Building Resilient Communities: A Preliminary Framework for Assessment

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THE PROBLEM

Governments, non-governmental organizations, and community leaders in many countries face a daunting task: the design and implementation of policies, programs, and systems that help local communities cope with a panoply of threats ranging from terrorist attacks to natural disasters. In highly developed societies, this task is often compounded by associated problems such as aged, overburdened, and complex critical infrastructure systems;[1] the catastrophic potential of chemical, biological, radiological, nuclear, and explosive (CBRNE) threats; and the increasing interconnectivity of many global systems of transportation and communication.

The idea of building resilience to natural and man-made disasters is now a dominant strategic theme and operational goal in the current U.S. national security policy discourse.[2] Yet, even with unlimited resources, it is highly unlikely that a community can prevent or protect itself from all the possible dangers it may face. In the United States for example, complex distribution systems are now the primary mechanism for supplying populations with food and water. Gasoline-powered vehicles remain the dominant mode of transportation. Individuals and organizations build their everyday activities around complex systems over which they have little control, such as electricity, computerized systems, and communication networks supported by distant satellites. Each of these modern conveniences allows communities to function more efficiently. Yet few people maintain a stockpile of food and water or possess alternative modes of transportation, power generation, or communication in the event of an emergency.

Meanwhile, governments, communities, and individuals have never been so devastatingly unprepared to cope with disturbances to infrastructure, vital resources, or public goods and services. Part of the problem is that the efficiencies inherent within these complex systems of modern life reduce resilience through a loss in redundancy and diversity. Another aspect is that few systems are designed with resilience as a specification. The ability of these systems to bounce back after a disaster will have a direct impact on the ability of a community to respond and recover. It is thus important to consider all the resources that a community must count on when assessing resilience.

Researchers in varied and distinct disciplines have struggled with the concept of *resilience* in their respective fields for decades.[3] Scholars and practitioners continue to wrestle with this concept in hope of developing useful prescriptive homeland security policy guidance,[4] and community-level assessment tools.[5] While there is still much to debate about how to draft precise definitions of resilience and its attributes, and how to operationalize and apply resilience concepts within each discipline, overlap in the

research of each discipline is significant enough to be instructive as to what makes systems resilient.

The recent focus on resilience marks a shift from *resistance* strategies focused solely on the anticipation of risk and the mitigation of vulnerability to more inclusive strategies that integrate both *resistance* (prevent, protect) and *resilience* (respond, recover) in the face of disasters. In the past, some scholars have maintained that anticipation strategies should be used to focus on known problems, while those geared towards resilience are better suited for the unknown. It is important to point out that individually, both aspects have shortfalls. Just as planning based on anticipated threats can lead to resource investments to counter hazards that never materialize, planning from the broader resilience standpoint may call for the short-term diversion of resources in an effort to ensure long-term sustainability.[6]

Compounding the challenge is the difficulty in developing a flexible planning process that responds to changing conditions.[7] The greater the uncertainty, the greater the need for flexibility.[8] Yet, the pervasiveness of "worst-case," "probabilistic" planning lacks the "possibilistic thinking" needed to face both the dangers *and* the opportunities that no one can predict.[9] Finding the right balance between anticipation and adaptation, order and chaos, resistance and resilience is the challenge each community must face and calls for an approach based on continuous learning and transformation,[10] rather than anticipation and control.[11]

This article moves beyond *debating definitions of resilience*, towards the development of a preliminary conceptual framework for *assessing community resilience*. We recognize that not all frameworks are created equal, nor do they satisfy all constituent audiences.[12] The proposed framework presented herein is consistent with Nobel Laureate Elinor Ostrom's stated purpose of a framework: to "identify the elements (and the relationships among these elements)…to consider for analysis…organize diagnostic and prescriptive inquiry…[and] provide the most general set of variables that should be used to analyze all types of settings relevant for the framework."[13] It does not outline a cookie-cutter solution for all communities to apply, but rather an approach that allows community leaders and policymakers to begin to think about resilience as it pertains to their own community's unique circumstances. While sacrificing operational specifics in the interim, it summarizes the core attributes of resilient systems (resource performance, resource diversity, resource redundancy, institutional memory, innovative learning, and connectedness) in the context of five key community subsystems (ecological, economic, physical infrastructure, civil society, and governance). Through the examination of each community subsystem, a preliminary, community-based, resilience assessment framework is proposed for continued development and refinement.

In leading up to this conceptual framework, however, the article presents the definition of resilience used here, an argument for a community-based approach, and a description of what we believe the research shows are the core attributes of resilience within community systems.

WHAT IS RESILIENCE?

In current policy debates, the meaning of resilience varies by disciplinary perspective. For most, resilience (with its roots in the Latin word *resilio*) means to adapt and "bounce back" from a disruptive event.[14] Similarly, resilience also refers to the ability of a system to absorb, change, and still carry on.[15] As applied to social systems, resilience refers to the capacity of a community system, or part of that system, to absorb and recover from disruptive events.[16] We have adopted the definition used by scholars at the multi-disciplinary Resilience Alliance because it is applicable across the relevant systems examined here: *the capacity of a system to absorb disturbance, undergo change, and retain the same essential functions, structure, identity, and feedbacks*.[17] It can be a characteristic of individuals, small groups, networks, organizations, regions, nations, or ecosystems. This definition retains the core concepts of those definitions semi-officially adopted by federal agencies responsible for homeland security.[18]

Note that resilience does not necessarily mean that the system will look just as it did before a disturbance or "surprise." It will maintain its functions but individual parts of the system may have changed (adapted) to new conditions in the environment. For example, sometimes, when part of a system is not resilient and fails, other parts of the system must assume its functions and appropriate its resources. Thus, a resilience strategy does not guarantee short-term stability, but rather survivability of the system's essential functions in the long term. Resilience is often an emergent property of the system,[19] and therefore often difficult to measure and predict.

Resilience is sometimes confused with the concept of "resistance" – an attempt to prevent or stop disruptive events from happening. Resistance strategies include physical countermeasures such as trying to stop terrorists from boarding aircraft and building firewalls to protect computer systems from intruders. Resilience strategies, on the other hand, assume that resistance may not always be possible and thus include the provision of or access to alternative resources and services if the resistance strategy fails.

Resistance is not antithetical to resilience. Rather, resilience subsumes it. If a community can resist a disturbance, its resources are robust enough to prevent the disturbance from reducing community functioning without any need for adaptation. However, a strategy that only directs resources toward resisting threats would almost certainly be costly, and possibly conflict with societal norms and individual liberties. Moreover, when resistance strategies fail, they have a tendency to fail catastrophically.[20]

A COMMUNITY-BASED APPROACH

We do not assume that government is the primary guarantor of resilience, although it can be an important facilitator. Similarly, we do not assume that there is one optimal set of choices or resource allocations for all societies preparing and planning for potential "surprises" that may come their way. Nor do we assume that the choices that social groups make today will work in the future. Although resilience can be fostered on multiple scales, the community is an appropriate level for building basic resilience.

A central reason we focus on resilience at the community level is because most disasters are local and affect communities differently – a flood or earthquake would not affect residents of Singapore the same way that it would affect residents of San

Francisco, California. Communities are unique and have their own local needs, experiences, resources, and ideas about prevention of, protection against, response to, and recovery from different types of disasters. Each community has access to resources and the ability to manipulate and make decisions that single individuals do not. Since all disaster planning and response requires the immediate involvement of a wide range of local institutions (often in concert with state and national organizations), they are typically the appropriate level of focus for emergency planning and response activities. A community-level focus on resilience – as opposed to a "one-size-fits-all" or "top-down" approach – results in local participation, ownership, and flexibility in building resilience.[21] Moreover, because communities are parts of greater wholes (states, regions, and nations), a bottom-up community resilience approach builds state, regional, and national resilience concurrently.[22] Strengthening local coping capacity can help empower local communities rather than foster institutional dependency.[23]

A community is a group of people who share a common physical environment, resources, and services, as well as risks and threats. It is also a collective body that has boundaries (often geographic), internal and external feedbacks, and "a shared fate."[24] Because of this, a community is a complex physical and social system comprised of many sub-systems.[25] For example, a typical metropolitan area encompasses a diverse collection of districts and neighborhoods within the central city and its suburbs, with very different land-use norms, social interactions, income levels, and access to resources. Some experts refer to the "footprint" of a community as the region from which a city pulls its resources, that receives the city's waste, or that depends on the city's economy. This footprint usually reaches well beyond the city limits.[26] Disruption of community systems can come from external points and have broad effects within and without. For instance, the source that generates and provides power to an urban energy system is part of that system, but may be located well outside of the given urban area.[27]

In contrast, a rural community might be limited to a smaller collective of residents inhabiting a valley or mountainous region. Likewise, rural subsystems will vary in form and significance to overall community functioning. For instance, the family (as an institution) and religious organizations may play a more dominant role in rural settings than they do in urban settings.

Within both communities and regions, there is usually a high level of interaction among government, corporate, nonprofit, and individual participants when addressing common needs.[28] Indeed, many communities already engage in comprehensive community planning. Therefore, we presume that communities will define themselves in conducting any resilience self-assessment. Also, our analytical model seeks to close the practical gap between state-provided security, human safety challenges such as disasters and terrorism, and trans-boundary connections between public and private resources as well as multiple planning and response levels within communities.[29]

Attributes of Community Resilience

What makes one community bounce back from a disruption quickly while another will struggle for years? What is resilience in a community setting? Simply put, it is the ability of a community to absorb a disturbance while retaining its essential functions. This does not mean that its degree of functionality remains in a constant state but that functionality will return in one form or another in a relatively short period of time. To be

resilient, the community must have both the resources available and the ability to apply or reorganize them in such a way to ensure essential functionality *during* and/or *after* the disturbance. Furthermore, since the community governance process will differ based on each geographical setting, measures taken with the aim of improving a community's assessment of its own resilience must be highly context-specific.[30] After a comprehensive literature review of resilience in multiple disciplines,[31] such as organization theory, political science, economics and specific grounding in the tradition of ecological resilience and the work of the Resilience Alliance,[32] we propose a model that allows communities to evaluate and plan for their resilience based on an analysis of the robustness of their available resources and adaptive capacity to utilize their resources.

Before elaborating further on what resource robustness and adaptive capacity entail, we note the broader implications for communities. Communities with a highly robust pool of resources and a high degree of adaptive capacity will be the most resilient. However, few communities will have the luxury of possessing high levels of both. If a community is either high in resources or high in adaptive capacity, they can afford to have somewhat less of the other and remain relatively resilient if they take these assets into account in their planning. However, when communities possess low levels of resources *and* low levels of adaptive capacity, they will be less resilient. So, if a community is lacking in resources, it should concentrate on building its adaptive capacity. For example, if a community lacks funds (resources) for advanced communications equipment, it can utilize resources on hand and self-organize in such a way (adaptive capacity) to perform the desired function. Hypothetically, two communities could have an equal amount of resilience, but a different mix of resources and adaptive capacity.

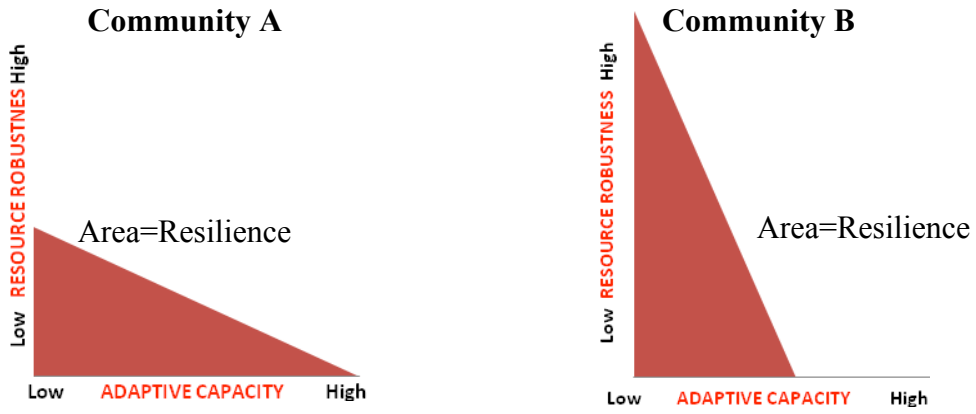

Figure 1. Resource Robustness and Adaptive Capacity

Resource Robustness

Resources are critical to a community's sustained functioning and provision of public services under a variety of conditions, in times of normalcy or crisis. Communities can evaluate the *robustness* of their resources by looking at the performance, diversity, and

redundancy of what is available to them. Resources are defined as "objects, conditions, characteristics, and energies that people value."[33] Importantly, this definition emphasizes the localized, value-laden quality of such an object or condition. Resources considered valuable to one community may not have the same inherent value to another, especially across different regions and cultures. Resources that are objects or conditions could range anywhere from snowplows to schools, from hospitals to food and water supplies, or from social cohesion to economic wealth. Likewise, characteristics and energies such as leadership, education level and ethical values could also be considered resources to a community.

Performance "describes the general level of capacity and quality at which an element or elements of a system performs an essential role."[34] Performance answers the question, "how well does this resource accomplish a particular function?" For example, a hammer performs better than a wrench for sinking a nail, because it is designed specifically to drive nails into solid objects. Performance of an object or condition also includes a quality relative to those of a similar nature. Thus, a stronger, more durable hammer performs better than those of inferior design, and thus has a higher relative quality. When looking at the function of water distribution within a community it would be important to know how well the water system works under average conditions and what might make it vulnerable to collapse.

Diversity is a measure of different types of available resources that perform a particular function.[35] A community that has high diversity in its available resources for critical functions will have a multitude of options for accomplishing those particular functions. Hammers, nail guns, and other hard objects all provide a diversity of options to sink nails. Yet, if the function is to attach one object to another, adhesives such as glue, screws and screwdrivers, staples and staplers, if available, provide a diversity of resources to draw upon, albeit with varying degrees of performance. Likewise, if there are several communication systems in a community (i.e., radio and reverse-911) there will be more chance to reach all citizens with important information and more likelihood of reaching people if one of those communication systems becomes inoperable.

Diversity can also come in the form of information and ideas for approaching a particular task. All else equal, a planning team comprised of individuals that come from a variety of backgrounds and experiences possesses a greater collective diversity of ideas and knowledge and, thus, a greater number of options to tackle a problem, compared to a team of individuals from similar backgrounds.

Redundancy is a quantifiable measure, or count, of a single resource type that performs a specific function.[36] Redundant resources provide a failsafe, or back-up, when any individual unit fails. Redundancy is also a form of operational slack, or buffering from external shocks. Having many hammers provides a high degree of redundancy for sinking nails. If one breaks, there are more to use. Likewise, emergency savings accounts are a form of redundancy in financial terms and allow for the continuance of an individual or family's lifestyle in the event of a job loss or unexpected event. A seventy-two-hour emergency preparedness kit allows a household to sustain itself in the event of a disaster, until a community response organization can respond and restore power and other basic services.

However, redundancy is often expensive. It means that there are resources sitting in reserve that may not be used – even while the community pays to maintain them. This becomes an important tradeoff that each community must make and depends in large part on how valuable a resource is to them and how likely it is that resource will be disrupted.

When combined, the performance, diversity, and redundancy of available resources determine a system's overall robustness.[37] That is, its ability to provide critical functions under a variety of conditions. For example, the robustness of a water system would be greatest when the system has high performance (i.e., sound delivery mechanisms, pipes, pumps, etc.), redundancy (i.e., multiple water lines), and diversity (i.e., multiple sources such as rivers, lakes, aquifers, and runoff). Every community, and each system within a community, must decide how to allocate time and money between performance, redundancy, and diversity, keeping in mind that it may be best to have a balance of the three attributes – not maximizing one to the detriment of the others.[38]

Adaptive Capacity

A community's *adaptive capacity* is a function of the ability of individuals and groups to: 1) store and *remember* experiences; 2) use that memory and experience to learn, *innovate*, and reorganize resources in order to adapt to changing environmental demands; and 3) *connect* with others inside and outside the community to communicate experiences and lessons learned, self-organize or reorganize in the absence of direction, or to obtain resources from outside sources.[39] Thus, institutional memory, innovative learning, and connectedness determine the foundation of adaptive capacity on a community level.

Institutional memory is the accumulated shared experience and local knowledge of a group of people. Over time, institutional memory is amassed through group-level observation and stored in a variety of ways such as documented records or repetitive rituals and ceremonies that are carried on as group membership evolves over time.[40] Rituals reinforce institutional memory by facilitating and reinforcing the recollection of rules and policies as well as the interpretation of changes or disturbances in the environment. Information and knowledge management systems that store, distribute, and aid in interpretation of large quantities of data are helpful in retaining institutional memory but only if they are accessible by people who need them, when they need them.

Innovative Learning is the ability of the group to use its information and experience to create novel adaptations to environmental changes or to avoid repeating old mistakes. Innovation is a form of dynamic learning that places emphasis on the capacity to identify and "create new responses or arrangements."[41] Innovative institutions sometimes encourage trial-and error type learning by allowing "errors and risk-taking behavior."[42] Other times innovations occur in a more deliberate way by putting new ideas or resources together with old ones when current strategies are not working. It is true that necessity is often the mother of invention. Innovative learning can be reduced by a failure to admit that something is not working to provide an important resource or function. This kind of learning can be especially difficult when it has to happen as an unanticipated disruption is unfolding. During a disruption, spreading information about the innovative learning going on in a community (both what is working and what is *not* working) requires a trusted source of information that may or may not be government

or the media. Identification of these trusted communication channels and maintaining that trust becomes critical.[43]

Innovation and learning are mutually increased through the practice of "adaptive co-management" which combines a management culture that places a premium on risk taking and experiential learning with the linkages and partnerships associated with cooperative management.[44] Leadership – a vital community resource – plays a pivotal role in establishing such a culture.

The creation of new ideas, resources, processes, and forms of organization are all results of innovative learning.[45] A community is in a position to learn and innovate when individuals and groups are able to experiment through trial and error. Repeated variations on experiments create knowledge – and hopefully institutional memory – of what new ideas, processes, and organizational designs work and those that do not. Ultimately, innovative learning allows the ability of a social group to anticipate both *future opportunities and future hazards*.

Finally, interpersonal and group *connectedness* is critical to the diffusion of institutional memory and innovative learning throughout the community. Community systems and subsystems typically have a variety of internal and external links between their various component parts of the system and the higher or lower levels of the system. These links are commonly characterized as social (informal) and organizational (formal) networks.[46] In the absence of formal direction, these connections – which often vary in strength[47] – contribute to a community system's ability to exchange, store, and recall knowledge, and take collective action in light of changing conditions.

However, the tightness or looseness of these connections can be both the community's strength and its vulnerability.[48] In *tightly coupled systems,* a change in one component (individual or subsystem) of the system engenders an immediate response from (or impact on) the other components. For example, an apartment complex is a tightly coupled shelter system because a fire in one living unit is likely to have an effect on the others. In a rural area, a fire at one farm will not have an immediate effect on the others as they are more loosely coupled. The efficiency of apartment complexes comes at the cost of less resilience to fires for individual units.

Yet, in *loosely coupled systems,* the components have weak enough links that they can ignore local disturbances. Since loosely connected units have more independence from the full system than tightly coupled ones, they can maintain their equilibrium or stability even when other parts of the system are affected by a change in the environment. Thus, if either innovation or localized responses to particular problems are specified goals, then loosely coupled systems seem most appropriate. For example, a more tightly coupled emergency management system would take longer to respond or have inappropriate responses for some unanticipated surprises if all the units in the system had to wait on centralized, bureaucratic decision making before they could act. Still, if the goal is standardization across the entire system, then a tight coupling is more likely to yield a desired outcome.

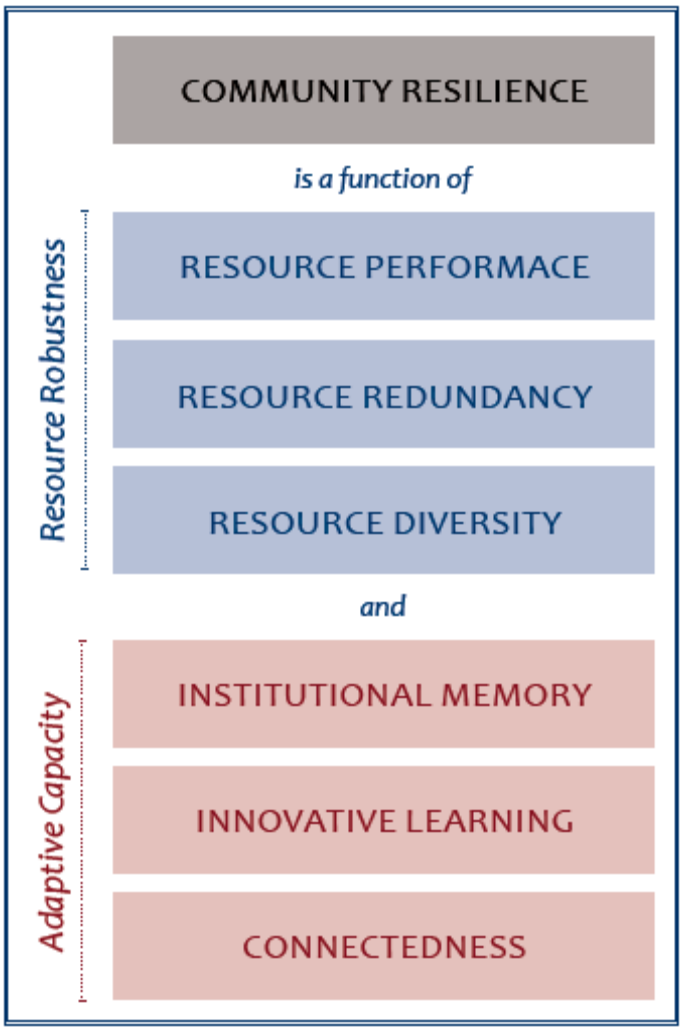

Figure 2. Aspects of Community Resilience

When a community possesses a high level of all three traits – institutional memory, innovative learning, and connectedness – it, in turn, possesses a high capacity to adapt to changes in the environment. If it has a relatively low level of one trait, it can often make up for this deficiency by addressing it directly or increasing the levels of the other two traits. For example, a large city with low levels of connectedness between ethnic groups could address this problem directly by creating bridges for dialogue and communication that will, in the event of a disruption, facilitate sharing and diffusion of institutional memory and innovative learning across groups. This requires that communities build connections and trust *before* a disruptive event. However, if such a strategy proves unfruitful, it may still be able to improve adaptability by increasing the access of these groups to a shared knowledge center, or by encouraging innovation and learning across all groups.

Living, or coping, with change and uncertainty requires the capability to integrate and apply learning, collective memory, innovation, and collaboration in ways that

sustain critical functions over time. A tall order – communities, governments, and organizations must continuously look forward, plan for multiple alternative futures, and test for or experiment with new ideas, while recalling and interpreting the past. In recognizing the directional nature of current hazards and changes, and by identifying external drivers of change, these social institutions have the opportunity to design the flexibility necessary to anticipate and adjust to change.

APPLYING A RESILIENCE APPROACH TO COMMUNITY SYSTEMS

With the ability to make sound self-assessments of their resilience to disasters and disruptions, communities can more appropriately prioritize preparedness efforts, allocate funding, and develop more innovative ways to organize their material and human resources. In order to help communities think about their resilience, our approach employs the concepts described above to assess each one of five key community subsystems: ecological, economic, civil society, governance, and physical infrastructure.[49]

These five were chosen based on an exhaustive review of academic and policy-oriented literature, and lengthy discussions on a set of sub-systems that, together, captured the core functions within a community. For example, earlier in our research, we included information and communication systems as a stand-alone system for analysis, but concluded it overlapped considerably with all other subsystems. We recognize that these subsystems are inherently interdependent, overlapping, and complex, even in small communities. Ultimately, the set of five key community subsystems represents a pragmatic choice between parsimony and exhaustiveness.[50] These five subsystems are a starting point for community analysis and individual communities may well identify other subsystems that are important to them.

Within each subsystem described below, we illustrate some of the attributes and characteristics of what we believe indicate resilience in each subsystem; that is, the robustness of the resources that make up the subsystem and its adaptive capacity. Attributes of resilience will vary depending on the type of system in question. For example, diversity in an ecosystem may be the number of different types of species, while diversity in an economic system may include the range of skill sets within a labor force. The discussion of each subsection is for explanatory purposes only. We do not attempt to "prove" the applications suggested or to offer a "how to" for each system. However, we hope that more specific guidance for communities will be developed as this research progresses.

Ecological Subsystems

Ecological systems are the combined biological and physical elements of the environment in which a community is located.

> [An] ecosystem is the complex of interconnected living organisms inhabiting a particular area or unit of space, together with their environment and all their interrelationships and relationships with the environment. An [e]cosystem is characterized by the description of populations; [the abundance] of individual species; interspecies relationships; activity of organisms; physical and chemical

> characteristics of environment; flows of matter, energy, and information; and description of changes of these parameters with time.[51]

Humans are an important part of a community's ecosystem but they are not the only important part. Without outside resources, humans cannot survive if the local environment does not support agriculture or provide enough clean water.

Some parts of an ecological subsystem will be beyond the control of a community, but are nonetheless helpful in describing a community's setting and the natural resources the community can use to provide for critical functions in times of disruption. The important natural resources might include items such as water supplies, wind patterns, climate, soil quality, and topography. The important task for each community is to look at the aspects of the ecological systems most valued in order to consider them when the community is forced to bounce back from a surprise. For example, it would be important to know wind patterns if you must respond to a cloud of volcanic ash or a biological attack. It may also be important to know the amount of available land for new uses such as temporary shelter construction. In addition, a diversity of habitats would allow some flora and fauna to survive if one habitat is rendered uninhabitable. Will these habitats support local food production? Does the environment support growing other crops if the current ones become economically unsustainable?

The adaptive capacity of ecological subsystems might be measured by how quickly key elements of the local environment can regenerate in the event of a disaster such as flooding or fire.[52] Grasses and insects will regenerate much faster than trees and mammals due to the length of their life cycles. Through evolution, many plants have developed adaptive capacity that allows them to be resilient because they "remember" how to bounce back from dangers such as fire by developing protective surfaces on their seeds. For agriculture, this adaptation period will be the time it takes to prepare the land and then plant either the existing crop or a new one that is more appropriate to new ecological (or economic) conditions. New crops may need new machinery and specialized knowledge to accomplish successful adaptation. Indicators of adaptive capacity include the ability of the environment to support a diversity of crops and wildlife.

Economic Subsytems

Economic systems are comprised of people, firms and institutions that interact to accomplish the production, distribution, and consumption of goods and services. A resilient economy can be essential for recovery efforts in a post-disaster setting.[53] The resources of an economic system are robust if they can deliver critical goods and services under a variety of conditions. The changes in conditions may happen quickly, like a flood. Or they may occur over a longer period of time, like climate change or the movement of firms to new markets.

A major disaster or catastrophic event could potentially put many economic activities at risk. Resilient local economic systems will have plans to get small businesses up and running to ensure that people feel safe going to markets, and to assure the public that the flow of currency is secure and individual bank accounts are protected. The first decision will be whether to try to return the economic system to its previous state or to adapt to new conditions.

Resource robustness in an economic subsystem would generally include performance, diversity, and redundancy within the labor markets and capital markets and 'land' or natural resources within a given community. According to some economists, the measure of these resources denotes the potential for "shock-absorption."[54] To assess the resources within an economic subsystem, economists might look at the conditions of the labor market, the make-up of the community's businesses, the preferences of consumers, measures of unemployment, and growth and/or inflation, among other signals.

Adaptive capacity in an economic subsystem might come in the form of policy options available to business or government leaders, such as whether to borrow, trade, finance, or substitute goods. Such tools increase the potential for "shock-counteraction,"[55] and amount to the ability of the economic subsystem to innovate and learn. To assess the adaptive capacity in an economic subsystem, experts could consider the fiscal position of the community – a healthy position would allow leaders to cut taxes or raise expenses to counteract the harmful shock. Economists might also look at the community's freedom to trade or make adjustments to trading relationships. In the labor market, economists might look at the ability of workers to change jobs or get new training in various industries.

Physical Infrastructure Subsystems

Physical infrastructure "refers to the substructure or underlying foundation or network used for providing goods and services; especially the basic installations and facilities on which the continuance and growth of a community, state, etc., depend…[and] include roads, water systems, communications facilities, sewers, sidewalks, cable, wiring, schools, power plants, and transportation and communication systems."[56] The practitioners, engineers, and policy makers that use, design, and manage these assets are included within the subsystem as well.

Assessing the resource robustness within a community's physical infrastructure subsystem would require an accounting for each of the infrastructure sectors listed above, especially considering that the robustness of each sector could vary dramatically within the same community. A community could have a superior transportation system, but a woefully inadequate water system. In addition, communities have varying control over the complex, networked infrastructure systems on which they rely. For example, many communities rely on power from the electric grid. Thus, they are unable to affect the performance or redundancy of their own energy infrastructure because it is managed and regulated on a broader scale. Realizing this, communities might work to require these higher levels of regulation to include appropriate redundancy to ensure that the system can bounce back after a disruption. Potentially costly, redundant telephone switches or electric generation and transmission capacity would almost certainly be paid for through increased rates for businesses and consumers. This illustrates tradeoffs that must be made between increasing resilience and reducing costs in the short term.

An adaptive capacity assessment in a given infrastructure sector depends, in part, on the nature of the component under consideration. Some components are structured or designed to adapt. The internet, for example, automatically reroutes information around damaged networks. Other components that consist of fixed resources, like a

transportation system that consists of bridges and roads, can only adapt in the short term through innovation by the system's users and managers that reroutes traffic around damaged areas.

Civil Society Subsystems

For our purposes, "civil society" refers to the formal and informal modes of social organization and collective action outside of governmental authority (i.e., non-governmental and philanthropic organizations, health and human service organizations, faith-based organizations, unions, associations, etc.). These institutions contribute to community values, provide forums for civic action and dialogue, and enhance quality of life and social welfare. They are often key players in recovery from a sudden disruption such as a natural disaster.

Assessing the resource robustness within a community's civil society subsystem would entail accounting for the diversity (number of different types) of civil society organizations, their redundancy (total number by category), and the performance of these diverse organizations in accomplishing their missions. A large number of volunteer organizations in a community may appear to offer high redundancy, but if these organizations experience difficulties maintaining membership, mobilizing support, or accomplishing meaningful projects for the community, they may not necessarily be considered *robust* resources.

An adaptive capacity assessment in a given community would require a careful examination of the mechanisms and procedures the civil society uses to retain and recall its collective experiences, the production of new and innovative techniques for achieving community goals, and the strength of ties between civil society organizations. Using the volunteer sector again as an example, indicators such as organizational longevity, employee turnover, and growth of new organizations would provide a general sense of institutional memory. However, this should also take into account how organizations retain and embed their experiences in processes and individuals.

Governance Subsystems

Systems of governance include the public organizations (political, administrative, legislative, and judicial institutions) that contribute to the administration of government functions of the community. There may be overlap into the social and private spheres through public-private partnerships. Governance also includes the processes through which government institutions, or any group of people with a mandate or with a common purpose, make decisions.[57] Governance also sets the parameters for ordered rule, cooperative action,[58] decision-making, and power sharing through institutions.[59]

Assessing the resource robustness of a community's governance subsystem is often limited to a performance assessment in terms of the governing entities themselves because competing governing entities sometimes undermine the functions of the system. This is apparent in post-conflict communities that suffer from diverse governing structures (tribal, national, and intervening structures) all operating at once. Performance may be measured in multiple ways – from the cost and quality of services delivered in relation to the resources collected from the citizens, to the strength of the government's mandate to act on the citizens' behalf.[60] In some communities there may

be great value in having redundancy and diversity in staffing, especially for critical functions and resources, even if this is not efficient and costs more in the short term.

An adaptive capacity assessment in a given community would entail a range of inquiries. Does the government have the capacity to institutionalize and adapt lessons-learned, such as modifying emergency response plans following an event? How extensive is the discretionary authority granted to government officials during a crisis (for example, the authority to commandeer resources or waive regulatory restrictions as needed)? How connected are the various units of government in times of disruption?

DEVELOPING AN ASSESSMENT FRAMEWORK

The critical elements of a local resilience assessment include an unflinching look at the five subsystems as they really are and a willingness to see possibilities for putting resources together in new ways in the event of a disruption. At a minimum, a comprehensive community resilience assessment would entail an examination across each of the five subsystems that make up the community, as briefly described above. Communities should assess each subsystem's resource robustness in terms of performance, diversity, and redundancy as well as its adaptive capacity in terms of institutional memory, capacity for innovation, and internal and external connectedness. Each system must be initially assessed separately because the attributes of resilience are manifested differently. Overlaps between these subsystems should then be dealt with to form a picture of the whole.

The following list of questions represents the most basic level of examination to assess the resilience of a community subsystem.

Basic Questions for Resilience Assessment

- Which functions are vital to our community within this subsystem?
- What resources are available to perform this function?
    - How well does this resource perform a particular function? How well would it perform in a disruption? ***(Performance)***
    - How much of this resource do we have? ***(Redundancy)***
    - Are there other resources available that could perform this function? ***(Diversity)***
- To what extent do organizations and informal social groups within this subsystem instill and maintain a common memory? ***(Institutional Memory)***
- To what extent do organizations and informal social groups within this subsystem foster a culture of continuous learning and innovation? ***(Innovative Learning)***
- To what extent are organizations and informal social groups within this subsystem internally and externally connected? Are they loosely connected or tightly connected? How will a disturbance that affects one organization or social group impact others? ***(Connectedness)***

While this list of questions appears rudimentary, it can easily lead to a lengthy set of functions and resources under each subsystem, accompanied by evaluative criteria and/or indicators for each resilience attribute (performance, redundancy, diversity, institutional memory, innovative learning, and connectedness). The boxes below provide a simple breakdown of how an analysis would be organized by subsystem with one or two example indicators. The potential depth and comprehensiveness of such an assessment is limitless and ultimately up to the prerogative of the community or analyst.

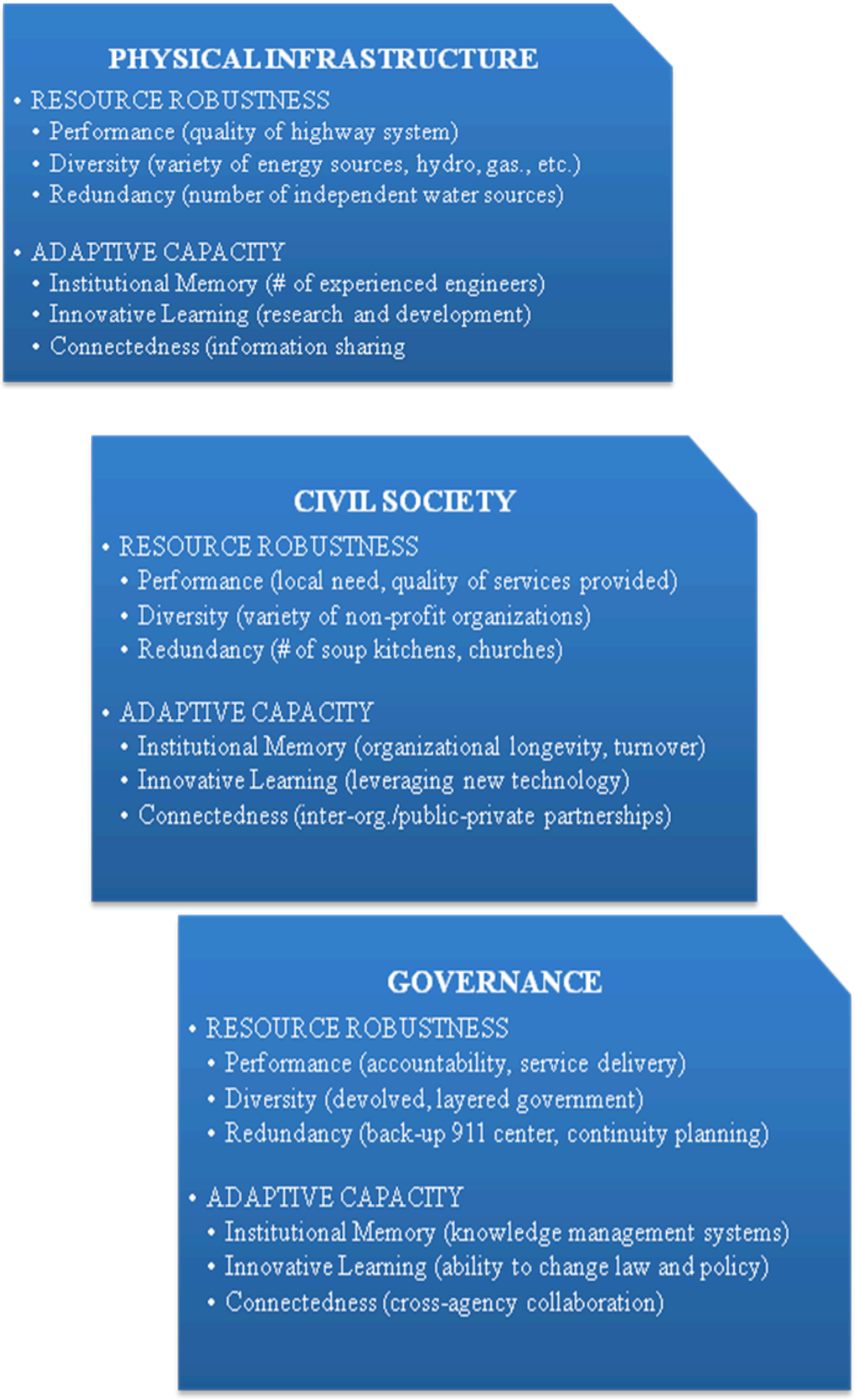

Figure 3. Resilience Analysis Breakdown (with example indicators)

CONCLUSION

As stated previously, this article outlines a *preliminary* conceptual framework for assessing resilience. It is a first step toward moving beyond academic debates and toward a useful policy tool. While discussion and debate will – and should – continue on the exact nature of resilient systems in the various disciplines, we believe there is a significant enough overlap in the research to propose this framework for more concrete analysis. Just as no one definition of resilience will fully satisfy participants in this diverse field of research and practice, no one tool will be equally satisfying or sufficient. What matters is that communities have an approach that is relatively easy to understand and use to guide decision-making.

Notably, this framework is community-based, holistic, and scalable. The design allows planners and policy-makers to conduct a resilience assessment that is adapted to fit their own particular circumstances, based on the assumption that communities themselves are best able to identify and make value judgments regarding which functions and resources matter most. Communities are also better equipped than outside evaluators to determine the scale and scope of the geographic and political boundaries that define them. In addition, because the proposed framework is scalable, it can potentially allow for application on multiple levels of state, regional, and international governance.

We acknowledge that this framework requires further development both in academic circles and communities. Options include assembling experts from each subsystem to evaluate how to best measure the resilience attributes (resource robustness and adaptive capacity) quantitatively, qualitatively, or in combination. Researchers might develop a catalog of evaluative questions to be assessed, scaled, and normalized according to subsystem, and then aggregate these questions to form a collective resilience index. Another option involves extensive case study analysis.

Lastly, the resilience approach described here is no panacea for addressing the wide range of natural and man-made threats to society. Nor should it completely supplant risk- and vulnerability-based approaches to homeland security. Rather, all of these efforts should be mutually supporting. But until researchers and practitioners move beyond the definitional debate and get on with developing something useful in the field, resilience will remain nothing more than just another good concept and meaningless buzz-word.

This article is based on research presented in P.H. Longstaff, N. Armstrong, and K. Perrin, "Building Resilient Communities: Tools for Assessment," Project on Resilience and Security white paper, Institute for National Security and Counterterrorism, Syracuse University (March, 2010), available at:
http://insct.syr.edu/uploadedFiles/insct/topics_and_projects/resilience/INSCT%20White%20Paper_Building%20Resilient%20Communities.pdf.

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[1] S. Flynn, *The Edge of Disaster: Rebuilding a Resilient Nation* (New York: Random House, 2007).

[2] See for example, The White House, *The National Security Strategy of the United States of America*. (Washington, DC: May 2010); U.S. Department of Homeland Security (DHS), *One Mission, Securing Our Homeland; U.S. Department of Homeland Security Strategic Plan 2008-2013* (Washington, DC: 2008); DHS, *National Infrastructure Protection Plan* (Washington, DC: 2009); DHS, *National Disaster Recovery Framework (Draft)* (Washington, DC: February 2010); and J. Cascio, "The Next Big Thing: Resilience," *Foreign Policy* 88, No. 3 (May/June, 2009).

[3] B. Walker, C. S. Holling, S. R. Carpenter, and A. Kinzig, "Resilience, adaptability and transformability in social–ecological systems," *Ecology and Society* 9 (2004): 5.

[4] J. H. Kahan, A. C. Allen, and J. K. George, "An Operational Framework for Resilience," *Journal of Homeland Security and Emergency Management* 6, No. 1 (2009): 1-47.

[5] K. Perrin participated in a Subject Matter Working Group meeting in June 2010 as part of the Community and Regional Resilience Institute's (CARRI) Community Resilience System Initiative. See http://www.resilientus.org/community_resilience_system_initiative.html. An earlier version of this paper was circulated at this meeting for feedback.

[6] A. Widalvsky, *Searching for Safety* (New Brunswick: Transaction Books, 1988); (cited in J. M. Normandin, M. C. Therrien, and G. A. Tanguay, "City Strength in Time of Turbulence: Strategic Resilience Indicators," (paper presented at the Joint Conference on City Futures, Madrid, 4-6 June, 2009). Available at http://www.cityfutures2009.com/PDF/43_Therrien_Marie_Christine.pdf).

[7] J. Rosenhead, "Planning Under Uncertainty I: The Inflexibility of Methodologies," *The Journal of the Operational Research Society* 31, No. 3 (1980): 209-216.

[8] A. Etzioni, *The Active Society: a Theory of Societal and Political Processes* (London: Collier-Macmillan, 1968); K. Boulding, "Reactions on Planning, the Value of Uncertainty," *Technology Review* 77, (Oct/Nov 1974); T. Marschak and R. Nelson, "Flexibility, Uncertainty and Economic Theory, *Metroeconomica* 14, (1962): 42-58; (cited in J.Rosenhead, "Planning Under Uncertainty I: The Inflexibility of Methodologies," *The Journal of the Operational Research Society* 31, No. 3 (1980): 209-216).

[9] L. Clarke, *Worst Cases: Terror and Catastrophe in the Popular Imagination* (Chicago: University of Chicago Press, 2006).

[10] L. Comfort, "Risk and Resilience: Inter-organizational Learning Following the Northridge Earthquake of 17 January 1994," *Journal of Contingencies and Crisis Management* 2, No. 3 (1994): 157-170.

[11] J. Gleick, *Chaos, Making a New Science* (London: Penguin Books, 1987).

[12] For example, "An Operational Framework for Resilience" (cited in note 18) is primarily a set of resilience planning and resource allocation guidelines for homeland security and emergency management policymakers. The framework provides an operationally relevant rubric for envisioning resilience across the four main homeland security mission areas (prevent, protect, respond, and recover). Yet, it neither explains what exactly makes complex systems resilient nor offers a method to evaluate resilience. How can resource allocation across the various mission areas be justified without a basic understanding of the underlying dynamics of resilience?

[13] E. Ostrom, *Understanding Institutional Diversity* (Princeton, NJ: Princeton University Press, 2005), 28.

[14] R. Klein, R. Nicholls, and F. Thomalla, "Resilience to Natural Hazards: How Useful is this Concept?" *Environmental Hazards* 4 (2003): 35–45; S. Manyena, "The Concept of Resilience Revisited," *Disasters* 30, No. 4 (2006): 434-450.

[15] C. S. Holling, "Resilience and Stability of Ecological Systems," *Annual Review of Ecological Systems* 4 (1973): 1-23.

[16] P. Timmerman, *Vulnerability, Resilience and the Collapse of Society: A Review of Models and Possible Climatic Applications* (Toronto: Institute for Environmental Studies, University of Toronto, 1981).

[17] The concept of "resilience thinking" was first developed in C.S. Holling, "Resilience and Stability of Ecological Systems," *Annual Review of Ecological Systems* 4 (1973): 1-23. See also the web site for the Resilience Alliance: http://www.resalliance.org, and L. Gunderson, C. Allen, and C.S. Holling (eds.), *Foundations of Ecological Resilience* (Washington D.C.: Island Press, 2010). These ideas were applied to homeland security issues by P. H. Longstaff in *Security, Resilience, and Communication in Unpredictable Environments Such As Terrorism, Natural Disasters, and Complex Technology*, Program for Information Resources Policy, Harvard University (November 2005), http://pirp.harvard.edu/pubs_pdf/longsta/longsta-p05-3.pdf.

[18] J. Kahan, A. Allen, and J. George, "An Operational Framework for Resilience," *Journal of Homeland Security and Emergency Management* 6 (2009): 1-48, http://www.bepress.com/jhsem/vol6/iss1/83. The Homeland Security Advisory Council Critical Infrastructure Taskforce (HSAC CITF) favors this definition: "Resiliency is defined as the capability of a system to maintain its functions and structure in the face of internal and external change and to degrade gracefully when it must." The Department of Homeland Security (DHS) uses this definition: "Resilience is the ability of systems, infrastructures, government, business, and citizenry to resist, absorb, and recover from or adapt to and adverse occurrence that may cause harm, destruction, or loss [that is] of national significance." Other definitions and an extensive review of the literature can be found at F. Norris et al., "Community Resilience as a Metaphor, Theory, Set of Capabilities, and Strategy for Disaster Readiness," *American Journal of Community Psychology* 41 (2008): 127-150.

[19] Phenomena are said to be emergent when they arise from the collective actions of many uncoordinated agents. See, e.g., Steven Johnson, *Emergence: The Connected Lives of Ants, Brains, Cities, and Software* (New York: Scribner, 2001).

[20] S.D. Sagan, *The Limits of Safety: Organizations, Accidents, and Nuclear Weapons* (Princeton, NJ: Princeton University Press, 1993).

[21] There is growing agreement among many organizational theorists that the best responses to challenges often come from the bottom up and not from the top down, or a combination thereof. See, e.g., John Seely Brown and Paul Duguid, *The Social Life of Information* (Cambridge, MA: Harvard University Press, 2000).

[22] For example see M. Bruneau, S. Chang, R. Eguchi, G. Lee, T. O'Rourke, and A. Reinhorn, "A Framework to Quantitatively Assess and Enhance the Seismic Resilience of Communities," *Earthquake Spectra* 19 (2003): 733-752; D. Godschalk, "Urban Hazard Mitigation: Creating Resilient Cities," *Natural Hazards Review* 4, No. 3 (2003): 136-143; and F. Norris et al., "Community Resilience as Metaphor."

[23] B. Wisner, P. Blaikie, T. Cannon, and I. Davis, *At Risk: Natural Hazards, People's Vulnerability and Disasters* (London: Routledge, 2004).

[24] F. Norris et al., "Community Resilience as Metaphor," 128.

[25] Communities must be thought of as *complex systems* as opposed to simple, linear systems (where 2+2 always equals 4). Researchers from many fields, including public administration, have discovered that complex systems often behave in similar ways; see, e.g., L. Dennard, K. Richardson, and G. Morcol, eds., *Complexity and Policy Analysis: Tools and Methods for Designing Robust Policies in a Complex World* (Goodyear, AZ: ISCE Publishing, 2008). Also, while there is no universally accepted and comprehensive definition of complex systems, there are some things that they seem to have in common: they are made up of many components; contain intricate webs of causal links and feedbacks that are tightly or loosely coupled; have interdependencies among components (or modules); are open to influences from the outside environment; as a whole, are more than a sum of their parts; exhibit nonlinear, dynamic behavior; have so many dimensions or variables that they are mathematically intractable. For an explanation of this list that is readable by a non-specialist, see, Melanie Mitchell, *Complexity: A Guided Tour* (Oxford and New York: Oxford University Press, 2009); and Thomas Homer-Dixon, *The Ingenuity Gap: Facing the Economic, Environmental, and Other Challenges of an Increasingly Complex and Unpredictable World* (New York: First Vintage Books, 2002), 110-115.

[26] V. Heiken, R. Brown, G. George, O. Jones, and C. Andersson, "Modeling Cities: The Los Alamos Urban Security Initiative," *Public Works Management and Policy* 4 (2000): 198-212.

[27] T. Lewis and R. Darken, "Potholes and Detours in the Road to Critical Infrastructure Protection Policy" *Homeland Security Affairs* 1, (2005): 1-11, http://www.hsaj.org/?article=1.2.1.

[28] R. Platt, *Disasters and Democracy* (Washington, D.C.: Island Press, 1999).

[29] B. Sundelius, "A Brief on Embedded Societal Security," *Information & Security* 17 (2005): 23-37.

[30] S. Cutter , L. Barnes, M. Berry, C. Burton, E. Evans, E. Tate, and J. Webb, "A Place-based Model for Understanding Community Resilience to Natural Disasters," *Global Environmental Chan*ge 18, No. 4 (October 2008): 598-606.

[31] For a more extensive review on resilience concepts and background literature, see both P.H. Longstaff at note 18 and also, P.H. Longstaff, N. Armstrong, and K. Perrin, "Building Resilient Communities: Tools for Assessment," Project on Resilience and Security white paper, Institute for National Security and Counterterrorism, Syracuse University (March, 2010), http://insct.syr.edu/uploadedFiles/insct/topics_and_projects/resilience/INSCT%20White%20Paper_Building%20Resilient%20Communities.pdf.

[32] More information about the Resilience Alliance is available at http://www.resalliance.org/1.php.

[33] F. Norris et al., "Community Resilience as Metaphor," 131.

[34] Homeland Security Studies and Analysis Institute, "Resilience Conceptual Development: An Operational Framework for Resilience" (August 27, 2009), 22, http://www.homelandsecurity.org/hsireports/Resilience_Task_09-01.pdf.

[35] Researchers in many disciplines have observed that having multiple different options, or diversification of resources, is an asset when developing resilience. See, e.g., W. Brian Arthur, "On the Evolution of Complexity," in *Complexity: Metaphors, Models and Reality* 19, ed. G. Cowan, D. Pines, D. Meltzer (Santa Fe Institute Studies in the Sciences of Complexity Proceedings, 1995), 65-78, 67. However, when a system gets more diverse, its complex interaction networks spread unevenly and the forces working on the system do not have the same effect on the diverse components. Thus, a successful strategy to increase the survivability of individuals or groups in such a system will almost never be "one size fits all" and will be most effective if choices and allocations are made at the lowest possible level.

[36] Redundancy is usually a resistance strategy and is employed where the danger to be avoided is relatively predictable or potentially catastrophic. Aircraft, for example, have multiple engines so that if one fails the redundant system will pick up that function. In human-engineered systems, sometimes-identical systems are added to back up critical systems that might fail. This type of redundancy is frequently designed into the system and generally makes it more costly. See, e.g., S.D. Sagan, *The Limits of Safety: Organizations, Accidents, and Nuclear Weapons* (Princeton, NJ: Princeton University Press, 1993).

[37] Fundamentally, robustness depends on the ability of individuals, groups, or technologies to tolerate a broad range of conditions. Robust systems have *broad tolerance* for changes in their environment. For example, a machine that can work under a wide variety of external conditions is said to be very robust. In other situations, broad tolerance depends on the ability to adapt to *changing* conditions. For example, some species are said to be robust because they can go into hibernation when water supplies are low. The ability of humans to find new ways to meet their needs in the face of surprise greatly increases their robustness or broad-tolerance resilience. We can often figure out alternative ways to procure water, food, and shelter. Sometimes robustness is accomplished with systems that are capable of performing multiple functions and can act as backup for another system. This is called *distributed robustness* in some systems and redundancy in others, see, e.g., A. Wagner, *Robustness and Evolvability in Living Systems* (Princeton NJ: Princeton University Press, 2005), 239-246.

Buffering is also a resilience strategy that results from building diversity and redundancy into a complex system. A buffering strategy may attempt to stop bad things from spreading to critical components of a system, or it might be a conscious allocation of resources that will be kept in reserve to use to shield the systems from the effects of a surprise. Levies are a buffer against rising water in a river. Computer systems often have buffers that will stop a virus from invading critical part of the system. Emergency savings accounts, surplus inventories, and slack time in manufacturing operations are also buffering strategies. All come with significant financial or opportunity cost, but they are good for dealing with frequently occurring or potentially catastrophic risks.

[38] There are tradeoffs between these three attributes. For technology with high customer expectations of reliability, betting the farm on redundancy can lead to disaster when the system is faced with a surprise that was not anticipated by the designers, and one that cannot be handled with redundant capabilities. In addition, redundancy and/or diversity could be counterproductive if the complexity of the system makes it more opaque and difficult to understand for the people who must operate it. Redundancy can also lead people to have too much confidence in the system and forget to watch for surprises. Heavy layers of redundancy or lots of diversity can furthermore make it possible to conceal errors and surprises (fearing the 'blame game"), with the result that there is less accurate information about how the system is operating.

[39] Complex systems are *adaptive* when individual agents operate independently and change their behavior in response to forces in their environments via feedback. Other agents will copy changes that result in the agents' obtaining more resources. There is some evidence that the most resilient organizations are those that have some experience with surprise and have adapted in order to survive. See Dennis S. Mileti and John H. Sorenson, "Determinants of Organizational Effectiveness in Responding to Low Probability Catastrophic Events," *Columbia Journal of World Business* (Spring 1987): 14. We would thus expect a culture that has not changed or adapted to be less resilient. In addition, the ability of an individual or group to adapt may be tied to the state of their development. Humans, organizations, social systems, and ecosystems all *develop*; that is, they change over time in form and function such that they grow, mature, die, and change in interesting ways characteristic of the species or type of organization or ecosystem, as shaped by cultural and biological evolution; see L. Gunderson and C.S. Holling, eds.,

Panarchy: Understanding Transformations in Human and Natural Systems (Washington, DC: Island Press, 2002).

[40] F. Berkes and C. Folke, "Back to the Future: Ecosystem Dynamics and Local Knowledge," in Gunderson and Holling, *Panarchy*, 141.

[41] F. Berkes, "Understanding Uncertainty and Reducing Vulnerability: Lessons from Resilience Thinking," *Natural Hazards* 41 (2007): 291.

[42] Ibid.

[43] See P.H. Longstaff at note 18.

[44] Ibid., citing C. Folke, S. Carpenter, T. Elmqvist, L. Gunderson, C.S. Holling and B. Walker, "Resilience and Sustainable Development: Building Adaptive Capacity in a World of Transformations," International Council for Science, ISCU Series on *Science for Sustainable Development*, No. 3 (April 2002), http://www.sou.gov.se/mvb/pdf/resiliens.pdf.

[45] K.G. Tidball and M.E. Krasny, "From Risk to Resilience: What Role for Community Greening and Civic Ecology in Cities?" in A. Wals, ed., *Social Learning Towards a more Sustainable World* (Wagengingen Academic Press, 2007), 149-164.

[46] There is almost universal agreement that the best starting point for trying to manage an unpredictable system is to identify the various temporal and organizational scales involved. See P. H. Longstaff at note 18. In systems that operate on more than one scale, resilience strategies can operate within each scale but also across scales. For example, in the human body, the immune system acts first on a local scale to confront an infection by sending a variety of forms of immune cells (within-scale resilience through diversity). If this strategy fails, the system responds by "scaling up" its response and inducing fever. When similar functions (not necessarily similar mechanisms) operate across scales, they make the system more resilient because they are redundant: if one function fails, the other goes into action. Each level of the system operates separately, and often each level has its own emergent properties and/or operates over different time scales and responds to different cycles. Surprises or risks that manifest themselves over a long period require different strategies than dangers that can pop up at any time. Risks to one part of the system are treated differently from those that might affect the entire system. The boundaries between scales should receive careful attention because that is where surprises are likely to occur.

[47] Network theory and science provide a substantial knowledge base on the significance of social and organizational links. See, e.g., A. Barabasi, *Linked: The New Science of Networks* (Cambridge, MA: Perseus Press, 2002), Chapter Six; D. J. Watts, *Small Worlds: The Dynamics of Networks Between Order and Randomness* (Princeton, NJ: Princeton University Press, 1999), 285; J.W. Meyer and W. R. Scott, *Organizational Environments: Ritual and Rationality* (Beverly Hills, CA: Sage, 1983); B. Uzzi, "Social Structure and Competition in Interfirm Networks: The Paradox of Embeddedness," *Administrative Science Quarterly* 42, No. 1 (1997): 35-67; M. J. Dollinger, "The Evolution of Collective Strategies in Fragmented Industries," *Academy of Management Review* 15, No. 2 (1990): 266–285; E. Patterson, D. Woods, R. Cook, and M. Render, "Collaborative Cross-Checking to Enhance Resilience," *Cognition, Technology and Work* 9, No. 3 (2007): 155-162; J. D. Orton and K. E. Weick, "Loosely Coupled Systems: A Reconceptualization," *Academy of Management Review* 15, No. 2 (1990): 203–223.

[48] See, e.g., M. Granovetter, "The Strength of Weak Ties," *The American Journal of Sociology* 48, No. 6 (1973): 1360-1380; S. Snook, *Friendly Fire: The Accidental Shootdown of U.S. Black Hawks Over Northern Iraq* (Princeton, N.J.: Princeton University Press, 2000).

[49] K. Perrin, "Operationalizing Resilience: Assessment Models for Community Resilience," resilience and security working paper (Institute for National Security and Counterterrorism, Syracuse University, August 2009), http://www.insct.syr.edu/Projects/Resilience/Home.htm.

[50] Additionally, these subsystems closely correspond to the six Recovery Support Functions outlined in the Department of Homeland Security's draft *National Disaster Recovery Framework* (Washington, DC: February 2010): Community Planning & Capacity Building; Economic Development; Health, Social & Community Services; Housing; Infrastructure Systems; and Natural and Cultural Resources. The major difference in our approach is that "housing" would be considered within the scope of physical infrastructure and "cultural resources" would be included in civil society. Fundamentally, both our chosen subsystems and DHS recovery support functions address the same core elements of a community – the

only real difference is the chosen boundaries between them. Yet, as the descriptions below illustrate, resilience attributes could just as easily be described within the narrower conception of disaster response functions.

[51] S.A. Ostroumov, "New Definitions of the Concepts and Terms Ecosystem and Biogeocenosis," *Doklady Biological Sciences* 383 (2002): 141–143. Translated from *Doklady Akademii Nauk* 383, No. 4 (2002): 571–573.

[52] B. Walker and D. Salt, *Resilience Thinking: Sustaining Ecosystems and People in a Changing World,* (Washington, DC: Island Press, 2006).

[53] See A. Rose, "Economic Resilience to Natural and Man-made Disasters: Multidisciplinary Origins and Contextual Dimensions," *Environmental Hazards* 7 (2007): 383–398.

[54] L. Brigulio, G. Cordina, S. Bugeja, and N. Farrugia, "Conceptualizing and Measuring Economic Resilience," working paper (Economics Department, University of Malta, 2006), https://secure.um.edu.mt/__data/assets/pdf_file/0013/44122/resilience_index.pdf.

[55] Ibid.

[56] See U.S. EPA, Office of Grants and Debarment, definition of "Infrastructure" for purposes of the American Recovery and Reinvestment Act of 2009, May 8, 2009, http://www.epa.gov/ogd/forms/Definition_of_Infrastructure_for_ARRA.pdf. Because of the critical nature of information sharing to community resilience, we exclude communication infrastructure from this section of our analysis and explore it as a stand alone category.

[57] U.S. Agency for International Development (USAID), "How Resilient is Your Coastal Community? A Guide for Evaluating Coastal Community Resilience to Tsunamis and Other Coastal Hazards," (U.S. Indian Ocean Tsunami Warning System Program, 2007), http://apps.develebridge.net/usiotws/13/CoastalCommunityResilience%20Guide.pdf.

[58] P. Healey, "Creativity and Urban Governance," *Policy Studies* 25, No. 2 (2004): 87-102.

[59] L. Lebel, J. Anderies, B. Campbell, C. Folke, S. Hatfield-Dodds, T. Hughes, and J. Wilson, "Governance and the Capacity to Manage Resilience in Regional Social-ecological Systems," *Ecology and Society* 1, No. 1 (2006): 19.

[60] For more background on performance management in public administration see G.A. Brewer, "Building Social Capital: Civic Attitudes and Behavior of Public Servants," *Journal of Public Administration Research and Theory* 13 (2003): 5-26; H. Hatry, *Performance Measurement: Getting Results* (Washington, DC: Urban Institute, 1999); E.T. Jennings and M. Patrick Haist, "Putting Performance Measurement in Context," in P.W. Ingraham and L.E. Lynn, eds., *The Art Of Governance* (Washington, DC: Georgetown University Press, 2006), 173-194; J. Melkers and K. Willoughby, "Models of Performance-Measurement Use in Local Governments: Understanding Budgeting, Communication, and Lasting Effects," *Public Administration Review* 65 (2005): 180-90; and T.H. Poister and G. Streib, "Performance Measurement in Municipal Government: Assessing the State of the Practice," *Public Administration Review* 59 (1999): 325-335.