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SCIENCE IS CRITICAL BUT IT'S NOT EVERYTHING: OUR FINDINGS

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ABSTRACT

While scientific institutions and forms of scientific knowledge are critical for understanding and mitigating natural hazard risk, there is significant debate about their real utility to policy and practice. We ask: how are practitioners able to use scientific methods and evidence to make risk reduction decisions; how useful is this science for arguing for and defending these decisions; and, what other knowledge sources might we need to reduce our risk? In this paper we provide an end-of-project synthesis of our research regarding the use of science and scientific research by risk mitigation practitioners across three case studies of bushfire and flood risk.

Publics demand and politicians promise greater certainty when it comes to understanding and mitigating the risks of traumatic natural hazard events. It is often the scientific approaches and methods that are expected to produce all the evidence required to know, and prove, the right course of action. This is when the cracks appear in the assumed linear model of 'evidenced-based policy and practice'. In this paper we interrogate what is meant by 'scientific facts', how they are employed to mitigate risk, and what the consequences are for policy and practice. We find that instead of relying solely on scientific approaches, or assuring publics or governments that certainty can be found, we need to affirm the critical importance of scientific methods and results whilst also incorporating other ways of understanding. The rich learnings from the various kinds of scientific inquiry are essential for complex problem solving, but are not sufficient in isolation.

INTRODUCTION

It is a common assumption that natural hazard mitigation practitioners are heavily reliant on scientific methods and results to produce the information they need for decision-making. In order to provide as much certainty as possible, this information must: be able to be translated and used across locations; have a predictive capacity within both present conditions and into the future; and, be defensible – to some extent – with other agencies, senior staff, ministers, publics, possible inquiries, and to the practitioners themselves. However, these assumptions do not necessarily align with the realities that practitioners are faced with. While scientific institutions and forms of scientific knowledge are critical for understanding and mitigating natural hazard risk, there is significant debate about their real utility to policy and practice. In this paper, by 'science' we mean the legacy term that people are most familiar with – the research and methods of the natural and physical sciences.

Scientific methods and evidence are just one part of the risk management equation, interacting and intersecting with the politics and perceptions of natural hazards practitioners.[1] Whether in day-to-day operations or during major policy shifts, for practitioners the scientific evidence and methods are used alongside other sources of knowledge – such as professional expertise, experiential knowledge, and local knowledge. Indeed, practitioners face a similar spectrum of complexities and contradictions in their work as found in the at-risk community, although as risk mitigation decision-makers it is likely that their experience of this spectrum is much more acute. Here, we use the term practitioners to describe a broad group of people. They might be people doing hazard reduction burns or working with laptops in boardrooms – all are engaged in everyday practices of governance.[2]

Clearly, the work of practitioners goes beyond being automatons that implement regulations and policies. They are in a unique position to influence policy and practice outcomes, and scientific results and methods have a privileged position in influencing them. Practitioners find that, on the one hand, natural hazard risk mitigation is a very social and uncertain undertaking, full of value-laden, cultural and other 'non-rational' factors that cannot be reduced to data or modelled with algorithms; whilst, on the other, science is often used to end conversations about the how, why, what, where, when and/or who of risk mitigation. Within this complex context, practitioners must manage the authority of scientific data and methods as part of their pursuit of what they think is best-practice risk mitigation, and how they then present and defend this work to others.

BACKGROUND AND METHODS

The study of practitioners is a critical gap in natural hazard research. Most research on policy and practice focuses on the regulatory environment and policy influences. To address this, for three years we have investigated the cultural, political, legal, economic, ecological and other influences on practitioners' use of scientific data and methods – the 'social life of science'. This research project *Scientific diversity, scientific uncertainty in bushfire and flood risk mitigation* has been funded by the Bushfire and Natural Hazard Cooperative Research Centre (BNHCRC), and is co-located at Western Sydney University and The Australian National University.

We have pursued the following research questions:

1. How are practitioners able to use scientific methods and evidence to make risk mitigation decisions?
2. How useful is this science for arguing for and defending these decisions? and,
3. What other knowledge sources do practitioners use to reduce risk?

Between 2014-2016 we conducted three case studies with practitioners responsible for reducing bushfire risk in the Barwon-Otway area (Victoria) and the Greater Darwin area (Northern Territory), and flood risk in the Hawkesbury-Nepean valley (New South Wales):

- *Barwon-Otway area, Victoria*
  A rugged coastal and rural region in which peak bushfire risk periods coincide with peak summer holiday seasons, with very constrained evacuation routes. Risk mitigation practitioners have successfully drawn on innovative scientific modelling (including the PHOENIX bushfire simulation model) to re-purpose prescribed burning around strategic approaches, as well as to raise bushfire awareness.[3] The practitioners involved in our project were mainly from public land management agencies, as well as consultants and experts that collaborate closely with these agencies.

- *Greater Darwin area, Northern Territory*
  The huge climactic flux between wet and dry seasons supports vigorous grass growth and curing in northern Australia's tropical savanna. Here, established bushfire risk mitigation techniques are proving no longer adequate to address the 'fire-weed' Gamba grass (*Andropogon gayanus*) that is spreading through the Greater Darwin area and its burgeoning peri-urban subdivisions. This management context is comparatively constrained in terms of environmental regulation, resourcing and research, though risk mitigation practitioners often have greater independent capacity for action.[4] Here, the practitioners we collaborated with were mainly from public land management agencies, fire and weed agencies, as well as university and federal researchers.

- *Hawkesbury-Nepean Valley, New South Wales*
  The flood plains of Western Sydney – densely populated and under development pressure for more affordable and available housing – is also an area prone to very low-probability high-impact floods. Following extensive flooding in Brisbane and NSW in 2011 and 2013, the Hawkesbury-Nepean Valley Flood Management Taskforce was set up to consider flood risk and advise the NSW Government accordingly. The Taskforce is drawing on a diverse range of expertise (both scientific and technical) to develop a sophisticated range of mitigation, preparedness and response strategies. The Taskforce practitioners we have interviewed have been mostly state government officers supported by a range of consultant specialists, all of whom had varying combinations of scientific, practical and policy expertise.

The three case studies were undertaken consequentially as part of a multi-sited ethnography, using semi-structured interviews and scenario exercises,[5] and thus the inquiry and methodology evolved as the research project progressed.

Through this research project, we consider not just what the practitioners are saying and doing, and how the socio-ecological context influences what is possible. We go further to consider the influence of different knowledge sources on this activity – their cultural traditions and the assumptions that carry through from that. We consider how these knowledge foundations are translated into risk mitigation decisions, and how shifting known or unknown assumptions behind these traditions might improve risk and resilience. This paper reports on the findings that are now arising out of our end-of-project synthesis.

RESULTS AND DISCUSSION

IS SCIENCE SCIENTIFIC?

In this project we have discussed 'science' as the legacy term that people are most familiar with – the research and methods of the natural and physical sciences. For example, the disciplines and inter-disciplines of maths, physics, chemistry, biology, hydrology, meteorology, climate science, agent modelling, and fire science, as well as the institutions, practices and values that have been created alongside. These disciplines employ diverse scientific methods to make inferences from evidence so as to generate 'scientific facts' – at least until disproven or confirmed by ongoing scientific inquiry. The intention is to uncover objective knowledge of the world. The rapid development of this knowledge tradition over 500 years is called the 'scientific revolution'. This expertise has fundamentally changed the knowledge basis for decision-making and governance, ostensibly replacing religion, intuition and emotion with science, reason and rationality.[6] However, as social studies of science have shown, it is misguided to conceive of science as an objective universal knowledge, applied and valued the world over. All science, as sociologist Brian Turnbull states, is arguably a form of local knowledge – it is produced by, and circulates through, specific people in specific places shaped by their specific interests.[7]

Nevertheless, societal expectations of science as an objective universal knowledge, also known as the 'normal science paradigm', continues to be influential, and so it is important to examine how we define and use this science. A key assumption of the normal science paradigm is the expectation that uncertainty can be reduced for decision making; that decision makers can predict, manage and control outcomes in the environment, it is just a matter of getting enough information.[8] It is this expectation that makes it so attractive and influential, including in the natural hazards sector. For example, being able to alter Bushfire Danger Ratings to both better reflect the fuel condition of changing landscapes and elicit greater fire suppression resources, as well as developing very basic risk mitigation tools such as flood and fire risk maps. In the Greater Darwin area case study, practitioners spoke about how the under-resourced over-stretched hazard management sector relied heavily on largely university-generated scientific research. In particular, scientific data on the fuel loads and invasiveness of Gamba Grass has been absolutely crucial to convincing policy makers to declare it a weed and fund containment activities.

The Northern Territory's less regulated and chronically underfunded governance context[9] contrasts sharply with our other fire risk case study, the Barwon-Otway area. The Barwon-Otway practitioners have had very close access to the bushfire simulator PHOENIX, with an array of impressive results. Using simulation and Bayesian networks, practitioners provided advice on different prescribed burning strategies locally, and helped found a new state wide policy, moves that were framed in terms of being 'more scientific' than previous approaches. In addition to providing greater certainty for their own decision-making, this predictive work also helped with difficult conversations in policy and community contexts. And yet the science still fell short of a 'fix' because, in the process of generating new modelling methods, practitioners found their answers actually created a host of other uncertainties – many of which require decisions about values. In short, more science did not resolve the big tensions around what should 'count' most to agencies, what approaches they should take and how they should communicate their decisions. Many of the practitioners were pragmatic about this, being very explicit about the scientific limitations of PHOENIX and their modelling in some contexts and omitting these limitations in others.

Across the case studies, it was shown that scientific evidence and scientists can have an important role in convincing *others,* whether they be individuals within the hazards sector, industry, the media, or in the public. This is critical because of the high-stakes high-accountability context that practitioners work in. However, while it may be expedient to rely on the authority of scientific knowledge when addressing concerned stakeholders or community members, it is clear from our research that there are downsides to mobilising this authority. In the Barwon-Otway case study, scientific tools and external scientific voices, such as university researchers, have been crucial to building trust in public land managers amongst sceptical communities; but having a deterministic colourful animated map which is a compelling communication device, is not the same as saying that it produces the right outcome for risk mitigation. In Greater Darwin, practitioners frustrated that their messages were not affecting policy found greater 'cut through' when they translated scientific knowledge of Gamba grass into the dominant terms of Northern Territory politics: namely, a physical threat to politically influential suburbs and a financial threat to the government budgets.

The Hawkesbury-Nepean case study was the most complex and risk-fraught context we studied. In this relatively highly populated area, very complex flood behaviour, tricky topography, climatic unpredictability and incredibly diverse stakeholder interests and knowledge, demanded a highly sophisticated and varied approach by the Hawkesbury-Nepean Valley Taskforce. The Taskforce not only combined researcher-practitioners from a broad range of disciplinary and practice backgrounds, it also placed a strong focus on a co-productive approach to generating new knowledge, with a highly collaborative and innovative approach to understanding. Seeking legitimacy with other stakeholders required careful thought and action. For example, the Taskforce has been meticulous in meeting governance and other review guidelines. The biggest challenge is currently unfolding, as the Taskforce engages with the broader range of stakeholders, including local communities, planning departments, developers etc., particularly with increasing pressure for new and affordable housing in the Greater Sydney area. The highly innovative and sophisticated modelling the Taskforce have generated will not decrease the uncertainty faced in this catchment, but rather highlights the uncertainty, ambiguity, complexity, intractability, instability and diversity of the situation.

It is thus clear that scientific methods and results do not always create the certainty that practitioners seek. Science is often very highly specialised, results are subject to numerous qualifications, and most scientists will tell you that science itself is inherently uncertain. Scientific uncertainties might be generated by historical gaps in the data, restrictions with adopting updated algorithms in new technology, socio-political interventions into which kinds of scientific research is funded, and so on.[10] Degrees of certainty can be reached, with some certainties more possible to reach than others, and this is work of immense value in risk mitigation. For example, that Gamba grass is a dangerous weed that can spread across the entire northern savannah; and, the modelling that shows where flood-risk is greatest, and where prescribed burning is best targeted. But to promulgate or expect certainty from science, and the linear translation of this into more certainty in risk-mitigation decision making, is completely unrealistic.

THE PROBLEM-KNOWLEDGE MATCH

In all the case studies there was a recognised need for engagement with a much broader range of expertise than just quantifiable 'physical' science. In the Barwon-Otway case study, the practitioners generated their own social science data on sense of place and community resilience. In the Hawkesbury-Nepean case study, more formal social science was recruited. However, the problems facing the practitioners require more than just adding social science to science. What is needed is an unsettling of our very understandings of these disciplines as part of re-thinking how we define and use knowledge. This re-think is already well underway in academia in response to the complexity of environmental issues arising out of the industrial revolution, and is work of high relevance to natural hazard risk mitigation. The re-think challenges us to move beyond expecting scientific information to produce a managerial solution, to directly acknowledging that in many situations "facts are uncertain, values in dispute, stakes high and decisions urgent".[11] This includes acknowledging that there may be more than one solution to a problem, or no solution at all. Some have called this re-think 'post-normal science'. It begins by first looking to understanding, defining and formulating what we think the problem actually is, before considering how to respond to it.[12]

Critically, this re-working of our knowledge traditions reveals that there are always multiple perspectives about a given problem, context, and solution. Multiple perspectives, or subjectivities, are common territory for social science research into human values. What holds true for an individual, group or sector, may or may not be shared with others. Thus, there can be no single 'knowing' of anything, including natural hazard risk. There will be multiple perspectives from within and between diverse individuals and groups, including scientists, at-risk populations, practitioners, and so on. Indeed, human values have always been part of the natural and physical sciences themselves. For example, the influence of seventeenth century Christian theology on the 'balance of nature' assumption in biology and ecology, which in the twentieth-century was replaced with a dynamic focus on energy flow.[13] Science has an internal logic, but it is also about trajectories and values.[14] Across the diversity of normal science methods there will be decisions to be made about: which questions are pursued; which uncertainties are ruled in or out of the scope; what standards of proof are needed; and, which arguments are made more forcefully. We also see human values in the types of sciences that attract funding, the professions that are held to be the most prestigious, and, the scientific results that are most readily accepted by others.

The normal science paradigm strives for objectivity, but can only partially achieve this, because this knowledge creation has always been a very human activity. Post-normal science continues to conduct methodical, evidence-based research, but by also engaging with its inherent subjectivity, this research is more robust and rigorous. It can be argued that bringing multiple subjectivities together can only increase uncertainty, but what it does facilitate is a partial-objectivity that stands up better under interrogation. Our research shows that, and as many scientists will attest, even the most sophisticated scientific attempts to get closer to reality can just generate more uncertainties. If you try to avoid this complexity, or simplify it or gloss over it, the uncertainties will persist and present themselves again, possibly when least welcome.[15] Unfortunately, there are risks associated with acknowledging uncertainty and subjectivity; chiefly the dismissal of scientific results and methods because they do not produce the anticipated hard evidence.

The influence of the re-think of our knowledge foundations has been profound, however technical-managerial approaches continue to dominate the decisions of experts and policy makers when addressing complex socio-ecological issues. To reiterate, in our research there were many examples of how practitioners understood that 'counting' through quantifiable methods produced 'hard data' that 'made things count', providing further opportunities for analysis – such as simulation models; and how these valuable options were not similarly possible through qualitative research results. It was also evident that the use of other sources of knowledge – such as intuition and local knowledge - was appreciated as being less legitimate than researched based knowledge. Whilst considered integral, essential, and indeed irreplaceable; at the same time it was apologised for, disparaged or marginalised for not carrying the authority of knowledge arising out of formalised methodologies. There were varying understandings across the case studies about how these attitudes were based in socio-cultural norms held more broadly in society.

The Hawkesbury-Nepean Taskforce is an example of both articulating a multi-world perspective and embracing it. They have understood that science is not enough on its own, and that they need to bring to bear multiple kinds of knowledge to deal with the complexity of flood hazard management in the Hawkesbury-Nepean catchment. They accept that all knowledge (scientific or otherwise) is partial and provisional and interpreted. They are now considering how to widen this discussion and the multi-world perspective to a broader range of stakeholders. However, this broader group has an even more diverse range of worldviews. This will provide many additional challenges as they work towards implementation of flood management adaptations. It will require embracing diversity at a new level.

CONCLUDING DISCUSSION

Natural hazard risk mitigation occurs within an intrinsically uncertain context. Practitioners work with multiple uncertainties that all interact with each other, including: the science, each unique natural hazard event, the identification of at-risk values, socio-political priorities, and climate change. These uncertainties are interlinked, and their interaction generates new uncertainties. Practitioners, scientists and many others appreciate this uncertain context. Politicians and other leaders in society need to help change societal expectations about what is possible through natural hazard risk mitigation. The assumption that natural hazard risk is 'governable' with the support of scientific methods should be made redundant – whether that is achieved through persuasive argument with or without the partially objective evidence. Otherwise, impossible expectations are placed on the science, whilst practitioners are left with gaps in what they also need. Perhaps the most invidious expression of societal expectations of certainty is the harsh treatment that practitioners receive in the cycles of blame and inquiry that follow catastrophic natural hazard events. Publics and policy makers who do not consider the many 'ungovernable' aspects of risk mitigation, subject practitioners to inquiries and media scrutiny based on their own unexamined expectations about certainty.

If scientific methods and evidence neatly provided straightforward risk mitigation answers, and we all lived in a world where decisions were then made based on this science, then we would be having a very different conversation. But we do not, never have and we never will live in such a tidily governable and knowable world. This is more than evident with what is happening up North. By not addressing Gamba grass today, it is highly certain that Australia will have a new catastrophic fire landscape in part of the northern savannah. The science is clear but the socio-political will to respond is missing.

Whilst the findings from our three case studies are still being synthesized, we have summarised the following conclusions:

- Automatic assumptions about the kind of expertise needed for risk mitigation are generally counterproductive. Privileging one area of expertise works against hazard management.
- Science is not just working with uncertainties, what actually *is* science is also permeable and unstable. In all the case studies, there were clear divergences in how practitioners identify where the science begins and ends, and where other types of knowledge are brought in.
- Uncertainty and complexity about expert knowledge and the world needs to be embraced (for example, in operations and in standards), but not exploited. Being upfront about scientific uncertainty decreases the risk that important scientific results and methods are dismissed or manipulated by other agendas.
- The world is not just more complex than we think, it is more complex than we can think.

So, what can we do?

1. We need to engage with broader perspectives to more fully understand the problem and then engage with multiple kinds of knowledge and expertise in developing solutions.

2. We need to keep interrogating how different knowledge sources are judged and evaluated in society, to ensure that we have the best information at hand.

3. Sector leaders need to keep critically reflecting on what is 'normal', and provide greater support for innovation. The influence and inertia of the status quo should not be underestimated.

4. We need to lose the emphasis on certainty in research, policy, practice, operations, inquiries, the media and so on; and, accept complexity instead of glossing over or avoiding it. New language and conceptual approaches such as 'resilience' are doing this.

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REFERENCES

[1] Rayner S, Lach D and Ingram H. 2005. Weather forecasts are for wimps: why water resource managers do not use climate forecasts. *Climatic Change*, 69: 197-227; Morss RE, Wilhelmi OV, Downton MW, et al. 2005 Flood risk, uncertainty, and scientific information for decision making: lessons from an interdisciplinary project. *Bulletin of the American Meteorological Society*, 86:1593-1601; Neale, T. 2017, Burning anticipation: wildfire, risk mitigation and simulation modelling in Victoria, Australia, *Environment & Planning A,* 48(10): 026-2045;

[2] Morss RE, Wilhelmi OV, Downton MW, et al. 2005, Flood risk, uncertainty, and scientific information for decision making: lessons from an interdisciplinary project. *Bulletin of the American Meteorological Society* 86:1593-1601

[3] Neale, T. 2017, Burning anticipation: wildfire, risk mitigation and simulation modelling in Victoria, Australia, *Environment & Planning A* 2017, 48 (10):2026-2045; Neale, T, Weir, JK & McGee, TK, 2016, Knowing Wildfire Risk: scientific interactions with risk mitigation policy and practice in Victoria, Australia, *Geoforum*, 72:16-25.

[4] Neale, T. 2017, 'Are we wasting our time?': bushfire practitioners and flammable futures in northern Australia, *Social & Cultural Geography,* 1-23, http://dx.doi.org/10.1080/14649365.2017.1285423.

[5] Wodak J and Neale T. 2015 A critical review of the application of environmental scenario exercises. *Futures* 73: 176-186.

[6] Mitchell, T 2000, The stage of modernity', in T Mitchell (ed.), *Questions of modernity*, University of Minnesota Press, Minneapolis and London.

[7] Turnbull, D, Reframing science and other local knowledge traditions,1997, *Futures* 29(6):551-562.

[8] Allison, HE & Hobbs, RJ 2006. *Science and Policy in Natural Resource Management: Understanding System Complexity,* Cambridge University Press, Cambridge.

[9] Neale, T. 2017, 'Are we wasting our time?': bushfire practitioners and flammable futures in northern Australia, *Social & Cultural Geography,* 1-23, http://dx.doi.org/10.1080/14649365.2017.1285423.

[10] Neale, T, and JK Weir, 2015, Navigating scientific uncertainty in wildfire and flood risk mitigation: a qualitative review, *International Journal of Disaster Risk Reduction*, 13(3):255–265.

[11] Ravetz, J 1999, 'What is Post-Normal Science?' *Futures*, 31:647-653. Page 649.

[12] Allison, HE & Hobbs, RJ 2006. *Science and Policy in Natural Resource Management: Understanding System Complexity,* Cambridge University Press, Cambridge.

[13] Egerton, FN, 1973 'Changing concepts of the balance of nature', *Quarterly Review of Biology* 48: 322–350. Page 330.

[14] Tadaki, M, Salmond, J, Le Heron, R and Grierley, G, 2012 'Nature, culture and the work of physical geography', *Transactions of the Institute of British Geographers,* 37(4):547-562

[15]Ang, I, 2011, Navigating Complexity: from cultural critique to cultural intelligence, *Continuum* 25, 779–794