Towards a (Socio-ecological) Science of Settlement: Relational Dynamics as a Basis for Place

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Abstract Cities are increasingly garnering attention on the global political stage, in light of the challenges and opportunities urbanization engenders for transition along sustainability and resilience pathways. Recently adopted as a target for change within sustainable development agendas, and recognized as central socioeconomic vehicles by which to mobilize related initiatives, the significance of urban systems to transition becomes most evident if we conceptualize them as being integrated within broader systems of settlements. Settlements are complex adaptive socio-ecological systems, which together as globalized networks embody the complete range of human-environment interactions and the complexity that has emerged along with these, over time. This framing is inspired by science of cities research and the dwelling perspective, both of which have elaborated on cities/settlements' (1) coupled social-ecological-technological phenomena, (2) fundamental nature and function, (3) embodiment of scale-/network-based processes, and (4) emergent, multi-scale patterns of organization and impact. Ultimately, this could inform a relational approach to both sustainability and settlement planning, guided by analyses of these factors. It could also complement the burgeoning inclination in science and design disciplines to deconstruct the reflexive interactions that can occur between processes and forms, meaning and matter, people and places, the ephemeral and the concrete, the normative and the positive. By this means, we begin to invert our systemic design problem space, turning attention away from our constructed worlds, instead contemplating the ways of life they enable, in an integration between research and practice, observation and intervention, analyses and innovation, scholarship and poetics.

Introduction

Through systems and complexity thinking, so much sits between sliding doors. By this, I mean that phenomena or issues can be difficult to isolate—as we seek to work with one, we may find ourselves, inadvertently, slipping into the territory of others.

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This is the challenge of boundary definition (Cilliers, 2007; Midgley, 2000, 2003), which may complicate project planning for those who prefer to establish fixed targets for change. However, if we let our thinking gently migrate between the borders of complex issues, periodically reorienting our foci within wicked problem spaces, we may discover interconnections between phenomena of which we were not previously aware and means of combining efforts across disciplinary and sectoral initiatives. How we choose to describe (concepts/theories) and engage (methodologies) with a problem area is just as significant as the solutions we propose (applications). Creative approaches to problem solving are evermore necessary (Berkes, Colding, & Folke, 2003; Waltner-Toews, Kay, & Lister, 2008) as we make our way through what has been positioned as a critical juncture or point of climax in human history (Steffen, Broadgate, Deutsch, Gaffney, & Ludwig, 2015; Wilson, 2002). To traverse this passage, societies in every nation are being called to the frontline of planning for transition along sustainability[1] and resilience[2] pathways, by default of the various pressures being placed on global socio-ecological systems (Helbing, 2013; Homer-Dixon et al., 2015). This intersects with an emerging and prominent narrative that we have entered a new geological era of the Anthropocene, wherein human activity is causing impact on planetary systems at unprecedented rates and scales (Olsson, Moore, Westley, & McCarthy, 2017; Steffen, Crutzen, & McNeill, 2007).

Many of these tensions have been analysed, for example, as pertaining to biodiversity loss, climate warming, extreme poverty, and reduction in cultural diversity (Homer-Dixon et al., 2015; Steffen, Broadgate, et al., 2015; Steffen, Richardson, et al., 2015); however, recognition of these is only one step in their resolution. Related areas of inquiry and practice acknowledge that pertinent challenges for transition are often multifaceted, interconnected, wicked, complex, and inherently difficult to define or solve (Berkes et al., 2003; Curran, 2009; Gallopín & Raskin, 2002; Gibson, 2016; Loorbach & Shiroyama, 2016). They also depict the non-linear processes of systems fluctuation or transformation that are common in complex problem domains (Gunderson & Holling, 2002; Holling, 2001; Scheffer, 2009; Walker & Salt, 2006). While it is increasingly apparent that these dynamics and uncertainties circumscribe conditions for transition management[3] (Rotmans & Loorbach, 2009), we are still honing the approaches by which we can effectively act on this understanding or cope with complexity for the benefit of sustainability and

[1] *Sustainability*: This term was sanctified in the Brundtland Commission's report, *Our Common Future*, wherein sustainable development has been defined as that which "meets the needs of the present without compromising the ability of future generations to meet their own needs" (Brundtland, 1987). Or as Gibson (2016) has summarized, more recently, "We can begin by treating sustainability as current language for lasting wellbeing and exploring what pursuing lasting wellbeing entails" (p. 3).

[2] *Resilience*: "The capacity of a system to absorb disturbance and reorganize while undergoing change so as to still retain essentially the same function, structure and feedbacks, and therefore identity…" (Folke et al., 2010, p. 20).

[3] *Transition*: "A transition is a radical, structural change of a societal (sub)system that is the result of a coevolution of economic, cultural, technological, ecological, and institutional developments at different scale levels" (Rotmans & Loorbach, 2009, p. 185).

resilience. With respect to cities, or human settlements, our sensibilities in this regard are maturing, as we continue to refine conceptualizations of urban systems—an effort that has found its way through diverse fields of scholarship since early civilization (Portugali, 2000). Urban and human settlement systems are slippery to characterize, as is their relevance to sustainability and resilience problem domains. There is much that could be written about the nature, form, function, and evolution of these systems, without any direct reflection on their position within and relationship to the biosphere, and not all planning theory will emphasize this aspect. However, if our goal is to achieve closer alignment between urban planning and transition agendas, developing portrayals, analyses, and plans of cities as *complex adaptive socio-ecological* systems[4] would seem to be the most logical approach (see Elmqvist et al., 2013a; McPhearson et al., 2016; Sassen, 2009; West, 2017).

Cities, on more than one occasion, have been brought into the spotlight of sustainability discourse (Bulkeley & Betsill, 2005; McCormick, Anderberg, Coenen, & Neij, 2013) and were recently adopted as an independent area of focus within the global agenda for sustainable development (United Nations, 2015b). However, there is something even more essential about human settlements (and therefore cities) to sustainability and resilience problem spaces than contemporary debates convey. Arguably, the doors between these fields of inquiry and action are sliding. While they (settlements and sustainability) may have emerged and progressed along distinct tracks (i.e. through discourses such as limits to growth and praxis such as urban planning), each with its own set of professional customs and political mandates, at their roots, they are quite close as intellectual and practical challenges. When we speak only of *applying* a sustainability (or resilience) approach *within* cities or settlements, we under-represent the parity between them, in effect, narrowing the scope of transition efforts to classic urban issues, as they are expressed within confined geographical boundaries (see Bulkeley & Betsill, 2005; Elmqvist et al., 2013b). This inadvertently frames the problem of urban transition on terms that would limit our ability to imagine transformative solutions. The coupled social, ecological, and technological dynamics of settlement systems are evident (McPhearson et al., 2016), as is their concurrent dependence and impact on the natural environment (McDonald, Marcotullio, & Güneralp, 2013); still, even these points do not quite capture their significance to sustainability (and resilience) issues. To comprehensively and accurately articulate the similarities and intersections between these fields (settlement and sustainability), we require an open position in the definition of each.

Fundamentally, both are concerned with how human populations have organized within the biosphere, over time, in an effort to survive and thrive; or, how we have

[4]*Socio-ecological Systems*: "The evolving world system can be considered a socio-ecological system, comprised of environmental and human subsystems and their interactions. The environmental subsystem, in turn, is composed of ecosystems, biophysical processes and other aspects of the natural world. The economic system includes capital, labor, other inputs, and the production processes in which they are used. The social subsystem includes consumption patterns, demographics, and culture" (Gallopín & Raskin, 2002, p. 5–6).

chosen to *dwell* within this home planet. Settlement(s) is the substantive process and outcome of this ordering, while sustainability (and resilience) is a condition of it, whereby the ways in which we inhabit the biosphere could be more or less conducive to maintaining socio-ecological systems integrity and lasting wellbeing. Human settlements (and therefore cities) are pivotal within sustainability and resilience problem spaces because they are an encapsulation of human dwelling within the biosphere. The socio-ecological systems complexities we now confront and critique, given the uncertainty of their long-term viability (Meadows, Randers, & Meadows, 2005), are primarily a product of our changing globalized patterns of dwelling (see de Vries & Goudsblom, 2002). The broadest stance we could take in our definition, then, is to argue that *settlement* and *settlements* embody(ies) the complete range of human-environment interactions, and the socio-ecological systems complexity that has emerged out of these, over time. As an intellectual premise, this is mundanely simple. Yet in practice, when operating in systems that are conventionally divided by disciplinary or sectoral categories, it is anticipated that such a description could be disruptively integrative; or, when analysing systems that are unmanageably complex, it could be refreshingly astute to orient around a straightforward idea. Effective problem framing could serve to organize interpretations of multiple layers of systems complexity, without compressing their nuances. Generally, this has been the role of science—to reveal similarities and patterns across variations on comparable phenomena. Through efforts to develop a science of cities/settlement, research-practitioners continue to search for the fundamental properties and dynamics of urban systems, whether quantitatively, qualitatively, or heuristically (Batty, 2013a; Doxiadis, 1974; Portugali, 2012a; West, 2017). Thus, urban transition can be prefaced and inspired by reconceptualizations of urban systems—ones that would entail syntheses of analyses across more than one field. At present, we struggle to reconcile the place of urbanism within visions for a sustainable future. Arguably, this alignment could emerge through examination of the deep-seated overlap between sustainability (resilience) and settlement challenges. As we continue scholarly and practical efforts to interpret the enigmatic nature of each, sustainability (resilience) and settlement(s), we may find ourselves solving problems within the territory of the other.

At the fifth *Relating Systems and Design Symposium* (RSD5), keynote speaker Humberto Maturana (2016) put forth a similar proposition: That we could distil most environmental and social justice concerns to a single question, "how do we want to live together?" His suggestion implicitly juxtaposes sustainability against settlement while opening the door for broader inquiry into the format of human life. Maturana has left the *how* unqualified: It could refer to anything from morality to community, to policy, to infrastructure, and so on. We could respond to his question with classic design initiatives, such as the development of shelter and urban places. However, it also compels interdisciplinary and transdisciplinary approaches—specifically, those which combine analyses of human ways of life with those of the systems that support them: the ephemeral and the concrete, the fill and the structure, the immaterial and the material, the intangible and the tangible, the processes and the forms, the people and the places, the normative and the positive. The latter

have been the predominant points of entry into conventional design and planning projects (Ingold, 2000; West, 2017), though this is giving way, as we designers extend our scope of interest to work in the territory of user experiences, services, social innovation, and sustainability transition (e.g. Irwin, 2015; Tonkinwise, 2015). Breaking from a preoccupation with form is necessary to hone designers' involvement in the sustainability/resilience problem space. In the case of human settlements, it is not the artefacts that require reform as much as what these systems represent, how they function, and the behaviours they permit or constrain. Maturana's (2016) question is timely, as industrial civilizations evaluate the socio-ecological systems pressures, risks, and vulnerabilities we have propagated in the name of human progress. It is also profound in that it reduces multiple complex issues to a simple line of inquiry—one that could cross into territory as routine as city building and as remote as the nature of human nature. Settlements are a support system for human life, as well as a self-organizing and emergent outcome of it. By situating these two interests (settlement and human life) within the same research and development programme, we could reduce redundancy within the transition problem space and reveal insights about one through exploration of the other. In effect, we would be stripping away conceptual complexity where it does not serve us, and engaging with settlements as a tractable forum wherein which we might secure at least an operational grip on systems change, across a range of factors.

Sharing its historical development with the fine arts, those in the design field have a proclivity for the philosophical as well as the poetic; we pontificate on ways of looking at the world to guide our approaches to creating, or co-creating, within it (i.e. Alexander, 2002–2005). At the same time, design thinking and practice, to various degrees, have attempted to adopt the methodological rigour of the sciences in problem solving (Cross, 2007; Edmonson, 2007/1987; Simon, 1996/1969). Jacobs (1961) has reminded us of the need for both in city planning. A city is artful though not a work of art; it must, in her words, be illuminous of and ennobling to everyday life. This chapter engages with the dwelling perspective, as initially introduced by Heidegger (1993/1971) and later expanded by Ingold (2000), to serve as a bridge between both art and science; to connect the intellectual and practical domains of human quality of life, settlement, and transition along sustainability and resilience pathways; and to ground urban planning and design decisions in a sense of our own embeddedness within the biosphere community. Its origins (by Heidegger) are phenomenological and poetic and offer an interpretation of the meaning of building as an extension of our being in the world. Its subsequent variation (by Ingold) integrates anthropological and human ecological influences to evoke processes of building (and dwelling) that are nothing short of complex and adaptive. In describing the co-evolutionary, embodied processes by which the built environment emerges, the dwelling perspective carries tones of design, planning, sustainability, resilience, complexity, and socio-ecological systems thinking. So too does it challenge us to reconsider the intrinsic nature and underlying functions that epitomize and drive the existence and development of settlement systems. In these ways, it contains seeds that could inform an integration between science and design, research and practice, observation and intervention, analyses and innovation, and as the conceptual basis for a socio-

ecological science of settlement. Some of the ideas explored within this chapter were reviewed in collaboration with the systemic design community, through two conference workshops (Ruttonsha, 2016a, b).

Cities: Sustainability

Settlements are a curious breed of human manifestation. More accurately, they are clusters of manifestations—some constructed, some emergent, some coordinated, and some self-organized—which appear together as generally cohesive systems. This is their paradox: Settlements are both planned and self-evolving systems, artefacts and dynamic systems (Batty & Marshall, 2012; Bretagnolle, Pumain, & Vacchiani-Marcuzzo, 2009; Portugali, 2016; Zamenopoulos & Alexiou, 2012). Cities have been framed as wicked, complex, inherently social, and key to sustainability transition (Castells, 2008; Pflieger, Pattaroni, Jemelin, & Kaufmann, 2008; Portugali, 2016; Rittel & Webber, 1973; Sassen, 2009). Sustainability challenges have also been described as wicked, complex, and inherently social (Curran, 2009; Gallopín & Raskin, 2002; Gibson, 2016; Rees, 2010, 2017; Wilson, 2002); additionally, international sustainable development agendas have recently granted more significance to cities as an area of focus (United Nations, 2015b).

With the Brundtland Commission's 1987 report positioning city planning as a prospective channel by which to achieve sustainable development, and the United Nations more recently incorporating a city-oriented category within the 2015 Sustainable Development Goals (SDGs), a unification of purpose between sustainability and urban planning has been underway for nearly a half century (Bulkeley & Betsill, 2005; United Nations, 2015a). However, there is a question of conceptual hierarchy to be addressed: Are settlements a practical point of entry for transition initiatives, or do they also embody something more, such as the extent to which human communities have en(dis)abled what we would deem to be sustainable ways of life, over time? Contemporary debates exploring the relationship between cities (settlements) and sustainability (resilience) recognize that urban systems are both locations and vibrant actor networks: "Cities are entities in transition themselves as much as that they are the spaces within which novelties emerge" (Loorbach & Shiroyama, 2016, p. 4). In the section that follows, I suggest this indicates the presence of two overlapping, though distinct, positions on how we could frame and work within the arena of urban transition: two positions which predicate a third. It is this third position—that settlements are complex adaptive socio-ecological systems, which embody the full range of human-environment interactions—which I argue is most central to aligning sustainability (resilience) and planning agendas. There are reasons to focus on cities (as opposed to smaller settlement systems or larger national systems) in transition planning, given how their certain qualities and impacts are magnified at scale, while being organized within ranges that are manageable for immediate and tangible interventions. So too have the implications of global urbanization trends provided impetus for review of municipal policy and planning approaches.

Much of the literature referenced in this chapter is urban-centric, though it is not intended to promote urbanized systems as a panacea for the future of sustainability. Rather, we could say that urban systems have become, of late, somewhat of an attractor for sustainability action, if only because they are seen as dominant or unwieldy. This leaves scholars and practitioners debating appropriate objectives, analytical tools, and pathways for urban transition, while also working to justify the relevance of cities to international sustainability agendas, more generally. Here, the author proposes that the significance of urbanism is understood best by examining its role within global socio-ecological networks. With the aim of contributing to a socio-ecological science of settlement, this chapter groups all settlement types, including cities, into one family, such that we might address related issues against the backdrop of what is evolving into globalized, networked systems—ones that are, notably, urbanized. The proceeding section progresses, first by discussing the general context compelling the advancement of a socio-ecological science of settlement within an urbanizing world (cities as tension) and then by outlining three positions on the relevance of cities to transition along sustainability and resilience pathways (cities as target, cities as traction, cities as embodiment). This typology is offered as an exercise in problem framing and has been derived through a reading of select discourse, coalescing recently to connect cities with international sustainability transition programmes. Each of these categories is seminal to urban transition discourse, though they will have different implications for the kinds of interventions pursued and the institutionalization or self-organization of related action. The final category reveals the closest parallels between urban and sustainability planning, and also illuminates why cities are most interesting when analysed in reference to their position within systems of settlements. If present explanations of the relationship between cities and sustainability are ambiguous, this may be indicative of another pivotal challenge for transition: To understand the connections among the numerous complex, cross-scale phenomena that characterize sustainability and resilience problem spaces.

Cities as Tension

There has been increasing international interest to place cities at the centre of sustainability transition, oriented around a general sensibility that they are the problem and solution to, or opportunity and challenge for, related concerns (UN-Habitat, n.d.; Elmqvist et al., 2013a; Ernston et al., 2010; Seto, Sánchez-Rodrígez, & Fragkias, 2010; West, 2017). More provocatively, it has been suggested that “The future of humanity and the long-term sustainability of the planet are inextricably linked to the fate of our cities” (West, 2017, p. 214) (also see Sassen, 2012). A few common arguments shape this conversation, namely, which emphasize the high percentage of world population located in urban regions (United Nations, 2015a); the stress of urbanization processes on global social and ecological systems (Elmqvist et al., 2013a); the debated links between urbanization and socioeconomic growth

(Fragkias et al., 2013); the considerable levels of resource demand and consumption, as well as carbon emissions, attributed to cities (Grimm et al., 2008; Loorbach & Shiroyama, 2016; Madlener & Sunak, 2011); the concurrent economies and diseconomies of scale enabled through urbanism (Batty, 2013b; Bettencourt, 2013a; Bloom, Canning, & Fink, 2008; McDonald et al., 2013; West, 2017); the social, political, and economic centrality of municipalities (Lane, Pumain, & van der Leeuw, 2009; Sassen, 2012); the extent to which our most prevalent issues of unsustainability take stage within urban contexts, especially as tied to the sociotechnical systems required for their operation (Florida, 2014; Loorbach & Shiroyama, 2016; Sassen, 2009; Tanguay, Rajaonson, Lefebvre, & Lanoie, 2010); and the potential to combine urban growth planning with other sustainability initiatives (Angel, 2012). This is the basic diagnosis, and as would be expected, the issues and opportunities under discussion are cross-cutting. However, despite a wealth of enthusiasm and debate within the field, still under-defined is the scope of change warranted to arrive at a sustainable future or how closely cities of tomorrow will resemble cities of today.

Resilience, social innovation, and urban transition literature all distinguish between incremental, adaptive change and radical systems transformation (Folke et al., 2010; McCormick et al., 2013; Rotmans & Loorbach, 2009; Westley & Antadze, 2010). In resilience thinking, magnitude of change is described with reference to a shift from one regime, or basin of attraction, to another, or conversion to a fundamentally new ecological, economic, and/or social system (Folke et al., 2010; Scheffer, 2009; Walker & Salt, 2006). In a similar vein, elsewhere (Ruttonsha, 2017), I differentiate between sustainable design and design for sustainability, with the purpose of examining relationships between design, innovation, complexity, and emergence. Sustainable design engenders a conscientious approach to practice and could be incorporated in any conventional design project, from building retrofits to green space development. As designers, we can adopt a sustainability mindset (or principles) without really changing the scope or focus of our practices. By extension, design for sustainability infers the application of design-based concepts, methods, and tools to grapple with a range of complex and interconnected phenomena, in addressing systems transformation, more broadly. With *sustainable design*, we might seek to improve the energy efficiency of the built environment; with *design for sustainability*, we might restructure its organization and socioeconomic function, within the urban plan, to permit an overall reduction in energy use. Here, the concept of upstream versus downstream approaches to sustainability planning is also relevant. In downstream approaches, we might mitigate the environmental impacts of human action—with initiatives such as recycling programmes—while in upstream ones we may attempt to prevent these impacts from occurring in the first place, for example, by developing products with minimal to no packaging (see James & Lahti, 2004). Namely, it is a fancy metaphor that encourages targeting solutions at the root causes of issues. However, where social, ecological, and technological factors are significantly entangled (which would certainly be the case in cities), our view and pathway out of the systems we inhabit may be obscured. The root causes of the urban sustainability dilemma are buried within complex socio-ecological relationships.

Design for sustainability, or upstream planning, need not entirely supersede sustainable design, or downstream planning, as the latter could lead into the former. The built environment can show us how. For example, using embodied energy calculations, Mazria (2003) has estimated the built environment accounts for 48% of total energy consumption in the United States. This figure is presented in a pie chart he created as an alternative to sector-based statistics on energy use and emissions, which are typically divided into the categories of transportation, industry, residential, and commercial. In his chart, Mazria folds residential, commercial, and part of industry under the new category of "architecture," to draw attention to the impact of built forms, building materials, and construction processes, as they are contained within these sectors. He has recommended targeting existing buildings, along with new development, as significant points of traction for energy transition. His approach to building reform is consistent with the conventions of sustainable architectural and engineering practices; however, he has also justified the work as pertinent to local and national energy policies, thus elevating it to a macro-level strategy. For Mazria, targeting the built environment in this way would represent a paradigm shift in how we analyse and manage national energy consumption, not simply a design imperative. As such, he has adapted a classic sustainable design programme with a broader view to designing for sustainability. At the same time, we should bear in mind that with every building retrofit we undertake, we recommit to the existence and placement of this form within the urban plan—a plan which will influence how we, as citizens, move through and engage with spaces of residence, leisure, and business. Designing for sustainability is a little like manoeuvring a sliding tile puzzle (or as Mazria has described, a Rubik's Cube), wherein we must determine the appropriate sequence of interconnected moves by which to arrive at a desired, yet only partially apparent, outcome. Seeking to improve the energy efficiency of the built environment is, no doubt, essential to sustainability strategies for cities; however, our pursuit of transition along these parameters should not offset simultaneous probing into the organization and function of the built environment, more generally, and the implications of these factors on resource consumption or quality of life.

The relevance of urban spatial layout to energy consumption is most apparent through the lens of transportation planning. Thus far, work in this area has taken advantage of the complete down-to-upstream planning gradient. At the bottom of the stream, we have options to reduce the ecological footprint of automobile technology; farther along, we have diversified the portfolio of personal transit options, with bike lanes, light rail, and otherwise; finally, near the top of the stream, we have redeveloped urban plans with walkable, mixed-use neighbourhoods (Condon, 2010; Newman, Kosonen, & Kenworthy, 2016). The wisdom of this final solution, as a planning strategy, is that citizens' path and frequency of transit through space is just as applicable to sustainability thinking as the devices employed to facilitate this movement. Walkable neighbourhoods place basic amenities and services within close proximity to residential areas, to minimize reliance on either automobiles or public transit. To augment this strategy further, we could continue to analyse the relationship between our daily routines and spatial use, over time (see Bulkeley &

Betsill, 2005). In the least, transformative change within urban contexts might entail disruption of existing urban plans, to complement or simplify the path of these flows. Some might perceive this to be a significant move.

In a design charrette, wherein participants were deliberating options for the revitalization of a European city, Architect Luigi Ferrara, Dean of the Centre for Arts, Design and Information Technology at George Brown College, said to one team, "Don't be afraid to be radical." In this instance, he was referring to knocking down the wall of a parking garage to make room for cultural amenities; however, his underlying point was that we should not hesitate to disrupt our own sense of certainty, with respect to the built environment, or otherwise. Though the parking garage in question exhibited relative permanence within the urban plan, it was also a relic of previous spatial-use priorities. Each of us will have personalized and socialized perceptions of what counts as radical action, or what qualifies as innovative, depending on our commitments and the current state of the systems in which we are embedded; in some instances, our characterization of the problem space informs these. One limitation of addressing urban transition through the analytical frames and praxis of urban planning and policy is that our view of whole systems may be subsumed under a categorical division among what we have defined to be our primary and functional needs—such as housing, transportation, energy, green space, public amenities, and cultural assets (see Jacobs, 1961; Mehaffy, 2008; Tomalty, 2009b). Without abandoning planning, altogether, we could use a means of ratcheting ourselves out of these boxes, to find our way to the top of the stream.

Today, urbanization is status quo and with modern industrial patterns of settlement being the dominant basin of attraction (Sassen, 2012). Thus, urbanized systems bestow much of our starting conditions for transition initiatives, whether we like it or not. The mantra that we can only ever *start from where we are at* is found in social innovation thinking (Westley, Zimmerman, & Patton, 2009). It could also be a proverb for systems transformation, more generally. Starting conditions can offer grist for innovation and present barriers to change. Currently, the lives and livelihoods of more than half the global population are reliant on the infrastructure, amenities, services, and social contracts imparted by urban systems (Loorbach & Shiroyama, 2016; Sassen, 2009). This does not dictate that urbanism as we know it must persist, that unsustainability is inherent in urbanism (McCormick et al., 2013), or that the current conditions of urban regions are the ultimate expression of urban ways of life:

> …is it urbanization *per se* that creates environmental problems, or is it the particular types of urban systems and industrial processes we have implemented? Are negative global ecological conditions the result of urban agglomeration and density, that is, the urban format? Or are they the result of the specific types of urban systems we have developed: the urban content, meaning the transportation, waste disposal, building, heating and cooling, food provision, and industrial processes through which we extract, grow, make, package, distribute, and dispose of all the foods, services, and materials we use? It is, doubtless, the latter…. (Sassen, 2012, p. 300–301)

If there is a new face of urbanism hovering somewhere in the adjacent possible[5] (from Kauffman, 2000), preoccupation with systems that have developed out of industrialization, and our efforts to render these "less bad," may elude our chance to discover it. Sustainable development has been criticized as ineffective, for similar reasons—essentially to say that we are not pushing systems far enough into a new basin or that we are locked in to perpetuating systemic unsustainability (Gibson, 2016; Loorbach & Shiroyama, 2016; McCormick et al., 2013). But what are the grounds by which we should be enabling path-breaking transformation? Here, I suggest the path to change will become apparent through deep deconstruction of socio-ecological systems, across multiple parameters, more so than efforts to envision radically different futures, or premature abandonment of our inhabited places; however, ultimately, both of the latter may occur. The reasons for the first step (this being systems analyses) are to overcome either our imagination or social behaviours reverting to familiar patterns, leading only to a remake of the past, and to ground our creative work in the logic of social and ecological systems phenomena. Notice Sassen's (2012) use of the word "content" in her quote above, and how she elaborates on what this urban content includes. Indeed, she is correct: How we have come to organize these subsystems and provide for basic services through the application of industrialized technologies, in many ways, has circumscribed the urban profile and what we would, therefore, associate with urbanism. Many of these subsystems are intrinsically indispensable, such as those which ensure appropriate food provision or waste disposal. However, also accompanying city systems are types of infrastructure and programmes which may not be intrinsic to urbanism, as much as an outcome of socio-ecological systems complexity, such as backyard swimming pools or movie theatres. Thus, determining the most suitable content for urban systems should remain an open point of inquiry. Analyses, or reinterpretations, of the systems in question, whether through qualitative or quantitative research, could disrupt convention and provide fodder for innovation.

We find methodological touchstones for this within the thinking of architect Christopher Alexander (1964), social and computer scientist Herbert Simon (1996/1969), and inventor Sakichi Toyoda. Alexander's (1964) concept of the *form-context boundary* relayed the importance of dissecting the relationships among the objects we construct and the world in which they are situated. By his estimation, at times, it may be the contexts, not the objects, which deserve review and modification (Ruttonsha, 2017). As an example, he has contrasted the exercise of redesigning a kettle against redeveloping the means by which we heat water in the home; in pursuit of the latter, it is possible the former would become obsolete. Simon's *limiting systems resources* concept suggested we probe at the key constraints we are attempting to manage for, within projects. He identified the scarce resource of human time as one such example, conceding this is equally important to assess as technological factors, when planning operational efficiencies in a business. His primary message

[5]*Adjacent Possible*: "The adjacent possible is a kind of shadow future, hovering on the edges of the present state of things, a map of all the ways in which the present can reinvent itself" (Johnson, 2010, p. 31).

was to focus on our ultimate goals, in problem solving, rather than fussing to improve the means by which we have attempted to accomplish something similar in the past. Following a comparable line of thinking, Toyoda's *five whys* method was intended to help teams evade superficial responses to problems encountered within industrial settings, through a process of sequential inquiry (Ohno, 1988). The five whys process is initiated by framing a basic question about the identified problem (i.e. why did this occur?). Then, the presumed trigger of the targeted issue is used to inspire a subsequent question (i.e. why did this trigger occur?), and so on, until finally, a root cause is isolated and a countermeasure proposed (Ohno, 1988).

If we apply the above three insights of these thinkers (Alexander, Simon, Toyoda) in urban contexts, we may find ourselves tearing our systems apart at the seams. Each of these authors has provoked us, in one way or another, to spend time considering, precisely, which problem we are addressing. In Simon's estimation, problem framing has implications for agency, in how actors mobilize around issues: "…different organizations [i.e. representations] would lead inevitably to the implementation of quite different programs, emphasizing certain goals and subordinating others…" (Simon, 1996/1969, p. 142). Of course, all three authors' methods have been described with respect to applications in semi-controlled environments; in complex systems, on the other hand, causality may be considerably more elusive to track (see Cilliers, 2007). For example, when attempting to analyse the drivers of resource usage rates within urban systems, our problem space could open into a sea of *whys* for which there may not be clear or easy countermeasures. Urban contexts are sufficiently complex that the above-listed methods could not be applied comprehensively in their planning. However, the underlying principles are still relevant and have potential to be scaled up to reconceptualize the types of issues we are solving for, or, in the words of urban theorist and activist Jane Jacobs (1961), *the kind of problem a city is.*

This influential phrase was put forth by Jacobs (1961) to capture a problem in problem solving within the context of urban planning: "Which avenues of thinking are apt to be useful and to help yield the truth depends not on how we might prefer to think about a subject, but rather on the inherent nature of the subject itself" (p. 428). In her effort to redefine the nature of urban systems, she characterized them as problems in organized complexity and advocated that analyses of urban processes and their catalysts should precede the development of urban objects, such as buildings. Around a similar point in time, Rittel and Webber (1973) classified urban planning problems as *wicked dilemmas*, in reference to their dynamic open state, and social heterogeneity. Today's *science of cities* research acknowledges Jacobs as a precursor to complexity theories of cities and Rittel and Webber as bringing a fresh perspective to urban planning (Batty, 2013a, 2014; Bettencourt, 2013b; Portugali, 2011; West, 2017). Within this niche field is a small pocket of international researchers on a mission to uncover a science that could underscore the nature of cities (their structure, properties, dynamics, growth, and evolution) as a "strategy for achieving long-term sustainability" (West, 2017, p. 215). Now, more than ever, research-practitioners studying urban contexts are realizing the challenge at hand is not only to understand cities as complex and enigmatic human enterprises, we must also do so with respect to their effect on human wellbeing and ecosystems integrity. These are

obvious components of sustainable development, though, again, there are various ways by which we could define and enter the problem space. The tensions raised by urbanization are clear, including the associated increases in socio-ecological systems complexity and impacts (Elmqvist et al., 2013a; Young et al., 2006). To begin to address these, Jacobs' call to reframe the problem space is still relevant. To do so, this chapter considers the distinctions of positioning cities as targets, points of traction, or something more significant, when planning for transition along sustainability and resilience pathways. As Simon (1996/1969) intimated, each of these positions will have different implications for how we devise interventions and coordinate stakeholder action.

Cities as Targets

The persuasion of urban living has been enduring, so much so that terms to further classify this era as notably urban are appearing, such as the "Urbanocene" (West, 2017) or the "Astycene" (derived from "'astos', a dweller of an urban area") (Seto et al., 2010, p. 168). At present, we are almost a decade deep into the third major wave of global urbanization,[6] which is anticipated to bring 5 billion people, or 60% of the world population, to urban regions by 2030, and 6.5 billion people by 2050 (United Nations, 2015a, 2017). This development trajectory and its accompanying socio-ecological impacts have invigorated discussion within local, provincial, and international policy settings on how to handle the host of complex issues emerging within and on account of cities: "Rapid urbanization has brought enormous challenges, including growing numbers of slum dwellers, increased air pollution, inadequate basic services and infrastructure, and unplanned urban sprawl…" (United Nations, 2017, p. 13). Shlomo Angel (2012), an architect and planner who has been preparing for the inevitability of urban expansion, has recommended we resolve the kinks of the urbanization project while cities are still growing and therefore in flux. Certainly, many municipalities would be under sufficient pressure to accommodate for growth that the political climate is favourable to review conventional approaches to urbanism, more generally. In this respect, cities have come under speculation as objects and systems for reform.

When systems are called out as targets for change, naturally we might deliberate the challenges to overcome, solutions by which to do so and indicators of success. Of course, there are a healthy complement of ideas and technologies for urban transition already on the table, as well as tested models to emulate, many of which fall into the sphere of conventional sustainable design. For example, Angel (2012) suggested a four-part strategy to growth planning, comprised of making room for growth, balancing densities, providing for decent housing, and pre desig-

[6]The first saw the rise of ancient civilizations around 10,000 B.C.; the second began around 1800 A.D., coinciding with the industrial revolution; and the third began in 2010, at which point 50% of global populations were living in urban regions (Angel, 2012).

nating space for public works. Urban planner and designer Patrick Condon's (2010) seven-rule plan for low-carbon cities includes restoring the streetcar city; designing an interconnected street system; locating services, transit, and schools within a 5-min walk from residential areas; locating good jobs close to affordable homes; providing a diversity of housing types; creating a linked system of natural areas and parks; and investing in lighter, greener, cheaper, and smarter infrastructure (pp. 14–15). Environmental scientist Peter Newman has encouraged polycentric design, oriented around the articulation of three urban fabric types (walking, transit, and automobile), and hypothesized which kinds of urban and infrastructural design schematics would be suitable for each one (Newman et al., 2016; Newman, Beatley, & Boyer, 2009). Other proposed options include everything from green to smart technologies; net-zero development; mixed-use development; diversification of energy, transit, and food systems; enhancement of ecosystem services, for example, to mitigate heat island effect and water runoff; decentralized production; circular production; resource sharing; microlending and community currencies; relocalization; social inclusion and community placemaking; and enrichment of livelihoods (Beatley & Newman, 2013; Curran & Tomalty, 2003; Hopkins, 2011; McPhearson et al., 2016; Newman et al., 2009; Thackara, 2015; Tomalty, 2009a, 2009b). At the same time, specific measures of sustainable urban development are debated, as are interpretations of urban sustainability (Tanguay et al., 2010; Tomalty, 2009b). Thus, in pursuing strategies for urban transition, we might exercise caution not to over-objectify cities as things to which we apply sustainability thinking, for example, through continued monitoring and mitigation of their performance on predesignated factors:

> While this is no doubt important, as Whitehead (2003) suggests, 'such work has tended to reduce the analysis of sustainable urban development to a technical matter of institutional restructuring, traffic management, architectural design and the development of green technologies'. (Bulkeley & Betsill, 2005, p. 43)

Targets for change provide a clear scope of action, around which different institutions and stakeholders could organize and advocate. They could also stimulate creative problem solving and innovation, where groups collaboratively brainstorm approaches for meeting stated objectives, as has been the case with local responses to climate change (climateactionwr.ca). However, targets also presume we know something about the systems in which we are operating, such as their constituent parts, how these parts relate, and how we want them to perform, cohesively. We have already started to encounter this tension in attempting to situate an urban agenda within sustainable development. The incorporation of an individual category for cities (Goal 11)[7] within the United Nations' (UN) recent list of Sustainable Development Goals (SDGs) is a notable addition from its previous eight Millennium Development Goals (MDGs), affording municipalities increased prominence on the international stage of sustainability planning. Each of the SDGs includes targets for

[7]*Goal 11, Sustainable Cities and Communities*: "Make cities and human settlements inclusive, safe, resilient and sustainable" (United Nations, 2015b, p. 14).

change and indicators of progress, and Goal 11 has its own set. However, the UN has also acknowledged that approximately one third of the other goals will link directly with or could be implemented through cities and settlements:

> …cities are a string that connects all other goals together; their density and economies of agglomeration link economy, energy, environment, science, technology and social and economic outputs. (UN-Habitat, n.d.)

The SDGs position sustainable cities as one goal among seventeen, though we could debate the extent to which it also encompasses the others. This is a challenge of relational organization, more so than goal setting or boundary definition—how one set of factors might influence another. For example, ecosystems and resilience thinking use the concepts of holarchy (Waltner-Toews et al., 2008) and panarchy (Gunderson & Holling, 2002) to describe hierarchical, nested, and/or cascading relationships among interlinked systems phenomena within complex systems (Cumming & Norberg, 2008). The list of SDGs assumes uniform significance among the seventeen goals, though some possible interdependencies have been identified, elsewhere (Biron, 2016; Rockström & Sukhdev, 2016). With respect to Goal 11, especially, there are questions of relational order with which to wrestle: Are sustainable cities an end in themselves, a means to attaining the other goals, and/or an outcome of successful sustainable development?

Cities as Traction

Some who hail the significance of cities to sustainability also stress that municipal governments are in a prime position to respond to related challenges, on the ground (UN-Habitat, n.d.; Biron, 2016; Bulkeley & Betsill, 2005; Loorbach & Shiroyama, 2016; Quitzau, Jensen, Elle, & Hoffman, 2013; Sassen, 2009). Given the dense clustering of people, resources, expertise, power, and innovative capacity, cities can serve as points of traction by which to mobilize global agendas (Sassen, 2009, 2012; van der Leeuw, Lane, & Read, 2009; Wittmayer & Loorbach, 2016); informal connections across diverse interest groups would enhance this effect (see Granovetter, 1973). As much as cities are places, they are also complex social enterprises (Seto et al., 2010):

> The rise of cities is not simply the growth of large collections of people—rather, it involves communities that are far more diverse than their predecessors and more interdependent. (Elmqvist, Redman, Barthel, & Costanza, 2013, p. 16)

Historically, part of the draw of urbanization has been the economies of scale, increasing returns and shared prosperity achieved through networking (Angel, 2012; Bloom et al., 2008; Pierson, 2004; van der Leeuw et al., 2009). In a comparable way, cities could put their social capital to work to tackle the challenges of the Anthropocene. When we set goals to reform urban infrastructure, programmes, and policies, as a focus for transition, we naturally enlist institutions and communities as the champions and vehicles of this action. As such, the first position, *cities as*

targets, stimulates the second, *cities as traction*. At the same time, this second category can remind us to examine the conditions and parameters of social organization, more specifically, and the extent to which these permit or limit the pursuit of sustainability.

Urban scientist Luis Bettencourt's (2013b) classification of cities as *social reactors* or *integrated social networks imbedded in space and time* encapsulates this. His colleague, physicist Geoffrey West, has presented a similar framing: "... cities are emergent complex adaptive social network systems resulting from the continuous interactions among their inhabitants, enhanced and facilitated by the feedback mechanisms provided by urban life" (2017, p. 253). These definitions were formed as part of a newer variation on the science of cities, initiated at the Santa Fe Institute at the turn of this century (West, 2017). Of course, a comparable premise underscores Jacobs' (1961) writing, for example, with her claims to the relevance of social interaction to urban vitality—the idea being that cities are places wherein people come together to connect, support, share, and learn, and in doing so, manifest unexpected, novel realities, possibly along with resilient communities. These descriptions of urban systems imply and justify the logic of diversified participation in processes of transition. Viewed as social reactors or networks, realistically, transformation within settlement systems could only be a phased, iterative, engaged social process, wherein we build capacity and nurture tolerance for change among numerous systems actors, whether this is managed or self-organized. These such processes could be employed to propose, review, and implement the kinds of conventional sustainable design initiatives listed earlier. Additionally, as we move from sustainable design to design for sustainability, we have witnessed the design space becoming more permeable to fluid agency—precedents for which can be found in systemic design, social innovation, urban planning, and transition management (charretteinstitute.org; James & Lahti, 2004; Jones, 2018; Mehaffy, 2008; Nevens, Frantzeskaki, Gorissen, & Loorbach, 2013; Newman & Jennings, 2008; Westley & McGowan, 2014). Process design is one mechanism by which we can organize within and among social networks, in order to facilitate transition. These methods are becoming increasingly popular, in design and other forums, though related methods continue to be evaluated and refined (Jones, 2018; Reed et al., 2018).

> In the past decade, however, the conviction has grown that the traditional way of planning has to be changed to a more 'process' route, exploring the communicative dimensions of collectively debating and deciding on matters of collective concern. (Rotmans, van Asselt, & Vellinga, 2000, p. 267)

Conventionally referred to as design charrettes and developed as a tool for stakeholder consultation, programmes for participatory engagement have since expanded into think tank and co-creation models and are on the threshold of reaching higher ground, both creatively and politically. These processes can be applied to share expertise and experiences, examine the values of diverse audiences, establish common agendas for change, and formulate multi-partner initiatives, all within an

extended peer community.[8] As an exercise in innovation, social learning, and democratic engagement, they are carving out new formats for decision making, and doing so within problem spaces that may have weak conceptual clarity, no obvious institutional or disciplinary home, and few clear-cut resolutions. The issues with which they are grappling are even starting to reflect post-normal science conditions[9] or points of critical transition[10] within local sites and institutional agendas. Additionally, project development can be reflexive: As we plan to apply sustainability principles within the built environment, the social settings in which we would realize prospective initiatives also come under review (Ruttonsha, 2017). If these conditions prove to be unfavourable to innovation and change, we may turn our attention from engineering infrastructures, instead, towards modifying the contexts in which we are acting:

> From these small and often simple beginnings, with all their practical objectives of improving housing, health and education, emerges an agenda of reforms to policy, legal frameworks and standards which help to build social capital, promote social integration and gender equality, reduce dependency, unlock resources and build livelihoods. (Hamdi, 2004)

As designers and innovators, we are no longer puzzle solving, in the classic Kuhnian (Kuhn, 1996/1962) sense, by responding to routine briefs for community centres, hospitals, schools, parks, or public squares. Rather, projects are becoming forums through which we collaboratively explore broader socio-ecological tensions and mandates, such as the redefinition of urban culture in a digital era; the reestablishment of a culture of nature in urban regions; the integration of vulnerable populations into urban life; the redevelopment of nations following conflict; and the enhancement of local indigenous communities' resilience to globalization (this list is based on actual cases). In the author's own experience, these opportunities can surface when existing protocols become unviable or are considered insufficient or when significant change in circumstance prompts redefinition within a system.

Cities may be in an ideal position to mobilize change, given the centralization of agency and assets; however, this does not guarantee their existing social, economic, and political institutions will be conducive to enabling *effective* change or the kind we require. Aligning actors to contribute to transition initiatives may entail strange transdisciplinary gymnastics between the articulation of options and the logistics of their implementation—especially, where the proposed alternatives cut across sectoral or institutional mandates. Envisioning transition initiatives that transcend dis-

[8] *Extended Peer Communities* "[consist] not merely of persons with some form or other of institutional accreditation [such as scientists, industry or government], but rather of all those with a desire to participate in the resolution of the issue" (Funtowicz & Ravetz, 2003, p. 7).

[9] *Post-Normal Science* decision-making conditions combine high uncertainty with high stakes, sit at the intersection of policy and science, require evaluation of both fact and value statements, and are often embedded within complex scenarios (Funtowicz & Ravetz, 2003; Ravetz, 2007).

[10] *Critical Transitions* occur when a system shifts from one state (i.e. basin of attraction) to another (also referred to as crossing a threshold) and without prospect of returning easily to its previous state (Scheffer, 2009; Walker & Salt, 2006).

ciplinary segregation comes with the additional task of proposing the social, economic, and political models by which we would undertake these projects. For example, we could examine the constraints by which actors are bound, redefine the rules of interaction (see Helbing, 2013) between project collaborators, or consider how stakeholders might share investment, accountability, risk, and reward in the implementation of cross-sectoral, multi-scale programmes (see Wittmayer & Loorbach, 2016). Is this not the impetus behind processes of settlement, anyway: To increase our capacity to problem-solve and survive through social organization?

> It is all too often forgotten that the whole point of a city is to bring people together, to facilitate interaction, and thereby to create ideas and wealth, to enhance innovative thinking and encourage entrepreneurship and cultural activity by taking advantage of the extraordinary opportunities that the diversity of a great city offers. (West, 2017, p. 252)

From this perspective, however, we can imagine how societies could undertake endogenous modification to existing urban systems, without explicitly demanding thoughtful reflection on the patterns of socio-ecological organization they enable. One limitation of the design charrette or change lab model is that pathways of innovation may continue from previous pathways of innovation. Where innovation is cumulative (see Arthur, 2009) and path dependent—with cogenerative processes being ones through which we disseminate, deliberate, and connect the most salient ideas—we may never disrupt the worldviews from which they were inspired. Still, on the back of this, there may be potential for the self-redefinition of industrial urban societies. Reflexive modernization theory evokes this kind of process. Reflexive modernization is a sociological proposition, which has observed a contemporary involution in modern societies (Beck, Bonss, & Lau, 2003; Beck, Giddens, & Lash, 1994). Its core premise is that the Western modern world has generated sets of dynamics that can no longer be sustained by the fundamental social principles and institutions on which it was initially founded. In reaction to the destabilization of these structures, rather than abandon modernism altogether, societies are leaning more deeply into the tools, resources, programmes, and formats of the modern world (capitalism, globalism, labour, state) to reinvent what we know of it; at the same time, they are undergoing metalevel conceptual shifts in delineating modernity, as well as the rules of the game by which change occurs, which are now unequivocally non-linear (Beck et al., 2003). Reflexive modernization is portrayed as a process of creative destruction occurring within systems of social organization (Beck et al., 2003). In urban systems, we are also at a point of breaking and redefinition, whereby the rules of the game are being reassessed through growth management agendas. Certainly, the conditions of urban systems are pushing us to the edge of our own tolerance, across a number of categories, such as traffic congestion, pollution, loss of habitat and agricultural lands, decline of rural communities, social alienation, underemployment, and increased cost of living. In this light, we could look to industrialized cities as places in custody of the infrastructural and institutional facility to implement transition initiatives while simultaneously rejecting the particular schematics and social conditions endowed by modern industry: Ostensibly, we could attempt to exist within our densely constructed bubbles while also reform-

ing them, endogenously. The impracticality of endeavouring this in isolated sectoral pockets continues to spawn collaborative social action. The question is whether this amalgamation of social energy can also summon the next wave of remodernization, within urban systems.

Realistically, the primary responsibility of municipal governments is to keep their ships flying; significant course correction would call for inquiry and action beyond their standard operations. Even within participatory design processes, we may not have time and incentive to engage with deeper issues, at least not with any degree of academic rigour. Neither are the most complex layers of the problem space easily accessible for intentional intervention (see Meadows, 1999). Some of these complexities include coupled interactions between nature and culture. If we contemplate the details of these interactions, we will arrive at an expanded explanation of why cities are well positioned as points of traction for transition: Namely, they are representative of how human life has organized within the biosphere, over time, and the socio-ecological systems complexity that has emerged or declined along the way (Bettencourt, 2013b; Christian, 2004; van der Leeuw et al., 2009; Tainter, 2008).

Cities as Embodiment

As a methodology, co-creation infers collaborative thought and action taking place among systems actors, to some desired effect, whether this be social learning or project development (Berkes et al., 2003). In design practice, the popularity of this approach (as described earlier) speaks to the loss of faith in the isolated, creative genius to innovate effectively within complex scenarios (see Mau, Leonard, & The Institute without Boundaries, 2004; Mehaffy, 2008). From a complex adaptive systems perspective, the term carries additional significance, with respect to the self-organizing or emergent outcomes that can arise through the cumulative actions of many. In these cases, co-creation is more like co-evolution, whereby reflexive interactions may occur between people and the systems of which they are a part (see Rotmans & Loorbach, 2009). Once we accept cities as points of traction for transition, given their dense social networks, we begin to encroach upon a further conception of these systems, wherein society could be described as the generative mechanism of urbanism or cities as an embodiment of social processes (Allen, 2012; Castells, 2008; Harvey, 1985; Portugali, 2000, 2012a; Sassen, 2010; West, 2017). In other words, not only are cities socially dynamic and diverse but also an outcome of the varied thoughts and actions of their social agents; neither are they bounded spaces, rather sites or nodes for the unfolding, or instantiation of these dynamics (Sassen, 2010). This framing reveals why the first two positions—*cities as targets* and *cities as traction*—are incomplete as approaches when identifying opportunities for transformative systems change. If urban systems are produced and reproduced through a combination of intentional, self-organized, and emergent

social processes, occurring at both local and global scales, then the study of these processes is key for urban transition.

> Cities are socially determined in their forms and in their processes. Some of their determinants are structural, linked to deep trends of social evolution that transcend geographic or social singularity. Others are historically and culturally specific. And all are played out, and twisted, by social actors that impose their interests and their values… . (Castells, 2006/1993, p. 135)

Embodiment, as a concept, implies reflexive interconnection between structures and processes. For example, cognitive science proposes a model of the embodied mind, wherein our bodily perceptions, existence, and experiences shape our thoughts and reasoning (Maturana & Varela, 1980; Varela, Thompson, & Rosch, 2016); Capra (2002) has used the concept in reference to the expression of ephemeral, dynamic phenomena within physical/material form. Thus, with embodiment, the direction of influence between agents and environments can travel either way: Environments shape the behaviours of agents, and agent actions are imprinted in environments. In short, each is seen to affect the other, which, of course, is what denotes a reflexive interaction, per complexity thinking (see Jervis, 1997). For design practice, the implication is that our relationships with the contexts in which we are situated will inherently guide our ideas and creations:

> …envisioning is itself an activity carried on by real people in a real-world environment, rather than by a disembodied intellect moving in a subjective space in which are represented the problems it seeks to solve. (Ingold, 2000, p. 186)

In sustainability and resilience thinking, some contend that cultivating a tacit or embodied engagement with the natural world will enhance our reverence for it (Cooke, West, & Boonstra, 2016). Moreover, ideas about embodiment can enrich how we understand urban systems. In effect, cities are complex adaptive systems, which can emerge by virtue of the interactions among their social agents within social networks, who are also *situated within environments*. This notion has been discussed by Jacobs (1961) and science of cities scholars (Batty, 2013a; Bettencourt, 2013b; West, 2017), as noted earlier: "…cities are an emergent self-organizing phenomenon that has resulted from the interaction and communication between human beings exchanging energy, resources and information" (West, 2017, p. 280). However, where these authors have focused on urban social dynamics and network organization, as they appear in space over time, to solidify the relevance of cities to sustainability and resilience challenges, we could benefit from another layer of urban theory that explicitly directs attention to the human presence within and reliance on the biophysical environment. Embodiment implies that we are one with the environments we inhabit, not separate. In an effort to reconnect development to the natural world, and balance against social-technological analyses of urban complexity, resilience scholars are expanding conceptualizations of cities as complex adaptive socio-ecological systems while indicating the pivotal role they play in organizing human life within the biosphere (Elmqvist et al., 2013a, 2013b; McPhearson et al., 2016).

> It is in cities and vast urban agglomerations that humankind is increasingly present on the planet and through cities that people mediate their relation to the various stocks and flows of environmental capital. (Sassen, 2012, p. 299)

This chapter has initiated this discussion with reference to cities, specifically, as many related debates are oriented around urban systems. As central nodes for production and consumption (Fragkias et al., 2013; Grimm et al., 2008), social hot spots or climax areas, cities have garnered a fair amount of attention, both positive and negative. It is not the intention of this chapter to argue an urban-idealist (i.e. accepting cities as beneficial for their own sake) approach to transition, nor to write off urban systems as inherently unsustainable. Rather, it serves as a preface to ultimately explore how various patterns of and prospects for settlement could enable or disable long-term sustainability and resilience. Naturally, cities would be included within this bigger picture. In this regard, they come into view as part of broader *systems of cities* or *systems of settlements*, wherein analyses of the impact of any given city become most salient with reference to its regional and global connections (Sassen, 2012; Seto et al., 2012). In other words, more significant to our understanding of the relationship between urbanism and transition than the study of cities as designed artefacts are analyses of systems of settlements as sets of dynamic, overlapping, and intersecting networks (see Batty, 2013a; Castells, 2010a). Even the earliest urban systems emerged as interconnected regional networks (Bretagnolle et al., 2009; de Vries & Goudsblom, 2002), and contemporary rural regions are certainly committed to patterns of industrial urbanization (Sassen, 2012). The importance of thinking about settlements in this way is to unravel their tracks of influence across globalized networks and to understand how complexity manifests at scale. Building on Jacobs' (1961) description of cities as problems in organized complexity, we could continue and deepen her argument with the proposition that systems of settlements represent the organization of socio-ecological systems complexity.

Following from Sassen's quote above, we could debate the extent to which it is possible to detach human presence on the planet, or the flows of environmental capital as enabled through human action, from the constructs of settlement. After all, if we log a forest or drill an oil field, are we ever doing so without targeting these resources for use within some settlement context, such as a market economy? And, is it not the demands, constraints, and structural properties of these contexts that determine how and why these resources are consumed? Sassen's (2012) words, thus, intimate why socio-ecological or human-environment interactions are inevitably linked to some form of settlement, not only centralized within or constituent of them. This leads to the most open position we could possibly adopt in defining human systems of settlements: That together, they encapsulate all of the processes and means by which human populations have inhabited the biosphere. Whether the format of habitation is mobile or fixed is not critical for this classification;[11] the

[11]In urbanized, globalized contexts, we have even redefined the meaning of a nomadic lifestyle. Today, we can live a life on the road, supported by transnational banking, international transit, digital communication, and otherwise.

notion of being settled, rather, denotes a rootedness within the biosphere as a whole, as opposed to a specific location, therein. Sustainability as a multidisciplinary and interdisciplinary praxis entails reflecting on and managing relationships between social and ecological systems (Gibson, 2016; Hawken, 2004a, 2004b). Arguably, it is settlement systems that embody these socio-ecological or human-environment interactions (see Batty & Marshall, 2012; Wilkinson, 2011); and, it is our efforts to cope with daily living therein, from which systems complexity has developed.

> Among many, the increase in social complexity occurred in response to the need and wish to bring forth food, water and shelter from an exacting and unpredictable natural environment. (de Vries & Goudsblom, 2002, p. 149)

If we view settlement(s) as an encapsulation of the organization of human life within the biosphere, as this has changed over time, then it becomes a problem of everything—no longer just about infrastructure, or social programmes, or tax incentives. Of course, human populations have undertaken the imperative of settlement within very different historical and geographical contexts and in the face of variant pressures (Christian, 2004; Diamond, 2005a, 2005b; Tainter, 2008). By framing the challenge as one that is common to all human communities, we can subsequently discuss how different groups have solved similar problems through a range of means; the conditions and constraints that predicated their choices; what has been lost or gained along the way; and the implications of these approaches for long-term sustainability and resilience. Since the transition of human communities from nomadic to stationary patterns of living, global population has increased, along with total energy consumption, by 1400 and 60,000 times, respectively (Christian, 2004), presenting two of the most significant hurdles for us to confront in managing for sustainability, today. At the same time, some planners hint at a transcendent quality of cities, whereby we can somehow escape the worst and uncover the best of our human tendencies through these systems of human development. After all, if we position *cities as embodiment*, are we not then distinguishing them as an extension of self and society? Patrick Geddes, for example, believed the urban and the social could develop concurrently, through town planning, with opportunity for improvement in both domains (Hysler-Rubin, 2011).

The mid-twentieth-century ekistic (the science of human settlements)[12] movement—championed by Constantinos Doxiadis (urban planner and architect) and Jaqueline Tyrwhitt (town planner)—followed from Geddes' inspiration, alluding to relationships between human evolution, human development, human action, and the emergence of settlements. This design-based programme to fortify planning with science reflected a *cities as embodiment* worldview:

> …human settlements have always been created by man's moving in space and defining the boundaries of his territorial interest. (Doxiadis, 1970, p. 3)

[12]"*Ekistics* denotes both a specific settlement orientation and at the same time a wide field of interest, encompassing all those processes which have served to form settlements throughout history" (Bell & Tyrwhitt, 1972, p. 28).

Without unequivocally embracing a process-oriented view of planning, Doxiadis (1970) introduced five principles[13] by which he contended settlement systems have manifested. His principles lean towards outlining a standard set of human-environment interactions, of which settlements are an embodiment (he has also referred to them as the physical expression of man's system of life). With this list, he strived to extract common mechanisms (i.e. processes) that underlie settlement and settlements, regardless of their size or type—nomadic or stationary, urban or rural, city or hamlet. In ekistic literature, settlements of all kinds (hamlets, villages, towns, and cities) are grouped under the same family. Their relationship to one another within a system of settlements is delineated within a logarithmically scaled ekistic grid (inspired by central place theory), which starts with the smallest unit of settlement—the individual human, or Anthropos—and ends with the largest, the earth-encompassing/universal city, or the Ecumenopolis, with its transcontinental systems flows (Bell & Tyrwhitt, 1972; Doxiadis, 1969, 1974). Together, these units govern the total urban system. Given that the individual is represented as the first ekistic unit in the grid, ekistic heuristics leave little within the human realm that could be excluded from human systems of settlements—especially if we presume their embodied connection with our cognitive and emotional worlds. By studying individual settlements with respect to their position within a system of settlements, the ekistic grid inferred the importance of scale and network analyses to planning. Through its collection of heuristics, ekistics aimed to forward a globally unified means by which to interpret settlement processes, contents, and forms, highlighting similarities among all human settlements, despite variation in their size, type, or geographical location. In this way, the movement was comparable to today's science of cities in its intentions, though it had yet to benefit from the detail and rigour of more recent quantitative work.

Today, it is recognized that cities secure resources from and have impact on areas beyond their immediate geographical boundaries (Elmqvist et al., 2013b; Grimm et al., 2008; Homer-Dixon, 2006; Kennedy, Cuddihy, & Engel-Yan, 2007; McPhearson et al., 2016; Seto et al., 2012; van der Leeuw et al., 2009); that they bleed together as metropolitan regions (Castells, 2010a); and that systems of cities[14] connect internationally through "relations of exchange, trade, migration, or others

[13] *Five Principles of Settlement*: (1) maximization of man's potential contacts with the elements of nature, with people, and with the works of man; (2) minimization of the effort required for the achievement of man's actual and potential contacts; (3) optimization of man's protective space, which means the selection of such a distance from other persons, animals, or objects that he can keep his contacts with them without any kind of sensory or psychological discomfort; (4) optimization of the quality of man's relationship with his environment, which consists of nature, society, shells, and networks; and (5) optimization of the four other principles, dependent on time and space, actual conditions, and man's ability to create a synthesis (Doxiadis, 1970, pp. 2–3).

[14] *Systems of Cities*: "What we call systems of cities are evolutionary objects that may include subsets of cities connected by long-distance networks or cities belonging to unified political territories…The precise identification of systems of cities is very difficult, due to the changing nature of the interactions that need to be considered, and the fluctuations in their spatial extension" (Bretagnolle et al., 2009, p. 200).

that sustain the flow of energy, matter and information…" (Ernston et al., 2010, p. 533; Bretagnolle et al., 2009), wherein there may exist some functional/economic differentiation among the units within each cluster (Abdel-Rahman & Anas, 2003, Castells, 2010a). Presumably, global settlement networks are self-reinforcing in their patterns. For example, some systems conditions would only be possible at a local scale given international interconnections, or perhaps also the establishment of what Sassen (2012) has referred to as a network of global cities.[15] At the same time, globalized systems of resource extraction, production, distribution, and consumption, would be entrenched *because* individual cities amass dense, captive audiences who support these processes (McDonald et al., 2013; Sassen, 2009; Young et al., 2006). In their work on teleconnections, Seto et al. (2012) have studied the effects of urban processes on land changes in distant and non-urban places. Settlements embody phenomena that occur across nested, global scales, as do sustainability challenges (Gibson, 2016; Sassen, 2010). Given the international, interconnected profile of these *systems of settlements*, we could argue that they constitute what McNeill and McNeill (2003) have described as the global human web, wherein there is potential to capitalize on their network effects to enable change (McCormick et al., 2013; Sassen, 2009). This raises questions of where to locate innovation initiatives. Are we targeting global settlement patterns as a common area of concern and/or focusing on specified local issues? From the perspective of sustainability and resilience assessment, a comprehensive view of interactions occurring across and between regions and nations would be prudent:

> Therefore, individual cities cannot be considered 'sustainable' without acknowledging and accounting for their teleconnections—in other words, the long-distance dependence and impact on ecosystems resources and populations in other regions around the world. (Elmqvist et al., 2013b, p. 735)

Settlements as Dwelling

The concept of embodiment is important both for planning and sustainability (resilience), in that it intimates the existence of coupled, or co-evolutionary, relationships between people and their environments. At the same time, it could ground urban theory and practice in sustainability and resilience interests, if applied to portray processes of settlement as analogous to human-environment or socio-ecological interactions and settlement systems as the materialization of these dynamics. Thus, the final category, *cities as embodiment*, elaborated above, is the one that draws the closest parallels between settlement and sustainability (resilience) and, arguably, is essential for transformative systems innovation within urban contexts. The first category (cities as target) recognizes efforts to adapt existing systems, in accordance

[15] *Global Cities*: This concept refers to a type of function, situated within complex cities, involving the production of advanced intermediary services (i.e. finance, legal, trade, etc.), that facilitate cross-border exchanges and globalized activities (Sassen, 2012).

with sustainability principles, for example, with energy retrofitting, diversified transportation alternatives, or affordable housing projects. The second (cities as traction) acknowledges efforts to enlist the capacities of municipal and local community networks to mobilize change, which are exemplified through design charrette and change lab methodologies. The third category (cities as embodiment) could incorporate the same kinds of technological, programmatic, and political initiatives, though it also transcends and defies intentional project planning. This category could lead to considerations of the metabolism of settlements, as complex adaptive socio-ecological systems; more so, it probes us to deconstruct how this metabolism might be tied to human thought, preference, behaviour, and action. It also positions settlement systems as integral to the human story—our history of experimentation, innovation, striving, and failure, though different in each region. This categorical progression, then, delivers us to the point of understanding the bearing of another concept—one that follows a comparable intellectual trajectory and shows clear thematic association with planning and resilience thinking. The *dwelling perspective* was coined by British anthropologist Tim Ingold (2000, 2005), though it was initially introduced by German philosopher Martin Heidegger (1993/1971, 2001/1971), and coaxes us towards a relational interpretation of the built environment and human settlement. The implications of this concept become most apparent when we accept the limitations of working with settlements as spatially bounded, constructed artefacts or as ecologically disembedded social networks. Rather, if we concede they emerge from humans interacting with each other and their environments, as part of routines of living, the notion of *settlement as dwelling* follows naturally.

Like *settlement*, the term *dwelling* could be construed to be a verb or a noun, though for these purposes the distinction is almost incidental—*dwellings*, as objects, emerge as an outcome of *dwelling*, as sets of actions, just as *settlements* appear through processes of *settlement*. The same would be the case for sustainable development, in that it can refer to an outcome or a process (Gibson, 2016). While *dwellings*, as objects, could be viewed as prospective sites for transition applications, such as building retrofits, it is also crucial to consider how *dwelling*, as a suite of processes, could be coordinated in ways that, to varying degrees, pay respect to biosphere integrity, social equality, the needs of future generations, and so on. True, we could design settlement forms with these same objectives in mind, limiting our socio-ecological systems analyses to factors that intersect directly with our intentional constructions. However, in doing so, we risk confounding means with ends. Sustainability criteria frameworks set worthy end goals, with respect to maintaining human life and wellbeing over the long term, in conjunction with socio-ecological systems integrity (see Gibson, 2006, 2016). Settlement systems are the means by which we could achieve this (rather than ends in themselves), and presumably, these means could vary widely. Also, as was discussed in the previous section, any boundary between settlement and non-settlement is vague, especially if we apply the concepts of embodiment (per Capra, 2002) or embodied cognition (per Maturana & Varela, 1980).

Wording can be crucial in problem framing, with its intimations potentially shifting perspectives. Dwelling, as a term, is more open and generic than settlement. While the latter has already been incorporated into international policy frameworks, with clear ties to sustainable development, the former, arguably, has fewer associations of this kind, thus offering some conceptual liberty. Here, I extend the commonly presumed significance of the term by relating it to globalized, networked phenomena. Heidegger's (1993/1971, 2001/1971) original treatises on dwelling were etymological and poetic. On the premise that language is seminal to discovering the nature of a thing, and poetry a revelation of truth (Heidegger, 2001/1971; Hofstadter, 2001), he unpacked the essence of dwelling through deconstruction of its linguistic roots (from the Old High German word for building, *buan)* as well as an eighteenth-century German poem by Hölderlin (*In Lieblicher Blaue/In Lovely Blue*). With this, he resurrected former connotations of the term dwelling (to stay, to cherish and protect, to preserve and care for, to cultivate the vine) and bestowed built form with enhanced meaning. To follow his method, we could contemplate the close association between the two words, *settlement* and *dwelling*, to interpret artefacts like cities as a means by which humans inhabit the earth. The dwelling perspective, in its various iterations, has carried direct and indirect tones of design, planning, systems, complexity, sustainability, resilience, and socio-ecological systems thinking and is becoming evermore versatile as it matures. Heidegger's initial depiction sought to capture a wholeness in the relationship between mortals and their inhabited environments, though with a spin that was more metaphysical than ecological. Others who have extended his thinking (Cooke et al., 2016; Ingold, 2000, 2005) have fortified the ecological, complexity, and human-environment angles. These articulations of the concept, and their significance to transition within settlement systems, are described below.

Heidegger's thoughts on dwelling are situated within his body of writing on language, truth, and Being (Hofstadter, 2001; Krell, 1993). Developed as part of a three-part lecture series in the early 1950s, in Heidegger's essays, *Building Dwelling Thinking*, *The Thing*, and *Poetically Man Dwells*, he ruminated on the human relationship to the world at large, as expressed through the preservation and making of things (Krell, 1993). In the first, he searched for a qualitative interpretation of what it means to dwell, and therefore build, arguing that we build only because we dwell. For him, dwelling, and therefore building, naturally entails some degree of systems integration. Through his writing, we get the sense that building as dwelling brings together a series of essential relationships, which are functional, symbolic, and symbolic in their functions. For example, symbolic functionality appears at the point wherein a house becomes a home in the minds of its inhabitants—not simply a space but a place that fosters experiences and contains memories of lives lived: "To clarify, let's call the physical structure, the building itself, the house; and the setting within which people dwell, the home" (Ingold, 2000, p. 185). Heidegger has entreated builders, as dwellers, to be conscientious of the relationships that arise between people and places, such that a general state of harmony is maintained. By the end of the first essay, he had idealized dwelling as a kind of holistic stewardship or preservation: "Mortals dwell in the way they safeguard the fourfold [earth, sky,

mortals, divinities] in its essential unfolding" (1993/1971, p. 352). In his philosophy, the constructing of things enacts the essence of dwelling, or the *gathering* of the fourfold: *Relations are enabled through forms*. More so, through building, locations and therefore spaces come into existence, providing a site for the engagement of these primary relations: "The bridge lets the stream run its course and at the same time grants mortals their way, so that they may come and go from shore to shore" (Heidegger, 1993/1971, p. 354, *Building Dwelling Thinking*).

Heidegger's language turns and folds around itself, toying with the reflexivity between his four elements and the mirroring of one within the other through their mutual definition and coordination. The concept of the fourfold is present throughout his writing as the cosmological system to which we are beholden, within which we find meaning through synchronous belonging, and from which we must take measure for the artefacts of our own making (Hofstadter, 2001; Krell, 1993). Underlying this system, we are told, is a great unknown, exposed only in part through the everyday sights and sounds of earth and sky. The mirror-play within the fourfold is depicted as the *ringing* of the world coming into itself, as a unified whole—a phenomenon too profoundly simple to be grasped cognitively (Hofstadter, 2001). As dwellers, he contended, it is our responsibility to uphold the authenticity of things within this interconnected system—to respect and reveal their truth, so to speak. With this, he has encouraged a type of reflective, grounded planning, design, and making, arising in response to, and as a bringing forth of, that which is genuinely meant to be—not driven by human will, industrial production, preoccupation, or dreaming (Hofstadter, 2001). For example, to craft a jug, he has clarified, is to fashion a vessel of offering, along with the many relations this engages: with the earth from which it is made, with the air that fills its void, with the spring whose water it will carry, with the citizens whose thirst it will quench, and with the divinities to which its wine is donated as gift (Heidegger, 2001/1971, *The Thing*). By Heidegger's description, paying regard to these many relations can bring us closer to our world in its making: "If we let the thing be present in its thinging from out of the worlding world, then we are thinking of the thing as thing" (2001/1971, p. 178, *The Thing*). For him, the fundamental nature of an object rests in the parameters of its integration within whole systems: *Relations specify the essence of things*. Thus, we see how Heidegger's portrayal of dwelling could awaken building to a sustainability approach—one that is founded in a reverence for the intrinsic value of the natural world and deliberation of our own fit within.

Heidegger's (2001/1971) essays wrestled with correlations between spirit and substance, and which precedes the other in the manifestation of our known reality. In this way, he evoked a brand of systemic design wherein constructed artefacts transcend their strictly functional and representational qualities. This was not intended as a surrealism or abstraction; Heidegger rejected philosophical detachment from worldly matters, but instead directed his thoughts to concrete issues and historically relevant problems; however, neither did he rely on their strictly quantitative or technical-scientific framings (Hofstadter, 2001; Krell, 1993). Rather, to attend to the prevalent issues of homelessness, job insecurity, political conflict, population growth, the lure of modern diversions, and modern excess, he focused

his scholarship on the meaning of Being, with the hope of uncovering a path to authentic human existence—one that recalls our earliest origins (Hofstadter, 2001; Krell, 1993). Heidegger venerated dwelling as a "basic character of Being [human]" (1993/1971, p. 362) or of human presence within the planet and cosmos. At least, this is the essence of dwelling. Through this existence, we are granted the power to gather things together into artefacts of our own design (Krell, 1993). If we are finding these to be crude and ecologically detached, perhaps we could amend this through reflection on our own humanity; in this regard, Heidegger has proposed we turn to the fourfold for inspiration.

To the extent that the nature of our being is profoundly unknowable, so too will the fundamental essence of dwelling remain enigmatic. For Heidegger, the knowledge by which we can take appropriate measure of the world, such that we might dwell humanely within it, is not so much scientific or technological as it is poetic: "…poetry, as the authentic gauging of the dimension of dwelling is the primal form of building" (Heidegger, 2001/1971, p. 225, *Poetically Man Dwells*). Poetic perception, wherein our creative sensibilities are attuned to the properties of the *worlding world*, is his solution to escaping our overly technologized existence (Hofstadter, 2001). Thus, he elevated building to an art form, though not one of mere aesthetic or fanciful imagination. For Heidegger, the poetry of dwelling is the art of precise discernment of the essential nature of things, as they exist in relationship to one another, as well as our place within this interconnected system: *The relations of our dwelling are engendered by the nature of our being*. Of course, we have made some miscalculations along the way. For Heidegger, the current state of dwelling and the socio-ecological challenges that accompany this are not an ultimate expression of its underlying essence; our constructed dwellings may not always demonstrate the best practices by which to manage our own dwelling or existence within the biosphere. To achieve balance between one and the other, he has left us with this task: "The proper dwelling plight lies in this, that mortals ever search anew for the essence of dwelling, that they must ever learn to dwell" (Heidegger, 1993/1971, p. 363, *Building Dwelling Thinking*).

Ingold's (2000) expansion on the dwelling perspective is spread across a collection of essays on livelihood, skill, technology, and what it means for human beings to inhabit an environment—all of which he has presented with the aim of reclaiming an ecology of life. He has defined both, dwelling and the ecology of life, with respect to the immersion and constitution of the organism-person in and from a dynamically unfolding lifeworld. His work continues with the phenomenological tone introduced by Heidegger, though he grounds this by accentuating the coupled relationships that arise between nature and culture, people and places, mind and matter, processes and forms, actions and spaces, past and future. His integrative approach strikes out against Cartesian dualism, which positions nature as an external reality over which cultural significance, or meaning, is organized and imposed. He has likened this dualism to a building perspective—a classic architectural stance whereby "…worlds are made before they are lived in…" (Ingold, 2000, p. 179) or wherein rationalized, procedural, cognitive analyses of places precede our tacit engagement with them. Through colonialism, modernism, and the ascendance of industry, he has suggested, design as an intellectual pursuit now overshadows the

physicality of making; so too does the world appear to us as a mere surface for occupation and nature as an object for transformation. As the antithesis to the building perspective, Ingold has positioned human creative acts, inclusive of design and science, as derivatives of both our biological and social existence within the natural world. In other words, science and technological production are embedded within life processes and with the borders between our inner and outer worlds being indistinct. While Heidegger never overtly tied our basic character of Being to the ecosystems in which we dwell, Ingold's adaptation suggests that people, place, and community are, indeed, mutually formative: *Relations are embodied*. As such, the reflexive feedbacks that are common in socio-ecological, complex adaptive, and emergent systems behaviour (Berkes et al., 2003; de Haan, 2006; Jervis, 1997; Levin et al., 2013; Liu et al., 2007) appear more prominently in his framing of dwelling.

Ingold's conception of dwelling underscores the embodied, relational, temporal, and co-evolutionary qualities of creating. Places, or forms, emerge through lives lived over time, in an ongoing state of becoming—never finished. Underlying this is a proposition about systems change that assumes continuity in the evolution and historical development of the human species, societies, and cultural artefacts. What we see in modern systems, he has contended, belongs to this process of unfolding as much as the huts of our early ancestors and is no less natural. Human lifecycles and daily activities (or taskscapes) are embodied within the inhabited physical environment (or landscapes), with tasks being the constitutive acts of dwelling. Ingold has portrayed the taskscape as a suite of time-based movements that occur within a place, propelled by the rhythms of social life, and as they are connected to the cycles of local ecosystems. The landscape, on the other hand, is the form that becomes the site of these dynamic processes, with its features being incorporated into routine patterns of behaviour. Its spaces and places are fluid, not fixed—suspended in movement, as Ingold has put it. Neither are their boundaries defined, with clear beginnings and endings. Rather, they present as connected centres of activity, lighting up across regional networks: *Relations emerge and extend through time-based action in space*. This leads us in a similar direction as contemporary science of cities work, which is increasingly looking to analyse forms as an outcome of flows (Batty, 2013a).

> What it means is that the forms people build, whether in the imagination or on the ground, arise within the current of their involved activity, in the specific relational contexts of their practical engagement with their surroundings…The 'final form' is but a fleeting moment in the life of any feature, when it is matched to a human purpose, likewise cut out from the flow of intentional activity. (Ingold, 2000, p. 186–188)

While Ingold's thinking is evocative of complexity science, he too has proposed a *poetics of dwelling*. Taking inspiration from traditional indigenous ways of life, he has explained that this poetic understanding can be drawn from our experiential engagement with the world. For example, in some hunter-gatherer communities, technology, society, and nature are closely entwined; so too do myth, dream, and performance contribute to processes of sensemaking, with respect to human-environment relations. In some indigenous communities, he has told us, the meaning, or essence, of things may shift, relative to their purpose and associations with

other things: *Relations are coordinated symbolically, as well as functionally*. Through the dwelling perspective, he has attributed this to Western societies, as well: "…meaning is immanent in the relational contexts of people's practical engagement with their lived-in environments" (Ingold, 2000, p. 168). Places (whether wild, rural, or urban) come into being as homes by virtue of our dwelling within them; the memories of our social histories impregnate their spaces. Ingold's poetics also infers a *resonance* between individuals, society, and the natural world. By this, he means that everything is in its right place, operating in concert with the remainder of the system. Thus again, the poetry of dwelling is, effectively, a systems view of life, enriched with a cosmological angle.

Though their sources of inspiration differ, as do their cosmological touchstones, Heidegger and Ingold offer comparable conceptions of dwelling. From both, we are granted a temporally articulated sense of being in the world, as enmeshed within a series of meaningful relations (Ingold, 2000; Krell, 1993), by which places and things emerge. Both authors endow humans, as productive agents, with the power to organize or *gather* these relations, whether through preservation or transformation; however, they also underscore the imperative to ground knowledge and decision-making in an intimate attunement to context. Further to this, design is seen as a discovery of that which is meant to be, or a revelation of truth, as opposed to the imposition of our creative will on the world. (This bears some connection to the concepts of the adjacent possible or design space,[16] which suggest that prospects for innovation exist before we have realized them.) They also aim to complement technical-scientific or rational-quantitative ontologies, exploring how direct experiences of consciousness, being, and enlightenment can be foundational to the nature of dwelling. Heidegger has presented his thoughts on dwelling to connect acts of building with the meaning of Being; Ingold has done so to counterbalance the tendency of Western thought and design to prioritize the development of forms over the analyses of processes.

More recently, the dwelling perspective has made its way into resilience scholarship, which is significant as a step by which we can align resilience thinking with urban planning. These scholars (Cooke et al., 2016; Davidson-Hunt & Berkes, 2003) have adopted the concept to articulate the complexity of human-environment interactions and facilitate our re-embodiment within natural systems, or to forward a human-in-ecosystem approach to management, with a focus on dynamic processes. Generally, their thinking reacts against nature/culture dichotomies, and the alleged need to keep people out of natural environments (see Hobbs, Higgs, & Hall, 2013). For these authors, tacit and sensory engagement with the biosphere can serve as an antidote to overly cognitive methods in sustainability and resilience planning and stimulate local action (Cooke et al., 2016). In other words, they advise putting our hands in the mud as reminder that it is this same earth that grants us life. They carry on with the same basic premises as Heidegger and Ingold, though with a view to local and global ecosystems management: that we should engage in land-based learning as a means of shifting mindsets; that features of environments appear through patterns of activity; that sense of place is emergent from relational experi-

[16] *Design Space*: The total set of prospective designs that could be rendered (Beinhocker, 2011).

ences (Davidson-Hunt & Berkes, 2003); and that the biosphere is dynamically co-produced through human-environment interactions, occurring at different spatial and temporal scales (Cooke et al., 2016).

There is a contextual predisposition in Ingold's writing, which other scholars have latched onto. Namely, the common presumption is that the dwelling perspective applies primarily to small, traditional communities, subsisting on land-based livelihoods, wherein connection to the natural environment is direct and explicit (Cooke et al., 2016; Davidson-Hunt & Berkes, 2003; Obrador-Pons, 2006). Certainly, Ingold's essays are most suggestive of these types of scenarios, as many of them are based on discussions of rural or traditional hunter-gatherer societies. However, his core premises can still apply in contemporary, industrialized settings, regardless of our supposed cultural and spatial detachment from the natural world. In fact, he has stated himself that industrial machinery and material paraphernalia form part of the dwelling context with which humans must learn to cope. The concept of dwelling can challenge us to assess how human life within the biosphere has scaled up and out, over time, and whereby distances between people and places have become compressed by virtue of technological advancement (see West, 2017). Conversely, if we assign it exclusively to our localized and immediate engagements with the natural world, we risk overlooking cumulative, globalized phenomena in project planning (Cooke et al., 2016). Processes of dwelling extend across space and time: The fields of relations they engender would be all of those within the globalized human-environment web. Dwelling is heterogeneous, in that there is no one way to dwell within each of the biosphere's many biomes or cultural contexts; however, together as a human community, we have entrenched some of the parameters by which we do so. The concept of dwelling reveals the tension between managing localized and globalized systems phenomena. To reconcile this, Heidegger, Ingold, and Cooke et al. have offered similar solutions, as follows: Our nearness to or intimacy with things is not a spatially dependent occurrence, rather something that is achieved by accounting for all of our relations (Heidegger, 2001/1971); so too do we become at home in a place when we orient our actions to the relations of the taskscape, or our lifeworld, as opposed to the technologized, routinized, capitalist system of production (Ingold, 2000); to synchronize the local with the global, we can consider how to operationalize the planetary boundaries framework (see Steffen, Richardson et al., 2015) within the context of these lifeworlds (Cooke et al., 2016). These recommendations rest on an ontology of engagement rather than detachment—from experiencing the world from within, as opposed to analysing and managing it from above (Ingold, 2000).

> …the local is not a more limited or narrowly focused apprehension than the global, it is one that rests on an altogether different mode of apprehension—one based on practical, perceptual engagement with components of a world that is inhabited or dwelt-in, rather than on the detached, disinterested observation of a world that is merely occupied. (Ingold, 2000, pp. 215–216)

If applied in urban planning, the dwelling perspective could alleviate the primacy of forms, instead, considering the ranges of human thought and action that contribute to the production of an ever-evolving environment; how *processes of settlement* have led to the *formation of settlements*, which enable further *processes of*

settlement; and, how these processes have integrated with or disintegrated from other biosphere phenomena. If settlement is analogous to dwelling and dwelling is oriented around fundamental processes of human life, as embodied within environments (per Heidegger's basic character of Being or Ingold's taskscape), then a socio-ecological science of human settlement could, by this right, be inducted from a science of human life within the biosphere. One weakness of the dwelling perspective is its tendency to project an apolitical flavour. For example, Heidegger (1993 /1971, 2001/1971) has painted his world like a mythology, with human agents taking the stage in service of a greater plan; in Ingold's essays, the messier dimensions of human behaviour are subsumed under a field of task-based action. Though his work did not reference dwelling, in particular, Doxiadis' (1970, 1974) five principles of settlement give some indication of what the related universal processes might be; however, like the others, he leaves us without a strong sense of the identities or proclivities of systems actors. Instead, his mechanisms of systems change revolve primarily around the proverbial man's calculated attempts to achieve maximization, minimization, or optimization of human-environment interactions. In revisiting his initial conceptualization of dwelling, Ingold (2005) has discussed the challenges of accounting for factors such as power relations and makes some effort to incorporate a political dimension:

> Dwelling encompasses building just as producing life encompasses the production of the material means by which it is carried on. And of course, Marx went out of his way to emphasise how the production of life is not only essentially social but also structured by power relations. (Ingold, 2005, p. 504)

In expanding a socio-ecological science of settlement, we could aim to articulate the *human life* processes from which settlements emerge, in all of their complexity.

Systems Dynamics as a Basis for Place

In revisiting the dwelling perspective, approximately a decade following his first essay on the subject, Ingold (2005) reasserted his relational, process-oriented intentions, pushing back against any lingering misperceptions that the concept evokes a secure place of rest. His compunction to do so reveals a key challenge for planning: to balance between the concrete and the ephemeral, the material and the energetic, the static and the dynamic, the enduring and the fleeting (Obrador-Pons, 2006). The concept teases at either side, with Heidegger's (1993/1971) search for essence and Ingold's (2000) emphasis on process. Neither author relieves us entirely of our responsibilities to the classic design interests of form, space, materiality, and aesthetics; however, both compel us to descend from our constructed realities into the socio-ecological phenomena they embody, whereby we can analyse reflexive relationships between structures and flows, forms and meanings. The section to

follow explores intersections between the concept of dwelling (which originated in phenomenological philosophy) and the evolving suite of science of cities methodologies (which could be drawn from quantitative, qualitative, and design-based approaches).

The Social, the Ecological, the Constructed

Architect Christopher Alexander (2002–2005) has sought to uncover life processes, or *life-enhancing* design processes, in his own practice, which he explains in his four-volume series, *The Nature of Order*. Through this extensive writing, he has described how to let design schemes unfold gradually, as one comes to know the local ecosystems and communities with which one is working, or to allow built form to extend out of nature and culture. Alexander's approach to building illustrates a contemporary and applied rendition of the philosophies underlying the dwelling perspective. For example, in the making of things, he aims to tune into the intrinsic nature of people, place, and form. For him, these central qualities are objective and specific, though tenuous to identify or label. Rather, he deliberated at length on how to perceive them, if only intuitively, through design process. Spaces created with meticulous consideration of these qualities, in every sensory detail (sight, sound, smell), he believed, connect us with the truth, beauty, and austerity of our own existence. To design in this way is to breathe life into a place, such that it becomes healthy and self-reproducing, not wretched and self-destructive. As was introduced in Ingold's thinking, in these living systems, the essential qualities of independent parts will be enhanced through the arrangement of the whole. Thus, Alexander's sustainable architecture is a relational one. Always customized to context, his approach is the antithesis to mass production and epitomizes what some might refer to as slow or adaptive design—the first which reveres quality in creation and connection (see Honoré, 2004) and the second which encourages responsiveness to dynamic contextual factors (Lister, 2013/2010). Though Alexander's writing elaborates considerably on holistic, systemic, and bio-conscious approaches to urban and architectural development, it also exposes some of the limitations of design for engaging in rigorous socio-ecological systems analyses. Throughout his four volumes on life-centric design philosophy and practice (Alexander, 2002–2005), we are afforded only a glimpse of the substantive content of our social and ecological worlds. Geddes too was regarded for his environmental ethic, attention to the influence of people and place on one another, and holistic interpretation of planners' responsibilities to social wellbeing (Hysler-Rubin, 2011). However, regardless of designers' sense of principle, we ultimately face Alexander's (1964) original methodological conundrum: to navigate form-context boundaries and delineate the sites of our interventions within dynamic settings. To do so, it is worth extrapolating the point at which a science of design should bleed into a science of that for which we are designing—the social, the ecological, the technological.

Part of the challenge is that design crosses into natural, social, and humanities' disciplines, yet remains distinct from any of these fields in its focus and methods (Buchanan, 1992; Cross, 2007; Nelson & Stolterman, 2012). As well, design outcomes are conventionally associated with things that are neither explicitly human nor natural, occupying instead the world of the artificial (Simon, 1996/1969). When Simon explained design as a *science of the artificial*, he aspired to grant it with a procedural, problem-solving logic "that would be acceptable to a community of engineers" (Margolin, 2002, p. 235). His efforts to do so came among others, who similarly wished to venerate design as a legitimate and distinct field of scholarship while also codifying its methods of practice and setting it apart from softer approaches to decision making (Edmonson, 2007/1987; Margolin, 2002; Mehaffy, 2008). This dichotomy is paralleled in what Portugali (2011, 2012a, 2012b) has termed the two cultures of cities/planning. Namely, these represented a clash between quantitative and qualitative camps, batting against each other in the late half of the twentieth century. On one side, there were positivist, quantitative analytic and rational comprehensive approaches, which sought to define the ideal city, and the optimal procedures by which it should be planned. On the other, there were social theories of cities, which painted political, pluralistic, humanistic, experiential, and philosophical views of urban systems and analysed macro-level social phenomena. There is also a third way, he contended, reflected in the work of the occasional, nonconformist luminary, for example, who highlighted bottom-up processes of development (Jacobs), the complex network structures that result (Alexander), and the routine space-time movements that act as a weak generative force on the city (Hägerstand) (Portugali, 2011). As methodologies, there is potential for integration, and Portugali (2000) has proposed that self-organizing theories of cities can serve as the bridge. If we were to take the above-mentioned cultures of cities/planning as a methodological package—examining globalized social trends, localized diversity, dynamic social networks, and properties shared with other complex systems—the key missing lens, still, would be analyses of ecological contexts. However, recent resilience-based approaches to urban ecology are filling this gap, with a view to contributing to science of cities thinking (Elmqvist et al., 2013a; McPhearson et al., 2016).

For practitioners designing conscientiously, or in accordance with a sustainable design mindset, it would be normal to assess site conditions and multi-stakeholder priorities in advance to project development and with reference to planning goals. We can pay regard to environments and people and include communities in creative processes. We might even consider this a traditionalist approach, with its lineage tracing to the work of Geddes: "A town or city in some sense grew out of its urban and rural environment in a complex web of causes and effects, its inter-related parts interwoven through time" (Batty & Marshall, 2012, p. 24 with reference to Geddes). Yet, each of these domains, the social and the ecological, is a world unto itself and could take a lifetime of study to understand. Their dynamic, intersecting behaviour is another matter, altogether, and methods for the empirical analyses of feedbacks between social and ecological systems, or between ecological and technological systems, are still

nascent, within urban fields and otherwise (Elmqvist et al., 2013b; Gallopín & Raskin, 2002; Levin et al., 2013; Liu et al., 2007; Rotmans et al., 2000). This is understandable. In a globalized setting, these feedbacks have become increasingly complex (Gibson, 2016; Young et al., 2006), and the profession of planning is not alone in its minimization of ecological considerations; for example, Olsson et al. (2017) have indicated that social innovation initiatives, too, have thus far been lacking in their attention to dynamic human-environment interactions or integration of social and ecological factors. This is changing, as a new domain of innovation and invention takes shape, which combines social and ecological mandates—socio-ecological innovation (Olsson et al., 2017).

In fields related to urban planning, design and study, nature, society, and technology have been merging through hybrid disciplinary approaches, such as urban ecology (Grimm et al., 2008; McPhearson et al., 2016; Mostafavi & Doherty, 2013/2010; Niemelä et al., 2011), landscape urbanism (Waldheim, 2006), biophilic design (Beatley, 2016; Kellert et al., 2008), and biomimicry (Benyus, 1997), along with efforts to reinsert humanity into industry (citiesforpeople.ca; Ellard, 2015; Gehl, 2013; UN-Habitat, 2014). Thus, planners and designers are acting to reform settlement systems on both sides of the nature/culture equation or the two rings of the planetary boundaries doughnut (the ecological ceiling and the social floor) (Raworth, 2017). We have recognized the impacts of the built environment on physical and mental health, linked to factors such as air pollution, sanitation, access to green space, active transportation, and cultivation of ecosystems functions and services (McPhearson et al., 2016; Rojas-Rueda et al., 2016; Tzoulas & Greening, 2011); that citizen wellbeing is an outcome of multiple intersecting factors, inclusive of but not limited to community context, engagement, socioeconomic status, and equity (Bromell & Cagney, 2015; Duhl, 1996, 2005; Kelley-Moore, Cagney, Skarupski, Everson-Rose, & Mendes de Leon, 2015; UN-Habitat, 2014); that urban design can contribute to citizen quality of life (McCormick et al., 2013); that cultural development and expression can derive both economic and social benefit (Florida, 2008); and that urbanization processes continue to place pressure on climate systems, biodiversity, coastal regions, ecosystems services, and agricultural production (Elmqvist et al., 2013a; Sassen, 2009). In our strategies to enable sustainable urban development, it would seem as though we are being categorically comprehensive (also see the list of targets and indicators for SDG Goal 11); if this is not propelling us towards a sustainable future as rapidly as we would hope, perhaps we are overlooking something within the coupled dynamics of social and ecological factors, the indirect impacts of the social realm on the environment, or the emergent properties of settlements.

For example, more elusive than planning sustainable cities is the task of re-embedding culture within nature; although, this is effectively what a number of research-practitioners have been attempting under mantras to design with respect to, or inspired by, living environments (arcosanti.org; Alexander, 2002–2005; Beatley, 2016; Benyus, 1997; living-future.org; McDonough & Braungart, 1992, 2002, 2013; McHarg, 1995/1969; Register, 2006; Todd, 1985; van der Ryn &

Cowan, 1996; Wann, 1996). In sustainable development, the conceptual construct of city has the potential to mislead our initiatives or at least cut them short. As a moderation, the lens of dwelling would ideally trigger intuitive responses by which to mitigate the nature/culture divide, within the setting of constructed systems, or intimate approaches by which to "fundamentally rewire human-environment relationships" (Olsson et al., 2017, p. 31). The complication with this, however, is that the link between one and the other, nature and culture, in human-environment interactions is not always direct (Liu et al., 2007; McDonald et al., 2013). More accurately, these relationships could be described as human-to-human-environment interactions or even human-to-human-environment-to-environment interactions; not to mention, somewhere between one and the other sits technology. Settlements are comprised of multiple, intersecting complex adaptive systems: "...the city as a whole is a complex system and each of its agents is also a complex system" (Portugali, 2016, p. 3). Any comprehensive science of settlement should, presumably, endeavour to deconstruct the dynamic layers of each, as well as the interaction among them. A science for the design of settlement systems could, effectively, be a science of the socio-ecological systems complexity within which we are designing.

Integrated Essence

It is not surprising that the dwelling perspective was initially conceptualized without significant representation of power dynamics, seeing that the term *human-environment interactions* similarly compresses these, as has resilience scholarship (Cooke et al., 2016; Wilkinson, 2011). The human dimensions of sustainability and resilience are too disparate to cover in one line of disciplinary inquiry: There are meta-layers to the social realm that are auxiliary to our basic survival. Neither is the impact of human activity on the environment always immediate nor localized (Elmqvist et al., 2013b; Mascaro et al., 2013; Perring & Ellis, 2013; Seto et al., 2012); some effects will be measurable, though we can also presume that the chain of causality will be dispersed among a broad field of endeavour and behaviour. Design, innovation, and planning practices confound these factors further, in that they mediate, and sometimes dislocate, our connection to the natural world (Liu et al., 2007). Furthermore, as the technologies and schematics by which we support human life continue to propagate, the significance societies attach to related forms could also evolve. The automobile presents a clear example of this—a technology that now holds social value beyond the fulfilment of our pragmatic mobility needs. To the extent that meaning is embedded within our constructed realities, designers are caught in an ontological feedback loop: Design sits on the leading edge of not knowing where we want to go; the possibilities it reveals may fuel latent desires. Furthermore, along this path of innovation, we may forget to stop along the way to contemplate what it all means—at least until the cumulative effects become apparent.

Heidegger (2001/1971) and Doxiadis (1974) hinted at this in their efforts to ascertain the essence of dwelling (or settlement). By definition, essence is "the real or ultimate nature of an individual being or thing…as opposed to its existence or its accidental qualities," and "the properties or attributes by means of which something can be categorized or identified" (Allen, 2006, p. 474). In effect, these two authors were grasping to pinpoint the aspects of settlement that are, more or less, enduring, regardless of systems change—those that transcend time and context. In their writing, as well as that of Alexander, this essential nature of settlement, or built form, is discussed as something that is real, yet intellectually inaccessible; for them, it may remain as elusive as the nature of human nature or being (see Doxiadis, 1974; Hofstadter, 2001). Complexity theories of cities have been working in this same accord and have revealed common properties and mechanisms of urban growth, scaling, form, and organization, which repeat across space and time, as well as patterns of behaviour that are shared with other complex systems (Batty, 2013a; Batty & Marshall, 2012; Bettencourt, 2013a, 2013b; Portugali, 2000, 2012a, 2016; West, 2017). This quantitative research does, indeed, offer some perspective on the essential nature of cities, as complex adaptive systems, though mainly focused on their general structures, properties, and dynamics, as opposed to their substance and specific qualities, which are matters for qualitative inquiry. Purportedly, repetition of quantitatively or qualitatively measurable factors would be the necessary criteria for the expression of a science. In searching for these, however, we should caution to distinguish the fundamental essence of dwelling (or settlement) from the many variations by which it has transpired. After all, the current state of urban systems may not be the epitome of urbanism (Sassen, 2012).

Partly, this is a dilemma for systems thinking: The whole of the city is greater than the sum of its individual parts. There may be integrative, relational, or emergent factors that are critical to its essence, appearing at the aggregate level and rendering urban planning different from object-based design endeavour (Batty & Marshall, 2012; Bretagnolle et al., 2009; Portugali, 2012a). As problems in *organized complexity*, the patterns that emerge within cities through the interrelation of innumerable factors are quintessential (Jacobs, 1961). Taken as such, there is a question as to whether essence and function are historically dependent and evolving. Do the nature and purpose of settlements, and our dwelling within them, change along with their repatterning? Urban sociology, past and present, has drawn attention to the major social processes that have brought with them new order within urban contexts, such as industrialization, digitization, and globalization (Sassen, 2010). At the same time, the similarity in features, composition, and logic between ancient and contemporary variations of cities, despite more than 5000 years of change (Portugali, 2000), raises the question as to whether urban systems encapsulate something that is intrinsic to human life. In this respect, following from Max Weber, Portugali (2000) classifies cities not based on their strict conformity to a list of features or criteria, rather as derivatives of an ideal type,[17] which arise within

[17]*Ideal Type*: In this method of analysis, a model exemplar of a given social or cultural phenomenon is identified, against which other instances can be compared and connected. Sociologist and

culturally and historically specific conditions. Others have noted a similar quandary with respect to studying the nature of human nature, and how we might do so without reducing interpretations to a list of attributes shared among all members of the human population (Capra, 1996):

> …the real problem would be 'to infer the *core* common to the whole human race from the innumerable manifestations of human nature…to recognize the laws inherent in human nature and the inherent goals of its development and unfolding [E. Fromm]'. (Capra, 1996, p. 56)

Though not obvious to combine within disciplinary contexts, these two areas of inquiry, settlements and human nature, are closely related, if only by the simple adage that cities are people (Jacobs, 1961; West, 2017). Further, we may discover new approaches for examining the relationship of each to sustainability, through their mutual association. If we associate settlement with dwelling, and dwelling with (human-to-)human-environment(−to-environment) interactions, and human-environment interactions with human life within the biosphere, we may ultimately discover means of answering questions about one with the other. For example, could we extract general premises about our own humanity based on the ways we have organized in space, over time, within the context of settlements (i.e. our ways of *being in the world*), or determine the best means of managing systems of settlements through analyses of ranges of human-environment interactions (i.e. the crux of sustainability)? Doing so might provide more empirical grist (see Sassen, 2010) when attempting to address the complex human dimensions of sustainability and resilience challenges and refine classification of the kinds of issues we are endeavouring to solve—reducing redundancy in our framing of the problem space while also inverting it. If settlements are sites wherein globalized social phenomena take effect (re. Sassen, 2010), through these systems we are granted access to complex and emergent social trends. Furthermore, if settlements are an embodiment of human-environment interactions, we can explore, more precisely, how these have been entrenched in physical space. We may even find that readings of our constructed worlds reveal to us our own implicit preferences or that changes in systems of settlements, over time, continue to liberate aspects of human experience that were unattainable in earlier systems states (whether desirable or undesirable).

Between their essence and schematics, systems of settlements have yielded contradictions. For example, they bring people together (Bettencourt, 2013b), yet produce experiences of social alienation (Montgomery, 2013). They enable economies of scale through the sharing of resources (Bloom et al., 2008), yet perpetuate socio-economic segregation (Harvey, 1985; McCormick et al., 2013; UN-Habitat, 2014). They have facilitated an impressive range of human achievement (Bretagnolle et al., 2009; West, 2017), yet at a pace of globalized development that is overtaking our ability to manage the impacts (Young et al., 2006). They exhibit lower per capita carbon emissions (West, 2017), yet are reproved for poor air quality. They have

political economist Max Weber analysed cities in this way, wherein he illustrated how those arising within very different times and places could be related through their shared characteristics, as opposed to generalized laws (Portugali, 2000).

fortified the human capacity to survive within and spread out across multiple niche ecosystems (Christian, 2004; de Vries & Goudsblom, 2002), yet the means by which they have done so are now compromising their long-term resilience (Elmqvist et al., 2013a). These incongruities speak to the paradoxical behaviour of cities, in particular, as they engender both challenges and opportunities for transition. This appears as a central narrative within science of cities thinking, which highlights one key tension exposed by the universal, superlinear, and sublinear scaling properties of urban systems: That is, as cities grow in size, they exhibit an exponential increase in certain desirable attributes (such as economic productivity and innovation) and similarly in undesirable ones (such as crime and traffic congestion) (Bettencourt & West, 2010; West, 2017). Returning to the question of essence, we could debate whether these listed attributes are intrinsic to any city or a product of how we have organized urbanism. The above contradictions and tensions signify a possible disjuncture between the current state of urban systems and their potential or between their existing variations and underlying nature. The learning curve along which they have matured has perhaps embedded systemic dysfunctions.

> [A contradiction is] a set of problems or tasks that cannot be resolved within the terms of reference (or 'paradigm') in which they are conceived… In the case of modern Western civilisation, there are two that are linked: the moral unsustainability of a lifestyle that most of the planet's people cannot ever enjoy; and the physical unsustainability of that lifestyle even for the (temporarily) fortunate minority. (Ravetz, 2007, p. 281)

Generally, it is deemed imprudent to pursue a paradigm shift as a course of habit, as opposed to something that unfolds through cumulative, collective discovery and action (Kuhn, 1996/1962; Meadows, 1999). However, we could certainly inspire change by engaging with complex problems through the application of new concepts, research methods, strategies, and/or practical techniques. For the two issues he has mentioned in the above quote, Ravetz (2007) has criticized the green-tech and localized, do-it-yourself solutions typically proposed, respectively, on the basis that neither has the capacity to fix nor transform rigid or degraded systems conditions. To endorse a possible paradigm shift, he has made one off-the-cuff recommendation for altering both sides of his linked contradiction: "…a revolution of consciousness, whereby affluence itself came to be seen as a disease" (Ravetz, 2007, p. 283). In other words, he has tentatively urged us towards the transformation of our current economic system—experiments for which are already underway through the auspices of ecological economics (Brown & Garver, 2009). Ravetz (2007) has presumed that acquisition of affluence, or capital wealth, occurs primarily through engagement with an economy that exploits nature as well as vulnerable communities. Ostensibly, this is the current state of the system, rather than its essence, however. It may be possible to construe other, nonmonetary forms of wealth, for example, as represented in ecological economics literature as natural and cultural capital (Berkes et al., 2003).

So, how does this relate to our science of settlement and help reconcile the tensions posed by contemporary urban systems? It comes back to Sassen's (2012) point about content: It may not be urbanism that is problematic, so much as the

means by which it has been conceptualized and accomplished. Our characterizations of the substance of a system will inform how we measure its performance. For example, gross domestic product (GDP) statistics, which are featured in urban scaling research (Bettencourt, 2013a), have come under scrutiny as a limited and outdated measure of the wealth of nations (Brown & Garver, 2009; Henderson, 1995); as an indicator, it is loaded with significance that some find contentious, for example, having objected that the productivity of the informal economy, or the value of social and natural capital, remain under-represented (Elmqvist et al., 2013a; Henderson, 1995). So too would something like crime have a context-dependent definition (Bettencourt, 2013b) and a variety of socioeconomic determinants. Finally, an example that is most illuminating of why content counts is found in a series of graphs on urban scaling—ones that illustrate the sublinear distribution of gasoline stations within Europe (see West, 2017). Clearly, the presence of this particular infrastructure is a phenomenon of the fossil fuel era; substantively, it is a modern outcome. Yet, its distribution within cities follows a mathematically predictable pattern, in accordance with city size; quantitatively, it exhibits a property that adheres even in cities of the past (see Bettencourt, 2013a, 2013b). In other words, scaling properties of cities have held across time, despite obvious modifications to the content of urban systems. To blend qualitative with quantitative insight, we could investigate whether comparable transportation infrastructure and energy technologies, of another era, conformed to this scaling behaviour and whether societies of the past were meeting analogous functional needs in similar ways. Also notable is the relevance of the gasoline station to urbanism and its role in the production of society and civilization. These kinds of qualitative questions could be developed to complement the existing body of quantitative research on scaling properties: For example, many of the phenomena that have been graphed would be multifaceted in their formulation, arising through series of relationships greater than the sums of their parts. Nurturing the desirable while mitigating the undesirable aspects of urbanism, therefore, calls for an integrated approach. The outcomes of urbanism are fundamentally relational, and many would be reflective of emergent patterns.

Form, Matter, Process, Meaning

Complexity and resilience scholars have been honing methods for tracking dynamically evolving systems and noting when they are verging towards fundamentally new states (see Scheffer, 2009), while, in design and innovation work, we may attempt the intentional facilitation of such transitions, especially within human-constructed systems. In both cases, we come up against the same predicament of distinguishing one state from another and assessing the relative complexity, novelty, diversity, sustainability, and resilience of each. Extending from the dwelling perspective, we could propose an integrated means of doing so—one that links with both science and design-based thinking; could bridge social, ecological, and technological considerations; and could be applied to assess multiple systems types. The

dwelling perspective evokes a methodological position that presumes interrelation between meaning and function and incidentally overlaps with those already present within a few other fields. Across strategic design, social innovation, complexity, systems thinking, and transition literature (Beddoe et al., 2009; Brown, 2009; Capra, 2002; IDEO, 2015; Loorbach, 2010; Odum 2007; Westley & Antadze, 2010; Westley et al., 2007; van der Leeuw et al., 2009), we find comparable categorical frameworks for deconstructing complex systems features, phases of systems change, areas for multi-stakeholder action, and/or actor roles. Elsewhere, I have synthesized these categories as *perspective*, *practice*, and *power*; another common classification cluster is *information*, *matter*, and *energy* (Odum, 2007). In all cases, these frameworks have aimed to comprehensively capture the parts comprising complex wholes, in a way that is universal and generalizable (though are not expressly empirical in their formulation). Analysing integrated phenomena on simple, yet astute, terms may ultimately help expose the roots of the contradictions emerging through contemporary urbanism.

Within this set, there is one framework, in particular, that aligns overtly with the dwelling perspective and has been presented with the similar intention of sparking a paradigm shift for sustainability. The related shift that has been unfolding within science and design is the relinquishment of Cartesian dualism, which is part of what initially spawned division between the realms of nature and culture, in both scholarly and creative work (Capra, 1996, 2002; Davidson-Hunt & Berkes, 2003; Ingold, 2000). Where Ingold (2000) has criticized design for prioritizing forms over processes, according to Capra (1996, 2002), a parallel fragmentation exists in Western science and philosophy, between the study of substance and form, the material and the non-material, and matter (natural) and behaviour (social). For him, we can achieve balanced analyses of life phenomena (inclusive of the biological, cognitive, and social) through the combined observation of their *form*, *matter*, *process*, and *meaning*, as well as the interrelations between these elements.[18]

> …culture is created and sustained by a network *(form)* of communications *(processes)* in which *(meaning)* is generated. The culture's material embodiments *(matter)* include artifacts and written texts, through which meaning is passed on from generation to generation. (Capra & Luisi, 2014, p. 304)

More so, he has contended this unifying framework is necessary for sustainability planning, to synchronize social organization with the biophysical world. By analysing social and ecological systems in accordance with comparable parameters, we might explain how each is like the other, constitutive of the same general elements. Thus, we reduce redundancy within our problem domain, both conceptually and methodologically. Patterns of settlement, and the relative complexity these engender, could be examined as an outcome of the dynamic, ongoing, reflexive interaction between these four elements. As with dwelling (social) *beings* and *world* could be

[18] *Form* is the physical embodiment of a system's pattern of organization; *matter* is the material structure of a system; the *process* of life is the activity involved in the continual embodiment of the system's pattern of organization; *meaning* is the inner world of reflective consciousness (derived from Capra & Luisi, 2014, pp. 303–304).

viewed as co-evolving, with the products of modern society emerging within this continuum (re Ingold, 2000).

To illustrate a simple application of this approach, I will return to the contradiction presented by Ravetz (2007), introduced earlier. For him, affluence as a concept is associated with a globally institutionalized, economic system, which includes some and excludes others, leading to social inequalities and instances of extreme poverty. If we were to identify the limiting resources (re Simon) applicable in this case, we might start by considering the pathways by which impoverished, underdeveloped communities could improve their circumstances. Lawyer Hernando de Soto (2000) has done just this: Working initially with communities in Lima, he noticed the assets of informal settlements were not being accounted for within legal, and therefore economic, systems, rendering it more difficult for these low-income citizens to participate in the market economy. To address this, de Soto established legal property titles for their shantytown dwellings, thus providing them with assets against which they could hypothetically leverage credit and loans (Fernandes, 2002; Mau et al., 2004).

> …shanty homes are essentially economic assets, 'dead capital', that should be revived by the official legal system and turned into liquid capital so people could gain access to formal credit, invest in their homes and businesses, and thus reinvigorate the economy as a whole. (Fernandes, 2002, p. 6)

Without reorganizing or intervening within their physical dwellings (form/matter), de Soto modified the legal status of their properties (meaning), thus altering residents' ability to engage with the market economy (process). He has mitigated Ravetz's (2007) contradiction while working within the parameters and opportunities of conventional economic and legal systems. Some criticize his approach as being overly conservative, under-analysed, unrealistic, and one-dimensional (Fernandes, 2002). Still, by ascribing one thing (informal settlements) with new significance (legal titles), de Soto endowed it with enhanced functionality and benefits. He also introduced socioeconomic complexity to these developing world contexts.

The dwelling perspective exalts the *field of relations*, in which both nature and culture are inevitably entangled, as a worthy subject of study and site for innovation (Ingold, 2000). If a paradigmatic transition is burgeoning in design—and with due regard to the influence of Jacobs (1961), who considered processes to be of the essence to urban planning—it is that practitioners are similarly looking to reveal the relationships embodied within our constructed realities. Phillip Beesley (2017) has employed the term (field of relations) to describe a renewal for architecture, no longer confined to the creation of buildings carried eternally on firm ground (as once depicted by Vitruvius), but also engaged in the production of semi-organized nuclei of exchanges (material and energetic)—a living architecture, though still emplaced. In a similar vein, Lally (2014) has explored how to shape energies (electromagnetic, thermodynamic, acoustic, and chemical), as well as social interactions within space. Urban planner and geographer, Michael Batty (2013a), has entreated us to turn our attention from urban artefacts to flows: "…instead of thinking of cities as sets of spaces, places, locations, we need to think of them as sets of actions, inter-

actions, and transactions that define their rationale and relate to the way scale economies generate wealth…" (p. 9). Tomalty (2009b) has recounted how urban sustainability initiatives are progressing beyond isolated issues (e.g. with recycling or conservation programmes), instead diving into the "…underlying processes that structure our relationship with nature…" (p. 19). Rotmans et al. (2000) have offered an integrated planning tool for sustainable cities, which evaluates systems stocks and flows (economic, sociocultural, ecological), to complement the narrow focus on urban environment and infrastructure that is common in conventional approaches. Urban metabolism research is maturing from analysing stocks and flows to predicting or directing them: "The challenge ahead is to design the urban metabolism of sustainable cities" (Kennedy, Pincetl, & Bunje, 2011, p. 1971). In Mau's (2010) portrayal of sustainable design, practitioners create artefacts with a view to their positioning within broader cycles of production and consumption. Sevaldson (2016) has codified general types of systems relations for designers (structural, semantic, social, hard) and has suggested ways by which these might be quantified and qualified. Of course, a core tenet of ecological design is to integrate "'…human purposes with the larger patterns and flows of the natural world'" (D. Orr in Capra & Luisi, 2014, p. 442). In short, underlying this shift is the idea that relational systems dynamics could be a subject of both empirical observation and substantive modification, within design-based projects. Moreover, through relational approaches, we may begin to view settlement systems as dynamic, living entities:

> Infrastructure is akin to a living system that brings increasing numbers of people together in more complex economic and social relationships. (Rifkin, 2011, p. 35)

There are a number of compelling reasons to undertake relational analyses between form, matter, process, and meaning, as these pertain to sustainability and resilience within settlement systems, especially if our goal is to disrupt prevalent models. The first is to examine how the state of a system entrenches *power*, as is revealed by Ingold's (2005) comment: The "production of the material means by which [life] is carried on…is structured by power relations" (p. 504). For example, these appear in our harvesting and distribution of natural resources (i.e. cycles of production and consumption), as well as our shared social spaces, in the way they en(dis)able participation in civic life. The second is to examine how the state of a system entrenches *values*. For example, we may perceive the significance of a thing, like an automobile, relative to its various practical and social uses. The third is to examine how the state of a system entrenches *functions*. For example, daily commuting and the transportation infrastructure that supports this are very much tied to the nature of citizens' formal participation in the economy. The fourth is to examine how the state of a system delivers *benefits*. Of course, part of the lure of urbanization has been the increased life opportunities it theoretically engenders for citizens (Jacobs, 1961). The fifth is to examine how the state of a system entrenches *cumulative impacts*. Traffic congestion resulting from sprawling development would be one example of this. The goal of such analyses would be to identify deeply rooted points of leverage by which to repattern settlement systems, understanding that these would appear more often as relational clusters than clearly delineated areas for

intervention. These kinds of analyses could intersect with existing methods, such as those which track energy returned on energy invested (EROI) (Hall, Tharakan, Cleveland, Hallock, & Jefferson, 2003), embedded energy (or emergy)[19] implications (Odum, 1988, 2007), human activity in space as captured through big data (Batty, 2013c; Bettencourt, 2014), and urban metabolism (Kennedy et al., 2007; Kennedy et al., 2011). We could experiment with the integration of qualitative and quantitative approaches, juxtaposing studies of meaning against those of infrastructural development and resource flows, exposing the values embedded within forms (see Mehaffy, 2007).

In the least, in Capra's (2002) categorical synthesis of living phenomena, he grants equal attention to processes as to forms, which is a perspective from which we could benefit when planning within urban contexts. Perhaps we temporarily lost sight of the former through the seduction of industrial technology for the built environment (such as steel beams and elevators) (see Ching, Jarzombek, & Vikramaditya, 2011); however, in digitized, globalized settings, we may also be losing grip on the latter (Sassen, 2010). Without the translation of flows into places, or meaning into form, one risks enabling a kind of cultural detachment that strips all character from the public realm. Castells (2006) fears we have, indeed, subsumed the significance of place under "...the exchanges of information, capital, and power that structures the basic processes of societies, economies and states between different localities..." (p. 136). Certainly, we can imagine the urban milieu transcending its physical spaces and taking on a quality of placelessness, especially through the digital realm, which is at once real and intangible, as well as global networks, which are localized in their siting, though international in their consequence. It is not that space and place could become altogether irrelevant, as major infrastructure still requires a physical home and spatial footprint (Castells, 2010a; Rifkin, 2011; West, 2017). When it is said that we are disconnecting from place, this is partly a matter of flow rather than form; our economies, cultures, politics, and ecologies are no longer place bound; they are globalized and may be displacing local identities (Castells, 2010a; Sassen, 2012). From a dwelling perspective, however, we could argue that processes such as industrialization and digitization emerged as part and parcel of the metabolism of human experience within the biosphere and thus can be positioned with respect to our rootedness or boundedness within this planet. Based on the recommendations of Heidegger, Ingold, or Cooke et al., we might resolve to reinvigorate these processes through localized, customized, human-scale expression: "Recovering place means recovering the multiplicity of presences in this landscape" (Sassen, 2010, p. 5).

At the crux of a relational approach to urban planning and design, as this has been developed in science of cities thinking (Batty, 2013a; Portugali, 2000; West, 2017), is the regard for networks as a foundational schematic: Cities are conceived as networks extending in time and space, with individual places as nodes, materializing through the intersection of multiple types of interactions (Castells, 2010b;

[19] *Emergy* "...is the available energy of one kind previously used up directly and indirectly to make a product or service" (Odum, 2007, p. 89).

Sassen, 2012). The Third Industrial Revolution[20] has mobilized around the logic of network organization and is informed by a philosophical acceptance of the interconnection of all things (Rifkin, 2011). Networks also represent the basic organizing pattern of living systems and are a central metaphor incorporated into ecological thinking (Capra, 1996, 2002). Thus, through network analyses, we may achieve some conceptual and methodological unification across the disciplines of ecology (and ecological sustainability), complexity, and urban planning.

Design practice has conventionally engaged in problem solving through the making of *things*, such as ovens to cook food, vehicles to transport people, or homes to protect against the elements. These things are designed as means to an end, though in an object-oriented practice, we could just as easily mistake them for ends in themselves. From a relational perspective, we might instead think about modifying parameters within space and time, innovating within a flexible continuum of viable systems states, organizing patterns of interaction (Batty, 2013a), or rewiring human-environment interactions. More simply, Schrödinger (1967/1944) had intimated that exchange between an organism and its environment, wherein order (or negative entropy) is extracted, is the qualifying property of living (see Portugali, 2016). If life is exchange, and settlements are designed for life, then perhaps settlements are designed for exchange (West, 2017); forms facilitate flows. This does not collapse the relevance of space, materiality, aesthetics, or place-based experience. Instead, each of these could be interpreted with respect to their significance within broader fields of relations. Interpreting settlements as an outcome of their flows, or relational factors, should not encourage a laissez-faire acceptance of circumstantial incident or cumulative effect. Rather, it would lead to a necessary balancing between the material and the ephemeral in analyses and intervention. If we overlook the relationships that exist between forms and processes, we run the risk of governing societies by the demands of our inanimate constructions. Indeed, our cities are almost at this stage, wherein our infrastructural plans drive how we use spaces and places or how we interpret quality of life.

Enhancing lasting social wellbeing and ecological systems integrity is the basic objective of sustainability planning (Gibson, 2006, 2016). To accomplish this, we are stuck with the wicked task of determining how to provide more for this planet's growing populations, with the consumption of fewer natural resources. This was the idea behind Fuller's (1971/1938) concept of ephemeralization—doing more with less through savvy systemic design. Given that our biosphere is one of hard ecological limits, some view this as an illusion of technological development, which has simplified our day-to-day routines, though presumably not without added material footprint.[21] Extending from a relational view of settlement, there may be a trick by which ephemeralization could become feasible, however. By practice, many designers (graphic, industrial, architectural, urban) are materialists. On the other

[20]*Third Industrial Revolution*: This current regime shift represents the implications of information technology on production, operational management, and distribution (Rifkin, 2011).

[21]Personal communication with William Rees, Canadian Society for Ecological Economics Conference, October 4, 2015, Vancouver.

hand, the dwelling perspective and science of cities thinking intimate that settlements are not as much material artefacts, as they are sets of dynamic interactions, organized across hierarchical network formations. From a design practice based on the creation of material things, a materialized world naturally propagates; from a design practice grounded in the coordination of relations, perhaps dematerialized systems could follow.

Emergent Engagement

People inhabit settlements, though, more precisely, we are situated within and co-creating them as natural, emergent, self-organizing, and intentionally constructed socio-ecological systems networks. Key to adopting a relational approach in settlement planning is acceptance that their processes of change can occur quite separately from our visions for idyllic or even functional places of living: They are contingent on multiple, interacting, cross-scale factors, beyond our explicit control or conception. In this light, complexity views of cities have acknowledged the importance of complementing top-down with bottom-up initiatives (Batty & Marshall, 2012; Bettencourt, 2013b; Jacobs, 1961; Portugali, 2012a)—a recommendation that is matched in discussions on innovating for systems transformation and transition, more generally (Loorbach & Shiroyama, 2016; Westley et al., 2011; Westley et al., 2013). From a methodological perspective, there is a more considerable challenge to contend with, however: That is to account for interlinked dynamics occurring across systems scales. For this, some authors have endorsed multilevel governance strategies (Bulkeley & Betsill, 2005; Rotmans & Loorbach, 2009). Regardless of our ability to enable diverse, networked participation in project management or processes of systems change, there may still be incongruity between the scales at which critical issues take effect and those at which we are equipped to track and address them—what resilience scholarship refers to as scale mismatch (Cumming & Norberg, 2008). Once we conceive of systems of settlements as regionalized and globalized networks, it becomes clear why scale mismatch could be an issue in their management.

In planning contexts, the term *process* has been familiarized to refer to collaborative social processes by which decisions are made and projects are developed (Mehaffy, 2008; Portugali, 2011; Rotmans et al., 2000), while design charrettes have slid into place as a proxy for democratic, bottom-up action. Here, I apply the term with an extended meaning (as discussed in the previous section), referring more broadly to the social, economic, political, and ecological dynamics that can be constitutive of systems of settlements. Collaborative innovation processes are embedded within these others. From a dwelling perspective, we could claim they occur as part of our *being* in the world; from a self-organizing city perspective, such would also be the case, as would urban agents be considered planners, in their own right, at a certain scale (Portugali, 2000, 2016). In Portugali's (2000, 2016) self-organizing city, top-down and bottom-up actions bleed together; the distinction

between professional and citizen actions is less critical. Arguably, however, at certain scales, the explicit agency behind systems change becomes opaque; neither would every scale of a system be accessible for direct analyses and intervention. According to Bulkeley and Betsill (2005), when it comes to planning for urban sustainability, the appeal of localized action through the implementation of best practices has tended to displace awareness of wider interacting systems processes, and how these take shape, emergently, at a local level. As a methodological philosophy, designing *for* sustainability is not so different from designing *with* emergence, since transition contexts are typically coloured by uncertain, non-linear, cross-scale systems dynamics.

Urbanization was not a product of urban planning, and its history speaks to the inadequacy of the planning profession to serve as a vehicle through which to study and manage its self-organizing, emergent, or coupled socio-ecological processes (Portugali, 2000). Cities would not have been the outcome of a single or linear plan for progress; rather, they represented concurrent and coupled development across varied social, ecological, and technological factors. For example, intensified agricultural production, division of labour, specialty craft-based trades, monumental architecture, science and writing, artistic expression, social stratification, state formation, and foreign trade are thought to have accompanied the first urban revolution in Mesopotamia (Bairoch, 1988; Childe, 1950; de Vries & Goudsblom, 2002; Elmqvist et al., 2013; Portugali, 2000; Redman, 2011; Smith, 2009). Prospects to access labour markets, trade routes, and knowledge networks, maintain individual anonymity, and earn higher wages, while enjoying upward mobility, may have stimulated the second (Angel, 2012). Some authors have identified social reorganization as either the key lever that permitted urbanization or a significant characteristic of it (Elmqvist et al., 2013; Ernston et al., 2010; Redman, 2011; van der Leeuw et al., 2009). Finally, Portugali (2000) has argued that cities are a generative socio-spatial order that have reproduced from within and from each other, as a single, self-evolving system. So too, he argues, are cities merely the elements of urbanization, the latter representing a new mode for the production of society (Portugali, 2000). If we attempt to plan cities as isolated entities, we are effectively condoning the provisions of contemporary urbanism, which are being globally reinforced.

> Cities emerge as one territorial or scalar moment in a trans-urban dynamic. This is however, not the city as a bounded unit, but the city as a complex structure that can articulate a variety of cross-boundary processes and reconstitute them as a partly urban condition. (Sassen, 2010, p. 5)

Complexity theories of cities inquire as to whether cities are, indeed, plannable, given their self-organizing, non-linear, uncertain dynamics, and as systems operating far from equilibrium (Batty & Marshall, 2012; de Roo & Rauws, 2012; Portugali, 2000). The realization that they may not be was notoriously canonized in the work of Rittel and Webber (1973), who characterized planning contexts as open, complex social systems, with the hope of distinguishing the planning profession from engineering and scientific work. Their critique accompanied a turn from Portugali's (2000) first to second culture of cities/planning, wherein quantitative/rationalized

approaches, which apply statistical models or claim ability to tame and control the built environment, were being viewed with scepticism (Batty & Marshall, 2012; Jacobs, 1961). They appealed, once planners have solved the easy problems, such as the provision of roads, shelter, infrastructure, schools, and hospitals, there are still stubborn issues to wrestle with, such as enabling social equity or governing amidst social heterogeneity: "In short, they argued that cities were so complex that it was near impossible to trace all the repercussions and impacts of proposed solutions, which often ended up making the original conditions more problematic …" (Batty, 2013a, p. 302).

Rittel and Webber's (1973) article reads like a surrendering of the planning field's early ambitions: There is more to the problem than meets the eye—in fact, we can barely perceive where the problem space begins and ends. In their manuscript, they offered a ten-point description of and guidelines for engaging with wicked dilemmas, which they declared as difficult to define, isolate, or bound in time and space (Batty, 2014). In short, they advised proceeding with caution, given the prospective impacts of decisions, while conceding it may be difficult to prove solutions to be correct, as much as they are suitable or coherent relative to their contexts and purposes. A similar stance is found in post-normal science thinking, which becomes relevant in circumstances wherein decision stakes are high and certainty low (Funtowicz & Ravetz, 2003). When transition management initiatives are embedded within complex systems dynamics, we are caught between the worlds of design and science: impelled to take imminent action, yet without sufficient knowledge to do so with any certain effect. In instances where systems fluctuate beyond precisely predictable states, perhaps our choices for intervention could only ever be coherent with respect to our current understanding of plausible futures (see Lister, 2013/2010).

Settlements display overlapping layers of fixed and variable order. Self-organizing behaviour between citizens may result in spontaneous, temporary activities, like drumming circles on the beach. In contrast, large-scale infrastructure requires controls for consistently safe functioning (Hamdi, 2004; Portugali, 2012b). The rise of smart growth planning in the late twentieth and early twenty-first century signals the significance of governance to certain aspects of settlement development, for example, in the negotiation among competing land-use interests (Curran & Tomalty, 2003). So too have the impacts of uncontained growth, which has plagued cities worldwide, illuminated the drawbacks of uncoordinated change. At the same time, overly stringent municipal policies could impede variation in, or the combination of, socio-ecological features and functions, within space and place. Arguably, the municipality as a political entity is less responsive to nuance than the settlement as a complex adaptive socio-ecological system. There may, however, be opportunity for interplay between centralized and decentralized mechanisms of growth and change (Loorbach & Shiroyama, 2016).

It is apparent that some types of change occur through citizens' direct, personal, intuitive, and adaptive engagement with places and some through the professional application of generalized theories and principles (Alexander, 1964; Portugali, 2012b). In settlement planning, we might consider how to combine one with the other. Attempting to envision and implement comprehensive plans, in their totality,

could result in a flattening of socio-ecological heterogeneity, as we have seen in suburban development (Frampton, 1983), neither is it a realistic pursuit: "The idea of the planned city as a knowable utopia is a chimera" (Batty & Marshall, 2012, p. 44). Conversely, while the former is representative of a democratically self-generating city (see Pflieger et al., 2008), there is no guarantee that uncoordinated adaptation would consistently produce sustainable outcomes, which are comprehensive in their response to social needs, optimal in their performance, or considerate of the interaction effects that occur across multiple systems scales (Batty & Marshall, 2012; Berger, 2009; Doxiadis, 1974; McCormick et al., 2013; Ruttonsha, 2017). To facilitate agency within diverse networks and at various levels of settlement (home to neighbourhood to city to metropolitan region to globalized systems of settlements), we face this question:

> …how much structure will be needed before the structure itself inhibits personal freedom, gets in the way of progress, destroys the very system which it is designed to serve, and becomes self-serving? (Hamdi, 2004, p. xviii)

However, the concern with governance structure in settlements is more about type than quantity. Bar-Yam (1992) has explained that networked governance structures are more effective than hierarchical ones, when the behavioural complexity of a collective is greater than that of any one agent or institution that could exercise authority over it. He has indicated how complexity would have initially spiked within agrarian and early industrial societies, through hierarchical control over simple, repetitive behaviours of many individuals, to large-scale effects. In the wake of increased environmental and social complexity, however, hierarchical governance is less viable: The demands evade the capacity of any one institution to respond. Instead, lateral communication between lower-level systems modules gradually takes over as a coordinating mechanism (Bar-Yam, 1992). Moving forward, in Bar-Yam's estimation, some degree of hierarchical order may persist within complex civilizations. He briefly cites a corporate trend to split management between strategic (hierarchical) and operational (networked) functions. Conceivably, this could be applied in contemporary settlements, as well.

In cities, it is not unheard of for localized diversification to take place on the back of systems that have developed through hierarchical control. As an example, we can run urban farms in our small, private yards, complete with chicken coops and beehives, while still benefiting from potable, piped water and electricity. We can sell and trade goods with our neighbours through informal, online networks (Botsman, 2010), on account of existing telecommunication infrastructure. In these instances, citizens are self-organizing within the boundaries of the modern world to disrupt its underlying order. Focused efforts to create and disseminate innovation in a distributed fashion have also appeared through generative and open-source design initiatives (see Architecture for Humanity, 2012; innonatives.com; Mehaffy, 2008; openstructures.net; Quilley, 2017; Stott, n.d.; Westley et al., 2011). Through these types of initiatives, the economies of scale that render urbanization compelling in the first place still appear—with many people sharing knowledge, resources, and market access—yet, without being tied to a particular place or what economist Paul

Krugman (1991) has referred to as an economic geography (also see Pierson, 2004), thus the placelessness of contemporary, globalized dwelling surfaces. With open-source initiatives, hierarchy does not disappear entirely; rather, the collaborative platforms, themselves, define the rules of the game by which everyone plays. They render creative production accessible to the masses, though always within a specified domain. In selecting the parameters for these forums, their creators exercise agency over user engagement, thus enacting *guided self-organization* (see Helbing, 2013)—which, in essence, is not so different from planning policy. Still, they permit a kind of self-organizing behaviour that could enable greater democratic participation in civic placemaking than public consultation processes, alone, could ever accomplish (Mehaffy, 2008) and at a scale that is indeterminate. Through open-source technologies and processes, we are problem solving across regional and global networks—though oftentimes in response to needs that are small and specific, such as the provision of emergency housing (see Architecture for Humanity, 2012). This is the easier direction in which to travel, when shifting frames between the global and the local—to task international communities with addressing the specific challenges of the few.

Innovating across the multiple globalized scales at which systems of settlements organize would be a considerably more difficult leap, and for which I will not provide any conclusive recommendations, only note briefly why the problem is a wicked one. There is more than one approach by which we could classify scales or levels within systems of settlements. Doxiadis' (1969, 1974) ekistic grid outlined these in accordance with a logarithmic progression, beginning with the individual and ending with the earth-encompassing/universal city. Bretagnolle et al. (2009) listed the levels of urban systems as micro (individual agents and institutions), meso (the geographical area of the city), and macro (the system of cities). Similarly, we could think about levels with respect to the type of municipal change enabled, with micro being indicative of routine operations (i.e. maintenance, renovation, etc.); meso signifying projects that change a neighbourhood or system—such as the development of a waterfront area, a cultural district, or a renewable energy infrastructure; and macro referring to intercity or regional initiatives, such as shared transit lines, climate action plans, or watershed management programmes. At a certain stage, however, it may not be suitable to conceive of and divide the problem space in this way. Some issues will cross levels, drifting or jumping over perceived governance hierarchies. For example, Portugali (2000) has described how the micro level of individual action within a city can have greater impact on the overall city system than intentional municipal planning; Sassen (2010) has discussed how some cities skip the nation-state in their interaction with global systems phenomena and how global city developments can supersede local identities; and Castells (2010b) has contended that megacities are disconnected from the local, altogether (Portugali, 2000). In sustainability planning for systems of settlements, the scales of interest are unbounded. Not to mention, their sources and sites of environmental impacts may vary (Sassen, 2012; Seto et al., 2012).

Thus, we arrive again at the question, what kind of change should we be implementing, and where? Macro-scale social processes may be less conducive to influence through intentional intervention (see Meadows, 1999) and may transform

slowly, over a period of generations (Loorbach & Shiroyama, 2016), or too rapidly for us to keep pace (Young et al., 2006). It may be that municipalities do not have access to or control over the critical levers for socio-ecological systems transformations (Loorbach & Shiroyama, 2016): ones wherein we reorient our ways of life, as individuals, communities, and societies (see Dusch, Crilly, & Moultrie, 2010), and with respect to how global phenomena take shape within settlement plans. Still, for some authors, the level of the city is an appropriate point of entry for transition management, as an entity that is conducive to enabling both top-down and bottom-up actions, operates as a node within globally dispersed networks, and engages directly with transnational and global processes (Batty & Marshall, 2012; Loorbach & Shiroyama, 2016; Sassen, 2009, 2010):

> Cities are also sites where each of these trends [globalization, digitization, transnational and translocal dynamics, and legitimation of socio-cultural diversity] interacts with the others in distinct, often complex manners, in a way they do not in just about any other setting. (Sassen, 2010, p. 3)

Thus, settlement systems (and cities) reveal a possible middle ground: to think big and start small (Mui, 2016). Conceptualize the problem at the broadest scale of cultural transformation, while implementing thus-inspired initiatives at a micro level, as settlements move through their natural cycles of retrofitting and growth. Exploit overlapping states of construction and deconstruction as an opportunity to repattern systems. As resilience literature has shown (Holling, 2001), flexibility within a system will be greatest during times of change. As long as settlements are in flux, due to growth pressures, the prospects for developing them on different terms remain open—especially within target growth and transitional areas. In other words, change is the opportunity context for transformation. Resilience literature has shown that complex systems follow natural cycles of fluctuation (Gunderson & Holling, 2002; Holling, 2001; Scheffer, 2009), while innovation thinking has encouraged us to capitalize on these by identifying windows of opportunity, therein, to intervene (Geels & Schot, 2007; Westley et al., 2011; Westley et al., 2013). During these fluctuations, systems may pass through periods of disorder, or loss of order, which permit their restructuring; connections or relationships may be dissolved and new ones generated; resources are reallocated (see Holling, 2001):

> ...in the end it seems that power has less to do with pushing leverage points than it does with strategically, profoundly, madly letting go. (p. 19)

Ultimately, choosing not to intervene, scaling back existing interventions, or *undesigning* could be powerful acts of creative agency.

Conclusion

Systems and complexity thinking advise attuning to interconnections among multiple phenomena (Midgley, 2000), while ecological worldviews claim everything is connected (Capra, 1996, 2002). Processes and outcomes of urbanization, however,

confound perspectives on the latter—especially, as these have taken shape within the past 200 years, or so, under the drive of industrialization. How, indeed, could these systems be deemed an integrated part of the same earth systems processes they are simultaneously degrading? The ideal to attain a sustainable future would seem incoherent with the current state of urbanism: "Cities do not fit easily in existing theories about environmental sustainability and global environmental governance" (Sassen, 2012, p. 304). They are a conceptual enigma—emergent from processes of human ecology while compromising their own long-term viability within the biosphere. Whether we embrace or abhor the trend towards urbanization, whether we see potential for a new face of urbanism or prefer to retreat to land-based living, there is no denying that the state of contemporary urban systems and their resonant impact on planetary systems delineate the starting conditions for transition, though the challenges differ in developing and developed nations. So, how should we incorporate this basic understanding into theories about environmental sustainability and global environmental governance?

Conceptual framing is not insignificant to problem-solving processes in systemic design; for example, authors such as Alexander (1964) and Simon (1996/1969) have encouraged experimenting with the focus of design project objectives, to isolate precisely which problem we are seeking to address, and where our interventions could be most effective. In some respects, this is an exercise in boundary definition (Midgley, 2003), though it is also one of perspective shifting. Meadows (1999) has proposed that paradigms or worldviews can be one of the most transformative points of leverage for systems change. In sustainability research, scholars have been assessing how narrative tone and position can en(dis)able action, for example, recognizing that messaging laden in despairing facts about an environment in decline may not inspire desired audience responses (Lynes & Wolfe, 2017; Quilley, 2017). In the field of urban planning, worldviews began to shift in the late twentieth century, as it became apparent that cities are complex adaptive, non-linear systems, operating far from equilibrium, and not subject to absolute control through top-down planning approaches (Batty, 2014; Batty & Marshall, 2012; Jacobs, 1961; Rittel & Webber, 1973). With this, a challenge was ignited, which still underlies science of cities thinking today—to define *the kind of problem a city is* (Jacobs, 1961; Bettencourt, 2013b). This represents an extensive part of the battle for urban planning; another would be to comprehensively conceptualize the relevance of urban systems to sustainability and resilience agendas.

As of late, an international narrative has been emerging, placing cities at the centre of the sustainability problem space (see *Cities as Tension*). This discourse turns on notions that cities are the primary opportunity and challenge for transition (Florida, 2014) and demarcate our fate and future (Sassen, 2012; West, 2017). Though still faint in its formulation, its effect has been to redefine the relationship between cities and sustainability. Proponents of this narrative are not so much advocating for an urban future, as they are recognizing the prevalence of urbanization and its coupling with contemporary ways of life (Sassen, 2012; West, 2017). Through discussion and action around the United Nations' 2015 Sustainable

Development Goals, urban systems have been positioned as both targets for change (see *Cities as Targets*) and the social, economic, and political vehicles by which to mobilize international agendas (see *Cities as Traction*). At the same time, science of cities thinking has hinted at a more significant connection between the intellectual and practical arenas of cities (settlements) and sustainability (resilience) (see *Cities as Embodiment*): The general assertion is that the long-term viability of our socially constructed world will be dependent on the extent to which this can be synchronized with the natural one; urban systems exemplify the historical development trajectory of the former, while complexity thinking can illustrate how this has been generated through interrelated socioeconomic processes (West, 2017). Informed by science of cities methodologies, and linking these with the dwelling perspective, this chapter engages with the problem of framing the relationship between cities (settlements) and sustainability (resilience) while also considering how elucidating *the kind of problem a city is* could reinvigorate approaches to systems change within settlements.

It may be that simple premises could serve to shift perspectives and reorient practices within complex problem domains; this chapter introduces three. The first is intended to suggest that, at their core, both settlement and sustainability, as areas of inquiry and practice, are concerned with the organization of human life within the biosphere. In this way, they are analogous challenges. *(I) Settlements are complex adaptive socio-ecological systems, which together as globalized networks embody the complete range of human-environment interactions, and the complexity that has emerged along with these, over time* (see *Cities: Sustainability*). This implies that human-environment interactions are the heart of settlement systems. It is not that form, space, materiality, and aesthetics are extraneous to matters of urban planning and design; for example, as Jacobs (1961) asserted, urban form ennobles human life. However, what science of cities research has illuminated is that, similar to other complex systems, cities organize in hierarchical network formations, arising from human interactions, as they play out in space over time (Batty, 2013a; Portugali, 2012a; West, 2017). This was also intuitively understood by early leaders in the field (see Doxiadis, 1974; Jacobs, 1961): "For cities, processes are of the essence" (Jacobs, 1961, p. 441).

Though this finding is based in complexity thinking, the means by which we analyse and intervene within systems networks could remain theoretically and methodologically pluralistic. Very generally (and non-exhaustively), quantitative work has been studying universal properties and dynamics that repeat across urban systems, regardless of their history or geography (Batty, 2013a; Bettencourt, 2013a; Portugali, 2012a; West, 2017); qualitative research, and that of urban sociology, have conventionally examined human experiences of place, as well as the localized expression of macro-level, globalized trends (Jacobs, 1961; Portugali, 2011; Sassen, 2010, 2012); urban ecology and resilience scholars have been reintroducing an ecological perspective to urban studies, and expanding an ecology *of* and *for* cities, as complex socio-ecological systems (Elmqvist et al., 2013a; McPhearson et al., 2016); and design-based approaches are well suited for projecting possibilities and pathways for systems change, incorporating cogenerative processes (Mehaffy, 2008).

Simple premises warrant minimalist wording, and there is already a concept that captures the basic intentions of science of cities thinking: the dwelling perspective. This concept originated within phenomenological philosophy, cultural anthropology, and human ecology (Heidegger, 1993/1971, 2001/1971; Ingold, 2000, 2005) and contains undertones of design, planning, sustainability, resilience, complexity, and socio-ecological systems thinking. Its central tenet is this: *(II) The continual unfolding of our socially constructed reality occurs as an extension of our being in the world, enmeshed in a web of meaningful nature/culture relations* (see *Settlements as Dwelling*) (Ingold, 2000; Krell, 1993). This interpretation solidifies the connection between urban planning and the *human-in-ecosystem* perspective found in resilience scholarship (see Cooke et al., 2016; Davidson-Hunt & Berkes, 2003); more importantly, settlement blossoms into dwelling, and dwelling becomes poetic. The dwelling perspective is fundamentally relational and sets us up for an approach to systems analyses that would explore reflexive interconnections between processes and forms, meaning and matter, people and places, actions and spaces, the ephemeral and the concrete, the normative and the positive. More so, its authors have advised that to understand a system—what it is, or what it should be—we can contemplate its many relations. Relations are of the essence, not only metabolically, not only communally, but also symbolically. Their poetry of dwelling is to maintain harmony, or *resonance*, across the interconnected web in which all things are entangled.

Incidentally, there is considerable overlap between the dwelling perspective and science of cities thinking. For example, Heidegger (2001/1971), Ingold (2000, 2005), and Cooke et al.'s (2016) articulations of the concept represent (**ai**) a plea to enhance our tacit engagement with inhabited environments, to balance overly cognitive approaches to transition (Cooke et al., 2016; Ingold, 2000); (**bi**) aspirations to reveal the authentic essence of self, community, world, and self in community/world, as a foundation for creative production (Heidegger, 2001/1971; Ingold, 2000); and (**ci**) a proposition that regionalized clusters of interconnected places emerge through routine life processes, occurring in space over time (Ingold, 2000). In science of cities work, there has been similar interest to unravel (**aii**) the coupling among social, ecological, and technological phenomena (Elmqvist et al., 2013a; McPhearson et al., 2016); (**bii**) the fundamental nature and function of cities (Bettencourt, 2013b; West, 2017); and (**cii**) how scale-/network-based interactions are embodied in urban places (Batty, 2013a; Castells, 2010a; Sassen, 2012). Moreover, both sets of authors have touched on the necessity to study (4) the multiscale profiles of human systems (Cooke et al., 2016; Elmqvist et al., 2013a; Heidegger, 2001/1971; Ingold, 2000; Portugali, 2012a; Sassen, 2012). Through globalized networks of many varieties, our patterns of dwelling exhibit expansive footprints. As a conceptual lens, then, dwelling is both local and global in scope—the processes of our human ecology enacted at multiple scales. According to the dwelling perspective, we can connect with the macro through the micro, by remaining accountable to all of our relations, as they appear within our own lifeworld (Cooke et al., 2016; Heidegger, 2001/1971; Ingold, 2000).

A third premise could be drawn out from the second, and one which could eventually compel a complete inversion of the problem space. Yet to be comprehensively

articulated is how a science of settlement could connect to or extrapolate from a science of human life within the biosphere; neither is it intuitive to branch out in this way, though we find a touchstone for doing so in the thinking of biologist and cybernetic theorist Humberto Maturana (2016). He has offered another framing of the relationship between settlement and sustainability, by positing that all transition agendas could be distilled to the simple question, *how do we want to live together?* This positioning is broad yet pithy. In spirit, it prompts pluralistic responses, without specifying the details. It could lead to classic design-based initiatives, though it also evokes a need for interdisciplinary and transdisciplinary work, which could compare human life ways against the constructed systems that support them. Really, these are two sides of the same problem space. This is apparent if we consider Maturana's query to be an inversion of Schrödinger's (1967/1944) *what is life?* and Capra's *what are the defining characteristics of living systems/social reality?* (2002, p. 3), or a simile of Mau's (2010) *how do we design for the welfare of all life?* Taken together, these questions bat between analyses and action, stretching to interpret and cope with the complexity of our planet's living systems, though each from a slightly different angle. Schrödinger's main proposition was that organisms maintain a state of living, or produce negative entropy, through ongoing exchanges with their environments. Capra's extension has bridged science with design:

> In the future, this strict division [between material and social structures] will no longer be possible, because the key challenge of this new century—for social scientists, natural scientists and everyone else—will be to build ecologically sustainable communities, designed in such a way that their technologies and social institutions—their material and social structures—do not interfere with nature's inherent ability to sustain life. (Capra, 2002)

In systemic design, Mau's team tackled the inquiry as part of their Massive Change project, which explored the capacity of design to enable positive action in light of pressing global challenges (Mau, 2010; Mau et al., 2004). There are many approaches by which we could respond to these comparable and foundationally orienting questions, whether through empirical, normative, or creative methodologies. They have clear affiliations with complexity science, though could also be associated with the work of ancient Greek philosophers, such as Aristotle. In addition, through these questions, we gain some sense of how a programme of research and practice, for transition within settlements, will flip, recursively, between structure and substance. To respond to the challenge of managing human settlements for growing populations with rigour and validity, eventually, we must assess the meaning of human welfare and ecosystems integrity, as well as the conditions that facilitate or constrain either or both. Thus, the third premise is this: *(III) Characterization of dwelling calls for rich deconstruction and classification of the content, composition, quality, quantity, catalysts, and extent of human-environment interactions* (see *Systems Dynamics as a Basis for Place*).

In systemic design communities, we have seen two intersecting trends, occurring intermittently, namely, in the late half of the twentieth century and onwards. In the first, we have sought to legitimize design as a unique way of knowing, a procedural practice, a social process embedded in discourse, and a discipline as rigorous as any science (Cross, 2007; Margolin, 2002; Nelson & Stolterman, 2012; Simon,

1996/1969); in the second, we have become increasingly concerned and involved with environmental and social issues (Fuller, 1981; Irwin, 2015; Margolin, 2002; Mau, 2010; Papanek, 1971; Tonkinwise, 2015). These trends are brought to a head within the context of cities, as the challenges we confront within urban systems become increasingly complex, high stake, and broad in their impact and implications. With this in mind, it would be timely to review the questions, methodologies, and goals on which our work is based. While complexity theories of cities tell us that urban systems are not conducive to control through planning processes, we could augment this argument by suggesting they cannot be evaluated and managed exclusively through urban planning and design. Through a socio-ecological science of settlement, we could integrate descriptive with prescriptive methodologies, to examine settlement systems on analytical terms such that we might rebuild them on practical ones. This could expand urban planning and design frameworks with reference to their socio-ecological contexts, informed by the observation of human-environment interactions; note the quintessential patterns that emerge through the interrelation of multiple systems phenomena; focus on network structures and dynamics as the basis of study and sites for innovation; and distribute action for transition among a range of stakeholders, across multiple scales. Ground this with the dwelling perspective, and we may arrive at an approach to systemic design that is critically and intuitively responsive, scientific and poetic.

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