The Critical Role of Open Space in Earthquake Recovery: A Case Study

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ABSTRACT: Recovery planning theory and normative urban design theories have a common interest in providing for the health and safety of urban communities. However the requirements of safe refuge and recovery in times of emergency are sometimes at odds with the needs of liveable cities. The concept of urban resilience provides a way of designing for the adaptability of cities while still accommodating everyday use. The paper overlays theories of urban design, recovery planning and urban resilience, examining their common ground through an analysis of the earthquake event of 1906 in San Francisco, its morphological analysis and first hand reports of its survivors. It proposes that the key to the successful integration of recovery planning and urban design lies in a shift of thinking that sees a city's open spaces as a 'second city': a network of open space designed not only to contribute significantly to the quality everyday urban life, but with the latent capacity to act as essential life support and an agent of recovery in the event of an earthquake.

1 INTRODUCTION

The extreme risk to life and property associated with earthquakes in urban centres has led to an enormous amount of research on the structural stability of buildings, the effectiveness of community preparedness and the planning and performance of lifeline services. One of the goals of this type of research is to promote effective recovery, here defined as 'the immediate, medium and long-term holistic regeneration of a community following a disaster', (MCDEM, 2005). Yet the role of the city's landscape its network of open space, and effectively the place where recovery happens, is almost never discussed and spatial planners, urban designers and landscape architects are rarely involved in earthquake recovery planning. It is not clear why this is so.

This paper examines these issues. It is part of a larger study investigating the latency inherent in a city's open space network and its influence on urban resilience (the capacity of a city to absorb and adapt to disturbance). That study acted as the catalyst for an enquiry into earthquakes and the way cities and communities respond to them.

The purpose of this paper is to develop and test a theoretical framework that can be used to investigate a number of earthquake-prone cities to understand how open space can influence recovery and adaptive behaviour leading to recovery. The open space network of one city, San Francisco, is examined through a series of morphological analyses of the relationships between the city's built form and open space at the time of the 1906 7.9 Richter scale earthquake and subsequent fire. We assess these relationships with respect to two sets of data:

1) Primary sources: personal accounts, government documents and plans. These are analysed for evidence relating to the way the configuration, distribution, amount, function and content of open space facilitated adaptation or 'community regeneration' in the immediate, medium and long term aftermath of the 1906 event.

2) Attributes of resilience and their relationship to urban design theory (Walker and Salt, 2006).

It is our intention that this analysis might begin to clarify the role of open space and the potential role of designers of open space in earthquake recovery planning.

2 BACKGROUND

2.1 Urban Morphology

What do we mean by the open space network and how do we analyse it? According to Lefebvre, cities are conglomerations of processes (social, economic, political, ecological) and forms (buildings, streets, infrastructure, parks, monuments etc) (Lefebvre, 2003). The two co-exist and are mutually interdependent. Urban form is a product of relationships and in particular, the relationship between built form and open space. Morphological analysis is the examination of that relationship and the way it changes over time, in response to a wide range of influences. It is sometimes used to highlight the capacity of a city to adapt and is typically conducted at a range of scales; the scale of the city, the neighbourhood and the lot (Moudon, 1983, Lipsky, 1999). It is a useful way to quickly analyse the open space/built form relationship of a city in terms of the amount, distribution and configuration (at the scale of the city) and in terms of structure and function at more detailed scales.

In the literature of urban design and landscape architecture, open space has a range of meanings, from 'green space' (parks, greenways, reserves etc) to all public open space (including streets and squares) to private open space (gardens, courtyards) (Swanick, 2003). More recently, in response to the growing intensification of cities, other spatial types have been considered for their potential to connect invigorate and provide support for urban life, for example public-private land, temporarily vacant spaces and car parks, road verges and the leftover space between buildings (Pollack, 2006). For the purposes of this research, and since we are looking for latencies, we have considered all of these categories, in other words, everything outside the building envelope.

2.2 Earthquakes and Open Space

Documented responses to earthquakes from around the world suggest that ample and adaptable amounts of open space surrounding buildings are of enormous value both during and after an earthquake event (Godschalk, 2003). Open space becomes a refuge for, and a temporary home to thousands of people who need to quickly adapt to their new environment for days, months or even years. After a major earthquake, the open space network becomes a kind of 'second city', providing multiple complex functions such as gathering and shelter, the distribution of goods and services, the re-establishment of commerce, temporary inhabitation, commemoration, and the storage of contaminated or hazardous materials (McGregor, 1998, Middleton, 2007). The network becomes charged with new meaning; its spaces and their components are re-assessed for their capacity to support survival and recovery.

However while there is a little information regarding the approximate quantities of open space per capita required for egress or refuge (Wang), research about quality is almost nonexistent. Are there particular qualities or arrangements that might encourage communities and governments to adapt to facilitate recovery or is it just a matter of providing as much 'empty' open space as possible?

2.3 Urban Design Theory

Current urban design theory would suggest not. 'Good' urban design and best practice earthquake planning are sometimes contradictory. Many earthquake planning recommendations, including the provision of large quantities of unstructured open space, can result in dispersed rather than compact urban form, making it difficult to achieve liveable, diverse and sustainable urban environments. This has been a criticism of the relatively recent reconstruction of Tangshan in China. The city may be less vulnerable to earthquakes, but its wide streets, low rise buildings and lack of an identifiable centre has left it without 'urbane refinements'(Mitchell, 2004).

In any case, this type of major reconstruction is rare. Even after a catastrophic event, change to the built environment is more likely to be achieved through small, expedient and incremental developments (MacDonald, 2004) where mitigation of hazards and the facilitation of recovery are usually seen as a constraint, rather than an opportunity. The unpredictability of hazards means that earthquake planning takes a back seat to planning our way out of the traffic snarl that disrupts us every day on our way to work.

2.4 **Urban planning and recovery planning**

Urban development in Wellington is controlled by the City's District Plan. In keeping with national policy, the Plan takes an all-hazards approach, recognising the need 'to avoid or mitigate the adverse effects of natural and technological hazards on people, property and the environment'**.** It mentions 'mitigation, preparedness, response and recovery' but only discusses mitigation, at any length. Open space has its own section in the Plan where the focus is on preserving character, amenity and ecosystem health; its agency in recovery planning is not discussed. The Plan's General Design Guides don't discuss hazards at all. They cover urban design considerations, which are largely aesthetic or visual and relate to character, context and amenity.

Recovery planners on the other hand, have recognized the need for a holistic approach to recovery. But in *2004 Resilient New Zealand: Focus on Recovery*, the Ministry for Civil Defence and Emergency Management refers to the built environment as a collection of individual elements rather than as an integrated whole. Open space is not recognized as a component of the built environment, but instead is covered in a section on the natural environment. The focus in the document is on recovery of these environments rather than their capacity to *support* recovery. Pre-planning or urban planning is mentioned as a way of taking advantage of 'opportunities presented by destroyed infrastructure' rather than as a way of developing strategies that might guide incremental, everyday change. Strangely missing from the body of the document, despite its emphasis in the introduction, is a detailed engagement with the concept of resilience and how it might influence strategies for recovery. The majority of the document focuses on sustainability; in fact the two concepts seem to be used interchangeably.

2.5 **Urban Resilience**

Resilience and sustainability are related concepts, but the activities and processes associated with them, the rules we make for them and the way we design for them are often quite different. The overwhelming goal for sustainability is the mitigation of impacts. The concept of resilience, strongly influenced by systems thinking and defined here as the capacity of a system to respond to disturbance while still maintaining structure and function (Holling, 1973), is useful because it shifts the focus away from controlling impacts or threats towards developing a system's capacity to respond to them. Ecologists Holling and Walker have developed a resilience model that suggests that a thorough understanding of a system's existing structure and function and its history of disturbance allows us to design for and manage resilience (Walker, 2004).

Cities are complex systems and communities, as an integral part of those systems, play an important part in the adaptive response. While recovery planners are concerned with encouraging communities to adapt, urban designers are beginning to be interested in how the design of cities might encourage that to happen. Both disciplines are making tentative moves, albeit unconsciously, towards the other. Because an earthquake may never happen there is likely to be a reluctance to retrofit a city to accommodate the needs of recovery, particularly if there are cost implications. But if urban design strategies and earthquake recovery planning strategies are aligned, through a focus on urban resilience, then the ongoing and incremental retrofitting of a city for day to day purposes will automatically create opportunities to facilitate effective recovery should an earthquake occur. The common denominator for urban design and recovery planning is a city's open space network: the streets and parks and left over spaces that are part of the everyday city, and that come to life as the 'second city' during recovery.

3 **AIMS**

Our aim for this research project was to determine how the open space network of a city contributes to adaptations that lead to recovery. The following questions provided a framework for enquiry and served to challenge our thinking about the potential of open space to encourage adaptive response:

1. How does a city's open space structure, function, distribution, proportion or design assist or detract from post earthquake recovery?
2. Which earthquake resilient characteristics also enhance the quality of urban design?

3. Does the way open space is used pre-earthquake influence recovery post earthquake?
4. How do communities appropriate/adapt open space to assist recovery?
5. How do governments encourage the use of open space to assist recovery?

Our intention was to stimulate interdisciplinary discussion concerning the critical role of open space in earthquake planning and the potential for design to facilitate earthquake recovery.

4 METHODOLOGY

The research was conducted in two related stages:

4.1 The Resilience Vocabulary: a typomorphological analysis

In order to determine the concept's cross-disciplinary potential, we assessed the resilience attributes described by Walker and Salt for their relevance to and congruence with urban design theory.

We then analysed case studies of earthquake damaged cities to determine which aspects of each city's urban form exhibited characteristics of those attributes.

4.2 Primary Sources: response and recovery

We corroborated these findings with evidence from primary sources (e.g. government documents, personal accounts, photographs, reconnaissance reports etc) showing adaptive behaviour both during and after the earthquake. Primary sources were evaluated according to a number of recovery functions including gathering and shelter, the distribution of goods and services, the re-establishment of commerce, temporary inhabitation, commemoration and worship, births deaths and marriages, storage of contaminated or hazardous materials, and the disposal of waste.

5 CASE STUDY # 1: SAN FRANCISCO

5.1 Urban morphology

San Francisco was a small Spanish mission, a harbour port for traders and a military outpost before the 1840s gold rush precipitated massive immigration. In 1839, the Mexican alcalde had regularized the settlement with a grid street pattern and a central plaza beside the Bay. As the city filled with settlers, so the city grid was somewhat expediently extended to the west. The layout of small blocks and wide streets gave no concession to the sometimes steep topography. More plazas were established on the lowlands. Market Street, a wide diagonal street that reconnected the mission and the hinterland to the main port, severed and rotated the grid.

Over the next 50 years, population growth was strong. The city centre stayed beside the deep-water harbour, which provided connections to the bay, the coast and international ports, but the gridiron was extended to the west. Landowners responded to market pressures by subdividing, making way for row housing and semi detached housing, following a fashion in the eastern states. The long east-west axis of the small blocks provided good solar access for a fine grained subdivision. Built form was intensive, leaving only small patches of private open space. The wetlands of the Bay were reclaimed and developed for housing. Neighbourhood centres developed in the troughs between the hills. Parks were set aside on the hilltops, the least accessible and therefore least valuable land, until a groundswell of public minded citizens lobbied for the establishment of a 1017 acre park on the edge of the city.

From a process that entailed inputs from some crude urban planning, immigration, market force pressure, and civic movements, the urban structure of San Francisco was established on the hills and sand dunes of a peninsula that extended into the biggest and deepest harbour on the west coast of USA. Within the city, development was framed by this urban structure of the harbour, the hills, the grid, the wide streets, the subdivision pattern and the open space distribution that were established in the late 19th century. Despite numerous fires and earthquakes in the 19th century, this framework persists.

These defining features, together with a range of cultural and economic catalysts have influenced the city's distinctive morphology. This can be described as follows:

The city's location on the tip of the peninsula provided multimodal transport opportunities.

Topography deformed the grid.

Within the grid a restricted street hierarchy is evident with wider streets (Market, Van Ness) in the valleys.

From the grid, the street hierarchy and the topography, a network of distinct neighbourhoods evolved.

Parks and squares are distributed evenly throughout the urban fabric.

Block size and orientation influences morphology at a neighbourhood scale.

5.2 **Resilience Vocabulary**

In their book, *Resilience Thinking*, Walker and Salt discuss nine resilience attributes. They are: diversity, variability, modularity, acknowledging slow variables, tight feedbacks, social capital, innovation, overlap in governance, and ecosystem services (Walker and Salt, 2006). For the purposes of this paper, we have discussed two; drawing parallels with urban design theory and examining the implications of our findings for the city of San Francisco in 1906 and its capacity to support recovery.

5.2.1 *Diversity*

Diversity is important as 'a major source of *future options* and a system's capacity to respond to change and disturbance in different ways' (ibid). The more diversity, the better the capacity for a group or system to adapt to a wide range of different and sometimes unpredictable circumstances.

For urban designers diversity of form is discussed in terms of its capacity to encourage social diversity and economic health (Jacobs, 1961) or creativity (Florida, 2004) rather than as a source of future options. Since *The death and life of great American cities,* written by Jacobs in the 1960s as a polemic against the homogenizing effects of modernism, there has been widespread acceptance that urban diversity goes hand in hand with liveable cities, although the causal relationship between formal and social diversity has been challenged (Fanstein, 2005). Jacobs recommended four conditions for urban diversity: multiple land uses; short blocks; variety in building age; and density.

Although the framework of its grid is repetitive and seemingly homogenous, San Francisco, in 1906, had a rich and diverse urban fabric. Its interface with the hilly topography generated a variety of connected neighbourhoods supporting diverse functions. The deformation of the grid as it met the hills, also resulted in a range of different open space typologies (Lipsky, 1999). The successive wave of developments in the city, resulted in different types of open space, from the small squares and waterfront of the original city, to the scattered neighbourhood parks and hilltop cemeteries of the Western addition to the expansive Golden Gate Park on the sand hills in the far west.

This diversity of spaces created a range of options during the emergency period immediately following the earthquake that allowed members of the community to come together, support each other and re-establish the pattern of their daily lives before a formal and co-ordinated relief strategy was available.

5.2.2 *Variability*

Walker and Salt suggest that 'a resilient world would embrace variability rather than attempting to control or reduce it' and that 'resilience is only maintained by probing its boundaries'. They suggest that attempting to control disturbance can actually increase vulnerability. For example, controlling fire in a forest will ultimately result in the loss of fire resistant species.

How can urban form embrace variability? Engineers design for variability and uncertainty by setting wide design tolerances to allow a system to have a greater range of function (Bergen et al., 2001). For example, streets are designed to carry storm water in a 100-year event. Constructed ecosystems (e.g. swales, rain gardens and wetlands) supporting the street-system widen the tolerances still further allowing more flexibility in the system to cope with very wet or very dry conditions, as well as enhancing urban amenity. Redundancy is another design strategy for embracing variability; if a system’s components are redundant or duplicated, they introduce a ‘safe to fail’ measure into a system. Many traffic networks have built in redundancies; if one street is blocked, it is easy to take a different route. Freeways on the other hand, have no built in functional redundancies. A breakdown on the freeway can leave motorists stranded for hours.

Architect Stanford Anderson would suggest that the freeway was an example of a ‘tight fit’: a system with its form and function so closely coupled that it could only ever do what it was designed to do. Anderson suggests that designing forms and spaces with a ‘loose fit’ makes them robust, capable of supporting a multiplicity of functions in time and space and with a high degree of latency which would allow for future adaptations (Anderson, 1978). In response to the charge that master plans are too prescriptive, spatial planners have adopted the idea of loose fit by designing “frameworks” instead of specific forms, which can deliver a robust spatial structure while allowing for change and flexibility.

There seems to have been a great deal of robustness and redundancy in San Francisco in 1906. Its wide gridded streets, its multi modal transport options, its evenly distributed framework of parks, which had remained largely unimproved in favour of the enormous government expenditure required to develop Golden Gate Park, and its associated overabundance of open space (for a long while San Francisco boasted the highest amount of open space per capita of any city in the US) gave the city plenty of room to move, maximizing its ‘range of function’. Repeated exposure to fire and earthquake tested the city and its community’s capacity for resilience. No wonder the city’s official seal is the phoenix.

The city’s greatest vulnerability to disaster was its access to fresh water, exacerbated by its location on the peninsula and its politics which allowed just one company and one system to supply the majority of the city’s water. Put simply, there was no redundancy in the water supply, and it failed miserably.

5.3 **Evidence of Recovery**

On April 18th, 1906 San Francisco was a city of about 500,000 people.

Within hours of the earthquake the key concern was for security and shelter. Many people refused to go back inside their houses for fear of another earthquake. Some people fled the city. However a large proportion, some 250,000, gathered in parks and open space. The local park was an important source of information and a form of solace and community support. The hilltop parks also gave a vantage point to survey the extent and direction of the fire. Ad hoc camps were established at first, with people ‘encamped or sleeping out in the open in the various military reservations, parks, and open spaces of the city’ (Greely, 1906). They settled wherever was most convenient to them, or where there was water; there were reservoirs in a few hilltop parks and at Golden Gate Park ‘there was an independent water supply…, where were also lakes of fresh water of considerable size’ (ibid.). Shelter was constructed using ‘materials taken from lumber yards, houses in the course of construction, advertising fences, etc…. Although a large number of tents were shipped into the town, these, in the very nature of things, arrived after a delay of a week to ten days or more’ (Phelan, 1906a). In the meantime, people slept in streets, parks, private gardens or vacant lots.

The camps supported a diversity of everyday functions; kitchens and restaurants were established quickly, all types of commerce flourished and people were married, gave birth and died. Some of the parks, especially Portsmouth Square, were used for temporary burials. Sanitation and disease was an ongoing problem and the camps were regularised by the army as quickly as possible, first with the establishment of military camps around the city, particularly in Golden Gate Park and the Presidio, and subsequently with the construction of low cost cabins and amenity buildings. In both cases, the gridded layout and flat land of these camps supported the establishment of an efficient sewerage system. In some parks, such as Jefferson, which is frequently mentioned in eyewitness accounts, the inconvenience of sloping land for camping seems to have been outweighed by the convenience of location. By May 13 ‘there were 50,000 people living in more than 100 separate camps, of which 21 were under military control’ (Greely, 1906). One of these camps was on the waterfront. Despite its construction on reclaimed land, the waterfront remained relatively unscathed; its industrial scale ensured large amounts of flat land and the survival of the recently reinforced ferry building and wharf meant that camp residents were in a prime position to receive the regular shipments of water and food from outlying suburbs.

San Francisco's network of open spaces contributed to its quick recovery. In a report to the authorities at the end of July that year, Major General Greely (1906) suggested that 'the question of providing temporary shelter for the 200,000 homeless people who remained in San Francisco was facilitated by the mildness of the climate, the abundance of canvas, and the considerable numbers of convenient squares and public grounds'. This degree of spatial redundancy ensured that recovery in place, now recognized as an important component of community survival and recovery, (Mitchell, 2004) was possible .

The city streets were another important locus of recovery. Their width and gridded layout encouraged a range of unimagined adaptive responses. Because of earthquake damage to chimneys, 'all food of the entire city was cooked over camp fires in the open streets' (Greely, 1906). People were resourceful and spirits in general were high. Kitchens were constructed in inventive ways; 'at first, pieces of sheet-iron were supported on bricks, but as time wore on, people moved old stoves into the street, surrounding them with screens made of window-shutters, bill-boards, or cloth attached to frames' (Keeler, 1906). Sometimes streets adopted a consistency in building materials, which gives them a cohesive, but poignant quality. The streets became an important community space, where families cooked together. Sometimes the whole street was invited for dinner. Streets were wide and uncluttered enough to allow for a strip of 'gutter kitchens' on either side of the road and still allow for vehicular passage down the centre and pedestrian passage on either side of the street. Certain streets were so wide they encouraged the rapid resumption of commercial activities by allowing makeshift shop fronts to be erected directly in front of damaged ones. In some cases new, more permanent buildings were erected, like carapaces over the temporary ones.

The width of streets facilitated access. People walked to open space, sometimes taking multiple trips to collect all their belongings Immediately following the earthquake, when many streets were filled 'with fallen brick, mortar and iron, and were lined and crossed with a tangled net-work of electric wires and poles' (Morrow, 19--) and impassable, the grid provided alternative options. The widest streets, Market and Van Ness, already prominent in people's minds as sites of gathering and procession, were thronged with people 'like a parade day' (Knox, 1906) looking for a quick escape to those outlying areas less affected by the earthquake. Most streets were wide and straight enough to accommodate important auxiliary infrastructure, such as water and sewer pipes. Some became the site of temporary heavy rail.

Phelan, ex-mayor and member of the committee of fifty established to manage the crisis, described that process in his report to the Red Cross later that year as having three distinct phases; the Emergency Period, the Experimental Period and the Period of Permanent Organisation. During the Emergency Period, which lasted for the first 10 days, the extent of damage to the fabric and infrastructure of the city was such that 'anything like a complete and coherent plan of relief was absolutely out of the question' (Phelan, 1906a). For a while, there was no water, no accommodation and food was scarce. The army had not yet taken over. It was during this time that communities were most resourceful, quickly adapting to life in a new environment without much input from the authorities.

Once relief started to arrive, in the form of food, tents and money, the capacity for resourcefulness was somewhat curtailed by a very strict rule of law and a lot of bureaucratic red tape. Minutes from committee meetings during this 'Experimental Period' reveal a local government fastidiously documenting the effectiveness of their recovery strategies as if in defence of unjust criticism. While it appears that most of this part of the recovery period was staged with military precision with little room for flexibility and adaptation, there are a few clues that suggest the government was, indeed experimenting with this challenging situation.

There was, for example, passionate debate regarding the viability of adopting part or all of Daniel Burnham's proposed plan for reshaping the city's framework. Within a matter of days following the earthquake, a Committee of the Reconstruction of the City was proposed. This committee would 'consider and recommend the revision of building laws, revision of street plants, widening, extending and grading of streets, creation of parks, park ways, reservoir sights, new streets and more convenient access between the lower and higher districts, and such other matters as may come before them relative (t)o the re-habilitation or beautification of the city', in accordance with Burnham's master plan (Phelan, 1906b). The plans were soon disbanded. Phelan recognised that government 'inertia' and opposition from land owners would make significant change to the structure of the city impossible. The city's nascent structure endured because it supported a vibrant, active and growing community who utilised the open space of the city to quickly adapt to change and who were committed to a grass-roots expeditious recovery.

One of the most innovative adaptations came later, in response to the vulnerability of the city's water supply. A revolutionary new and auxiliary water supply was designed and constructed, building much needed redundancy into the infrastructure system.

6 IMPLICATIONS AND CONCLUSION

This paper documents the initial stages of a research project that has two primary aims; 1) through a series of case studies, to more fully understand the role of open space in earthquake hazard mitigation and recovery and 2) by doing this, to reinforce the potential for the alignment of urban design and recovery planning so that incremental everyday changes to urban structure can improve urban life now while facilitating recovery in the event of a disaster.

The research is still in its early stages. We plan to analyse the remainder of Walker and Salt's resilience attributes and, perhaps, add a few of our own. We still have a number of cities to investigate. We need to make a comparative analysis between them and we need to understand the significance of this analysis in the light of the contemporary experience in Wellington.

This paper introduces the research question and methodology and gives a taste of future directions. In the process, some useful lines of questioning have been established and at this stage it may be worth making a few preliminary comments.

This paper introduces the research question and methodology and gives a taste of future directions. In the process, some useful lines of questioning have been established and at this stage it may be worth making a few preliminary comments.

First, at this very early stage of the process the methodology looks promising. We have been able to draw correlations between the concepts of resilience and urban design. Diversity and variability are important characteristics for resilience; they are also key concepts in urban design theory. It also appears that certain urban morphological characteristics can enhance diversity and allow for variability. For example, the wide tolerances and diversity inherent in San Francisco's grid and network of parks may have influenced its capacity to recover. Based on our review of San Francisco, we are cautiously optimistic about identifying open space characteristics that not only enhance resilience and facilitate recovery, but also contribute to the quality of everyday urban life and that this knowledge will help to align and integrate the disciplines of spatial and recovery planning.

Secondly, we have learned more about the role of open space in earthquake recovery, but obviously, not enough. Specifically, we are aware of the limitations of historic analysis (contemporary recovery strategies are different from those applied in the U.S. in 1906) and we are still lacking detail regarding the singularity of individual spaces and the implications for design. For example a question that is currently challenging the profession of landscape architecture is, 'given the space demands and functional requirements of contemporary cities, how can we design open space that has a tight fit or is at least fit for purpose while still remaining flexible and open to future adaptation?'

We hope that our investigations of other earthquake-damaged cities and subsequent comparative analysis between these and the city of Wellington, will give us more insight. If successful the work may go some way to ensuring cities are inspiring places to live while, just incidentally, having attributes of resilience that allow communities to adapt to unpredictable, dramatic change.

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