

Implications of abrupt environmental change for urban Australia

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ABSTRACT

Recently, attention in global change science has shifted away from predictions of trends that imply linear or steady rates of change in, for example, temperature and precipitation, weather events such as storms, heatwaves and cyclones, and responses to these phenomena in human and natural systems. The possibility of significant, non-linear or abrupt change is now increasingly recognized; that is, human-induced or -exacerbated environmental change may be characterized not by smooth transitions but by surprise, threshold effects and abrupt shifts. This paper summarises recent scientific work on abrupt change, with selected examples of apparent sudden shifts in environmental variables. These phenomena define a particularly difficult set of research and policy problems within the sustainability domain. However, the magnitude and direction of such changes are attended by pervasive uncertainty, and provide both an opportunity and a deep challenge to research and policy. The opportunity is to allow a focus on the historical and current capacities of natural and human systems to cope with past or existing patterns of abrupt change, providing considerable data and experience to be drawn upon. The challenge is that radical uncertainty is not well constructed or handled by either traditional disciplines, and especially by modern policy systems. Most attention in global change in Australia has been focused on agriculture, selected public health issues, and to a lesser extent on weather events and human settlements, with a relative lesser focus on whole urban systems. This paper proposes some implications of abrupt change for urban Australia, and offers an initial scoping of research and policy challenges, focusing on increasing understanding of the parameters of possible non-linear change and its impacts, the capacity of policy and institutional systems to respond, and implications for styles of governance.

INTRODUCTION

This paper considers research and policy implications of abrupt environmental change for Australian urban areas. This is very much an emerging area of research, as the importance of extreme events and rapid or abrupt change is only now being recognized as a significant feature of global change. The range of extreme climatic events in 2005, especially the large number of very intense tropical cyclones, has underscored the threat that abrupt environmental change poses for urban areas. In treating this emerging issue in this paper, we counterpose insights gained from research in (i) earth system science, with a particular emphasis on nonlinear and rapid environmental change; (ii) environmental policy and institutions; and (iii) emergency management.

The aims of the paper are to summarise recent scientific work on abrupt change (part 2), present some cases of such change (part 3), discuss the general character of such change as a challenge to policy, institutions and governance (part 4), and identify selected issues relevant to urban research and policy (part 5). On the last of these, the intent is to scope issues rather than to offer any definitive treatment, and to introduce the idea of abrupt environmental change more clearly to the urban policy and research field.

ABRUPT ENVIRONMENTAL CHANGE

Rapid advances in the palaeo-sciences over the past few decades have shown that non-linear change in important aspects of the functioning of the global environment is much more common than earlier thought (Alverson et al. 2003). Here the term *abrupt change* is used to characterise environmental change that occurs at an unexpectedly rapid rate. One of the best-known such examples is the series of exceptionally rapid increases in temperature, sometimes up to 10 °C in only a decade or two, that occurred in the North Atlantic region during the last glacial period from 70,000 to 12,000 years ago (Grootes et al. 1993). Non-linear change in the past is not confined to temperature nor to the North Atlantic region. Abrupt changes in the hydrological cycle, more than anything experienced during the modern instrumental record, have been relatively common in the low latitudes. For example, unexpectedly severe and prolonged droughts have been implicated in the collapses of the Akkadian civilisation in the Near East about 4000 BC (Cullen et al. 2000) and of the Classic Mayan civilisation in meso-America around 1000 years ago (Hodell et al. 2001). About 500 years ago, the southwestern region of what is now the United States suffered a drought that easily eclipsed in length and severity the well-known Dust Bowl drought of the 1930s (Cook et al. 1999). Abrupt change can also occur in the chemical as well as the physical aspects of the global environment. The unexpected and rapid appearance last century of the stratospheric ozone hole over Antarctica is an example of a human-triggered non-linearity in the atmospheric chemical system (Crutzen 2004).

With intensifying human pressure on many components of the global environment (e.g., IPCC 2001, Reid et al. 2005), there is increasing concern that such pressures could trigger abrupt, non-linear environmental change that would have serious consequences for urban areas (Steffen et al. 2004a,b). Much research in the northern hemisphere over the past few years has been focused on the possible slow-down or shut-down of the North Atlantic thermohaline circulation, which could lead to rapid and severe cooling in the North Atlantic, and, thus, regional cooling in the midst of global warming. Such regional cooling would, in effect, lead to a redistribution of heat at the Earth's surface and hence to further warming in Australia, increasing the probability of heat waves. Even more recently, likely irreversible, and possibly abrupt, changes in the cryosphere (snow, ice and permafrost) have received much attention. The interest is focused primarily on Arctic sea ice and on the Greenland ice sheet, both of which are undergoing rapid change at present. There is also concern for the future of the West Antarctic Ice Sheet, earlier thought to be stable under all global warming scenarios; recent observations from the Antarctic Peninsula have raised the possibility of much more rapid change in Antarctic ice sheets than previously understood (Rapley 2005). Significant melting of the large land-based ice sheets would raise sea level globally, which, when coupled with storm surges associated with cyclones and other storms, would pose threats to Australia's coastal urban areas.

Thus characterised, the challenges presented by abrupt environmental change are typical of higher-level problems in the sustainability field, where policy problems are often defined by a

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combination of attributes that make them especially difficult for researchers, policy processes and communities, including (Dovers 1997; 2005):

- broadened, deepened and highly variable spatial and temporal scales;
- irreversible impacts, and related policy urgency;
- complexity within and connectivity between problems;
- pervasive uncertainty;
- 'systemic' problem causes, embedded deeply in patterns of production, consumption, settlement and governance;
- difficulty in separating public and private costs and benefits;
- contested research methods, policy instruments and management approaches;
- lack of defined policy, management and property rights, roles and responsibilities;
- strong demands and justification for increased community participation in both policy formulation and actual management; and
- requirements for integrated approaches to research and policy formulation.

These attributes are encountered more often, and especially more often in combination, with significant sustainability problems – such as climate change and its impacts, biodiversity protection, integrated land and water management and population-environment linkages – than in many other policy sectors. That is not to say that other policy sectors are somehow easy, but that sustainability problems are at least different in kind, and demand different research and policy approaches.

In the case of abrupt change, its implications and policy responses to it, key attributes are temporal scale, pervasive uncertainty, complexity and connectivity, interrelated public and private costs and benefits, and ill-defined policy and property rights and responsibilities. These attributes will recur later in the paper when discussing research and policy implications.

To further illustrate the nature of non-linear environmental change, the next section provides summaries of a range of cases or prospects of abrupt change from Australia and elsewhere.

ABRUPT CHANGE: CASES & PROSPECTS

This section provides a series of sharply summarized examples of apparent cases of and prospects for non-linear environmental change. The first set of illustrative examples are actual cases of abrupt environmental change, likely associated with human-induced climate change although the precise linkages are uncertain. The following illustrate the potential nature of place-specific shifts in the function of and pressures on human and natural systems that pose challenges for adaptation by human societies:

- Tick-borne encephalitis (TBE) was the subject of an aggressive immunisation campaign in Stockholm county in the early 1990s. There was concern that with increased usage of Stockholm's parks and seashore by residents and the growing numbers of roe deer (the tick's host) in the region, Stockholm's population was at greater risk of contracting TBE. Although the immunisation campaign was very successful and thus was expected to reduce the incidence of TBE sharply, the incidence of the disease did not decrease. The solution to the mystery lay in a non-linear environmental change that was almost impossible to predict (Lindgren 2000). The reproductive cycle that controls the population size of the tick that carries TBE is temperature-limited and normally requires two summer seasons to complete. With the strong warming trend in the northern high latitudes, including the Stockholm region,

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over recent decades, the tick's physiology crossed a reproductive threshold and was able to complete its life cycle in one summer season rather than two. This was a highly non-linear change, and resulted in a massive and unexpected outbreak of tick populations in Stockholm's parklands. More by chance than by anticipatory planning, the immunisation campaign coincided with the tick outbreak, the two effects cancelling each other with no net change in the incidence of TBE in the Stockholm region.

- The bushfires which killed four people, injured hundreds of others, destroyed 500 homes and inflicted severe damage to Canberra's infrastructure in January 2003 have had a longer term impact on the city's water supply. The severe damage to the forested catchments west of the city – 98% of the Cotter catchment was burnt – led to subsequent runoff that was heavily laden with sediments and charcoal from the bared ground. As a result, the quality of the water in three of the city's four dams was so low that the water could not be used, and Canberra was rendered dependent on a reserve storage from a single catchment southeast of the city which was already under pressure from prolonged drought. The January 2003 bushfires were, in effect, a highly nonlinear event, the severity of which was beyond previous experience and could not easily have been anticipated. One of the important contributing factors to the fires was the exceptionally dry condition of the forests, owing to the persistently hot, dry climatic conditions in the months leading up to the event. For the 3-4 months immediately before the fires the relative humidity was at a record low, temperatures were 3-4 °C above normal, and there had been virtually no rainfall (as part of the multi-year drought that is still afflicting most of eastern Australia). The most convincing explanation for this set of climatic conditions, due to a persistent and intense high pressure ridge over the eastern half of the continent, is higher sea surface temperature in both the Indian and Pacific Oceans. The Canberra bushfire disaster is also an example in which a number of longer term climatic trends pushed an ecological system over a threshold and triggered an abrupt event (Lavorel and Steffen 2004).
- Climatic change can affect urban water supplies in more direct ways. Perth's water supply has been affected by an abrupt decrease in the normally reliable winter rainfall in the southwestern corner of Western Australia. The reduction in rainfall occurred in the mid-1970s, apparently as part of a global shift in the climate system, as evidenced also by a sharp change in the fire regime of the Canadian boreal forest and a regime shift in the marine ecosystems of the northern Pacific Ocean. The drop in rainfall in the Perth region was about 15%, but this change was amplified in terms of runoff so that the city's dams received only about 50% of their normal inflow (Foster 2002). The ongoing Perth water shortage has prompted the city to build a desalination plant and triggered a vigorous debate during the February 2005 Western Australian state election campaign about building a canal to access the water resources of the Kimberley. Smaller communities are also facing severe water shortages. By mid-2005 the town of Goulburn (about 23,000 inhabitants) on the Southern Tablelands of New South Wales had seen its water supply drop to only 11% due to the multi-year drought in eastern Australia. The drought is triggering a number of non-linear responses - severe water restrictions; a 30% reduction in industrial use, leading to production cuts and job losses; and the possibility of having to truck in water at a cost of AUD 2 million per month.
- Heatwaves are a well-known consequence of a warming climate, with potentially severe impacts on urban areas. The central European heatwave of August 2003, in which the maximum temperature was 6-8 °C above normal for a two-week period, is a

good example. Over 15,000 premature deaths were reported in the Paris region, with the city's coping capacity severely limited by the nature of the building stock and by the inadequate medical support during the height of the summer holiday season. By contrast, in February 2004 Brisbane experienced a heatwave of similar severity and duration but with far fewer casualties. The Australian heatwave was characterised by mean maximum temperatures that were 5-6 °C above average during the 1-22 February period throughout large areas of the eastern half of the country. In Brisbane the temperature peaked at nearly 42 °C (2 °C higher than the Paris maximum during its heatwave) during the weekend of 21-22 February, leading to number cases of heat stress and collapse. During that weekend the Queensland ambulance service recorded a 53% increase in ambulance call-outs, prompting the commissioner of the ambulance service to describe the event as "...the most significant medical emergency in the south-east corner (of Queensland) on record" (Steffen et al. 2005). Nevertheless, the number of excess deaths in Brisbane was insignificant, especially compared to the Paris case, demonstrating that the vulnerability of urban areas towards environmental extremes or abrupt changes is at least as important as the nature of the environmental change itself.

Note that the four cases above represent *changes in degree* in phenomena that are already familiar to communities, economies and policy systems. In all cases, existing adaptation or response measures exist, even if the unexpected nature of the changes presented significant challenges and in some cases outstripped coping capacity at least for a period of time. In the encephalitis case, the research and health systems fortuitously acted at an appropriate time to prevent a sharp increase in the disease. With the Canberra fires, Australia's sophisticated system of semi-professional, semi-volunteer fire and emergency response was briefly overwhelmed, with immediate costs and ongoing political problems. Although well-practised and internationally recognized as effective, Australian fire policy and management regimes face ongoing challenges, especially in terms of better integrating different research disciplines, policy settings and management organizations to account for multiple values over the long term, across highly varying ecological and socio-economic settings (for a summary, see Dovers et al 2004). Water supply issues in places such as WA and smaller centres such as Goulburn (and many others that have failed to attract media and political attention) are being handled in various ways by a combination of extra investment in supply, technological improvements in water use efficiency, behaviour change to reduce demand, and new policy approaches including market-based rights mechanisms. Heatwave occurrence is managed through the health system and adjustments to building stocks. Such changes in degree challenge existing research and policy capacities, especially if they occur more often and more often in combination, but do not, in isolation at least, threaten those systems. However, they do present society with a greater level of uncertainty and difficult choices.

The second set of examples comprises realistically prospective environmental changes and impacts, raising the prospect of potential *changes in kind* or at least raise the possibility of changes in degree of a magnitude previously unrecognized or not experienced:

- Although Australia has no permafrost, the rapid changes that are occurring to the permafrost regions of the northern hemisphere raise generic issues about the viability of urban infrastructure under rapid environmental change. Significant changes are occurring to permafrost regions across the high latitudes, with the most rapid changes occurring in Alaska (a 2-4 °C warming of permafrost during the last century) (Anisimov 2004). The most important effect of such warming is an increase in the uppermost layer of seasonal thawing, which can in turn lead to severe distortions of the

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terrain. For example, in some areas of central Alaska the ground surface has subsided by as much as 2.5 m due to permafrost thawing. Such distortions are obviously detrimental to built infrastructure and are leading to noticeable impacts in some of the northernmost Siberian cities, such as Yakutsk. The broader issue that permafrost thawing raises is the vulnerability of built infrastructure, with projected lifetimes of decades and sometimes centuries, to rapid geophysical change of any type.

- Of more direct relevance for Australia's urban areas are significant losses of land-based ice, as these changes affect sea level at the global scale. The present projections are for global mean sea level to rise by approximately 10 - 90 cm by the end of this century (IPCC 2001). The cause for most of this rise is thermal expansion due to the increasing temperature of the ocean's surface waters. However, a major uncertainty in these projections is the potential for rapid loss of land-based ice, most notably the Greenland ice sheet. If mean global temperature rises by 2.5 or 3.0 °C towards the end of this century, land-based ice on Greenland is probably committed to melt, although the process will take at least a millennium to play out completely. Complete loss of the Greenland ice sheet would raise global mean sea level by about 6 m. The rate at which large ice sheets disappear is almost completely unknown, raising questions such as, for example, whether there are strong non-linearities in the melting process that would lead to significant changes in projections of sea-level rise over the next century or two. A further uncertainty for projections of sea-level rise is the stability of land-based ice in Antarctica, where recent research has shown that these glaciers and ice sheets may be more mobile under climate warming than current models suggest (Rapley 2005). The consequences for urban infrastructure of even modest increases in relative sea level, especially when coupled with storm surges associated with tropical cyclones, can be dramatic, as the recent case of New Orleans demonstrates.
- The insurance industry may provide an early-warning sign of the types of socio-economic responses that might be driven by non-linear environmental change. Rapid change in both the availability of insurance and its cost is already underway as the re-insurance industry evaluates the impacts on the industry's viability of climatic extremes and other abrupt changes in the environment. In effect, the risks borne by society due to environmental extremes, traditionally covered to a large extent by the insurance industry, are now being effectively transferred from that industry to private individuals and to governments (Mills 2005). The ultimate impact on urban areas of this socio-economic change is unclear, but the recent New Orleans disaster may provide an initial test case.
- The most devastating impacts on Australian urban areas of non-linear environmental change will almost surely not be caused by individual events or phenomena, but rather by interacting stresses or sequences of events. A likely combination of stresses is prolonged and severe drought coupled with heatwaves, a combination that could eventually render areas of inland Australia largely uninhabitable and could severely challenge the viability of large coastal cities. Coastal cities will also increasingly be vulnerable to inundation due to rising sea level coupled with storm surges. Northern urban areas will be especially vulnerable, as the destructiveness of tropical cyclones appears to have increased sharply in the last 30 years as a result of rising sea surface temperatures (Emanuel 2005). In fact, both Cairns and Darwin were lucky to escape significant damage in March 2005 when Cyclone Ingrid, which was just as intense as Katrina, narrowly missed both cities.

The division above between differences in kind and degree are inevitably arbitrary and to an extent very imprecise – such is the nature of uncertainty. Nevertheless, it focuses on a continuum of unexpected change and events, from those that, although difficult, are within our capacities to understand and respond, to those which may overwhelm current capacities. It is not only the scale and magnitude of events that will determine the adequacy of coping capacity. Two other factors are likely to be crucial: (i) the frequency of problematic events, where fewer events may be easily enough handled but repeated or concurrent disturbance prove too much; and (ii) familiarity with and thus institutional provision for a particular issue. The last of these is revisited at the end of the next section, which discusses the broad nature of the challenge of adapting to non-linear change.

CHALLENGES OF ADAPTATION TO ABRUPT CHANGE

The aim above in identifying potential non-linear and sudden environmental change is not to paint a doomsday portrait of the future, but rather to characterise such changes as research and policy problems and to draw focus toward urban Australia. We do not know the precise likelihood, timing, magnitude or even always the most vulnerable locations. However, if the *realistic possibility* of significant abrupt change is accepted – and the historical and scientific evidence is mounting – it is the significant uncertainty attached to the prospect that is a major determinant of the research and especially policy challenges. Closely linked to that uncertainty are the problem attributes of temporal scale, complexity and irreversibility.

A central issue is the degree of action – policy activity, time, financial cost, community behavioural change, development opportunities revised, postponed or foregone, etc – that can be justified on the basis of (i) potentially severe impacts, but (ii) considerable uncertainty. Modern political and policy systems especially in the English-speaking liberal democracies express themselves now through lean, short-term focused public administration and policy processes, in which complexity, long term issues and preventative responses in the face of uncertainty may be difficult to mount (Marsh and Yencken 2004).

Three categories of response can be posited in the face of this dilemma. *First*, to seek better information and understanding of the drivers, scale and likelihood of possible changes and events: a research response. *Second*, to adapt in ways that are justified or at least not unjustified on other grounds, such as engineering works to prevent storm surge in already vulnerable areas, or increased medical preparation for epidemics. The *third* option is precautionary or preventative, substantially new policy and institutional strategies.

In considering responses to possible abrupt change, both positive and negative perspectives can be taken. The negative is that modern policy and institutional systems do not cope with long-term issues or uncertainty particularly well, as ongoing debates over implementing the precautionary principle evidences (Fisher et al, in press). The positive perspective is that societies have been coping with and adapting to environmental change for millennia, and nowhere more so than in Australia. This suggests that, even if environmental change in future is more unpredictable and of greater magnitude than in the past, there should be a range of lessons available. Such policy lessons may drawn from successes or failures, or from the more typical combination of both, and in terms of broad policy styles, policy programs and institutional designs, or specific instruments and strategies, from suitable situations (Dovers 2005). Obvious candidates for lesson-drawing are policy and management sectors where uncertainty and variable temporal scales are prime characteristics: emergency management,

drought, disease outbreak response, policing and security. The recognition and comparative analysis of such cognate policy sectors is an often unrealized opportunity.

However, there are limits to lesson drawing from analogous situations in the case of abrupt changes magnitudes, or in combinations, genuinely different in kind and thus outside previous experience. As well as preparation for response, such a scenario begs consideration of different policy styles and conceptions of governance, given doubt as to the capability of existing settings to cope with change at the severe end of possibilities. While the underlying institutions that shape policy and governance are resilient by definition, shocks outside previous experience may exceed this adaptability (Handmer et al 1999). While adaptation to change is an attribute of successful and long-lived institutions, so is 'fit' within normal operating environments (Goodin 1996), and patterns of institutional adaptation to sudden change vary in their logic and degree of risk aversion (Handmer and Dovers 1996).

In particular, major environmental change affects multiple values, assets and policy sectors, in terms of both direct impacts and demands on response capacities. This demands strong whole-of-government policy development and coordination, a challenge recognized as important under normal circumstances and a current focus of public administration (eg. Cabinet Office 2000; APSC 2004), very important in the sustainability field (eg. Lenschow 2002; Connor and Dovers 2004), and crucial in the case of extreme events (eg. Cornall 2004).

The whole-of-government issue is a particularly sharp one in the case of prospective abrupt change. Maintaining cross-linkages in policy systems is challenging enough in the face of familiar issues, but significantly harder with uncertain, large-scale and unpredictable events – time consuming and expensive coordination efforts, likely involving designed-in redundancy measures, may easily lapse in the absence of events to justify them. While 'connected government' is one contemporary trend in what is known as the New Public Management (McLaughlin et al 2002), other trends may counterbalance this, including near-term economic justification of public expense, an emphasis of generic managerialist skills and perspectives at the expense of domain-specific knowledge, and an immediate client focus and accountability.

The challenges, however, extend well beyond government. In both sustainability and emergency management – the policy domains in which abrupt change are mostly discussed – the engagement of non-government actors (interest groups, professions, communities, epistemic groups, industry, etc) is recognized as both essential in theory and (albeit imperfectly) occurring in practice (Salter 1998; Dovers 2005). Australian emergency management is strongly based on volunteers and community-based risk management is an increasingly embedded approach; resource and environmental management is being increasingly undertaken at local and regional scales; and sustainability policy is as populated by non-government as it is by government players. Informing and designing policy and institutional responses to abrupt environmental change is more an issue of *governance*, involving multiple players acting in networks of activity, than it is of *government* responses. Some implications of that are now explored.

IMPLICATIONS FOR URBAN RESEARCH AND POLICY

Following the above characterization of abrupt environmental change as a policy and institutional challenge, this part proposes a number of implications for urban research and policy. As stated in the Introduction, the purpose here is not to go into detail or attempt a

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definitive schedule of implications, but to prompt further consideration by those more familiar with urban policy and research than the present authors.

- The first, obvious implication for urban research and policy is to generate an enhanced understanding of possible impacts of abrupt change. While significant work has been undertaken on climate change impacts, there are significant gaps in (i) understanding the parameters of abrupt events, (ii) characterizing the possible interplay between more than single events or stressors, and (iii) developing a finer resolution profiling of different vulnerabilities across settlement types. Integrated assessment of climate change impacts is an emerging area in Australia, and demands unprecedented levels of coordination between a range of research providers and users.
- Following from (iii) in the point above, considerable work is required to identify potential critical elements determining the vulnerability and response capacity in specific urban areas. In the case of the more likely (in degree) changes, these might include specific localities (eg. low lying land), energy prices/systems (in particularly private vehicle-dependent systems), critical infrastructure points, response capacities, insurance regimes, local government budget resilience, or institutional gaps and disconnections, noting that to be effective and coherent this requires whole system modeling/network analysis type approaches. However, the nature of abrupt change, involving shocks to systems whose parameters may be outside scientific or institutional experience, mounts a serious challenge to available methods.
- Establishing the character and implications of secondary or indirect impacts of abrupt environmental change, including that affecting other countries or regions, in terms of Australian urban systems. For example, severe events elsewhere may have indirect impacts via energy prices or supply, disease control measures or trade disruption.
- More specifically, the vulnerability of connections between urban areas and their rural hinterlands may be important to consider, as rural and urban policy are rarely well coordinated. Away from major urban settlements, the collective capacity of scattered organizations and dispersed urban settlements to withstand shocks deserves close attention. A robust differentiation of settlement types (not just according to size, but accounting for other variables) would need to inform this.
- Estimation of thresholds of capacity in emergency services and other response resources, most simply by extending considerably the prospect of known hazard events, singly or in combination. Australia's emergency management and medical emergency capacities are impressive, widely regarded by the public, and strongly based on volunteerism. Nevertheless, the 2003 Canberra fires was a recent example of such capacity being briefly overwhelmed, and the ongoing legacy of policy dilemmas, litigation and erosion of public trust in government is a sharp pointer to future possibilities. Large urban areas in Australia have been rarely affected by major environmental events in the past – at least by ones of the magnitude discussed here – and response capacities remain in many ways untested.
- Following from the above point, events outside normal experience that exceed response capacities may result in a loss of public trust in institutional processes and organizations responsible – or assumed responsible – for protecting the community. Increasing litigation and or high profile or contested inquiry processes may exacerbate such

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destabilization. This may be particularly the case in major urban areas relatively unused to major natural hazard events and less familiar with volunteer-based response systems. The exposure to major disruptions of segments of the population previously not considered to be vulnerable (whether by themselves or others) would be in itself outside parameters of experience. Major shocks to societies and economies, whether natural hazards, technological failures or military/terrorist activities, provide superb openings for cynical or opportunistic populism by those so inclined, in and outside government.

- Exploration and discussion of changing policy agendas and their resonance or otherwise with prospective abrupt change may expose weakness in preparation and response capacities and in knowledge resources. In particular, the domination of policy agendas by issues of security and counter-terrorism has been felt as sharply in the emergency management field as anywhere, and the degree to which this agenda shift has lessened focus on and even capacities to deal with other events is unknown. Differences in perceived risk profiling across general communities, professional and research communities, and the policy and political domain may be worth investigating.
- As well as mapping perceptions of risk, exploration of different understandings and preferences across the community of categories of response to the prospect of significant abrupt change suitable to handling residual uncertainty. Such categories include; information seeking; preventative measures addressing the cause of climate change (eg. greenhouse gas emissions); protective measures to ward off impacts (eg. levees, changes to planning and development strategies); enhanced emergency or other response capacities; and reasoned inaction.
- The capacities and role of strategic planning in urban areas, particularly major cities and at regional scales, is an important factor in incorporating the prospect of abrupt change into the forward design of resilient urban system. Long time horizons and the requirement for integrated approaches recommend strategic regional planning as a prime response. However, there would appear to be some prima facie evidence that strategic planning does not enjoy strong support in some quarters, and certainly has a chequered history in Australia in terms of its impact and the persistence with it. A further question is how to incorporate variable (and equally valid) risk perceptions and response preferences into long term planning using participatory approaches.
- Estimation of the degree of spare capacity and redundancy needed in the face of uncertain but significant impacts, accepting that such a prospect may recommend the designing in of safety margins in response capacities. Spare capacity is difficult to maintain in already stressed resource use situations such as over-allocated water resources or heavily developed coastal lands. Also, as noted earlier, such redundancy may be difficult in light of dominant public sector trends.
- Existing policy settings relevant to abrupt change impacts may be usefully reviewed against extended event characterizations. For example, Australia's long history of ad hoc shifts in drought policy (Botterill et al 2003) suggests that existing policy styles and instruments may be inadequate to more severe or protracted shifts to drier climate. Recent major consolidation and proposed reform of water policy via the National Water Initiative may be tested by increased variability imposing on already stressed water systems and an evolving and unstable policy regime (Connell et al, in press).

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These implications and associated research and policy challenges are selected and illustrative, and are aimed to open inquiry rather than define a clear agenda. Nevertheless, they do portray possibilities that would stretch capacities, possible in ways in which those capacities may be seriously tested.

CONCLUDING COMMENT

The science of abrupt change has proceeded rapidly in recent years, combining historical record with empirical observation and earth system modeling, but significant uncertainties remain. It is likely that abrupt environment changes of magnitudes previously unimagined will impact on urban Australia, placing pressure on response capacities and exposing new vulnerabilities. Such a prospect, especially if multiple such events occur and impact in combination, poses questions not only for immediate capacities such as medical response and emergency management, but for policy styles, planning systems and modes of governance. This paper has sought to place the prospect of abrupt environmental change more on the agenda of urban research and policy than previously, so that such questions can be more explicitly addressed.

REFERENCES

- Alverson, K., Bradley, R., Pedersen, T. (2003) *Paleoclimate, global change and the future*. IGBP Global Change Series. Springer-Verlag, Berlin Heidelberg New York 220pp
- APSC (Australian Public Service Commission). (2004). *Connecting Government: Whole of Government Responses to Australia's Priority Challenges*. Management Advisory Committee Report 4, April 2004. Canberra: APSC.
- Anisimov, O. (2004) Global change and the cryosphere: impacts on snow, ice and permafrost. In: Steffen, W., Sanderson, A., Tyson, P., Jäger, J., Matson, P., Moore III, B., Oldfield, F., Richardson, K., Schellnhuber, H.-J., Turner II, B.L., Wasson, R. *Global Change and the Earth System: A Planet Under Pressure*. IGBP Global Change Series. Springer-Verlag, Berlin Heidelberg New York, p.150-151.
- Botterill, L.C. and Fisher, M. (eds). (2004). *Beyond Drought: People, Policy and Perspectives*. Melbourne: CSIRO Publishing.
- Cabinet Office (UK). (2000). *Wiring It Up: Whitehall's Management of Cross-cutting Policies and Services*. London: HMSO.
- Connell, D., Dovers, S. and Grafton, R.Q. (in press). A critical analysis of the National Water Initiative. *Australasian Journal of Natural Resources Law and Policy*.
- Connor, R. and Dovers, S. (2004) *Institutional Change for Sustainable Development*. Edward Elgar, Cheltenham.
- Cook, E.R., Meko, D.M., Stahle, D.W., Cleaveland, M.K. (1999) Drought reconstructions for the continental United States. *Journal of Climate* 12:1145-1162.
- Cornall, R. 2004. New levels of responsiveness: how governments are preparing to deal with crises. *Public Administration Today*. December: 54-58.
- Crutzen, P. (2004) The ozone hole. In: Steffen, W., Sanderson, A., Tyson, P., Jäger, J., Matson, P., Moore III, B., Oldfield, F., Richardson, K., Schellnhuber, H.-J., Turner II, B.L., Wasson, R. *Global*

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Change and the Earth System: A Planet Under Pressure. IGBP Global Change Series. Springer-Verlag, Berlin Heidelberg New York, p 236-237.

Cullen, H.M., DeMenocal, P.B., Hemming, S., Hemming, G., Brown, F.H., Guilderson, T., Sirocko, F. (2000) Climate change and the collapse of the Akkadian empire: Evidence from the deep sea. *Geology* 28:379-382.

Dovers, S. (1997). Sustainability: demands on policy. *Journal of Public Policy*. 16: 303-318.

Dovers, S. (2005) *Environment and Sustainability Policy: Creation, Implementation, Evaluation*. Federation Press, Sydney.

Dovers, S., Cary, G. and Lindenmayer, D. (2004). Fire research and policy priorities: insights from the 2003 national fire forum. *Australian Journal of Emergency Management*. 19(4): 76-84.

Emanuel, K. (2005) Increasing destructiveness of tropical cyclones over the past 30 years. *Nature* 436: 686-688

Fisher, E., Jones, J. and von Schomberg, R. (eds). (in press). *Implementing the Precautionary Principle: Perspectives and Prospect*. Cheltenham: Edward Elgar.

Foster, I. (2002) Climate change position paper. Western Australia Department of Agriculture, Perth. Draft, 31 May 2002.

Goodin, R.E. 1996. Institutions and their design. In: Goodin, R.E. (ed). *The Theory of Institutional Design*. pp.1-53. Cambridge: Cambridge University Press.

Grootes, P.M., Stuiver, M., White, J.W.C., Johnsen, S., Jouzel, J. (1993) Comparison of oxygen isotope records from the GISP2 and GRIP Greenland ice cores. *Nature* 366:552-554

Handmer, J. and Dovers, S. 1996. A typology of resilience: rethinking institutions for sustainability. *Industrial and Environmental Crisis Quarterly*. 9: 482-511.

Handmer, J., Dovers, S. and Downing, T. (1999). Societal vulnerability to climate change and variability. *Mitigation and Adaptation Strategies for Global Change*. 4: 267-281.

Hodell, D.A., Brenner, M., Curtis, J.H., Guilderson, T. (2001) Solar forcing of drought frequency in the Mayan lowlands. *Science* 292:1367-1370

IPCC (2001) Climate change 2001: The scientific basis. Contribution of Working Group I to the Third Assessment Report of the Intergovernmental Panel on Climate Change. In: Houghton, J.T., Ding, Y., Griggs, D.J., Noguer, M., van der Linden, P.J., Dai, X., Maskell, K., Johnson, C.A. (eds.) *Intergovernmental Panel on Climate Change*. Cambridge University Press, Cambridge, U.K. and New York, United States, 881pp

Lavorel, S., Steffen, W. (2004) Cascading impacts of land use through time: the Canberra bushfire disaster. In: Steffen, W., Sanderson, A., Tyson, P., Jäger, J., Matson, P., Moore III, B., Oldfield, F., Richardson, K., Schellnhuber, H.-J., Turner II, B.L., Wasson, R. *Global Change and the Earth System: A Planet Under Pressure*. IGBP Global Change Series. Springer-Verlag, Berlin Heidelberg New York, p 186-188.

Lenschow, A. (ed). 2002. *Environmental Policy Integration*. London: Earthscan.

Lindgren, E. (2000) The new environmental context for disease transmission, with case studies on climate change and tick-borne encephalitis. PhD Thesis. Natural Resources Management, Department

Governance 02

of Systems Ecology, Stockholm University, Sweden.

Marsh, I. And Yencken, D. (2004). *Into the Future: the Neglect of the Long Term in Australian Politics*. Melbourne: Australian Collaboration and Black Inc.

McLaughlin, K., Osborne, S.P. and Ferlie, E. (eds). (2002). *New Public Management: current trends and future prospects*. London: Routledge.

Mills, E. (2005) Insurance in a climate of change. *Science* 309: 1040-1044.

Rapley, C.G. (2005) Antarctic ice sheets and sea level rise. In: H.J. Schellnhuber, W. Cramer, N. Nakicenovic, T. Wigley and G. Yohe (eds) *Avoiding Dangerous Climate Change*. Cambridge University Press, in press.

Reid, W.V. et. al. (2005) *Millennium Ecosystem Assessment synthesis report*. Island Press, Washington.

Salter, J. (1998). *Risk management in the emergency management context*. Australian Journal of Emergency Management. 12(4): 22-28.

Steffen, W., Andreae, M.O., Bolin, B., Crutzen, P.J., Cox, P., Cubasch, U., Held, H., Nakicenovic, N., Scholes, R., Talaue-McManus, L., Turner II, B.L. (2004a) Abrupt changes: the Achilles heels of the Earth System. *Environment* 46 (No. 3): 9-20.

Steffen, W., Sanderson, A., Tyson, P., Jäger, J., Matson, P., Moore III, B., Oldfield, F., Richardson, K., Schellnhuber, H.-J., Turner II, B.L., Wasson, R. (2004b) *Global Change and the Earth System: A Planet Under Pressure*. IGBP Global Change Series. Springer-Verlag, Berlin Heidelberg New York, 336 pp.

Steffen, W., Love, G., Whetton, P. (2006) Approaches to defining dangerous climate change: an Australian perspective. In: H.J. Schellnhuber, W. Cramer, N. Nakicenovic, T. Wigley and G. Yohe (eds) *Avoiding Dangerous Climate Change*. Cambridge University Press, in press.