013) and Ernstson and Sörlin (2013) uses perspectives from environmental justice and science and technology studies to bring questions of power and the politics of knowledge production into frameworks for understanding ES. Ernstson (2013) critiques the idea that ES are a form of ‘apolitical knowledge’ and proposes three analytical moments for the study of ES that, he proposes, will situate ES in local social and political contexts. The *articulation* of ES refers to the discourses and artifacts used by different groups to articulate the value of a certain ecosystem or process. The *generation* of ES is affected by decisions and practices for land-use and

management. The *distribution* of ES refers to the spatial and temporal location of ES within a particular geographic unit, including who has access and who can benefit from these ES. Using this analytical framework in combination with disaggregated models of wellbeing, such as Daw *et al.* (2011) above, may enable the identification of multiple potential pathways for use of ES in an area based on whose articulation is included in decisions, and who can influence decisions affecting generation and mechanisms of access.

The existence of multiple pathways, or system trajectories for development, is recognised not only in the pathways approach but also in the resilience approach (Enfors 2013). The resilience approach tends to focus on the set of ecosystem services generated from each trajectory. Synthesising research questions can be posed at two levels. (1) The outcomes of the different pathways (the set of ecosystem services generated), including: who frames the assessment of the outcomes? Who selects the ecosystem services to include? How are the benefits from the set of ecosystem services distributed? And (2) the divergence of different pathways, including: Which drivers act at the point of divergence to create different pathways? How do power relations and global narratives (e.g. of payment for ecosystem services) create or close down pathways?

Work on equity and environmental justice in ES reflects broader tensions in sustainability research. How can researchers bridge the rhetorical and material aspects of ecological concepts? ES relate to material entities but at the same time are inherently discursive constructs or imaginaries. The SRC has tended to place more weight on the former while STEPS has generally pursued the latter. Exciting future research lies in exploring how the two interact and constitute each other. What would research look like that incorporated both materiality and discursive dynamics from the start in research design and objectives? One way is to democratise the articulation of ES, moving ES away from a 'top-down' concept for communication between science and policy-makers and towards a tool for communities to articulate what is of value for them and deliberate between a range of possible scenarios (Berbés-Blázquez 2012; Sinare *et al.* forthcoming).

Knowledge systems and response diversity

A critical area of research for sustainability is interpretation of human-environment interactions and the knowledge we need to adapt effectively and equitably to changing environmental conditions. Both resilience and pathways approaches suggest that local and traditional knowledge will play a fundamental role alongside expert knowledge of all kinds in developing sustainable trajectories; both therefore identify the co-production of knowledge as necessary and desirable (Jasanoff and Wynne 1998; Fairhead and Leach 2003; Leach *et al.* 2010; Armitage *et al.* 2011). Importantly, scholars from both centres assume that knowledge will always be incomplete, and consequently that actions need to nurture ongoing learning and possibilities for adaptation.

However, resilience and pathways have different perspectives on the ways that different knowledges can and should be integrated, particularly with regard to the effects of power on knowledge. A resilience perspective tends to see ecological knowledge as a part of cultural capital (Berkes and Folke 1992) and addresses the role ecological knowledge can play in ecosystem management. In other words, local or indigenous knowledge can be incorporated to support existing knowledge (Armitage *et al.* 2011), and is recognised when it has a function for a predetermined end. The pathways approach insists that power and knowledge cannot be separated, and incumbent power interests will favour dominant pathways to become established, drowning out weaker ones.

The Multiple Evidence Base, a new initiative led by SRC researchers, provides the opportunity for synergy with pathways by recognising the situated nature of knowledge and the support that marginalised knowledges need to be heard in the context of international environmental assessments. Despite widespread recognition in environmental management, policy and science of the importance of local ecological knowledge, international assessments have generally failed to

effectively incorporate multiple knowledges (Sutherland *et al.* 2013). The Multiple Evidence Base attempts to ameliorate these failures by rejecting cross-validation of local and traditional knowledge with science and calls for parallel and equally valid types of knowledge to be considered alongside each other (Tengö *et al.* 2014). By promoting complementarities between knowledge systems while avoiding validation across them, the Multiple Evidence Base may help create a 'level playing field' for multiple pathways to emerge.

Recognition of diversity in knowledge systems is therefore a key point of synergy between resilience and pathways, but equally promising is understanding the role of diversity itself as a quality driving and enabling responses to system change. Diversity is central to both resilience and pathways approaches as a crucial element of any change process. In resilience thinking, diversity is often acknowledged as a security strategy of human or ecological communities (alongside other system qualities such as redundancy and memory) in the face of disturbance and surprise (Gunderson and Holling 2002; Berkes *et al.* 2003). In slight contrast, the pathways approach places more importance on subjective plurality as well as objective diversity, by treating diversity as a means to systematically make sense of varied possible trajectories, ensuring a plurality of perspectives on desirable change, and enhancing deliberative democratic processes relating to, for instance, energy and water policy, geo-engineering and urban planning (e.g. Stirling 2007; Stirling 2010b; Cairns 2013). While diversity is almost inherently thought of as a positive system attribute to enhance resilience, the pathways approach emphasises that diversity without power to enable 'real choices' among marginalised people or along weaker pathways is not enough (Leach *et al.* 2010).

An exciting new area of research is using response diversity as a way to understand the continued adaptive capacity of a given social ecological system. Response diversity is defined as the range of reactions to environmental change among species contributing to similar ecosystem functions, and is critical to ecosystem resilience (Elmqvist *et al.* 2003). Anthropologists Leslie and McCabe (2013) have recently extended this concept to understand the diversity of human behavior in the face of disturbance. Putting these two approaches to diversity together is an exciting point of synergy for the SRC and STEPS, for instance using heuristics of diversity, developed by Queiroz *et al.* (in review) in ecological systems and Stirling (2010b) in energy systems, to generate a more nuanced understanding of the types of diversity helpful for future adaptation strategies, particularly among marginalised communities. d'Armengol (2013) in an unpublished Masters thesis (submitted for the programme 'Social-Ecological Resilience for Sustainable Development', Stockholm Resilience Centre) has produced exciting work where she uses a diversity metric based on Stirling (2007) to understand the local ecological knowledge (LEK) of the stewards of La Palma Sea, Spain. Meanwhile, Haider *et al.* (in preparation) use response diversity as a way to think about how equitable transformations may occur in biocultural systems.

5.2. Methods

Questions of method are crucial in trans-disciplinary sustainability research, refracting tensions between subjectivity and objectivity, qualitative and quantitative perspectives, experts and citizens. The array of possible methods from multiple disciplines can appear daunting to young trans-disciplinary researchers, as methods are often replete with their own disciplinary histories. Trans-disciplinary researchers are forced to embrace what Law (2004) describes in a social research context as 'mess.' Realities often appear vague, ephemeral, and contradictory and methods need to become better at reflecting this complexity, while still speaking productively to extra-academic audiences, including citizens, policy-makers, civil society and the private sector. The authors of this paper are experimenting with a variety of methods to these ends, and while we find significant differences between methods favoured by SRC and STEPS there are also many exciting areas for potential collaboration.

An interesting way to think about the uses of different methods at the SRC and STEPS, and their relationship to the ontological and epistemological choices that we have outlined in this paper, is to draw on Stirling *et al.*'s (2007) schematic representation of appraisal methods and their responsiveness to the dynamics of social, economic, ecological and technological systems. Stirling *et al.* (2007: 56) distinguish between appraisals demonstrating 'narrow' or 'broad' characteristics (referring to the degree of reflection 'over the full character of dynamic systems and diverse knowledges of them') and appraisals that are 'closed' or 'open' (referring to the 'degree of reflexivity with which appraisal designs convey the plural and conditional nature of relevant knowledges into wider processes of governance').

We have adapted Stirling *et al.*'s schema to highlight methods favoured by the SRC and STEPS in order to identify areas of divergence, complementarity and synergy (Figure 5.1). We share Stirling *et al.*'s view that these qualities of narrow/broad and closed/open are ideal types, and that these methods may be subject to divergent interpretation or display other stylistic, structural, methodological and contextual features that affect their position in relation to other methods indicated. We think the schema is a useful way to begin thinking about ways of collaborating, and do not intend the schematic to be exhaustive or deterministic.

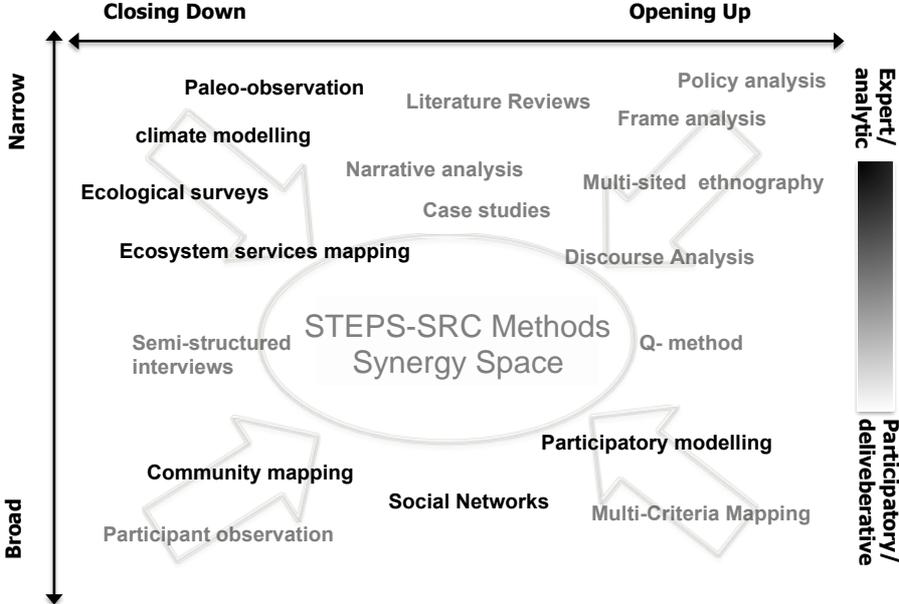


Figure 5.1: A schematic of STEPS and SRC research methods
 Common SRC methods indicated black; common STEPS methods indicated grey. This schematic is intended to indicate the core strengths of each research centre and is not intended to be exhaustive or deterministic (adapted from Stirling *et al.* 2007: 57)

The upper left quadrant of Figure 5.1 indicates methods that tend toward reductive-aggregative forms of knowledge production. These are generally, though not universally, derived from the natural sciences. Ecological surveys and ecosystem service mapping are among the SRC's core strengths and have been productively used to examine regime shifts and tipping points in ecosystems (Gordon *et al.* 2010; Hughes *et al.* 2013). Insights, methods and tools used by ecology and climate modelers are becoming increasingly integrated within the broader resilience community to determine key socio-ecological properties, such as critical transitions in ecosystem behavior across broader scales (Rietkerk *et al.* 2011). In the upper right quadrant of the schematic we find methods that are geared towards generating knowledge about the diversity of different opinions around a topic or question. These methods have been used extensively in STEPS-oriented research and tend to reflect social science concerns. Such methods are 'less about producing and defending claims', and

more about 'empowering and facilitating more effective learning on the basis of qualities such as resilience, flexibility, reversibility, option values and diversity' (Stirling *et al.* 2007: 35). For example, Van Zwanenberg *et al.* (2008) use frame analysis to highlight diversity between different stakeholder positions in relation to seed and drug regulation. Nevertheless, these methods still reflect an implicit prioritization of expertise, in this case expertise from the social as opposed to the natural sciences.

As we move towards the middle and lower right quadrants of the schema, we find methods that are more participatory and allow greater room for co-construction of knowledge. SRC-related researchers have pioneered the use of social network analysis (SNA) as a tool to understand complex processes of self-organisation in natural resource management and environmental governance (Bodin *et al.* 2006; Bodin and Crona 2009; Ernstson *et al.* 2010), and are increasingly turning to SNA to trace social learning and shared values among stakeholders (Prell *et al.* 2010; De Nooy 2013). While social network analysis requires expertise it does have participatory potential. Participatory modeling tools are also becoming popular as ways of democratising knowledge inputs and generation in the context of resilience research for improved ecosystem stewardship (Schlüter *et al.* 2013; d'Aquino and Bah 2013). Meanwhile, STEPS-related researchers are making use of participatory mapping tools that provide for interactive appraisal of complex strategic and policy issues. For instance, one STEPS Centre project used multi-criteria mapping (MCM) to explore agricultural innovation pathways with Kenyan farmers in the Sakai valley.⁴ While it is likely these methods will always require some degree of expertise they also have the potential to provide more participatory, endogenous and open assessments of social, ecological and technological systems.

We sense that resilience and pathways-oriented approaches are both evolving to incorporate more participatory methods that break down traditional divides between 'experts' and 'subjects' and enable as yet unimagined contextually relevant pathways to take root (e.g. through photo-voice (Berbez-Blazquez 2012) and using food as a lens for dialogue (van Oudenhoven and Haider 2012)). There is also great potential in combining more traditional 'expertise-based' approaches with participatory exercises in ways that enhance reflexivity and explanatory power. For instance, the GLEAN Project (A Global Survey of Learning, Participation and Ecosystem Management in Biosphere Reserves)⁵ based at the SRC is using a combination of R-statistical methods (traditional surveys) with Q-method, participant observation and qualitative interviewing to examine patterns of stakeholder participation in ecosystem management. While R-statistics are used to examine the existence of an expert-defined phenomenon across a population, in this case the use of participatory processes in UNESCO Biosphere Reserves, Q-statistics help to reveal the different interpretations of what 'participation' might mean in a particular context. Working with the tension between 'closing down' and 'opening up' is helping researchers in the GLEAN project to identify new research questions and gain new insight about the relationships between stakeholder participation and learning in a state of complexity.

5.3 Practical Initiatives

PhD and early-career researcher courses

Cross-fertilisation between multiple frameworks for sustainability is inspiring and we are exploring the potential for interaction between different ontologies and epistemologies in a range of PhD and

⁴ A report on the initiative can be found here: <http://steps-centre.org/wp-content/uploads/Steps-3-MCM-Maize-Project.pdf>

⁵ The GLEAN Project is a five year project running from 2012–2017. More information can be found on the project website: www.gleanproject.org

young-researcher courses at the Resilience Research School (RRS) at the SRC.⁶ For instance, recent and upcoming courses have put classical social science thinkers into dialogue with resilience and social-ecological systems thinking,⁷ examined critical, scientific and policy discourses surrounding ecosystem services,⁸ and explored the environmental history of China.⁹ The RRS has established a 'Critical Seminars' series where invited speakers critically challenge key aspects of resilience thinking with a view to simulating new research questions and debate. We are particularly excited about opportunities to organise joint PhD courses and seminars with young researchers from other sustainability research centres, for instance around methods and research techniques, and we invite interested parties to get in touch.

Conference sessions and dialogue

How do the challenges and opportunities faced by young trans-disciplinary scholars today compare and contrast to those experienced by our predecessors (for instance the founders of the SRC and STEPS)? In various creative forms, including dialogue, theatre and art, we have explored the question of what it means to be trans-disciplinary scientists today. Conference sessions are one way we hope to help develop a critical mass of young trans-disciplinary sustainability researchers interested in critically reflecting on the nature of our work and its position within society. The first of these sessions was held at Resilience 2014 (Resilience and Development: Mobilizing for Transformation),¹⁰ titled 'Student's perspectives on sustainability science research – are we moving towards un-disciplinarity?' In this session we asked the question: how do we as graduate students and future researchers perform high quality research and build identity in the field of sustainability science, when starting as trans- or inter- disciplinary individuals without profound roots in a discipline, and working within a world dominated by established disciplines? We used the session to build an inter-generational forum between sustainability researchers, to stimulate the ongoing creation of supportive spaces for trans-disciplinary research.

Paper collaborations

Building on PhD courses and conference sessions, we are interested in developing an ongoing series of critical but policy-oriented explorations of sustainability frameworks, concepts and heuristics. These papers will be geared towards exploring young researcher perspectives and experiences applying emerging approaches to trans- and inter- disciplinary sustainability research. In particular it is envisaged that these papers will explore the ontological and epistemological foundations of each approach and place them in historical and institutional context. This work will enable young researchers to position their own work, share experiences, produce new research questions, and identify key areas of collaboration with other approaches. In addition to formal papers, we see

⁶ The webpage of the RRS can be found here: <http://www.stockholmresilience.org/21/education/resilience-research-school.html>

⁷ For a series of blogs on the RRS class 'Why Bother with Durkheim? Using (classical) social science to understand the social dynamics of social-ecological systems', see the Resilience Science Blog. The introductory piece can be found here: <http://rs.resalliance.org/2014/01/31/why-bother-with-durkheim-using-classical-social-science-to-understand-the-social-dynamics-of-social-ecological-systems/>

⁸ A course description for the RRS course 'Ecosystem services, economic theory and economic analysis: an introduction from an ecological economics perspective' can be found here: <http://www.stockholmresilience.org/21/education/resilience-research-school/current-upcoming-courses.html>

⁹ The course blog for the RRS course 'Social-ecological transformation in China: A historical perspective on ecosystem services' can be found here: <http://chinareads.wordpress.com/>

¹⁰ For proceedings see the conference website: <http://www.resilience2014.org/>

working papers such as this as a key means to create a productive exchange between researchers working on similar research questions from different ontological and epistemological starting points.

6. Conclusions

Complexity and associated 'wicked problems' have rendered traditional ways of producing and applying knowledge insufficient. Trans-disciplinary sustainability research centres such as STEPS and the SRC have emerged in response to demands for knowledge production processes that break down divides between academic disciplines and between experts and citizens. The pathways and resilience approaches represent distinct theoretical frameworks for addressing these divides. However, these trans-disciplinary varieties have, so far, tended to produce collaboration between disciplines with more or less common ontological and epistemological foundations. This makes it difficult for young researchers, who increasingly find their interests at the intersection of multiple frameworks, to speak across trans-disciplinary clusters in a productive way. We think it is important that this space is encouraged because we see the most exciting future sustainability research lying at the crossroads between different approaches.

In this paper we discussed how the ontological commitments of resilience and pathways lead us to see the world differently. While both work within systems frameworks, the willingness in resilience research to draw firmer system boundaries enables researchers to establish functional relations and identities. In contrast, the emphasis in pathways research on the production of system boundaries enables researchers to uncover the discursive (and contingent) mechanisms that enable us to establish identities and relations in the first place. Given these ontological stances we then examined the epistemological strategies of resilience and pathways. We established that, generally speaking, the resilience emphasis on functionality leads to questions of 'what works?'. In the pathways approach the emphasis on distribution leads to questions of 'who's losing, who's benefiting?'. Therefore, while participatory governance structures are encouraged in resilience research primarily as a means of increasing the pool of knowledge available, in pathways oriented research they are promoted to facilitate deliberation and contestation between different knowledges.

These epistemologies, supported by distinct methods, frame the role of the trans-disciplinary sustainability researcher in different ways. For resilience-oriented researchers, appropriate action for sustainability, conceived as maintenance of biophysical processes, may take the form of empowering 'system-level' resilience, engaging with a wide range of actors from the private sector, civil society and the state. Pathways researchers, conceiving of sustainability in terms of social inequity and inequality, are more likely to see their role as highlighting marginalised perspectives and subaltern narratives, in which case engaging with powerful private sector voices may not be so relevant. However, at the same time, we see pathways and resilience researchers acting in the same policy arenas, and, in some areas, supporting each other's agendas. This suggests that these two visions for the role of the sustainability researcher may not be mutually exclusive but actually beneficial. The problem remains, however, how to work across these perspectives and produce trans-disciplinary, rather than simply multi-disciplinary, spaces.

Willingness among the social sciences, natural sciences and humanities to work together on sustainability challenges has increased rapidly in recent years. If this interest is to be capitalised upon, we need to find new ways of relating, reconciling and talking across the epistemological and ontological differences between them. In order to do this effectively we need to be able to reflexively challenge our own commitments and also reach out to understand others. A productive way of beginning this journey is to put two prominent frameworks into dialogue, establishing common ground and identifying contradictions. In this working paper we have outlined some of the ways that we, a group of young trans-disciplinary researchers, are trying to work between multiple frameworks, theories, and methods. Reaching out to understand the differences between approaches, and creating space where these differences meet to establish common ground, is

necessary for trans-disciplinary research to move forward and identify exciting areas of future research.

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