# Collapse Informatics and Practice: Theory, Method, and Design

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What happens if efforts to achieve sustainability fail? Research in many fields argues that contemporary global industrial civilization will not persist indefinitely in its current form, and may, like many past human societies, eventually collapse. Arguments in environmental studies, anthropology, and other fields indicate that this transformation could begin within the next half-century. While imminent collapse is far from certain, it is prudent to consider now how to develop sociotechnical systems for use in these scenarios. We introduce the notion of collapse informatics—the study, design, and development of sociotechnical systems in the abundant present for use in a future of scarcity. We sketch the design space of collapse informatics and a variety of example projects. We ask how notions of practice—theorized as collective activity in the "here and now"—can shift to the future since collapse has yet to occur.

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## 1. INTRODUCTION

History documents the rise and fall of many complex societies. Large human civilizations form over long periods of expansion, sometimes lasting centuries; however, most civilizations that have ever existed have collapsed [Tainter 1990; Diamond 2004]. The archaeologist Joseph Tainter defines collapse as "a rapid, significant loss of an established level of sociopolitical complexity" [Tainter 1990, p. 7]. In his parlance, "rapid" means "no more than a few decades" [Tainter 1990, p. 4]. Collapse manifests as the loss of the hallmarks of political complexity, namely:

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> a lower degree of stratification and social differentiation; less economic and occupational specialization, of individuals, groups, and territories; less centralized control; that is, less regulation and integration of diverse economic and political groups by elites; less behavioral control and regimentation; less investment in the epiphenomena of complexity, those elements that define the concept of "civilization": monumental architecture, artistic and literary achievements, and the like; less flow of information between individuals, between political and economic groups, and between a center and its periphery; less sharing, trading, and redistribution of resources; less overall coordination and organization of individuals and groups; a smaller territory integrated within a single political unit ([Tainter 1990], p. 4).

We live in a world that includes the first global civilization. Despite the relatively continuous growth—in economic productivity, energy consumption, population, and many other forms—that this civilization has experienced over the past two centuries (or, perhaps, because of it), it is plausible that this civilization may someday enter a period of decline. Many scholars have suggested that this decline may have already begun, or may begin within the next several decades [Diamond 2004; Tainter 1990]. The US military, as well, has an ongoing engagement with preparedness for collapse (e.g., Freier [2008]).

Many people look at the past several hundred years of fairly steady growth and see growth as eternal and unconditionally desirable. Growth has led to higher standards of living in many areas, in particular in the industrialized world, and, as an idea, is supported by the bulk of major governments and corporations of the world. However, continuous growth is, by virtue of limited global resources, unable to continue indefinitely. The collapse of global civilization, whether imminent or not, would carry enormous costs that novel research may be able to reduce. It is time to consider how the CHI community can help civilization react to and plan for this possibility.

In this article, we propose that there is a need for research in *collapse informatics*—the study, design, and development of sociotechnical systems in the abundant present for use in a future of scarcity. The core challenge of collapse informatics involves designing sociotechnical systems in our present context, even though the primary usage of these systems will occur in a very different situation, in the future. Collapse informatics focuses on the role and potential effects of ICT in dealing with changes—however induced—that create massive shifts in the way humanity must adapt to new conditions—political, social, and ecological.

In many societies and contexts, progressive acts of social policy can lead to innovations which reach far beyond their target populations—for example, child labor laws which lead to fairer labor laws for a more general population, laws applying to people with disabilities which lead to increased access for a more general population, social safety net legislation which creates a common sense of belonging for everyone, educational access laws which improve the educational effectiveness for all of society, and so forth. Similarly, collapse informatics may produce innovations that are broadly useful, for example, in localized collapse situations, disaster-preparedness and response, or in ICT for Development (ICT4D), even in the event that the global community is able to sustain itself indefinitely. Through this research, we envision the possibility of a future characterized by scarcity and shrinking opportunity, and seek to make that future a better place.

We approach this goal with the intent of examining everyday practices to inform planning for a future of collapse. In particular, we want to explore how digital technology may mediate activity in a future of scarcity, and how we may envision both old and new digital technologies in ways that will support future practices as gracefully as possible. In a very practical way, addressing practice is necessary to collapse informatics. Broad-scale social norms to address many aspects of life in a future of collapse do not yet exist, and individual behavioral adaptations are insufficient to respond to the magnitude of collapse; therefore, we seek to discover

approaches to collapse at the intermediate analytical level of practice. This does not mean that analyses of practice cannot engage higher levels of organization such as institutions and governments, but it does mean that we find it essential to conduct focal investigations grounded in "human activity centrally organized around shared practical understanding" as Schatzki [2001] suggests (see also Nicolini [2009]).

We begin the discussion by describing the potential characteristics of collapse. We then examine practice theory and assess its usefulness to collapse informatics. Finally, we suggest several empirical studies we believe will inform emerging notions of what collapse informatics can be, and discuss design practices to foster the development of collapse informatics.

## 2. BACKGROUND

### 2.1. Collapse is Not Apocalypse

If collapse is potentially in our civilization's future, it is relevant to consider how soon, and in what styles, collapse may occur. Hollywood movies (e.g., *Carriers*, *28 Days Later*, *The Terminator*, *2012*) and postapocalyptic fiction (e.g., Rawles [2006]), often focus on very rapid collapse, occurring on the scale of days or weeks—an apocalypse.

While rapid and powerful events such as nuclear attacks may cause events to unfold in a way that merits the term "apocalypse," and while various "tipping point" phenomena [Diamond 2004; Lovelock 2009] may cause nonlinear changes to occur very rapidly (as is common in ecosystems), Tainter [1990], geographer Jared Diamond [2004], and others note that collapse frequently occurs more gradually. In the popular press recently, there has been discussion of a "double dip recession" [Norris 2011]; collapse may take the form of an "N-dip recession."

### 2.2. The Unfolding of Collapse

When, exactly, collapse may begin is difficult to predict with precision. Many scholars tie the collapse timeline to our primarily fossil fuel-based energy supply. "Recent history seems to indicate that we have at least reached declining returns for our reliance on fossil fuels, and possibly for some raw materials," writes Tainter [1990, p. 215]. He continues: "[a] new energy subsidy is necessary if a declining standard of living and a future global collapse are to be averted." One barrel of oil does an equivalent amount of work to 25,000 hours of human manual labor [McKibben 2010]; it is the subsidy and externalized costs from this vast resource that makes our current ways of living possible. The term "peak oil" has entered popular parlance to describe the point at which global oil production reaches its highest point and then enters a period of decline. There is some debate over the timing of this phenomenon; some researchers say it has already occurred, others that it will occur within the next several decades. And recent increases in potential oil production [Maugeri 2012] may delay a fossil-fuel based energy crisis for sufficiently long that some other energy source has time to emerge to take its place. Nevertheless, if collapse is tied to shortfalls in energy, the finite nature of fossil fuels (at least on a human time scale) and the lack of an obvious successor to fuel global activity means that collapse is far from impossible.

Diamond also argues that environmental problems that could cause civilization-scale collapse will manifest within the century. "[A]t current rates most or all of the dozen major sets of environmental problems ... will become acute within the life-time of young adults now alive" Diamond [2004, p. 513]. The Intergovernmental Panel on Climate Change (IPCC) ([2007, p. 7], Figure SPM.5) states that the world is very likely to reach a tipping point by 2040 with respect to global warming/climate change unless humans are able to reduce GHG emissions to 1999 levels by the year 2015. A more recent report by the IPCC is "Managing The Risks Of Extreme Events And Disasters

To Advance Climate Change Adaptation," [IPCC 2012] which tackles some of the very same issues implicated in our discussion of collapse. Taken together, these sources suggest that collapse could begin within the next several decades. If it does, it is likely to usher in profound changes.

Not surprisingly, military thinkers are already considering collapse scenarios. Another important bellwether of the possible imminence of collapse events arrives in the form of various writings from military strategists. For example, Nathan Frier of the US Government Strategic Studies Institute writes the following.

> Threats of context might include but are not limited to contagious un- and under-governance; civil violence; the swift catastrophic onset of consequential natural, environmental, and/or human disaster; a rapidly expanding and uncontrolled trans-regional epidemic; and the sudden crippling instability or collapse of a large and important state. Indeed, pushing at the boundaries of current convention, it would be prudent to add catastrophic dislocation inside the United States or homegrown domestic civil disorder and/or violence to this category as well. [Freier 2008]

In this same publication, Frier quotes from many others who raise similar future scenarios, such as Phil Williams, who writes as follows.

> In the 21st century in most parts of the world, issues of security and stability have little to do with traditional power politics, military conflict between states, and issues of grand strategy. Instead, they revolve around the disruptive consequences of globalization, governance, public safety, inequality, urbanization, violent non-state actors, and the like. [Williams 2008] (As quoted in Freier [2008], p. 41, footnote 32.)

### 2.3. Effects of Collapse

In this article, we use the term "civilization" to mean a large, complex society, where a society is a collection of cooperating individuals. A civilization in which there is cooperation between globally distributed individuals can be described as a "global civilization." With these definitions we can describe a "collapse of global civilization" as the transition from a state of affairs in which such cooperation exists to one in which it no longer exists or is severely attenuated. (No moral valuation is intended by our use of the term "civilization.")

Diamond [2004] and Tainter [1990] describe numerous examples of collapse across the history of human civilizations, and point to scarcities of many kinds, including dramatic shortfalls in food, energy, and raw materials. In a scarce, post-collapse future, we may see crumbling infrastructures (e.g., power, manufacturing, government regulation). In the "Inside Risks" column in *Communications of the ACM*, Horning and Neumann [2008] noted that "[c]ivilization and infrastructure are intimately intertwined. Rising civilizations build and benefit from their infrastructures in a 'virtuous cycle.' As civilizations decline, their infrastructures decay—although unmaintained vestiges, such as roads and aqueducts, may outlive them" [Horning and Neumann 2008, p. 112]. In the wake of collapse, the largest level of human organization is likely to be a smaller social unit than the current global civilization [Tainter 1990]. We may see scarcities of energy as a result of peak oil, and scarcities of other resources as a result of reduced global trade. The lack of infrastructures, energy sources, and trade would likely impact food supplies for a large portion of the world population, who either do not raise their own food, or do so relying on imported water, seed, fertilizers, pesticides, and other supplies. Taken together, these kinds of civilizational repercussions would bring about significant lifestyle changes for many people.

### 2.4. ICT and Collapse

ICT systems are among the most powerful tools humanity has ever created; understanding how to design ICT and sociotechnical systems to enable social wellbeing in times of collapse could benefit many. There has been some discussion of collapse in the

computing community (e.g., Nelson [1997]). Within HCI specifically, Blevis and Blevis [2010] have written about the need to emphasize adaptation in addition to mitigation, as a matter of planning for the effects and altered practices that may arise from societal collapse resulting from the planet reaching a climate change tipping point. Wong [2009] has discussed the need for a broadening of the scope of research in order to have effects that are sufficiently impactful to address the gravity of the crises facing human civilization. In Wong's view, researchers "should also consider ... the design context to be a world radically altered by environmental damage; solutions that fit into today's lifestyles risk irrelevance" ([Wong 2009], p. 1). Silberman and Tomlinson have considered how HCI research may be relevant to contexts characterized by a "rapid, significant loss of sociopolitical complexity which in itself constitutes an event whose impacts exceed the responsive capacities of [those] affected" [Silberman and Tomlinson 2010, p. 1].

Despite these initial forays by HCI researchers into the space of research relating to collapse, we as a discipline have largely failed to appreciate the need to investigate, design, and build technologies that may be of use on the "downward slope" of social complexity. Furthermore, ICT may itself play a role in bringing about collapse. ICT is a force multiplier and has hastened the development of the various environmental issues that surround us [Tomlinson 2010]. With regard to the recession in the late 2000s, CACM editor Moshe Vardi argued that "information technology played a major role in the crisis" [Vardi 2009, p. 5]. Vardi gives examples showing how ICT is linked to economic complexity and makes a link, albeit apocalyptic, to collapse explicit: "if a massive electromagnetic pulse wiped out our computing infrastructure, our society would face a catastrophic collapse" [Vardi 2009, p. 5]. The bulk of ICT innovations in the past half-century reflect an implicit expectation of perpetual growth. Infrastructures will expand, markets will grow, and materials will become more readily available. While recently proponents of "green" technologies have begun to consider that it may be desirable to have civilization plateau and achieve a sustainable steady state or dynamic equilibrium, this outlook is far from the norm [Costanza et al. 1997; Daly 1973]. In addition, harmonizing consistent global perspectives on appropriate resource use and fair distribution of resources from one society to another seems unlikely.

## 3. COLLAPSE INFORMATICS AND PRACTICE

"Collapse" is such a monumental notion, a vast envisionment of civilizational dystopia, that it scarcely seems possible to cut it down to a size in which we, as practitioners of HCI, could meaningfully address it. Rattled by disturbing anticipations of a dark future, the prospect of collapse may move us to action. But what action? How exactly could we intervene in a future of collapse?

Most people are unlikely to foment a national (or international) revolution, or alter major political institutions. But because many forms of ICT are ultimately about everyday practice we are, in fact, in a strong position to confront a difficult future. Designed artifacts—things that we in our research community are capable of imagining—enter streams of practice through market mechanisms and open source development. These processes allow artifacts to penetrate independently of legislative processes or massive changes in ideology. Witness our current lifeworld with the everyday-ness of the Web, Facebook, Twitter, YouTube, instant messaging, blogging, texting, and so on—a world that did not exist before 1993. Precursors of today's technologies furnished specialist communities with Unix utilities, online games, bulletin boards, and other bits of software, but contemporary internet technologies have transformed national-scale everyday practices without mainstream political intervention or the vigorous propagation of new ideology. As members of the HCI community we have a tremendous opportunity to impact the future through digital design aimed at everyday practice.

This is not to say that legislative processes and ideological development are not important; they are, and they come into play. But markets and technical innovation operate with their own dynamics and agency. These mechanisms afford an opening for us to intervene in everyday practice: this opening is our "way in" to the future. As noted above, markets and technical innovation constitute a force multiplier that creates the potential for collapse in the first place, but we argue that we can strategically use these powerful mechanisms to develop and distribute technologies to create new everyday practices suitable to futures of scarcity.

How should the HCI research community think about practice beyond its common sense meanings? It is important to carefully theorize practice for a few simple but critical reasons often overlooked in our very pragmatic field [Kaptelinin and Nardi 2012]. Theory enables the development of common concepts and vocabularies that can be leveraged across research projects for greater impact. Theory enables deeper, more insightful analysis. Theory reduces the silo effect of separate efforts, each its own idiosyncratic inquiry reinventing, often superficially and fragmentarily, tools for thought. The magnitude of problems surrounding collapse calls for contributions to a larger, more integrated program of research. In what follows we argue that collapse informatics can use practice theory as a necessary tool for thought. We discuss practice theory and how it might fruitfully be applied in empirical investigations. In the subsequent section we link such investigations to *design practice*, assessing how the empirics of studies of localized practices connect to design research broadly conceived and respond to trends at larger scale.

## 4. PRACTICE THEORY IN THE CONTEXT OF COLLAPSE INFORMATICS

Theoretically, practice remains a loosely defined "boundary concept" [Löwy 1992], unconstrained enough to allow disparate proponents to appropriate it in consonance with their fields' preoccupations [Huizing and Cavanagh 2011]. Practice theory has a rich history extending back centuries and spans a range of fields including philosophy, anthropology, sociology, psychology, gender studies, organization studies, and science studies [Reckwitz 2002].

Out of this diversity, a conceptual core defining practice has emerged. The core comprises a small number of propositions which can be summarized as: routinized embodied action forms the basis of activity; material artifacts (and more generally, things) mediate our relationship with reality; knowledge derives from and exists within acting in the world, not simply as mental representations or symbolic categories [Huizing and Cavanagh 2011; Reckwitz 2002]. As Reckwitz put it, practices are "body/knowledge/things-complexes" ([2002], p. 258). Shove and Pantzar ([2005], p. 44) offers a similar formulation, observing that "practices involve the active integration of materials, meanings and forms of competence." In conformance with all versions of practice theory, we understand practice as developing and occurring in complex collective sociocultural contexts, not as individualistic behavioral adaptations to changing circumstances or as general societal norms.

Beyond the core propositions, practice theory is capable of absorbing a variety of approaches and research concerns [Huizing and Cavanagh 2011]. Some view the impreciseness and provisionality of practice as a boundary concept as a weakness [Corradi et al. 2010] but we believe these qualities work in our favor: the concept is ours to develop and expand according to our research objectives. As with any theory, it is imperative to subject practice theory to a variety of empirical scenarios and contexts to see how it holds up, and to locate points at which it can be enhanced, deepened, and made more useful while still retaining its fundamentals.

Practice theory is not the same as describing practices (which can be accomplished through several straightforward methodologies such as ethnography, observation, and

analysis of artifacts). The interweaving of distinctive theoretical propositions, methodologies, and epistemology distinguish practice theory [Huizing and Cavanagh 2011; Reckwitz 2002]. For purposes of collapse informatics, our approach to practice is inflected by our methodological commitment to closely observed ethnographic investigations of technology and its uses in everyday life (e.g., Nardi [2010]), coupled with a theoretical orientation to technology as a principal mediator of human activity [Bødker and Andersen 2005; Kaptelinin and Nardi 2006, 2012; Schatzki 2001]. Schatzki's seminal paper describes practice as "materially mediated arrays of human activity centrally organized around shared practical understanding" ([2001], p. 2). This grounding statement informs our work.

With respect to collapse informatics, practice theory entails some challenges that prompt us to propose certain adjustments. First, questions of method arise because of our orientation to the future. Second, a prevailing notion of practice as taken-for-granted and in-the-background [Bourdieu 1977] overlooks a type of practice of deep interest to collapse informatics, that is, reflexive practices that deliberately question and destabilize everyday routines. We examine these two concerns in turn.

### 4.1. The "Here and Now" in Practice Theory

While it seems that it could hardly be otherwise, current practice theory takes as its subject matter analysis of present practice. Motivated by an agenda of addressing the shortcomings of dominant mentalist and macro theories, as well as influential reductionist theories such as sociobiology and formal linguistics (which does not consider how language is actually used in practice) [Stetsenko 2008], a concern with the "*here-and-now*" shapes practice theory. In their appraisals of practice theory, both Miettinen [1999] and Huizing and Cavanagh [2011] stress the importance of the here-and-now (and use the identical phrase). They observe that it is precisely the lack of attention to the goings-on of everyday life that impoverish other theoretical traditions [Gherardi 2006].

However, as scholars of collapse, we have a special problem. Because collapse informatics projects ahead to a future at least a few decades away, we cannot simply turn our attention to straightforwardly theorizing current practice (as do e.g., [Bourdieu 1977; Latour 1993; Schatzki 2001]). We must find a way to link today's practices to tomorrow's possible futures. How do we reconcile practice theory's primary concern with current practice with our necessary orientation to imagined futures?

We propose three steps toward solving this problem. First, expanding the time scale across which the notion of practice is considered will loosen its grip on the present as the natural focal point of analysis. Second, we must work comparatively, across several cases. And third, we highlight the provisionality of our findings and designs, continually monitoring the present to recalibrate notions of the future. Collapse informatics will thus depend on long time horizons during which assessing the present will be critical to visiting the future.

## 5. APPLYING PRACTICE THEORY: TEMPORAL CONSIDERATIONS

### 5.1. Expanding the Time Horizon of Practice

As routinized actions, practices have a clearly observable temporal structure (Reckwitz [2002], p. 257). A routine is enacted over time and its progress can be tracked. But this progress, in the here-and-now, is usually conceived as occurring within a fairly short time frame—typically what an observer sees given the scope of an average field study. Practice-oriented accounts produce a sense of immediacy and nuance—a strength of the approach—but at the same time, the temporal scope could often be larger.

While this scope could be problematic for collapse informatics and its future orientation, a focus on the present appears to derive not from basic logics of practice theory, but as a methodological artifact of the span of conventional observational study. We see nothing in practice theory that forecloses addressing longer time horizons. The "here-and-now," and its typical temporal framing, is an issue to be managed through methodological adjustment, with no need to address a conceptual weakness or failure of logic in practice theory.

Furthermore, relevant research suggests that longer time horizons are desirable. In a special issue of *Organization Studies* devoted to practice theory, Finnish scholar Reijo Miettinen indicates the value of a more expansive sense of time when he observes that "[t]he concept of practice calls for developing vocabularies and approaches ... such that we are able to understand practice as taking place simultaneously both locally and globally, being both unique and culturally shared, *and 'here and now' as well as historically constituted and path-dependent*" [Miettinen et al. 2009, p. 1310], (emphasis added). In other words, practice is what we do now, and have done, but is also "path-dependent," or facing forward historically. Miettinen's acknowledgment of the temporal complexity of practice lights a beacon for work on collapse informatics in which we situate research in the past, present, and a fairly distant future. Miettinen suggests that we stretch practice theory forward, "developing vocabularies and approaches" that expand its fundamental notions including time [Huizing and Cavanagh 2011]. Shove and Pantzar's work on the uptake of Nordic walking in different countries [Shove and Pantzar 2005] provides a nice empirical example of Miettinen's claim. They show that we must take into account the history—sometimes going back a long way—of local practices and concepts that may inform what they call the "reinvention" of a practice. Shove and Pantzar's work is exemplary with respect to our point, but the historical sweep they engage in their analysis is, in contemporary practice studies, unusual. The strategy behind the work is appropriate for collapse informatics. The depth and interestingness of their understandings are possible only because they trace artifacts and practices over time (and space). Friedman and Nathan [2010] advocate "multi-lifespan" time frames for HCI. They do not engage practice theory per se, but the spirit of accepting much longer time frames as reasonable and necessary for some problems of interest to HCI is consonant with the aims of collapse informatics.

Miettinen [1999] builds on the work of theorists in the sociocultural tradition in which he participates, in particular activity theory, which he identifies as itself a version of practice theory. Vygotsky (the founder of the sociocultural school), along with his students, stressed the importance of material mediation in human practice, observing that our relation to reality is shaped by the artifacts we have at hand that transform, in powerful ways, how we are able to conceive and enact practice (see [Bødker and Andersen 2005; Kaptelinin and Nardi 2006, 2012; Vygotsky 1978]). Mediating artifacts themselves can embody a future orientation. The philosopher Marx Wartofsky (influenced by the sociocultural school), proposed a specialized type of artifact that we find useful—"tertiary artifacts" (as one type in a larger scheme).[1] Tertiary artifacts emphasize creativity. They are positioned somewhat outside ordinary life, thus potentially linking to possibilities beyond the everyday. According to Wartofsky ([1979], p. 79), a tertiary artifact "transcends the more immediate necessities of productive praxis," giving freer rein to imagining "possible worlds"; see also [Miettinen 1999]). Tertiary artifacts indicate a corollary logic of "tertiary practices"—practices that allow the same free rein for imagining possible worlds. We update Wartofsky's terminology to "possible-worlds" artifacts and practices and provide contextualized examples in the next section.

[1]Primary artifacts enable an everyday task, for instance, a word processor for writing. Secondary artifacts explain how to use a primary artifact, for instance, documentation for a word processor.

### 5.2. Comparative Research

The future is unknowable, at least compared to the present, therefore it is critical to study numerous cases to produce accounts of multiple possible futures. Comparative work draws out differences across cases to provide an array of possibilities (see Nardi et al. [2011]).[2] Comparative study reveals what is common across cases, allowing for identification of concerns and conditions to which we may want to be especially responsive in our designs, as well as differences to inform a range of designs. Comparative study is a well-established research strategy, and yet it is not as common in human-computer interaction as it might be (see Nardi et al. [2011]). We thus highlight its importance for collapse informatics. We point again to the work of Shove and Pantzar [2005] as exemplary.

### 5.3. Checkpointing the Future

Because the practices of interest to collapse informatics are ultimately located in the future, and because present practice is our way to triangulate toward future practices, it will be important to continually monitor what we study. What new economic and political conditions affect practice? Have new practices and technologies been invented? How are they being used? What obstacles have arisen? This approach requires strategic checkpointing over time and collaborative work to synthesize what we will learn across multiple sites. Such an approach is a variant of longitudinal study but with the added requirement of keeping present and future constantly in play with one another. The time horizon is similar to epidemiological studies that track outcomes across decades (a time frame that would be innovative in human-computer interaction research and is proposed as a desirable future aim by Friedman and Nathan [2010]). Unlike epidemiological studies, which typically target precise, well-defined variables in advance, and measure only those variables at specified times, our research must be open to new inputs given the dynamic, unpredictable mix of social, economic, political, and environmental forces that can impact practices of interest to collapse informatics. Friedman and Nathan ([2010], p. 2246) observe that unpredictable change must be accommodated in long-term study: "[R]igidly prescriptive approaches are likely to fail in the multi-lifespan context as they lack internal mechanisms for responding to changes in conditions over time." In a study of energy use and ICTs, Røpke and Christensen ([2012], p. 359–360) also underscore the need for expansive, flexible analysis: "The point is rather that the energy impacts of ICT depend on wider economic and political conditions . . . And as a more wide-ranging perspective, efforts to reduce global inequality can increase prices of raw materials and wages in sweatshops and thus make ICTs into something expensive that must be applied with care."

We should not be daunted by the difficulty of such checkpointing or its tenuousness. As psychologist Kenneth Gergen argued in his call for "generative theory," if we confine inquiry to slavish assembly of verifiable facts said to describe a timeless "taken for granted" universe, we theoretically and ethically foreclose the critical role of theory in producing alternative futures [Gergen [1978, p. 1346]. Gergen remarked, "It may be useful to consider competing theoretical accounts in terms of their generative capacity, that is, the capacity to challenge the guiding assumptions of the culture, to raise fundamental questions regarding contemporary social life, that is, to foster reconsideration of that which is 'taken for granted,' and thereby to furnish new alternatives for social action" [Gergen 1978, p. 1346]. A plan to knit together present and future through empirical study of practice, joined to concomitant development of practice theory, has the potential to reveal alternatives for practice, the objective of collapse informatics.

[2]Comparative work is not the same as a multi-sited methodology [Marcus 1995] in which an entity such a person, artifact, or idea is followed across different locales.

## 6. APPLYING PRACTICE THEORY: REFLEXIVE PRACTICE

We believe that current practice theory easily accommodates longer time horizons even though they are not (yet) emphasized. However, certain kinds of practices important to collapse informatics fit less comfortably. In particular, practices that seek to reflexively bring practice to awareness in order to evaluate and change it seem undertheorized or even hostile to practice theory.

How does practice theory propose that changes in practice occur? Reckwitz observes that the "shifting" structures of routine practices emerge in "everyday crises" in which "the agent, carrying out a practice, is confronted in the face of a 'situation'" [Reckwitz 2002, p. 255]. While Reckwitz does not spell out exactly what is meant by "everyday crises," we can assume that the agent is busily "carrying out a practice" and that something happens that must be dealt with reactively in the immediacy of the moment.

Collapse informatics must examine practices beyond reactive maneuvers—practices that, in fact, purposefully seek to unseat everyday practice. "Practices of destabilization" do not arise in response to external crises to be confronted in the moment, but within a more broadly conceived, deliberative assessment in which self-conscious acts of evaluation and action are instrumental to producing change (see, e.g., Cervantes and Nardi [2012]).

For much of practice theory, an unconscious cultural substrate of habitual, unexamined practice is assumed as definitive of *what practice is*. Bourdieu's influential formulation of habitus as this substrate of taken for granted schemes of thought and action is its classic formulation. Practice, as Bourdieu says, is "harmonized without any intentional calculation or conscious reference to a norm" [Bourdieu 1977, p. 80]. Stated this way, "practice" excludes or downplays practices in which conscious, reflexive awareness predominates. Shove and Pantzar [2005, p. 44] observe that "Writers like Bourdieu [1984, 1992], de Certeau [1984] and Giddens [1984] ... are alike in emphasizing routines, shared habits, technique and competence. Their crucial point is that practices, as recognizable entities, are made by and through ... routine reproduction." Shove and Pantzar place their own work in contrast to this orientation. Their research on the emergence of Nordic walking in various countries helps us take practice theory forward in understanding the deliberative cultural reflections that prompted the emergence of different forms of Nordic walking in different locales.

Relatedly, Wilk [2009], in a contribution to a recent collection on time, rhythms, and routines in everyday life [Shove et al. (eds.) 2009], augments classic concepts of practice theory (e.g., habitus, praxis) to sketch a taxonomy of the processes by which practices change—or fail to change. Focusing specifically on consumption practices, Wilk divides "the process of absorbing a new form of consumption into two parts: cultivation and naturalization" [Wilk 2009, p. 149]. For Wilk, *cultivation* denotes the "processes which bring unconscious habits ... into consciousness"; *naturalization* denotes the converse [Wilk 2009, p. 150]. This taxonomy raises a range of empirical questions, some of which Wilk asks explicitly. For example, "We have many defences which simply filter out ... cultivating messages [to] keep them from impinging on our existing routines. What is the nature of these defences, and how do they work?" [Wilk 2009, p. 150] Sociologically, how are the processes of cultivation and naturalization, and the habits we choose to cultivate, influenced by our broader ideological context? Technologically, what is the role of designed artifacts in mediating these processes?

To study practices in a manner relevant to collapse informatics is to study changes in practices—that is, changes in "body/knowledge/things-complexes" [Reckwitz 2002, p. 258]. As a result this research offers a broad range of opportunities for empirical work to explore and refine Wilk's [2009]—and other (e.g., Shove et al. (eds.) [2009])—recent conceptual extensions to practice theory.

Fig. 1. Environmentally motivated practice: Bloomington Bike Project. Community members who help build bikes from scrap parts for others are compensated by being given the resources to build bikes for thmeselves.

While not all changes germane to collapse will be prompted through reflexive engagement, this class of cases holds significant methodological valence for collapse informatics. By examining groups purposefully experimenting with practices and their associated technologies that may bear on futures of collapse, we have some chance of developing an empirically grounded sense of what is possible. Analyzing the genesis of changes in practices beyond those that occur as in-the-moment reactions to everyday crises—changes that deliberately transform ordinary practices—is essential to collapse informatics. In short, we want to study practices that themselves are objects of contemplation as well as enactments of praxis (in the sense of everydayness). Taking Gergen's bracing advice, we are called to "liberat[e] the theorist from the press of contemporary pattern," thereby permitting theory to push on "envisioned alternatives" that "engender change" [Gergen 1978, p. 1354].

Compelling empirical analyses of deliberative change have begun to populate the literature. Nathan [2008] and Woodruff et al. [2008] describe "ecovillage" communities and "bright green" families whose practices were organized around hyper-awareness of the impacts of their daily actions and purposeful attempts to live green lives. Participants did not merely enact routines; their actions self-consciously expressed their values. For example, in building a passive solar food drier out of an old refrigerator, an ecovillage community evaluated and articulated the impact of the drier on environmental, social, and economic sustainability [Nathan 2008]. The food drier was a possible-worlds artifact; it served to dry food, but was also designed and used as an object of contemplation of possible futures and assessment of the wider impacts of its use. Woodruff et al. [2008] recounted how bright greens conceived of their homes in unconventional ways—as "alive" or as ships to be kept in tiptop shape. They were constantly thinking deliberatively about action in relation to their homes, such as opening and shutting windows at precise times to minimize energy usage. They described themselves as "mindful" and "aware." Unlike Bourdieu's practices that lack intentional calculation or reference to norms [Bourdieu 1977], the practices of bright greens and ecovillage residents were replete with exactly such calculations and references. Some of these practices exemplify Fry's notions of "redirective practice" and "acts of elimination" [Fry 2008]—potentially transformative practices responsive to environmental concerns. Figures 1–5 are photoethnographic images of various current eco-practices that illustrate the previous discussion. The figures illustrate various forms of present day adaptation, primarily in terms of learning to live with less, or more self-sufficiently.

Figure 1 shows an environmentally motivated re-directive practice. The image shows Bloomington Bike Project, in which community members who help build bikes from scrap parts for others are compensated by being given the resources to build bikes for themselves. The practice is redirective in the sense that it presents an alternative to discarding old bikes and purchasing new ones. This practice is conservationist in a way that illustrates practices that make communities more adaptable to collapse conditions, (i) by creating skills needed to better adjust to possible collapse conditions—that is, eliminating reliance on newly manufactured things and (ii) by serving as an example

Fig. 2. Suburban curbside farming.

Fig. 3. Grow your own food consultancy. A business publicly advertises that it will help clients learn how to grow their own food.

of conservationist practice that may inspire others to adopt this re-directive practice—that is, creating working bikes from parts at hand, rather than supporting the practice of acquiring new things.

Figure 2 shows suburban curbside farming. The conversion of farmland into suburban lawns that accompanied the last decades of suburban and peri-urban development happened over time. Nowadays, this conversion is being reversed here and there in suburban settings by the return of suburban lawns back to small scale, local, organic food gardening. While the scale of these on-goings are a small trend, those who participate target a wholesale dismantling of the apparatus of suburban lawn and landscape maintenance. The picture shows suburban land being converted to agricultural use

Fig. 4. Access to drinking water is an essential element of life at risk under many collapse scenarios.

Fig. 5. Suburban farming. The colorful ribbon is used to fend off deer.

at the curbside, visible to the neighbors and street, as a kind of activism to prompt others to do the same. The renaissance of practice of suburban, and peri-urban, and indeed urban farming is a form of adaptation to certain possible collapse effects, such as ensuring food safety by means of ultra-local supply. The trend and interviews with peri-urban/suburban farmers is described in Blevis and Coleman Morse [2009].

Figure 3 shows a public display promoting a grow-your-own food consultancy. The business advertises that it will help clients learn how to grow their own food. Even at a small scale, this business indicates a trend towards the economic possibilities for adaptation as an enterprise opportunity for instruction about practices that target healthy, organic, safe, and participatory food supply. The picture also appears and is discussed in [Blevis 2010].

Figure 4 shows drinking water flowing from a tap. Access to drinking water is an essential element of life at risk under many collapse scenarios. The practice of filtering water at home is supported by a large industry already in the US, with a variety of systems that promise a variety of resulting water quality. Access to water that is clean enough even to be possibly made safe for drinking by such home filtering is not available in many places globally. Per the IPCC, access to fresh water is a huge issue in terms of the effects of climate change, and the practices associated with fresh water supply are a matter of adaptation to such collapse-inducing effects.

Figure 5 shows another example of suburban farming. In the image, the colorful ribbon is used to fend off deer. Like Figure 2 above, the practice of converting a street-facing lawn to agricultural use is a form of activist practice targeted at inspiring others,

as well as providing a local, organic, safe, packaging-free food supply. The particular suburban farm also grows and sells mushrooms as an enterprise. This suburban farm is also described in Blevis and Coleman Morse [2009].

Are reflexive practices outside the scope of practice theory? We believe that any notion of practice should theorize practices that aim to destabilize and subvert the prevailing habitus. Such theorization seems an essential part of understanding how practices change in ways that overtake the microadjustments to which Reckwitz alludes. Addressing contemporary inflections of such subversion demands fresh eyes. Concepts such as "critique" and "resistance" (e.g., deCerteau [1984]) may apply although we want to empirically confront such practices in the contemporary moment. deCerteau [1984], for example, examines practices of resistance woven into habits of everyday life, while we have seen that it is also pertinent to collapse informatics to investigate attempts to break with everyday habits in a self-aware mode of deliberative action. Thus it is imperative to get up close to practices of destabilization, and develop theoretical descriptors to faithfully capture the spirit of current practices. For example, playful experimentation, extreme mindfulness, or radical tinkering might be closer to the emic sensibilities of relevant groups than classic notions of resistance or critique. A grounded theory approach [Clarke 2005; Glaser and Strauss 1967] will be useful for developing relevant concepts.

### 6.1. Studies of Reflexive Practice

We have some ideas about the kinds of practice-based studies pertaining to futures of collapse as well as to theorizing reflexive changes in practice. We identify two populations of potential interest to collapse informatics: people who believe collapse is imminent and are purposefully devising ways to meet it head on, and people envisioning technological development in ways that we think may fit into a future of collapse. We call the first type "purposefully marginal" as they act outside conventional societal expectations but are not marginalized through economic or other circumstances. The second type we refer to as "technofuturists." They may or may not believe collapse is imminent, and they may self-identify as belonging to mainstream academic or business communities. These groups are examples of sites of investigation we believe will be fruitful. The following discussion identifies these groups as of interest but does not attempt to bring to bear practice theory since we have not yet conducted the research.

*6.1.1. Purposefully Marginal Groups.* All contemporary complex societies maintain a "margin" of artists, free thinkers, anarchists, historically separate groups (such as the Amish), activists, and radical intellectuals, who, for one reason or another, do not align themselves with the propositions of the wider culture. Drawing on sociocultural theory, the practices of these groups can be considered a "contradiction" within society: "a direct coincidence of two polar mutually exclusive opposites" as Ilyenkov writes ([2008], p. 263). In taking up a position "opposite" the mainstream, marginal groups challenge habitus. They may cause serious trouble (such as violent political activists do) but more often they carry the potential to inject a culture with vibrant and necessary new ideas (as the Occupy protestors have done worldwide). Marginal groups may wish to be the vanguard for what they hope will someday be mainstream practices, but at the same time, their critique of society and their distinctive practices inescapably position them at a margin.

Foot and Groleau [2011] (scholars in the sociocultural tradition) theorize the potential of societal contradictions to result in expansive growth. They state: "[T]he general dynamic of contradictions [is] 'growth buds' rather than . . . points of failure, deficits or even problems to be solved . . . Contradictions reveal the growing edges of . . . activity . . . where development is possible and likely to take place." Growth buds emerge within everyday practice; they are neither large-scale norms nor individualistic behaviors.

Purposefully marginal practices create the "buds" of future practice now, in the present, affording empirical access to possible futures.

Our plan is to study a number of groups chosen to represent diversity in potential future practices. In particular we want to investigate practices at different scales: localized practices at small and medium scale, and transnational practices at medium scale. (Other scales are relevant but we believe initial research will profit from focus.) We will also capture diversity in political philosophies, interests, and values.

Let us start with a practice in which literal growth buds are the objective. The practice of aquaponics revives and modernizes ancient water saving techniques combining fish farming and hydroponic agriculture into a unified recirculating system [Rakocy et al. 2006]. For collapse informatics, this practice is an important instance of a sophisticated effort with potentially high output beyond the productive capacities of small scale organic farmers using conventional techniques or the traditional agricultural practices of farmers in nonindustrialized nations planting in increasingly marginal land. Aquaponics has the potential to break the cycle of soil depletion by recirculating nutrients using experimental technologies currently under development. Aquaponics requires capital investment and skilled management [Rakocy et al. 2006] so we imagine that as a midscale practice it has high potential to benefit from digital technologies. We are also impressed by the creativity in the aquaponics community; for example, the practice of growing plants for modern pharmaceuticals is reported in Rakocy et al. [2006].

Not all groups pertinent to futures of collapse are politically liberal, "green," or idealistic. Survivalists are dedicated to developing practices they believe will be useful in conditions of collapse or at least apocalypse. They place less emphasis on technological development and market capitalization than proponents of aquaponics, but their preparations are uniquely responsive to a comprehensive, broad spectrum vision of a changed society. Many (though not all) survivalists envision a future in which authorities such as police and government will be ineffectual, food scarce, communication infrastructure limited, and access to raw materials reduced. As a result, among their concerns is a focus on maintaining communications, power, access to medical knowledge and access to a community with which to exchange resources and skills. ICTs are central to these tasks in current practice. Survivalists often argue for maintaining access to technology from a previous age. In the here-and-now, however, these groups are often using the ICT equipment and knowledge that they are readying in ways that they don't think is noteworthy. For example, creating specialized dating web sites for survivalists, maintaining elaborate rotation calendars for stockpiled canned food and promoting the use and off-grid charging of electric cars for transportation redundancy. Despite the survivalist nostalgia for returning to a more self-reliant age, these current practices are exactly the ones of interest to collapse informatics researchers because they are likely to be the buds from which future practice emerge. In a nonapocalyptic collapse, this will be the material from which survivalists will be working while they continue to prepare for a proximate future that may always be right around the corner [Rawles 2006].

Other groups such as freegans, who promote an ecological agenda through the practice of dumpster diving, indicate how middle class people may radically rethink and alter resource acquisition. People living (mostly) off the electrical grid are experimenting with practices to manage life in the absence of power purchased from large utilities. Zero-waste proponents intentionally experience the impact of not disposing of anything for stretches of time. Zero-consumption lifestyle advocates argue for not purchasing anything for similar stretches of time. While not all of the people who are engaged with these activities are reflecting on technology directly, they are engaging in reflective practice. This engagement has value for understanding what reflective practice looks like from a theoretical perspective. How these groups are using ICTs

consciously or unconsciously offers ideas about future practices in these lifestyles that have hallmarks of collapsed futures. Finally, studying these groups suggests visions for what a reflective practice that *does* focus on ICT use might be like.

We are interested in the everyday practices of these purposefully marginal groups, as well as others. Our questions to these groups will extend beyond the basics to inquiring about practices related to collective emotional, spiritual, aesthetic, and civic needs, as we do not believe any cultural group can thrive in their absence. A small but vivid example of aesthetic activity comes from aquaponics practitioners who have found that flowers such as marigolds and zinnias grow well in aquaculture.

*6.1.2. Technofuturists.* By technofuturists we do not mean academics or pundits who engage in predictive exercises, but those conducting hands-on experiments with new practices of design and manufacture. These are collectives of technically skilled individuals with different expertise and varying degrees of organization that band together to promote future oriented visions to create and experiment with new practices. In many cases the vision is one of assumed destabilization, if not complete collapse. Their formation may arise out of the experience of living in a collapse scenario, through the realization that a collapse scenario elsewhere could easily affect them, or through the observation of events that almost resulted in collapse and which could reasonably happen again.

The visions are often articulated in moral imperatives but they are predominantly intended to be realized through technological artifacts, hardware and software, which become a substrate on which the moral values can be practiced. Although generally useful in niche scenarios in the present, the time, energy and sometimes money that are redirected from present abundance are taken to be justified by their value in a future of scarcity. We consider these groups important because the kinds of technologies they propose could have significant impact on practice, and are intended to do so. Although these groups focus on the technical development of artifacts, it is in the spirit of changing practice; for example allowing ordinary people freedom of expression in repressive regimes.

An example of a technofuturist collective is the FreedomBox Foundation, a nonprofit U.S. Corporation founded by Eben Moglen [FreedomBox Foundation 2012]. This organization coordinates and organizes the activities of global communities working to bring about a future of decentralized communication. A few co-occurring events became the source of their narrative vision. The first was the institutional response to the Wikileaks leak of diplomatic communications in which complicit websites were shut down or blocked. Simultaneously archived and centralized communications in social media were pursued as legal evidence. These actions were interpreted as a repression of free speech that was enabled by the centralization of *corporate* communications services in internet service providers and social media companies. The second event was the filtering and monitoring of internet communications in China, which was and is seen as a repression of free speech stemming from centralized *state* communication infrastructure. A third event was the observation of the Egyptian authorities' attack on popular uprisings by shutting down internet and cell phone infrastructures.

A physical FreedomBox is conceived as a solution. Currently under development, it is envisioned as a box preinstalled with sophisticated encryption, networking, and communication software that when plugged into an outlet configures and connects itself to a global peer-to-peer network immune from centralized points of software control and failure. The moral vision is communicated in terms of privacy and freedom. The engineering solutions are therefore designed to limit practices of eavesdropping and packet blocking. But strategies for the latter are agnostic to whether the blockages are artificially induced by state control or secondarily caused by some other collapse

scenario. In all cases the FreedomBox is designed for a future when crises dominate. The moral niche it is advertised to address in the present is only the rather banal blocking of advertisements.

A similar project colloquially referred to as "Internet in a Suitcase" is being partially financed by the U.S. State Department and by entrepreneurs through public-private partnerships [Glanz and Markoff 2011]. While far less is known about this collection of technologies, it appears to be drawing on many of the same kinds of participants attracted to the FreedomBox project, although the vision is described as one of human rights through free speech. The role of the U.S. government foregrounds the ways in which it would support future uprisings against autocratic regimes. This, plus a number of other projects that are developing mesh networks, are more directly attempting to create parallel hardware architectures to those provided by ISPs by encouraging individuals to relay information for each other (e.g., [Meraki Inc. 2012]). Again these networks are seen as a hedge against lost infrastructure whether through restriction or through destruction. The more a given project frames its vision in terms of infrastructure independence, the more likely other kinds of infrastructure collapse are implicated and subsequently the more likely other resources are necessarily marshaled. For example the SolarMESH project [McMaster University Wireless Networking Group 2012] augments its mesh networking technology with solar power in case the electrical grid is no longer available.

3D printing technologies (e.g., Shipman [2012]) have the potential to localize manufacturing because it is easy to propagate digital designs (probably best accomplished with open design arrangements). While materials such as resin or metal powders would still be needed and might sometimes prove obstacles under conditions of collapse, once-specialized design knowledge would no longer be a bottleneck. While mass production is unlikely to be reborn post-collapse because of this, the knowledge of how to print objects such as firearms, keys, and homemade aerial drones are quite provocative in their potential to alter practice at local levels.

## 7. FUTURE PRACTICE AND COLLAPSE INFORMATICS AS A STRATEGIC DESIGN PROBLEM

Seriously engaging practice studies in collapse informatics means aligning empirical studies of practice of the sort we have described above with a suite of design experiments. We have an important opportunity to design now, in times of relative abundance in many places around the world, building on the wealth of resources and expanding infrastructures brought about by fossil fuels and globalization. In present times, we have the cognitive surplus [Shirky 2008] to design systems for purposes beyond immediate needs and short-term interests, and we have the excess materials and energy to bring these systems to fruition.

The three steps discussed above—expanding the temporality of practice theory, working comparatively, and remaining aware of the constantly changing relationship between present and future—inspire criteria for a method for design practice in collapse informatics. The method of design entails not just iterative development, but iterative planning to adjust to changing and predicted changes to local and global conditions, a necessity which makes design much more complex. In prior accounts of sustainable HCI, there is a claim that design in the context of sustainability involves not just an account of what is invented, but also an account of what is displaced or prematurely obsoleted by an invention [Blevis 2007]. By similar reasoning, collapse informatics design entails not just an account of what is invented, proposed as intervention, or innovated, but also an account of what is implied for changing practices and conditions and the long term value proposition of why this particular invention, intervention, or innovation creates a more effective recovery in the face of collapse than alternatives.

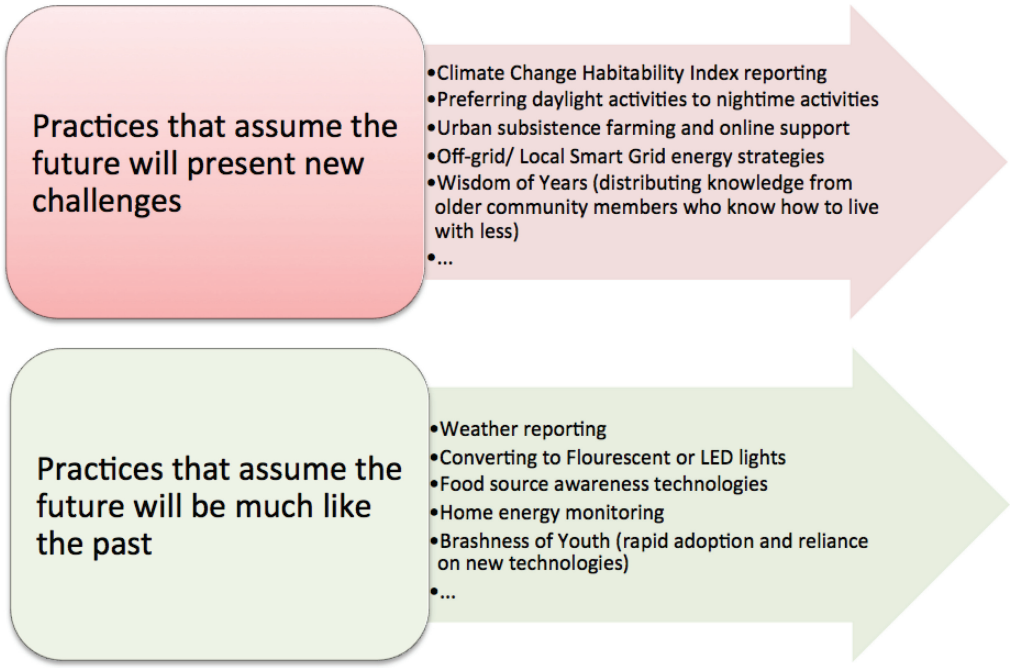


Fig. 6. Examples of practices that correspond to different outlooks concerning potential futures and attitudes towards the possibility of collapse. These and other examples are discussed in greater length in Section 7.

Some of the examples of design contexts that entail this sort of discussion appear in Figure 6.

As we design, we will consider how new designs would impact the practices we observe in purposefully marginal groups. We will analyze and draw from the technologies proposed by technofuturists. Such activities could devolve into sterile exercises. Making them meaningful will not be easy because "users"— beings central to constructions of how to do HCI—do not yet exist within relevant conditions of collapse. We take this difficulty as an opportunity to expand current HCI practice. As Gergen argued, generative research is predicated on not getting too hung up on standards of conventional positivism often deployed so cautiously that they constrain imagination and creativity [Gergen 1978]. Gergen invoked not wild-eyed experimentation or lack of respect for rigor, but stepping out of the safe zone of conventional approaches that produce only normal science. Careful integrative analysis across ethnographic study and design practice is essential to collapse informatics.

### 7.1. Design Practice

As we examine purposefully marginal groups and technofuturists, a parallel design effort will address design practice, seeking innovative means of designing for possible futures. Considering how much the literature about sustainability has changed in only the past half decade since the 2007 IPCC report [IPCC 2007]—with a new report due in 2013—it will be incumbent on us to be diligent in charting secondary sources, both scientific and popular, as a form of tracking changes and trends over time that bear on collapse. This effort is needed to avoid going "down the rabbit hole" of intensive, focused ethnographic studies of practice. A forcing function to keep localized studies situated within larger framings will serve to connect investigations of practice with ongoing debates, societal changes, and evolving conditions. Studies of practice are powerful

because they document and reveal nuance, detail, and lived activity. But collapse must also be investigated in the context of the currents of societal change and discourse within which practices exist and develop. We noted that part of our methodology will be to monitor and calibrate research sites across time with the checkpointing strategy. This is a critical methodological move to attempt to bind localized studies to the larger conditions that affect them. We will construct diagrams, particularly semantic differentials, and graphics that classify the literature and track emergent trends, inventions, and pertinent national and global events.

### 7.2. Application Ideations and Context Scenarios

The following are unimplemented "fictional abstracts" for research projects that serve as ideas we hope others will take up, or which we ourselves will investigate in future work. These ideas/scenarios illustrate the range of what may be possible in terms of collapse informatics. For each of these ideas, we demonstrate how it is relevant to the strategic design effort.

The "Climate Change Habitability Index" is a design sketch of a system to help people understand how local conditions in various locations are tied to global climate change. The "Wisdom of Years" is an idea for augmenting an application like the CCHI, by providing the knowledge for changes in practices that arrive together with the changes in conditions that the CCHI reports. "Local Smart Grids" is an idea for achieving transparency in energy sources as a matter of motivating community scale and large energy practices. "Currency, Infrastructure, and Practice" is an idea for using the properties of alternative digital currencies to explicate the ways in which existing currencies support nonfinancial social practices.

*7.2.1. Climate Change Habitability Index.* As a detailed example of practice-directed interaction design targeted at adaptation to collapse, we describe the Climate Change Habitability Index (CCHI) in this section. Notions of how localized conditions such as weather, growing conditions, population density, health conditions, and other matters may not be adequately connected—as a matter of practice—to global conditions induced by climate change. The true costs of localized practices may be externalized or unrecognized in present day practices. The CCHI seeks to change this practice by connecting local conditions to global trends with respect to informing changes in practices over longer time horizons, as a matter of adaptation to globally changing conditions.

The Climate Change Habitability Index (CCHI) is a design exercise and catalyst to a program of ongoing research. The idea of the CCHI is to allow ordinary individuals in general—rather than climate scientists in particular—to understand the state of the world in terms of habitability at particular places. As interpreters of science and the alarms of the majority of the scientific community, interaction designers may focus on mechanisms of awareness that educate nonscientist individuals and groups about the possibility to balance awareness of energy use as a matter of sustainability with planning for what happens if the effects of climate change begin to accelerate.

The issues that may be presented in the things we design are no longer just matters of lowering your own carbon footprint, but now include (a) becoming aware of the implications of various energy production choices that best serve the possibility of mitigation of climate change; (b) highlighting local knowledge and abilities to plan for and deal with local effects of climate change; (c) promoting awareness of what is happening globally as a matter of planning for humanitarian responses. In the face of climate change, individuals and practice communities will need to be able to use the CCHI and other measures to answer questions like (i) can we continue to live where we live, (ii) where can we move if we can't continue to live where we are living, and (iii) how many people can the place where we live sustainably support, if where we live

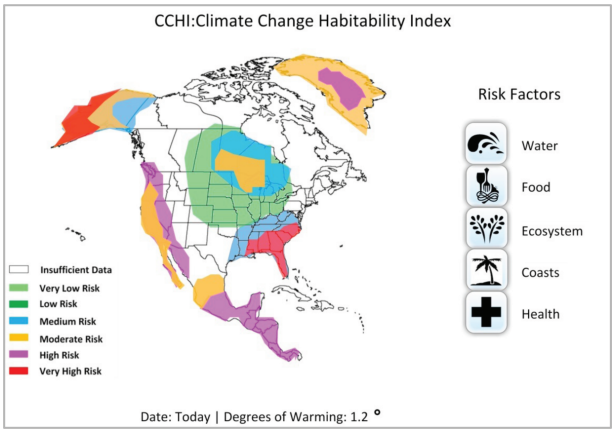


Fig. 7. CCHI view on a specific day given a specific amount of warming. Illustrative data only.

continues to be habitable, and how do we muster the community to share our resources with newcomers? The CCHI needs to be stated in a way that is as easily understood by ordinary people as other summary reporting such as weather forecasting. Like response to and preparedness for potential weather disasters, the CCHI needs to operate at civic levels of practice—neighborhood, town, city, state, national, and international.

The CCHI is defined abstractly as a metric that can be stated in ordinary language and diagrams and that allows people to answer the preceding three questions related to sustainability and adaptation to climate change about particular places on Earth.

The notion of making the habitability index as highly accessible as a notion like "temperature" is co-requisite to the social imperative to provide for the safety and security of every person and creature whose life or home may be impacted by climate change events and effects. In [Pan et al. 2010], we describe some of the potential data sources.

We are designing a tool to support the summarization of the suitability of any particular place for habitation as a dynamically changing metric corresponding to historical, current, and predicted states of water systems, ecosystems, food supplies, coastal conditions, and health conditions, as well as the likelihood of hazard events. Interactivity of the habitability index may be presented using cloud-based technologies, such as layers implemented as part of the "Google Earth" or "Google Maps" application programming interfaces (APIs), or other geographic information systems (GIS). Figure 7 shows the essential interactivity elements we imagine are needed to support interactivity with the CCHI representation as a cascading summary of more detailed data. Our design is deliberately minimalist and it is easy to image a gray scale version as a matter of accessibility. The regions defined in the map denote a cumulative summary of the risk factors indicated by the risk factor icons.

Another two essential features of CCHI are time and degrees of warming (or cooling). Our purpose is to allow people to see historical trends and future predictions about how climate change affects our Earth over periods of time. People need to be able to see what the Earth may look like when the average temperature increases by a specific amount which in the IPCC summary diagrams (IPCC [2007], p. 7) ranges from 0 to 6 degrees Celsius of warming. 2 degrees Celsius of warming is generally considered to be the dangerous tipping point. Figure 8 illustrates as a matrix the space of what needs to be represented apropos of time and degrees of warming historically and in prediction as underlying data to support the interactivity. Based on the assumptions of the IPCC

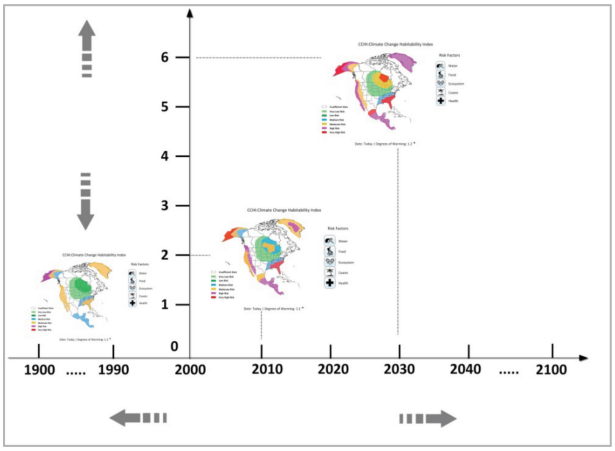


Fig. 8. Matrix of possible CCHI maps at different times and degrees of warming. Illustrative data only.

reports, we define year 2000 to be the base point and set the temperature change to be 0 for 2000, relative to the period from 1980–1999 [IPCC 2007, p. 7].

One primary goal of the CCHI is to serve as a powerful collective tool, that is to target a wider audience than climate scientists, local policy holders, planners, and managers—namely individuals in the general public and societal groups at various levels, from civic, groups and municipal officials to regional, national, and international bodies. We also hope to include formal scientific data resources as well as crowdsource reporting and the wiki-style editing of data about global habitability conditions. The latter form of data collection risks confidence in the data compared to peer-reviewed reporting by the scientific community, but so long as such contributions are clearly demarcated, they also have the benefit of involving the public, raising awareness, and prompting debate.

*7.2.2. Wisdom of Years.* Many older adults now use the Internet. Given their varied life experiences, individual members of this community may have collapse-relevant knowledge of practices that younger people typically lack. This project would seek to record videos of older adults recounting practical information about specific topics, ways of living, and ways of working with various artifacts—either in response to requests made by members of the online community, or based on elements that they themselves believe may be of use to others. These videos would be uploaded to Youtube or a similar site, and would then be tagged with such features as what human need they serve and what current ways of living they could potentially supplant, and collaboratively filtered for quality and relevance to various collapse-related topics. By documenting the details of practices from years past, older adults may be able to provide valuable information about ways of living in the world that are less resource-intensive than current everyday practices. Such knowledge has the capacity to impact new (or newly rediscovered) practices in important ways by drawing on deep wells of experience. Figures 9 and 10, which record old world knowledge and practice of gathering edible flowers as central ingredients to a meal, are here used to illustrate the Wisdom of Years' potential.

The Wisdom of Years project is strategically significant as a design effort because it helps illustrate the numerous alternate ways that people can live. Because each video would be tagged with the lifestyle choices that it supplants, it would make explicit the acts of substitution implied in the videos themselves. And as everyday practices changed, the project could serve as a repository of potential futures.

Fig. 9. Gathering black locust tree flowers behind a strip mall.

Fig. 10. Using the flowers to make a meal.

With systems such as the Wisdom of Years, it may be relevant to deploy them on platforms that do not rely heavily on ICT infrastructures. For example, in a future where energy to power electronics is scarce, users might benefit from a print-out of a transcript augmented with printed screen shots.

*7.2.3. Local Smart Grids.* A great deal of research has explored the use of smart electrical grids for increasing energy efficiency, and tracking energy usage for a variety of other purposes. However, the bulk of this research focuses on centralized grids used by large-scale institutions such as power companies or universities. Despite this focus, many of these advances may be able to be applied to local power contexts such as off-the-grid communities and self-sufficient survival retreats. Everyday practices in these contexts tend to operate under much more stringent constraints on power; as such, they would benefit from intelligent power tracking and management. This project would explore how sensing, measurement, and control techniques developed for large smart grids may be adapted to help local smart grids address canonical concerns in renewable energy such as the intermittency problem, in which energy sources such as solar or wind power vary dramatically based on cloud cover, time of day, etc.

By seeking to replace some or all of the need for centralized power, this project obviates several phenomena with implications for people's everyday practices. Modern power is currently largely invisible to those who harness that power; plugging devices into a wall is so close to free that people rarely concern themselves with it, and filling a car with gas is decoupled from the many small trips enabled by each tank-full. Localized

smart grids could reduce the current ability for many people to ignore the provision of power, and thereby also help reveal alternatives to current practices based on the universal availability of power taken for granted in many cultures.

*7.2.4. Currency, Infrastructure, and Practice.* Societies require the storage of value using media of exchange such as currencies in order to enable the easy transfer of seasonal and localized work across time and distance. Currencies typically require exchange participants to trust the issuer of the currency as well as the validity of the physical currency itself. The social and physical infrastructure of currency, however, enables the central authority to act in other gatekeeping roles as well. For example, flows of money across national borders are restricted, tax structures can be enforced, and a primary crime can be effectively punished on the basis of tax evasion as a secondary crime. When the trust in the centralized authority of the physical currency fails, not only does the currency system fail but so do the gatekeeping roles as well. To the degree that these gatekeeping roles are not typically considered as the reason why currency exist, but rather emerge out of the practice of using currencies in the infrastructural context, they can be considered part of the practice of using currency. When new forms of digital currencies are proposed to account for collapse-like scenarios (e.g., bitcoin's resilience to hyperinflation (see https://en.bitcoin.it/wiki/Controlled_inflation)) they are framed in terms of the explicit roles of monetary storage and transfer. But even very small changes in the properties of currency can have enormous impact on current practice. For example, a digital currency that supports anonymous transactions makes blackmail and tax evasion much easier. This project would first connect the ways in which practices around existing monetary structures are tied to features of the currency itself. Then it would seek to observe the impact on those practices when the currency features change in emerging currency markets and how the people respond. Finally new practices in emerging currency markets will be studied to understand how the sociotechnical environment around collapse compatible digital currencies needs to be designed for the critical role of money to function.

## 8. CONCLUSION

This article discusses the possibility that global industrial civilization may enter a period of collapse, rather than indefinitely continuing the growth that has been its hallmark for much of the past two centuries. We propose that it is now appropriate for CHI researchers to begin exploring how our discipline may help to address the problems that would be likely to arise in such a scenario.

In this article, we have defined collapse informatics as encompassing the study, design, and building of ICT and sociotechnical systems in the abundant present for use in a future of scarcity. Work in this area would seek to serve basic human needs, situated in particular contexts and habitats. We have drawn connections between collapse informatics and practice theory and provided a selection of potential practice-oriented projects that would be relevant to this domain.

In addition to the projects outlined above, a variety of research trajectories can contribute to the further development of collapse informatics. First, more work is needed to understand the details of how previous studies of collapse and various collapse scenarios may influence the goals and processes of collapse informatics as a genre of research.

Second, there are abundant potential projects in this area, across a wide variety of human needs, contexts, and habitats. The selection of practice-oriented ethnographic studies and fictional abstracts above provides just a small sampling of the wide range of potential research efforts that could be undertaken, and that could help improve human quality of life in collapse contexts.

Third, the question of how best to evaluate collapse informatics projects is of critical importance. The particular challenges of this class of design problems make evaluation an exciting area for future research.

Finally, there may be ways that collapse informatics can lay the groundwork for research outside of HCI pertaining to collapse, providing new kinds of collapse-compliant infrastructures that support efforts in other domains. To use a term from economics, computers are powerful "general purpose technologies"—their ability to amplify human efforts could have a profound effect on a range of other disciplines.

While we see collapse as an unfortunate potential future, it is one that humanity's current ways of living make increasingly likely. There are many efforts afoot across many disciplines to enable sustainability; however, these efforts are often diametrically opposed to the culture of growth and consumption that pervades industrialized society. Perhaps by thinking now about life after collapse, we may both prepare ourselves for such an outcome, and also make that outcome less likely.

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