FireAUS: Bushfire Relative Risk Ratings

While previous scientific research has largely focused on the physical attributes of fires and their landscape-level impacts, *FireAUS* concentrates on *properties at risk* at the urban-bushland interface. This focus represents a paradigm shift for bushfire risk assessment, from hazard-centric to integrative risk assessment involving exposure and vulnerability analyses. The project develops *FireAUS* bushfire risk ratings at an *address level*, information that is important to property owners, the insurance industry, city councils and emergency services.

The project has comprised three major components:

(1) Learning from the past,

(2) Estimating property site-specific attributes, and

(3) Developing tools to enable the calculation of bushfire risk ratings efficiently.

We began by exploring property damage data from three extreme historical fires. The 18 January 2003 Canberra proved a useful benchmark given a fire out of control, a community ill-prepared and large-scale evacuation leaving homes undefended. We also managed to find useful data for the 7-8 January 1994 Sydney bushfires, and the 16 February 1983 "Ash Wednesday" bushfires in Victoria and South Australia. Main findings are:

- The maximum distance at which homes are destroyed is typically less than 700 m.
- The probability of home destruction emerges as a simple linear and decreasing function of distance from the bushland but with a variable slope.
- The collective data suggest that the probability of home destruction within the first 50 m of the forest edge is about 60%.

Figure 1: Damaged areas from the 7-8 January, 1994 Sydney bushfires in Como-Jannali

Property survival during bushfires can be seen as a local process, with site-specific attributes such as surrounding tree cover important. We calculated a series of attributes that are physically-based and quantifiable, including shortest distances between property addresses and the first row of properties immediately adjacent to bushland, surrounding tree coverage, local aspect and slope. To obtain these variables, we used the most detailed geospatial data sets available, such as geocoded street addresses, 0.6 m spatial resolution satellite images, and 5 m resolution digital terrain models. These variables feed into a multi-criteria decision tool to calculate a composite Risk Rating for each address.

A set of in-house programs has been developed to facilitate the analyses described above. These allow us to replicate our methodology for other study areas in a very cost-effective and semi-automated manner. These tools allow:

- Delineation of bushland-urban boundaries
- Identification of the first row of properties adjacent to continuous bushland
- Calculating the shortest distance between addresses and bushland at any direction
- Discriminating trees from other ground objects
- Aspect and slope determinations
- Extracting site-specific attributes (e.g., tree density, aspect) at any prescribed radii and orientations

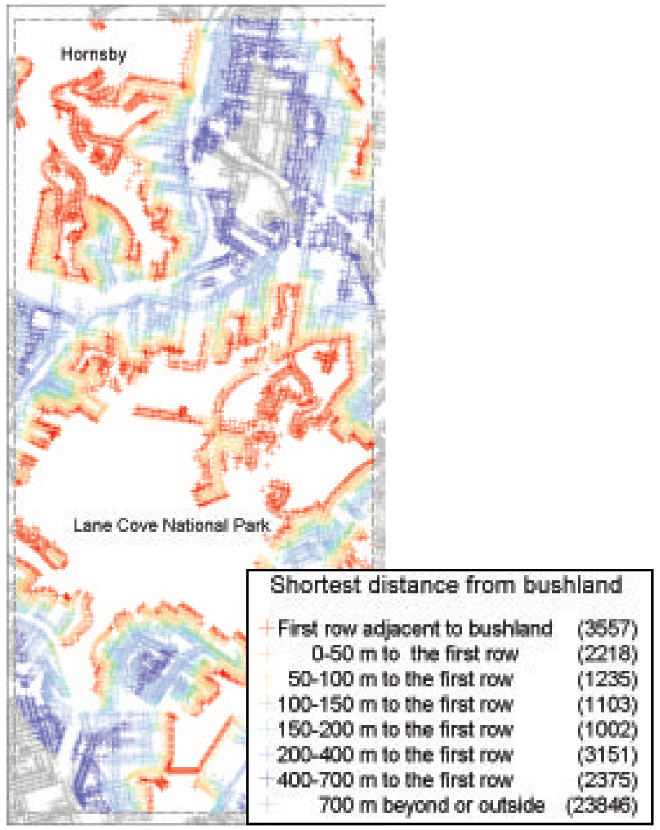

Figure 2: Shortest distance between property addresses and nearby continuous bushland

Final deliverables include maps and relative risk ratings for individual addresses.

Risk Frontiers has completed studies for a few bushfire-prone areas in the Greater Sydney region, and aims to expand this more widely.

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Tsunami – the Underrated Hazard!

Tsunami (often called 'tidal waves') are a significant and destructive hazard for many coastal areas of the world. They may be generated by undersea earthquakes, volcanic eruptions, coastal or undersea landslides and by asteroid and meteorite strikes into the ocean. The vast majority of all known tsunami have occurred in the Pacific – a reflection of the presence of the great "Ring of Fire". However, really big tsunami have also occurred in the Atlantic Ocean, Mediterranean, Black Sea and the Caribbean.

Recent tsunami have caused massive loss of life, destruction to coastal urban infrastructure and lifelines and resulted in significant interruptions to normal economic and business activity. The 1998 Papua New Guinea tsunami, for example, drowned nearly 3,000 people. The 1993 Hokkaido, Japan event destroyed more than 400 homes, the entire harbour infrastructure of Aonae and damaged coastal lifeline facilities. It was over a year before normal activities were finally restored to Okushiri Island and its communities.

The area affected can be impressive. For example, the tsunami that accompanied the 1883 eruption of Krakatau volcano in Indonesia flooded to distances inland of more than 3 km. This tsunami also drowned more than 36,000 people. Even closer to home, recent geological work in Western Australia has revealed that 6,000 years ago, a tsunami flooded inland to distances of 30 km!

Small tsunami occur quite regularly at the rate of around two per year and flooding to heights of 1 or 2 metres above sea level. About once a decade (and often in the Pacific) a large tsunami occurs, flooding to heights of 10 to 20 metres above sea level. Megatsunami flood to heights greater than 40 metres. It is not clear how often these occur; however, during the last 3,000 years or so, at least five megatsunami in different parts of the world are known, with the most severe taking place in Alaska in 1958. In this case, a large earthquake triggered the collapse of half a mountain side into a narrow inlet on the southwest coast. The resulting tsunami flooded to a height of 565 metres above sea level stripping the forest off hill slopes and eroding the soil down to solid bedrock!

With increasing coastal populations, infrastructure and insured assets, we should be concerned about the tsunami hazard. Increasingly, research is demonstrating that for all the coasts studied, the frequency and size of tsunami have been underestimated. This finding has special significance for Australia where the historical record is short. For correct assessments of potential losses, work needs to be undertaken looking at those areas at greatest risk.

The vulnerability of coastal infrastructure and people to tsunami damage is dependent on a complex mix of factors that vary in time and space. The Risk Frontiers Seminar Series 2004 talk will introduce a new tsunami vulnerability assessment approach called the "Papathoma Method" and demonstrate its application to two coastal areas in Greece: Herakleio, the capital city of Crete and the south shore of the Gulf of Corinth – both important regions of industrial, residential and tourist activity. The method makes heavy use of GIS technology. Lessons for at-risk communities in Australia will be extrapolated.

Photo of 1957 Aleutian Islands tsunami flooding a Hawai'ian beach

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A Volcanic Loss Model for Auckland

Auckland, New Zealand's largest city and fastest growing Region, has more than 30% of the New Zealand population. It is also home to over one third of New Zealand businesses, the nation's largest cargo port and the busiest airport.

Centred on Auckland city is the Auckland volcanic field (AVF) containing approximately 50 small-volume volcanoes. A characteristic of the AVF is that each event occurs at a new position and may involve multiple eruptions from a number of locations. The most recent occurred around 750 years ago creating a 25 square kilometre island of lava and large thicknesses of ash that extended much further. A future eruption of this magnitude could occur at any time and would significantly impact the national economy.

Potentially even greater risks are posed by the very large volume volcanic centres in the central North Island. Ash falls from these centres have covered the region in the past to thicknesses exceeding 60 cm and, despite being some 200 km from their source, Auckland has even experienced pyroclastic flows. A repeat of the 180AD Taupo eruption, regarded by volcanologists as one of the largest known eruptions anywhere in the world, would result in significant losses over the entire Region and the total destruction of smaller cities and towns closer to the volcano.

With this in mind, Risk Frontiers has been developing a probabilistic volcanic loss model for the Auckland Region. It considers potential eruptions from both the local field and the much larger distal volcanic centres. The first stage of this model, which will be used to calculate expected losses to residential buildings as a result of ash fall, will be completed shortly. It comprises three components.

Scenario module

Physical characteristics of simulated events – location, magnitude and style – are simulated using Monte Carlo techniques. Parameters are sampled from probability distributions describing attributes of previous eruptions including the spatial interdependence of past eruptions in the local AVF. Scenarios may be generated for individual eruption centres or for every centre potentially impacting the Region. The frequency of events impacting Auckland local and distal has been estimated from ash layers preserved in cores extracted from eruption craters within the Auckland volcanic field. As not all past events have been preserved, we also examined geological evidence from nearer to the eruption sources and considered present day wind conditions.

Ash fall module

A database of potential ash fall dispersal patterns affecting Auckland has been created using an ash dispersal model. This database represents the range of eruption volumes, column heights, grain sizes and wind conditions likely in a future eruption. For each modelled event, scenario characteristics are considered and an appropriate ash dispersal pattern selected.

Residential building loss module

Building vulnerability is also important. A building survey of some 1600 buildings within Auckland has been conducted. Data collected included construction materials, roof and wall coatings, roof design and slope, height above ground and the presence of vulnerable elements such as satellite dishes and air-conditioning units. This sample has been interpolated to approximate the characteristics of every residential building within the Auckland Region. This information is combined with ash thicknesses from the ash fall module, historical experience and valuation data to determine likely losses for individual simulations. Outcomes are statistics relevant to the insurance industry.

Future developments

The next step is to consider lava flow and base surge as these hazards are expected to generate the next largest losses after ash fall. In fact, they will destroy almost everything in their path! The extension of the model to deal with likely commercial and industrial buildings losses will follow. Business interruption and human losses may also be investigated.

Ash fall damage from Tavurvur volcano, Rabaul, Papua New Guinea 1994

Five of the 49 Auckland volcanic field volcanoes underlying Auckland

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Terrorism – Natural versus Manmade Disasters

The Australian Terrorism Insurance Act 2003 established the Australian Reinsurance Pool Corporation to provide a basis for cover for acts of terrorism on Australian soil. Its aim is to provide a facility for terrorism risk to be transferred until the insurance industry becomes able to insure this risk. The Bill requires insurers to provide cover to commercial insureds on a compulsory basis wherever cover has been provided for property or business interruption.

Natural disasters include tropical cyclones, earthquakes, floods, hail, bushfires, tsunami, meteor strikes, drought, ice storms, windstorms and landslides. Man-made disasters can include large fires, building collapses, oil-spills, landscape modification causing landslides, gas leaks, large-scale theft or heist, transportation accidents, explosions and terrorism. For the majority of these man-made disasters, cause is accidental. Terrorism is different: while terrorism is a man-made peril, it is also intentional.

Fully stochastic catastrophe models involve the development of a database of potential events, each event having a given probability of occurrence. With terrorism, a similar approach is problematic since the probability of an event of a particular nature is unknown.

A probabilistic model can be thought of having three components: the "where", the "what" and the "when". As shown in Table 1, the where and what can be defined in a similar way to those for a model of natural perils.

	Tropical Cyclone	Terrorism
Where?	Category 5 hurricane crosses over Philippines	Two ton truck bomb detonates at United Nations
What?	Wind speeds at each distance from eye cause given levels of damage, leading to financial and human loss	Shock waves and fire cause damage at each distance, leading to financial and human loss
When?	Based on historic records and scientific analysis, this event is expected once every 250 years.	??? Human behaviour ???

Table 1 – Where/What/When of terrorism modelling

Again for terrorism and for a number of reasons, the when cannot be estimated:

- There is no database of historic terrorism from which to accurately estimate statistics and identify trends for Australia.
- Terrorists can seek to attack at the most vulnerable location and time, and aim to cause maximum damage and casualties. Although Mother Nature can be deadly, she is not known for being spiteful.
- It is not appropriate to model the occurrence of a terrorism event using a Poisson process, the approach typically used in simulating natural perils.
- Terrorism is reactive – it is not independent of, and responds to, security activities or geo political events.

Although determining probabilities of terrorism attacks is not possible, we can still quantify the risk contingent upon an attack. This information is useful to insurers who may wish to determine:

- How their company risk compares with their peers
- The maximum event loss
- How much to charge for the retention
- Whether to retain the risk or not
- Whether to be in the Pool or use reinsurance instead

The Risk Frontiers Seminar Series 2004 talk will discuss a scenario-based model that can help insurers answer some of these questions and help determine relative risk premium rates by location (for example see Figure 1 below).

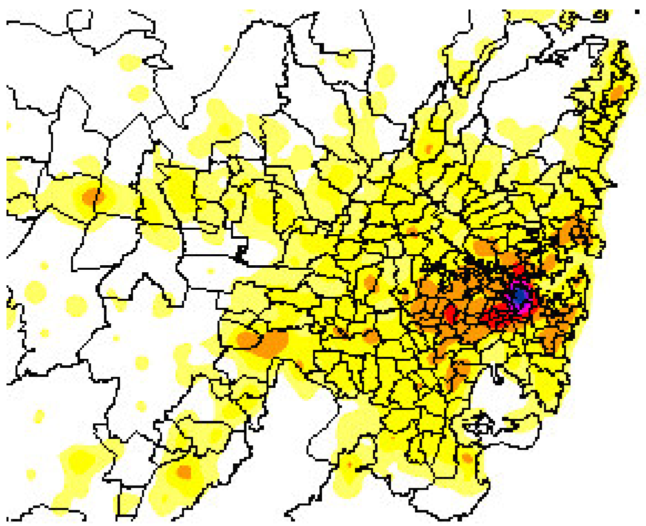

Figure 1 – Relative Terrorism Risk by Location - Sydney

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