

Final published version available at *Climatic Change*: Moser, S., Meerow, S., Arnott, J. et al. *Climatic Change* (2019). <https://doi.org/10.1007/s10584-018-2358-0> ; For download go to: <https://link.springer.com/article/10.1007/s10584-018-2358-0>.

1 **The turbulent world of resilience:**
2 **Interpretations and themes for transdisciplinary dialogue**

3
4 by

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13 **Abstract**

14 Resilience has experienced exponential growth in scholarship and practice over the past several
15 decades. We conduct a meta-analysis of recent review papers on resilience from all relevant fields to
16 distill *key themes* emanating from both research and practice. These themes reflect prevalent debates,
17 trends and insights from the thousands of underlying papers. The seven themes are: 1) the distinction
18 between resilience as a system trait, process, or outcome; 2) the importance of resilience as a strategy
19 for dealing with uncertainty; 3) a shift from understanding resilience to active resilience-building; 4) the
20 incorporation of transformation into resilience; 5) the increasingly normative interpretation of
21 resilience; 6) the growing emphasis on measuring and evaluating resilience; and 7) the mounting
22 critiques of the resilience agenda demanding attention. We discuss each in detail and find that they help
23 explain both why resilience has attracted widespread attention, but also why it is an increasingly
24 contested concept. We offer several steps to engage in productive dialogue across differences in
25 resilience interpretations and conclude that this inter- and transdisciplinary dialogue is the difficult and
26 necessary work that must be done, if resilience scholarship and practice is to advance in productive
27 ways in the future.
28

29 **1 Introduction**
30

31 A simple search for the term *resilience* on Google yields nearly 67 million hits in less than a second. Its
32 usage spans a wide spectrum of contexts: from natural disasters to mass shootings to elementary school
33 counseling. Presidents and mayors invoke the term in the wake of tragedy while parents and school
34 administrators work to instill it in their children and students. In the Trump era, use of the term climate
35 change on government websites is sometimes replaced with resilience.¹ In such politically polarized
36 times, the concept of resilience apparently resonates across partisan divides.
37

38 But what really does it mean? Where should one begin to understand this concept, especially given
39 multiple disciplinary lines of thinking and increasing cross-fertilization across fields? A slightly narrower
40 search for *scholarly* publications on resilience in Google Scholar yields nearly 2 million hits and an even
41 more restrictive, yet still inclusive search in the Scopus citation database for “resilien*” between 1973,

¹ March 28, 2017 www.envirodatagov.org

1 when C.S. Holling’s incisive article (Holling 1973) on the topic was published, and 2017 produces 97,796
2 references. Over 60,000 of these are journal articles; more than 5,000 are review articles, and resilience
3 scholarship represents a growing percentage of the total publications in the database (Figure 1).

4
5 [insert figure 1 here]

6
7 Diving just below the surface of this sea of resilience papers quickly reveals intense debates over the
8 meaning, characteristics, and usefulness of the term resilience. Anyone with an inclination toward multi-
9 or interdisciplinarity might decry the extent to which certain interpretations are perpetuated within
10 fields, as balkanization among researchers makes it easy to ignore neighboring fields. Others critique the
11 imprecision, duplication, overuse, and loss of meaning of the term, to the point of declaring irrelevance.

12
13 At the same time, particularly in the face of growing threats from weather-related disasters and climate
14 change and the proliferation of policies and large funding opportunities for resilience work, many
15 practitioners urgently search for concrete guidance on how to build resilience. While some are aware of,
16 and show interest in, the finer nuances of academic debate, others simply recognize the concept’s utility
17 and avoid haggling over interpretations. For some practitioners navigating the polarized debates on
18 climate change, resilience opens, rather than closes, doors (Moser 2017). The concept’s ambiguity
19 allows resilience to serve as a “boundary object” that enables engagement (Fujimura 1992; Brand and
20 Jax 2007). For others, resilience does the opposite, as divergent, unspecified, or non-resonant
21 understandings of the concept can stymie engagement and policy support (MacInnis et al. 2015;
22 McGreavy 2016).

23
24 And yet, if the exponential trend shown in Figure 1 and the tens of millions of results in public search
25 engines are indicative of reality, resilience seems to enjoy a growing popularity in science, practice, and
26 society far beyond a fleeting interest. The apparent purchase that the term has for many, juxtaposed
27 with the frustration expressed over the lack of a clear meaning and actionable insights, is the starting
28 point for this paper.

29
30 Fully aware of the irony of adding yet another paper to the existing plethora of publications, we wish to
31 be useful in several ways:

- 32 1. We identify *key* themes within the growing communities of resilience research and practice.
33 These themes—observed by the authors as tensions within the resilience discussions occurring
34 among researchers and between researchers and practitioners and, in this paper, validated by a
35 meta-analysis of review articles about resilience—crystallize prevalent trends and insights of
36 both practical and scholarly significance. Such a distillation can help orient the novice and
37 probably even the advanced scholar in the resilience field.
- 38 2. We introduce a basic categorization of resilience interpretations—that is, resilience as a system
39 trait, a process, or an outcome—to distinguish and discern the multiplicity of meanings, while at
40 the same time enabling a conversation across fundamentally different ways of thinking about
41 resilience.
- 42 3. We discuss implications of these themes and interpretations that lead to recommendations for
43 more productive cross- and even trans-disciplinary dialogue on resilience in a world hungry for
44 rapid scientific and practical progress.

45
46 There is no guarantee that any one singular or synthetic perspective on resilience will help make on-the-
47 ground progress. Furthermore, in completing this review, we do not assume that such a synthesis, on its
48 own, transforms resilience from the theoretical to the practical, nor do we resolve the many

1 fundamental critiques about the concept that persist. For those actively working to promote resilience
2 agendas in practice or to contribute further to its scholarship, we hope this review will afford a basis for
3 a more constructive and broadly-informed discussion moving forward. While we hope this may be of
4 some benefit to those seeking to apply resilience in practice, we do not intend to discourage continued
5 critical arguments surrounding the fundamental nature of resilience.

6
7 This paper is structured accordingly. The next section outlines the origins and approach that enabled us
8 to identify themes in the resilience dialogue and literature. Section 3 synthesizes the seven themes we
9 derived from our engagement in this dialogue and the literature review. Section 4 offers our synthesis of
10 these findings in the form of recommendations for fruitful exchange across different resilience
11 interpretations, and Section 5 briefly concludes.

12 13 **2 Methods**

14
15 The challenge described in the introduction motivated a transdisciplinary workshop that included both
16 scholars and practitioners at the Aspen Global Change Institute in December 2015 to explore
17 possibilities of advancing mutual understanding, assessment approaches, and lessons for research and
18 practice regarding resilience in the face of global change. Thirty-one experts from various disciplines and
19 areas of practice participated in the five-day event (the participant list, agenda, videos, and other
20 outputs are available at <https://www.agci.org/event/15s5>). To us, organizing and participating in this
21 workshop starkly surfaced the deep differences in understandings and perspectives about the concept
22 of resilience. While we were previously aware of scholarly and practical debates—this encounter in
23 particular convinced us that improved fluency across these differences was needed among resilience
24 professionals to effectively communicate and collaborate. We observed participants becoming more,
25 rather than less entrenched within their particular theoretical or disciplinary lenses, resulting in
26 unproductive debates. Similar entrenchment has been observed by authors in various disciplines and
27 subfields (e.g., Righi et al. 2015 for engineering; Meerow et al. 2016 for urban resilience; or Fletcher and
28 Sarkar 2013 for psychology) and is reflected in practical guidance (e.g., the Island Press and Kresge
29 Foundation’s 2015 report on urban resilience). To develop a more productive resilience dialogue across
30 disciplines – which we believe is important for tackling global change – we needed to first understand
31 the key differences in concepts, foci, action implications, and value commitments. This became a focus
32 for the workshop, and a key output was an initial framework for distinguishing "resilience
33 interpretations" to enable mutual understanding and communication (Table 1).

34
35 [insert Table 1 here]

36
37 Our subsequent work - which supports this paper – helped to refine and expand this initial framework.
38 To better understand the recent trends and trajectory of resilience research, we conducted a systematic
39 meta-analysis of the growing number of resilience *review* papers. We intentionally targeted recent
40 review papers to tease out themes across the resilience literature, rather than force a highly diverse
41 resilience literature with a range of theoretical commitments through a single theoretical lens. We
42 performed an advanced academic literature search in the Scopus citation database for references with
43 the following in the title, abstract, or keywords: resilience AND urban OR risk OR ecological OR
44 community OR hazards OR disasters OR infrastructure OR climate OR psycholog*.² The search was
45 limited to review papers published between 2011 and 2015. This produced 155 results. Because we

² These search terms reflected the expertise of Aspen workshop invitees and – inter alia – the expertise of this author team.

1 recognized that we might be overlooking some relevant keywords that were outside our own areas of
2 expertise, and that not all publications are in Scopus, we crosschecked and supplemented this list with a
3 citation list compiled by the above-mentioned multidisciplinary group of resilience experts convened at
4 the Aspen Global Change Institute, which included some reviews officially published later. Nevertheless,
5 some scholarship may still have been overlooked, for example we did not explicitly search for reviews on
6 rural or agricultural resilience, so this could be an area for future work.

7
8 Subsequently, three of the authors reviewed the abstracts and excluded citations that were not
9 primarily review papers, not primarily related to resilience, or were focused on resilience at a highly
10 specific level (e.g., specific species or geographic regions). The researchers then systematically reviewed
11 the remaining 52 review papers from the domains of urban studies, hazard/disaster reduction, ecology,
12 psychology, child/human development, international development, climate change adaptation,
13 engineering, geography, archeology, energy, epidemiology, public administration/policy, food systems,
14 along with other fields and perspectives.

15
16 The review focused on identifying and characterizing the papers' definitions of resilience, characteristics
17 associated with resilience, conclusions about the trajectory of the concept, any indications of how to
18 operationalize resilience, critiques of resilience, and whether the authors of these review papers
19 considered it to be a purely descriptive or normative concept. These questions were based in large part
20 on questions and debates that emerged in the workshop. All co-authors reviewed the full results of the
21 review and independently identified themes that rose to prominence for them. These were then
22 compared and deliberated over until we had a consensus around the seven themes. Given the nature of
23 review papers, and that this is a meta-analysis of those reviews, the common themes described below
24 are twice removed from the original underlying papers. Thus, they cannot reveal the contexts or
25 nuances of the original or review authors' views, but rather focus on the higher-order synthetic findings
26 that emerge from them. In part because of this limitation, we also focus on describing the themes in the
27 literature, as opposed to making explanatory claims. This again, could be a potential avenue for future
28 research. Clearly, our backgrounds and interests influenced the themes that stood out to us; different
29 scholars might find others. That said, our backgrounds are quite different (geography; interdisciplinary
30 social-ecological systems science and urban planning; science-policy interactions and resource policy
31 and behavior; and forest and environmental science, respectively), thus providing some confidence that
32 the themes discerned are not merely artifacts of homophilous thinking. However, the seven themes are
33 not meant to be exhaustive, but rather a foundation for further dialogue.

34 35 **3 Findings: Seven themes in resilience discourse**

36
37 We were able to distill seven prevalent themes/insights from our meta-analysis that help make sense of
38 the diverse and rapidly evolving resilience discourse. The seven themes are: 1) the distinction between
39 resilience as a system trait, process, or outcome; 2) the importance of resilience as a strategy for dealing
40 with uncertainty; 3) a shift from understanding resilience to active resilience-building; 4) the
41 incorporation of transformation into resilience; 5) the increasing normative interpretation of resilience;
42 6) the growing emphasis on measuring and evaluating resilience; and 7) mounting critiques of the
43 resilience agenda demanding attention. Below we address each of these themes in more detail.

44 45 **3.1 System, process, and outcome resilience interpretations**

46
47 First, we observe categorical distinctions in how resilience is used across the research landscape. Our
48 review of the definitions reveals a clustering of interpretations around resilience as a *trait of a system*

1 (ecological, social, social-ecological, technological etc.), as *a set of processes*, or as *an outcome*. In the
2 first instance, researchers are primarily concerned with identifying *system* characteristics (Bhamra et al.
3 2011; Molyneaux et al. 2012; Perz et al. 2013; Hassler and Kohler 2014), whereas in the case of *process*
4 interpretations, researchers focus on actions and interventions (Brown and Westaway 2011; Tyler and
5 Moench 2012; Brownlee et al. 2013; Ross and Berkes 2014). Finally, in the *outcome* interpretation,
6 researchers are focused on (temporary) states of a system. At times, measurable outcomes are viewed
7 entirely neutrally, without value judgements attached to a particular system state; at other times, they
8 are assessed as desirable or undesirable (Angell 2014; Tendall et al. 2015). While we distinguish these
9 three basic resilience interpretations, there are a number of researchers who adopt more than one, for
10 example as both a process and an outcome (Matyas and Pelling 2014; Wilson 2014). In general,
11 however, the ecology and engineering fields tend to focus on resilience as a system property (e.g., a
12 resilient ecosystem or levee), whereas social scientists tend to be more focused on resilience as a
13 process (e.g., developing a resilience plan) or outcome (e.g., the continuation of a resilient community).
14 Debates over interpretations persist within and among fields as if there was a single “correct” one. For
15 example, Panter-Brick (2014, 433) points out that within the health field it is unclear whether resilience
16 refers to “individual attributes, developmental processes, or population outcomes.”
17

18 Through our systematic review, we were able to identify a number of characteristics that are repeatedly
19 associated with resilience in the literature (Table 2). We compile them here under the three major
20 categories of resilience interpretations with illustrative review papers in which they were cited. In some
21 cases, delineation of interpretations in the review papers is blurred; in those cases, the attribution to
22 the most likely interpretation is used for simplicity’s sake. Diversity as a system trait, for example might
23 enhance resilience in an electricity system by reducing dependence on a single fuel source (Molyneaux
24 et al. 2012) or be viewed as a resilient outcome in an ecological system in the form of increased genetic
25 diversity (Sasaki et al. 2015). In a governance system, when the focus is on interventions indicative of
26 resilience, researchers might emphasize the importance of including multiple forms of knowledge or
27 inclusive, participatory decision-making processes (Brown and Westaway 2011; Tyler and Moench 2012;
28 Matyas and Pelling 2014). Future research could further test how these major distinctions and
29 associated characteristics are applied across different systems and scales.
30

31 [insert Table 2 near here]

32 33 **3.2 Resilience as a strategy for managing complexity and uncertainty**

34
35 Scholars increasingly recognize the inherent limits of quantifying and controlling “risk” and the high
36 stakes involved in less predictable and less manageable situations. Consequently, resilience is
37 increasingly presented as an organizing concept and strategy for handling complexity and uncertainty
38 within and between dynamic systems. This conceptualization is striking when considering early uses of
39 the term in materials science and later in ecology to describe the property of a single object or a well-
40 contained ecological system such as a lake (Holling 1973; Alexander 2013). Climate change offers a
41 prominent example of complex and uncertain challenges where resilience may have particular salience
42 as an approach. Resilience as a strategy for managing complexity and uncertainty is particularly
43 prominent in the literature on urban resilience, including a subset of foci on urbanization in developing
44 contexts (Tyler and Moench 2012; Johnson and Blackburn 2014; Coaffee and Clarke 2015; Jarvie et al.
45 2015; Pizzo 2015; Meerow et al. 2016), as well as in the study of socioecological systems (SES)
46 (Wilkinson 2012; Xu et al. 2015). But this conceptualization is also present in other disciplinary and
47 topical literatures including conservation and ecology (Perz et al. 2013); energy systems (McLellan et al.
48 2012); engineering, construction, and safety management (Hassler and Kohler 2014; Righi et al. 2015).

1
2 In many of these sectoral and topical focus areas the dominant perspective is that risk, uncertainty, and
3 surprises must be understood as the norm in a highly dynamic, interconnected world and, accordingly,
4 planning and decision structures for these systems must learn to prepare for and adapt to this more
5 dynamic reality. As Bergström, van Winsen and Henriqson (2015) observe in the context of safety
6 management, resilience fills a need in many disciplines and applications for an idea to help society deal
7 with growing complexity, uncertainty, and potentially substantial challenges.

9 **3.3 From understanding resilience to active resilience-building**

10
11 We identify a complementary trend wherein resilience is seen as a system capacity that can be
12 intentionally cultivated, as opposed to an underlying system property that results from intrinsic system
13 interactions. In this conceptualization, resilience is a trait that can be considered as *evolving* (Hassler
14 and Kohler 2014), *emergent* (Cabel and Oelofse 2012), and one that can be *intentionally fostered* (Brown
15 and Westaway 2011). Yet, if resilience is something that can be built over time, there emerges
16 significant scholarly and practical interest about *how* to build resilience. This raises questions about the
17 causal evolution of resilience, including whether resilience is built through adversity, the prevention of
18 adversity, or some other kind of intervention that strengthens key capacities or traits involved in
19 resilience (Table 2). Hence, the ongoing debate within the literature about the relative role of proactive
20 versus reactive efforts to build resilience.

21
22 In the health and psychological literatures, for example, resilience is frequently conveyed as being both
23 built and revealed *through* adversity (Brown and Westaway 2011; Smith-Osborne and Whitehill Bolton
24 2013; Wu et al. 2013). Brown and Westaway (2011, quoting Luthar and Cichetti 2000, 858), for example,
25 define resilience as a “dynamic process wherein individuals display positive adaptation despite
26 experiences of significant adversity or trauma.” In fact, psychologists have found that when people face
27 adversity constructively, this can bring forth their strength, maturity, and wisdom. This hints at learning
28 from adverse experiences but also at an innate capacity that is called upon when needed. Yet, in the
29 context of societal response to environmental change or disaster, the notion of building resilience
30 through facing adversity has led to critiques that embracing the concept can foster a certain
31 acquiescence to disaster and its impacts rather than addressing the underlying causes of exposures or
32 sensitivities that causes suffering among the most vulnerable (Bergström et al. 2015). In this view, as
33 Bergström and colleagues write (2015, 25), the intentional turn towards resilience thinking “functions
34 chiefly to load the [...] risks [...] onto the backs of the individual, asking them to rely on their adaptive
35 capacities to overcome potentially dangerous disturbances.”

36
37 In a similar vein, the opportunity to intentionally build capacity for resilience over time implies an
38 opportunity for more proactive—rather than reactive—measures to do so (Coaffee and Clarke 2015).
39 Yet, persistent vagueness in usage may continue to conflate resilience as a coping mechanism (Brownlee
40 et al. 2013) with resilience as a preemptive strategy (e.g., Tyler and Moench 2012; Johnson and
41 Blackburn 2014; Xu, Marinova, and Guo 2015).

43 **3.4 Incorporating system(s) transformation into resilience**

44
45 Early ecological and engineering conceptualizations of resilience focused on the capacity to resist
46 change or return to prior conditions following a disturbance. Many scholars still adopt this ‘bounce back’
47 conceptualization of resilience, particularly in the fields of ecology (e.g., Perz et al. 2013; Zell and

1 Hubbart 2013; Standish et al. 2014; Angeler et al. 2016) and engineering (e.g., Bhamra et al. 2011;
2 Molyneaux et al. 2012; Righi et al. 2015).

3
4 But scholarship on global environmental and climatic changes has challenged this 'bounce back'
5 understanding of resilience in recent decades. A growing number of scholars now work to incorporate
6 transformation or fundamental system change into their interpretation of resilience (Tyler and Moench
7 2012; Bene et al. 2014; Gillard 2014; Matyas and Pelling 2014; Panter-Brick 2014; Weichselgartner and
8 Kelman 2015; McGreavy 2016). As Brown (2014, 112) observes, "more recent writings on resilience in
9 [social-ecological systems research] signal a realignment – indeed a redefinition – of resilience linked to
10 profound change and to transformation." It is this shift from system maintenance within known
11 parameters to complete transformation of a system that has led critics to suggest that the concept of
12 resilience is no longer a useful or valid construct.

13
14 Moreover, despite efforts to incorporate transformation into resilience thinking in some circles, recent
15 discourse and policy analyses suggest that resilience efforts remain focused on maintaining the status
16 quo and incremental change rather than radical transformation (Brown 2014; Pizzo 2015). Within the
17 context of climate change, for example, some observe that resilience may be used to foster individuals'
18 or communities' capacities to adapt to impacts, while others read it as a charge to transform the fossil
19 fuel-driven economic system that is causing the problem in the first place (Martin-Breen and Anderies
20 2011; Olsson et al. 2015).

21 22 **3.5 Resilience as an increasingly normative concept**

23
24 Following the concept's rapid expansion from the fields of ecology and engineering to social systems
25 and policy realms (Brown 2014), numerous reviews point out that resilience has evolved from a
26 primarily analytical and descriptive concept to a normative goal or management approach, or even a
27 way of thinking (Reid and Botterill 2013; Bene et al. 2014; Weichselgartner and Kelman 2015; Thorén
28 and Olsson 2018). This evolution also correlates with the wish to manage uncertainty and complexity
29 (Section 3.2), doing so proactively (Section 3.3), and embracing transformative change in a particular
30 direction (Section 3.4). Yet, positivist and overtly normative perspectives persist side by side.

31
32 In his seminal paper on resilience, Holling (1973, 17) defined resilience as the "measure of the ability of
33 these systems to absorb changes of state variables, driving variables, and parameters, and still persist."
34 In more recent ecological studies, resilience is still often seen as a measurable system characteristic,
35 neither inherently positive nor negative (Perz et al. 2013; Sasaki et al. 2015; Angeler et al. 2016). In some
36 cases, highly undesirable systems like poverty traps are recognized as being highly resilient (Martin-
37 Breen and Anderies 2011). Yet social scientists (e.g., in psychology, urban studies) and policymakers, by
38 contrast, often adopt a more normative perspective (Olsson et al. 2015). Meerow, Newell, and Stults'
39 (2016) review of definitions of urban resilience, for example, found that resilience is universally assumed
40 to be a desirable aim for cities.

41
42 While many scholars recognize the increasingly normative interpretation of resilience, they are not
43 necessarily supportive of the trajectory. Some scholars argue that normative definitions obscure the
44 concept's original descriptive meaning and measurement. As Standish et al. (2014, 44) write, "Despite
45 this historically clear and straight-forward definition, the concept has, over the years, become
46 increasingly vague, often used as a hook to attract an audience rather than being a truly meaningful
47 concept driving research or informing ecosystem management." Along similar lines, some view
48 resilience discourses as embedded in political and political-economic contexts and as such as being used

1 opportunistically for political expediency (e.g., Moser 2014; Thorén and Olsson 2018). For example, in
2 the US, where “climate change” is not always accepted as fact, “resilience” often is more palatable,
3 enabling grant programs for research and project applications to continue or allowing political and
4 policy to go forward where it otherwise might be stalled.

5
6 Other researchers reject the universal desirability of any resilience goal, arguing that resilience is
7 inherently value-laden, political and contested (Bahadur et al. 2013; Gillard 2014; Hassler and Kohler
8 2014; Pizzo 2015; Weichselgartner and Kelman 2015; Thorén and Olsson 2018). As Alexander (2013,
9 2714) cautions, “one person’s resilience may be another’s vulnerability.” If resilience-building efforts are
10 assumed to be universally positive for a community, it may forestall critical debates, or negotiations,
11 about the underlying values, associated trade-offs, and winners and losers (Harris et al. 2017). This
12 concern about the trend toward greater normativity has led to demands that researchers and
13 policymakers clarify and acknowledge trade-offs related to questions of resilience of what to what and
14 for/by whom (Meerow et al. 2016). This trend also has significant implications for the question of how
15 to measure resilience.

16 17 **3.6 Measuring and evaluating resilience**

18
19 The growing prevalence of resilience in policy discourses is driving efforts to operationalize and measure
20 the concept (Quinlan et al. 2016). Yet many of the resilience reviews recognize the challenge of
21 quantifying resilience (Martin-Breen and Anderies 2011; Cabel and Oelofse 2012; Bahadur et al. 2013;
22 Perz et al. 2013; Johnson and Blackburn 2014; Panter-Brick 2014). Given the multitude of resilience
23 definitions, a lack of convergence on measurement, monitoring, and evaluation (MME) is not surprising.
24 Our review took particular note of the growing interest in MME and catalogued many of the challenges,
25 opportunities, and broader considerations involved (Table 3).

26
27 [insert Table 3 here]

28
29 A first observation is that there is significant variation in form and level of attention being afforded to
30 MME. Some scholars have tried to offer both generic and specific frameworks about how to proceed
31 with tracking resilience, while others lament that MME is not given the attention it deserves. Concerns
32 about the imprecision of resilience and lack of quantification abound in the fields of engineering (Righi
33 et al. 2015), agroecosystems (Cabel and Oelofse 2012), health sciences (Panter-Brick 2014), the
34 electricity sector (Molyneaux et al. 2012), and others. Some suggest giving up altogether on resilience
35 and associated MME attempts and instead focus on particular resilience outcomes (e.g., risk reduction),
36 chart a path to achieve it, and track performance accordingly (e.g., Reid and Botterill 2013). Others
37 advocate for narrower approaches, for example:

- 38 • drawing on the bounce-back notion of resilience and attempt quantification along those lines
39 (Bhamra et al. 2011);
- 40 • utilizing the “ball and cup” diagrams that have been used to conceptually describe the resilience
41 of ecological systems (Perz et al. 2013);
- 42 • applying specific concepts from disciplines such as energy balance to evaluate resilience in
43 ecological systems (Zell and Hubbart 2013), or, more generally,
- 44 • identifying critical thresholds for system beyond which they irreversibly change into new states
45 (Standish et al. 2014; Sasaki et al. 2015; Xu et al. 2015; Angeler et al. 2016).

1 Those who persist in measuring resilience comprehensively mirror the themes we have observed. For
2 example, Xu and colleagues (2015) suggest that efforts to measure resilience must incorporate the
3 abilities of social-ecological systems for reorganization, learning, and adaptation as well as the capacity
4 and motivation for knowledge generation and creativity. Leichenko (2011) argues there should be
5 different means of measuring resilience to fit the varied meanings of the term.

6
7 Given the varying and often tentative considerations regarding MME provided in the literature, concrete
8 guidance for MME development and implementation is largely missing. Yet, insight from this meta-
9 analysis point to important implications for MME. Table 3 presents some of these implications identified
10 by the authors across the three resilience interpretations and the evolutionary trends across disciplines
11 discussed here.

12 **3.7 Prominent lines of critique of resilience**

13
14
15 Maybe it is unavoidable that a long-lasting, multidisciplinary discourse about a concept of growing
16 interest to policymaking and practice moves from positivist to normative orientations. Maybe it is
17 unavoidable that the meaning of such long-debated concepts change. Unsurprisingly, the ubiquity of
18 resilience discourses has generated a number of trenchant critiques of the concept. The primary
19 criticisms mentioned repeatedly in the literature and already alluded to in the above discussion include:

- 20 • the multiple meanings of resilience and resulting confusion;
- 21 • concerns over the uncritical translation of resilience concepts from natural to social systems;
- 22 • the inherent conservatism in interpretations of resilience that aim at a return to a prior
23 state; and
- 24 • insufficient attention, at least in some circles, to normative questions and the unavoidable
25 politics of resilience.

26
27 Many review papers included in our analysis lament the increasingly vague meaning of resilience
28 (Leichenko 2011; Tyler and Moench 2012; Gillard 2014; Hassler and Kohler 2014; Standish et al. 2014;
29 Olsson et al. 2015). This conceptual fuzziness makes it difficult, as the previous section made clear, to
30 apply resilience in practice, test characteristics, or develop stable metrics that can be applied across
31 contexts. Brown and Westaway (2011, 334) cite concerns that resilience may simply be “too vague” to
32 inform a disaster risk reduction agenda. Similarly, Pizzo (2015) suggests that as a planning goal,
33 resilience does not provide any guidance on the specific changes required to meet anticipated
34 outcomes. On the other hand, this ambiguity may be part of the concept’s appeal and practical
35 usefulness: it is malleable enough to be adopted by different interests and fields. Moreover, the concept
36 can serve a valuable function as a boundary object, enabling people to come together around an idea
37 that allows for dialogue, and can – if properly explained and sufficiently discussed – bridge disciplinary
38 and stakeholder divides (Gillard 2014; Matyas and Pelling 2014; Tendall et al. 2015; Meerow et al. 2016).
39 Some scholars thus support pluralism in resilience conceptualizations (Olsson et al. 2015).³

40
41 Other critical reviews of resilience question whether it is appropriate to apply the ecological definitions
42 and characteristics of resilience to complex social or social-ecological systems (Weichselgartner and
43 Kelman 2015). Critics ask: can the same characteristics that appear to prevent lake ecosystem
44 eutrophication be applied to support urban resilience? Brown (2014) argues that the social-ecological

³ It is precisely this opportunity afforded by resilience as a boundary object that brought the transdisciplinary group of researchers and practitioners together in Aspen, resulting in a week of grappling with imprecise or divergent meanings and searching for mutual understanding.

1 resilience literature “under-theorizes” the social components – a criticism some in that subfield seem to
2 be taking to heart in recent years.

3
4 A third critique posits that the concept primarily supports the status quo and offers an ideological fit
5 with neoliberalism. As Brown and Westaway (2011, 336) note, “resilience theory may be readily
6 incorporated into neoliberal policy with an emphasis on individual responsibility for coping,
7 competence, and success.” Along similar lines of critique, resilience is seen as naturalizing a state of
8 constant crisis and potentially forestalling more systemic transformations (Gillard 2014). Anecdotally, it
9 is for just this reason that the environmental justice community in the US largely rejects the uncritical
10 use of “resilience” in the context of communities that have – for far too long – had to endure the chronic
11 stresses of structural racism and economic and political disenfranchisement now magnified by climatic
12 extremes and change.

13
14 Finally, many of the reviews argue for a need to critically examine normative questions related to
15 resilience, such as: how much adversity should be tolerated and by whom? Or: Which outcomes do
16 policymakers or stakeholders strive for and what or who benefits or fails to benefit from them (Gillard
17 2014; Hassler and Kohler 2014; Olsson et al. 2015; Pizzo 2015; Weichselgartner and Kelman 2015;
18 Meerow et al. 2016; Quinlan et al. 2016)? For these scholars, resilience is not an objective system
19 characteristic, but rather a construct of power and values, which underscores the political implications
20 of resilience that are sometimes unacknowledged in some resilience interpretations (Table 1). As Matyas
21 and Pelling (2014, S5) write, “resilience is not only normative, but deeply implicated in issues of power
22 and politics. From the perspective of action and intervention, cultural values can constrain or enable a
23 spectrum of choices.” They feel these value- and interest-driven matters have been inadequately
24 theorized or confronted in practice.

25 26 **4 Implications for Communication Across Difference**

27
28 The highly synthetic, yet insightful delineation of themes from the vast literature on resilience reveals
29 why resilience has such widespread appeal, particularly in the face of the complexity and uncertainty
30 associated with global environmental change. At the same time, the trends and multiple interpretations
31 also help explain why resilience remains such a slippery and frustratingly difficult concept to grasp.
32 Accordingly, this tension also makes clear why communication across disciplines, subfields, and
33 “paradigms” has been so challenging – in fact, so challenging that some have sought to withdraw from
34 scholarly and public debates about the topic (Evans and Reid 2015). As academic debates about
35 resilience become easily enmeshed in broader differences of opinion (and training) over what is
36 ‘scientific,’ ‘objective,’ and ‘robust,’ and as public and policy debates quickly get embroiled in interest-
37 driven debates over how to read the status quo and what desirable outcomes of resilience-building
38 efforts might be, it is obvious that these debates cannot be resolved once and for all, much less by
39 scholarly advance. All sides, including scientists and scholars who bring their own intellectual and
40 professional commitments to the table, have high stakes (such as professional identities, and the
41 security of lives, livelihoods and investments) in deciding these debates in their respective favor.

42
43 Rather than abandoning the resilience concept, our analysis leads us to suggest a number of possible
44 avenues for future progress, particularly through improving fluency and enhancing mutual
45 understanding across differences in resilience interpretations.

46
47 There are two overarching yet countervailing observations we made in our workshop and meta-analysis.
48 First, growing exchange across different resilience interpretations has led to the confusion and loss of

1 meaning, but also growing influence across disciplines. Second, there seems to be a certain degree of
2 entrenchment of views in specific fields. Given these trends, we see opportunities and challenges for
3 exchange, both of which could benefit from more careful, intentional, proactive, and open-minded
4 deliberation.

5
6 Given the apparent hardening of views and the level of frustration across different resilience
7 interpretations, we suggest that absent a higher-level perspective that helps adherents of different
8 persuasions recognize valid differences in focus and understanding, the debates over meaning,
9 measurement, the benefits or drawbacks of interventions, and outcomes are likely to stall. Thus, helping
10 different groups of scholars or other stakeholders in this debate see that they are talking about
11 resilience in different, albeit complementary and overlapping ways seems like a useful first step. Table 1
12 – a product of such intense transdisciplinary exchange – served that purpose well. We observed this
13 opening to others' views in the Aspen workshop, as the acknowledgement of differences both validated
14 them, but also placed them in perspective. This supported open exchange and diminished the tendency
15 to defensive entrenchment. Together with the more detailed delineations of distinguishing
16 characteristics offered in Table 2, participants felt heard in their unique views and consequently became
17 more open to accepting alternative views as complementary. Particularly the explicit identification of
18 normative (and thus profoundly political) dimensions opened the dialogue in constructive ways.

19
20 The desire to be in conversation across these differences depends on a fundamental curiosity and
21 willingness to accept – a priori – the existence of alternative viewpoints, even if this would not entail any
22 requirement to accept the contents of those viewpoints or their implications. Exploring one's own
23 understanding through the lens offered here might be a useful next step.

24
25 Further, a dialogic approach would aim for interest in, and mutual understanding of, alternative
26 perspectives, rather than persuasion, or even necessarily finding overlap, compromise, or common
27 ground. While these secondary outcomes often emerge as a result of truly dialogic, open, and well-
28 meaning (as opposed to self-righteous or hostile) exchange, they are by no means assured nor are they
29 the intent of true dialogue (Bohm 1996; Isaacs 1999; Herzig and Chasin 2006). Pragmatically, having
30 validated different views and contributions to the debate, those in dialogue might be more willing and
31 ready to move toward practical implications, synthesis or integration, rather than defend one's own or
32 debate another's contribution as less important or useless.

33
34 The diversity of viewpoints and findings across and even within a particular resilience interpretation
35 suggests it would be unwise to assume that adherents of one particular resilience interpretation
36 necessarily agree on the importance of certain traits, interventions, or outcomes. However, these
37 differences may yield testable hypotheses and fruitful multidisciplinary or transdisciplinary
38 investigations, and stimulate challenging, yet crucial deliberations on scientific theories and methods as
39 well as on policy priorities and approaches (Kinzig 2001). The benefits of such multi- and
40 transdisciplinary collaborations are increasingly apparent in social-ecological systems research where
41 the understanding of the resilience of natural resource or ecosystems is as crucial to proper
42 management as a better understanding of resilient economic, governance or knowledge systems (e.g.,
43 Deppisch and Hasibovic 2013; Stone-Jovicich 2015; Arora-Jonsson 2016).

44
45 However, the more charged these discussions across differences are, the more useful it might be to
46 involve a neutral facilitator. For some, such dialogues will be difficult to have without significant
47 attention being paid first to trust-building, ensuring evenhandedness and mutuality, and fostering good
48 will and cohesion. The underlying differences in such charged situations are not first and foremost

1 disagreements among experts or well-informed scientific opinions, but among interests, identities, and
2 value stances.

3
4 We believe, dialogue could help surface those values and enable participants to explore areas for
5 agreement on means and ends. In fact, non-confrontational dialogue might in fact make it possible to
6 find such areas of agreement as the underlying drivers of the debate are validated and aired. Such joint
7 exploration may also lead to useful partnerships in which differences become assets rather than
8 obstacles: different skills and capacities are brought to bear on jointly agreed upon goals. Alternatively,
9 the exploration may reveal areas of workable differences and other areas too sensitive to constructively
10 work together, at least until some progress in the workable areas has been made (AGCI 2015a, b).
11 Mutual respect and trust-building are often essential preconditions to next steps.

12 13 **5 Conclusion**

14
15 In this paper we have tried to delineate – from a workshop and a literature review – fundamental
16 differences in perspective found across disciplinary and practical resilience discourses, differentiate
17 these different perspectives, and then outline seven themes that are repeatedly discussed in the extant
18 resilience discourse. In our experience – and echoed by other writers in the literature – these
19 differences can cause substantial blocks to mutual understanding and productive dialogue if they remain
20 unspoken. This is problematic, because tackling resilience challenges like climate change will require
21 collaboration from a wide range of disciplines and practitioners. The workshop and the literature review
22 that resulted in this paper have helped us recognize that there is not one resilience discourse, but at
23 least three. These discourses occur side-by-side and sometimes intersect. When they do, the exchange is
24 not always easy or immediately fruitful; more often than not, it can lead to frustration from
25 misunderstandings or stale accusations of imprecise use of technical terminology and inadequate
26 scholarship and understanding. On the other hand, making the differences apparent – as we witnessed –
27 can support more productive and deeper exchanges. In light of the growing challenges from climatic and
28 related disruptions, we believe practical progress in building resilience is essential but can be stalled, if
29 experts send unclear or contradictory signals to the world of policy and practice as to what resilience is
30 and how to achieve it. Making resilience interpretations more transparent and intelligible, in our view, is
31 thus an essential next step to more rapid advances in understanding and practice. We thus believe that
32 resilience scholars must advance the debate on two fronts: (1) internally within science, grappling with
33 the similarities and differences in a more productive fashion so as to advance theory and empirical
34 insights, and (2) externally beyond science, making those insights more readily available and actionable
35 to practitioners who are urgently in need of useful advice.

36
37 Recognizing and articulating the fundamental differences in perspective then is of utmost importance
38 for more productive exchanges *and* practical application in the future. Our tripartite framework and
39 seven themes can help to structure or disentangle resilience conversations so future dialogues among
40 researchers and/or practitioners can more rapidly advance to productive exchange and deepening.
41 Participants in such dialogues can quickly locate themselves in the different interpretations and debates
42 and move on to negotiating fruitful areas of collaborative research and the practical and policy
43 implications of resilience for whom, of what, to what, where, how, etc. For example, how to rebuild
44 Puerto Rico after Hurricane Maria in 2017 or how to rebuild Paradise after the devastating wildfire in
45 November 2018 in ways that make them more resilient in the face of future climate risks calls for urgent
46 science-based advice, but as we tried to illustrate here, normative positions are part of this question. A
47 productive dialogue among natural and social scientists as well as practitioners guided by our

1 categorization and even our seven themes might help generate greater clarity and a transparently
2 justified list of interventions.

3
4 Clearly, the notion of resilience has captured the imagination – and the critical lens – of researchers
5 across the academic spectrum and is widely used in public and policy circles. Despite the many
6 frustrations in academic and political debate, it is likely to persist. As social scientists, we are intrigued
7 by this development. As climate change confronts us with unprecedented degrees of uncertainty and
8 complexity, the growing resonance with the concept – beyond everything else it may be – may well
9 signify something of cultural significance. It suggests the emergence of a term that increasingly bears
10 symbolic meaning and value; a phrase that combines stability and change in complex ways at a time
11 when the world changes from being experienced as relatively stable into something dynamic, variable,
12 unpredictable, and unknown. Maybe resilience and all the debate over its changing meaning mirrors this
13 cultural grappling and as such is not merely embedded in political(-economic) contexts, but in
14 profoundly societal and cultural.

15
16 Borrowing the words of one participant at the Aspen Global Change Institute workshop which initiated
17 this analysis, we see this dialogue across differences thus not as an elective add-on to be undertaken if
18 and when more important scholarly or policy work has been done, but as “the work we must do.” It is
19 “cultural work” in the sense of Ulrich Beck (2016, 118), whereby members of society – be they in
20 academia or in the world of practice – must grapple with the profound changes upon them so as to find
21 a compass to a desirable future through chaotic and uncertain times. This dialogic, cultural work
22 constitutes a necessary precondition for us to build the intellectual and political muscle for facing a
23 world in which change and stability – good and bad – stand in creative tension.

24 25 **6 References**

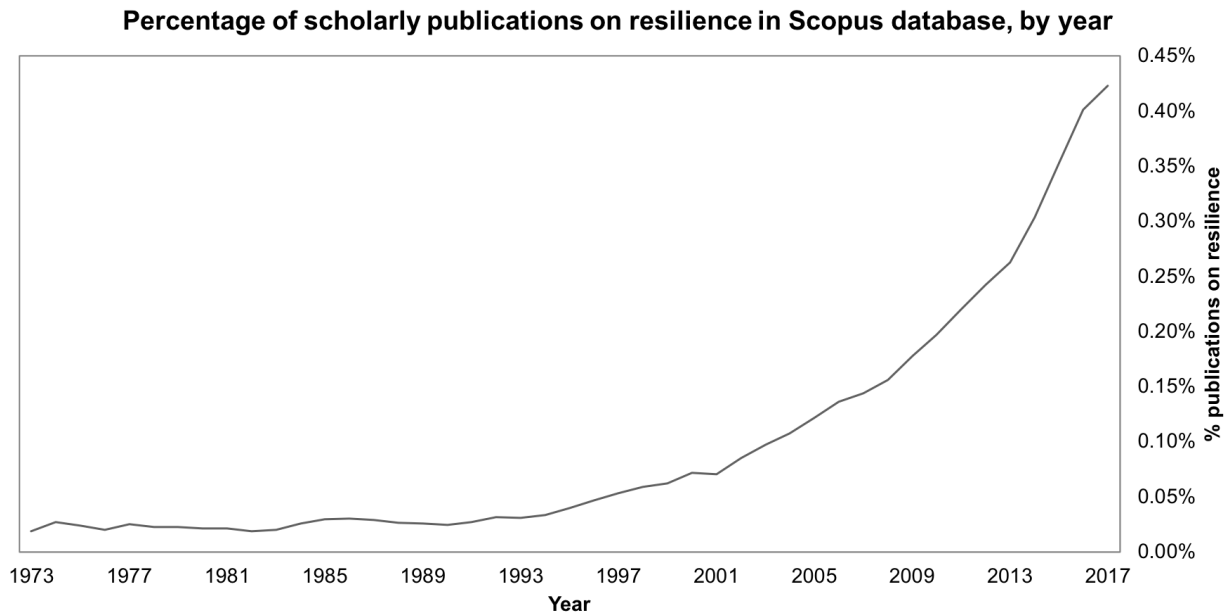
- 26
27 AGCI (2015a) Fostering Dialogue to Support Community Resilience. Resilience Road Marker #1: Ideas for
28 Implementation from Research & Practice
29 AGCI (2015b) The Possibility of Resilience. Resilience Road Marker #2: Ideas for Implementation from
30 Research & Practice
31 Ahern J (2011) From fail-safe to safe-to-fail: Sustainability and resilience in the new urban world. *Landsc*
32 *Urban Plan* 100:341–343. doi:10.1016/j.landurbplan.2011.02.021
33 Alexander DE (2013) Resilience and disaster risk reduction: An etymological journey. *Nat Hazards Earth*
34 *Syst Sci* 13:2707–2716. doi:10.5194/nhess-13-2707-2013
35 Angeler DG, Allen CR, Barichievy C, et al (2016) Review: Quantifying resilience: Management
36 applications of discontinuity theory. *J Appl Ecol* 53:688–698. doi:10.1111/1365-2664.12494
37 Angell E (2014) Psychological resilience in clinical practice: A discussion. *Clin Psychol Forum* 260:12–15
38 Arora-Jonsson, S (2016) Does resilience have a culture? *Ecocultures and the politics of knowledge*
39 *production. Ecol Econ*, 121, 98–107. doi:10.1016/j.ecolecon.2015.11.020
40 Bahadur A V., Ibrahim M, Tanner T (2013) Characterising resilience: Unpacking the concept for tackling
41 climate change and development. *Clim Dev* 5:55–65. doi:10.1080/17565529.2012.762334
42 Beck, U (2016) *The Metamorphosis of the World*. Cambridge: Polity Press.
43 Bene C, Newsham A, Davies M, et al (2014) Review Article: Resilience, poverty, and development. *J Int*
44 *Dev* 26:598–623. doi:10.1002/jid
45 Bergström J, van Winsen R, Henriqson E (2015) On the rationale of resilience in the domain of safety: A
46 literature review. *Reliab Eng Syst Saf* 141:131–141. doi:10.1016/j.res.2015.03.008
47 Bhamra R, Dani S, Burnard K (2011) Resilience: The concept, a literature review and future directions. *Int*
48 *J Prod Res* 49:5375–5393. doi:10.1080/00207543.2011.563826

1 Biggs R, Schlüter M, Biggs D, et al (2012) Toward principles for enhancing the resilience of ecosystem
2 services. *Annu Rev Environ Resour* 37:421–448. doi:10.1146/annurev-environ-051211-123836
3 Bohm D (1996) *On Dialogue*. Routledge, London, UK and New York, NY
4 Brand FS, Jax K (2007) Focusing the meaning(s) of resilience: Resilience as a descriptive concept and a
5 boundary object. *Ecol Soc* 12:23. <https://www.ecologyandsociety.org/vol12/iss1/art23/>
6 Brown K (2014) Global environmental change I: A social turn for resilience? *Prog Hum Geogr* 38:107–
7 117. doi:10.1177/0309132513498837
8 Brown K, Westaway E (2011) Agency, capacity, and resilience to environmental change: Lessons from
9 human development, well-being, and disasters. *Annu Rev Environ Resour* 36:321–342.
10 doi:10.1146/annurev-environ-052610-092905
11 Brownlee K, Rawana J, Franks J, et al (2013) A systematic review of strengths and resilience outcome
12 literature relevant to children and adolescents. *Child Adolesc Soc Work J* 30:435–459.
13 doi:10.1007/s10560-013-0301-9
14 Cabel JF, Oelofse M (2012) An indicator framework for assessing agroecosystem resilience. *Ecol Soc*
15 17,1: 18. doi:10.5751/ES-04666-170118
16 Coaffee J, Clarke J (2015) On securing the generational challenge of urban resilience. *Town Plan Rev*
17 86:249–255. doi:10.3828/tpr.2015.16
18 Deppisch, S, Hasibovic, S (2013) Social-ecological resilience thinking as a bridging concept in
19 transdisciplinary research on climate-change adaptation. *Nat Hazards*, 67, 117–127.
20 doi:10.1007/s11069-011-9821-9
21 Evans B, Reid J (2015) Exhausted by resilience: Response to the commentaries. *Resilience* 3:154–159.
22 doi:10.1080/21693293.2015.1022991
23 Fletcher D, Sarkar M (2013) Psychological resilience: A review and critique of definitions, concepts, and
24 theory. *Eur Psychol* 18:12–23. doi:10.1027/1016-9040/a000124
25 Flood S, Schechtman J (2014) The rise of resilience: Evolution of a new concept in coastal planning in
26 Ireland and the US. *Ocean Coast Manag* 102:19–31. doi:10.1016/j.ocecoaman.2014.08.015
27 Francis R, Bekera B (2014) A metric and frameworks for resilience analysis of engineered and
28 infrastructure systems. *Reliab Eng Syst Saf* 121:90–103. doi:10.1016/j.res.2013.07.004
29 Fujimura J (1992) Crafting science: Standardized packages, boundary objects, and “translation.” In:
30 Pickering A (ed) *Science as a Culture and Practice*. Chicago University Press, Chicago, Ill
31 Gillard R (2014) Questioning the diffusion of resilience discourses in pursuit of transformational change.
32 *Glob Environ Polit* 16:13–20. doi:10.1162/GLEP
33 Harris LM, Chu EK, Ziervogel G (2017) Negotiated resilience. *Resilience*, online first, 1–19.
34 doi:10.1080/21693293.2017.1353196
35 Hassler U, Kohler N (2014) Resilience in the built environment. *Build Res Inf* 42:119–129.
36 doi:10.1080/09613218.2014.873593
37 Herzig M, Chasin L (2006) *Fostering Dialogue Across Divides*. Watert Public Conversations Proj 188
38 Holling C (1973) Resilience and stability of ecological systems. *Annu Rev Ecol Syst* 4:1–23
39 Isaacs W (1999) *Dialogue: The Art of Thinking Together*. Currency Books, New York City
40 Island Press, Kresge Foundation (2015). *Bounce Forward: Urban Resilience in the Era of Climate Change*.
41 A Strategy Paper. Washington, DC: Island Press.
42 Jarvie J, Sutarto R, Syam D, Jeffery P (2015) Lessons for Africa from urban climate change resilience
43 building in Indonesia. *Curr Opin Environ Sustain* 13:19–24. doi:10.1016/j.cosust.2014.12.006
44 Johnson C, Blackburn S (2014) Advocacy for urban resilience: UNISDR’s Making Cities Resilient
45 Campaign. *Environ Urban* 26:29–52. doi:10.1177/0956247813518684
46 Kinzig, AP (2001) Bridging disciplinary divides to address environmental and intellectual challenges.
47 *Ecosystems*, 4, 8, 709–715. doi:10.1007/s10021-001-0039-7
48 Leichenko R (2011) Climate change and urban resilience. *Curr Opin Environ Sustain* 3:164–168.

- 1 doi:10.1016/j.cosust.2010.12.014
- 2 Maclnnis B, Krosnick JA, Abeles A, et al (2015) The American public's preference for preparation for the
3 possible effects of global warming: Impact of communication strategies. *Clim Change* 128:17–33.
4 doi:10.1007/s10584-014-1286-x
- 5 Martin-Breen P, Anderies JM (2011) Resilience: A literature review. *Bellagio Initiat Futur Philanthr Dev*
6 *Purs Hum Wellbeing* 67. <http://opendocs.ids.ac.uk/opendocs/handle/123456789/3692>
- 7 Matyas D, Pelling M (2014) Positioning resilience for 2015 : The role of resistance , incremental
8 adjustment and transformation in disaster risk management policy. *Disasters* 39:S1–S18.
9 doi:10.1111/disa.12107
- 10 McGreavy B (2016) Resilience as discourse. *Environ Commun* 10:104–121.
11 doi:10.1080/17524032.2015.1014390
- 12 McLellan B, Zhang Q, Farzaneh H, et al (2012) Resilience, sustainability and risk management: A focus on
13 energy. *Challenges* 3:153–182. doi:10.3390/challe3020153
- 14 Meerow S, Newell JP, Stults M (2016) Defining urban resilience : A review. *Landsc Urban Plan* 147:38–49.
15 doi:10.1016/j.landurbplan.2015.11.011
- 16 Molyneaux L, Wagner L, Froome C, Foster J (2012) Resilience and electricity systems: A comparative
17 analysis. *Energy Policy* 47:188–201. doi:10.1016/j.enpol.2012.04.057
- 18 Moser SC (2017) Communicating climate change adaptation and resilience. In: Nisbet M (ed) *Oxford*
19 *Research Encyclopedia, Climate Science*. Oxford University Press, Oxford, UK
- 20 Olsson L, Jerneck A, Thoren H, et al (2015) Why resilience is unappealing to social science: Theoretical
21 and empirical investigations of the scientific use of resilience. *Sci Adv* 1:e1400217–e1400217.
22 doi:10.1126/sciadv.1400217
- 23 Panter-Brick C (2014) Health, risk, and resilience: Interdisciplinary concepts and applications. *Annu Rev*
24 *Anthropol* 43:431–448. doi:10.1146/annurev-anthro-102313-025944
- 25 Perz SG, Muñoz-Carpena R, Kiker G, Holt RD (2013) Evaluating ecological resilience with global sensitivity
26 and uncertainty analysis. *Ecol Modell* 263:174–186. doi:10.1016/j.ecolmodel.2013.04.024
- 27 Pizzo B (2015) Problematizing resilience: Implications for planning theory and practice. *Cities* 43:133–
28 140. doi:10.1016/j.cities.2014.11.015
- 29 Quinlan AE, Berb??s-BI??zquez M, Haider LJ, et al (2016) Measuring and assessing resilience: Broadening
30 understanding through multiple disciplinary perspectives. *J Appl Ecol* 53:677–687.
31 doi:10.1111/1365-2664.12550
- 32 Reid R, Botterill LC (2013) The multiple meanings of “resilience”: An overview of the literature. *Aust J*
33 *Public Adm* 72:31–40. doi:10.1111/1467-8500.12009
- 34 Righi AW, Saurin TA, Wachs P (2015) A systematic literature review of resilience engineering: Research
35 areas and a research agenda proposal. *Reliab Eng Syst Saf* 141:142–152.
36 doi:10.1016/j.ress.2015.03.007
- 37 Rogers CDF, Bouch CJ, Williams S, et al (2012) Resistance and resilience – paradigms for critical local
38 infrastructure. *Proc Inst Civ Eng - Munic Eng* 165:73–83. doi:10.1680/muen.11.00030
- 39 Romero-Lankao P, Dodman D (2011) Cities in transition: Transforming urban centers from hotbeds of
40 GHG emissions and vulnerability to seedbeds of sustainability and resilience. Introduction and
41 editorial overview. *Curr Opin Environ Sustain* 3:113–120. doi:10.1016/j.cosust.2011.02.002
- 42 Ross H, Berkes F (2014) Research approaches for understanding, enhancing, and monitoring community
43 resilience. *Soc Nat Resour* 27:787–804. doi:10.1080/08941920.2014.905668
- 44 Sasaki T, Furukawa T, Iwasaki Y, et al (2015) Perspectives for ecosystem management based on
45 ecosystem resilience and ecological thresholds against multiple and stochastic disturbances. *Ecol*
46 *Indic* 57:395–408. doi:10.1016/j.ecolind.2015.05.019
- 47 Sharma D, Singh R, Singh R (2014) Building urban climate resilience: Learning from the ACCCRN
48 experience in India. *Int J Urban Sustain Dev* 6:133–153. doi:10.1080/19463138.2014.937720

1 Smith-Osborne A, Whitehill Bolton K (2013) Assessing resilience: A review of measures across the life
 2 course. *J Evid Based Soc Work* 10:111–126. doi:10.1080/15433714.2011.597305
 3 Standish RJ, Hobbs RJ, Mayfield MM, et al (2014) Resilience in ecology: Abstraction, distraction, or
 4 where the action is? *Biol Conserv* 177:43–51. doi:10.1016/j.biocon.2014.06.008
 5 Stone-Jovicich, S (2015) Probing the interfaces between the social sciences and social-ecological
 6 resilience: Insights from integrative and hybrid perspectives in the social sciences. *Ecol and Soc*, 20,
 7 23. doi:10.5751/es-07347-200225
 8 Tendall DM, Joerin J, Kopainsky B, et al (2015) Food system resilience: Defining the concept. *Glob Food*
 9 *Sec* 6:17–23. doi:10.1016/j.gfs.2015.08.001
 10 Thorén H, Olsson L (2018) Is resilience a normative concept? *Resilience*, 6, 2 112–128.
 11 doi:10.1080/21693293.2017.1406842
 12 Tyler S, Moench M (2012) A framework for urban climate resilience. *Clim Dev* 4:311–326.
 13 doi:10.1080/17565529.2012.745389
 14 Weichselgartner J, Kelman I (2015) Geographies of resilience: Challenges and opportunities of a
 15 descriptive concept. *Prog Hum Geogr* 39:249–267. doi:10.1177/0309132513518834
 16 Wilkinson C (2012) Social-ecological resilience: Insights and issues for planning theory. *Plan Theory*
 17 11:148–169. doi:10.1177/1473095211426274
 18 Wilson GA (2014) Community resilience: Path dependency, lock-in effects and transitional ruptures. *J*
 19 *Environ Plan Manag* 57:1–26. doi:10.1080/09640568.2012.741519
 20 Wu G, Feder A, Cohen H, et al (2013) Understanding resilience. *Front Behav Neurosci* 7:1–15.
 21 doi:10.3389/fnbeh.2013.00010
 22 Xu L, Marinova D, Guo X (2015) Resilience thinking: A renewed system approach for sustainability
 23 science. *Sustain Sci* 10:123–138. doi:10.1007/s11625-014-0274-4
 24 Zell C, Hubbart JA (2013) Interdisciplinary linkages of biophysical processes and resilience theory:
 25 Pursuing predictability. *Ecol Modell* 248:1–10. doi:10.1016/j.ecolmodel.2012.09.021
 26

27 Figure 1:



28
 29
 30

1
2

Table 1: Comparison of Qualities and Foci of Resilience under Different Interpretations

Resilience as... Qualities	SYSTEM TRAIT or CONDITION	PROCESS (or set of processes)	OUTCOME (or set of outcomes)
Focus of Study or Action	System as a whole	Actions or decisions	State of at-risk entity (people or systems)
Objective	System functions & services (e.g., diversity)	System functionality/ performance (e.g., flood system acts as advertised)	System improvement or persistence (e.g., well-being)
Simplified Definition	Ability to self-organize so as to main functioning, i.e. to withstand disruption and stay or come back the same	Ability to stay functional by way of coping, absorbing, recovering and adapting	Ability to make all kinds of changes to address env. and socioeconomic problems and thus thrive, maintain or increase well-being, be safe, sustain livelihoods etc.
Guiding Question	What makes a system resilient?	What can be done to reduce impacts/losses and speed up recovery?	What system/ community is desirable to be built or to keep (despite shocks and stresses)?
Causal Means	Leverage points to nudge the system to more desirable states	Decision support tools and actions that help to plan, prepare, absorb, recover, adapt	Tools, resources, governance mechanisms, coalitions, to assess, plan, implement actions
Embedded Values	A priori neutral on outcome(s) (theory)	Normative about “best practices”, assumed to lead to desirable outcomes	Normative about outcomes; explicitly or implicitly value-driven
Politics	Supposedly apolitical	Implicitly political (does not question, but still aims to perpetuate a particular system)	Inherently and explicitly political (aims to maintain or deeply change systems)
Link to Sustainability	Resilience may or may not at all support sustainability	Resilience is a requirement for sustainability	Resilience is essentially the same as sustainability (in a dynamic context)
Link to Risk Management	Informational input to risk management	Part or extension of risk management	Goal of risk management (and other efforts)
Challenges	Simplistic application of ecological theory to social systems	Neglect of the larger context beyond the immediate system of concern	Risk of neglecting history, change, cross-scale, social and ecological impacts, complexity
Recent Scientific Progress	From isolated to interlinked systems	From command-and-control to adaptive approaches	From siloed to whole-system approaches

3
4

1 **Table 2: Common Characteristics and Aspects of Resilience Given Different Resilience**
 2 **Interpretations**

Resilience Interpretation	Illustrative citations
Resilience as System Trait	
Redundancy	Brown and Westaway 2011; Ahern 2011; Tyler and Moench 2012; Wilkinson 2012; Biggs et al. 2012; Molyneaux et al. 2012; Zell and Hubbart 2013; Standish et al. 2014; Hassler and Kohler 2014; Ross and Berkes 2014; Francis and Bekera 2014; Tendall et al. 2015; Sasaki et al. 2015; Angeler et al. 2016; Quinlan et al. 2016
Connectivity	Ahern 2011; Biggs et al. 2012; Cabel and Oelofse 2012; Wilkinson 2012; Angell 2014; Standish et al. 2014; Jarvie et al. 2015; Quinlan et al. 2016
Modularity	Ahern 2011; Tyler and Moench 2012; Wilkinson 2012; Tendall et al. 2015
Buffering capacity	Wilkinson 2012; McLellan et al. 2012; Tendall et al. 2015
Flexibility	Romero-Lankao and Dodman 2011; Rogers et al. 2012; Tyler and Moench 2012; Alexander 2013; Tendall et al. 2015
Diversity	Romero-Lankao and Dodman 2011; Ahern 2011; Tyler and Moench 2012; Rogers et al. 2012; Molyneaux et al. 2012; McLellan et al. 2012; Zell and Hubbart 2013; Hassler and Kohler 2014; Standish et al. 2014; Tendall et al. 2015; Jarvie et al. 2015; Sasaki et al. 2015; Meerow et al. 2016; Quinlan et al. 2016
Capital (social, economic, etc.)	Wilkinson 2012; Wilson 2014; Tendall et al. 2015
Self-organization capacity	Tyler and Moench 2012; Wilkinson 2012; Tendall et al. 2015
Responsiveness	Tyler and Moench 2012; McLellan et al. 2012
Resourcefulness	Tyler and Moench 2012; Francis and Bekera 2014; Tendall et al. 2015
Efficiency	Bhamra et al. 2011; Rogers et al. 2012
Rapidity	Francis and Bekera 2014; Tendall et al. 2015; Meerow et al. 2016
Tight feedbacks	Ahern 2011; Wilkinson 2012
Capacity for learning and innovation	Romero-Lankao and Dodman 2011; Tendall et al. 2015; Tyler and Moench 2012; Wilkinson 2012; Johnson and Blackburn 2014; Matyas and Pelling 2014; Quinlan et al. 2016; Biggs et al. 2012
Adaptive capacity or adaptability	Ross and Berkes 2014; Tendall et al. 2015; Francis and Bekera 2014; Jarvie et al. 2015; Johnson and Blackburn 2014; Leichenko 2011; Meerow, Newell, and Stults 2016;

	Ahern 2011; Alexander 2013; Angell 2003; Bhamra, Dani, and Burnard 2011; Biggs et al. 2012; Brownlee et al. 2013
Resilience as Process	
Embrace change and uncertainty	Wilkinson 2012; Bahadur et al. 2013; Perz et al. 2013; Hassler and Kohler 2014; Pizzo 2015
Embrace equitable/inclusive/participatory decision-making process	Brown and Westaway 2011; Leichenko 2011; Tyler and Moench 2012; Johnson and Blackburn 2014; Matyas and Pelling 2014; Jarvie et al. 2015; Tendall et al. 2015; Quinlan et al. 2016
Be accountable to marginalized groups	Leichenko 2011; Tyler and Moench 2012; McGreavy 2016
Form and use collaborative social networks/multi-level governance	Martin-Breen and Anderies 2011; Leichenko 2011; Bahadur et al. 2013; Johnson and Blackburn 2014; Ross and Berkes 2014; Sharma et al. 2014; Jarvie et al. 2015; Xu et al. 2015
Create or use flexible/adaptive governance	Wilkinson 2012; Flood and Schechtman 2014; Hassler and Kohler 2014; Johnson and Blackburn 2014; Francis and Bekera 2014; Xu et al. 2015
Integrate local knowledge	Bahadur et al. 2013; Sharma et al. 2014; Jarvie et al. 2015; Xu et al. 2015
Foster social learning	Biggs et al. 2012; Bahadur et al. 2013; Matyas and Pelling 2014; Ross and Berkes 2014; Jarvie et al. 2015; Xu et al. 2015
Advocate collective action	Xu et al. 2015
Focus on human-environment connections	Ross and Berkes 2014; Meerow et al. 2016; Quinlan et al. 2016
Emphasize coproduction of knowledge/knowledge integration	Wilkinson 2012; Jarvie et al. 2015; Weichselgartner and Kelman 2015
Ensure efficient recovery mechanisms	Alexander 2013; Francis and Bekera 2014
Foster and be able to rely on supporting relationships, social networks	Bahadur et al. 2013; Wu et al. 2013; Ross and Berkes 2014
Exhibit strong leadership	Bahadur et al. 2013; Ross and Berkes 2014; Pizzo 2015
Include effective monitoring and evaluation	Tyler and Moench 2012; Matyas and Pelling 2014; Ross and Berkes 2014; Xu et al. 2015
Resilience as Outcome	
Safe failure	Ahern 2011; Tyler and Moench 2012; McLellan et al. 2012
Reliability	Molyneaux et al. 2012; McLellan et al. 2012
Robustness	Brown and Westaway 2011; Alexander 2013; Hassler and Kohler 2014
Strength	Flood and Schechtman 2014

Maintained system functionality	Martin-Breen and Anderies 2011; Biggs et al. 2012; Cabel and Oelofse 2012; McLellan et al. 2012; Olsson et al. 2015; Angeler et al. 2016; Meerow et al. 2016
Protection of valued assets	Flood and Schechtman 2014
Risk reduction (to people, structures, assets)	Brown and Westaway 2011; Ahern 2011; Tyler and Moench 2012; Molyneaux et al. 2012; McLellan et al. 2012; Alexander 2013; Hassler and Kohler 2014
Improved psychological functioning (incl. optimism, self-efficacy, high cognitive function, motivation, etc.)	Fletcher and Sarkar 2013; Wu et al. 2013; Angell 2014
Positive adaptation/decreased vulnerability	McLellan et al. 2012; Brownlee et al. 2013
Increased equity in governance and outcome	Ahern 2011; Bahadur et al. 2013
Decentralization and independence	Ahern 2011; McLellan et al. 2012
Radical transformation	Matyas and Pelling 2014; Panter-Brick 2014; Meerow et al. 2016

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1 **Table 3: Implications for Measurement, Monitoring and Evaluation Across Different Resilience Interpretations**
 2 **and Selected Themes in the Literature**

Signal Resilience interpretation	Managing complexity and uncertainty	Intentional resilience-building	Bounce-forward (transformation)	Normative stances
System trait	Given limitations and costs of MME, identifying and tracking performance of key traits (see Table 2) that approximate overall performance of a complex system, even under variable and insufficiently understood circumstances	MME would focus on performance against known operating parameters/ expectations when possible. But for intentional management, new standards or operating conditions may need to be determined (or be borrowed from analogue systems)	MME would go beyond measuring return of system functions to normal behavior or a prior state by identifying and measuring components of system change required for transformation	While resilience interpretations (and related MME) as system traits assume objectivity, caution should be maintained about the assumption that value-free measurements at the system level is possible. Instead, values may be embedded and measurements can become subject of political strategies
Process	Tracking the management of complexity, uncertainty could focus in part on decision-making and institutional processes (e.g., quality of information inputs, incorporation of complete system understanding)	Tracking actions or interventions specifically aimed at improving resilience is a common focus of MME under this paradigm (e.g., plans adopted, assets hardened, or protections constructed)	Social processes that foster bounce-back resilience will be distinct from those that seek bounce-forward or transformational change and thus will likely require distinct indicators and metrics	Normativity becomes apparent in the system a given set of actions aims to maintain. To be transparent, what is being tracked should mirror and clarify these normative assumptions for stakeholders
Outcome	MME approaches should adapt to accommodate multiple feasible pathways as well as shifts between pathways toward different outcomes	Emergent properties are inherently impossible to track. MME thus becomes a form of societal detection system of signals that indicate or demand significant change	Design of on MME can reveal significant tensions that arise between those wishing to keep existing systems and those wishing to transform them and therefore what to track	What is being tracked in MME can help make the normative choices explicit and therefore subject to the political process

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