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Resilience and Regions:

Building Understanding of the Metaphor

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Introduction

In this paper, we review literature that explains and extends the meaning of resilience across several fields: ecology, psychology, economics, disaster studies, geography, political science and archeology. For metropolitan regions, the review suggests that we must proceed with caution and precision if we choose to make resilience a guiding metaphor for planning and policy, as well as for understanding regional dynamics.

Across these fields, there are several common themes that may or may not apply to all aspects of metropolitan economic, social, political, and environmental dynamics. The next part of the paper ties together these themes across the literatures; at the end of the paper, we return to pose some of the implications of the resilience metaphor for metropolitan regions.

First, most analysis that employs the resilience metaphor presumes that the phenomenon of interest exhibits at least one **equilibrium;** the majority of the research begins, in fact, from the possibility of multiple equilibria, and explains how and why those equilibria become unstable. When we say that a person, society, ecosystem, or city is resilient, we generally mean that in the face of shock or stress, it either "returns to normal" (i.e., equilibrium) rapidly afterward or at the least does not easily get pushed into a "new normal" (i.e., an alternative equilibrium). Recent studies, however, have begun to move past the equilibrium view, shifting their focus from resting points to processes of adaptation.

Second, and related to the first point, analysis using the resilience metaphor generally takes a **systems perspective.** Some factors internal to the system, and some external to it, tend to strengthen it; others—again, both internal and external—can place it under stress. Some literatures (e.g., psychology, disaster studies) tend to focus more on internal resources that strengthen the system under study and exogenous stresses that threaten it. A key idea arising from ecological studies, "panarchy," helps overcome some of the determinism of such systems perspectives as functionalism in sociology; whereas other systems views tend to portray individual actions and interactions as pre-determined outcomes of larger structural forces, the panarchy view leads observers to expect interaction between structure and agents.

Third, most, but not all, of the literatures tend to adopt at least partially the view that observed equilibria are **path-dependent,** that is, they are a consequence of cumulative decisions, often over a long time period, that shift a system from having a very open future to having increasingly predictable (or "locked in") paths. The interest in path dependency is particularly high in fields that attempt to understand multiple equilibria and the persistence of sub-optimal ones; in any multi-equilibrium world, any of a number of sometimes apparently random events or actions can lead a system toward a particular equilibrium.

Finally, work that uses resilience as a metaphor tends to take a **long view,** whether of individuals (e.g., personality in the transition from a stressed childhood to functional or dysfunctional adulthood) or of cities (e.g., long-term recovery after a disaster). This long perspective tends to reinforce the first three points. Over the long run, an observer will often observe or impute one or more periods of stability amidst change at some level of function for the phenomenon of interest, reinforcing the belief in equilibrium. This is even truer if the analyst's attention is shaped by the resilience metaphor in ways that encourage her to look for equilibria. As a practical matter, furthermore, the analyst must bound the phenomenon of study (city, ecosystem, person) in ways that encourage her to view that phenomenon as having a persistent internal logic; that is, the phenomenon isn't just a social or political process or a series of unconnected events but is, rather, a system.

Four Themes of Resilience

1. Equilibrium

Probably the most comprehensive development of the idea of resilience comes from studies of ecology and of coupled social-ecological systems. A first definition of resilience ("engineering resilience") "concentrates on stability at a presumed steady-state, and stresses resistance to a disturbance and the speed of return to the equilibrium point" (Berkes and Folke 1998, 12).[i] Here, the interest and focus are on systems with a single equilibrium. This sense of resilience tends to dominate in the fields of psychology and disaster studies, both of which seek to understand why people, cities, and regions recover from disturbances or intense stresses. It also persists in ecosystem studies, despite the growth in interest in multi-equilibrium systems discussed below.

In psychology, studies of resilience have tended to center on behaviors and attributes that allow people to get along with one another and to succeed socially. As Bonanno (2004: 20) puts it: "Resilience to loss and trauma… pertains to the ability of adults in otherwise normal circumstances who are exposed to an isolated and potentially highly disruptive event, such as the death of a close relation or a violent or life-threatening situation, to maintain *relatively stable, healthy levels of psychological and physical functioning*" (emphasis added).

Social integration, in this case, becomes an expected equilibrium outcome that the field treats as natural—or at the very least, most desirable—for individuals. Psychological studies on resilience tend to take as normal, at least in the US, conformity to such behaviors as adjustment to school, making friends, following rules, earning a living, establishing a family, and performing community service.

> When these expectations are met in circumstances where it would be understandable (if not forgivable) that the expectations were not met, the individual would be evaluated in terms of being resilient, heroic, or otherwise extraordinary… [A] major limitation of the concept of resilience is that it is tied to normative judgments relating to particular

> outcomes. If the outcomes were not desirable, then the ability to reach the outcomes in the face of putative risk factors would not be considered resilience (Kaplan 1999: 31).

Commentators in the psychological literature have also made much of the ideological nature of resilience:

> Resilience is a quintessentially U.S. concept. It has roots in the U.S. hero myth commemorated in books and stories by Horatio Alger in the latter half of the 19th Century (Kaplan 1999: 30, quoting Rigsby 1994).

Studies of responses to disasters also tend to embrace the "engineering" version of resilience. Much of this research focuses on the vulnerability of neighborhoods, cities, regions, and people to disaster, more specifically focusing on the probability that a catastrophic event (e.g., hurricane, flood, tornado, tsunami) will cause systematic breakdowns and consequent loss of life, property, and social support networks. Do transportation systems break down so badly that people cannot get away in time? Do local neighborhood organizations help residents survive for the first two weeks after a massive earthquake, when many government efforts will be directed toward finding and rescuing survivors in the rubble? Over the longer run, disaster studies try to measure resilience by learning whether a city or region recovered its population, economy, or built form (Vale and Campanella, eds., 2005); the resilient city, in this view, would be one that resumed its previous growth trajectory after a lag.

As the examples from psychology and disaster studies suggest, any focus on equilibrium defines resilience as the persistence of some phenomenon in the face of some stress. Identifying resilience therefore requires the selection of some observable characteristic or outcome of the phenomenon. As Walker puts it (1998: 187), "Any discussion of resilience in a particular ecosystem must be prefaced by the question, 'The resilience of what to what?'… The system needs to be defined in terms of (1) the variables that describe the state, and (2) the nature and measures of the external shocks." The determination that a person or a city has "recovered," or that an ecosystem is "stable," presumes that the analyst pays attention to some things but not to others.

A second definition of resilience begins from the presumption that a system might have multiple equilibria, a presumption that—according to Berkes and Folke (1998)—implies a different, "ecological" definition of resilience. This sense of resilience

> emphasizes conditions in which disturbances (or perturbations) can flip a system from one equilibrium to another. In this case, the important measure of resilience is the magnitude or scale of disturbance that can be absorbed before the system changes in structure by the change of variables and processes that control system behaviour... [S]ystems are seen to be complex, non-linear, multi-equilibrium, and self-organizing; they are permeated by uncertainty and discontinuities. Resilience in this context is a measure of robustness and buffering capacity of the system to changing conditions (Berkes and Folke 1998, 12).

As analysts explore the possibility and implications of multiple equilibria, the focus on speed of return to a single equilibrium gives way to a focus on explaining the length of

residence in a particular "basin of attraction" (Figure 1). Less metaphorically, an ecosystem study might consider whether a lake has the internal capacity to retain self-regulated ecological productivity over time; the lake might have a productive state with a diverse range of species, a complex food web, and high biomass productivity and a eutrophic state with less species diversity, a simpler food web, and low biomass productivity. Questions framed from an engineering perspective on resilience would focus upon how rapidly a lake returns to its peak level of productivity after a disturbance, whereas those framed from an ecological perspective would focus on the magnitude and nature of perturbation required to tip the balance from one state to the other (Gunderson et al. 2002).

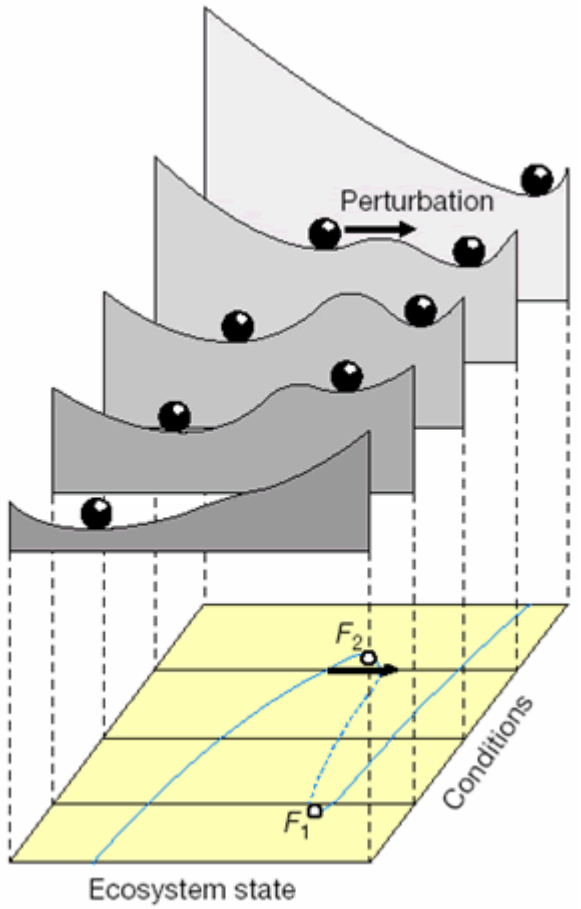


Figure 1. This depiction of a multi-equilibrium system shows the connection between ecosystem state (X axis on the bottom plane) and external conditions (Y axis on the bottom plane). The plan (landscape) views depict single or multiple equilibria depending on external conditions, with the frontmost and rearmost landscapes representing the deterministic single-equilibrium states of the system (represented by the ball) at the extremes of the range of conditions. In the second and especially the fourth landscapes, the alternative system states are less stable, because a modest perturbation could shift the ball to the alternative basin of attraction; these two landscapes portray the conditions under which this ecosystem is at its least resilient. Figure source: NOAA Coastal Services Center, "Irreversibility, Sustainability, and Safe Minimum Standard" (web page last updated 6/13/2006 and accessed December 26, 2006, on-line at: http://www.csc.noaa.gov/coastal/economics/images/sa7_fig02.gif). NOAA credits the original illustration to Scheffer et al. (2001).

Current debates in the psychological literature also hint that a multi-equilibrium model of resilience may be evolving on crisis and human function. People often perceive that they grow stronger from stressful experiences, but the debate has not resolved whether these perceptions are borne out in objective tests of function. As Joseph and Linley note (2005: 263), "comprehensive models of human functioning should span the full range of human experience, from distress, through resilience, to growth and optimal development. Thus, a focus on resilience alone sells the argument short. A holistic perspective that also includes adversarial growth is required." On the other hand, the literature on post-traumatic stress syndrome (PTSS) suggests that crises and stresses can at least as often lead to medium- to long-term dysfunction; after wars and displacement, people may descend to a lower level of function for the long term.

Recent work in institutional economics and macroeconomics also focuses on and attempts to explain putatively multi-equilibrium systems. Persistent sub-optimal equilibria would not be anticipated by standard microeconomic theory, but macroeconomic theory does allow such an outcome. Why might a person, firm, product, or even nation that is successful continue being successful and a person, firm, product, or nation that is struggling continue to struggle in the future? One explanation is that the absence of scale economies is an unrealistic assumption of microeconomics. If a product, company or process succeeds initially, increasing returns may reinforce that initial advantage and the product, company or process may then proceed towards complete domination or "lock in" of the industry. Related to "lock-in" is the theory of cumulative advantage and disadvantage which social scientists use to describe how an initial comparative advantage or disadvantage of resources can lead to successive incremental gains or losses that are often without merit. These gains or losses exacerbate the original comparative condition, causing a snowball effect and increasing the gap between the haves and the have-nots.

One example of a long-term struggle (as opposed to long-term success) is the "poverty trap," defined as "any self-reinforcing mechanism which causes poverty to persist" (Azariades and Stachurski 2006). Throughout the latter half of the 20th Century, a set of small nations—mostly in sub-Saharan Africa—have remained desperately poor while middle-income nations have become wealthier in terms of GDP per capita. Graham and Temple (2006) provide empirical evidence that the persistence of low GDP per capita in a subset of very poor nations is partially explained by variable returns to scale. Sunk costs can also explain the persistence of sub-optimal outcomes; a sunk cost is any cost associated with the disposal of current investments and the replacement of new investments. Generally, as the presence of both increasing returns and sunk costs escalates over time, so too does the cost of choosing an alternative path. Of course, economists remind decision-makers that "sunk costs are sunk," suggesting that the smart decision-maker ignores previous costs when making decisions about future investments.

Political scientists also accept the possibility of multiple equilibria and the persistence of sub-optimal institutional arrangements. Political scientists also call this phenomenon "lock-in." Hassink suggests that lock-in results from "institutional tissues," which "consist both of organizations ('formal structures with an explicit purpose'), such as political administrations at all spatial levels, trade unions, large enterprises and business support agencies, and 'things that pattern behavior' such as norms, rules and laws" (Hassink 2005: 523, referring to Edquist 1997 at 27). Such institutional tissues are often thought to preserve existing political and institutional structure by encouraging a slow down in restructuring and by obstructing political entrepreneurs. So, in the political science literature, getting "locked in" means that you are strongly encouraged to agree to a set of sub-optimal policies even though better alternatives may exist.

Only recently have some of the resilience literatures begun to grapple with non-equilibrium systems; this is true mainly of ecologists who have begun considering resilience as a process rather than as an end state or a resting state (see for example Carpenter et al. 2005). Necessarily, this means a shift from judgments that an ecosystem is (intrinsically) resilient to understandings of how it adapts through time to stresses. Such a framework does not require any assumptions about equilibria; while it can accommodate one or more equilibria, the process-based view of equilibrium also encompasses situations of constant change in which functions continually improve or deteriorate or where cycling, rather than stability, is the norm. If cycling is the norm, the points that an equilibrium perspective would consider equilibria might be reframed as turning points without abandoning the resilience metaphor.

2. Systems perspectives

The literature on ecological resilience has developed a coherent paradigm that relies heavily on systems thinking within an adaptive cycle model, summarized in Figure 2. This model posits a four-phase process of continual adjustment. Each phase is characterized by varying levels of three dimensions of change: 1) the **potential** of accumulated resources available to the system; 2) the internal **connectedness** of system actors or variables; and 3) **resilience,** a measure of system vulnerability to surprise, stresses, and shocks, with high resilience associated with phases of creative and flexible response (Holling and Gunderson 2002).

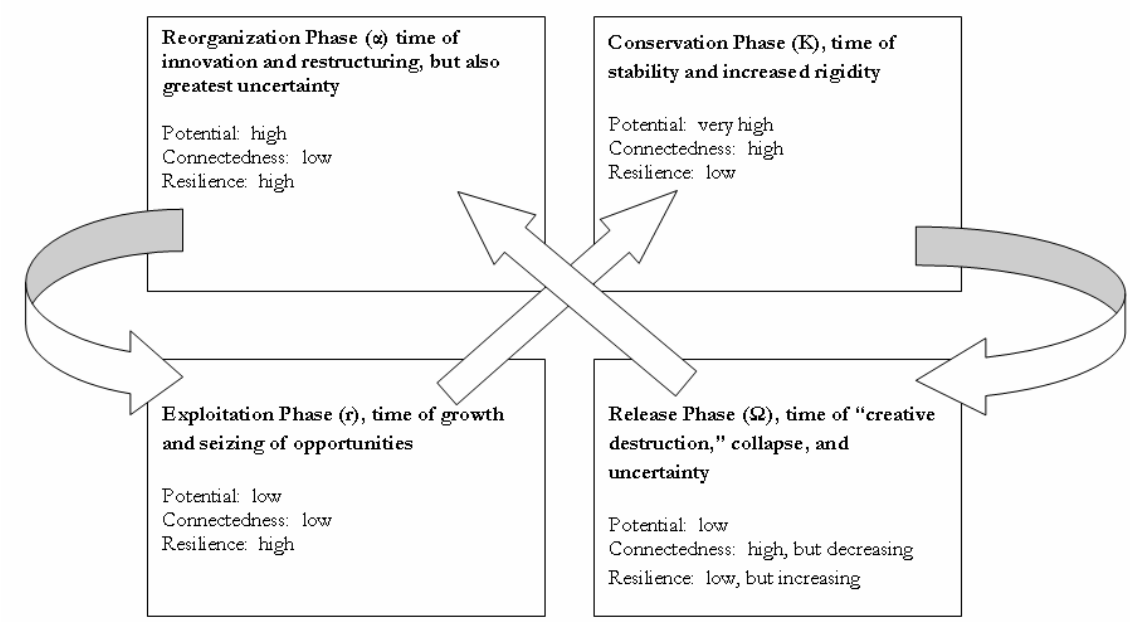


Figure 2. Ecological studies of resilience propose a four-phase cycle of system adaptation and change. Adapted from Holling and Gunderson, 2002.

The Figure 8 cycle has two loops, each with two phases. In the "front-loop stage" the system experiences a slow process of growth or innovation (labeled phase "r") eventually attaining high levels and peak of accumulation (labeled phase "K").[ii] This loop of phases creates the conditions for a back-loop stage of rapid destruction or collapse (labeled phase omega, or Ω) and reorganization and restructuring (labeled phase alpha or α). This loop of phases creates the conditions for another round of innovation, growth and accumulation (Holling and Gunderson 2002).

In each phase the system has varying levels and combinations of potential, connectedness, and resilience, the three properties characterizing the system. In phase r, the period of innovation and growth, the system has emerged from a period of high ferment, uncertainty and reorganization. Potential and connectedness are low—there is scant accumulation of resources and old relations have given way to nascent alliances and connections. Resilience, though, is high with ample opportunity spurring intense competition, entrepreneurialism and energy. Drawing upon the example of a burgeoning forest, observers could expect to see a multitude of seedlings at various stages in their development at this stage. Or, to use the example of a recently elected government, one would expect to see the beginnings stages of new partnerships and agreements.

Start-up projects and pioneers that survive the ferment of phase r—that is, those adapting best to the reigning conditions of uncertainty and variability—start accumulating potential in the form of resources, information, experience and wealth on the path from phase r to phase K. Connectedness increases, too, as internal relations deepen along with regulatory systems, rules, practices and mechanisms of control that

solidify or codify those relations. Conservative behaviors trump innovative ones in phase K as the system's dominant players successfully organize to secure gains, safeguard resources, and lower short-term uncertainty. Meanwhile, resilience diminishes as the system becomes more rigid, inflexible, and perhaps overconfident, and thus more vulnerable to an external shock or stress. The system is now an "accident waiting to happen," especially vulnerable to a triggering action or condition such as a lit match meeting a dry spell in the forest or emergence of a charismatic opposition leader calling for change in government or corporate life. As Holling and Gunderson (2002) point out, in human systems such outcomes are tendencies rather than inevitabilities and may presumably be anticipated and thwarted by good system design and management.

The transition from phase K to phase Ω happens rapidly through a period of destabilization, destruction, and release. The system expels and eventually exhausts accumulated resources (the forest fire burns out, the old political guard exits and is followed by extensive turnover), sending system potential plummeting in the short term. Connectedness remains high, but old relations are tested and many are sundered under destabilized conditions. Resilience grows, however, as release, ferment, and flexibility increase the system's sensitivity to and awareness of external variables, thus lowering its vulnerability to shock or surprise. The declining connectedness, increasing resilience and dormant potential create conditions for new alignments and opportunities.

The system then transitions from Phase Ω to a phase α, a period of significant experimentation, reorganization and renewal. This is the most uncertain phase, with little system control over external environments and the greatest probability that potential (e.g., vegetative growth, people, capital, material resources) will leak away from and further weaken the system. At the same time, the system is poised for radical reorganization, novel experimentation, and rapid recharge. Dormant potential reactivates to exploit post-crisis opportunities. Political entrepreneurs, for example, may enter the political arena. The tree trunks and seedlings that survived the forest fire send up new growth. Connectedness remains low, but times are ripe for new alliances of promise. Experiments, new relations and adaptations that hold the most promise survive this volatile and competitive period to enter the r phase and begin again a cycle of growth and consolidation.

A second characteristic of complex systems under panarchy is linkages across scale—that is, magnitudes of time and space—through two principal mechanisms. Larger scales affect smaller ones through a "remember" function, with long-term, large-area processes shaping if not determining interactions and outcomes over shorter periods and in smaller spaces (Figure 3). But smaller scales sometimes also act back upon larger ones through a "revolt" function; this is most likely to happen during the release (Ω) period at the smaller scale. If the larger system lacks resilience, such revolts from smaller scales can initiate the release phase at the larger scale. Consequently, if such surprise "revolts" frequently occur in a system, "Responding to the rapid change may become routinized,

and may or may not improve the ability of a system to respond to moderately or slowly changing variables" (Ostrom and Janssen 2004: 251). The threat of such routinization highlights the importance of having a relatively independent, multi-level "remember" functionality.

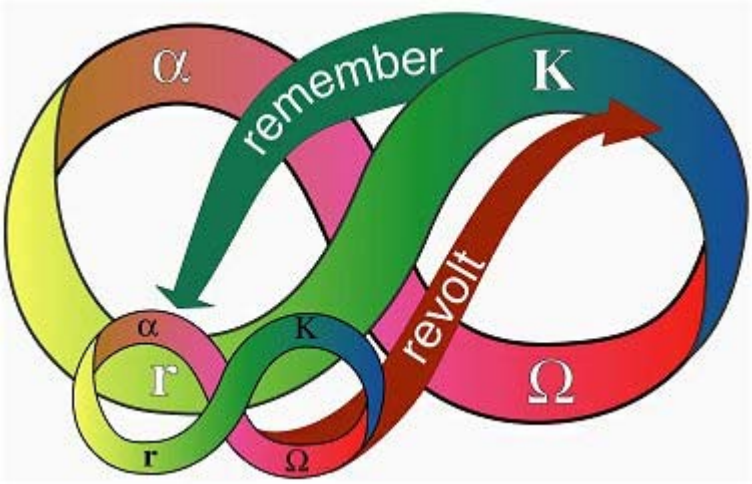


Figure 3. Panarchy proposes a model of change linking structure to agency, in which large-scale systems usually dominate smaller systems but at certain times can be changed by "revolt" at smaller scales. Source: Garry Peterson, Theories for Sustainable Futures, available as of December 13, 2006 at http://www.geog.mcgill.ca/faculty/peterson/susfut/panarchy/revoltRem.jpg.

3. Path dependence

If one assumes that economies, societies, and ecosystems work as systems, this implies that they have internal logics that guide their development. But the huge variety of outcomes in many areas—and the existence of multiple, and sometimes persistently sub-optimal equilibria—leads to questions about how central those internal logics can be. A partial answer to these questions can be found in the idea of path dependence.

Path dependence is a common explanation for why the choices that people or organizations make based upon a given set of circumstances may persist long after those initial circumstances have changed. Seemingly minor decisions, which are often made with imperfect information, can sometimes lead to long-term consequences; a path-dependent system will likely continue to adhere to its ongoing course even if superior alternatives exist. That is, path dependence is a common explanation for the existence and persistence of sub-optimal equilibria.

The main proponents of the path dependency model have been Paul David and W. Brian Arthur. Their work challenges the predictability of typical neoclassical models by emphasizing the multiple potential outcomes of path-dependent processes. Their critics, namely S.J. Liebowitz and Stephen Margolis, generally support the notion of rational choice as a component of the neoclassical model. They argue that it is a combination of financial and market incentives and innovative actors, and not history or path

dependence, that moves markets and processes towards efficiency in cases of imperfect information and transaction costs.

Numerous examples have been used in the economics literature to illustrate path dependence. A commonly cited case is the continued use of the QWERTY keyboard despite known inefficiencies. The QWERTY keyboard was developed first but was quickly challenged by August Dvorak's more efficient keyboard system. Despite widely documented improvements in efficiency, Dvorak's keyboard was never adopted. Paul David (1985) has argued that "competition in the absence of perfect futures markets drove the industry prematurely into standardization *on the wrong system* – where decentralized decision making subsequently has sufficed to hold it" (David 1985: 336). A decentralized decision making process, as well as strong technical connectedness scale economies, and irreversibility due to learning and habituation are the main reasons why Dvorak's more efficient keyboard arrangement was never adopted and the QWERTY keyboard remains.

Another example used to illustrate path dependence is the regional variations often seen in railway gauges. When railroads were being constructed throughout the 19th century, there was no uniform standard to determine the appropriate distance between a pair of rails. Without a standard gauge, institutions and actors experimented with the laying of their railway track gauge. These decisions were not as arbitrary as once thought, however. A series of contingent events and positive feedback mechanisms influenced the adoption of particular gauges in particular regions. Of notable importance is the initial gauge, developed by George Stephenson, an English engineer. This original gauge was widely adopted by many engineers, but eventually others began to experiment with different size gauges that were thought to be more efficient. Generally, once a size was adopted in a particular region, it was also adopted by neighboring areas in close proximity. This path-dependent trend persisted even after more efficient gauges had been discovered because positive feedback mechanisms associated with the ease of traffic exchange generally meant that compatible railways could offer lower costs, improved service, and greater profits (Puffert 2002). The gauge that is now used by nearly 60 percent of the world's railways was not "primarily the result of fundamental incentives, systematic optimization, or a market test but rather of a series of contingent events—even of historical accidents—reinforced by positive feedbacks" (Puffert 2002: 311). Thus, a region was more likely to continue using gauges of a certain size not because of perceived efficiencies, but more so because a particular engineer had picked a certain gauge early on in the process.

The VHS versus Beta example is also frequently cited in the economics literature as proof of path dependence. In the late 1970s two new videocassette recorders were introduced to the market: first, Betamax and then VHS. Even though Betamax hit the market first, VHS was able to quickly capture greater market share and increase its lead until Betamax was all but obsolete. Researchers point to a number of reasons as to why

this reversal occurred. A combination of management errors (namely, a failure to adequately develop manufacturing and marketing allies) and exterior design decisions were blamed for Betamax's initial decline. Subsequent gains in VHS market share resulted because of perceived deficiencies in the Betamax format (shorter playing time, less features, etc…) and the perceived opportunities thought to be associated with the more popular VHS format (more people to share with and more rental tapes to choose from) (Cusumano et al. 1992). Although improvements were made to the Betamax product so that it was competitive with, if not better than VHS, the positive feedback mechanisms reinforced a path-dependent market share that proved too strong for Betamax to overcome.

4. The long view

When observers of systems try to learn about their resilience, they often take an interest not just in the current equilibrium conditions but also in the performance of the system through time. Ecologists look at ecosystems over long periods to identify moments of system change that punctuate long periods of equilibrium. Psychologists identify the resilience of individuals by considering what happens to traumatized children as teenagers and adults; as Litz notes, "the study of resilience and recovery and of posttraumatic growth requires a life course framework and multiwave examination of the trajectory of response to trauma" (Litz 2005: 262). A long historical perspective allows institutional economists to observe and understand sub-optimal equilibria; according to microeconomic theory, such outcomes should be transitory, but institutional arrangements and market peculiarities might cause them to persist for a long time. Pierson and Skocpol note that for political scientists, and for historical institutionalists in particular, the long view is especially important in making "visible and understandable the overarching contexts and interacting processes that shape and reshape states, politics, and public policymaking" (Pierson and Skocpol 2002: get page number). In the long run, of course, many equilibria may appear to be a very minor part of the story, and systems that appear to be punctuated by sub-optimal outcomes in the medium term might appear either to be non-equilibrium or to be dominated by optimal outcomes on average. Hence a final characteristic of most studies of resilience is a methodological approach that takes in time spans of not just a decade or two but generations or even centuries, depending on the system in question.

Implications for the study of regions

The review of literature shows that the "resilience" metaphor has been applied broadly across literatures and with many different frames of reference. In this section, we review some of the principal questions that regional research needs to account for when it uses the resilience frame. We also pose some tentative, though not final, answers, to some of these questions.

The equilibrium question

The first question is whether regions are equilibrium systems, and if they are, whether they exhibit single or multiple equilibria. This question can't be answered, however, without remembering the admonition that our judgments of resilience depend on which regional phenomena we're considering. The next question after, "Are regions resilient?" must always be, "What is it about the region that is resilient, and in the face of what disturbance?" Only then can we have a clearer idea whether an equilibrium viewpoint is appropriate. It may or may not be, depending first on the nature of the *challenge* or *disturbance,* and second on the *outcomes* that are being measured.

Challenges and equilibria. Broadly speaking, regions face two large categories of disturbance: Shocks and "slow burns." The best-studied system shocks include disasters (e.g., Hurricane Katrina, California earthquakes, the Philadelphia yellow fever epidemic) and, to a lesser extent, plant closings in cities that are heavily dependent on those plants. Shocks can, of course, recur, even every year, as when Florida experiences repeated hurricanes or southern California bursts into flame in the late summer. Shocks can also be of the positive variety, such as when a region wins a bid for the Olympic Games or learns of success in luring a major new economic investment to the community. Examples of "slow burns" (or "slow-moving challenges") include deindustrialization, urban sprawl (which usually occurs "below the radar"), prolonged population growth, and global climate change (among many other environmental challenges documented in Diamond 2005).

Most of the literature on shocks suggests that although regions "recover" from them, they are seldom "transformed" by them. This terminology implies, with regard to equilibrium, a return to a pre-shock state: that is, it suggests that we believe that certain aspects of the region have an equilibrium character, because of, for example, path-dependence, or perhaps because of a more or less "natural" equilibrium in a region's economy, politics, and society. To answer the question, "Was the region resilient in the aftermath of the hurricane?," the researcher would look for outcome measures that she would expect to resume either their pre-shock *levels* or their pre-shock *trajectories.* If population and economic growth, for example, resumed their pre-shock rates within a few years of a shock or never paused even in the face of multiple shocks, then the

researcher would conclude that, indeed, this region's population and economic growth were resilient in the face of a disaster.

Resilience often occurs after major shocks because one shock often brings the region together, allowing people to understand their common fate after previously long-standing division. In the wake of the 1992 civil unrest, the city of Los Angeles was surprisingly resilient. This is in part due to the constant flow of both people and capital into L.A., which was seen as both a contributing factor to the unrest and an important factor in the years of recovery that followed. In many ways, "the very meddling of the First and Third worlds that causes so many of L.A.'s problems also provides the basis for the city's resilience" (Fulton 2005, 310). Response to earthquakes in California or to 9/11 also exemplify the tendency of shocks to bring people together, and even the short-lived national response to Hurricane Katrina provides a qualified example of the unifying impact of disasters or shocks. Multiple shocks of a similar kind can enhance awareness of problems and lead to systemic changes that make regions more disaster proof. Regulatory and building code responses to season after season of hurricanes are a good example, as are incentive-based economic development efforts to lure a diverse selection of industries to a region characterized by industrial specialization.

Slow burns and slow-moving challenges, by contrast, occur in systems undergoing transformation, systems that are arguably long since out of equilibrium. Conditions are deteriorating or improving, and established institutions are trying to cope with the changes in a time when resources may be in flux or scarce. A researcher who studies one region's adjustment to deindustrialization or another one's rapid increase in immigrants can probably remain safely agnostic about equilibrium; in these cases, he would measure resilience as, for example, a gradual reduction in the rate of job loss, or in ready integration of immigrants into the regional economy. Rather than a supposed equilibrium, the point of reference becomes the constantly changing recent past, such as "last year" or "previous quarter." If the region has improved on any of these outcomes since the previous time period, or at least hasn't gotten worse, then the researcher would conclude that it is more resilient in the face of the slow burn than a region where the outcomes have deteriorated.

Slow burns (slow-moving crises), unlike shocks, tend to be corrosive of regional unity for at least three reasons. First, they can exacerbate division among constituencies who perceive that resource levels or allocations are shifting, creating winners and losers as resource supply falls out of step with demand. Second, they can lead to flight by those who have enough resources to leave but too few resources to win in competitions for the region's remaining resources, a form of regional survival of the fittest. Third, incremental changes to the reigning institutional tissue in organizations and practices can upset the political and social balance of power, creating tensions across generations, regional tenure, ethnicity, political affiliation, and geographic location, among other intraregional lines of demarcation.

Outcomes and equilibria. Certain regional outcomes probably have "natural" steady states: if left alone, they will remain at about those levels unless they are subjected to either a shock or a slow burn. Such outcomes might include, for example, housing vacancy rates (with rental housing vacancy that differ too much from about 5 percent associating with either high rents or deteriorating housing stock) or unemployment rates (where 5 percent is sometimes considered "full employment"). If a researcher saw that a region departed significantly from these outcomes, then she might conclude that it is out of equilibrium and that market forces should be applied to bring the system back into balance. Another researcher might logically conclude, however, that the region's housing market or economy is not a single- but a multiple-equilibrium system, and that low vacancy rates or high unemployment rates have been locked in by some combination of factors. But either researcher would probably be inclined to conclude that at some point, vacancy rates and unemployment will stabilize. A researcher with a normative agenda might also try to understand the conditions producing sub-optimal equilibria to help the region shift to a more acceptable level.

Other outcomes might, from a normative standpoint, have threshold characteristics even if they do not have natural "resting points." If regional air pollution, for example, has a "natural" equilibrium level (which it might), we have decided not to accept such a high level, imposing ambient air quality standards instead and forcing regions to meet these standards through concerted and sometimes costly actions.

Evaluation of the resilience of "natural" systems, though complex, pales in comparison with evaluation of human systems, largely—as noted above—because humans have foresight and creativity and can adapt in advance to anticipated future states. Foresight and creativity work to best advantage, of course, when the "luck" of natural endowments provide more certainty to forecasts and more resources for creative responses. A metropolitan region on a flat plain where the wind blows all the time, for example, has a natural advantage over one surrounded by mountain ranges when it comes to accommodating growth without a severe increase in air pollution. The first region would and should still be categorized as more resilient than the second if its air quality doesn't deteriorate in the face of rapid growth, but the explanation for its resilience might rest more in luck than in intention. To the extent that we can identify and replicate structural reasons for resilience, it's important to find them. Decisions about where to build cities are, after all, still subject at some point to agency, but even if we can't change structure in the short term, it helps to know the ultimate limits imposed by structure.

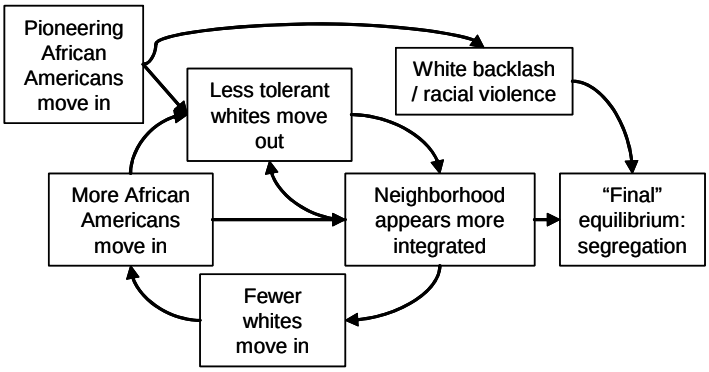
Whether because of endowments or creative response, however, we propose that it is most precise to call a region "resilient" if, when faced with a challenge, it responds in ways that maintain or even increase good outcomes. Even if no one intervenes deliberately to protect air quality in our flat-plain region, we would call its air quality resilient in the face of growth; conversely, we would not call the air quality in our high-elevation basin region resilient in the face of fast growth even if people were prepared,

worked as hard as they could, and applied themselves to new institutions that in the end failed to prevent rapidly rising air pollution.

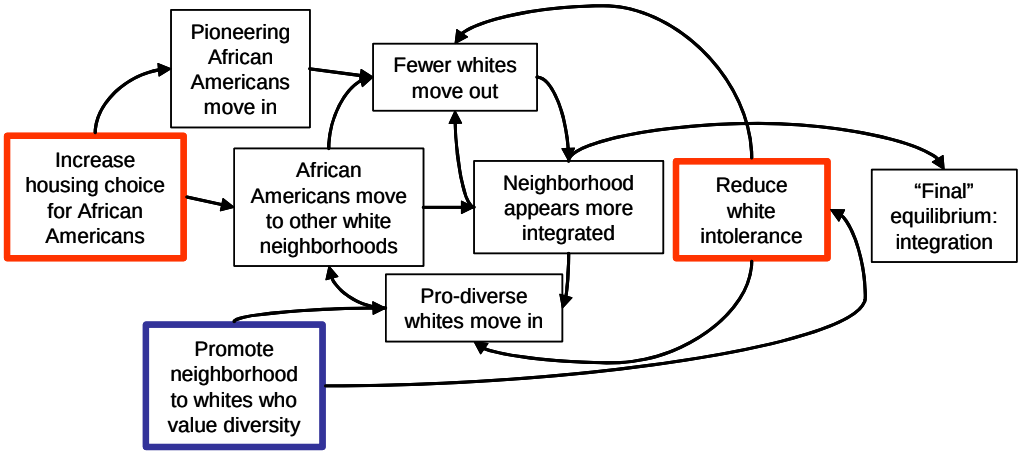
Questions of system and scale

The panarchy model posits that social-ecological systems operate at multiple geographic scales and that feedbacks operate both within and among the scales. Systems that operate on small geographic scales can experience substantial changes over short time periods because single agents at that scale can exert a relatively large influence; those that operate over larger scales typically require longer periods to experience changes, because more interactions among more agents must occur before the system changes. Complexity theory suggests that the properties of the larger systems often emerge from interactions at smaller levels.

One well-studied example of the complex operation and interrelationship of multiple scales at the regional level is in racial residential segregation, in which modest differences between the preferences or tolerances of blacks and whites for same-race neighbors can result in substantial separation by race throughout an entire region even without the guiding hand of institutions or laws (Schelling 1971; see Figure 4a). Of course, such institutions and laws also operate at higher levels either to reinforce differential preferences (e.g., Apartheid in South Africa, FHA lending guidelines in the United States) or to counteract them (e.g., deliberate efforts to encourage racial integration in such suburbs as Oak Park, IL and Shaker Heights, OH; see Figure 4b). Such institutions can themselves change preferences, as can broader shifts in society; in fact, surveys over time suggest that whites have become either more tolerant of living among African Americans or less willing to concede their intolerance (Farley et al. 1978, Farley et al. 1993, Farley et al. 1997), and their levels of tolerance vary among regions.



a. Assuming fixed preferences and no intervention



b. Assuming modifiable preferences and policy intervention

Figure 4. Dynamics of neighborhood and metropolitan segregation assuming no intervention (4a) and potential pro-integrative policy intervention (4b). Red boxes are long-term intervention, blue box is short-term intervention.

The vast literature on racial residential segregation holds out important lessons for studying other regional systems. To understand how regions respond to such challenges as fast population growth, immigration, deindustrialization, a shifting geography of poverty, aging, or technological change, studies in the short term at small scales and in the long term at larger scales are both essential. The short-term, small-scale studies will reveal bellwether changes and immediate responses to macro-level structural or policy changes. Longer-term studies at larger scales (i.e., the scale of the whole region) will reveal whether and why micro-level changes resonate enough to promote broader change; they will also show both the internal dynamic of these larger scales and their responses to even larger scales (state, national, and global forces).

Matching geographic scale to time scale, however, is still an open question. Is a one- or two-decade span enough to identify and understand regional differences? Like the equilibrium issue, the answer to this question probably depends on the nature of the challenge; while a decade might be enough to understand a region's resilience in the face

of a single shock, it might take a generation to learn how a region is changing in the face of repeated shocks. To understand the resilience of regions in the face of a slow burn, by contrast, might require more than a generation and even as much as a century of data. At smaller scales of organization (geography, industry), however, institutions and individuals should respond much more quickly, whether to shocks or to slow burns.

Questions of Path Dependence and Timing

A final set of questions concerns the potential path dependent mechanisms and choices operating in metropolitan regions that may shape resilience capacities and, thus, potentially destine a region to one future or another. Infrastructure investments or technological choices, for example, can determine development options for generations, as a highway bypass, airport runway width or rail gauge decision may attest. Still, such choices are not irreversible, notwithstanding typically high transaction costs of change: waterfront highways can be torn down, airport runways widened, rail gauges rebuilt. Leadership and agency enable regional pathbreaking, as regions that have "bounced back" or "turned a corner" demonstrate.

A corollary question for regional researchers is the degree to which cultural norms and habits may "lock-in" regions even more than concrete infrastructure systems do. For example, a region accustomed to a localist mode of governance in which each community has veto power over a regional decision constrains, if not predetermines, a pace and type of outcome. What might be possible through a centralized, relatively autocratic decision-making process might be impossible through a decentralized, relatively democratic one and vice versa. Social mores and expectations—of, say, high civic participation, environmental conservation, patronage politics, or business role in governance—condition different ways of addressing problems. Breaking such community norms and habits—*this is how we do things here*—may take generations, until which regional choices and outcomes might reflect a kind of path dependence.

Conclusion

Resilience as a metaphor for understanding social and physical phenomena has itself shown considerable resilience. As this paper's review of the literature demonstrates, resilience's use has been frequent and enduring over a range of disciplines from disaster studies to psychology.

Our application to metropolitan regions of four fundamental themes of resilience—equilibrium, systems perspective, path dependence and the long view—suggests several conclusions. First, the relevance to regions of equilibrium concepts depends on the nature of the challenge (immediate shock or slow-burn challenge) and characteristics of the desired outcome (one with a "natural" resting point or one with unlimited trajectory, for

example). Within these contingencies, we argue that a region merits a label of resilient only if it maintains or improves its performance on outcomes regardless of effort, process or starting point.

Second, given the myriad factors shaping regional impacts and responses, regional resilience is inevitably highly complex. We expect it to vary by scale (local to global) and time (immediate to slow-moving), suggesting that an array of studies—of small-scale impacts in the short term for a modest challenge to large-scale impacts over a long period for an insidious challenge—are necessary.

Finally, the different nature and magnitude of various challenges will complicate assessment of regional resilience. Each challenge, from responding to rapid influx of immigrants or suburbanization of poverty to addressing issues of prolonged economic decline or growth, may be associated with regional performance criteria outlining expectations for performance over scale and time. Deriving such criteria and matrices to assess relative performance of regions in the face of a common challenge is an important exercise for future research.

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Notes

[i] The distinction parallels that made by Arne Naess (Naess, Arne. 1973. "The Shallow and the Deep, Long-Range Ecology Movement: A Summary." *Inquiry* 16:95-100.) regarding "deep ecology," inasmuch as it involves at least a little disrespect for the old (or shallow) model.

[ii] The "r" and "K" labels are carryovers from the ecological literature in which the r parameter traditionally designates the rate of growth of a population and the K parameter designates the sustained or peak population attained. Scholars developing the adaptive cycle named the phase of destruction for the last letter of the Greek alphabet, omega, and the phase of reorganization and regrouping for the first Greek letter, alpha.

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