University of Southern Queensland
Faculty of Engineering and Surveying

Applications of Geospatial Information Technology for Fire Risk Assessment and Management in NSW

A dissertation submitted by

Maree Wilson

in fulfilment of the requirements of

Courses ENG4111 and ENG4112 Research Project

towards the degree of

Bachelor of Technology (Geographic Information Systems)

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Abstract

The New South Wales Fire Brigades (NSWFB) is a premium emergency management organisation. The purpose of the NSWFB is to enhance community safety, quality of life and confidence by minimising the impact of hazards and emergency incidents on the people, environment and economy of NSW.

To do this, the organisation must ensure resources are positioned in appropriate locations to access incidents and correct equipment is allocated to each location to best protect the community. This study aims to produce a model to determine this distribution of resources based upon variables of fire risk that can be used for any fire region in NSW.

Risk is defined as a combination of the existing hazard and the potential for that hazard to become a risk. Research into risk from fire has been conducted in all parts of the world, however this research focuses mainly on the effect of bushfires on the urban interface. These studies give only general descriptions of the variables that affect the assessment of risk in a fire situation.

Few attempts have been made, either in Australia or overseas, to study risk in the context of urban fire management, separate from the rural-urban interface. Studies tend to focus on risk as a function of a particular hazard or event and few take the holistic view. This makes it difficult to link important details about the specific hazards unique to the urban environment relating to fire management.

The project aims to develop a fire risk model that may assist in the strategic location and allocation of dynamic and static resources for the NSWFB. This has been achieved using a GIS to spatially and temporally analyse and map variability of risk in 4 contrasting study areas in NSW. The chosen study areas and the results of the risk assessment are representative of other risk areas in Australia and the model may be extrapolated to cover these sites.

The study considers three variables of risk, namely Structural Hazard, Vulnerability and Likelihood. These variables were measured and modelled in four study sites around New South Wales. The study sites were selected based upon the unique characteristics of each in the variables of risk.

Data for each of the variables for each study site were collected and collated and risk maps compiled for each site. These were used to create a holistic fire risk model of NSW to identify regions where urban fire risk is highest. These results will be used in conjunction with NSWFB resource allocation procedures to best identify the allocation and location of new and existing resources. The study also provides the basis for further research into risk models in urban fire emergencies both in Australia and world-wide.

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ENG4111/2 *Research Project*

Limitations of Use

Certification

I certify that the ideas, designs and experimental work, results, analyses and conclusions set out in this dissertation are entirely my own effort, except where otherwise indicated and acknowledged.

I further certify that the work is original and has not been previously submitted for assessment in any other course or institution, except where specifically stated.

Maree Wilson

Student Number: 0050008206

Signature

Date

Acknowledgements

I would like to extend my thanks to my supervisor, Dr Sunil Bhaskaran of USQ, for his assistance and guidance during the construction of this project.

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Chapter 1

Introduction

The New South Wales Fire Brigades (NSWFB) is a premium emergency management organisation. The purpose of the NSWFB is to enhance community safety, quality of life and confidence by minimising the impact of hazards and emergency incidents on the people, environment and economy of NSW (NSWFB 2004). In order to protect the community, the NSWFB must respond and take control of incidents as quickly as possible. To do this, the organisation must ensure resources are located in appropriate locations to access the incident and correct equipment is allocated to each location to best protect the community.

To determine this distribution of resources, a model is needed. Currently, the NSWFB rely on a combination of local knowledge and basic data to determine the location and allocation of resources. This study aims to produce a model based upon variables of fire risk that can be used for any fire region in NSW.

1.1 Background and Rationale

Any definition of risk is particularly dependent on the field of study from which it is derived, which therefore provides a large array of definitions. A standard occupational health and safety definition of risk, for example, is that the "likelihood that death, injury or illness might result because of a hazard" (CCH 2002, p.215). Other, more general definitions, describe risk as the potential harm that may arise from a process or future event.

Risk is therefore defined as a combination of the existing hazard and the potential for that hazard to become a risk. In the case of fire, the potential for bushfires (also known as wildfires) is more easily determined than the potential for an urban fire. Bushfire hazards are measured by such variables as fuel load, moisture content, wind conditions and slope of the land. These variables enable bushfire outbreaks and burn paths to be predicted to some extent. Compared to bushfires, structural or urban fires are more random and dispersed, and do not follow a specific pattern of fire spread.

The need for intelligent resource allocation in both cases is very important, and the ability to create a model of risk management is imperative. A risk assessment model, when managed efficiently, provides emergency services with correctly located resources to ensure equitable coverage of the community and appropriate time frames for incident response.

An effective resource management plan is the desired outcome from a risk assessment model, in order to locate and allocate resources based upon a researched method and not just using local knowledge. The location of resources refers to the physical placement of static resources (such as fire stations) in such a location where they are of the most use to the community. The allocation of resources refers to the distribution of dynamic resources across the static resources of the NSWFB. Dynamic resources include people, fire engines, and equipment. An example of effective resource allocation is the distribution of an aerial appliance (where fires are able to be put out overhead) to a location with a large industrial presence. The use of an aerial appliance is limited in residential areas and therefore allocation to a station in such an area would not be an effective allocation of the resource.

In order to produce a risk assessment model, and therefore a resource management plan, certain geospatial information technologies can be of great assistance. Such technologies include GIS, remote sensing and GPS. GIS provides a suitable platform for emergency services to construct the risk assessment model in an environment where data entry from GPS and other sources is quite simple and easy to update. Remote sensing can provide additional data, including roof type, although its use is currently minimal.

These technologies are quite expensive, but it would be prudent for an emergency management organisation to work in conjunction with another government department (such as Natural Resources) for data sharing. The level and frequency of data required to compose the risk assessment model is minimal, so sharing the cost of data acquisition is an avenue to be considered. As data needs increase, so could the level of involvement in the agreement. This arrangement could also increase the use of temporal data as a factor in risk assessment.

1.2 Literature Review

Research into risk from fire has been conducted in all parts of the world. This research focuses mainly on the effect of bushfires on the urban interface. One such study investigated an integrated forest fire risk index for Europe. The variables of fire risk for this study were identified as the Normalized Difference Vegetation Index (NDVI) to calculate relative greenness, meteorological data to estimate dead fuels moisture content and fuel maps to estimate fuel loads (A. Sebastián-López, J. San Miguel-Ayanz & G. Libertà 2000). Similarly, Brenner et al. (2001) consider the variables of surface fuels, upper canopy crown closure, slope, aspect, elevation and potential weather. Both these studies are interested in modelling fire behaviour to determine the risk to the urban interface. The variables in these studies are typical of those used to assess risk in bushfires, and they are used in conjunction with structural hazard in urban areas to determine the risk at the urban interface.

Kamp and Sampson (2002) use the variables of home ignitability, fuel management and public policy to identify potential urban interface risk areas based upon population density. The inclusion of population density and home ignitability begins to touch upon the issues surrounding urban fire risk, however the source of the fire is external (bushfire) and not internal of the structure.

Brenner et al. (2001) used an integrated system of remote sensing and GIS to assess bushfire risk in Florida. This system is also utilised in Justice et al. (2003) where space-based fire monitoring is used to estimate bushfire danger, damage and post-fire ecosystem recovery. While this system is not directly applicable to urban fires, the use of GIS and remote sensing in fire management is very important. For example, remote sensing for urban fires is useful in determining structural hazards.

Research into bushfire risk is not the only emergency management study area relevant to discussion of fire risk management. Simonovic and Ahmad (2005) modelled flood evacuation emergency planning based primarily on the social aspect of the emergency management process. Flooding conditions and population variables were mapped to gain an understanding of human behaviour in an emergency and to facilitate better preparedness for such an emergency (Simonovic & Ahmad, 2005).

In Australia, the environment is prone to bushfires year-round, although summer remains the most vulnerable period (Cheney 1995). The widespread and spectacular nature of these events is a catalyst for a number of studies into the effect of bushfires on the urban interface. The identification of bushfire risks in specific areas of Australia are presented, such as those in South-East Queensland by Granger, Luxton and Berechree (2001). These risks are directly attributed to the location of structural property in relation to the urban interface. Ahern and Chladil (1999) created a model to predict the number of houses that could be expected to burn down when a fire breaches an urban area and calculated that 95% of urban dwellings destroyed by a bushfire were within 100m of the bush interface.

These studies give only general descriptions of the variables that affect the assessment of risk in a fire situation. Few attempts have been made, either in Australia or overseas, to study risk in the context of urban fire management, separate from the rural-urban interface. Studies tend to look at risk as a function of a particular hazard or event and few take the holistic view. This makes it difficult to link important details about the specific hazards unique to the urban environment relating to fire management.

1.3 The NSWFB Urban Fire Risk Model

Urban fire risk needs to be defined in accordance with the general definition and further defined by a number of variables. The variables that are involved in defining risk for this subject are numerous, however as this project is designed to assist the NSWFB in resource location and allocation, the variables chosen must be of a sufficient number to achieve the goal, but at minimum cost.

In the context of this project, risk is determined by a combination of the likelihood of the fire occurring, the community at risk from the fire and the structural hazards that contribute to the fire. This meets the general definition of risk by considering the hazard and the probability of the risk occurring. Due to the nature of urban fires, the probability of a fire occurring in any one building is almost impossible to determine, so the likelihood variable encompasses previous incident data to determine the pattern of behaviour.

These three variables were chosen based upon their contribution to overall fire risk and the ability of the NSWFB to acquire the data. Further discussion of the variables can be found in Chapter 2.

1.4 Project Aims and Objectives

The project aims to develop a fire risk model that may assist in the strategic location and allocation of dynamic and static resources for the NSWFB. This will be achieved by using GIS to spatially and temporally analyse and map variability of risk in four contrasting study areas in NSW, which after modelling will be representative of risk sites in Australia. The model may then be extrapolated to other sites.

The specific objectives for this study are:

- To assess and evaluate risk data in the four selected study sites
- To model spatial and temporal risk-related data to determine and map spatial and temporal variability of risk for the study sites
- To evaluate geospatial software for modelling risk variables, verify and interpret final results
- Provide recommendations for resource location and allocation.

1.5 Overview of Dissertation

This dissertation is organised as follows:

Chapter 2 describes the variables of risk for this study.

Chapter 3 discusses the selected study sites.

Chapter 4 discusses the methodology used to construct a fire risk assessment model.

Chapter 5 investigates the effectiveness of the risk assessment.

Chapter 6 concludes the dissertation.

Chapter 2

Variables of Risk

The variables selected to represent urban fire risk were chosen based upon their contribution to overall fire risk and the ability of the NSWFB to acquire the data. In accordance with the definition of risk in this study, the variables selected were structural hazard, community vulnerability and likelihood.

In addition to the variables discussed, other variables were considered for inclusion into the model. Such variables included population data for identifying areas with high numbers of teenagers which could contribute to determining where fire events may occur. This data, and others, were discarded as they did not contribute significantly to the outcome of the model.

Structural hazard refers to the physical threat of a fire occurring. Hazard categorisation distinguishes between residential and industrial properties, but not between individual building types (i.e. brick and timber). Community vulnerability identifies 'at-risk' groups in the community, such as the elderly, that would be most vulnerable to a fire event. Likelihood identifies previous incidents in an area to highlight any patterns or trends.

2.1 Hazard

No suitable existing data for the structural hazard variable of the model was available to the NSWFB, meaning that the data had to be collected through field work. A system was implemented whereby local station staff categorised the hazards for their region.

A common size of study area was created to ensure that hazard levels in each location were able to be compared to another. This was achieved by overlaying a 500m x 500m grid on each fire district. The grid squares were constructed by quartering the 1km squares of the Australian Mapping Grid.

The study area is assessed by two members who survey the area to be classified from a vehicle. The surveyors use a mobile GIS and GPS system to append the classification and data is either streamed live to the head office or through a laptop download when reception is not reliable.

The classification of the grid square is determined by whichever classification is deemed to be in the majority within the square. In the case of residential areas that have a couple of light industrial properties, the square will be determined to be residential as it is the predominant class. The hazard categories that can be assigned are detailed in Table 2.1.

GENERAL HAZARD TYPE	SPECIFIC HAZARD CATEGORY	MAP COLOUR CODE	BRIEF DESCRIPTION OF HAZARD CATEGORY
Special Hazard	Category 1	Red	A site that poses extreme hazards for people, property or environment, eg some hospitals & aged hostels, major LPG depots, chemical plants, oil refinery, etc
Intermediate	Category 2	Orange	May include some high hazard residential - but basically high hazard industrial / commercial occupancies with a high level of structural density within the grid
Hazard	Category 3	Yellow	May include some high hazard residential - but basically high hazard industrial / commercial occupancy's with low to moderate level of structural density in the grid square
Low (or Base Level)	Category 4	Dark Green	A fully developed area of residential and low hazard industrial/commercial occupancies
Hazard	Category 5	Light Green	A partially developed area of residential and low hazard industrial/commercial occupancies

Table 1 Hazard Categorisation (Source: NSWFB 2003)

This system is robust as it identifies areas with specific resource needs, and Category 1 sites are particularly noted. This method does not identify individual property characteristics such as the building materials used as survey of this data would take much longer and become out of date much sooner. It does provide a practical assessment of the properties in an area which assists with the allocation of suitable dynamic resources.

The process of categorising all of the NSWFB fire districts is continuing, with all districts expected to be completed by the end of 2005. This data will then need to be continually updated as urban areas continue to expand.

2.2 Vulnerability

The Department of Emergency Services (1998) publication, *Fire Fatalities: Who's at risk?* found that the people most at risk of dying from fires in the home were:

- People aged 65 years and over;
- Children aged between zero and four years;
- People not in the workforce (eg. pensioner, retired, home duties or unemployed);
- People living in rental properties; and
- Adults affected by alcohol.

With the exception of adults affected by alcohol, data on the demographics represented above is available from the Australian Bureau of Statistics (ABS), Census 2001. Data in this variable is restricted in its use due to the census collection districts used by the ABS. This model uses the assumption that the demographic characteristics of the census district are distributed evenly across the district.

2.3 Likelihood

The variable of likelihood is used to represent the probability of a fire event occurring in an area. Although the incorrect use of heaters is a commonly accepted source of home fires, it is impossible to predict the location of the next urban fire. Unlike bushfires, it is difficult to define specific physical characteristics of an area that could lead to a fire event.

In order to procure some data on this variable, data from previous incidents in an area was consulted. This historical data showed certain patterns emerging where incidences of fire activity were often clustered in an area of no particular structural type or vulnerability group. The reasons for this have not been investigated, however it is thought to be a result of increased numbers of teenage residents in the area or proximity to transport routes.

Likelihood data for this project was sourced from the Australian Incident Reporting System (AIRS). AIRS is a national incident reporting software that allows emergency services to input information about all incidents attended. In the case of the NSWFB, data is recorded into approximately 200 fields and includes:

- Incident ID;
- Alarm Time and Date;
- Incident Type;
- Property Address; and
- Property Use.

The above fields were chosen as the most relevant to the study as they give the necessary data to determine the location and type of incidents. Although the NSWFB has AIRS data for the past 20 years, due to the ever-changing urban environment in Australia, only data from the past 10 years has been included.

Data in this variable is restricted in its use by the accuracy and consistency of information provided by the attending fire station. While measures are in place to provide direction for completing an incident form, inconsistencies may exist.

Chapter 3

Study Sites

In order to create a suitable model of fire risk, four study sites in New South Wales were selected. The selection of these sites was based upon the availability of hazard data at the start of the project. From those areas available, the sites were chosen for a unique characteristic that could then be extrapolated to other areas with a similar characteristic.

The four study sites selected were Batemans Bay, Port Macquarie, Lithgow, and Campbelltown.

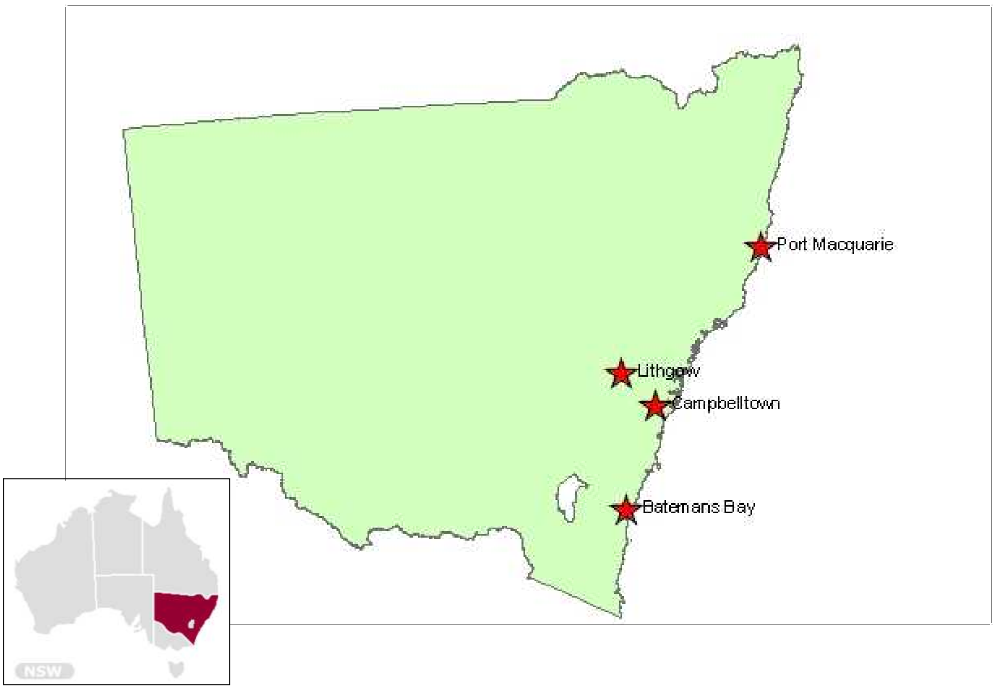

Figure 3.1 New South Wales study sites

3.1 Batemans Bay Site Analysis

3.1.1 Town History

Batemans Bay is located on the south coast of NSW, approximately 279km south of Sydney by road. Situated 160km east of Canberra, it is the city's nearest coastal town. The town was sited at the mouth of the Clyde River in 1859 to service the logging of the surrounding hills. The advent of the gold rush led to the decline of logging around Batemans Bay and the town stagnated until the early 1930s when Canberra's residents discovered its lushly forested mountains and pristine waterways.

Today, the commercial and retail hub remains at the site of the original village, located on a triangular sandflat, bounded on two sides by the Clyde River. While Batemans Bay is the largest town on the coast of NSW south of Nowra, it has retained a small-town atmosphere, and it has become a popular tourist resort and retirement town. Most of the area's fame is based on its environment, and its proximity to Canberra ensures the town's population triples during holiday season. The bridge crossing the Clyde was completed in 1956 and since then development has increased rapidly both on the northern shores of the river mouth and to the south towards Moruya.

3.1.2 Factors Influencing Inclusion in Study

Batemans Bay was included in this study for a number of reasons, including:

- Recent hazard data was available from the NSWFB;
- Hazard data consistent with small coastal town;
- Expansion to the north and south has meant that the town has outgrown the fire district;
- The area boasts an ageing population;
- There is a great fluctuation of population during peak tourist season, when the population of the town triples; and
- AIRS data showed a concentration of incidents, however a relatively small number when compared to other study sites.

3.2 Port Macquarie Site Analysis

3.2.1 Town History

Port Macquarie is located midway between Brisbane and Sydney on the mid coast of NSW. The town was originally settled in the 1820s and many historic buildings still stand today. Historically, it was the most significant town between Newcastle and the Queensland border, and although today it is rivalled by cities such as Coffs Harbour, it remains the major regional town for the area.

Port Macquarie is renowned for its sand dunes, coastal wetlands, floodplains and rugged mountains. Visitors flock to the town in holiday seasons to take in the view from Transit Hill along the coast and back into the hinterland. The town is situated along the state rail line, making it easily accessible for tourists.

3.2.2 Factors Influencing Inclusion in Study

Port Macquarie was included in this study for the following reasons:

- Recent hazard data available from the NSWFB;
- Hazard data consistent with large coastal town, including some Category 2 areas;
- Large population, including significant proportion of elderly and children under 9;
- No significant population from Aboriginal or Non-English speaking backgrounds; and
- AIRS data showed a concentration of incidents.

3.3 Lithgow Site Analysis

3.3.1 Town History

Lithgow is a medium-sized town located on the western slopes of the Blue Mountains. It is approximately 145km from Sydney and sits at an elevation of approximately 900m. The town is bounded by national park to the east and grazing properties to the west.

Lithgow was established as a town in 1837 after Blaxland, Lawson and Wentworth forged a route across the Blue Mountains. After the discovery of gold in Bathurst (1851), the town became the administrative centre for the area and experienced rapid growth. Since the early 1900's, Lithgow has been renowned for its fluctuating periods of boom and bust. The town boasts an unusual quality in that people that work in Lithgow tend to live in other towns such as Bathurst and the Blue Mountains.

This trend has been slowly changing with the advent of new estates on the northern side of town. In addition, the exorbitant housing prices in Sydney are forcing families to move further west and commute to jobs in western Sydney and the Blue Mountains. As Sydney continues to expand further westward, it is expected that Lithgow will become more and more populated.

3.3.2 Factors Influencing Inclusion in Study

The factors influencing Lithgow's inclusion in this study are:

- Recent hazard data was available from the NSWFB;
- Hazard data consistent with medium-sized inland town, including Category 2 area;
- Medium-sized population with good representation of population over 65 years of age and under 9 years;
- Significant portion of the population is unemployed; and
- AIRS data showed concentration of incidents, although relatively few compared to some other study sites.

3.4 Campbelltown Site Analysis

3.4.1 Town History

Campbelltown was once a small town situated an hour's drive to the west of Sydney. The population explosion experienced by Sydney has caused Campbelltown to almost become a suburb. Bounded by the Georges River and rolling hills, the town is a significant regional hub for the surrounding rural land.

3.4.2 Factors Influencing Inclusion in Study

The factors influencing Campbelltown's inclusion in the study are:

- Recent hazard data was available from the NSWFB;
- Hazard data typical of regional hub or outlying suburb;
- Hazard data includes some areas noted as extreme hazard;
- Population data shows high number of the population under years of age and a very small representation of the over 65 group;
- Relatively large percentage of persons from a Non-English speaking background, particularly compared to other study sites;
- Unemployment rates are present but not significant; and
- AIRS data showed a very high concentration of incidents.

Chapter 4

Methodology

The methodology undertaken to achieve the aim and objectives of the project involved:

- Meeting with staff at the NSWFB, data acquisition and extraction
- Determination of study sites
- Risk assessment of each of the study sites
- Recommendations – report
- Results and conclusions

To achieve the project aims and objectives, an arrangement was made for travel to Sydney to meet with the GIS staff at the NSWFB. The purpose of the visit was to become acquainted with the fire brigade's policy on risk and resource allocation. The three weeks spent working with the GIS staff was used to become familiar with their entire range of data sets.

The knowledge gained from the visit was used to acquire the necessary data which was then extracted and converted to an appropriate format. The determination of study sites in NSW was based upon this data, as discussed in Chapter 3.

The data analysis of the study sites was originally planned to be conducted using Model Builder software by Esri. The available suite of GIS software (Esri ArcGIS 8.3) did not however include this extension as part of the package.

Further investigation revealed that a model building software was not necessary as the desired output of the model was not one single figure but rather a rating of all three fire risk variables. The purpose of the fire risk model was to assist with the location and allocation of resources for the NSWFB. Each of the variables discussed have a different impact upon allocation and location and therefore they cannot be simply quantified into one "risk number". For example, hazard data is required to determine the allocation of dynamic resources so that the correct equipment is available for fires in the area. Conversely, vulnerability data has little to do with dynamic resources but is much more crucial when determining the location of static resources to ensure that response times by the brigade are kept to a minimum.

Each variable was therefore analysed individually to determine a rating of Very High, High, Medium, Low, or Very Low for the study site. The ratings for the three variables were determined as per Table F.1. The results of the risk assessment for the four study sites, in accordance with this risk rating are shown in Table 4.1.

Study Site	**Hazard Rating**	**Vulnerability Rating**	**Likelihood Rating**
Batemans Bay	Medium	High	Low
Port Macquarie	High	Medium	High
Lithgow	Medium	Medium	Medium
Campbelltown	Very High	Medium	Very High

Table 2 Results of risk assessment for the four study sites

Chapter 5

Effectiveness of Fire Risk Assessment

The fire risk assessment model that has been created in this study is a useful tool for the NSWFB to manage their resources more efficiently. There are a number of limitations to this model, many of which can be addressed with further study in this area. In addition, there are a number of recommendations that could benefit the NSWFB and any other emergency management agency that desires to construct a model of this type.

The hazard data being used in this model is very coarse and does not address individual property's fire characteristics. While it would be useful to have a classification for every dwelling in the urban area, it is not practical to collect this amount of data. Not only is the volume of data extremely large, it has a very short accurate time span as new dwellings are being constructed daily, and the general face of urban Australia is tending towards high density housing.

Hazard data is subjective due to the nature of survey undertaken. The operators of the equipment may decide that an area is fully residential based upon their observations but the area may contain high risk businesses that are not obvious from the street. In this instance, it is useful to employ the local knowledge of the area fire station or the local council.

The hazard and vulnerability data together are also limited due to the different spatial units they occupy. It would be impossible to classify census districts with the classification system currently in place as it would be more likely to omit minor differences in a large area. Similarly, it is not possible to get census data from the Bureau of Statistics in any other format.

The vulnerability data is also limited in that the data contained within each census district is assumed to be evenly spatially distributed. When mapping this data, large census districts are treated equally across the entire collection district when in fact it may be that the population is concentrated in one part of that area. This sort of skew is unavoidable but must be acknowledged before this model can be usefully employed.

The likelihood data is entered by the fire station staff who attended an incident. As there is human involvement in this process, there is some element of error attached to the data. In addition, fire brigades are often called to incidents of no fixed address, such as a vehicle on fire in a street. In this case, the operator must enter the street name but the street number is left blank. When geocoding, these addresses are not recognised by the program and are therefore assigned to a random location along the street (although usually the very end of the street). Due to privacy laws, the exact location of fire instances cannot be disclosed, however the rough location of the incident is achieved when geocoding. The misinformation from incorrect geocoding could lead to some incident data being attributed to the wrong area and therefore skewing the results from the model.

It is recommended that this model be further improved by the inclusion of more study sites. Such sites could include areas that have special characteristics so that a more comprehensive model can be constructed which will then have the capability to be extrapolated to all other towns in New South Wales and possibly further afield.

Chapter 6

Conclusions and Further Work

The management of location and allocation of static and dynamic resources can be achieved using the model presented. This will therefore assist the NSWFB to achieve their goals of enhancing community safety, quality of life and confidence and minimising the impact of hazards and emergency situations on the people, environment and economy of NSW.

6.1 Achievement of Project Objectives

The following objectives have been addressed:

Assess and evaluate risk data in the four selected study sites: Chapter 2 presented a summary of the variables of risk in this study, and Chapter 3 integrated these variables to evaluate risk in the study sites.

Model spatial and temporal risk-related data to determine and map spatial and temporal variability of risk for the study sites: Spatial variables of risk include hazard and vulnerability and temporal variability is examined in likelihood data.

Evaluate geospatial software for modelling risk variables, verify and interpret final results: The GIS suite used did not have the Model Builder component as an installation feature, however the derivation of a model to reduce risk to a single number or rank was found to be less desirable than first thought.

Provide recommendations for resource location and allocation: The constructed model has the capacity to provide recommendations for resource location and allocation. It is expected that the NSWFB will use this model for future planning and resource funding applications.

6.2 Future Work

There is the opportunity to further explore the variabilities of risk and to investigate the possibility of including other variables of risk. Some variables that might be considered could be the population of teenagers in an area which could contribute to the likelihood of a fire event occurring. This could also be cross-referenced with previous fire data to see if there is in fact a link between the two.

Another area in which future work would be beneficial would be the inclusion of the bush-urban interface into the model. This would add another dimension to the model that has not previously been explored and it could make more use of the international work that has been done in this area.

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Appendix A

Project Specification

University of Southern Queensland

FACULTY OF ENGINEERING AND SURVEYING

ENG4111/4112 Research Project
PROJECT SPECIFICATION

FOR: **Maree WILSON**

TOPIC: Applications of Geospatial Information Technology for Fire Risk Assessment and Management in NSW

SUPERVISOR: Dr. Sunil Bhaskaran

PROJECT AIM: To use Geospatial Information Technologies to assess and model fire risk in NSW.

SPONSORSHIP: New South Wales Fire Brigade

PROGRAMME: **Issue B, 24 October 2005**

1. Research risk and risk management in organisations (national and international). Focus on studies that define risk holistically. Define risk in the context of this study.

2. Study in detail the influence of different variables of risk, such as structures (hazard), previous incidents (likelihood), and number and type of people who may be exposed (vulnerability).

3. Conduct a site analysis on four contrasting fire regions of NSW and provide a brief description for the reasons of their inclusion in this study. Compare these regions for risk using hazard, likelihood and vulnerability.

4. Critically assess the advantages and disadvantages of the NSWFB risk model and include any problems, inconsistencies or upgrades identified in previous research that might be useful in future.

As time permits

5. Use Geospatial data for visualization of risk variations in the rural-urban interfaces of the same four study sites to determine hazard level for each and to determine limitations of this analysis.

6. Describe the effect of location in the rural-urban interface to overall risk.

7. Consider another factor of risk that has not been included in the previous model and conduct analysis on its suitability for inclusion into the model.

AGREED: _________________ (Student) ______________________ (Supervisor)

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Appendix B

Batemans Bay Images

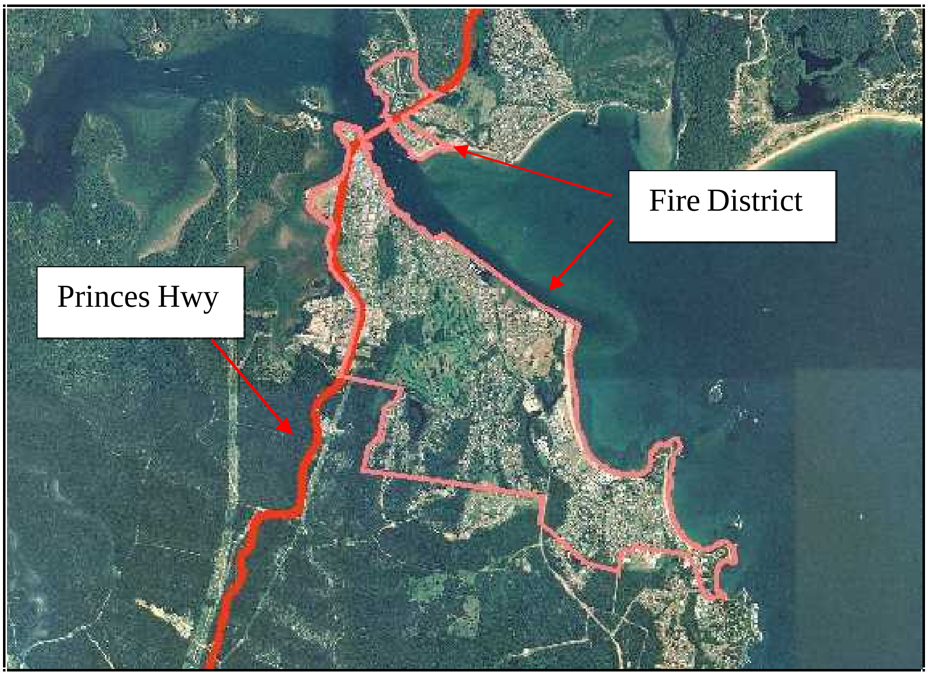

Figure B.1 Satellite photograph of Batemans Bay area showing Princes Highway and the NSWFB Fire District

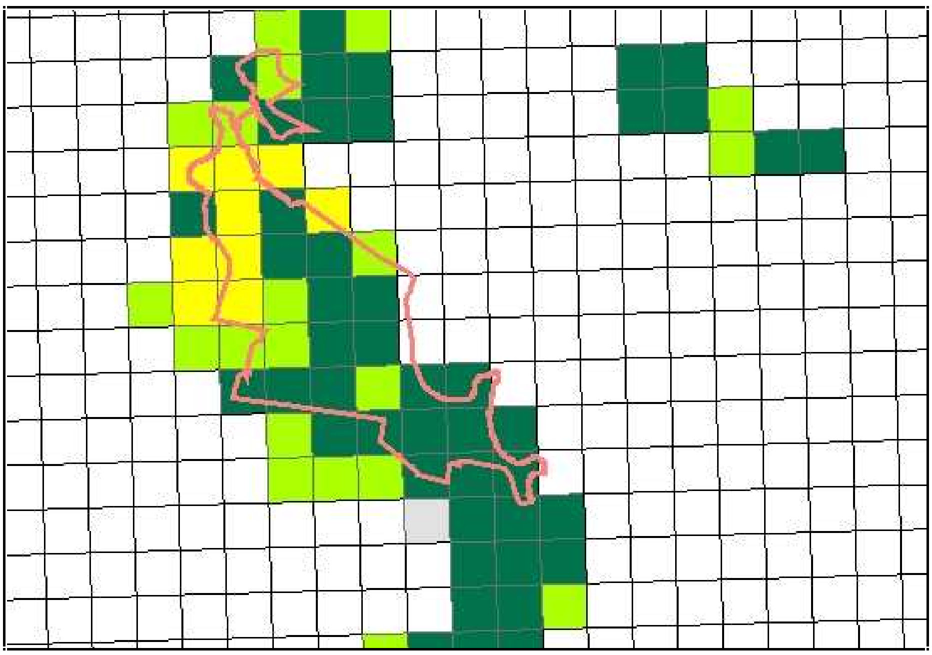

Figure B.2 Hazard categorisation for Batemans Bay area

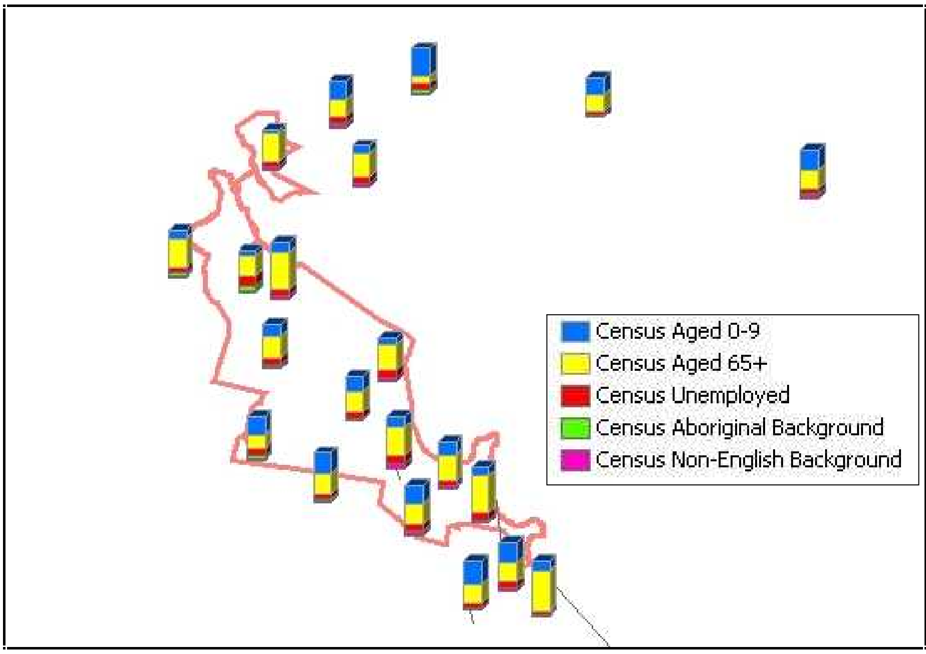

Figure B.3 Census data (2001) for Batemans Bay area

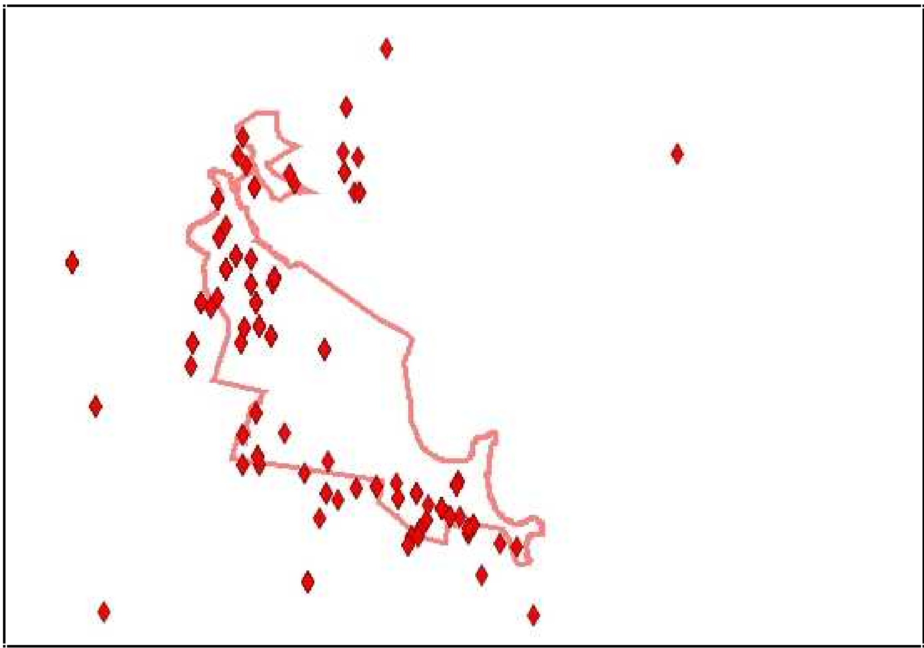

Figure B.4 AIRS data from 1994-2004, Batemans Bay area

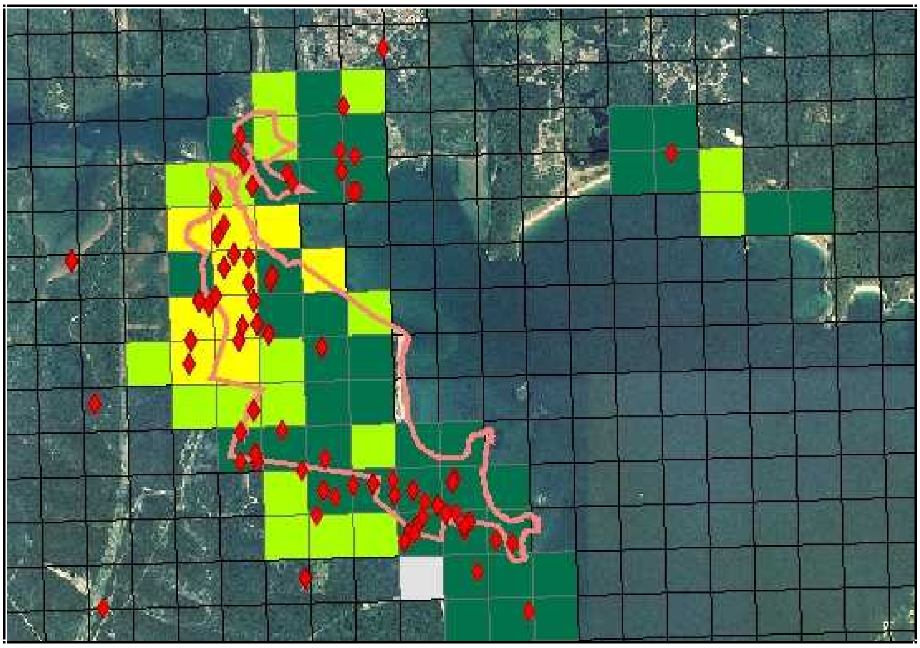

Figure B.5 Combined hazard and likelihood layers for Batemans Bay showing no correlation between incidents and hazards

Appendix C

Port Macquarie Images

Figure C.1 Satellite photograph of Port Macquarie showing Pacific Highway and the NSWFB Fire District

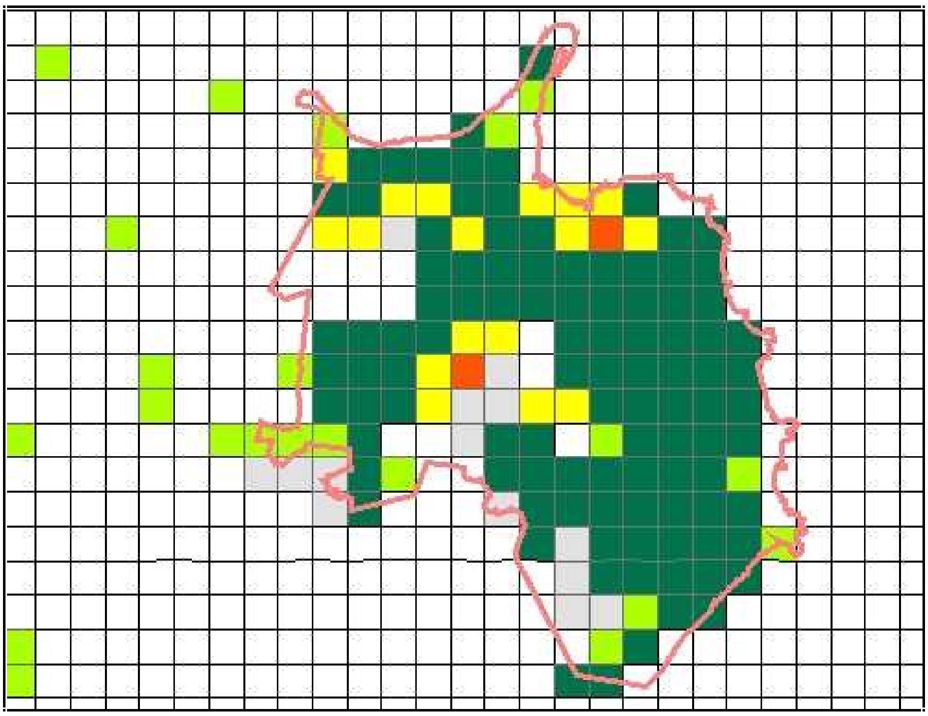

Figure C.2 Hazard categorisation for Port Macquarie area

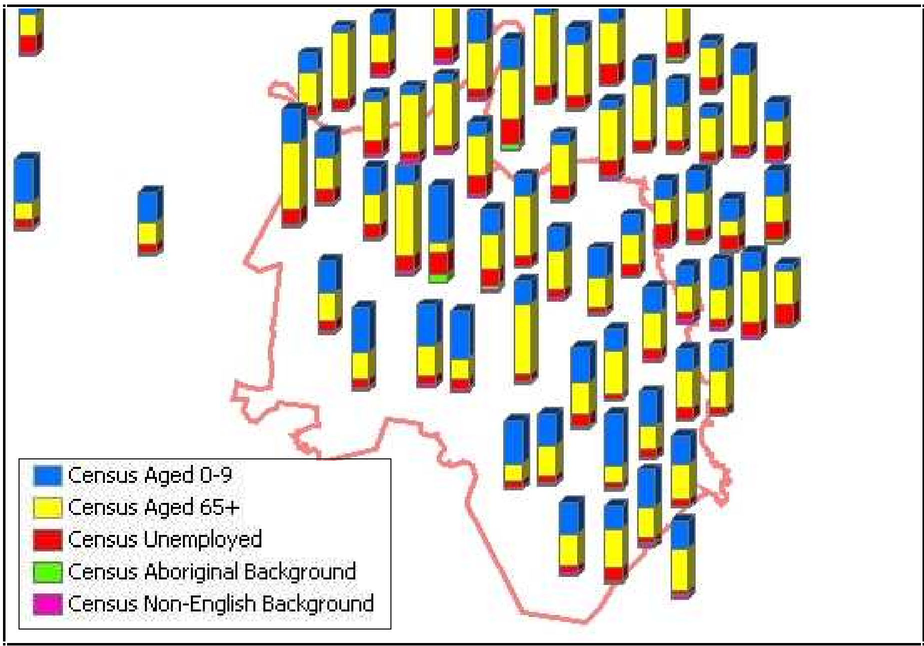

Figure C.3 Census data (2001) for Port Macquarie area

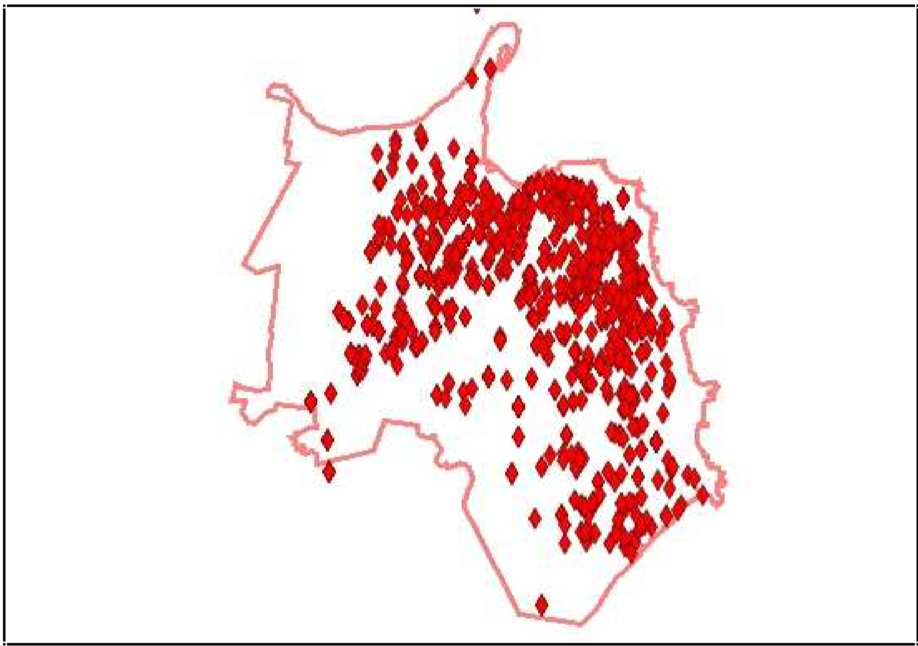

Figure C.4 AIRS data from 1994-2004, Port Macquarie area

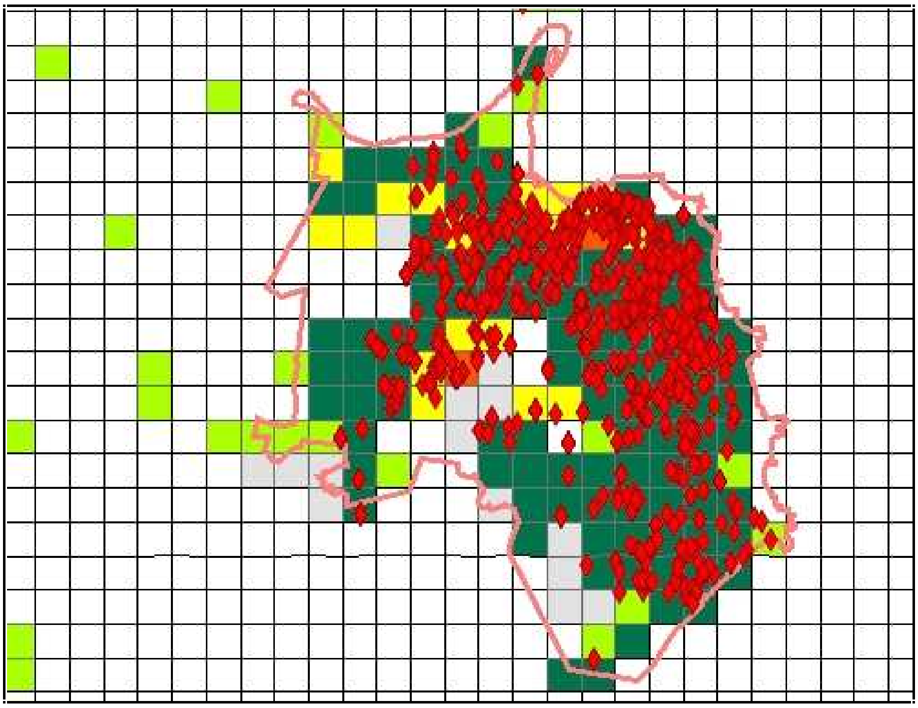

Figure C.5 Combined hazard and likelihood layers for Port Macquarie showing no correlation between incidents and hazards

Appendix D

Lithgow Images

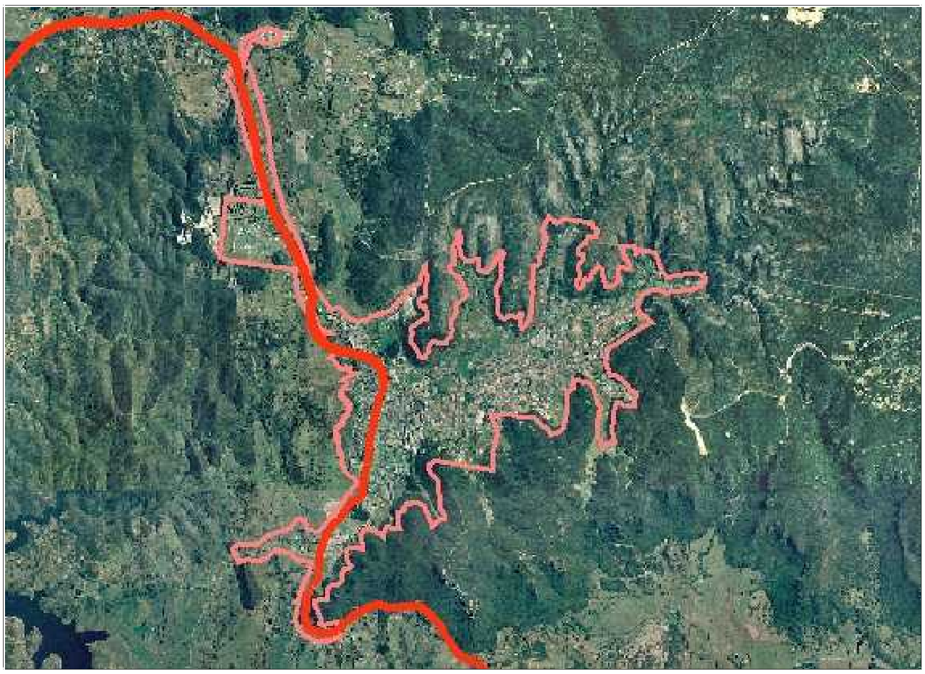

Figure D.1 Satellite photograph of Lithgow area showing
Great Western Highway and the NSWFB Fire District

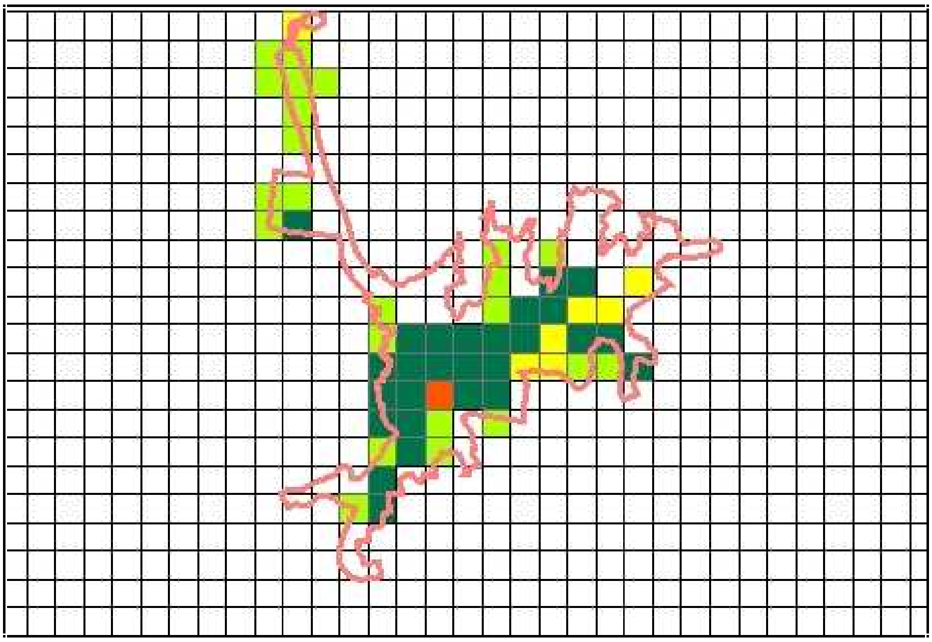

Figure D.2 Hazard categorisation for Lithgow area

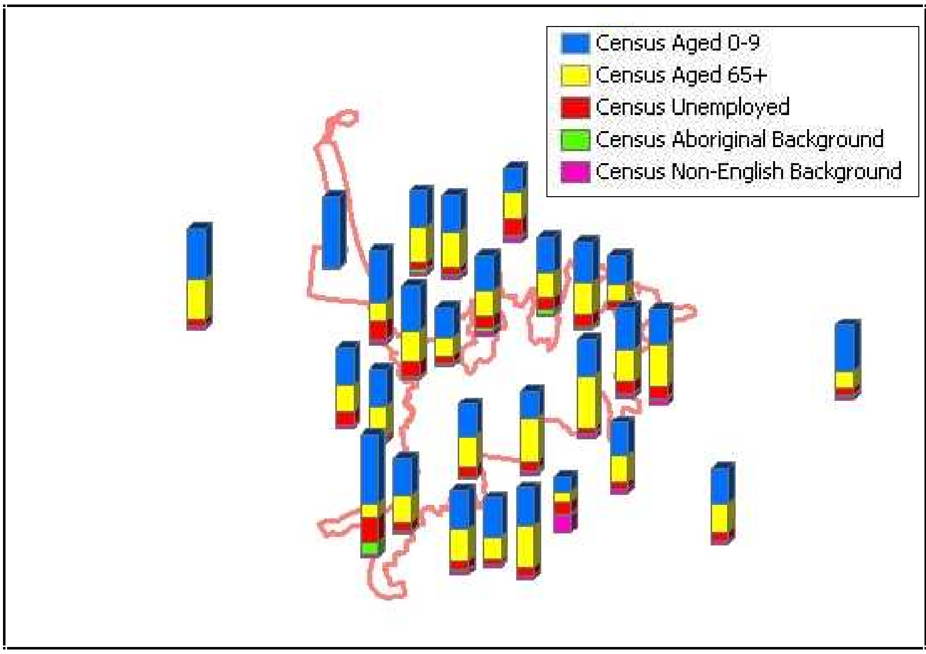

Figure D.3 Census data (2001) for Lithgow area

Figure D.4 AIRS data from 1994-2004, Lithgow area

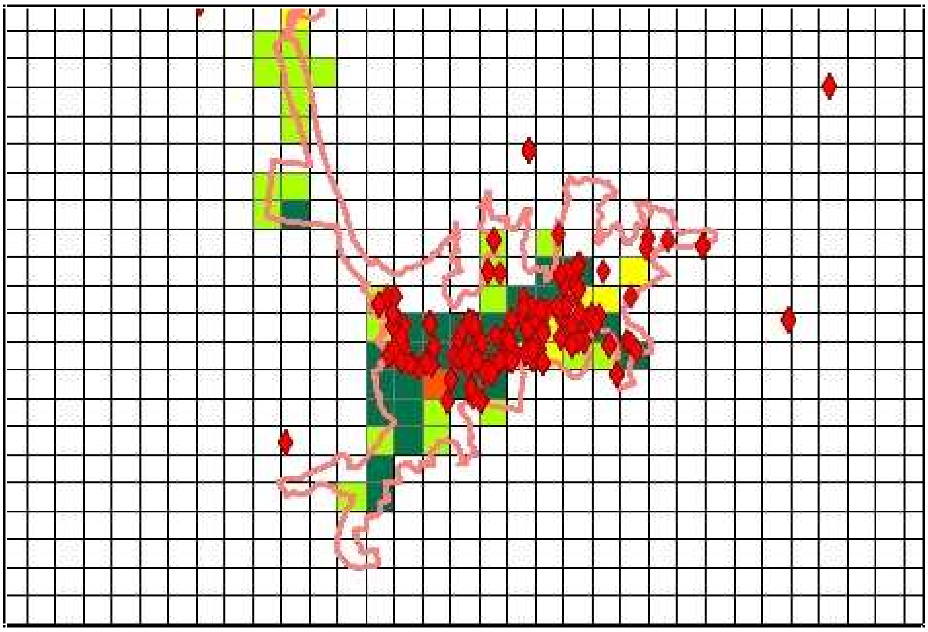

Figure D.5 Combined hazard and likelihood layers for Lithgow showing no correlation between incidents and hazards

Appendix E

Campbelltown Images

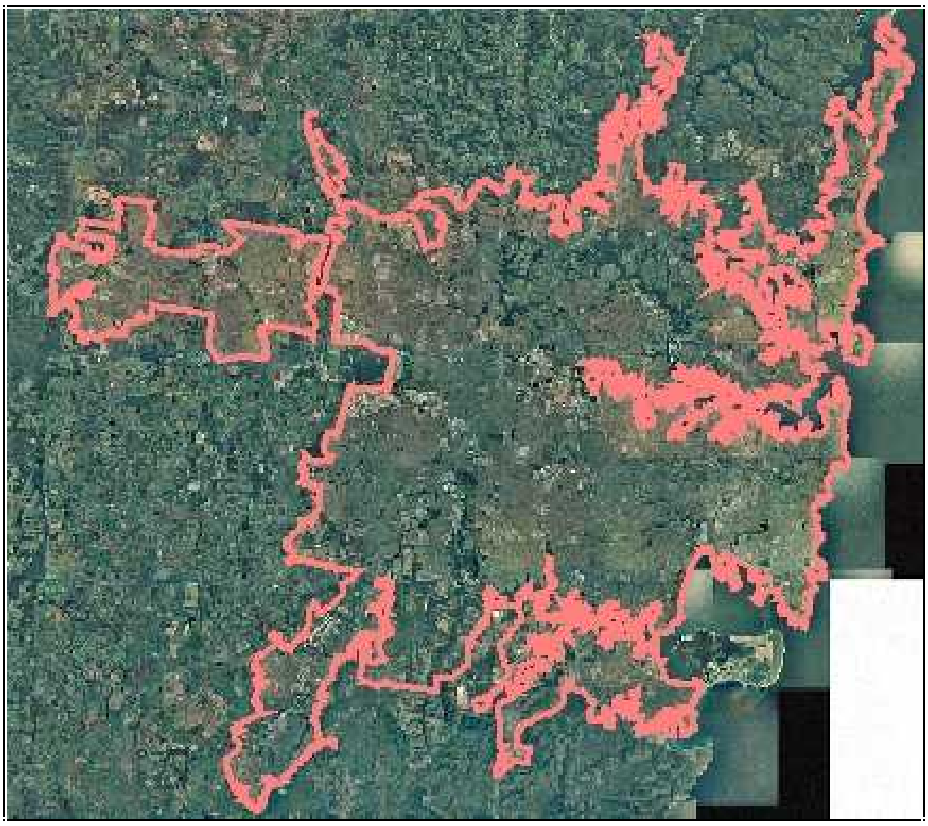

Figure E.1 Satellite photograph of entire NSWFB Greater Sydney Fire District

Figure E.2 Satellite photograph of Campbelltown section of NSWFB Greater Sydney Fire District

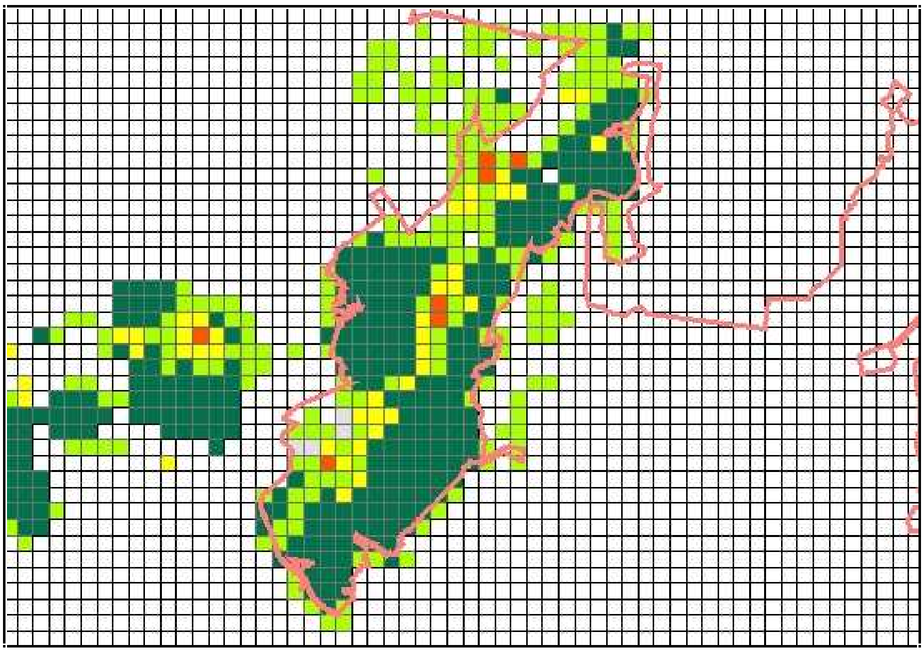

Figure E.3 Hazard categorisation of Campbelltown area

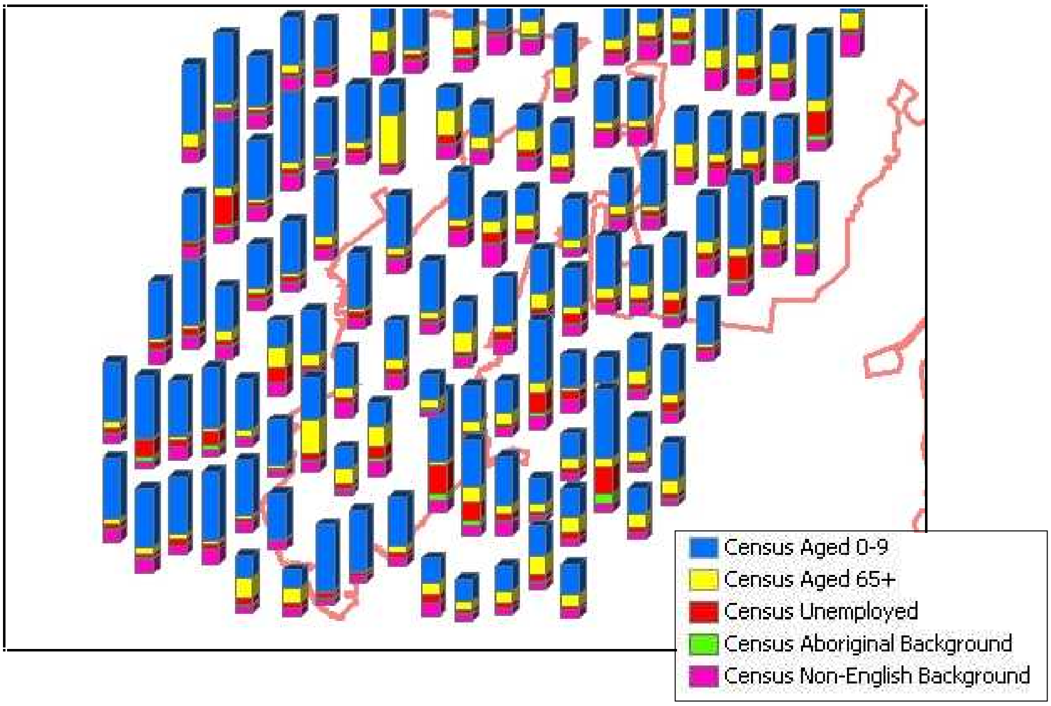

Figure E.4 Census data (2001) for Campbelltown area

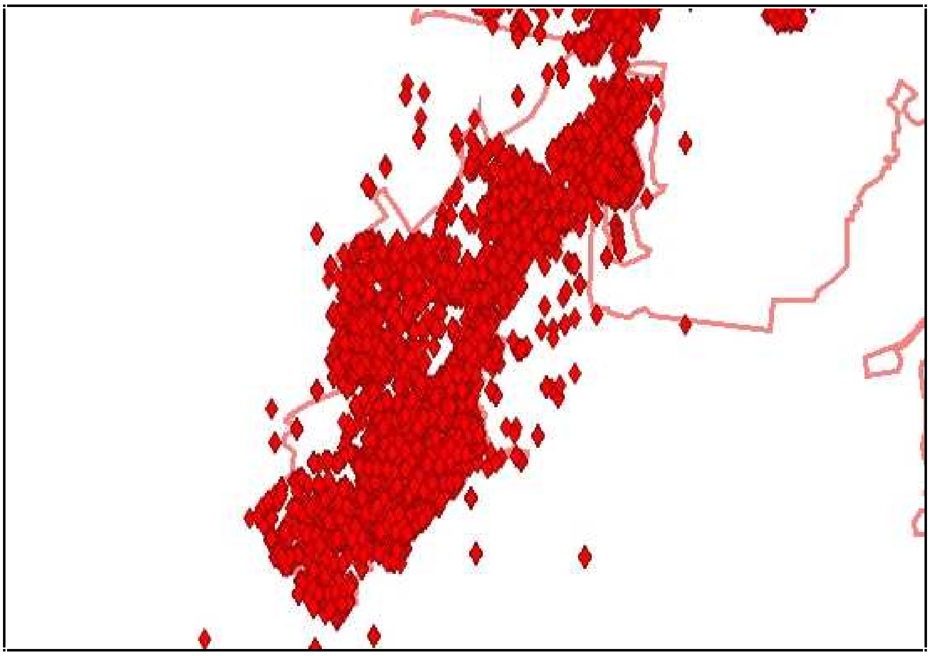

Figure E.5 AIRS data from 1994-2004, Campbelltown area

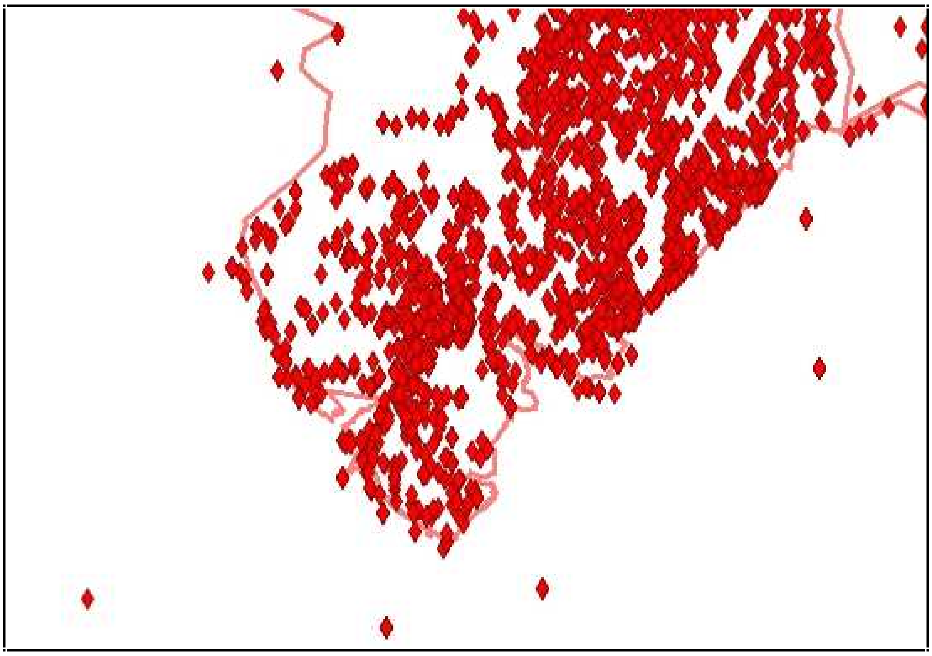

Figure E.6 AIRS data for southern portion of Campbelltown

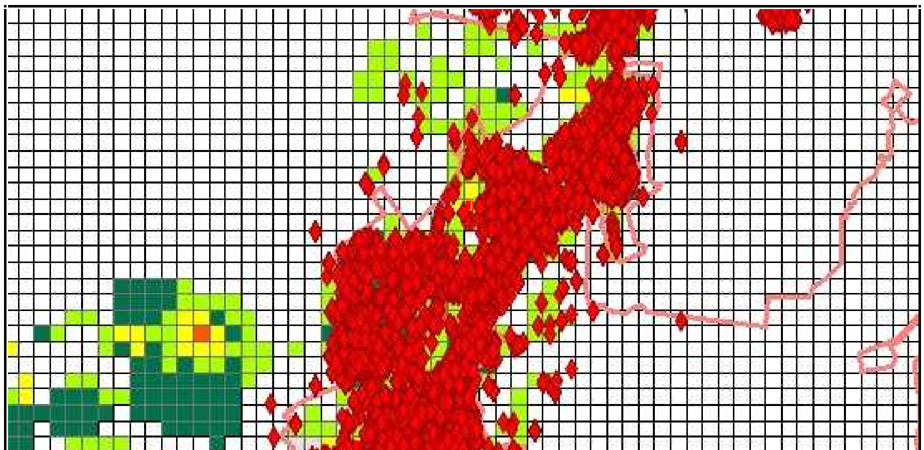

Figure E.7 Combined hazard and likelihood layers for Campbelltown

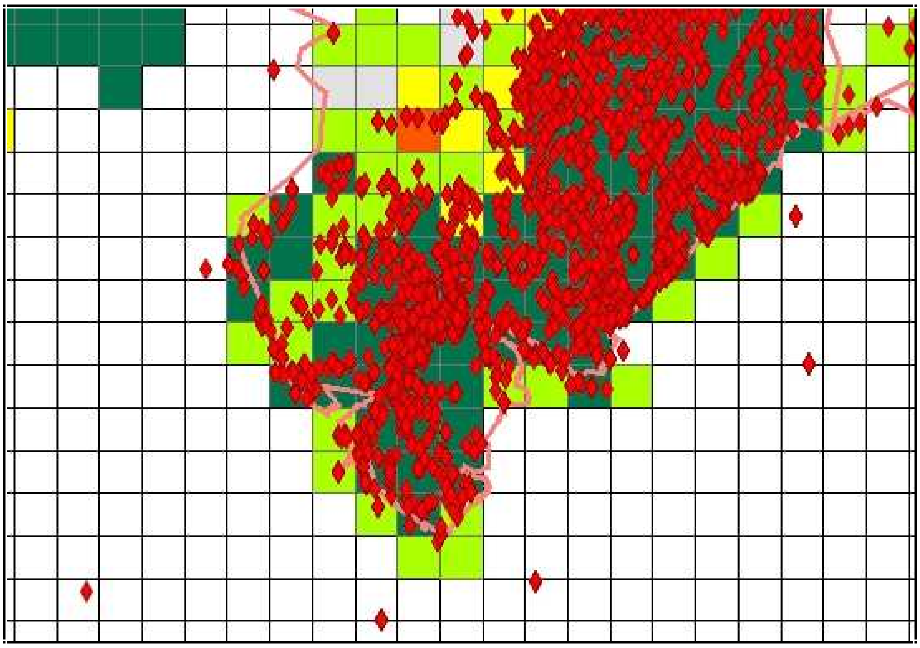

Figure E.8 Combined hazard and likelihood layers for southern portion of Campbelltown (for better comparison with other sites)

Appendix F

Risk Assessment

Rating	Determination
HAZARD DATA	
Very High	Includes Special Hazard (Category 1) grid squares (usually more than one)
High	May include Special Hazard (Category 1) and includes more than one grid square classified as Category 2
Medium	May include some Category 2 hazards and includes Category 3 hazards
Low	Majority is Category 4 hazards with some Category 5
Very Low	Majority is Category 5 hazards
VULNERABILITY DATA	
Very High	Includes proportion of population identified as vulnerable greater than 50%
High	Includes proportion of population identified as vulnerable greater than 33% but less than 50%
Medium	Includes proportion of population identified as vulnerable greater than 25% but less than 33%
Low	Includes proportion of population identified as vulnerable greater than 10% but less than 25%
Very Low	Includes proportion of population identified as vulnerable less than 10%
LIKELIHOOD DATA	
Very High	Number of attended incidents exceeds 100 per year
High	Number of attended incidents does not exceed 100 per year or less than 50 per year.
Medium	Number of attended incidents does not exceed 50 per year or less than 25 per year.
Low	Number of attended incidents does not exceed 25 per year or less than 10 per year.
Very Low	Number of attended incidents does not exceed 10 per year.

Table 3 Determination scale for ascertaining risk variable rating for a study site