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ORIGINAL PAPER

Bronfenbrenner's bioecological theory for modelling community resilience to natural disasters

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Abstract This paper advocates the use of *Bronfenbrenner's bioecological theory as a* framework to analyse resilience at diverse scales. Bronfenbrenner's bioecological theory can be employed to (a) benchmark social resilience, (b) target the priority interventions required and (c) measure progress arising from these interventions to enhance resilience to natural disasters. First, the paper explores resilience to natural disasters in the context of climatic change as building resilience is seen as a way to mitigate impacts of natural disasters. Second, concepts of resilience are systematically examined and documented, outlining resilience as a trait and resilience as a process. Third, issues arising in relation to the measurement of resilience are discussed. Fourth, Bronfenbrenner's bioecological systems theory is described and proffered to model and assess resilience at different scales. Fifth, studies are described which have supported the use of the bioecological systems theory for the study of resilience. Sixth, an example of the use of Bronfenbrenner's theory is offered and the paper concludes with suggestions for future research using Bronfenbrenner's theory.

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1 Introduction

The world's climate is experiencing marked changes (IPCC 2007). These changes are set to be accompanied by an increase in the number and severity of natural disasters such as floods and droughts and present a need to formulate policy to deal with these predictions (Bosomworth and Handmer 2008; Bosher et al. 2009; COAG 2009; McBean and Rodgers 2010). In Australia, and elsewhere, we need to be prepared for rapid onset events such as wildfires, cyclones and floods and slow onset hazards such as drought.

Emergency Management considers resilience essential for safeguarding communities or building safer communities. Disaster resilience is seen as a quality, characteristic or result that is developed by processes that foster or promote it. The ability of an individual, group, community or nation to deal with unique destabilising situations, or disaster resilience, is also seen as the

> …'shield', 'shock absorber' or buffer that moderates the outcome to ensure benign or small-scale negative consequences. Indeed, the goal of disaster risk management is to guarantee minimal loss of life and livelihoods and to allow the affected community or system to return to 'normal' within the shortest possible time. (Manyena 2006: 438)

Prosser and Peters (2010) remind us that to support a disaster-resilient community, studies must focus on prevention, preparedness, response and recovery. Current Emergency Management policy in Australia (COAG 2009) and internationally (Berkes 2007; Folke et al. 2003; Tompkins and Adger 2004) concurs, asserting that building resilience into communities is essential in order to cope with climate change and concomitant natural disasters. This paper advocates the use of *Bronfenbrenner's bioecological theory as a* framework to analyse community resilience. Bronfenbrenner's bioecological theory can be employed to (a) benchmark social resilience, (b) target the priority interventions required and (c) measure progress arising from these interventions to enhance community resilience to natural disasters. First, resilience to natural disasters is explored. Second, concepts of resilience are systematically examined and documented, outlining resilience as a trait and resilience as a process. Third, the measurement of resilience is discussed. Fourth, Bronfenbrenner's bioecological theory is described and proffered to model and assess resilience at different scales. Fifth, studies are described which support the use of the bioecological theory for the study of resilience. We conclude with, an example of the use of Bronfenbrenner's theory, an application of Bronfenbrenner's model illustrating findings from our ongoing research and suggestions for future research using Bronfenbrenner's theory.

2 The concept of resilience

Resilience has been variously defined depending on the level of analysis, for example, individual, community or ecological system. Most definitions incorporate a stressor and the notion of adaptation and return to pre-stressor levels of functioning (Norris et al. 2008b). Because climate change impacts involve both rapid and slower onset stressors, the resilience definition adopted here is: "a process linking a set of adaptive capacities to a positive

trajectory of functioning and adaptation after a disturbance" (Norris et al. 2008b: 130). This definition can be applied to either individual or community resilience.

3 Research method and article screening

To thoroughly explore the existing literature on resilience to disasters, an article screening process was undertaken. The search was executed using the search engine Scopus. Scopus was investigated for listings published between 1972 and Nov 2010 which contained the word "resilience" in their abstract, title or as part of their keywords, (17401) then the saved search was further refined to extract articles including the word "disaster" (1252). The listings from the subject areas of psychology, social sciences, medicine and environmental science (959) were retained. Results were then modified to exclude earth and planetary sciences (878), accounting and business (838), agricultural and biological sciences (801) and engineering (774). The 774 remaining listings included peer reviewed publications from medicine, psychology, social science, environmental science, health professions, nursing and multidisciplinary articles. The citations and abstracts of the 774 publications were then examined by the lead author and the research assistant for relevance on the basis of either individual or community resilience to disaster Prior to exploring concepts of resilience; it is necessary to define important terms relevant to the discussion such as disaster and disaster communities.

4 Disaster

A disaster is defined as a "serious disruption affecting a community or population, causing deaths, injuries, or damage to property, livelihoods, or the environment, that exceeds the ability of the affected community to cope using its own resources" (UN/ISDR 2004: 17). Natural disasters include earthquakes, tsunamis, floods, windstorms, famine, droughts and epidemics, and examples of man-made or technological disasters are industrial accidents, chemical spills, fires, explosions and the like.

5 Disaster communities

'Community' has been defined in many different ways from diverse disciplinary perspectives (Kumar 2005). A community can be a group of people coming together in physical, environmental, economic, relational, political or social ways (Kumar 2005). For the purposes of this review, 'community' is defined in three ways: those who live in a similar region; those who relate to each other as a community; and those who come together in response to an issue such as a disaster. In relation to environmental and social change, each of these types of community enacts similar processes, but only the first, community defined by geography, is of a longer term nature.

Focusing on disasters, many researchers tend to identify the physical location where a disaster took place along with its name as synonymous with a disaster community. The underlying assumption is that a common set of disaster behaviours exist that supersede differing types of disasters and local cultural differences. In other words, one expects a common set of community level patterns of disaster behaviours. With specific reference to communities impacted by a disaster, therefore Allen (2006) defines community as the

"population living within the territorial bounds of a town or village administrative unit, which is considered to be exposed to a relatively high degree of environmental hazard risk" (p. 84). However, others propose that disasters are also significant social constructs, formed within a particular social context (Kirschenbaum 2004; Quarantelli 1998). From this, it follows that any individual or family who has links through diverse social networks to others involved in a disaster becomes part of the disaster community. This notion accounts for observations which show that, in practice, disasters touch people who are not directly or physically involved in the actual disaster (Perilla et al. 2002).

Geographic physical destruction remains important because the extent of physical damage, by creating economic, environmental and human losses, also has an impact on the social networks of interactions in such communities (Kirschenbaum 2004). A disaster community therefore has a specific geographic disaster epicentre but is perceived and experienced through a complex web of social networks. Importantly, these social networks can affect collective community behaviour which might have an impact on community resilience to disasters. Studies have suggested social networks impact on, among other things, local governance (Beall 2001; Schafft and Brown 2000), health levels (Berkman 2000), child survival (Adams et al. 2002) and even happiness (Fowler and Christakis 2008).

6 Resilience

Many definitions have been proposed to capture resilience from a range of academic perspectives: ecological science, social science, human-environment system and natural disasters (e.g. Folke 2006; Norris et al. 2008a; Zhou et al. 2010). Zhou et al. (2010) identified at least twenty-eight definitions of social resilience while Norris et al. (2008a) cite twenty-one definitions. An additional confounding issue encountered in the literature is that the terms community and social resilience are sometimes used interchangeably. An understanding of the term's meaning consistent with its original use requires a consideration of the term's history.

The field in which the term resilience was originally used is contested, with some saying ecology (Batabyal 1998), others saying physics (Van der Leeuw and Leygonie 2000). The term gained currency in ecology following the 1973 release of Holling's *Resilience and Stability of Ecological Systems* (Blaikie and Brookfield 1987; Adger 2000; Van der Leeuw and Leygonie 2000; Stockholm Environmental Institute 2004) when it was used to describe the ability of an ecosystem to absorb and adapt to change while maintaining its existing state of functioning. In the late 1980s, the ecological concept of resilience was applied to understanding interactions between people and the environment (Janssen and Ostrom 2006; Timmerman 1981). In that context, resilience was used to understand the complexity of community-environment interactions and the complexity of change. However, the earliest studies to use the term resilience are found in the disciplines of psychology and psychiatry in the 1940s work of Norman Garmezy, Emmy Werner and Ruth Smith which was focused on understanding the development of psychopathology in children 'at risk'(Waller 2001; Johnson and Wielchelt 2004). These children were 'at risk' of psychopathological disorders due to long-standing stressors such as parental mental illness, perinatal problems, inter-parental conflict, poverty or a combination of the above (Werner 2000). These studies concluded that in the face of stressors sustained over a period of time, resilience was achieved in children and youths through interplay between adaptive behaviours and particular personality attributes.

Today resilience is cited across a number of fields, including emergency management. Nelson et al. (2007) argue that resilience provides a useful framework to analyse adaptation

processes to disaster and to identify appropriate policy responses in the face of increasing climate change. To enhance resilience, it is necessary to have a good initial understanding of what it is, its determinants (Klein et al. 1998) and how it can be measured, maintained and improved (Klein et al. 2003).

Resilience has been generally defined in two broad ways: as a desired outcome(s) or as a process leading to a desired outcome(s) (Kaplan 1999; Winkworth et al. 2009). It can be investigated at diverse levels: for example, individual, community, organisation or ecosystem. Which level one chooses for investigation depends on the issue or question of interest. Conceptually, the simplest level of investigation is individual resilience.

7 Individual resilience

Bonanno's (2004) definition of resilience postulates that resilience is the ability of an individual to maintain healthy psychological and physical well-being despite exposure to adversity. However, there are limitations to this definition in that it does not include the wider community aspects that appear to influence resilience (Masten and Obradovic 2008). Therefore, resilience is better described as "the capacity for successful adaptation, positive functioning or competence despite high-risk status, chronic stress, or following prolonged or severe trauma" (Egeland et al. 1993: 517).

In accord with the above definition, Norris et al. (2008a) further propose 4 indicators of resilience as a manifestation of an individual's adaptation: (1) absence of psychopathology; (2) healthy patterns of behaviour; (3) adequate role functioning at home, school, and/or work; and (4) high quality of life (p. 133). Norris et al. (2008a) stress the quicker one returns to pre-event functioning, the greater one's resilience. Note here the term functioning rather than state. Functioning does not imply return to status quo but rather healthy functioning which may be different from pre-stressor functioning but is none the less adaptive.

In consideration of temporal aspects, Bonanno (2004) differentiated between recovery and resilience trajectories in relation to individual resilience. The former involves a period of dysfunction lasting several months or more, followed by a gradual return to pre-event functioning. Resilience, on the other hand, may involve transient disturbances, lasting as long as several weeks, but generally involves a stable trajectory of healthy functioning. Individual resilience is often regarded as a personality trait, such as "hardiness" (Kobasa 1982) or "sense of coherence" (Antonovsky 1987). As a personality trait, resilience includes factors such as the will to live, perception of a situation as challenging, sense of commitment and control, sense of meaning, self-efficacy and learned resourcefulness (Antonovsky 1987; Kobasa 1982). In addition to personal traits, social relations, such as social support, warmth and caring, have been empirically identified as crucial to the ability to cope with stressors (Cicchetti and Garmezy 1993; Cowen et al. 1995). These findings are somewhat similar to results found in studies that focus on resilient families (Walsh 1998).

Resilience within an individual is also believed to be a process rather than a steady state (for example, Winkworth et al. 2009), with a person's level of resilience potentially varying over their lifetime (Hegney et al. 2007). Polk (1997) emphasises the psychological growth which occurs as a result of living through adversity and which is available to the individual when future stressors are encountered. Similarly, Aldwin (2007), whose work originates from studies into stress, adaptation and coping, identifies the concept of resilience as appearing to be more than stoicism or survival; it assumes post-stress growth. This dynamic aspect of resilience, i.e., the interaction with the environment and the variation

over the lifespan, has regularly been highlighted (Garmezy and Rutter 1983; Connor and Davidson 2003) but rarely researched (Masten and Obradovic 2008). Gillespie et al. (2007) conducted a concept analysis study of resilience which led them to argue that resilience is the process of struggle against hardship that can be learned at any age. This presents the notion of the concept as an acquired skill, one that Masten and Obradovic (2006) argue is likely to be complex. For them, it is not a single trait or process, but a "complex family of concepts" (p. 22). Masten and Obradovic (2008) further describe several adaptive patterns to acute-onset disasters including resistance, positive transformation from various starting levels of adaptive functioning and normal response and recovery. Independently, Gillespie et al. (2007) postulated that the constructs of self-efficacy, hope and coping are defining attributes of resilience. It is likely therefore that resilience is a dynamic process that develops in individuals with the capacity to adapt and learn in response to a range of stressors over a period of time, allowing them to regain and maintain healthy functioning.

In an historical review of the construct, Tusaie and Dyer (2004) concluded that factors found to be influential in the development of resilience could be divided into intrapersonal and environmental factors. Factors that were intrapersonal included cognitive factors (intelligence, optimism, creativity, humour and a belief in one's self) and competencies (coping strategies, social skills, above average memory and educational abilities). Environmental factors included perceived social support. The authors also emphasise the importance of recognising the dynamic, interactive nature of resilience and the interplay between an individual and their broader environment. An important thing to note is that such an interplay is important for resilience as a *trait* and resilience as a *process.* Luthar and Cicchetti (2000) emphasise that the challenge for resilience researchers is to identify the underlying mechanisms or processes of resilience and to ensure that resilience-enhancing interventions are soundly based on both theory and prior research findings. To do so, they contend resilience researchers must first empirically identify protective factors from *multiple levels of influence* (community, family and individual) which might mitigate the negative effects of adverse life circumstances. In such an endeavour, Bonanno and Mancini (2008) reviewed the available evidence on factors that predict resilience to traumatic events such as natural disasters and found they included a variety of person-centred variables (e.g. temperament of the child, coping strategies), demographic variables (e.g. male gender, older age, greater education) and socio-contextual factors (e.g. supportive relations, community resources). Thus, the development of individual resilience is thought to be based on the synergy between individuals and their environments and experiences.

Empirical evidence to support the above proposals is patchy. The measurement of an individual's resilience is rather difficult because of variations in the definitions used in studies, variations in age groups and contexts studied and the preponderance of qualitative studies examining resilience (Atkinson et al. 2009). However, the extensive literature on resilience has identified a consistent set of findings about the elements that comprise resilience (Masten and Obradovic 2006). Concept analysis of resilience research by Polk (1997) isolated dispositional, relational, situational and philosophical factors significant for resilience. These include good health, intelligence, easy-going temperament, sociability, self-efficacy, confidence, optimism, hope, social support, problem-solving ability, an internal locus of control, appraisal skills, flexibility in goal setting and the ability to mobilise available resources. Combinations of these factors have been found to be instrumental in promoting positive trajectories in children who have been abused or neglected, in patients diagnosed with coronary artery disease and in populations exposed to war, trauma or terrorism in relation to post-traumatic stress disorder (Atkinson et al. 2009). For resilience to disasters, Norris and Stevens (2007) similarly endorse these ideas but with

a caveat that economic resilience, in terms of physical capital, employment opportunities and health services, is necessary to support individual's resilience. Their contentions are given credence by recent longitudinal evidence from research on Hurricane Katrina survivors. Children's resilience was promoted by a number of environmental factors including stable housing, family connectedness, economic stability, school, friends and safe neighbourhoods (Kronenberg et al. 2010).

8 Community resilience to disasters

In contrast to individual resilience, community resilience is described differently in various studies and defined more loosely (Kulig 2000). Moreover, there is limited empirical data about community resilience. In general, the descriptions of community resilience take three different forms: (a) resistance, which refers to the ability of a community to absorb perturbation (Geis 2000); (b) recovery, which focuses on the speed and ability to recover from the stressors (Adger 2000; Breton 2001; Paton and Johnston 2001) and (c) creativity, which addresses the ability of a social system to maintain a constant process of creating and recreating, so that the community not only responds to adversity, but in doing so, reaches a higher level of functioning (Kulig 1996; Kulig and Hanson 1996).

Adger (2000) defines social or community resilience as the ability of communities to withstand external shocks to their social infrastructure. Social resilience like 'individual resilience' must take into account the economic, institutional, social and ecological dimensions of a community (Adger 2000). Community (social) resilience is clearly related to population and its stability. *As such, it is also linked to individual resilience.* Population movement can be evidence of instability, or the converse, depending on the type of migration. In the face of significant external stress such as a natural disaster impact, population displacement is often an indicator of the breakdown of community social resilience and is influenced by economic, social and demographic factors (Adger 2000). However, migration positively selects population characteristics (Lee 1966) such that loss from a community of impact might be a gain to the destination location.

As a result of a wide ranging literature review about community resilience to disasters, Norris et al. (2008b) assert that community resilience is also a process. Their investigations excluded chronic environmental disasters such as drought, because the way such stressors unfold over time is different enough to warrant boundaries of the potential applicability of theory and research. They argue that community resilience understanding applies equally well to most types of collective stressors and adversities because the data informing their proposal were gathered from various types of stressors and fields of study. They also cite evidence that disaster location (developed country, developing country) is a stronger predictor of sample-level effects than either disaster type or sample type (child, adult, rescue/recovery) (in Norris et al.'s (2002a, b) empirical review). They describe two approaches evident in the literature of community resilience: (1) community resilience that prevents disaster-related health or mental health problems of community members and (2) community resilience as it applies to effective organisational behaviour and disaster management. Norris et al. (2008a) concluded that community resilience involves a set of adaptive capacities and is a strategy for promoting effective disaster readiness and response, views endorsed earlier by Berkes (2007) and O'Brien et al. (2006). *The key idea is that community resilience then is promoted through adaptive capacity enacted by individuals* (San Juan Guillen 2011; Walsh 2007) *who form various organisations that become mobilised in response to a disaster* (King 2007).

These views are implicit in Colten et al. (2008) paper. In the wake of Hurricane Katrina, Colten et al. (2008) uphold the definition of community resilience that the federal program Community and Regional Resilience Initiative (CARRI) formulated: "a community or region's capability to prepare for, respond to and recover from significant multi disaster threats with minimum damage to public safety and health, the economy and national security" (p. 38). They emphasise that this goes beyond infrastructure to include an individual's capacity to respond and remain resilient, as Godschalk (2003) stresses: "Building a disaster resilient city goes beyond changing land use and physical facilities. It must also build the capacity of the multiple involved communities to anticipate and respond to disasters" (p. 140). Following the lessons learnt from Katrina, Colten et al. (2008) describe resilient communities as those that have: integrated emergency institutions and communications; formal disaster plans; trained emergency responders; a reserve of personnel, material and financial resources; public education and information about risks and potential disasters and long-term planning for recovery and vulnerability reduction. One of the crucial elements of community resilience Colten et al. (2008) emphasise is a built environment infrastructure that is capable of withstanding the assault of severe weather disasters and the availability of enough safe neighbourhood refuge shelters in the form of public buildings such as schools, community halls and public civic centres. Adding another layer, Prosser and Peters (2010) argue that a disaster resilient community is "…one that… is also aware of the responsibility of all levels of government" (p. 11).

Another conceptualisation of community resilience is proposed by Zhou et al. (2010). They developed a spatial/temporal/attribute model for community resilience that draws on geographic principles. They claim that using this model, local resiliency with regard to disasters means that a locale is able to withstand a natural disaster without suffering devastating losses, damage, diminished productivity, or quality of life and, importantly, without much assistance from outside the community. They define disaster resilience as "the capacity of hazard-affected bodies (HABs) to resist loss during disaster and to regenerate and reorganise after disaster in a specific area in a given period" (p. 28).

To assess whether community resilience definitions are accurate, ways of measuring community resilience must be available. Community or social resilience can be assessed at the macro, sociological level through proxy indicators, such as institutional change, economic structure and demographic change. Economic growth, stability of livelihoods and equitable distribution of income and assets within populations are all proxy measures of community resilience. Because of interdependencies at the macroeconomic level, economic resilience depends not only on the capacities of individual businesses but also on the capacities of all the entities that depend on them and on which they depend thus involving an ecological conceptualisation (Rose 2004). The temporal scale of recovery is also important since disasters can have long-term economic ramifications which can lead to a delayed economic recovery, as has been the case with New Orleans which did not fully recover from the 1965 Hurricane Betsy and might not fully recover from Katrina (Hallegatte et al. 2011). Not only is the volume of economic resources important to economic resilience but also their diversity. Dependency on a narrow range of natural resources can increase variance in income across a community and decrease community resilience (Adger 2000; Zhou et al. 2010). Extreme events, such as droughts, floods or infestations, increase the risk of being dependent on particular resources and therefore decrease resilience. In addition, economic resilience is critical for supporting individuals' psychological resilience because mental health issues related to disaster experiences require formal ongoing support available where there are sufficient economic community resources (Norris and Stevens 2007). Formal sector employment, recorded crime rates and

demographic factors as well as mobility and migration can also be used to provide a sense of social or community resilience (Adger 2000).

In considering the measurement of resilience, two matters emerge: (a) Recovery: how well do people and entities recover fully from challenge (Masten 2001; Rutter 1987)? People who are resilient display a greater capacity to quickly regain equilibrium physiologically, psychologically and socially following stressful events, thus also supporting community resilience; (b) Sustainability: the capacity to continue forward in the face of adversity (Bonanno 2004), which is a particularly important aspect of community resilience especially in the face of climate change-induced natural disasters. To probe this aspect of resilience, we need to know how well people sustain health and meaningful positive engagement within a dynamic and challenging environment. Healthy communities confer a capacity for resilience to their constituents. Others propose community resilience is best assessed by applying ecological principles to the analysis of social systems in terms of these two defining features of resilience: recovery and sustainability (Zautra et al. 2008; Gunderson 2010).

There is a challenge in relating individual and community resilience because the existing models are from either the psychological or sociological perspective, but without an integration of the two. Bronfenbrenner's theory offers a suitable lens through which to measure resilience because it has the potential to link the micro-individual level to the macro-social/ecological by permitting a modelling of influences on developing resilience.

9 Bronfenbrenner's bioecological theory of development and resilience

Bronfenbrenner's bioecological systems theory (1979, 1989, 2005) is useful for organising factors that enhance individual resilience because each factor can be placed around an individual according to the proximity of the factor in relation to the individual's ecosystem. Using this framework, we can evaluate effectiveness of within person characteristics, such as adaptive coping, self-efficacy and optimism, as well as factors external to the person, such as family support, neighbourhood networks, health provision, government financial support and so on for promoting individual resilience.

Resilience, like development, is said to arise from processes of interaction across multiple levels of functioning, e.g., from genes to neural systems to relationships to individual-media interaction (Masten and Obradovic 2007, 2008). Further, a living system must maintain its own functioning or equilibrium and also adapt to environmental conditions. The individual is continually interacting with people, objects, information and other aspects of the unfolding contexts in which the individual's life is embedded.

Bronfenbrenner's development model is based on the hypothesis that one's well-being is influenced by social context and the function and quality of relationships one has with others such as family, neighbours and institutional systems (Bronfenbrenner 1979, 1989, 2005; Sun and Stewart 2007). Figure 1 shows a conceptual summary of the model, indicating the different levels of influence, or proximal processes, Bronfenbrenner proposed would impact upon an individual. The individual is thought to develop in a way that is reflective of their interactions within their environment or social contexts (Bronfenbrenner 1979, 1989, 2005; Bronfenbrenner and Ceci 1994).

Bronfenbrenner structures an individual's social context into five areas (Bronfenbrenner 1989):

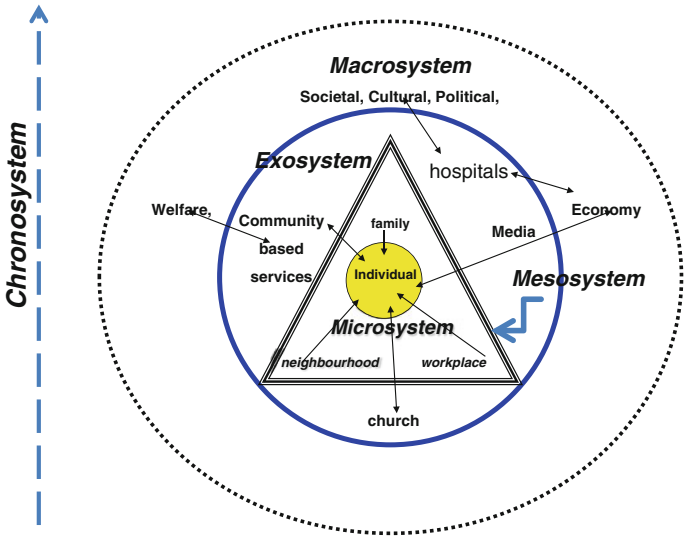

Fig. 1 Conceptual scheme of Bronfenbrenner's systems and their interactions (Diagram constructed by authors to illustrate Bronfenbrenner's theory)

(a) Microsystem—where the individual participates directly.
(b) Mesosystem—where members from different microsystems interact with each other independent of the central individual.
(c) Exosystem—entities and organisations that might be accessed by the individual or their family.
(d) Macrosystem—the politics, views and customs that represent the cultural fabric of the individuals' society.
(e) Chronosystem—time as it relates to events in the individual's environment.

The processes and experiences that the individual is exposed to either directly or through proximal interactions with the various systems above are thought to interact with their genetic predispositions to structure their perceptions and responses, their behaviours, their adaptation, coping with stress and resilience (Bronfenbrenner and Ceci 1994).

In Bronfenbrenner's model, the individual interacts directly with people, ideas and things in his or her microsystem, which include family, peers and school systems.

Development is also subject to the next level, the mesosystem. This describes how the different parts of an individual's microsystem work together. This represents the interconnections or lack thereof, between the individual's microsystems; connections between home and work or school, for example, or between home and friends/peers.

The exosystem level includes the other people and places where an individual may not interact with often but that still have a large effect on her, such as spouse's workplaces, extended family members, the neighbourhood, etc. For example, if an extended family member gets laid off from work, this may have negative spillover effects.

Bronfenbrenner's final level is the macrosystem. This is located furthest from the individual and is the largest, most remote set of people and structures/organisations which have a great influence over the person. The macrosystem includes things such as the relative freedoms permitted by the national government, cultural values, the economy, wars, etc. These things can also affect resilience either positively or negatively.

Macrosystem factors such as type of government, media, cultural biases and mores and religions do have a functional presence in the expectations, values, hopes, training and knowledge that individuals and local families in communities carry with them all the time, particularly in their memories and know-how which can facilitate the process of resilience (Masten and Obradovic 2007, 2008). It is at the macrosystem level that policy and planning take place which affect individuals and communities.

An ecological understanding of human development and resilience requires an examination of the influence of community, subculture and culture on basic psychological and interpersonal processes throughout the lifespan. The extent to which interpersonal and psychological processes facilitate adaptive, positive development varies with relational, familial, social and cultural contexts and includes bidirectional processes of influence between contexts and the individual. For Bronfenbrenner (1979), the environment (e.g. home, work, community, state, nation) where an individual is located is conceived of as "a set of nested structures, each inside the next, like a set of Russian dolls" (p. 3). Others concur with his proposal.

10 Bronfenbrenner's bioecological theory for assessing resilience to a natural disaster

In discussing *emergency and disaster risk management planning for the promotion of community resilience to disasters,* Cottrell and King (2010) argue for a need to take into consideration community factors that yield a picture of the community at micro, individual-level characteristics of citizens such as psychological and demographic descriptors, as well as macro and community level characteristics which might include economic, infrastructure, environmental and social infrastructure indicators. They recognise that support for resilience to disaster can be conferred from any level in a geographical community and therefore propose that data are gathered to plan for effective interventions and post-event impact assessments. They invoke a model that parallels Bronfenbrenner's bioecological framework closely.

Keim (2008) concurs urging effective preparation for and response to the increasing threat of natural disasters require integration of resilience factors across interdependent systems and across scales. Because adaptation must occur at the community level, local public health agencies are important organisations to build human resilience to natural disasters (Keim 2008). Illustrating the importance of this Rodríguez and Aguirre (2006) focused on how hospitals prepared for, responded to and coped with Hurricane Katrina, USA. Katrina magnified the existing problems and deficiencies of the health system and disrupted the external systems supplying hospitals with key services and resources needed for the organisations to function, increased the number of patients that required medical care and directly affected the physical plants of the hospitals, challenging their functionality. Recognising that an effective health care system is highly implicated in disaster resilience at both individual and community levels, Rodríguez and Aguirre (2006) concluded that planning, access to adequate resources, networking, effective communication and coordination, and training and education of medical staff are essential for the development of infrastructure that will be able to provide the critical services to populations affected by future disasters. Bronfenbrenner's chronosystem can also be used to assess and model sustainability, an integral part of resilience in the form of economic adaptive capacity (Hallegatte et al. 2011). The use of models like Bronfenbrenner's is helpful for the purpose of such planning (Masten and Obradovic 2007, 2008). Harney (2007) also argues

for Bronfenbrenner's framework, emphasising that it can highlight the interrelationships between individuals and the contexts in which they reside, their communities and the reciprocal interactive processes occurring between macro- and micro-level contexts. Mesosystem effects manifest in within-level social networks, and important for forging resilience (Moore and Westley 2011) can also be assessed and modelled. In sum, it is very probable that community resilience and individual resilience are interdependent and mutually supportive and thus best examined using a theoretical model such as Bronfenbrenner's.

11 Measuring resilience: theoretical considerations and the interconnectedness of individual and community resilience

Bronfenbrenner's model can be used to measure the influences of discrete entities/organizations/policies upon either individual or community resilience because it can organise their effects into direct or indirect influences by virtue of their position within the model's spatiotemporal ordering. In this way, the question of resilience of what and to what (Carpenter et al. 2001) can be addressed, and the effects of culture, both historical and contemporary, (Clauss-Ehlers 2008; Clauss-Ehlers and Lopez-Levi 2002) can be modelled and quantified.

Scalar and temporal issues have permeated resilience research (Cutter et al. 2008; Hallegatte et al. 2011; Nelson et al. 2007). Questions of how to translate models and data between scales and how to characterise the relationships of different components and domains across time and space are critical to the ability to develop assessment tools and to model and quantify change and impacts. For example, at the individual level, issues of livelihood come into play, yet at the regional scale, the Gross Domestic Product (GDP) is often used as an indicator of resilience (Pelling 2003). Sudden disasters, hurricanes/cyclones, require an immediate response and time for modification in behaviours and practices in the preparedness (pre-event) or post-event (mitigation) phases. Indicators of resilience to such rapid onset events could be community evacuation plans, clear and trusted communication systems, or mandated mitigation such as storm shutters. Disasters that manifest over time, such as climate change, sea level rise, drought and famine, paired with less definitive spatial patterns, sometimes also referred to as "pressures" (Cutter et al. 2008), lead to resilience indicators based on adaptive capacity concepts. This is because slow onset events allow an individual or community the opportunity to modify practices to reduce the impact of a disaster as the disaster develops. Indicators of resilience to climate change threat might include, for example, conversion to drought-resistant crop species, water conservation and so on. Nelson et al. (2007) maintain adaptive capacity is specific to "(a) the length and frequency of perturbations, (b) the spatial scale at which perturbations occur, and (c) the organisational scale of focus. Therefore, the scale at which adaptive capacity is analysed has implications for evaluating resilience" (p. 406). The type of resilience we want to assess necessitates a particular scale of measure. For example, Nelson et al. (2007) cite that community adaptation to drought in northeast Brazil entailed livelihood diversification and agricultural risk management practices by individuals and action on a community scale by putting into place irrigation scheme projects by government groups.

Such considerations present the issue of what methods are best suited for the assessment of resilience. Flint and Luloff (2005) suggest a mixed methods approach to investigating resilience and the adaptive capacity that supports it. Powell (1999) and Klein et al. (2003) view qualitative methods in a favourable light since fine-grained data are needed to identify

issues of importance. Powell (1999) and AHPRC (1999) suggest that qualitative methods at the local level are what will develop more relevant understandings of change in a given context. Change is better understood and communicated when it is quantified, necessitating the use of indicators to measure resilience.

Suitable indicators can be selected from information about the population (in the case of socio-economic indicators), developed from either primary (e.g. questionnaires) or secondary (e.g. census) data sources. Since indicators are derived from societal characteristics, because they describe an idea, construct, theory or model about an aspect of society, the use of indicators must stem from qualitative data and a sound theoretical model or construct that is to be examined (King 2001; King and MacGregor 2000; Zautra et al. 2008). In addition, a clear understanding of whether an indicator is causal or associative is needed, particularly when assessing the predictive potential of theoretical models like Bronfenbrenner's. Key to these matters is temporal issues related to the nature of indicator and sampling techniques. Longitudinal data are always preferable to cross-sectional data for the purpose of prediction and direction of causality. A more thorough depiction of community resilience therefore requires a mix of strategies (Cottrell and King 2010) and also a sound theoretical model (Zautra et al. 2008). These considerations point to the salience of Bronfenbrenner's model for measuring resilience at both individual and community levels.

Several researchers have attempted to measure resilience. Cutter et al. (2008) used a theoretical model (DROP: disaster resilience of place) to select indicators to measure community resilience. These indicators were based on different types of resilience thought to contribute to overall community resilience and required different forms of measurement. The types of resilience that Cutter et al. (2008) proposed that would act in concert to produce a resilient community of place were: ecological (e.g. biodiversity, governance and management plans; social (e.g. communications, risk awareness, and preparedness, disaster plans, the purchase of insurance—some of these depend on the demographics of the community); economic (e.g. measures of property loss and the effects of business disruption post-event); organisational, including institutions and organisations (e.g. assessments of the physical properties of the organisations such as number of members, communications technology, number of emergency assets such as vehicles, hospital beds, and measures of organisational response to disasters such as leadership); infrastructure (e.g. physical systems themselves such as the number of pipelines, exit/delivery road miles); and community competence (e.g. local understanding of risk, counselling services, mental health, quality of life and emotional health). Glavovic et al. (2010) endorse these, adding that governments need to mainstream climate change adaptation, suggesting an additional level of measurement.

Following a rationale previously highlighted (e.g. Bruneau et al. 2003); Cutter et al. (2010) selected a set of indicators to measuring baseline levels of community resilience. These indicators previously identified as supporting community resilience, are based on social, economic, institutional, infrastructural, ecological and community elements. Their rationale stems from the sound notion that by establishing baseline conditions, it is easier to monitor changes in resilience over time in particular places and to compare one place to another. Their selection of variables was based on empirical justification of the variable's relevance to resilience in the US, and on the availability of consistent quality data from national data sources, but this approach is also relevant to disaster-struck areas in less developed countries which lack relevant and up to date pre-disaster information to help to quickly assess the type and extent of damage, especially in populated places.

It is important to note that Cutter et al's (2010) assessment framework while comprehensive did not include ecological measures which underpin sustainable agricultural

practices and livelihoods (Zhou et al. 2010) that have flow on effects to the whole community or perceptions of quality of life known to influence individual resilience (Zautra and Bachrach 2000). It could be argued that the impact of ecological variables upon the local economy is indirectly accounted for in their model through their assessment of economic resilience by the measure: single sector employment dependence. The gap in quality of life perception measures, however, is problematic because it is conceivable that there are cases of wealthy, highly organised and disaster protected communities some of whose residents nonetheless suffer mental health consequences from the impact of a disaster such as a cyclone, or other sudden or gradual impact event. All the variables Cutter et al. (2010) use are macro-level measures, based on community scale measures. As such, they do not give any indication of individual resilience within a community, a factor critical for community preparedness and recovery post-disaster, ultimately supporting community resilience. Most agree (e.g. Nelson et al. 2007; Stewart et al. 2009; Zhou et al. 2010) that resilient communities integrate the adaptive capabilities of relevant stakeholders to manage the impacts of a disaster to create a positive trajectory of functioning and adaptation. Relevant stakeholders are private and public organisations and infrastructure and their management which might operate at local, state and federal levels (Berkes 2007). It follows that if the nodes of action, the individuals, are not resilient themselves, then processes leading to resilience will be slower, if not stalled. Conversely, Norris et al. (2008a) argue "a collection of resilient individuals does not guarantee a resilient community" (p. 128).

These conceptualisations fit in well with Adger's (2000) notions of community resilience. Further, since Norris et al. (2008a) sum the basis of a resilient community as being "manifest in population wellness, defined as high and non-disparate levels of mental and behavioural health, functioning, and quality of life" (p. 3) characteristics aggregated at population level from individual resilience. Thus, if individual community members do not contribute to community competence via resilient functioning at individual and family level, then infrastructure, social, economic, institutional and even ecological dimensions of community will be less able to buffer disasters and stressors. On the other hand, it is important to augment the social resilience of communities with economic resilience because the economic systems will provide the resources to adapt and act in ways that remedy the impact of the disaster (Pfefferbaum et al. 2005). The key message here is that economic community resilience and resources can help support individuals' resilience (mental health, quality of life perceptions and collective self-efficacy) but individual resilience alone is not sufficient to promote community resilience if the infrastructures, governance and economic underpinning of communities are not present.

12 Issues arising from attempts to measure individual and community resilience

The indicators and scale used to measure community resilience need to be carefully considered to avoid contradictory results. For example, researchers constructed inventories to examine individual's perceptions of their own health and well-being (Andrews and Withey 1976; Campbell and Converse 1972). In these efforts, individuals were asked to rate their well-being and life satisfaction. Interestingly, this work exposed distinct differences between perceptions of quality of life as defined by the subject in contrast to those defined by social indicators. The disconnect between the two sets of findings suggests the

need to incorporate ways of estimating both the social and psychological well-being of individuals with community indicators.

The effective measurement of community resilience requires the assessment of social networks. The ability of a geographical community to survive a disaster depends on the size of social networks in its neighbourhoods and on the interconnection between the social networks (Wallace and Wallace 2008). Without other forms of social control, for example, even the highest level of policing would not be able to keep violent crime rates low. Even very high levels of public health activity would be unable to keep diseases in check without the support of the social fabric of neighbourhoods. Most importantly, social networks play key roles in disasters to pick up the pieces and save families and the community. The neighbourhood forms a critical level of organisation between the individual or family level and the municipality and metropolitan region (Wallace and Wallace 2008).

To illustrate this, Zautra et al. (2008) compiled a list of attributes and processes necessary for resilient communities of geographic location derived from a range of research studies. They describe resilient communities as having: neighbours that trust one another and interact on a regular basis, residents who own their houses, remain in the area for a length of time, have a sense of community and cohesion and work together for the common good with involvement in community events and affairs and place which also have formal and informal civic spaces for gathering.

When assessing community resilience, therefore there is a need to include indicators at diverse scales of measurement, perhaps by triangulating community level indicators from the perspective of stakeholders with those emanating from the perspective of individual citizens. A research design based on Bronfenbrenner's model is therefore useful.

13 Indicators

The search for suitable indicators needs to be confined to those pertaining to disaster resilience of a community. Several types of resilience are distinguished in the literature requiring different forms of measurement and temporal scales, depending on whether they pertain to ecological, social, economic, infrastructure or institutional resilience and community competence (Cutter et al. 2008).

> "The conditions defining resilience are dynamic and ultimately change with differences in spatial, social, and temporal scales. A community may be deemed resilient to environmental disasters at one time scale (e.g. short-term phenomena such as severe weather) due to mitigation measures that have been adopted but not another (e.g. long term such as climate change)." (Cutter et al. 2008: 603)

The selection of indicators will depend on the scale chosen for measurement, individual or community. Indicators should also include cultural, demographic, psychological as well as socio-contextual factors. Given that individual and community resilience appear to be interconnected, a theoretical model like Bronfenbrenner's capable of incorporating analyses of individual and community indicators is preferable.

14 Use of Bronfenbrenner's theoretical model to assess disaster resilience

A number of researchers have cited support for using Bronfenbrenner's theoretical lens in the study of resilience. Kiter Edwards (1998) argued for the use of Bronfenbrenner's theory

in examining psychological resilience to disaster because family processes and characteristics as well as particular features of the disaster event can be incorporated into the model and their impact assessed. Measures like suddenness of impact, duration of the event, degree of climatic discomfort or evacuation shelter conditions, perception of future risk of the disaster and the like can be incorporated into the assessment of resilience via this model.

Masten and Obradovic (2007, 2008), Sun and Stewart (2007), Mowbray et al. (2007), Bürgin and Steck (2008) and Swick and Williams (2006) emphasise the linkages between the individual and family to the larger social environment of neighbourhood entities such as the school and the neighbourhood social network and how they influence individual resilience and family function. Tummala-Narra (2007) stresses that for many ethnic minorities, notions of resilience shaped largely by middle class European and North American values may not capture positive adaptation to adverse and traumatic experience that is culturally recognised and understood. Therefore, to study responses to trauma of those from different ethnic groups, Bronfenbrenner's model offers a more complete framework of interpretation. This is an important point in the endeavour to understand resilience.

In describing psychological trauma, trauma recovery and resilience, Harvey (1996, 2007) stressed the relevance of the ecological tenets of community psychology to the study and promotion of resilience emphasising the interdependence of person and context. Bates and Pelanda (1994) argued for ecological models in the interdisciplinary study of disasters and mental health because they acknowledge the interplay of forces that influence individual stress and coping, human behaviour being an integrated negotiated response to individuals, families, organisations and institutions that exist within a constantly changing physical environment (Kiter Edwards 1998; Waller 2001). In disaster situations, for example, disaster victims may have to negotiate harsh weather conditions (extreme exposure to heat or cold), health hazards (toxins, disease, wounds) and crowded or otherwise inadequate living conditions. More detrimental effects on well-being, even fatalities, may occur for events that have no warning phase because people do not have time to prepare for the impact, as in the recent flash flooding that occurred in Toowoomba, Queensland, Australia.

Berger (2005) used Bronfenbrenner's framework to develop an application to build community resilience and reduce trauma in disaster-affected individuals. Berger (2005) concluded that adopting a multi-systemic approach was effective, not only in dealing with individuals and families, but also in changing the mood and functioning of the community. Ager et al. (2010), Kumpfer and Summerhays (2006), Landau (2007), Mertensmeyer and Fine (2000) and Ungar (2010) cite similar theoretical frameworks for assessing, initiating and sustaining change in traumatised individuals and families.

At a different level, Stewart et al. (2009) discuss the interrelationships between public and private organisations to support community resilience and described a model of interaction that parallels Bronfenbrenner's framework. Community resilience is embedded within its economic and social systems. While each citizen, private sector firm and public sector entity is challenged individually to be resilient, their efforts need to be coordinated to function and adapt to the consequences of disasters. For a response to a disaster to be adequate for community recovery and resilience, urgent decision-making needs to bring public and private sectors together to collaborate at the local, state and federal levels. As such, this invokes the role played by politics (a macrosystem issue) as well as the roles played by exosystem and mesosystem organisations to promote the resilience process. The response to disasters begins at the local level and must become a local/state level event

before garnering the resources of the federal government. Stewart et al. (2009) describe how private–public interaction can vary relative to government levels. First, federal agencies should typically interact with industry associations or large firms which have a national presence. Second, state-level agencies should interact with industry associations that are important to the state's economy and firms which have the capacity to respond to regional level disasters. Third, local-level governments should interact with local and/or regional companies to build resilience within supply chains that have a vested interest in the local community. Problems might arise if these interactions are not taking place.

15 An example of how Bronfenbrenner's theory can be used to measure community resilience to a natural disaster

A hypothetical application of Bronfenbrenner's theory to assess community resilience is shown in Table 1. This application uses empirically derived indicators/themes from prior studies about community resilience (e.g. Cutter et al. 2008, 2010; Murphy 2007) and is not specific to a context or disaster type. However, in a real setting, context-specific indicators would be applied.

Community resilience can be assessed using the model via a two-step, longitudinal research design. It is assumed and desirable that baseline levels of community indicators would be available, as suggested by Cutter et al. (2010). Step 1, a macro-sociological perspective would involve population-scale, cross-sectional measures obtained over a period of time, using Bronfenbrenner's chronosystem to quantify changes in community resilience levels within and across the various ecosystems described by the theory. Step 2, a quality of life, psychological perspective on an individual scale, would involve randomised sampling of community members. This would assess their levels of preparedness, risk perceptions, knowledge, self-efficacy, coping mechanisms, resilience and their use and evaluation of microsystem, mesosystem, exosystem and macrosystem support, organisations and functionality in relation to pre- and post-disaster times. This could provide additional measures for the purpose of triangulating community resilience levels and identifying the most effective and efficient interventions for the support of individual resilience. Community and individual resilience could thus be more effectively connected and assessed.

To illustrate an application of the model, Table 2 has incorporated many of the principal population and community characteristics and issues of resilience that emerged from qualitative research carried out in Beechworth, Victoria, and Innisfail and Ingham in north Queensland following discrete disaster events. Inevitably, the table has to simplify a diverse and complex range of issues, but it provides an extremely useful summary of quite different events and communities that enable identification of themes of resilience. In the case of Beechworth, the events have been compressed, although the experience of the 2003 bushfires was different to that of the much greater 2009 disaster. Similarly with Ingham, there have been a number of floods in successive years. The chronosystem has also been simplified in this table into just the response and recovery periods, when in fact there is a preparedness period that precedes the event, and several stages in the recovery phase, although all of these vary considerably in time and level of impact for different individuals, families and sectors of the community. These issues of complexity, and the identification of them in the community research process, form part of our understanding of resilience and can be subdivided as categories within each of the sectors of the model.

Table 1 Community resilience assessment using Bronfenbrenner's bioecological theory

Ecosystem	Chronosystem	Core community and member characteristics	Community microsystems	Community mesosystem	Exosystem	Macrosystem
Measure/ quantification	Chosen time scale	(Census data/other local government data bases)	Number and functionality of entities	Number of entities/membership of entities/functionality of entities	Functionality and/or funds and services dispensed	Response time/ flexibility/funds dispensed
Time 1 Pre-disaster	Year X	Workforce participation Employment rates Hospitalisation rates Crime rates Demographics Economic diversity Built environment assessment	Educational organisations Health provision organisations Parks, recreational and physical facilities Religious organisations Entertainment venues and facilities Local government	Communication networks Volunteer networks Local transport facilities Sporting and social networks Disaster preparedness programs/ education	Social services Insurance providers Disaster relief funds Energy and communication providers Media Charities Adjunct disaster relief (armed forces) State Emergency Services Rail, Air and Sea transport services Postal services	Welfare system Political will Federal responsiveness
Time 2 Response phase	Year Y	Repeat as above				
Time 3 Post-disaster	Year Z	Repeat as above				

Table 2 Community resilience assessment of disaster events using Bronfenbrenner's structures: issues and characteristics that indicate resilience strengths and weaknesses

Ecosystem/ disaster event	Chronosystem	Core community and member characteristics	Community microsystems	Community mesosystem	Exosystem	Macrosystem
Beechworth Bushfires 2009/2003	2009 & 2003 Response, behaviour & capacity during the event	Deaths. Evacuation Self sufficiency Capacity to defend Newcomers—lack of experience	Warnings & preparation Evacuation Care of family & friends Sense of confusion Business & financial loss	CFA Neighbourliness Word of mouth Sense of community Phone systems Business impact Community transport	Relief centres CFA Insurance ABC Emergency management agencies State govt. departments	
	Recovery period	Women's strength Health Ability to process the event Stress & coping Grief—loss of life Loss of property Newcomers & tourists Old people & kids Experience—length of residence Keeping busy	Outmigration Slow immigration Business slow Fire-fighters Tree-changers Community spirit Local knowledge Climate change consideration	Networks Networks & community communications Local shops Mutual help Leadership Climate change scepticism	Dept. of community services Volunteers Mental health issues DPI, BoM Relief centres VBAF & red cross Bushfire youth recovery program State govt. programs	Legislative change Royal commission VBAF Women in power Generosity Govt. ability to cut red tape

Table 2 continued

Ecosystem/ disaster event	Chronosystem	Core community and member characteristics	Community microsystems	Community mesosystem	Exosystem	Macrosystem
Ingham Floods 2009	2009 Response, behaviour & capacity during the event	Country town demographics Newcomer vulnerability Flood vulnerability of low S-E group Women more resilient Young male irresponsibility Ethnic group and indigenous resilience Young indigenous men's vulnerability Disempowerment feelings	Warnings Observation & local knowledge Strong community spirit	Internet Word of mouth Issues for low S-E groups 2 weeks of impact event Indigenous impacts	BoM	Acceptance of flood Commitment to place
	Recovery period	Women's issues Break in routines Higher workloads Local knowledge Youth resilient	Businesses Local Council Leadership Low S-E groups Sense of place Climate change scepticism	Hinchinbrook Community Support Centre Business impact Transport infrastructure impact	State and federal govt. depts. EMQ NGOs & GROs Financial assistance Loss of infrastructure	Loss of community spirit Lack of LGA support Morale loss

Table 2 continued

Ecosystem/ disaster event	Chronosystem	Core community and member characteristics	Community microsystems	Community mesosystem	Exosystem	Macrosystem
Innisfail Severe cyclone 2006	2006 Response, behaviour & capacity during the event	Country town demographic profile Extended family Humour independence	Extended family Shops & businesses Groups of families	NGOs Businesses Churches	NGOs SES & EMQ	Spirit of resilience Culture of tropical lifestyle
	Recovery period	Family & friends	Assist others in need Volunteers & strangers Business generosity	NGOs & churches Volunteers	Businesses NGOs Prisoners Army LGA & Mayor Counselling services Mental health Children's support State & federal govt. depts. Financial assist	Cosgrove (armed Forces) Community spirit Life style

Some issues/characteristics operated at multiple levels of the model, such as impact on businesses affecting household businesses as well as a broader community impact, and CFA involving household members as well as the community

Source: Focus groups and Key Informant Interviews in each community in 2010/2011

CFA Country Fire Authority, *VBAF* Victorian Bushfire Appeal Fund, *BoM* Bureau of Meteorology, *DPI* Department of Primary Industries, *S-E* Socio-Economic, *SES* State Emergency Services, *EMQ* Emergency Management Queensland

A number of characteristics of households and communities cross over the boundaries of system sectors, because they exist as separate entities in each one. For example, many household economies depended upon a business, such as a trade, a farm or a shop The disaster affected the household directly through the impact on that business (many households in all communities that depended on a business were without income after the disaster, apart from losses to capital equipment and goods, while public servants, for example, continued to receive salaries and in many instances had an increased workload) and affected the community directly through the loss or closure of local businesses. Thus in Table 2, characteristics have been allocated to model sectors according to the context in which they were identified.

There is also limited indication in Table 2 on the extent to which the issue strengthened or weakened resilience. This has been done simply to keep the table as a summary. The research indicated clearly which direction each issue or characteristic influenced resilience; for example, tourists are identified as a group that was poorly prepared for the disaster and newcomers, a group who were both unprepared and less capable of recovering in the contexts where they experienced a disaster.

The resilience indicators that have been identified from the qualitative research in these communities and the disasters that affected them complement the literature on resilience discussed above. Bronfenbrenner's model provides a useful tool to disaggregate and to structure a wealth of resilience indicators and issues identified by community members. In the subsequent component of this ongoing research, the issues and characteristics, within the construct of the model, are used to quantify resilience through the use of household surveys that build on those areas that have already been identified and summarised as an illustration in Table 2.

16 Conclusion

Climate change is predicted to influence the severity of natural disasters. Governments and emergency managers are seeking ways to enhance individual and community resilience to such events. Perspectives on resilience include the ability to respond positively to stress or change. Disasters are inherently cross-scale in their impact, disrupting functioning across multiple levels of the interdependent socio-cultural systems where human lives are embedded. Most studies indicate that individual resilience is partly a trait and partly dynamic process and is promoted by two groups of generic factors:

1. personal attributes such as social competence, problem solving, autonomy, self-efficacy and sense of future and purpose and
2. contextual, environmental influences such as peers, family, work, school and local community

Research linking individual to community resilience is very scarce worldwide and non-existent in Australia, especially in relation to predicted climate change disasters. Some studies have examined how individual-level perceptions of community resilience (Pooley et al. 2010), sense of community (Paton 2008) or collective efficacy (Benight 2004) correlate with individual-level resilience, but no study appears to have examined how independently assessed community resources influence the post-disaster resilience of community or individuals and their interdependence. For example, how does the degree of pre-disaster economic diversity of a community affect the resilience of different groups of individuals post-disaster? This is problematic because developmental science and

ecological science perspectives intersect to explain resilience at both individual and community levels (e.g. Cutter et al. 2008; Evans 2011; Masten and Obradovic 2007). Moreover, some studies have identified that an individual's resilience might in fact be a barrier to the development of community level resilience (Li 2009; Sapountzaki 2007). This affects community recovery because of the interdependence of social and economic networks influencing community resilience to disasters (Stewart et al. 2009). Flint and Luloff (2005) have stressed that research must focus on the recovery period post-disaster where there is currently an empirical gap, to understand the interdependence of individual and community resilience and because the response phase may or may not support the community's long-term recovery and resilience.

Bronfenbrenner's bioecological theory (1979, 1989, 2005) provides a suitable framework of analysis to explore resilience at individual and community level because resilience has repeatedly been found to rest on relationships between social and community infrastructure factors (Luthar 2006; Walker and Salt 2006). The use of this framework enables the measure of influences of microsystem, mesosystem, exosystem and macrosytem factors upon an individual's resilience, irrespective of whether it is seen as a trait or as a process. An indication of community resilience can also be obtained through the interconnections of factors across systems, and over time. Results can be used for strategic interventions and policies because the model can indicate where they will have maximum effect to build resilience to future disasters. Further, such a model can be used to evaluate interventions over time in longitudinal studies as well as interventions in diverse types of community, for example, metropolitan areas. An advantage of Bronfenbrenner's theory is it allows influences across, between and within systems to be estimated. In addition such an assessment of community factors upon individual resilience can provide a proxy measure of the strength of those factors in a community. Conversely, Bronfenbrenner's model can be used to organise and measure links between community organisations and institutions and between a community and the larger exosystem/macrosystem to assess economic, material and infrastructure dependences which can determine the community's resilience.

In most published studies of community resilience to disaster, the research design has taken either a sociological, macro perspective or a psychological, micro perspective. Rarely, have the two been used at the same time to triangulate findings. Given the interconnectedness of individual and community resilience, this leaves many questions unanswered. Unresolved issues include: how levels of preparedness affect the response and recovery phases of individuals and communities and subsequently community resilience; how the resilience of vulnerable groups, including the infirm, the elderly, the young, the indigent can be increased; how, when and if, government responses and interventions are necessary to build long-term resilience to climate change-induced disasters; how do different disaster types affect community resilience and what interventions are necessary at individual and community level to support post-disaster functioning and resilience and who decides what should be made resilient to what, for whom resilience is managed, and to what purpose? (Lebel et al. 2006).

Overall then, in assessing community resilience to disaster, we need a multi-method, multi-scale longitudinal approach, that includes baseline pre-disaster, community data. Besides qualitative data, we need indicators from several levels within and beyond a community, including individuals' ratings, and a model such as Bronfenbrenner's to collate, triangulate and interpret findings and gauge the relative strength of relationships within data in order to apply suitable interventions.

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References

Adams AM, Madhavan S, Simon D (2002) Women's social networks and child survival in Mali. Soc Sci Med 54:165–178

Adger WN (2000) Social and ecological resilience; are they related? Prog Hum Geogr 24(3):347–364

Ager A, Stark L, Akesson B, Boothby N (2010) Defining best practice in care and protection of children in crisis-affected settings: a delphi study. Child Dev 81(4):1271–1286

Aldwin CA (2007) Stress, coping, and development: an integrative perspective, 2nd edn. The Guilford Press. ISBN: 1572308400

Allen KM (2006) Community-based disaster preparedness and climate adaptation: local capacity-building in the Philippines. Disasters 30(1):81–101

Andrews FM, Withey SB (1976) Social indicators of wellbeing: Americans' perceptions of life quality. Plenum Press, New York

Antonovsky A (1987) Unravelling the mystery of health. Jossey Bass, San Francisco

Atkinson PA, Martin CR, Rankin J (2009) Resilience revisited. J Psychiatr Ment Health Nurs 16:137–145

Atlanta Health Promotion Research Centre (AHPRC) (1999) A study of resiliency in communities. Report for the office of alcohol, drugs and dependency issues, Health Canada, p 99. http://www.hc-sc-gc.ca/hppb/alcohol-otherdrugs

Batabyal AA (1998) The concept of resilience: retrospect and prospect. Environ Dev Econ 3(2):235–239

Bates FL, Pelanda C (1994) An ecological approach to disasters. In: Dynes RR, Tierney KJ (eds) Disasters: collective behaviour and social organisation. University of Delaware, Newark, pp 145–159

Beall J (2001) From social networks to public action in urban governance: where does benefit accrue? J Int Dev 13:1015–1021

Benight CC (2004) Collective efficacy following a series of natural disasters. Anxiety Stress Coping 17(4):401–420

Berger R (2005) An ecological community-based approach for dealing with traumatic stress: a case of terror attack on a Kibbutz. J Aggress Maltreat Trauma 10(1–2):513–526

Berkes F (2007) Understanding uncertainty and reducing vulnerability: lessons from resilience thinking. Nat Hazards 41:283–295

Berkman LF (2000) Social support, social networks, social cohesion and health. Soc Work Health Care 31:3–14

Blaikie P, Brookfield H (1987) Land degradation and society. Metheun and Company, London

Bonanno GA (2004) Loss, trauma, and human resilience: have we underestimated the human capacity to thrive after extremely aversive events? Am Psychol 59:20–28

Bonanno GA, Mancini AD (2008) The human capacity to thrive in the face of potential trauma. Pediatrics 121(2):369–375

Bosher L, Dainty A, Carrillo P, Glass J, Price A (2009) Attaining improved resilience to floods: a proactive multi-stakeholder approach. Disaster Prev Manag 18(1):9–22

Bosomworth K, Handmer J (2008) Climate change adaptation, disaster risk reduction and a fire management policy framework. Paper presented at the International Bushfire Research Conference, At the Adelaide Convention Centre, Adelaide, 1–3 Sept 2008

Breton M (2001) Neighborhood resiliency. J Community Pract 19(1):21–36

Bronfenbrenner U (1979) The ecology of human development: experiments by nature and design. Harvard University Press, Cambridge

Bronfenbrenner U (1989) Ecological systems theory. Ann Child Dev 6:187–249

Bronfenbrenner U (2005) Making human beings human: bioecological perspectives on human development. Sage, Thousand Oaks

Bronfenbrenner U, Ceci SJ (1994) Nature nurture reconceptualised in developmental perspective: a bio-ecological model. Psychol Rev 101(4):568–586

Bruneau M, Chang SE, Eguchi RT, Lee GC, O'Rourke TD, Reinhorn AM, Shinozuka M, Tierney K, Wallace WA, Von Winterfeldt D (2003) A framework to quantitatively assess and enhance the seismic resilience of communities. Earthq Spectra 19(4):733–752
Bürgin D, Steck B (2008) Resilience in childhood and adolescence [Resilienz im kindes- und jugendalter]. Schweiz Arch Neurol Psychiatr 159(8):480–489
Campbell A, Converse PE (1972) The human meaning of social change. Russell Sage Foundation, New York
Carpenter S, Walker B, Anderies JM, Abel N (2001) From metaphor to measurement: resilience of what to what? Ecosystems 4(8):765–781
Cicchetti K, Garmezy N (1993) Prospects and promises in the study of resilience. Dev Psychopathol 5:597–603
Clauss-Ehlers CS (2008) Sociocultural factors, resilience, and coping: support for a culturally sensitive measure of resilience. J Appl Dev Psychol 29:197–212
Clauss-Ehlers CS, Lopez-Levi L (2002) Violence and community, terms in conflict: an ecological approach to resilience. J Soc Distress Homeless 11(4):265–278
COAG (Council of Australian Governments) (2009) Climate change adaptation action plan. COAG, Canberra
Colten CE, Kates RW, Laska SB (2008) Three years after Katrina: lessons for community resilience. Environment 50(5):36–47
Connor K, Davidson J (2003) Development of a new resilience scale: the Connor Davidson Resilience Scale (CD-RISC). Depress Anxiety 18:76–82
Cottrell A, King D (2010) Social assessment as a complementary tool to hazard risk assessment and disaster planning. Australas J Disaster Trauma Stud 1. ISSN: 1174-4707
Cowen EL, Wyman PA, Work WC, Iker MR (1995) A preventive intervention for enhancing resilience among highly stressed urban children. J Prim Prev 15:247–260
Cutter SL, Barnes L, Berry M, Burton C, Evans E, Tate E, Webb J (2008) A place-based model for understanding community resilience to natural disasters. Glob Environ Change 18:598–606
Cutter SL, Burtony CG, Emrichz CT (2010) Disaster resilience indicators for benchmarking baseline conditions. J Homel Secur Emerg Manag 7(1):1–22 (Article 51)
Egeland B, Carlson E, Sroufe LA (1993) Resilience as process. Dev Psychopathol 5:517–528
Evans JP (2011) Resilience, ecology and adaptation in the experimental city. Trans Inst Br Geogr 36:223–237. doi:10.1111/j.1475-5661.2010.00420.x
Flint CG, Luloff AE (2005) Natural resource-based communities, risk, and disaster: an intersection of theories. Soc Nat Resour 18:399–412
Folke C (2006) Resilience: the emergence of a perspective for social-ecological systems analyses. Glob Environ Change 16:253–267
Folke C, Colding J, Berkes F (2003) Building resilience and adaptive capacity in social-ecological systems. In: Berkes F, Colding J, Folke C (eds) Navigating social-ecological systems. Cambridge University Press, Cambridge, pp 352–387
Fowler JH, Christakis NA (2008) Dynamic spread of happiness in a large social network: longitudinal analysis over 20 years in the Framingham Heart Study. BMJ 337:a2338. doi:10.1136/bmj.a2338
Garmezy N, Rutter M (1983) Stress, coping and development in children. McGraw-Hill, New York
Geis DE (2000) By design: the disaster resistant and quality of life community. Nat Hazards Rev 1(3):23
Gillespie BM, Chaboyer W, Wallis M (2007) Development of a theoretically derived model of resilience through concept analysis. Contemp Nurse J Aust Nurs Prof 25(1–2):124–135
Glavovic BC, Saunders WSA, Becker JS (2010) Land-use planning for natural hazards in New Zealand: the setting, barriers, 'burning issues' and priority actions. Nat Hazards 54(3):679–706
Godschalk DR (2003) Urban hazard mitigation: creating resilient cities. Nat Hazards Rev 4(3):136–143
Gunderson L (2010) Ecological and human community resilience in response to natural disasters. Ecol Soc 15(2):18. [online] URL: http://www.ecologyandsociety.org/vol15/iss2/art18/
Hallegatte S, Henriet F, Corfee-Morlot J (2011) The economics of climate change impacts and policy benefits at city scale: a conceptual framework. Clim Change 104:51–87
Harney PA (2007) Resilience processes in context. J Aggress Maltreat Trauma 14(3):73–87
Harvey MR (1996) An ecological view of trauma. J Trauma Stress 9:3–23
Harvey MR (2007) Towards an ecological understanding of resilience in trauma survivors: contributions from the field of community psychology. J Aggress Maltreat Trauma 14(1/2):9–32
Hegney DG, Buikstra E, Baker P, Rogers-Clark C, Pearce S, Ross H, King C, Watson-Luke A (2007) Individual resilience in rural people: a Queensland study, Australia. Rural Remote Health 7(4):620
IPCC (2007) Climate change 2007: the physical science basis, summary for policy makers. Intergovernmental Panel on Climate Change (IPCC), Cambridge University Press, Cambridge, UK and New York, NY, USA. http://www.ipcc.ch

Janssen MA, Ostrom E (2006) Editorial: resilience, vulnerability, and adaptation: a cross-cutting theme of the International Human Dimensions Program on Global Environmental Change. Glob Environ Change 16:237–239
Johnson JL, Wielchelt SA (2004) Introduction to the special issue on resilience. Subst Use Misuse 39(5):657–670
Kaplan HB (1999) Toward an understanding of resilience: a critical review of definitions and models. In: Glantz MD, Johnson JL (eds) Resilience and development. Kluwer Academic, New York, pp 17–83
Keim ME (2008) Building human resilience: the role of public health preparedness and response as an adaptation to climate change. Am J Prev Med 35(5):508–516
King D (2001) Uses and limitations of socioeconomic indicators of community vulnerability to natural hazards: data and disasters in Northern Australia. Nat Hazards 24:147–156 and in disaster prevention for the 21st century, Proceedings of the Australian Disaster Conference 1999. Emergency Management Australia, Canberra
King D (2007) Organisations in disaster. Nat Hazards 40:657–665
King D, MacGregor C (2000) Using social indicators to measure community vulnerability to natural hazards. Aust J Emerg Manag 15(3):52–57
Kirschenbaum A (2004) Generic sources of disaster communities: a social network approach. Int J Sociol Soc Policy 24(10/11):94–129
Kiter Edwards ML (1998) An interdisciplinary perspective on disasters and stress: the promise of an ecological framework. Sociol Forum 13(1):115–132
Klein RJT, Smit MJ, Goosen H, Hulsbergen CH (1998) Resilience and vulnerability: coastal dynamics or Dutch dikes. Geogr J 164(3):259–268
Klein RJT, Nicholls RJ, Thomalla F (2003) Resilience to natural hazards: how useful is this concept? Environ Hazards 5:35–45
Kobasa SC (1982) The hardy personality: toward a social psychology of stress and health. In: Sanders GS, Suls J (eds) Social psychology of health and illness. Erlbaum, Hillsdale
Kronenberg ME, Cross-Hansel T, Brennan AM, Osofsky HJ, Osofsky JD (2010) Children of Katrina: lessons learned about post-disaster symptoms and recovery patterns. Child Dev 81(4):1241–1259
Kulig J (1996) Surviving and thriving in the Crowsnest Pass. University of Lethbridge, Regional Center of Health Promotion and Community Studies, Lethbridge
Kulig J (2000) Community resiliency: the potential for community health nursing theory development. Public Health Nurs 17(5):374–385
Kulig J, Hanson L (1996) Discussion and expansion of the concept of resiliency: summary of think tank. University of Lethbridge, Regional Center of Health Promotion and Cummunity Studies, Lethbridge
Kumar C (2005) Revisiting 'community' in community-based natural resource management. Community Dev J 40:275–285
Kumpfer KL, Summerhays JF (2006) Prevention approaches to enhance resilience among high-risk youth comments on the papers of Dishion and Connell and Greenberg. Ann N Y Acad Sci 1094:151–163
Landau J (2007) Enhancing resilience: families and communities as agents for change. Fam Process 46(3):351–365
Lebel L, Anderies JM, Campbell B, Folke C, Hatfield-Dodds S et al. (2006) Governance and the capacity to manage resilience in regional social-ecological systems. Ecol Soc 11(9). http://www.ecologyandsociety.org/vol11/iss1/art19/
Lee E (1966) A theory of migration. Demography 3(1):47–57
Li GM (2009) Tropical cyclone risk perceptions in Darwin, Australia: a comparison of different residential groups. Nat Hazards 48:365–382
Luthar SS (2006) Resilience in development: a synthesis of research across five decades. In: Cicchetti D, Cohen DJ (eds) Developmental psychopathology: risk, disorder, and adaptation, vol 3, 2nd edn. Wiley, Hoboken, NJ, USA, pp 739–795
Luthar SS, Cicchetti D (2000) The construct of resilience: implications for interventions and social policies. Dev Psychopathol 12:857–885
Manyena SB (2006) The concept of resilience revisited. Disasters 30(4):433–450
Masten AS (2001) Ordinary magic: resilience processes in development. Am Psychol 56(3):227–238
Masten AS, Obradovic J (2006) Competence and resilience in development. Ann N Y Acad Sci 1094:13–27
Masten AS, Obradovic J (2007) Disaster preparation and recovery: lessons from research on resilience in human development. Ecol Soc 13(1):9. [online] URL: http://www.ecologyandsociety.org/vol13/iss1/art9/
Masten AS, Obradovic J (2008) Disaster preparation and recovery: lessons from research on resilience in human development. Ecol Soc 13(1):9. [online] URL: http://www.ecologyandsociety.org/vol13/iss1/art9/

McBean G, Rodgers C (2010) Climate hazards and disasters: the need for capacity building. WIREs Clim Chang 1:871–884. doi:10.1002/wcc.77
Mertensmeyer C, Fine M (2000) ParentLink: a model of integration and support for parents. Fam Relat 49:257–265
Moore M, Westley F (2011) Surmountable chasms: networks and social innovation for resilient systems. Ecol Soc 16(1):5. [online] URL: http://www.ecologyandsociety.org/vol16/iss1/art5/
Mowbray CT, Woolley ME, Grogan-Kaylor A, Gant LM, Gilster ME, Shanks TRW (2007) Neighbourhood research from a spatially oriented strengths perspective. J Community Psychol 35:667–680
Murphy BL (2007) Locating social capital in resilient community-level emergency management. Nat Hazards 41(2):297–315
Nelson DR, Adger WN, Brown K (2007) Adaptation to environmental change: contributions of a resilience framework. Annu Rev Environ Resour 32:395–419
Norris FH, Stevens SP (2007) Community resilience and the principles of mass trauma intervention. Psychiatry 70(4):320–328
Norris F, Friedman M, Watson P (2002a) 60, 000 disaster victims speak: part II, summary and implications of the disaster mental health research. Psychiatry 65:240–260
Norris F, Friedman M, Watson P, Byrne C, Diaz E, Kaniasty K (2002b) 60, 000 disaster victims speak: part I, an empirical review of the empirical literature, 1981–2001. Psychiatry 65:207–239
Norris FH, Sherrieb K, Galea S, Pfefferbaum B (2008a) Capacities that promote community resilience: can we assess them? Paper presented at the 2nd Annual Department of Homeland Security University Network Summit, Washington, DC. Available http://www.orau.gov/dhsresummit08/presentations/Mar20/Norris.pdf
Norris FH, Stevens SP, Pfefferbaum B, Wyche KF, Pfefferbaum RL (2008b) Community resilience as a metaphor, theory, set of capacities, and strategy for disaster readiness. Am J Community Psychol 41:127–150
O'Brien G, O'Keefe P, Rose J, Wisner B (2006) Climate change and disaster management. Disasters 30(1):64–80
Paton D (2008) Community resilience: integrating individual, community and society perspectives. In: Gow K, Paton D (eds) Phoenix of natural disasters: community resilience. Nova Science Publishers, Inc., New York, pp 13–31
Paton D, Johnston D (2001) Disasters and communities: vulnerability, resilience and preparedness. Disaster Prev Manag 10(4):270–277
Pelling M (2003) The vulnerability of cities: natural disasters and social resilience. Earthscan, London
Perilla JL, Norris FH, Lavizzo EA (2002) Ethnicity, culture and disaster response: identifying and explaining ethnic differences in PTSD six months after Hurricane Andrew. J Soc Clin Psychol 21:20–45
Pfefferbaum B, Reissman D, Pfefferbaum R, Klomp R, Gurwitch R (2005) Building resilience to mass trauma events. In: Doll L, Bonzo S, Mercy J, Sleet D (eds) Handbook on injury and violence prevention interventions. Kluwer Academic Publishers, New York
Polk LV (1997) Toward a middle-range theory of resilience. Adv Nurs Sci 19:1–13
Pooley JA, Cohen L, O'Connor M (2010) Bushfire communities and resilience: what can they tell us? Aust J Emerg Manag 25(2):33–38
Powell N (1999) Reconceptualising resilience for impact assessment in conditions of systemic uncertainty. In: Proceedings from the 3rd Nordic EIA/SEA conference, 22–23 Nov 1999, pp 163–174
Prosser B, Peters C (2010) Directions in disaster resilience policy. Aust J Emerg Manag 25(3):8–11
Quarantelli EL (ed) (1998) What is a disaster? Perspectives on the question. Routledge, London
Rodríguez H, Aguirre BE (2006) Hurricane Katrina and the healthcare infrastructure: a focus on disaster preparedness, response, and resiliency. Front Health Serv Manage 23(1):13–23
Rose A (2004) Defining and measuring economic resilience to disasters. Disaster Prev Manag 13:307–314
Rutter ME (1987) Psychosocial resilience and protective mechanisms. Am J Orthopsychiatr 57:316–331
San Juan Guillen C (2011) The role of the organisational psychologist in disasters and emergency situations. Disasters 35(2):346–361
Sapountzaki K (2007) Social resilience to environmental risks: a mechanism of vulnerability transfer? Manag Environ Qual 18(3):274–297
Schafft KA, Brown DL (2000) Social capital and grassroots development: the case of Roma self-governance in Hungary. Soc Probl 47(2):201–219
Stewart GT, Kolluru RE, Smith M (2009) Leveraging public-private partnerships to improve community resilience in times of disaster. Int J Phys Distrib Logist Manag 39(5):343–364
Stockholm Environmental Institute (2004) Resilience and vulnerability. Poverty and Vulnerability Program, Global Environmental Change and Food Systems (GECAFS) Project, Stockholm

Sun J, Stewart D (2007) Development of population-based resilience measures in the primary school setting. Health Educ 107(6):575–599
Swick KJ, Williams RD (2006) An analysis of Bronfenbrenner's bio-ecological perspective for early childhood educators: implications for working with families experiencing stress. Early Childhood Educ J 33(5):371–378
Timmerman P (1981) Vulnerability, resilience and the collapse of society: a review of models and possible climatic applications. Institute of environmental studies, University of Toronto, Toronto
Tompkins EL, Adger WN (2004) Does adaptive management of natural resources enhance resilience to climate change? Ecol Soc 9(2):14 (article 10)
Tummala-Narra P (2007) Conceptualizing trauma and resilience across diverse contexts. J Aggress Maltreat Trauma 14(1):33–53
Tusaie K, Dyer J (2004) Resilience: a historical review of the construct. Holist Nurs Pract 18:3–8
UN/ISDR (2004) Living with risk: a global review of disaster reduction initiatives. United Nations Inter-Agency Secretariat of the International Strategy for Disaster Reduction, Geneva
Ungar M (2010) Families as navigators and negotiators: facilitating culturally and contextually specific expressions of resilience. Fam Process 49(3):421–435
Van der Leeuw SE, Leygonie CA (2000) A long-term perspective on resilience in socio-natural systems. Paper presented at the workshop on System shocks–system resilience, Abisko, Sweden, 22–26 May
Walker BH, Salt D (2006) Resilience thinking: sustaining ecosystems and people in a changing world. Island Press, Washington
Wallace D, Wallace R (2008) Urban systems during disasters: factors for resilience. Ecol Soc 13(1):18. [online] URL: http://www.ecologyandsociety.org/vol13/iss1/art18/
Waller MW (2001) Resilience in ecosystemic context: evolution of the concept. Am J Orthopsychiatry 71(3):1–8
Walsh F (1998) Strengthening family resilience. Guilford, New York
Walsh F (2007) Traumatic loss and major disasters: strengthening family and community resilience. Fam Process 46(2):207–227
Werner EE (2000) Protective factors and individual resilience. In: Shonkoff JP, Meisels SJ (eds) Handbook of early childhood intervention, 2nd edn. Cambridge University Press, New York, pp 115–132
Winkworth G, Healy C, Woodward M, Camilleri P (2009) Community capacity building: learning from the 2003 Canberra bushfires. Aust J Emerg Manag 24(2):5–12
Zautra A, Bachrach K (2000) Psychological dysfunction and wellbeing: public health and social indicator approaches. In: Rappaport J, Seidman E (eds) Handbook of community psychology. Kluwer Academic Publishers, Dordrecht, pp 165–186
Zautra A, Hall J, Murray K (2008) Community development and community resilience: an integrative approach. Community Dev 39(3):130–147
Zhou H, Wang J, Wan J, Jia H (2010) Resilience to natural hazards: a geographic perspective. Nat Hazards 53:21–41