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Is conceptual vagueness an asset? Resilience research from the perspective of philosophy of science

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Abstract: I analyze the research on social-ecological resilience from the perspective of philosophy of science in three steps. First, I explore to what degree resilience research exhibits conceptual vagueness. I find a wide spectrum of research, ranging from approaches relying on a concise conceptual framework to the perspective of "resilience thinking", which builds on a cluster of vague concepts. Second, I set out the methodological arguments in favor and against conceptual vagueness. Merging both strands of reasoning in the third step, I conclude that a trade-off between vagueness and precision exists, which is to be solved differently depending on the context of resilience research. In some contexts, resilience research benefits from conceptual vagueness while in others it depends on precision. Specifically, I argue that in "resilience thinking" the trade-off might be enhanced by a coherent restructuring of the conceptual framework.

Keywords: vagueness, philosophy of science, precision, resilience thinking, social-ecological systems

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1 Introduction

> "*'But is a blurred concept a concept at all?' - Is an indistinct photograph a picture of a person at all? Is it even always an advantage to replace an indistinct picture by a sharp one? Isn't the indistinct one often exactly what we need?*"
>
> (Ludwig Wittgenstein, Philosophical Investigations, § 71)

In this paper, I direct Wittgenstein's question about the (in-)desirability of sharp boundaries of concepts to resilience research: does the latter exhibit conceptual vagueness, and, if so, is that beneficial? Can looseness in concepts and meanings lend itself to shedding light on unsolved problems? While resilience research has established that redundancy is an asset for complex adaptive systems, does this finding also hold for conceptual frameworks?

Resilience research integrates different disciplines, research contexts and is concerned with a variety of topics. Hence, it is not surprising that it sometimes appears as a vast field, fuzzy not only at the boundaries, but also within: "Resilience is a broad, multi-faced, and loosely organized cluster of concepts, [...] a changing constellation of ideas [...]" (Carpenter and Brock 2008: 1). More systematically, a literature survey (Brand and Jax 2007) inventories the prevalent meanings of resilience in a typology comprising ten (!) different categories of concepts. However, not every *individual* research approach relies on a vague conceptual scheme. There is a wide spectrum of resilience research with respect to the degree of conceptual vagueness. On the precise end of this spectrum lie specific approaches employing concise conceptualizations. Here, different meanings of resilience and their relation to other concepts are clearly observable. On the vague end of the spectrum lies "resilience thinking", a holistic perspective on human-nature relationships (Folke et al. 2010, Kirchhoff et al. 2010, Walker and Salt 2006). It expands the original ecological definition of resilience (Holling 1973) to encompass social systems as well and complements it by a variety of other notions, such as adaptability, transformability (Walker et al. 2004) or panarchy (Gunderson and Holling 2002).

When speaking of conceptual vagueness, I use *vagueness* in the linguistic, purely

descriptive sense of the word: *vagueness* refers to the phenomenon of a term that has several meanings which "have so much in common that it is difficult to separate them" (Tuggy 1993: 273). In contrast, *polysemy* refers to a term whose several meanings are similar but separable and *ambiguity* to a term whose several meanings have "little or nothing in common beyond the phonological structure they share" (ibid.). Although these categories themselves are vague because borderline cases may exist, they are helpful in shaping the focus of this paper: I am not concerned with ambiguity since I ignore meanings from completely different contexts, such as psychological resilience during childhood development. Rather, I concentrate on resilience in social-ecological systems and present how conceptually precise research establishes a polysemous concept of resilience whereas "resilience thinking" is based on a vague concept of resilience.

While ecology regularly discusses wether conceptual precision is found wanting in its discipline (McCoy and Shrader-Frechette 1992, Odenbaugh 2001, Davis and Thompson 2001, Hodges 2008a, Jax 2008, Hodges 2008b), resilience research has not yet payed much attention to this question. This albeit resilience research roots in ecology and comprises ecology as an important part. Some scholars refer affirmatively (Carpenter and Brock 2008) to the conceptual variety in resilience research, others are concerned about dilution of the original ecological concept of resilience (Brand and Jax 2007), yet a systematic discussion about the potential benefits or damages from vagueness is lacking in resilience research.

In order to fill this gap, I contrast two conflicting positions within philosophy of science concerning the importance of conceptual precision.[1] On the one hand, I set out the traditional view of science that emphasizes precision and conceptual clarity as precondition for empirical science. This view relegates all vague concepts and statements to the realm of pseudo-science and belief. On the other hand, I present an alternative view that highlights the merits of vagueness as fuel for creativity, means of communication

[1] I am not interested in the manifold disputes in philosophy and cognitive science whether concepts are objects or abilities, mental representations or abstract entities and so forth. I leave it at the observation that "[c]oncepts, pretheoretically, are the constituents of thoughts (Margolis and Laurence 2006)" and focus on the methodological question whether scientific concepts should be vague.

across disciplinary boundaries and part of pragmatic problem-solving.

Discussing the implications of this methodological dispute for resilience research, I propose that the advantages of precision and vagueness constitute a trade-off. A universal solution to this trade-off that perfectly balances the benefits and problems of conceptual vagueness may not exist. Rather, the trade-off may be solved differently depending on the specific context of resilience research. By consciously approaching the trade-off and giving explicit justification for a particular solution, inappropriate degrees of vagueness/precision could be avoided.

Assessing the specific case of "resilience thinking", I argue that it currently does not display a consistent balance between vagueness and precision. "Resilience thinking" includes several other notions, such as sustainability, adaptability and transformability, which circle around resilience as a core concept (Folke et al. 2010) and which are often vaguely normative (Nykvist 2011). I suggest that a more structured organization of the concepts and an explicit distinction between descriptive and normative content would enhance the vagueness/precision trade-off in "resilience thinking". By relating the concepts of resilience, sustainability, adaptability and transfomability in analogy to the approach of transdisciplinary research (Hirsch Hadorn et al. 2006), I show how "resilience thinking" could handle the benefits and dangers of conceptual vagueness in a coherent way.

The paper is organized as follows: In Section 2, I give an introduction to the wide spectrum of current resilience research. In Section 3, I present arguments from philosophy of science in favor and against conceptual vagueness. I discuss the implications of this methodological dispute in Section 4 and propose a restructuring of the "resilience thinking" conceptual framework. Finally, in Section 5, I summarize and conclude.

2 Resilience research: a wide spectrum

First, I present research that relies on a very precise and narrow concept of resilience. Second, I sketch the approach of "resilience thinking" which subsumes a cluster of concepts under a vague notion of resilience. In doing so, I set out the extreme end-points

of the whole spectrum of resilience research with respect to the degree of conceptual vagueness/precision.

2.1 Precise concepts

Rather than giving an encompassing literature overview, which recently has been provided in form of a typology (Brand and Jax 2007), I present the distinctiveness of precise concepts of resilience in an exemplary manner. I highlight three different ways of framing a concise notion of resilience.

First, Pimm's (1984: 322) well-known concept of resilience refers to the time a system needs to recover from a disturbance: "How fast the variables return towards their equilibrium following a perturbation." This definition is applicable only to stable systems with one equilibrium. It is a precise, one-dimensional measure. The faster a systems returns to equilibrium, the larger its resilience.

Second, building on general thoughts of how to apply economic reasoning to non-linear ecosystems (Dasgupta and Mäler 2003), Mäler et al. (2007, 2009) develop an approach to determine the economic value of resilience. To that aim, they define resilience theoretically as a stock variable where the height of the stock is equivalent to the system's resilience. Applied to the problem of salinization in South-East Australia, they operationalize resilience as the distance of the groundwater table from a critical threshold value. Hence, resilience figures as a precise, one-dimensional measure. The bigger the groundwater table's distance to the critical salinization level, the bigger the system's resilience.

Third, Derissen et al. (2011: 10) define resilience in a relative way. They ask wether an ecological-economic system is persistent relative to a specific disturbance: a given state of a system is called resilient with respect to a specific disturbance "if and only if the disturbed system is in the same domain of attraction in which the system has been at the time of disturbance". Hence, the question wether a system is resilient or not can only be evaluated after a disturbance has occurred. Resilience, in this view, is an ex-post description of a dynamic system's trajectory. It is coupled to a precise, formally

specified condition. This implies that resilience is not continuously measurable - either the condition is met and the system is resilient or the system fails to comply with the condition and is deemed not resilient. Thus, resilience boils down to a 0/1 decision.

These are three, concise definitions of resilience. In some respects they are similar, in others they show differences: In the first and second concept, resilience is continuously measurable, in the third it is a 0/1 decision. In the first and third concept, the resilience of a system is determined ex-post, after some perturbation occurred, in the second concept, current resilience is assessed in order to determine the consequences of future disturbances. Finally, concepts two and three are inspired by Holling's (1973) notion of resilience, whereas the first concept is not.

In sum, at the precise end of resilience research, different research questions yield the appropriate specific definitions, which partly overlap in structure. Crucially, the similarities and differences between these precise definitions are clearly observable. Resilience, then, is a polysemous concept in that its "meanings are clearly distinguishable, yet clearly related" (Tuggy 1993: 273). The possibility to clearly distinguish one meaning from another is what separates precise conceptual frameworks of resilience research from the vague cluster of concepts of "resilience thinking" presented in the next subsection.

2.2 Resilience thinking: a cluster of concepts

The perspective of "[r]esilience thinking addresses the dynamics and development of complex social-ecological systems" (Folke et al. 2010: 1). Here, "addressing" refers not only to scientific apprehending for "resilience thinking" is more than a research program. It is also a resource-management approach and a view of the world that is not necessarily tied to scientific discourse and academic institutions (Walker and Salt 2006). "Resilience thinking" moves away from the specific question "resilience *of* what *to* what?" (Carpenter et al. 2001) and puts more emphasis on the qualities of the state of mind denoted by "resilience thinking" (Folke et al. 2010). Consequently, there is a whole cluster of concepts gathering under the umbrella "resilience thinking".

In the following, I present four characteristics that mark "resilience thinking" as

vague extreme of the resilience research spectrum. "Resilience thinking" displays blurred boundaries of concepts (1), redundancy (2), metaphors (3) and mixing of normative and positive aspects (4).

First, several other concepts are suggested as complementary to resilience. The boundaries between these concepts are blurred. Consider, for example, adaptability and transformability – concepts that are proposed as prerequisites for resilience (Walker et al. 2004, Folke et al. 2010). Adaptability is often defined as "the capacity of actors to influence resilience", transformability as "the capacity to transform the stability landscape itself to become a different kind of system" (Folke et al. 2010: 3). However, the boundaries between these concepts are not clear, since the capacities evoked in the definitions are roughly the same - both on the empirical as well as on the conceptual level. Empirically, adaptability and transformability of a social-ecological system rely on similar characteristics as resilience, such as institutional diversity, learning possibilities or openness to experimental change (Folke et al. 2010: 5). Thus, rather than being an empirically grounded distinction, the difference between resilience, adaptability and transformability figures as a conceptual categorization. On the conceptual level, however, the concepts' boundaries are also blurred: one way to influence a system's resilience (=adaptability) consists in changing the topology of the stability landscape (Walker et al. 2004). Then again, the ability to create and frame new stability basins is critical to manage fundamental change in social-ecological systems (=transformability). It seems that transformability is some kind of super-adaptability, where adaptability refers to small changes in the stability landscape's topology and transformability to large changes. The boundary between small and large changes is, of course, hard to pin down (Walker et al. 2004: 2). In sum, resilience, adaptability and transformability are presented as closely related concepts, which cannot be precisely separated, neither on the empirical, nor on the conceptual level.

Second, not only are the boundaries between concepts blurred, but also is there redundancy. That is, concepts overlap in meaning up to the point of complete congruency. The use of the concepts of resilience and adaptability illustrates. Consider, for instance, common definitions of adaptive capacity as one aspect of resilience (Carpenter

and Brock 2008, Folke et al. 2010). This component is often related to "learning, flexibility to experiment and adopt novel solutions" (Walker et al. 2002: 6). Following this view, it would seem reasonable to understand adaptive capacity as (i) being delineated as an exclusively human attribute and (ii) being one component of the main concept of social-ecological resilience. However, the concepts are also used in ways contradicting both (i) and (ii). Contra (i), for instance, Scheffer (2009: 103) writes : "In ecosystems, adaptive capacity is determined largely by the (response) diversity of species". In this perspective, adaptive capacity no longer exclusively represents human capabilities but it appears as an encompassing social-ecological concept. Contra (ii), for instance, Bierman et al. (2010: 284) indicate "adaptiveness" as an "umbrella concept for a set of related concepts", among them resilience. In other words, adaptive capacity and resilience seem to *mutually contain each other* and converge to one concept that addresses all attributes of social-ecological systems.

Third, "resilience thinking" includes two metaphorical concepts, "adaptive cycle" and "panarchy" (Gunderson and Holling 2002). Both metaphors refer to distinct categories that, following "resilience thinking", are crucial for the resilience of complex, adaptive systems. The adaptive cycle notion highlights the time dimension of "resilience thinking" as a forward-looking conceptual mindset. The metaphor serves to counter a possible conservative connotation of resilience as a backward-looking concept aiming at persistence of the status-quo. Hence, it emphasizes working with change, transformation and the adaptive cycle's circulation through different phases. The panarchy notion highlights the spatial dimension of resilience and the importance of scales below and above the system in question. In contrast to a hierarchy that is organized in a top-down fashion, the panarchy metaphor indicates that in dynamic systems, no level is preferential. Albeit these metaphors do not come down to a single hypothesis, they serve as "heuristic models" (Folke et al. 2010) that structure research.

Fourth, "resilience thinking" mixes normative and positive aspects. While resilience was introduced as a purely descriptive concept (Holling 1973), "resilience thinking" now carries heavy normative content (Brand and Jax 2007, Nykvist 2011). In other words, "resilience thinking" replaced an initially "thin" concept of resilience with a "thick"

concept that mixes both description and evaluation (Williams 1985). Contrariwise, the influence of the normative notion of sustainability is fading in "resilience thinking". Sustainability used to figure prominently within the resilience research discourse (e.g., Common and Perrings 1992, Holling et al. 2002b), representing a guiding principle, or meta-concept above resilience and its attributes. By now, "resilience thinking" substitutes the normative content of sustainability. Folke et al. (2010), while introducing "resilience thinking", do not refer to sustainability at all (!); instead, they endow "resilience thinking" with an additional normative streak in the form of "Earth system resilience". The latter aims at preventing a global transition out of the Holocene, the current stable climate configuration on Earth (Folke et al. 2010: 2). This idea of "Earth system resilience" – keeping our planet in a favorable stability domain – replaces sustainability as normative anchor and orientation point.

In sum, at the vague end of resilience research lies the cluster of concepts called "resilience thinking". Individual meanings inside this cluster are not clearly distinguishable, partly redundant, metaphorical and evaluative.

3 Conceptual vagueness vs. precision

In the following, I turn to philosophy of science and the question wether conceptual vagueness is an asset. I first set out the "traditional" view of science that emphasizes precision and conceptual clarity. Then, I present the arguments highlighting the merits of vagueness that stem from various attacks on this "traditional" view.

3.1 Precision

In traditional philosophy of science, several arguments back the claim that conceptual clarity is essential for scientific research: (P 1) Conceptual precision sets science apart from faith. (P 2) Precise concepts reveal the limits of their validity. (P 3) Empirical testability necessarily presupposes conceptual precision. I will put forward arguments (P 1) and (P 2) by presenting Max Weber's reasoning. Subsequently, I introduce two rationalizations of argument (P 3) by presenting the dispute between the logical empiricists

of the Vienna Circle and Karl Popper.

First, consider Weber's argument for conceptual precision as the main virtue of a researcher. Weber argues that scientists make value-judgments when choosing on how to deal with the "infinite multiplicity of successively and coexistently emerging and disappearing events" (Weber 1949: 72). The researcher's perspective is no less subjective than the individual actions she intends to explain. The establishment of ends-means relationships as a basis for understanding human actions is an inherently value-laden activity. Therefore, the researcher must state her own perspective as clearly as possible. She needs to disclose her own starting-point in order to separate her subjective value-judgments from the empirical knowledge delivered by the respective analysis. In other words, total *Wertfreiheit* ("value-freedom") is impossible. Albeit the researcher should strive to distinguish her subjective view from empirical facts, she cannot attain a perspective-free point from where to conduct research. Value-judgments are unavoidable. They should be clearly indicated and recognizable as such – for if they are not made explicitly up front, they silently enter subsequent research. It is only a "hair-line which separates science from faith" (Weber [1904] 1949: 110). Hence, it is of uttermost importance for the researcher to make the normative foundation of her conceptual framework as explicit as possible.

Second, Weber argues that conceptual clarity is necessary to be aware of a concept's limits. In contrast, failing to clarify one's perspective and assumptions obfuscates the merits of a given research approach. Only by means of clear conceptual boundaries can the limits of produced empirical knowledge be established. Only by concise delineation of a concept's content can its applicability be judged. That reality is complex and multilayered should not be a pretext for using soft and blurred concepts that accommodate reality more easily. Very broad concepts may tempt researchers to believe the concepts could explain everything. Then, however, they explain nothing. Weber concludes:

> "...the construction of sharp and unambiguous concepts relevant to the concrete individual viewpoint which directs our interest at any given time, affords the possibility of clearly realizing the limits of their validity." (Weber [1904] 1949: 107)

Hence, Weber suggests abstract *Idealtypen* (ideal types) which serve as instruments to structure social reality. Whether these theoretical constructs are mere intellectual games or useful categories cannot be determined a priori. It is through their capacity to provide meaningful empirical knowledge that they reveal their validity.

Third, the relationship between theories, concepts and the empirical world is at the core of the reasoning of the logical empiricists of the Vienna Circle and their critic Popper. Both sides contend that without conceptual precision, no scientific theory can be empirically tested, thereby losing its scientific status. Basically, both the logical empiricists as well as Popper build their philosophies of science on the dictum of 19th century physicist Mach (1960: 587) that "where neither confirmation nor refutation is possible, science is not concerned." Hence, seeking empirical validation constitutes the heart of science.

In their assault on metaphysics, Schlick, Carnap and other thinkers of the Vienna Circle reject any statement that belongs neither to the realm of logic nor to the realm of empirical science. That is, they dismiss any statement which is neither *a priori* analytical nor *a posteriori* synthetical as meaningless. Since they consider logical or mathematical statements as tautological, their main interest consists in providing a criterion for empirical significance. That criterion is found in the possibility of verification: either a statement is verifiable in principle or it refers only to a pseudo-problem.[2] The logical empiricists radicalize this reasoning to the point that *meaning* and *possibility of verification* are equalized. They contend that the only appropriate answer to the question "What does statement X mean?" is to indicate a procedure by which X could be empirically tested. Hence, verifiability serves as criterion by which all relevant statements can be distinguished from meaningless statements:

> "The dividing line between logical possibility and impossibility of verification is absolutely sharp and distinct; there is no gradual transition between meaning and nonsense. For either you have given the grammatical rules

[2]The point is not that a statement has to be positively confirmed to bear meaning but that you have to be able to denote a procedure by which it could be empirically verified.

for verification, or you have not; *tertium non datur*." (Schlick 1936: 352, emphasis in original)

Following this reasoning, conceptual precision is crucial for empirical meaningfulness. Vague statements may easily be verified and are trivially true. Only sharp propositions can be put to a real empirical test. Logical empiricism dismisses any gray area between verifiable and meaningless statements and aims at discarding the latter. If all pseudo-problems are dismissed, empirical science can do its job:

> "Neatness and clarity are striven for, and dark distances and unfathomable depths rejected. [...] Clarification of the traditional philosophical problems leads us partly to unmask them as pseudo-problems, and partly to transform them into empirical problems and thereby subject them to the judgment of experimental science." (Carnap et al. [1929] 1973: 306)

Whereas Popper rejects verification as criterion of meaning, he agrees with the Vienna Circle on a very fundamental level: Science strives for empirical validation which implies conceptual precision as a precondition. Empirical validation, for Popper, is not positively possible. Hypotheses can never be logically verified, only refuted by empirical tests. Hence, Popper substitutes falsifiability for verifiability. The degree of falsifiability indicates a theory's quality: "Every "good" scientific theory is a prohibition: it forbids certain things to happen. The more a theory forbids, the better it is" (Popper 1963: 36). Falsifiability, in turn, increases in the degree of clarity and precision of a theory (Popper 1959). Vague theories are more difficult to falsify than clearly stated ones because vague concepts and hypotheses are easily reconciled with whatever may eventuate. Precise statements, in contrast, exhibit a higher probability of being refuted since they yield a much higher set of events that are prohibited. Thus, vagueness in concepts is bad science – as it accommodates reality more easily, vagueness impedes the scientific progress which relies on the trial-and-error mechanism of repeated formulation and refutation of hypotheses.

3.2 Vagueness

In contrast to the "traditional" view of science presented in the last Section, other authors hold that that precision is not a precondition for good science or even that conceptual vagueness is an asset. The arguments to support that claim can be summarized as follows: (V 1) Creativity relies on open, vague language. (V 2) Inter- and transdisciplinary communication may profit from blurred concepts. (V 3) Problem-solving requires participative processes rather than precise, abstract conceptualization. I first introduce argument (V 1) which figures most prominently in Feyerabend's attack on traditional philosophy of science. Then, I set out argument (V 2) by presenting Wittgenstein's classic discussion of blurred concepts and argument (V 3) by presenting the recently emerging perspective of "post-normal" science.

First, in a famous attack against traditional philosophy of science, Feyerabend (1975, 1998) rejects the latter's emphasis on precision, clarity and abstraction and highlights vagueness as a source of creativity (cf. Hodges 2008a for a similar argument in the ecological discussion). Feyerabend dismisses the traditional assumption of a superiority of science and argues that there cannot be a decisive argument against other forms of knowledge (possibly vague and inconsistent) that are incommensurable with science. Just as the choice between competing scientific theories always includes a subjective value-judgement, the choice between scientific knowledge and other forms cannot be grounded on purely objective arguments. Hence, traditionally precise scientific concepts and definitions are not a priori superior to others. On this reasoning builds Feyerabend's (1998) case for vagueness as source of creativity. Every-day language is mostly vague, in contrast to the traditional requirements for scientific language which Feyerabend dismisses in the first place. He insists that there is no decisive, objective argument in favor of "scientific standards" of precision and abstraction. To the contrary, science looses its creative potential when it gets to obsessed with precise language and conceptual rigor. Every attempt to dispose of ambiguities is detrimental because open-minded, creative thinking thrives on vagueness. The traditional quest for scientific rigor and absolutely precise concepts, in Feyerabend's view, may yield a deadlock instead of the

desired progress. The capacity to find genuine research questions and inventive solutions is dependent on some degree of blurredness. While inconsistencies and ambiguities traditionally are seen as flaws to be eliminated, they are fuel for constructive, open-ended science. A perfectly precise and closed conceptual scheme would rather terminate creativity and epistemic motivation than promote new research. Feyerabend (1998: 131, own translation) concludes: "Thus, I would say that it is better to remain vague."

Second, Wittgenstein (2009) insists that some concepts cannot be pinned down to a single, concise definition but rather have a "family of meanings". Wittgenstein's example is the question of how to explain to someone what a *game* is. It is not advisable, he argues, to try to give an exact definition. Rather, some paradigmatic examples of games give a better idea of the concept. For some special purpose, a precise definition may be useful, but the concept *game* as a whole refers to a "family of meanings" and thus cannot be squeezed into a single definition. In general, a vague concept with blurred boundaries is more adaptable to different cases. While employing a narrow definition gives a clear justification for using the respective term in that particular way, it couples the concept to a special purpose and sharply restricts the concept's applicability. By refusing to draw exact boundaries, that is, avoiding a precise definition, the set of possible examples for a concept is not circumscribed. Hence, it is easier to accommodate new members to the family of meanings. While Wittgenstein makes his argument in a very general way, the point easily transfers to philosophy of science. Precise definitions are appropriate for the respective specific research purposes. Yet they are less adaptable to other cases and purposes. This problem will be magnified when a concept is used across disciplines and outside the scientific discourse. Thus, inter- and transdisciplinary communication will be easy when the different participants are aware of the whole family of meanings; it will be difficult if each insists on a specific meaning and definition. For example, resilience as a "boundary object" (Brand and Jax 2007) with less specific content and more openness to usage in other contexts, facilitates inter- and transdisciplinary communication.

Third, while traditional views of science, like Weber's presented in Section 3.1, call for abstraction and rigor in order to achieve scientific certainty, the idea of "post-normal" science (Funtowicz and Ravetz 1993, 2003) challenges this quest for truth. The "post-

normal" perspective questions the traditional assumption of science as an unbiased and objective endeavor. In a "post-normal" world, research takes place in an environment where decision stakes and uncertainty are high. Thus, the traditional aim of research, truth, "...may be a luxury or indeed an irrelevance" (Funtowicz and Ravetz 2003: 653). Rather, the "maintenance and enhancement of quality" (Funtowicz and Ravetz 2003: 653) is the appropriate aim of research. The shift to a "post-normal" perspective implies that science no longer possesses the authority to provide hard inputs that guide soft policy decisions. On the contrary, science becomes an equal participant in a public discourse, where everyone who desires has a say and no one is morally or epistemically superior. Science, in this "post-normal" view, engages in a mutually respectful dialogue with stakeholders to solve pressing problems (Luks 1999). This dialogue does not necessarily profit from conceptual rigor and abstract, theoretical knowledge. In that vein, Hirsch Hadorn et al. (2006: 125) argue that "knowledge achieved in transdisciplinary research does not conform to the ideal of scientific knowledge as universal, explanatory and proven." High-quality problem-solving, then, is not equal to scientific "puzzle-solving" and does not stem from the same source as traditional science. The traditional striving for objective knowledge and conceptual precision might even be a hindrance for socially inclusive problem-solving by obfuscating scientists' own value-driven involvement in a specific issue. It is not surprising, from this perspective, that scientific input sometimes makes controversies even worse (Sarewitz 2004). "Post-normal" science should participate in public debate but it needs to be aware that it is only one voice amongst others (Frame and Brown 2008) and that the traditional scientific goal of precise, objective knowledge should not stand in the way of pragmatic problem-solving.

4 Assessment

Resilience research comes in a wide spectrum, ranging from approaches relying on concise conceptualizations on the one hand, to the vague approach of "resilience thinking" on the other hand (cf. Section 2). Both ways can draw on arguments from philosophy of science (cf. Section 3). Does one side prevail? First, I argue that there is not

a generally appropriate level of vagueness for resilience research. Rather, a trade-off between vagueness and precision exists, which might be solved differently depending on the specific research context. Second, I suggest that "resilience thinking" might benefit from a less vague conceptual framework and sketch a restructuring proposal.

4.1 The vagueness-precision trade-off in resilience research

I assume that extreme philosophical positions are untenable. Neither must all research comply with the logical empiricists' standards, nor is all research interdisciplinary, transdisciplinary and embedded in post-normal contexts. As Wittgenstein's reasoning about the (dis-)advantages of precise definitions indicates, a trade-off between vagueness and precision exists. Vague definitions do accommodate a variety of cases but this comes at the cost of reduced usefulness in particular cases. The arguments from Section 3 that add to this trade-off are summarized in Table 1. Whereas Hodges (2008b: 179) recognizes a "dangerous trade-off between quantifiable operational definitions and meanings understood in natural language", I propose that this trade-off is mainly harmful if its existence is not acknowledged and one side inadvertently dominates. A universal balance between vagueness and precision is probably not achievable: careful use of concepts distinguishes between situations where general concepts are appropriate and those where precise concepts fit better (Jax 2008). Furthermore, some of the methodological arguments draw on fundamental issues that are not objectively reconcilable. Different philosophical points of view may lead to diverging appraisals of the same research context. However, I conjecture that consciously approaching the trade-off and giving explicit justification for a particular solution should prevent excessive precision where vague delimitations would be more appropriate and vice versa.

Some research contexts favor the arguments of traditional philosophy of science, others favor the arguments attacking this traditional view. Especially the weights of the traditional argument (P 3), requiring precision to ensure empirical testability, as well as the counter-arguments (V 2), promoting vagueness to facilitate inter- and transdisciplinay communication and (V 3), focussing on problem-solving instead of puzzle-solving,

precision	vagueness
(P 1) scientific method	(V 1) creativity
(P 2) establishing the validity of concepts	(V 2) inter- and transdisciplinary communication
(P 3) empirical testability	(V 3) problem-solving instead of puzzle-solving

Table 1: Summary of arguments from philosophy of science in favor of precision and vagueness, respectively

are context-dependent. The research contexts may be distinguished with respect to their degree of "normalcy": In normal circumstances research takes place in a well-defined area, under a paradigm which includes the relevant problems ("puzzles") as well the methods that are regarded as adequate to their solution (Kuhn 1970). Here, the traditional call for empirical testability (P 3) is highly relevant. In contrast, contexts that deviate from the normal situation of science as puzzle-solving favor post-normal arguments. The argument for vagueness to promote transdisciplinary communication (V 2) is more relevant when research is directly in touch with societal stakeholders. Yet it is debatable wether conceptual precision itself inhibits communication or wether it is the apologetic defense of a particular definition that poses an obstacle to common understanding. Precision should not hinder communication across disciplinary boundaries as long as researchers are aware of other, equally legitimate meanings of concepts. Post-normal situations, where decision stakes and uncertainty are high, also favor pragmatic problem-solving (V 3). To achieve that aim, conceptual precision may be of less outstanding importance than for normal puzzle-solving. Furthermore, conceptual vagueness may be a sign that research in that particular area is just beginning and has not yet reached the normal state (Hodges 2008a).

While some part of the vagueness-precision trade-off can be solved according to the particular research context, another part of it concerns more general questions. The traditional argument for strictly delimited concepts as precondition for establishing their validity (P 2) and Feyerabend's argument for vagueness as a source of creativity (V 1) must be traded off. Both are relevant for all contexts of resilience research. Creativity

may be a main concern in other-than-normal circumstances, where no paradigm is in place, yet scientific progress generally is not conceivable without creativity. On the other hand, generalization and validation of concepts is not only important to traditional science contexts but also to transdisciplinary research if the latter does not content itself with "counseling" (Hirsch Hadorn et al. 2006: 125). That is, some compromise must be made between the call for valid statements and open space for creativity. Furthermore, the question of whether and how to separate descriptive knowledge from normative knowledge is a crucial issue and cannot be answered solely by reference to the research context. While traditional philosophy of science emphasizes attention for the "hair-line which separates science from faith" (Weber [1904] 1949: 110), post-normal science disposes of the fact-value dichotomy (Funtowicz and Ravetz 2003). Wether evaluation and description can be distinguished is a fundamental issue.

What does this mean for resilience research? Its contexts are certainly diverse. Sometimes, it aims at solving fundamental questions, like understanding ecological interactions in a specified setting, and sometimes it has transdisciplinary, non-epistemic targets, such as improving outreach to societal actors. For instance, the Resilience Alliance's project to assemble a database of thresholds and regime shifts in ecological and social-ecological systems fundamentally depends on the falsifiability of key concepts in empirical settings. Here, conceptual precision is a *conditio sine qua non*. In contrast, some research approaches are explicitly directed at practitioners who are not bound to any scientific standard. In delivering this transdisciplinary message, the traditional focus on rigor and precision may be dispensable. Furthermore, the initially metaphorical concepts adaptive cycle and panarchy should never have entered the academic discourse following the logical empiricists' standards. Yet these metaphors are useful in that they generate new research questions (Holling et al. 2002b). This might indicate that some areas of resilience research have not yet reached a normal phase of puzzle-solving but still constitute a situation that rewards creativity and fuzzyness more than precision and rigor.

4.2 Resilience thinking

In my view, "resilience thinking" lacks a consistent balance between vagueness and precision. Consider the two weaknesses of "resilience thinking" following Fischer et al. (2009: 550). First, there is an "inherent weakness" to the perspective because it is "potentially difficult to apply to systems without identifiable alternate states". Second, a "weakness in practice" arises from the fact that "the term 'resilience' can appear vague to policymakers and the general public". If vagueness and precision were coherently traded off, "resilience thinking" should *not* exhibit *both* weaknesses. Suppose researchers would explicitly and consciously rely on a very vague notion of resilience (e.g., embrace change and anticipate undesirable events). Then, the first weakness should not pose a problem because resilience is not coupled to the existence of multiple stability domains. Such a vague notion of resilience could very well be applied to systems without identified alternate states. In that case, of course, the term could appear vague to policymakers and the general public. In contrast, suppose researchers would exclusively rely on a narrow, precise concept of resilience, such as Holling's (1973) "amount of disturbance a system can absorb" as a one-dimensional measure, which is to be specified for particular settings (e.g., distance groundwater-table to critical threshold in agricultural regions prone to salinization, Mäler et al. 2007). Such a concise concept of resilience should not run in danger of appearing vague to concerned policymakers and ecosystem managers. It would not be applicable to systems without identified dynamics, thresholds and alternate states, however.[3] Either degree of precision has its drawbacks, but a research approach that exhibits *both* weaknesses displays too much and not enough vagueness at the same time.

As a further argument that "resilience thinking" displays inappropriate vagueness, consider its mix of normative and descriptive aspects. It has been suggested that due to an unduly amalgamation of evaluative and descriptive content, resilience runs the risk

[3]One might argue that there is no inherent weakness in the first place since that concept is *not meant* to be applicable to other systems. Yet the argument for vagueness as a source of creativity implies that there lies a weakness in restricting resilience research to particular kinds of systems.

of becoming too much like sustainability (Brand and Jax 2007). Sustainability constitutes a "thick" concept with considerable normative content (Williams 1985) and a long tradition as a guiding principle for ecosystem management (Grober 2010). It is widely discussed, evoked and also contested. That is, sustainability has evolved into a buzzword whose "plethora of meanings" and definitions draw heavy criticism: "This definitional chaos has nearly rendered the term *sustainability* meaningless [...]" (Marshall and Toffel 2005: 1). Indeed, its positive connotation and the variety of meanings make sustainability prone to inflationary use in dubious contexts. For instance, Shell advertises the extraction of oil from Canada's tar sands as a "sustainable" operation (The Economist 2008). I agree that by increasingly mixing positive and normative aspects, "resilience thinking" also lends itself to figure as a buzzword. Should sustainability be permanently excluded from the "resilience thinking" discourse, its normative content will be absorbed by the concept of resilience. While influential papers (e.g., Walker et al. 2004) do mention that resilience is – originally – a descriptive concept and resilient system states may be undesirable from an anthropocentric perspective, the recent conceptual development indicates an increase in resilience's normative connotation (cf. Section 2.2). By contrast, I would favor a way of framing "resilience thinking" that explicitly and separately includes a normative notion of sustainability. Whereas Weber's "hair-line between science and faith" might be a construct, I am not sure wether it is a good idea to completely dismiss it.

Following these arguments, I suggest that the "resilience thinking" family of concepts would benefit from a restructuring. Specifically, I propose (i) an emphasis on the descriptive side of resilience, (ii) a return to sustainability as the normative meta-goal of resilience research and (iii) the use of adaptability and transformability as concepts that represent human capabilities to manage resilience following the sustainability target. I reckon that established definitions (Walker et al. 2004, Derissen et al. 2011, Hirsch Hadorn et al. 2006) can be used to advance the conceptual framework of "resilience thinking" in a coherent way.

(i),(ii) Derissen et al. (2011) employ resilience as a purely descriptive and sustainability as a normative concept. They argue that sustainability comprises a society's basic

normative orientation, thereby providing a "sustainability set". This set circumscribes those future states which satisfy a society's norms of intra- and intergenerational justice. Wether a resilient system is also sustainable cannot be determined a priori. It depends on the system's location on the stability landscape with respect to the sustainability set. Derissen et al.'s (2011) analysis implies that a social-ecological system is on a sustainable path if and only if human actors are able to shape the stability landscape so as to keep the system within the normatively given target set. Hence, (iii) adaptability and transformability, defined as the capabilities to influence resilience and devise new system configurations (Walker et al. 2004) are preconditions for sustainability. While Folke et al. (2010) add evaluative content to the concept of resilience, thereby establishing a normative meta-goal "Earth-system resilience", I would be more comfortable with keeping the concept of resilience clear of evaluative content and subsuming all normative considerations under the notion of sustainability. In short, my suggestion boils down to the following relation: *sustainability implies that social-ecological resilience can be successfully managed through adaption and transformation.*

There is a close structural similarity between my proposal and the categories of knowledge in transdisciplinarity research, following the Swiss system approach (ProClim 1997). Hirsch Hadorn et al. (2006: 127) distinguish three different categories of knowledge:

i) Systems knowledge – Why and how do processes occur and where is change needed: empirical level?

ii) Target knowledge – What are better practices (targets): purposive level?

iii) Transformation knowledge – How can existing practices be transformed: pragmatic and normative level?

The correspondence, as summarized in Table 2, should be clear: resilience refers to empirical knowledge about social-ecological systems (category i). Sustainability embodies the normative considerations which system states are desirable and where change is necessary (category ii). Adaptability and transformability refer to practical knowledge about how to manage resilience and initiate transformations (category iii).

concept in resilience thinking	category in transdisciplinary research	type of knowledge
resilience	systems knowledge	empirical
sustainability	target knowledge	purposive, normative
adaptability, transformability	transformation knowledge	pragmatic

Table 2: Correspondence of categories between resilience thinking and transdisciplinary research

While my proposal slightly differs from the systems understanding of Hirsch Hadorn et al. (2006: 127) in that the second category (target knowledge) instead of the third category (transformation knowledge) includes normative considerations, the crucial point and main similarity is the separation of empirical category and purposive category (P 1). Then again, my framework is also vague (e.g., it is compatible with multiple resilience definitions and multiple views on transformations) in order to provide enough scope for creativity (V 1). Depending on the specific research context, empirical testability (P 3) or pragmatic problem-solving (V 2,3) could be emphasized. In sum, a more structured "resilience thinking" framework accounts for the arguments of both vagueness and precision.

Acknowledging that use of language does not follow prescription (Hodges 2008a), I would like to stress that I do not claim to have established the final, definite structure of the "resilience thinking" family of concepts. Resilience is certainly a polysemous concept with a variety of plausible meanings and structuring possibilities. However, this does not rule out the use of a precisely structured resilience framework. As I understand it, the arguments for conceptual vagueness imply that researchers should be aware of legitimate other notions of resilience. They do not imply that every individual definition or categorization must be vague. Conceptual precision is not a problem for inter- and transdiscplinary communication and problem-solving as long as researchers acknowledge the existence of a plurality of meanings and structuring possibilities. Hence, my proposal should be seen as one way to structure "resilience thinking" more coherently.

5 Conclusion

A wide spectrum of resilience research exists. On the precise end of the spectrum, research approaches rely on concise definitions and operationalizations, thereby establishing a polysemous concept of resilience. On the vague end of the spectrum, "resilience thinking" builds on a vague cluster of concepts. Both extremes can draw on different arguments from philosophy of science. These arguments must be traded off in order to find an appropriate mix of vagueness and precision. A universal solution to the trade-off does probably not exist. This is for two reasons. First, fundamental methodological points of view cannot objectively be reconciled and second, different research contexts may call for individual degrees of vagueness. Thus, every particular research approach should explicitly justify its balance of vagueness/precision in order to avoid inadvertent and excessive domination of one side.

Assessing "resilience thinking", I conclude that the approach fails to explicitly and consistently trade off vagueness and precision. Rather, vagueness is implicitly prioritized: "Resilience is a broad, multifaced, and loosely organized cluster of concepts [...]. As long as resilience thinking produces interesting research ideas, people are likely to pursue it. When it seems empty of ideas, it will be abandoned or transformed into something else" (Carpenter and Brock 2008: 1). This view tacitly passes over the arguments for conceptual precision. Therefore, I propose a restructuring of the "resilience thinking" family of concepts. By relating resilience, sustainability and adaptability/transfomability in analogy to the approach of transdisciplinary research (Hirsch Hadorn et al. 2006), I indicate how "resilience thinking" could balance vagueness and precision in a more coherent way. In particular, I explicitly distinguish between descriptive and normative content. This differentiation is crucial for those contexts of "resilience thinking" that do rely on a separation of empirical knowledge and evaluation.

In sum, I offer guidance for the further conceptual development of resilience research. I sketch how conflicting arguments from philosophy of science can be productively employed to assess whether, in some specific research context, conceptual vagueness is an asset or a liability. By analyzing "resilience thinking" and offering a coherent restruc-

turing proposal, I provide an example of how to improve trade-offs between vagueness and precision.

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