Classifying and Systemising Uncertainty and Instability – a Dynamic social Network approach to Risk

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The narrow and probabilistic, ergodic approach to risk, to date, has potentially not fully understood or incorporated the dynamical synthetic ecology in which our systems actually operate. A dynamic synthetic ecology made even more complex and potentially uncertain and unstable through the degrees of socio-info/techno connectivity we now enjoy compared to 30 years ago. This means our decisions and solutions are often deeply entangled in ways that it is almost impossible to measure. Yet Risk Management continues to call for measured certainty based upon a potentially increasingly narrow and frozen understanding of Risk – usually 'taken' at the unit / operational but not the systems level. In this paper, we look at uncertainty and instability as being connected but not necessarily synonymous indicators of risk. In terms of instability, we look to classify different types of instability that a system may face including, for example, technical risks introduced through disruptive technologies.

Keywords: *ergodic, synthetic ecology, instability, uncertainty, socio-info/techno, instrumentation.*

1. INTRODUCTION

> Fire scientists and managers recognized that *fire-adapted ecosystems* had been harmed by overzealous suppression, that growing fuel loads were exacerbating wildfire problems, and that restoring natural fire regimes should be a priority in fire management policy and practice. Nonetheless, despite changes in agency rhetoric and fire management policy over the last several decades, fire suppression continues to be reinforced through incentive structures, agency budgets, and professional practice *(Arno and Allison-Bunnell 2002)*. Instead of making ecological restoration the core of fire management practice, land management agencies are devoting ever greater resources to suppressing fires that continue to grow in extent and intensity *(Butler and Goldstein, 2010)*.

In this paper, we consider *classification* and *ecological* [system] *identification* (what are the systems we are looking at?) as being essential precursors to making and taking robust decisions regarding Risk, its measurement, instrumentation and management. *Instabilities* can lead to *uncertainty* – sometimes through shocks to the system, for example a *Physical Instability* such as an earth quake or Tsunami. These more *Complex Instabilities* (connecting a Tsunami with the siting of a Nuclear Power Reactor for example) need to be understood and factored into any adequate measurements of risk, so that the *uncertainties* (in any measure of risk) can be properly and adequately understood. This, in itself, provides for a more dynamical and resilient understanding of risk than potentially has been the case hitherto – and so may act as an *aid* to improved decision making and taking.

From classification and identification of the systems we are seeking to address we consider how, rather than measuring and *metricating* risk as a static singular No., we may *instrument* risk and devise models that can provide a dynamical (non-ergodic) and *non-obtrusive* means of assessing risk. By *instrument*, we mean creating network models of the system that can act like a petrol gauge in a car, to give managers good *indicators* and *warnings* of system health and therefore its ability to identify and manage risks over time, not simply in time, in which we consider, after ATL (2007); Ford et al (2009) and Reay Atkinson (2011a), instrumentation to be:

> 'The ontological modelling of dynamic system ecologies so as to identify what has occurred at different combinations and scales in order to synthesise, analyse, influence and / or control future socio-info/techno and info/techno-socio phenomenon, strategies and processes'

The *instruments* we propose are Dynamic social Networks (DsN) *(Uddin et al, 2012)* that represent a model – imperfect as it may be – of the *socio-info/techno (Reay Atkinson et al, 2012)* and *info/techno-socio (Reay Atkinson et al, 2011b)* systems we are often addressing, be they in the physical or cyber / virtual worlds in which increasingly we work, design, engineer and solve more complex problems. We also distinguish between *decision making* and *decision taking* (DMT) *(Reay Atkinson et al, 2014b)* and consider an alternative model for dynamically arriving at decisions that differentiates between *strong* control type signals and the *weaker* social signals of innovation, change and adaptation (Ansoff, 1975; Coffman, 1997; Granovetter, 1973; Hansen, 1999; Hiltunen, 2010; Hiltunen, 2008). Weaker signals often drowned out by the control measures put in place to minimise risk *(Reay Atkinson, 2011a)*! Instrumentation may also allow a company or organisation to understand the impact of uncertainty and instability on risk and so guide, steer or influence the organisation towards alternative equilibriums.

In this paper, we first introduce the concepts of instability and uncertainty we will be examining. We then develop the concepts for the synthetic ecology, as applied to political, economic assurance and instability models. We then suggest how these concepts and models may and will be applied as part of a wider informal investigation into the Blue Mountains Region in support of the Blue Mountains City Council, the people it represents and the wider region.

2. SYNTHETIC ECOLOGY AND IDENTIFICATION

> 'In 1770 Lieutenant James Cook, HMS Endeavour, saw something remarkable along Australia's east coast: the trees had "no underwood". On 1 May he "made an excursion into the country which we found diversified with woods, lawns and marshes; the woods are free from underwood of every kind and the trees are at such a distance from one another that the whole country or at least a great part of it might be cultivated without being obliged to cut down a single tree".' James Cook quoted in Bill Gammage (2011).

Bill Gammage's point is that in 1788, when British and European settlers first *colonised* Australia, there existed a *synthetic ecology* adapted to fire and managed accordingly, where we consider a synthetic ecology to be:

> 'a system (being or entity) that adapts, over time, by combining, through design and by natural processes, two or more dynamically interacting networks, including organisms, the communities they make up, and the non-living (physical and technological) mechanical components of their environment' (*Reay Atkinson et al, 2014a)*.

Similarly, the Pacific Biodiversity Institute[1] considers a *Fire Ecology* to be:

> 'A branch of ecology that focuses on the origins of wild-land fire and it's relationship to the environment that surrounds it, both living and non-living'.

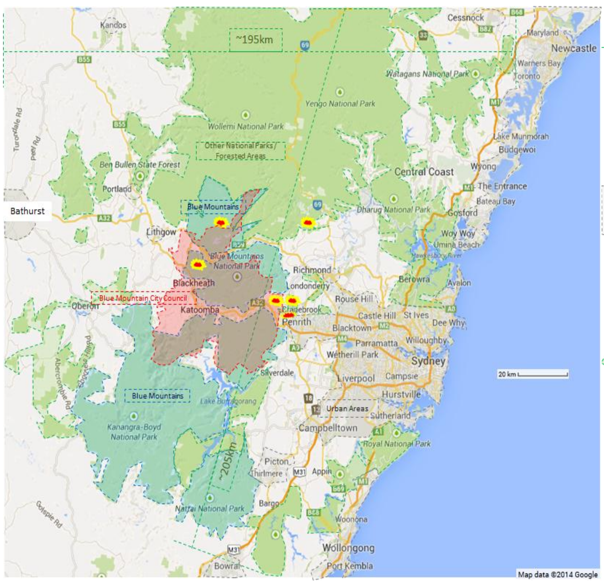
Today, 'the parks have gone…1788's controlled fire [undertaken by Aboriginal / Indigenous peoples] stopped when Europeans arrived. Today's bushfires devastate, and decimate species which

[1] http://www.pacificbio.org/initiatives/fire/fire_ecology.html

flourished during millennia of Aboriginal burning. In heath near Kiama (NSW), ground parrots needed fire every 3–7 years to balance food and shelter. In 1788 they got this, but after 1788 they got infrequent hot fires, and by 1968 had died out. …since 1788 at least 23 mammal species have become extinct, and since about 1940 almost a third of world mammal extinctions have been in Australia. Recognising how extensive such changes have been, to plants, animals and the land, is crucial to understanding how constant and purposeful 1788 management was' (Gammage, 2011).

In our research, we consider the Fire Ecology to be one part of the Synthetic Ecology that represents the 'Blue Mountains Region' (or Greater Blue Mountains Area) that forms the basis of this paper and its area of research. We use, by way of example, research[2] currently being undertaken (March-July 2014) by undergraduate students taking the ENGG 3853 Risk Management Tools and Techniques course at the University of Sydney. The second half of the course involves the students researching and developing an Ecological Fire Risk Register of the Blue Mountains. The study is based on the fires that occurred in the region of the Blue Mountains from 17 to 28 October 2013. The area called the 'Blue Mountains Region' is called so because, as temperatures rise, the oils of the different Eucalyptus species evaporate to create an aerosol haze or mist that appears blue to human eyes. It is also these oils contained within eucalyptus that create the fire ecology of the region and the Flammable Ecosystems identified by Bond and Keeley (2005) to include boreal forests, eucalyptus woodlands, shrub lands, grasslands and savannas.

The Blue Mountains National Park constitutes one part of the area traditionally considered as belonging to the 'Blue Mountains Region' and including also the Kanangra-Boyd, Wollemi and Nattai National Parks, see Figure 1. As seen by Figures 1 and 2, reproduced from Google Maps, the fires occurred both inside and outside the Blue Mountains National Park and the wider Blue Mountains Region, somewhat adding to the perceptual confusion at the time and during recovery. Considering the roughly 44,500 square kilometres / 4.45 Mega Hectares (MHa) – or 16,864 square miles / 10.9 Million Acres – shown by Figure 1, about 2 MHa (45%) is forested / National Park of which approximately one third (0.7 MHa / 15% of the Map) constitutes the Blue Mountains Region, see Table 1. Put in perspective, the area covered by the map shown in Figure 1 is over twice the size of Wales and the forested / rural areas are about the same size as Belgium.



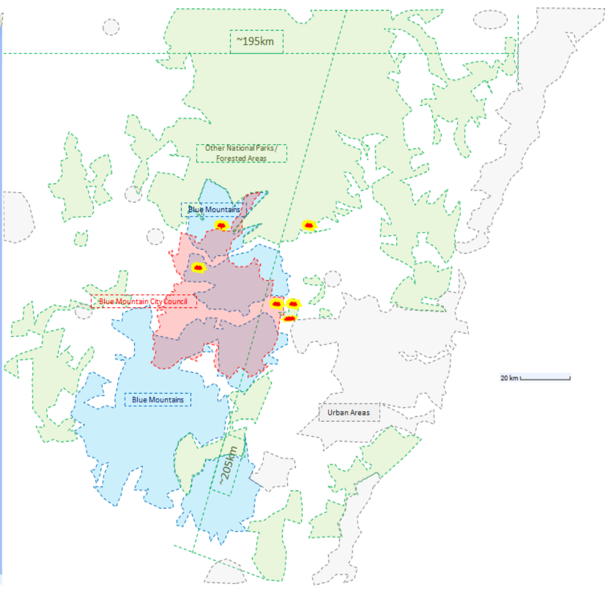


Figure 1 – (LHS) Map of the Region showing major seats of Fire *(Map Data @ 2014 Google)*
Figure 2 – (RHS) System Ecological Map of the Region showing National Parks / Forested; Urban and Rural / Agricultural Areas in addition to the Blue Mountains City Council.

From the main seats of the fires, shown in Figure 1, it will be seen that while two fires were within the Blue Mountains National Park; one was in the Wollemi National Park and three were in the Penrith region. Similarly, three of the fires were within the area covered by the Blue Mountains City Council,

[2] This is a new concept for research as part of a course and undertaken at the undergraduate level – taking research into the wider ecology and considering it as a dynamic.

two of them were in adjacent urban council areas and one was outside both the Blue Mountain Region and City Council. Yet the perception from news coverage of the event was that the Blue Mountains, as a whole, were 'up in flames' and, consequently, 'not open for business'. Although important for minimising traffic to the fires (and so-called disaster tourism), it was a bit like closing the countries of Wales or Belgium as a result of five or six relatively well identified and located fires! As a result, the economy of the whole region suffered as bonified tourists stopped coming.

Table 1 Synthetic Ecology of the Blue Mountains-Sydney Region

Physical-Socio Ecology	**Approx. Area (MHa)**	**Approx. %**
Maritime / Rivers / Lakes	0.9	20%
Urban	0.45	10%
Forested / National Parks (Blue Mountains Region) (Blue Mountains National Park)	2.0 (0.7) (0.27)	45% (15%) (6%)
(Blue Mountains City Council)	(0.143)	(3.2%)
Rural / Agricultural	1.1	25%
	4.45MHa	

Note 1: The Blue Mountains National Park, itself, covers about .27 MHa (6% of the Map); whereas the 'Blue Mountains Region', identified above, incorporates other adjacent National Parks to describe the area as a whole.

Note 2: The Blue Mountains City Council incorporates parts of the Blue Mountains National Park and essentially runs East-West along the famous vehicular routes that first opened up the hinterland of New South Wales to European settlers, early in the 19th Century.

3. UNCERTAINTIES AND INSTABILITIES: PREVENTION & RECOVERY

In this paper we consider *Instability* to be 'the quality or state of being *unstable* and / or the tendency to behave in an *unpredictable*, changeable, or erratic manner'. We further suggest that there are four different classes of instability that need to be understood when managing risk and which we consider to be the Physical, Human, Technological and Complex:

- **Physical**: e.g. fire, earthquake, tsunami;
- **Human**: e.g. war, politics, Global Financial Crisis; famine, social change etc;
- **Technological**: e.g. Cyber, ICT and, potentially disruptive technologies such as nanotechnology;
- **Complex**: some combination of Physical; Human, Social or Technological,(socio-info/techno or info/techno-socio) e.g. Morwell town disabled by the Brown Coal Fire.

Situating 'risk' in terms of an economy is clearly an imperative as has been seen when *recovering* shattered countries such as in Bosnia or Sierra-Leone. If people do not feel secure and safe – *assured* – they will not invest their time in the local ecology and will endeavour, naturally, to go somewhere else where they may be rewarded, see Gilpin (2000). We conclude, therefore, that the same applies to recovering local economies and regions from physical / human instabilities such as fire. 'Decision making and taking can be considered as the political element necessary to create the context in which decisions can be taken: politicking' *(Reay Atkinson et al, 2011c, 2012, 2014b).* This was coupled to the economy by Keohane and Nye (1972) who considered the 'Political Economy' and then extended to the 'International Political Economy (IPE)' by Gilpin (2000). Rather than the IPE, the more coupled Political Sûréte[3] Economy (PŜE) acting at both a Global and Local (glocal) levels or GPŜE[4] (pronounced gypsy) is suggested.

[3]Encompassing safety, security, assuredness (including insurance) and trust.

In this paper we consider the Freedman-Morgan[5] (*Freedman, 2009*) understanding of 'Prevent' being about preventing a hostile act / damaging event in the first instance through all other means short of the use of force, including the use of meaningful inducements and encouragement (influence, policies, laws and rules). Our model considers the management of three phases: Prevention; Engagement and Recovery (PER). Other four stage models exist, including Mitigate, Preparedness, Response & Recovery (MPRR) and Prevent, Prepare, Respond & Recover (P2R2). However, we consider that *engagement* incorporate response and that *mitigation* and *preparedness* are elements of recovery and prevention. Moreover, we also suggest that the ability to prevent, engage and recover is indicative of resilience, where we see: 'Resilience to be the ability of the *system* to transform, renew, and *recover* in a timely response to events' (Bryant, 2012). The aim of the PER Model is to move *agents* as quickly towards the Recovery phase as is possible, ideally without having to enforce and / or enact new laws. Yet having formal enforcement and legislative bodies available as an option to enable the recovery and prevention processes.

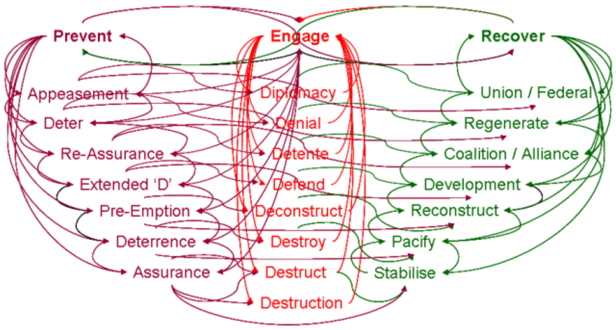


Figure 3: Prevent-Engage-Recover Model – 'The Rose Bowl' (Hemlock, 2012)

The Prevent-Engage[6] -Recover model, Figure 3, is not exhaustive and considers political options relating more to defence and security. It attempts to identify alternative connected-strategies that might be available to diffuse complex situations. There is no 'one size fits all but there are elements within the model that may be applied to recovery from complex instabilities. Specifically, the PER model recognises work by Gray (2003) and Luttwak (2001) 'that placed emphasis on the importance of strategic culture in *networked social processes* and which underpin planning, *decision-making* and so *decision-taking*: good decisions are not capability driven' (*Reay Atkinson and Goodman, 2008)*. Frequently we are presented with situations where decisions need to be taken and yet when there is *uncertainty* as to how best to proceed. In other words, there is more than one solution and we are dealing, potentially, with a complex problem. Uncertainty applies to probabilities, as in a Risk Register and to physical measurements that are already made, or to *known-unknowns*, *unknown-knowns* and *unknown-unknowns*. Specifically, we consider uncertainty to 'arise in partially observable, opaque, stochastic environments / non-ergodic (complex) ecologies, overly prescribed, ruled or controlled regimes as well as due to ignorance and / or lack of caring and shared awareness (or indolence)':

> In the formulation of a traditional Performance Assessment System (PAS) in the Occupational Health & Safety (OHS) area, most Performance Indicators (PIs) are affected by non-probabilistic *uncertainty* like the imprecision, the indefiniteness or the ambiguity, however, they are usually represented by deterministic values. This is mainly due to the inability of current PASs to adequately represent this kind of uncertainty. It is considered, however, that a good PAS must be able to deal with the uncertainty since this uncertainty is part of the models used to obtain the PIs and also part of data that support them. Generally, each PI is represented by a

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[4]Ascribed to Dr Jamie MacIntosh and Dr Simon Reay Atkinson, Advanced Research Assessment Group (ARAG), UK Defence Academy, 2007. ARAG is under Hansard's Parliamentary record as being the only UK Public organisation to have identified the potential of the Global Financial Crisis; its depth and duration some years beforehand.
[5]Distinction credited to P.M. Morgan, Deterrence: A Conceptual Analysis, Beverly Hills, CA: Sage Publications, 1977, ch. 2.
[6]This model, considered during the UK Strategic Security and Defence Review (SDSR) is implicitly referred to by General Sir David Richards, then Chief of General Staff in his letter to all [British] Army Commanding Officers, dated 29 Oct 09, in which he states inter-alia : 'Prevention will be a key element of British foreign policy in the years ahead and we in the Army will have a critical role to play in this. Whether we are training indigenous security forces to build their capacity to cope with violence and terrorism overseas or merely reassuring our allies that we are there to support them, we must be *prepared* to be *deployed* and *engaged* in *prevention* operations across the globe'.

number that is not able to represent uncertainty. The problem is how to overcome this situation or how to deal with data uncertainty *(Cavallare, 2013)*.

According to Lopes et al. (2013), the performance measurement (PM) process, involves three different activities: measurement, data record/transmission and performance measure determination. Each of these three activities can be made automatically (for example by a computer application), it can be made manually (i.e. it may depend on human tasks), or it may be a combination of both. All these activities can influence the results or values of any PM. Thus an unknown error or uncertainty is present in any PM *(Sousa et al., 2013)*. This uncertainty can be induced by several factors (Lopes et al, 2013), some of which are described in Table 2.

Table 2 Some Causes or Sources of Uncertainty in the Performance Measurement of Risk during the Prevention, Engagement and Recovery Phases, from (*Sousa et al., 2013*)

Phase	Factor	Description
Prevention	Physical	Changes to Vegetation
	Human	Changing Land Use, Human Error, Politicking
	Technological	Building Types
	Complex	Climate Change, extreme weather
Engagement with Fire	Physical	Communication Routes
	Human	Formal-Informal Networks (Federal State / Council / Rural Fire Service) Operational Response Time
	Technological	Media & Medium (IT, Cyber Communications, Twitter etc.)
	Complex	Safe Messaging, Water Availability
Recovery	Physical	Location / Extent of Damage
	Human	Rules, Regulations, Insurance, Politics, Lack of Competencies, Health, Knowledge Networks
	Technological	Building Designs & Classes
	Complex	Governance, Political Layers

To support this classification and systems analysis, we will apply 'cause-and-effect, Ishikawa or fishbone diagrams' developed in 1950 by the late Professor Kaoru Ishikawa, 'with a force-field analysis' to provide 'a diagram combining the restraining and driving forces…to assist in [system] diagnosis' (*Juran and Godfrey, 1999*).

4. HIC SUNT DRACONES (HERE BE DRAGONS)

The dragon-crocodile[7] possessed fire sticks. The rainbow bird would ask for fire, but was knocked back every time. The dragon had fire. No man made it. The dragon had had fire from a long time ago. Then the rainbow bird took the fire and put it everywhere. Every tree has fire inside now *(Isaacs, 1980)*.

[7] The Dream Time Story is of the crocodile itself a form of 'terrible lizard' or dinosaur which we might, in this regard, think of as the dragon in European or Chinese mythology. This story is paraphrased from Jennifer Isaacs (1980) compilation of stories under the title 'Crocodile took the Firestick', see also Fire and Rescue NSW, http://www.fire.nsw.gov.au/page.php?id=647 visited February 2014

We may, in some respects, be better thinking of the ecology of the region in terms not simply of its blue azure but also in terms of fire. Rather than simply being the Blue Mountains, the region might also be described as the 'Blue Dragon Mountains' (montes puteulanus dracones). The Blue Mountains *ecology* represents an *ecosystem* composed of dynamically interacting networks, hence our work to create a dynamical ecological fire risk register. The output will be a register designed and intended to scope these interacting organisms, and communities and their associated physical and technological networks and to provide an instrument for assessing them and thereby the future resilience of the region as a whole to cope with fire, recover from fire and prevent the excesses of fire in the future.

To undertake this research, we intend to take a *systems* level approach, looking at the whole *ecology* (of the Blue Mountains) and identifying the different types of networks interacting within it. This leads to *System Classification*, necessary as a first step to *identifying* the types of tools and techniques one will apply to manage the whole system. We have begun this process by developing some of the classifications in terms of instabilities and uncertainties we will be seeking to identify (assess and measure) as part of our research.

Building on the identified causes or sources of uncertainty, we intend to quantify them in different means for example applying probability or fuzzy theories to deal with subjectivity and Likert-type scales to allow experts or users to express their degree of importance/agreement of a given subject' *(Sousa et al., 2013)*. We intend then, by applying graph theory showing interconnected uncertainty sources and their dependencies, to convert this into a matrix. From this matrix, we can then develop individual levels of uncertainty about particular identified risks to the Blue Mountains Ecology. Our intention is to create a dynamic risk register and one that we can *instrument* – and so to show changing levels of risks and the uncertainties associated with their measurements. From these uncertainties, we can then examine reasons for them and potentially advise on actions that are increasing uncertainties – for example climate change leading to reduced opportunities for back burning leading to increased growth and fuel for fires – and so *instrument* the ecology.

Our aim is to create an *instrument* that enables us to better manage in particular the recovery and prevention phases so as to improve the resilience of the region as a whole and its ability to engage and recover from fires. Such an instrument would be an aid to better management – but may have considerable impact upon future governance arrangements and the way we do our business and politics. In other words, the instrument itself and the potential opportunities for industry it creates may enable a resilient future Knowledge Enterprise Economy (KEE) and export opportunities on a national and regional basis.

ACKNOWLEDGMENTS

The Blue Mountains City Council, the peoples of the region and the Recovery from Fire Programme, 2013- and the international and local charities from many different Australian cultures and religions who responded and gave so magnificently during and after the fires.

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