NSW GOVERNMENT | Premier & Cabinet

Reference: A877709

Commissioners Coppel and Chester
Natural Disaster Funding Arrangements
Productivity Commission
Locked Bag 2, Collins Street
EAST MELBOURNE VICTORIA 8003

19 JUN 2014

Dear Commissioners

I write to you regarding the Productivity Commission's Inquiry into Natural Disaster Funding. The NSW Government will be making its submission to the Inquiry in two stages.

The first stage contains factual information regarding natural disaster governance and funding. The NSW Factual Information Submission is enclosed.

Through the second stage the NSW Government will consider the issues raised through the Productivity Commission's Issues Paper. This will be made available to the Commission shortly.

Finally, I understand arrangements are being made to provide the Productivity Commission with data sought through the Issues Paper.

Should you have any further queries please do not hesitate to contact the Communities and Social Investment Group within the Department of Premier and Cabinet on 02 9228 5308.

Yours sincerely

Rebecca Falkingham
Deputy Secretary
Communities and Social Investment Group

NSW Factual Information

Productivity Commission Inquiry into Natural Disaster Funding Arrangements

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Abbreviations

BFCC	Bush Fire Coordinating Committee
BFMC	Bush Fire Management Committee
BFRMP	Bush Fire Risk Management Plan
BoM	Bureau of Meteorology
the Commission	Productivity Commission
CFU	Community Fire Unit
EBFMP	Enhanced Bush Fire Management Program
EMPLAN	NSW State Emergency Management Plan
EPA	Essential Public Asset
CSIRO	Commonwealth Scientific Industrial Research Organisation
DRA	Disaster Relief Account
FRM	Floodplain Risk Management
FRNSW	Fire and Rescue NSW
ICA	Insurance Council of Australia
IPCC	Intergovernmental Panel on Climate Change
LGA	Local Government Area
NDRRA	Natural Disaster Relief and Recovery Arrangements
NPWS	National Parks and Wildlife Service
NSW	New South Wales
NSWDAG	NSW Disaster Assistance Guidelines
OEH	Office of Environment and Heritage
PPRR	prevent, prepare for, respond to and recovery from natural disasters
RAA	Rural Assistance Authority
RMS	NSW Roads and Maritime Services
RFS	NSW Rural Fire Service
SERM Act	State Emergency and Rescue Management Act 1989
SES	NSW State Emergency Service
SICorp	NSW Self Insurance Corporation
TMF	NSW Treasury Managed Fund

Introduction

The Commonwealth Treasurer, the Hon Joe Hockey MP, has requested that the Productivity Commission (the Commission) undertake an inquiry into the efficacy of current national natural disaster funding arrangements. The Inquiry was requested to take into account the priority of effective mitigation to reduce the impact of disasters on communities. The Commission was asked to undertake an appropriate public consultation process including holding hearings, inviting public submissions and releasing a draft report to the public by September 2014. The final report is to be provided to the Commonwealth Government by the end of December 2014.

The New South Wales (NSW) Government is currently considering a number of issues and questions raised within the Commission's Terms of Reference and Issues Paper. While this consideration is underway, in order to allow the Commission to progress its Inquiry, NSW Government agencies have compiled this NSW Factual Information.

Natural disasters have a devastating and long lasting impact on communities, not only in terms of rebuilding and restoring infrastructure and assets such as roads and bridges, but also the long term socio-economic recovery. This NSW Factual Information outlines the way NSW prepares for, prevents, responds to and recovers from (PPRR) these natural disasters, including mitigation and resilience programs and activities.

The NSW Factual Submission also recognises that a substantive part of the work done to mitigate and prepare for natural disasters is conducted through the normal purpose and business of NSW Government agencies. The NSW Budget will fund the agencies through their annual allocation; however it may not identify funding specifically for the purpose of disaster mitigation. Examples of this relating to bush fires and flooding have been included, and further NSW agency programs like this will be included in a further submission to the Commission once the NSW Government has reviewed and considered its position on the issues and questions raised.

A brief overview of NSW natural disaster budgeting and funding is included at Attachment B.

Governance and overview

In NSW, natural disaster recovery, mitigation and resilience functions are governed through a hierarchy of legislation, strategic plans and supporting policy:

- Legislation provides the general legal framework and governance for emergency management in NSW including ministerial accountability.
- Strategic plans provide clarity as to command and control, roles and coordination of functions in emergency management across all levels.
- Operational policies are developed by line agencies involved in the delivery of functions set out in legislation and strategic plans.
- Cabinet oversight is both for policy and financial impacts.

The *State Emergency and Rescue Management (SERM) Act 1989*[i] establishes the legislative base for NSW disaster management and sets out Ministerial accountability and the responsibilities of a number of key parties. Under the *SERM Act* the Minister for Police and Emergency Services is responsible for:

"(a) ensuring that adequate measures are taken by government agencies to prevent, prepare for, respond to and assist recovery from emergencies, and

(b) co-ordinating the activities of government agencies in taking those measures, and

(c) approving the State Emergency Management Plan or any alterations to the State Emergency Management Plan."

The SERM Act designates the following roles, which are subject to the control and direction of the Minister for Police and Emergency Services:

- The State Emergency Management Committee – Advises the Minister and provides strategic policy advice in relation to emergency management including recovery and mitigation.
- The State Emergency Operations Controller - Responsible for controlling, in accordance with the *SERM Act*, the response to an emergency that affects more than one region, or for which they assumes responsibility.
- The State Emergency Recovery Controller – Responsible for controlling, in accordance with the *SERM Act*, the response to an emergency that affects more than one region, or for which they assumes responsibility.

Planning and hazard management

The NSW State Emergency Management Plan[ii] (EMPLAN) details a comprehensive approach to emergency management. The EMPLAN outlines the governance and coordination arrangements and roles and responsibilities of agencies.

The EMPLAN is complemented by other Sub Plans, Supporting Plans and Regional Plans, including the State Recovery Plan. A sub plan is an action plan required for a specific hazard, or event. Supporting plans are prepared by a NSW Government agency or Functional Area, which describes the support which is to be provided to the controlling or coordinating authority during emergency operations. All sub and supporting plans must take a comprehensive, whole-of-government approach to emergency management, by considering prevention, preparation, response and recovery.

Emergency service organisations perform a wide range of emergency management functions at different levels under EMPLAN and its sub or supporting plans. Regardless of the precise role performed, these agencies cooperate and share information relevant to the task across the PPRR spectrum. They are enabled by legislation to perform their roles under EMPLAN.

As defined in the SERM Act, emergency service organisations include the NSW Police Force, Fire and Rescue NSW (FRNSW), the NSW Rural Fire Service (RFS), Ambulance Service of NSW, NSW State Emergency Service (SES), NSW Volunteer Rescue Association or any other agency which manages or controls an accredited rescue unit.

Emergency services organisations perform hazard management tasks across PPRR. They maintain operational capabilities as well as the capacity to plan and conduct major operations.

Certain emergency services organisations are appointed as combat agencies, giving them primary responsibility for managing the risks posed by a particular hazard type. The combat agency may typically require the support of other agencies.

The hierarchy of plans and the planning framework is outlined in the EMPLAN.

Approach to recovery

Recovery is defined in NSW legislation as "the process of returning an effected community to its proper level of functioning after an emergency." This does not necessarily mean returning the effected community to its pre-disaster level of functioning. If communities or individuals were exposed to an unacceptable level of risk, or prior development was uneconomical in the first case, the objectives of recovery may not involve a return of that community to its exact prior condition. The need to rebuild after a disaster may provide an opportunity to re-establish a more appropriate level of functioning.

The broad principle behind NSW disaster assistance measures is to provide relief to individuals and communities, public asset restoration and assistance to primary producers, small business, voluntary non-profit organisation and sporting clubs.

Measures are designed to help meet the immediate needs of safety, sustenance, shelter and the longer term recovery needs. Disaster assistance should complement and provide incentive, wherever possible, to promote the principle of resilience.

Assistance is not to supplant, or operate as a disincentive for, self-help by way of commercial insurance arrangements and/or other appropriate strategies for disaster mitigation. Assistance is not provided as compensation for commercial damage or revenue loss (whether for private or public sector operations).

NSW has adopted the Natural Disaster Relief and Recovery Arrangements (NDRRA) terms and conditions as the basis for financial assistance offered for recovery and then, in certain areas, applied its own requirements.

In applying the NDRRA, NSW recognises that it can apply the terms and conditions as it considers appropriate for recovery. This means that NSW does not offer assistance for all eligible measures under NDRRA, and similarly it offers assistance for some measures that cannot be claimed for partial reimbursement from the Commonwealth under NDRRA.

The full suite of financial assistance recovery policies of the NSW Government are catalogued in the NSW Disaster Assistance Guidelines (NSWDAG).

There are other recovery policies and activity which result in expenditure by agencies that are not given specific funding under the NSWDAG and as such are met from within usual operating budgets of agencies, or in certain circumstances they may be reimbursed from the Crown's Disaster Relief Account (DRA).

Financial support for recovery is provided on the basis that the level of support provided for one event is not impacted by the level of expenditure on earlier events or other pressures on the State Budget. Most assistance measures are triggered by a natural disaster declaration.

In NSW, the Treasurer is responsible for formally making natural disaster declarations. The declaration is not made under legislation but is a financial policy decision made in accordance with the NDRRA requirements. A declaration is recommended to the Treasurer if the event meets the NDRRA definition of a natural disaster and the costs of eligible response and recovery measures exceed the small disaster threshold ($240,000). The declaration process activates financial assistance to the affected areas, which is usually defined by the local government areas impacted by the event.

In 2012-13 natural disaster declarations were made with respect to a specific LGA in 181 instances. A further activation process is required for assistance which falls under NDRRA Category C assistance, as per the requirement for prior Commonwealth approval.

The Minister for Primary Industries also declares some events a disaster and these are referred to as "agricultural natural disasters". This declaration makes assistance available to primary producers affected by an event. Such disasters fall outside of NDRRA requirements and assistance provided under Agricultural natural disaster declarations is not reimbursed by the Federal government.

The full suite of recovery measures, including conditions for eligibility and exclusions, are included in the NSWDAG[iii].

Risk management and insurance of State Government assets

Risk management by state agencies is required by NSW Treasury Policy Paper 09-05: *Internal audit and risk management policy for the NSW Public Sector*[iv] and legislation such as the *Public Finance and Audit Act 1983*[v], *Work Health and Safety Act 2011*[vi], *Environmental Planning and Assessment Act 1979*[vii], and *Protection of the Environment Operations Act 1997*[viii].

Risk management standards require a comprehensive and systematic approach to all identified risks. As such, the approach to risk management for natural disasters by state agencies is part of a broader, all-hazards approach. There is no dedicated funding source for natural disaster recovery that absolves state agencies of the need to manage the natural disaster risks to their assets.

Damages to state owned assets are either covered by insurance arrangements in which premiums price risk and incentivise mitigation, or require the agency to meet costs through reprioritisation of operating budgets. In extraordinary cases the agency may be granted supplementary funding to meet natural disaster costs however this process is separated from any Commonwealth reimbursement and funding is not assured before the event.

For instance, the agency responsible for state owned roads in NSW, Roads and Maritime Services (RMS), has insurance coverage for its structural assets and vehicles. Natural disaster damage to these assets is met through insurance coverage with the NSW Self Insurance Corporation (SICorp). The road assets of RMS are not covered by insurance; however this does not reflect an absence of risk management. In this case it has been determined by the State that it is better to retain the risk of damage to state owned roads from natural disasters because of the likely high costs of commercial insurance due to significant uncertainties in calculating probable maximum loss, the geographic spread of risk and the capacity to reallocate maintenance budgets to fund repairs.

The implied reinsurance of NDRRA is not a factor in making this decision as neither RMS nor SICorp have access to this funding source. Given these arrangements, RMS has financial incentive to manage natural disaster risks through mitigation works and to fully consider risks when making capital investment decisions.

Further detail on insurance and risk management arrangements in NSW, both of state and local governments, is provided in the independent assessment of insurance arrangements commissioned by NSW[ix] in response to the 2012 review conducted by the then Commonwealth Department of Finance and Deregulation[x].

NSW Self Insurance Corporation

SICorp was established in 2005 to manage a number of NSW Government related insurance schemes, the largest being the NSW Treasury Managed Fund (TMF)[xi]. The TMF was created in 1989 to bring the insurable risk exposures of general government agencies together into a uniform and structured system creating consistency of protection and transparency of spend. Over the past 25 years, the TMF has consistently responded to all property based insurable risk events. Current outstanding liabilities (across TMF coverage classes) are fully funded to a level exceeding $7 billion. NSW's superior and comprehensive approach to the protection of insurable assets and risks is demonstrated by:

- Insisting member agencies annually declare the value of their assets at full replacement cost;
- funding for expected losses are derived from 25 years of actuarially assessed claims history, allocating a fully funded Target premium for NSW Government property losses;
- contracting private sector reinsurance experts to professionally assess Probable Maximum Loss values and return periods, and advise NSW on the most suitable risk transfer options to maintain superior reinsurance protection for government assets; and
- declaring higher asset values and purchasing higher reinsurance limits than any other jurisdiction in Australia.

Approach to mitigation and resilience

NSW also takes a whole-of-government approach to support mitigation and resilience building activities. Funding has been provided under National Partnership Agreements since 2003. NSW has legislation and regulations designating "no-build zones" in specified risk areas and structural standards to meet certain levels of natural disaster risks. Government agencies, specifically those involved in natural disaster risk management, have community engagement strategies to ensure that the community, and particularly the vulnerable, are prepared and resilient to disaster risks. Funding to support these activities come from the agencies' annual appropriations.

There was $54.9m provided between 2003-2008 to a range of local and State government agencies under the Natural Disaster Mitigation Program and the Bush Fire Mitigation Program. Funding was approved for activities that included flood levee modification, local flood studies, flood hazard mapping, community fire unit training and trailers, tsunami modelling, cliff stabilisation works and detention basin, bush fire 'Hot Spots' planning, fire trail maintenance and fuel mapping.

During 2009-2013 NSW entered into the four year National Partnership Agreement on Natural Disaster Resilience with funding provided through the Natural Disaster Resilience Program.

In NSW, the Program was divided into a number of separate schemes to target specific mitigation and resilience activities. Projects were awarded through a competitive application process to a range of agencies, local and State government and non-government organisations with a role in emergency management. The schemes were:

- Natural Disaster Resilience Grants Scheme (2009 -2011): $14.05m was offered to local and state government agencies for 94 projects such as flood studies, levee repairs, flood warning systems, tsunami awareness fire mitigation plans.
- State Emergency Management Projects (from 2011): $7.4m was offered for 36 significant emergency management projects with state-wide benefit to NSW. Projects included sea level rise risk assessments, bush fire self-assessment tools, bush fire resilience project for aboriginal communities, increasing agricultural production resilience on coastal floodplains.
- Bush Fire Risk Management Grants Scheme (from 2011): This program is administered by the NSW Rural Fire Service on behalf of the Ministry and complements other State based bush fire mitigation programs. $5.2m was offered to 80 priority projects identified in local Bush Fire Risk Management Plans for bush fire hazard reduction, fire trail and fire tower maintenance.
- Floodplain Risk Management Grants Scheme (from 2011): This Program is administered by the OEH on behalf of the Ministry and complements other State based flood mitigation programs. $7.3m was offered to councils to undertake 191 projects for flood studies and flood mitigation works such as levees, detention basins and the installation of flood warning systems.
- Auxiliary Disaster Resilience Grants Scheme (2011 – 2013): $1.1m was offered to local organisations to undertake 19 projects that reduced natural disaster risk and enhanced emergency management capability, for hazards other than fire and flood. Projects included education and community engagement plans for coastal hazards, coastal zone hazards community awareness strategies, all hazards community education information.
- Emergency Volunteer Support Scheme (from 2010) : $2.6m was offered to agencies that provide volunteer services and have a role in emergency management to undertake 116 projects for activities such as; online volunteer training projects, development of volunteer training packages, young volunteer leadership programs.

State goals and targets to mitigate natural disasters

NSW 2021[xii] provides state-wide priorities for action and guides NSW Government resource allocation in conjunction with the NSW Budget. Goal 28 is *Ensure NSW is ready to deal with major emergencies and natural disasters*. Goal 28 recognises the significant impact emergencies and natural disasters have on our communities, the economy, infrastructure and the environment. To help achieve the Goal, NSW 2021 sets out targets to:

- Ensure NSW has appropriate arrangements in place to respond to and recover from natural disasters
- Defend against suburban and bushland fires
  - Increase community resilience to the impact of fires through prevention and preparedness activities
    - Increase the number of households who are 'fire safe' through expansion of awareness programs
    - Enhance volunteer training programs with a particular focus on cadet training schemes
    - Increase the number of identified Neighbourhood Safer Places
  - Increase hazard reduction across NSW
    - Increase the number of properties protected by hazard reduction works across all bush fire prone land tenures by 20,000 per year by 2016
    - Increase the annual average level of area treated by hazard reduction activities by 45% by 2016
- Increase the number of FRM plans available to support emergency management planning
- Maintain preparedness to deal with biosecurity threats

Mitigating major hazards – bush fires

In 1993/94 severe fires caused the loss of 4 lives, 205 houses and burned more than 800,000 hectares. During those fires 20,000 fire fighters were deployed at over 800 fires across NSW. The *Rural Fires Act 1997* (RF Act) was introduced by the NSW State Government following a 1994 Legislative Assembly Select Committee Inquiry and a wide ranging Coronial Inquiry into the 1993/94 fires.

The RF Act established the NSW RFS, which incorporated the existing bush fire brigades, some of which had been in operation for about 100 years. The objects of the RF Act are to provide:

(a) "for the prevention, mitigation and suppression of bush and other fires in local government areas, (or parts of areas) and other parts of the State constituted as rural fire districts;

(b) for the co-ordination of bush fire fighting and bush fire prevention throughout the State;

(c) for the protection of persons from injury or death, and property from damage, arising from fires;

(c1) for the protection of infrastructure and environmental, economic, cultural, agricultural and community assets from damage arising from fires, and

(d) for the protection of the environment ... having regard to the principles of ecologically sustainable development described in section 6(2) of the Protection of the Environment Administration Act 1991."

The RF Act also sets out the structure, duties and powers of the NSW RFS and provides for the coordinated firefighting arrangements:

- the ability for the Commissioner to take charge of bush fire control, bush fire prevention and bush fire suppression activities anywhere in NSW where appropriate; and

- the formation of the Bush Fire Coordinating Committee (BFCC), bush fire management planning and coordinated fire management arrangements.

The *Rural Fires Regulation 2013* also prescribes, among other things:

- Bush Fire Management Committees (BFMC);
- volunteers and constitutions of brigades;
- fire prevention measures;
- notices required under the Act; and
- awards, fire permits, bush fire prone land, hazard reduction and penalty notices.

Further documents from the NSW RFS, Bush Fire Coordinating Committee (BFCC) and Fire Services Joint Standing Committee are available on the NSW RFS website[xiii].

Bush Fire Risk Management Plans

A Bush Fire Risk Management Plan (BFRMP) is prepared by a BFMC (one or more local government areas) in accordance with BFCC Policy 01/08 – Bush Fire Risk Management[xiv]. It is a publicly available document that is designed to detail the bush fire risk for a BFMC area.

A BFRMP is a comprehensive document that maps and describes the level of bush fire risk across a landscape. The BFMC identifies assets at risk of bush fire and uses methods specific to the type of asset to assess the consequence and likelihood ratings. These ratings are then applied to a risk matrix which determines the level of bush fire risk for an asset and its priority.

To reduce the likelihood of harmful consequences of bush fire to the community and environment, the BFRMP establishes risk treatment for those assets exposed to highest risk and determines who is responsible for carrying out those risk treatments.

The BFRMP is an effective hazard reduction planning tool that assists in determining where mechanical clearing or hazard reduction burns are to be conducted, which areas require specialised fire protection and which areas need to be targeted for community education[xv].

The risk assessment process has a strong emphasis on community engagement and ownership. The current process allows for qualitative data that is based on local knowledge to be included in the risk assessment process. The map based outputs provide an effective communication tool to show the community where assets most at risk of bush fire are located and the actions being taken to treat those risks.

The Bush Fire Risk Register (BFRR) is a custom built software tool to assist BFMCs in the development of BFRMPs. It uses spatially based data to identify assets at risk of bush fire and assists in the risk assessment process. This allows analysis and decision making to occur at the local level throughout the Plan development. The BFRR developed in NSW is also being used by Victorian and South Australian fire agencies to undertake bush fire risk assessment.

Community Protection Plans

Community Protection Plans (CPP) are tactical level plans that incorporate a range of aspects relevant to bush fire risk management into a single document that is prepared at a community level. Communities targeted for Community Protection Plans are those specifically identified in risk treatments or those where the assets have the highest risk in the BFRMP.

Three maps are produced for a community as part of the CPP process.

- The Bush Fire Preparation Map: Focus on risk treatments in place for a community and is targeted at land managers, fire agencies and community members.
- The Brigade Operations Map: Focus on depicting important data that is used for operational purposes only (e.g. Pre-incident planning).
- The Bush Fire Survival Map: This map will target members of the community and depicts information on evacuation, shelter options and bush fire threat for the community.

Annual Works Programme

Each fire service, land manager and agency responsible for implementing the risk treatments included in the BFRMP prepares and submits an annual works programme to the BFMC. The annual works programme provides a prioritised list of hazard reduction activities scheduled to be carried out within a particular financial year. This list is developed locally based on the experience of the BFMC and includes considerations such as:

- The level of bush fire risk in the BFRMP
- Planning capacity
- Suitable weather conditions (e.g. average number of days available for HR per year within an area)
- Availability of funding and resources (e.g. mitigation crews)

Living with fire in NSW National Parks

Strategic issues and a State-wide direction for NPWS in regards to fire management over a 10 year time frame are provided by Living with Fire in NSW National Parks – A Strategy for Managing Bush fire in National Parks and Reserves to 2021[xvi]. The strategy identifies a vision, objectives and principles to ensure that people and other resources are used to best advantage:

- in managing fire in parks and reserves. The primary objective is always to protect life and property. The NPWS fire management objectives identified in the strategy are;
- to protect life, property and community assets from the adverse impacts of fire;
- to develop and implement cooperative and coordinated fire management arrangements with other fire authorities, park and reserve neighbours and the community;
- to manage fire regimes in reserves to maintain and enhance biodiversity;
- to protect Aboriginal sites and places, historic places and culturally significant features from damage by fire; and
- to assist other fire agencies, land management authorities and landholders in developing fire management practices that contribute to conserving biodiversity and cultural heritage across the landscape.

Another program, the Enhanced Bush Fire Management Program, is increasing hazard reduction and improving bush fire response capabilities on parks and reserves. It includes:

- dedicated resources at a regional level working towards treating 135,000 hectares per annum of hazard reduced land as a 5 year rolling average and effectively doubling the number of existing outputs to more than 800 individual burning and mechanical fuel treatment activities per annum.
- increased rapid response capacity through the provision of additional remote area fire crew resources in high priority and key regional areas, supported by aircraft operating from strategic locations during the fire season.

Significant planning to undertake prescribed burning

Hazard reduction burns require significant planning before they can be implemented. State-wide interagency templates are in place for Level 1 and Level 2 hazard reduction burns. These levels reflect the complexity of the planned activity and the extent of planning, preparation and operational resources required.

The planning process analyses the individual circumstances of individual proposed burns, which include an assessment of the site, fuel, assets and environment, including any environmental assessments / approvals required. The plan also documents details of the mission, how the plan is to be executed, administration, command and communication arrangements and safety.

Bush Fire Environmental Assessment Code

The Bush Fire Environmental Assessment Code provides a one-stop-shop free environmental assessment for bush fire hazard reduction via the issuing of Bush Fire Hazard Reduction Certificates. The objective of this document is to streamline the environmental approval process for hazard reduction whilst addressing important environmental issues.

The initial Code was successfully introduced in 2003. A number of additional matters were addressed and incorporated into the revised Code in 2006. The Bush Fire Environmental Assessment Code 2006 has now been successfully in operation for 5 years and is due for its second review.

Hotspots

The Hotspots Fire Project is an education and training model for sustainable fire management practices that protect biodiversity and cultural values, while at the same time providing protection for life and property. The programme is a series of workshops underpinned by the best available science and delivered by trained teams.

Each individual Hotspots project is run over two or three days and delivery is shared by Nature Conservation Council and NSW RFS. The Hotspots project has been running successfully for 6 years and has recently announced as the national winner of the 2011 Australian Safer Community Awards in the Education, Training and Research category.

Community Engagement

A disaster-resilient community is one where people are capable of organising themselves before, during and after disasters to maintain social, institutional and economic activity. Fundamental to the concept of disaster resilience is that individuals and the community should be more self-reliant and prepared to take more responsibility for the risks they live with. They need to understand their role, and have the skills and abilities to support actions required during an emergency and to support recovery efforts.

The NSW RFS, through both staff and volunteers, provide a wide variety of engagement and education programs, including fire safety resources. These include children and schools programs, resources for children and young people, fire preparation and safety instruction

The AIDER (Assist Infirm, Disabled and Elderly Residents) Programme is one-off service provided by the NSW RFS which involves the implementation of risk mitigation works such as clearing gutters, thinning vegetation, removing leaf and tree debris, trimming branches from around and overhanging the home, mowing or slashing long grass.

While this programme is on a small scale and only applies to individual residential properties, it targets the most vulnerable members of the community that have limited capacity to help themselves during a bush fire.

Community Fire Units

Community Fire Units (CFU) comprise local residents living near the bushland interface, who are trained, equipped and supported by both Fire and Rescue NSW (FRNSW) and NSW RFS. The program empowers local residents and increases their resilience to bush fires. CFU members prepare their properties to be more bush fire safe and activate when bushfires occur in their local area, protecting their properties and that of their neighbours. FRNSW currently supports over 600 CFUs with more than 7,000 volunteers.

State Mitigation Support Services

Hazard reduction burning generally requires on the ground preparation works and creation of control lines. The introduction of the State Mitigation Crews to assist with this work has increased the capacity of volunteer crews to undertake burns.

Bush Fire Development Control

Legislative amendments came into effect on 1 August 2002, as well as changes to the Building Code of Australia, requiring certain Development Applications on Bush Fire Prone Land to be referred to the RFS for assessment and the issue of a Bush Fire Safety Authority.

Planning, design and construction provisions for developments in bush fire prone areas provides one of the most effective ways of minimising the effects of bush fire on a development and the people occupying that development.

Our Bush Fire Prone Areas will become more liveable and sustainable by reducing community exposure to the impact of bush fires by building resilience into the landscape through planning, design and construction standards and control of development in bush fire prone areas.

Suppressing fires to mitigate their impact

Of a critical nature to the NSW system of bush fire management is both the ability and unreserved willingness of the agencies to operate in a cohesive and coordinated fashion when adverse fire conditions prevail. The system enables a graded response to fires depending upon their perceived and actual severity and the weather conditions that prevail or are forecast to prevail.

The central platform of the NSW fire management system is that the four separate agencies with fire fighting capacity work together when adverse conditions develop or are likely to develop. Additionally, the Commissioner possesses extremely broad powers to ensure that long before severe fire weather conditions eventuate, appropriate interaction and coordination between the respective agencies is in fact occurring.

A recent initiative to enhance operational response in remote areas has been the Rapid Aerial Response Teams (RART) program.

Many fires which start in NSW occur in remote areas, often due to lightning activity. These fires, if not quickly extinguished, become large fires with the potential to cause widespread damage and are costly to contain. The RART program was introduced to address these remote fires. This program involves RFS and NPWS having aircraft and specially trained crews ready to be immediately deployed in strategic locations based on a set of triggers for activation.

Research by the Bush Fire CRC and the University of Wollongong is included at Attachment C and indicates that early attack by aircraft, supported by specially trained ground forces can increase the probability of successful containment of wildfires in all but Very High to Extreme fire danger days by up to 50% and is the most economically efficient approach to fire suppression.

When remote area fires are detected and they are not readily accessible by road or fire trail, helicopters are dispatched to conduct initial water bombing. This however, is usually not successful without the support of ground crews.

RFS and NPWS have Remote Area Fire Team (RAFT) members around the State and within Sydney's drinking water catchments, which assemble when needed and deploy normally by helicopter to these remote fires, which has proven a successful strategy.

In 2013/14 RART attended 39 fires. Of these some 31 fires were less than 10 hectares (threshold size of fire for RART) in size at the time of their arrival, with 29 kept to under 10ha in size, a success rate of 93.5%.

Mitigating major hazards – floods

Flood risk to critical infrastructure and homes can be reduced by improving flood prediction and warning systems and designing urban areas to better funnel water from assets. The NSW Government has targets to increase local government Floodplain Risk Management (FRM) Plans to support emergency management planning. Funding and technical support is provided to local government by OEH to support this objective. The 2013-14 budget allocation for the Floodplain Management Program is approximately $13.6 million.

Completion of FRM Plans in compliance with the NSW Floodplain Development Manual[xvii] provides councils with a degree of legal liability under the *Local Government Act*[xviii] . Active flood mitigation planning encourages community stakeholders to better understand flood risk and map out contingency strategies to protect life and property.

Coupled with the State's Floodplain Management Grant Program, the manual outlines the government framework for managing the risks resulting from natural hazards to reduce their impacts in NSW. It incorporates the NSW Flood Prone Land Policy, which aims to reduce the impact of flooding on individual owners and occupiers of flood prone property and to reduce private and public losses resulting from floods. The policy also recognises the benefits of use, occupation and development of flood prone land.

Floodplain Risk Management Committees

The formation of a FRM Committee is the first step in undertaking the FRM process. The committee generally includes members drawn from the community who have indicated their interest in the study and plan being undertaken and generally who are associated with local community groups. This is to facilitate a more inclusive collection of data and conveyance of information to the public in their area. The committee also has representatives from social and business groups, councillors, council staff, State Government representatives and specialist consultants.

The committee has the task of finding solutions to minimise the full range of flood risks to people and public and private property using the most cost effective measures. Those measures should also adequately address, where possible, issues of local communities being overly reliant on emergency services for flood evacuation. The committee achieves this by steering the work that needs to be undertaken to produce the Management Plan using the risk management approach outlined in the NSW Floodplain Development Manual.

Developing in flood prone land

Local government has the primary responsibility for controlling the development of flood-prone land and managing flood risk. The NSW State Government, through the OEH, the SES and the Bureau of Meteorology (BoM) also play a major role in managing the flood risk.

Technical and funding support assists local government to complete flood studies and risk management assessments necessary for the preparation of the FRM Plans.

The NSW Government's Flood Prone Land Policy is directed at providing solutions to existing flooding problems in developed areas and ensuring that future developments will not create flooding problems in other areas. The NSW Government provides specialist technical advice and financial support to assist local councils to develop FRM Plans which consist of the following stages:

1. Flood Study
2. Floodplain Risk Management Study
3. Floodplain Risk Management Plan
4. Implementation of the Plan

Councils carry out studies into flood risks in their area resulting in the creation of FRM Studies and Plans, conducted under the Commonwealth Government's Natural Disaster Mitigation Programme and the NSW Government's Floodplain Management Program.

Councils investigate areas for flood liability and planning certificates (under section 149(2) of the *Environmental Planning and Assessment Act 1979*[xix]) record the application of a flood policy to land. The management studies and plans involve the identification of significant flooding issues and evaluate a range of potential flood mitigation options and strategies to reduce the flood risk. Flood mitigation options may include emergency response measures, land modification, property acquisition, structural works, and planning and development controls.

Studies undertaken by councils generally plan for a future sea level rise projection of 0.9m and also for increased rainfall intensities, both as a result from Climate Change. This is in line with the State Government's Climate Change policies and direction that has been based on Intergovernmental Panel on Climate Change (IPCC) and Commonwealth Scientific and Industrial Research Organisation (CSIRO) projections. Council is responsible for planning for future development, and decisions made now may still be on the ground in 50 to 100 years' time. Meaning councils have to plan for the future based on the best available information.

Improved knowledge for coastal and floodplain management

OEH undertakes coastal and marine research and monitoring to better understand coastal hazards, the underwater environment, and the impacts of land use on coastal catchments, estuaries and lakes. This work enables the support of local planning authorities to manage these environments. The work program is part of OEH's Knowledge Strategy for Coastal, Estuarine and Marine Environments and is supported by a Service Level Agreement with Manly Hydraulics Lab. The aims of the knowledge strategy include assisting coastal planners to understand coastal hazards and adapt to current and future sea level variability.

NSW Flood Database

The NSW Flood Database supports strategic risk management decisions by bringing together spatial and textual information currently recorded in local flood studies. The joint project between SES and OEH is building a NSW Flood Studies Database to capture all NSW local government and state agency flood studies.

Hawkesbury-Nepean Valley Flood Management Review

The Hawkesbury-Nepean Valley Flood Management Review commenced in early 2013, in response to the Government's adoption of *The State Infrastructure Strategy 2012-2032* and ongoing community concerns about flood risk. This Review concluded the first stage of the assessment of current flood mitigation arrangements.

In 2012, extensive flooding across south-eastern Australia, including the Hawkesbury-Nepean Valley, saw Warragamba Dam spill for the first time in 14 years. This raised awareness about the potential impacts of flooding.

In response, the NSW Government began the Hawkesbury-Nepean Valley Flood Management Review to consider flood planning, flood mitigation and flood response in the Hawkesbury-Nepean Valley.

The key findings of Stage One of the review are:

- There is no simple solution or single infrastructure option that can address all of the flood risk in the Hawkesbury-Nepean Valley floodplain. The risk will continue to increase with population growth;
- infrastructure options can reduce, but not eliminate the risk to life and property in the Valley; and

- evacuation is the only mitigation measure that can guarantee to reduce risk to life, and that detailed investigation is required to support an integrated approach to reduce overall flood risk in the Valley.

Management of the flood risk in the Hawkesbury-Nepean Valley includes mitigating the impact of flood, planning and preparedness for flooding, as well as response to and recovery from floods.

The potential infrastructure strategies include works that can be built to mitigate floods, as well as the enhancement of flood evacuation capacity through improved transport infrastructure.

The NSW Government has commenced work on several priority areas for action:

- increasing flood awareness and preparedness in the community
- the enhancement of emergency planning, response and recovery
- better consideration of flood risk in land use planning
- detailed cost benefit assessment of potential infrastructure options
- reviewing effective flood management arrangements.

This work will be overseen by an inter-agency Taskforce. The immediate priority of the task force is building the resilience and preparedness of the communities and businesses of the Hawkesbury-Nepean Valley to future flood.

Stage Two of the review will undertake a detailed cost benefit assessment of the most practical and cost effective flood mitigation options for the government to consider.

More detailed information on the NSW Government's Hawkesbury-Nepean Valley Flood Management Review[xx] is available in the following reports:

- Hawkesbury-Nepean Valley Flood Management Review Stage One – Review Report
- Hawkesbury-Nepean Valley Flood Management Review Stage One – Summary Report

Attachment A

Overview of NSW natural disaster budgeting and funding

The NSW Treasury is responsible for budgeting for response and recovery activity via the central provision held in the DRA. This budget is not intended to cover all recovery costs, with some agencies required to meet funding needs through reprioritisation of budgets, while some other minor provisions exist for specific agencies and functions.

Unlike the budget for most other Government activity which is managed by the agency, Treasury manages the natural disaster budget centrally. This is due to the acute variance in natural disaster expenditure, which is not known in advance. Aggregating different response and recovery expenditure streams into one central account allows for some pooling of risks to better manage this volatility. Resilience and Mitigation activities are funded through separate programs that follow the usual agency budgeting process – details of which will be the provided in the next NSW Government submission to the Productivity Commission Inquiry.

Currently, the central disaster provision is set at $95 million for 2014-15. The figure is based on past expenditures and the expected impact of new policies. This budget does not attempt to capture all volatility in natural disaster costs but to reasonably capture expected costs based on a long term annual median cost calculation.

Apart from the annual provision, there is no reserve fund dedicated to natural disaster expenditure. In years when the natural disaster budget in the DRA is insufficient to meet the funding needs of all eligible response and recovery activity, supplementary funds are sought through either a diversion of resources from the budget, supplementation from the consolidated fund or borrowing.

Apart from the central provision held in the DRA and managed by Treasury, there are some other minor budgeted provisions for recovery activity funded separately. Currently these consist of:

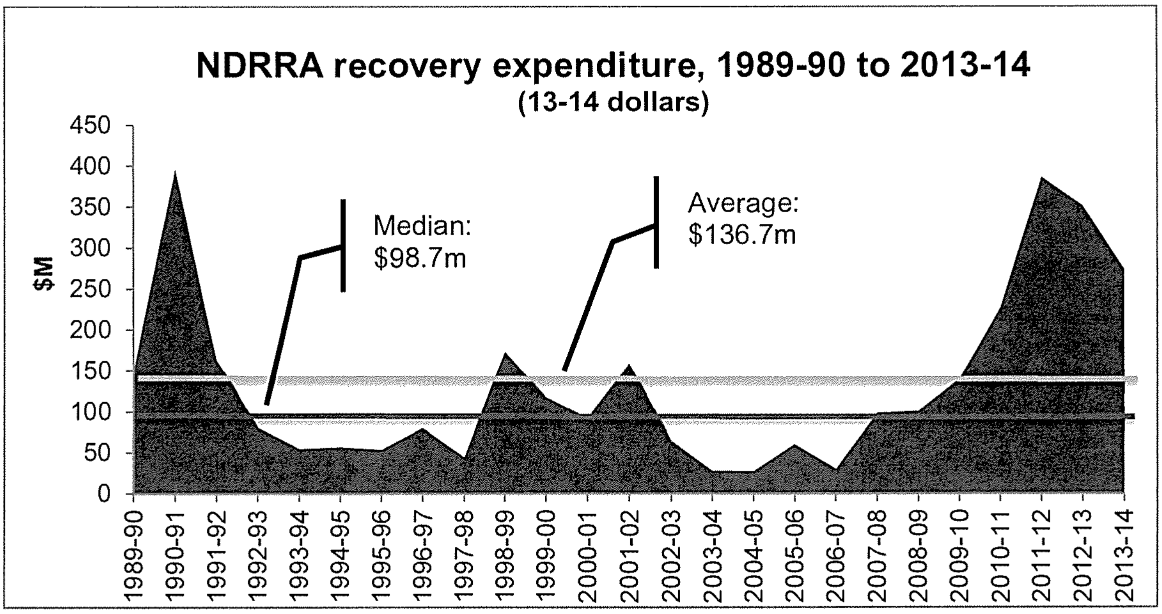
- $20 million internal provision set aside by RMS from its maintenance budget.
- A nominal $20 million budget for Rural Assistance Authority (RAA) loans to primary producers and small businesses (note this represents the total value of the loans, not the cost of the interest rate subsidy).
- A nominal $1.4 million budget for MPES Disaster Welfare Services and recovery operations.

Natural disaster expenditure

Expenditure data for natural disasters is collected for the purpose of submitting the NSW's claim for partial reimbursement under NDRRA. This does not capture all recovery expenditure, as some costs that are not eligible under the arrangements are captured within agency budgets. NSW's recovery policies are however aligned with the NDRRA so the data largely reflects direct costs to the NSW Government for recovery.

Expenditure over time

Treasury's records of NDRRA expenditure extend from 1989-90 to an estimate of 2013-14. Over time there is a cyclical pattern of recovery expenditure associated with natural events. Peaks occurred in 1990-91 (Newcastle earthquake recovery), 1998-99 (Sydney hailstorm) and 2011-12 (widespread flooding across NSW).



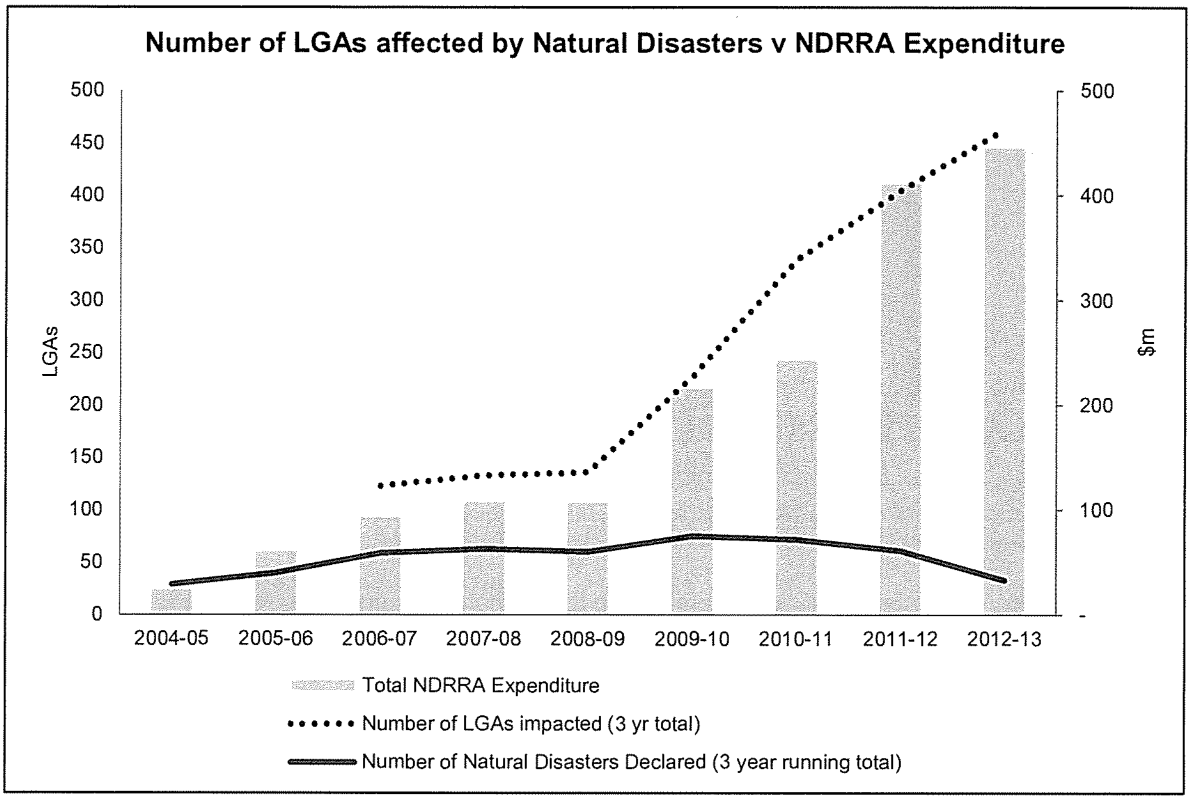
Natural disaster severity

Due to the complexity associated with natural disasters it is difficult to determine an objective measure of the frequency or severity of natural disasters. Two events that are equally classified as natural disasters may vary significantly in their expenditure impact. This means measures of frequency, severity, duration and cost incurred can potentially be conflicting variables.

Disasters are catalogued by type and date, with the Local Government Areas (LGAs) declared disaster zones annexed. These measures of natural disaster occurrence and expenditure are tied (natural disasters are declared after $240,000 of eligible damage has been incurred) so declared disasters and expenditure should be expected to correlate.

Shown in the graph below, the three-year running total of the number of natural disasters appears to be trending downwards from 2009-10 onwards. This is in comparison to an upward trend in NDRRA expenditure. However when expenditure is considered against the number of LGAs impacted on a three year rolling basis, there is a clear trend between the two.

The data provides some evidence to suggest that in recent years there has been an increase in natural disaster severity (by floods, fires and storms that impact large areas of the state) which has contributed to the upward trend in expenditure. It is important to note however that this correlation only explains the trend, not the quantum of expenditure. The graph below indicates recent expenditure increase is broadly consistent with past expenditure given the difference in severity over time.

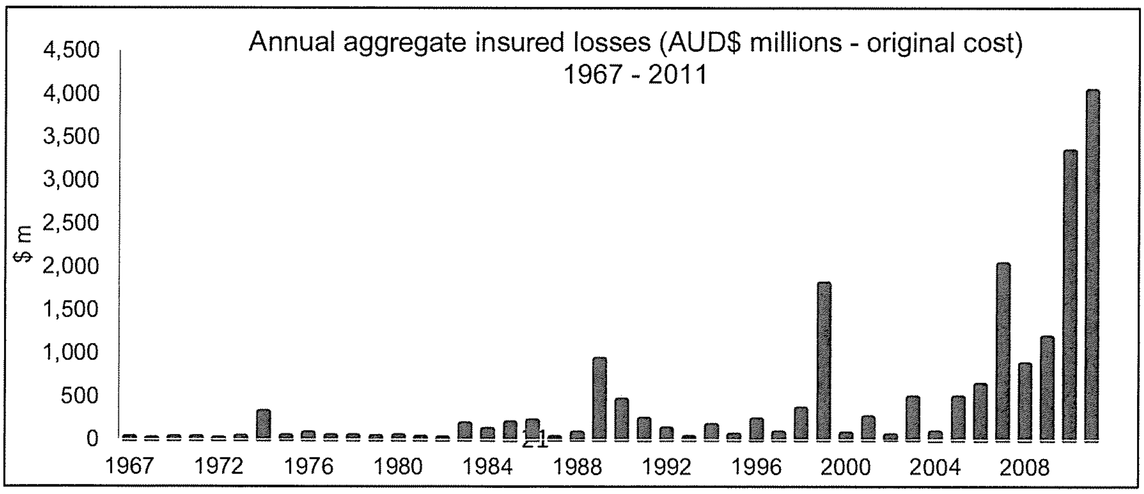


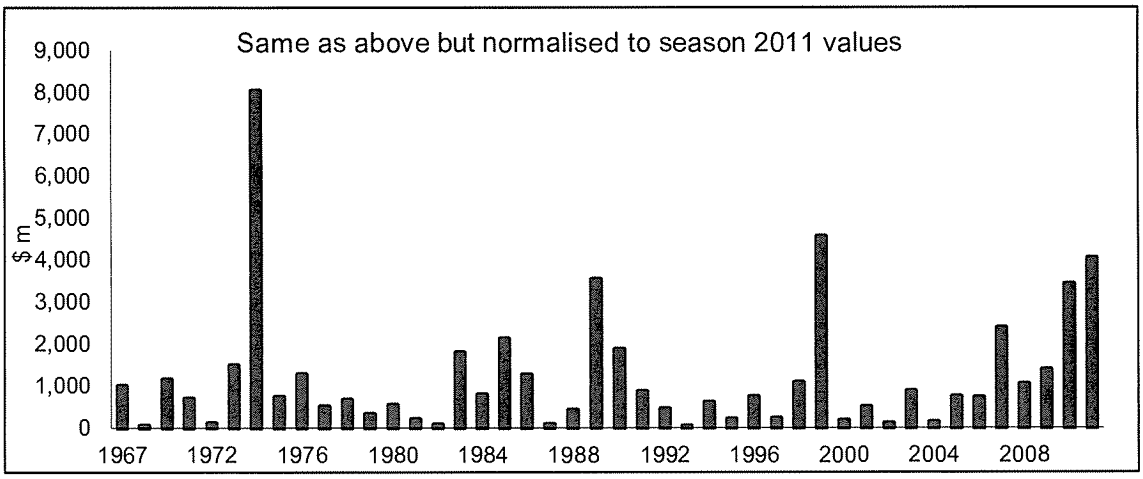
Where LGAs are affected by more than one disaster event they are counted twice. Because annual natural disaster expenditure reflects response and recovery for events during the year plus recovery costs for events over the previous two years, the number of events / LGAs is presented as a three-year running total.

Trends in private losses

The Insurance Council of Australia (ICA) keeps data on losses from natural disasters. The data is derived from submissions from insurance companies following events that incur over $10 million in insured losses.

ICA commissioned Macquarie University to calculate 'normalisation' of costs from disasters over time. Cost normalisation is a process used to estimate the costs that would have been sustained if previous events were to impact in the same geographic location on the present day community. Costs are controlled for specific factors such as growth in asset prices and density of development to make a like for like comparison of events. The analysis is shown in the graph below.





Source: Insurance Council of Australia, 'Submission to Senate enquiry: recent trends in and preparedness for extreme weather events'

Based on this analysis, the ICA submission to the Senate enquiry, 'Recent trends in and preparedness for extreme weather events', commented:

"When normalised the time series of insured losses exhibits no obvious increase or decrease in catastrophe costs over the last four decades. The increasing cost of insured losses over time is explained predominantly by growth in the number of insured buildings exposed to weather events and the nature of those buildings."

In NSW population growth has been concentrated in coastal regions with relatively high exposure to both river flooding and bush fire fuel. This population is also ageing, thus requiring greater government support during and after events and reducing the capacity to mitigate risks at the household level.

Cost sharing under NDRRA

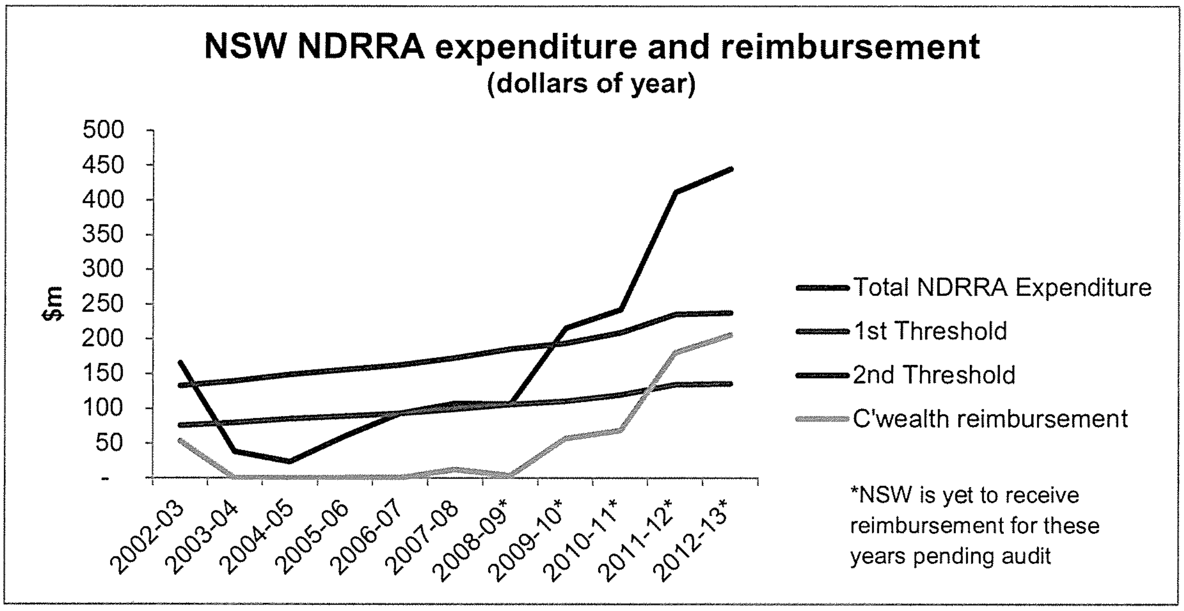
While it is frequently quoted that the NDRRA provides between 50per cent and 75per cent reimbursement of natural disaster costs to the State, in reality NSW has received on average 30per cent reimbursement over the past 11 years.

This is because expenditure has generally been within a range that does not trigger the higher levels of reimbursement under the cost sharing formula.

The Commonwealth / State cost sharing arrangements are calculated on the basis of pre-determined thresholds:

- First threshold – 0.225 percent of the State's total general government sector revenue and grants ($140 million in 2013-14).
- Second threshold – 1.75 times the State's first threshold ($246 million in 2013-14)

The State receives almost no reimbursement for expenses up to the first threshold, 50per cent reimbursement between the first and second thresholds and 75per cent reimbursement beyond the second threshold. Expenditure and reimbursement under NDRRA are shown below.



Recovery funding

The principles for agency funding are established in EMPLAN, but NSW Treasury manages the process for agency reimbursement of expenses and other natural disaster funding provisions.

NSW Treasury Circular 12/02 *Guidelines for reimbursing agencies expenditure related to disaster emergency and recovery operations*[xxi] defines the emergency response and recovery expenditures that may be claimed from the DRA and those that must be met from other sources. NSW Treasury Circular 12/02 also establishes key reporting and compliance requirements for NDRRA purposes.

Many NSW Government agencies incur expenses for natural disaster recovery. However not all agencies or expenditures are eligible for funding from the DRA. Funding for recovery is provided through a number of channels:

- Direct reimbursement of eligible expenditures from the DRA for assistance delivered to individuals and households, small businesses, primary producers, not for profits and local governments. This applies to eligible agencies which are responsible for delivering assistance under the NSWDAG with the exception of RMS for road reconstruction (both state and local government owned) and RAA for the provision of concessional loans. For eligible agencies, this reimbursement is guaranteed before the event for activity delivered under the NSWDAG.
- Cost recovery from insurance policies.
- Other small budgeted recovery provisions. Currently these consist of:
    - $20 million internal provision set aside by RMS from its maintenance budget.
    - A nominal $20 million budget for RAA loans to primary producers and small businesses (note this represents the total value of the loans, not the cost of the interest rate subsidy).

- A nominal $1.4 million budget for MPES Disaster Welfare Services and recovery operations.

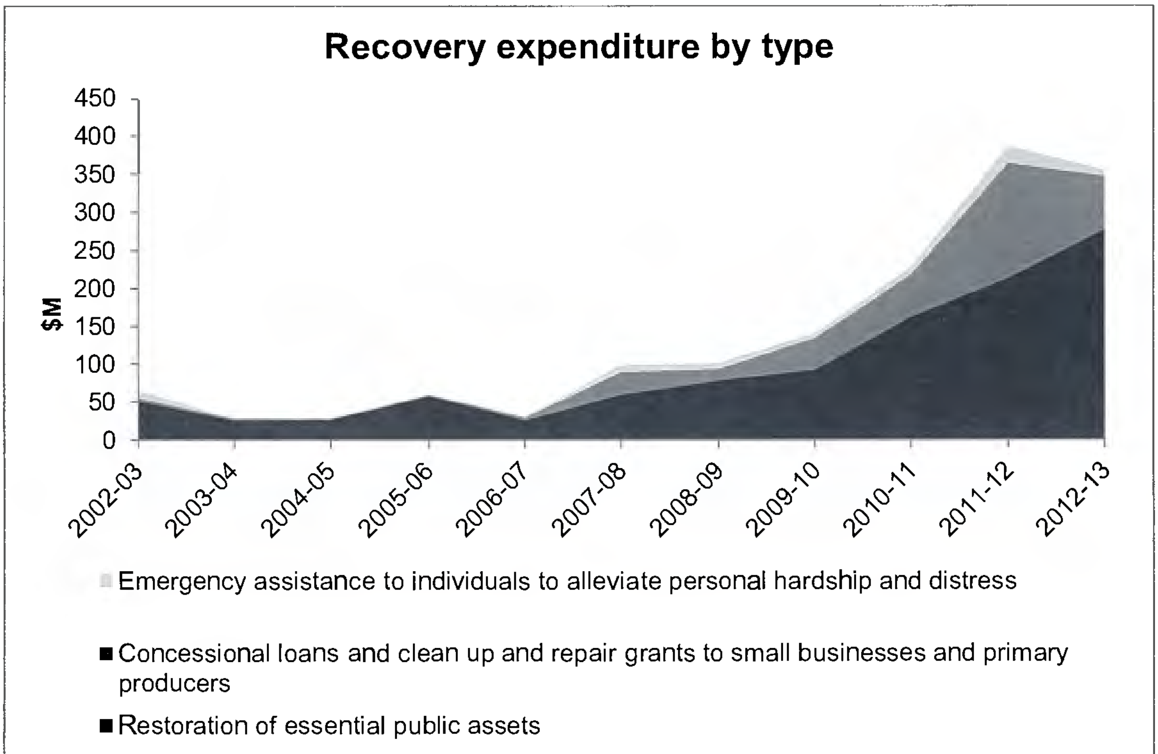
- ERC approved supplementation; for expenditures that are not covered by the DRA and cannot be met by reprioritisation.

NSW Treasury Circular 12/02 and the NSWDAG are the key policies which determine how agencies access funding.

For all agencies, including those not eligible to receive state funding for recovery, expenditure details are collected and recorded for the purpose of the state's claim for partial reimbursement under the NDRRA.

Recovery expenditure by category

NSW spent about $1.5 billion (in 2012-13 dollars) on recovery under NDRRA categories of assistance from 2002-03 to 2012-13. The breakdown between major expenditure categories is shown below.



Emergency recovery assistance

This covers immediate measures provided to alleviate personal hardship and distress suffered by individuals due to emergency events. This category accounted for 5per-cent of recovery costs since 2002-03.

Concessional loans and clean up and repair grants

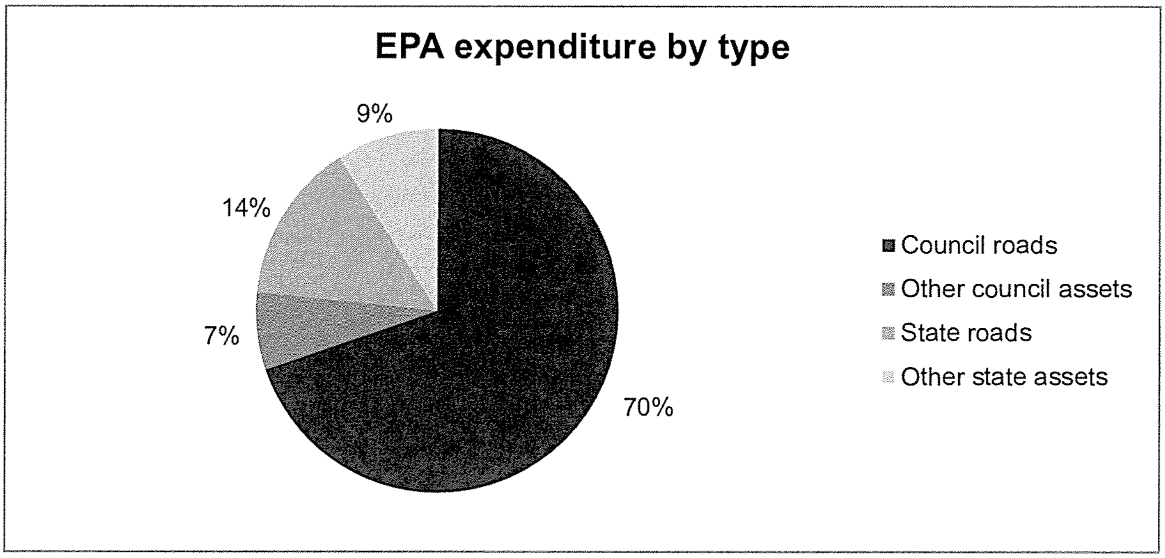
These are provided largely by the Rural Assistance Authority under several NSWDAG guidelines, based on NDRRA categories of assistance. Where the NDRRA allows for grants of up to $25,000 however, in NSW grants have been historically provided up to $15,000. This category accounted for 25per cent of recovery costs since 2002-03. Most of this expenditure occurred since 2006-07 when grants were introduced in the NDRRA and adopted by NSW.

Restoration of essential public assets

This is delivered largely in the form of grants to councils by RMS and NSW Public Works (part of the Office of Finance and Services) under NSWDAG. This category accounted for 70per cent of recovery costs since 2002-03.

Expenditure on essential public assets

The breakdown of expenditure on essential public assets (EPA) is shown below. This demonstrates that expenditure is predominantly for the reconstruction of council owned assets, in particular local roads for which the State has no direct responsibility. Council assets accounted for 77per cent of total EPA expenditure since 2002-03, with most of this cost for roads.



Budgeting and funding - Roads hierarchy, responsibilities and insurance in NSW

Roads are managed in NSW on the basis of an administrative system of State, Regional and Local roads. This operates within the legislative framework of the *Roads Act 1993*. This administrative system was developed to more clearly identify the roles and responsibilities of RMS[xxii] and councils.

State and regional roads are accepted as EPAs as these perform major arterial or support functions. 'Local roads' is a broad classification under which assets of varying significance and value to the public are combined.

Local and regional roads represent 90per cent of the total road network in NSW. While councils receive funding support for annual road maintenance from the State, RMS is not responsible for the stewardship of local and regional roads.

Classification	Responsibility	kms	%
State	RMS for funding, priorities and outcomes	18,031	10%
Regional	Councils with funding assistance from RMS	18,231	10%
Local	Councils	145,619	80%
Total		181,881	100%

Road reconstruction

RMS is the coordinating agency for NSWDAG scheme *B.2 – Restoration of Public Roads.* This scheme only applies to local government roads.

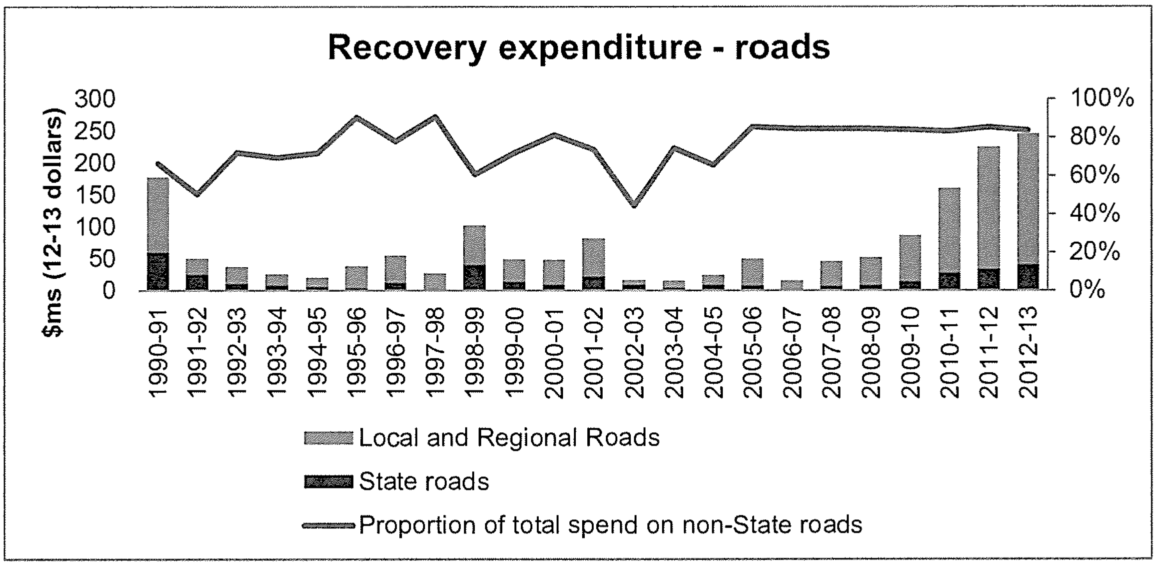
Local government refers collectively to the 152 councils in NSW, which are responsible for managing over 160,000kms of local and regional roads, noting that these councils operate independently of each other and are diverse entities. Under the NSWDAG scheme, assistance to councils is provided in the form of an upper limit grant. Once approved, RMS pays claims to councils on receipt of monthly invoices.

Eligibility criteria are defined in the NSWDAG, with the key criteria being the NDRRA EPA definition determined by the Commonwealth, which to date has covered all local, regional and State roads. Assistance is provided to reinstate the pre-event level of service or to current engineering standards if the pre-event condition was out-dated.

The scheme is only accessible by councils following the declaration of a natural disaster by the NSW Government with reference to the LGA in which the damaged road is located.

Spend on council roads has driven the recent spike in total expenditure

The State spent about $750 million (2012-13 dollars) under the NSWDAG scheme for restoration of local roads administered by RMS in the 11 years to 2012-13, representing 51per cent of total expenditure on recovery. Over two-thirds of this expenditure was in the last four years. The split between recovery expenditure on local vs state roads has consistently been around 83per cent for local, 17per cent for state owned. This relationship is demonstrated below over a longer time frame.

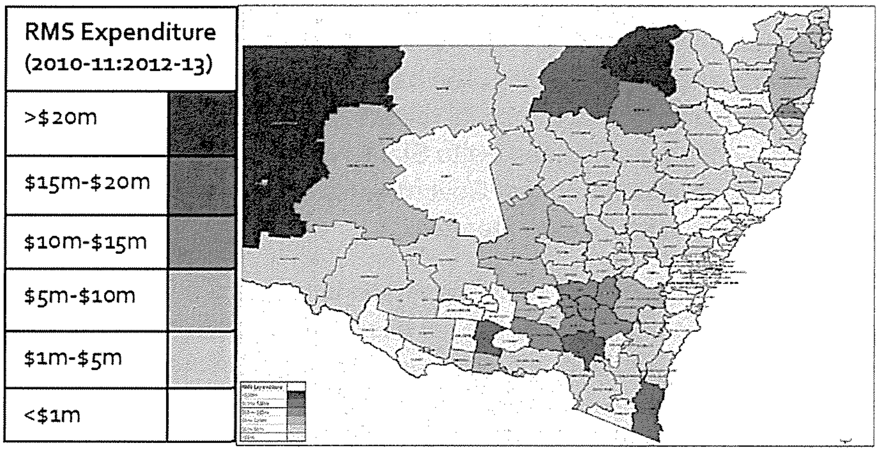


Having road repairs as the driver of total recovery costs is not unique to NSW. The terms of reference of the Commission review of natural disaster recovery and mitigation notes that the $12 billion provided to States and Territories under NDRRA since 2009 has largely been "for rebuilding essential public assets, in particular roads and road infrastructure."

Damage to roads is principally caused by flooding and heavy rain events which typically impact over a large geographic area. As flood waters move along river systems and through the State, a flood event is likely to impact a large number of LGAs. In 2012-13, 106 different councils made claims to RMS under the NSWDAG.

Areas with the greatest damage have been far west and northern councils. Western LGAs are typified by flat terrain which makes them vulnerable to flooding, while northern LGA's typically experience the highest frequency of flood events. Urban LGAs, with lower risk exposure and greater financial capacity compared to rural and regional LGAs have made limited claims to RMS. The spread of expenditure on local government roads in recent years is shown below.

RMS expenditure by LGA (2010-11 to 2012-13)



Cost sharing under the NSWDAG

Under the NSWDAG, councils are required to make a contribution to costs for approved works undertaken on council owned essential public assets. The contribution requirement of councils for roads is 25 per-cent of costs up to $116,000 and zero per-cent of costs thereafter, for each disaster event, with total council contributions capped at $58,000 over the financial year (the cost of two $116,000+ events).

Above $116,000	•State funds 100% of costs
First $116,000	•State funds 75% of costs (total council contribution capped at $58,000 pa)

In 2012-13 the average funding provided to the 106 councils which made claims for road restoration under the State's natural disaster assistance scheme was $2.3 million, with the largest single council's claims totalling $27.8 million. NSW anticipates receiving Commonwealth reimbursement of 46.3per cent under the NDRRA in 2012-13 (based on total eligible expenditure in that year, on average the recoup to NSW is around 30%).

Based on these figures, and assuming councils incurred expenditure in two or more natural disaster events, an average council's $2.3 million in road restoration expenditure was funded as follows:

Level of government	Share of $2.3m (12-13 average)	Contribution rate
Commonwealth	$1,064,900	46.3%
State	$1,177,100	51.2%
Local	$58,000	2.5%

Different states have developed a range of elements in their co-contribution arrangements between councils and states.

Insurance options for State roads

SICorp does not reinsure the state road network because the costs of risk transfer would outweigh the benefits, and the asset base of the State is significantly diversified to be risk neutral. This view is reaffirmed by most other jurisdictions, who also do not engage the market to reinsure roads and retain this risk. The exceptions to this are Victoria and the ACT, which have coverage in the form of commercial reinsurance of their state self-insurance schemes. As such, this coverage only applies to State owned roads (100per cent of roads in ACT, 15per cent of roads in Victoria). Local Governments (90per cent of roads in NSW) have no coverage for roads in any state or territory.

For Victoria, the reinsurance only pays after $50 million in property damage to state owned assets (including roads) for a single event. To put this in perspective, the most damage that NSW has had to state owned roads for a single year (not event) in the past two decades is $40 million in 2012-13. The largest claim made through SICorp for damage to other (covered) assets was $22 million for the Sydney hailstorm of 1999.

Budgeting and funding - Grants to small businesses and primary producers

There is a subsection of disaster assistance measures in the NDRRA which are termed 'Category C measures'. A Category C measure is described in the NDRRA as:

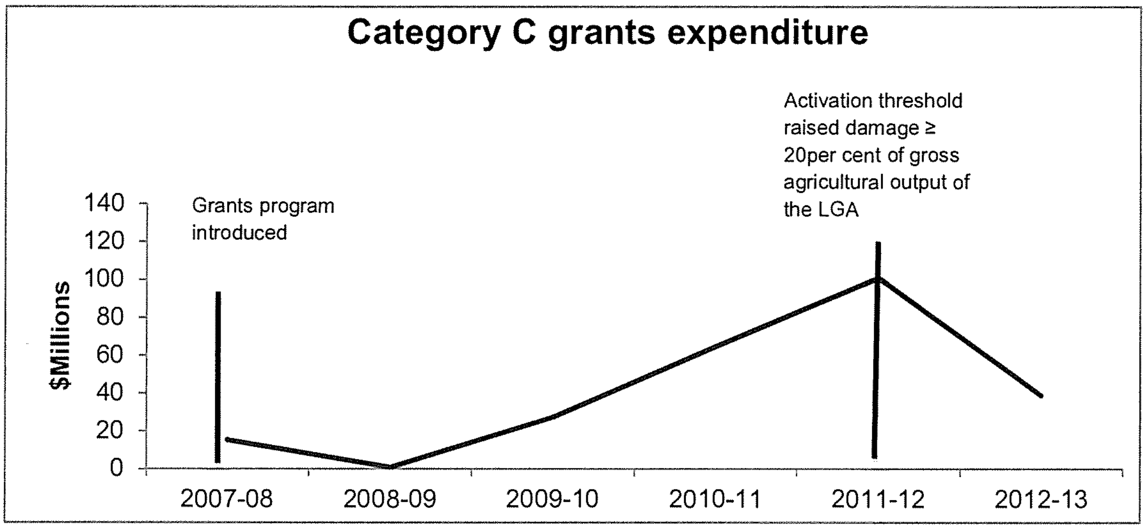
"a community recovery package designed to support a holistic approach to the recovery of regions, communities or sectors severely affected by a natural disaster"

Eligible Category C assistance schemes listed in the NDRRA are:

- Recovery grants for small business
- Recovery grants for primary producers
- A community recovery fund

Generally, NSW offers only grants to small businesses and primary producers, following severe natural disasters. The community recovery fund has been made available on two occasions since it was introduced.

Expenditure on Category C grants grew by a cumulative annual rate of 44per cent from 2007-08 to 2011-12. Of these grants, 91per cent were directed to primary producers. Grants to primary producers have been more targeted since the implementation of activation thresholds in the 2012 NDRRA Determination.



Farmers and small businesses within eligible LGAs are required to provide an invoice to RAA as evidence of works required following a natural disaster event. These works are not subject to individual assessment because of the volume of claims received and the costs of checking works relative to the size of individual grants. The RAA conducts desktop checks for reasonableness.

The largest expenditure under this recovery measure was $104 million in 2011-12, in which widespread flooding resulted in Category C assistance being activated across most of the state outside of the Sydney metropolitan area.

Attachment B

References and Further Information

[i] *State Emergency and Rescue Management Act 1989* available at http://www.legislation.nsw.gov.au/maintop/view/inforce/act+165+1989+cd+0+N

[ii] NSW State Emergency Management Plan available at http://www.emergency.nsw.gov.au/media/1621.pdf

[iii] NSW Disaster Assistance Guidelines available at http://www.mpes.nsw.gov.au/media/1149.pdf

[iv] Treasury Policy Paper 09-05: Internal audit and risk management policy for the NSW Public Sector available at http://www.treasury.nsw.gov.au/__data/assets/pdf_file/0020/15077/tpp09-5_dnd.pdf

[v] *Public Finance and Audit Act 1983* available at http://www.legislation.nsw.gov.au/maintop/view/inforce/act+152+1983+cd+0+N

[vi] *Work Health and Safety Act 2011* available at http://www.legislation.nsw.gov.au/maintop/view/inforce/act+10+2011+cd+0+N

[vii] *Environmental Planning and Assessment Act 1979* available at http://www.legislation.nsw.gov.au/maintop/view/inforce/act+203+1979+cd+0+N

[viii] *Protection of the Environment Operations Act 1997* available at http://www.legislation.nsw.gov.au/maintop/view/inforce/act+156+1997+cd+0+N

[ix] NDRRA Independent Assessment of NSW State Insurance Arrangements available at http://www.treasury.nsw.gov.au/__data/assets/pdf_file/0019/20782/NDRRA_Independent_Assessment_of_State_Insurance_Arrangements.pdf

[x] Commonwealth Natural Disaster Insurance Review is available at http://www.ndir.gov.au/content/Content.aspx?doc=home.htm

[xi]TMF Statement of Cover is available at https://riskinsite.nsw.gov.au/portal/server.pt/document/157525/treasury_managed_fund_-_statement_of_cover

[xii] NSW 2021 information and reporting is available at www.2021.nsw.gov.au

[xiii] NSW Rural Fire Service website is www.rfs.nsw.gov.au

[xiv] Bush Fire Coordinating Committee Policy 01/08 available at http://www.rfs.nsw.gov.au/dsp_content.cfm?CAT_ID=537

[xv] NSW RFS reports on hazard reduction mitigation activity in its annual report http://www.rfs.nsw.gov.au/dsp_content.cfm?CAT_ID=540

[xvi]Living with Fire in NSW National Parks – A Strategy for Managing Bush fire in National Parks and Reserves to 2021is available at http://www.environment.nsw.gov.au/resources/firemanagement/120690LiveFire.pdf

[xvii] NSW Floodplain Development Manual available at http://www.environment.nsw.gov.au/floodplains/manual.htm

[xviii] *Local Government Act 1993* available at http://www.legislation.nsw.gov.au/maintop/view/inforce/act+30+1993+cd+0+N

[xix] *Environmental Planning and Assessment Act 1979* available at http://www.legislation.nsw.gov.au/maintop/view/inforce/act+203+1979+cd+0+N

[xx]Hawkesbury-Nepean Valley Flood Management Review Stage One – Review Report and Hawkesbury-Nepean Valley Flood Management Review Stage One – Summary Report available at http://www.water.nsw.gov.au/Water-management/Water-availability/Flood-management/Hawkesbury-Nepean-Valley-Flood-Management-Review/Hawkesbury-Nepean-Valley-Flood-Management-Review

[xxi]NSW Treasury Circular 12/02 Guidelines for reimbursing agencies expenditure related to disaster emergency and recovery operations is available at http://www.treasury.nsw.gov.au/__data/assets/pdf_file/0010/21520/TC12-02_Guidelines_for_Reimbursing_Agency_Expenditures_Related_to_Natural_Disasters_dnd.pdf

[xxii] RMS Natural Disaster Arrangements is available at http://www.rms.nsw.gov.au/doingbusinesswithus/downloads/lgr/nat_disaster_arrangments.pdf

Attachment C
University of Wollongong Research

University of Wollongong

Developing protocols to improve early intervention in remote fires:

Ignition patterns in the Greater Blue Mountains World Heritage Area 1997 – 2007 and case study in Wollemi National Park 2006

Report to Department of Environment, Climate Change and Water

Owen Price
Centre for Environmental Risk Management of Bushfires
University of Wollongong
NSW 5221

October 2009

Contents

Commonly Used Terms

CERMB	Centre for Environmental Management of Bushfire (University of Wollongong)
DECCW	Department of Environment, Climate Change and Water
GBMWHA	Greater Blue Mountains World Heritage Area
RAFT	Remote Area Fire Team (used to perform RIA)
RFS	Rural Fire Service
RIA	Rapid Initial Attack

Summary

The pattern of lightning and arson ignition for the Greater Blue Mountains World Heritage Area (GBMWHA) over an 11 year period (1997-2007) were analysed to identify spatial patterns that might assist in allocating fire-fighting resources. Lighting ignitions are more likely where fuels are old (and so higher), on ridge tops, in higher rainfall areas and to the north of the region. However, these influences are all weak and of little value in predicting fire occurrence. The main influence on the occurrence of lighting ignitions is fire-weather (temperature, humidity and wind-speed). Arson ignition has a very distinctive pattern, occurring near to roads and with a concentration in the eastern foothills of the Blue Mountains.

The 42 fires that occurred in the Wollemi National Park (and surrounds) in late 2006 were used as a case study to explore options for increasing the effort on rapid attack of fires. Nine ignitions began on November 13th on a day of moderate fire weather, but relatively high wind, and two of these eventually spread and burned 74,000 ha. Ignitions that were attacked quickly during this season were successfully contained. Had the resources available on the following day (Nov. 14th) been available on the 13th, the fires probably would have contained. A simulation model (Phoenix) predicted that six of the nine fires would have burned a large area if they had not been suppressed, and that any one of these six ignitions would have burned almost as much area as the combined fires did.

Over the past 11 years, six events have occurred with several ignitions during fire weather as bad or equal to November 2006. Many of these ignitions would have been uncontainable even if extra resources had been available. Using the model of RAFT teams (~12 people and one helicopter), a cost-benefit analysis was conducted. One additional RAFT team would probably have led to the prevention of a large proportion of wildfire area (between 50% and 62%). To prevent a higher proportion of wildfire area would require a different model, where more resources can be deployed quickly on the very rare days when many ignitions occur during bad weather. At least some of the prevented wildfire area must be replaced with prescribed burning to keep fuels to acceptable levels and to maintain ecological health. Depending on the level of replacement, the level of success of the team and the relative costs of campaign suppression and prescribed fire, the addition of one RAFT team could yield a net saving of between $1 - $2 m per year for an outlay of $0.5 m per year, which is a very good return for investment. Deploying more than one team may not save money because most ignitions occur singly, though the analysis has not factored in the benefit of work done by the team while not fighting fires.

Climate change will probably increase the incidence of ignition, bad fire weather, and the area and intensity of wildfires. This will make rapid attack a more attractive management solution. Also, it will become cheaper because less prescribed burning will be needed to replace lost wildfire area.

Introduction

Bushfire is a natural phenomenon in Australia, but it causes substantial social and economic costs, especially in the south-eastern states (averaging $400 m per year, Ellis *et al.* 2004). Therefore, the managers of fire-prone vegetation put considerable effort into fire management. The objective is usually to reduce the risk of intense, uncontrollable fires destroying assets, though there are ecological objectives as well, particularly in National Parks. Managers are also interested in optimising their activities in terms of return-for-effort. Several complementary strategies are used to manage bushfire risk, including prescribed fire, regulating the built environment, community preparedness, ignition management, rapid initial attack and campaign fire suppression. There is little scientific evidence of the effectiveness of these strategies either alone or as part of a mixed strategy.

Rapid Initial Attack has received increasing emphasis in recent years because it holds the promise of preventing potentially damaging fires before they become established. There have been some evaluations of the effectiveness of Rapid Initial Attack (RIA) that have concluded that it is very successful. For example, McCarthy and Tollhurst (1998) found that 99% of 2000 RIAs in Victoria were successful. Arienti *et al.* 2006 found that 93% of fires attended in Alberta, Canada were successfully contained. Plucinski (2008) examined the factors influencing RIA success and found that success decreased with the time taken to send aircraft, the time taken to send crew, and the size of the fire at deployment, as well as with increasing fuel hazard and wind speed.

The NSW Department of Environment, Climate Change and Water (DECCW) has long recognised the value of RIA, for example mentioning it as a useful strategy in its submission to the NSW Parliamentary Joint Select Commission Inquiry into 2001-2002 Bushfires (Anon 2002). In order to make the best use of limited resources, the Blue Mountains region of the Parks and Wildlife Group commissioned the Centre for Environmental Management of Bushfires at the University of Wollongong to analyse the potential gain from putting more resources into Remote Area Fire Teams (RAFT). These teams combine a crew that can be dropped into inaccessible bushland and a helicopter for transport and water-bombing. This report has three sections. First, the historical pattern of ignitions in the Greater Blue Mountains World Heritage Area (GBMWHA) is explored to identify optimal locations for stationing fire-fighting resources. Then, the series of fires in Wollemi National Park in 2006 are used as a case study to explore the success of RIA and the consequences had there been more or fewer fire-fighting resources available. This analysis includes a reconstruction of the fires using a bushfire spread simulator. Lastly, the results are combined with economic data to explore the costs and benefits of different levels of resourcing for RAFT.

1) Ignition Patterns 1997-2007

Introduction

Any review of resourcing for bushfire-fighting should incorporate an assessment of where the high risk areas are. This will help to guide where the resources should be stationed. For this reason, the historical pattern of lightning and arson ignitions in the GBMWHA were analysed for spatial and temporal patterns.

Data and Methods

Ignition data supplied by DECCW were compiled from situation reports from 1997 to 2007, comprising 628 ignitions with known location and date within the GBMWHA (Figure 1.1). The weather on the ignition day was sourced from the closest weather station. Five stations were used for this: Nullo Mountain, Mount Boyce, Cessnock, and Moss Vale. The temperature was corrected for altitude difference between the ignition point and the station using a lapse rate of 0.98°C per 100 m altitude. Since the Moss Vale station became operational in 2001, Mt Boyce was used for ignitions in the southern part of the study area before this date. In addition, a range of mapped environmental variables were obtained for each ignition point: the vegetation, time since the previous fires, distance to roads, altitude, slope, aspect, topographic position (where 0 represents valley bottoms and 100 represents hill tops). In order to develop a statistical model of ignitions, a matching set of 628 randomly located not-ignition points was also created.

Also, lightning strike data for the period July 1999 to June 2009 were provided by Kattron p.t.y. (through an agreement between them, the Rural Fire Service and the CERMB).

The general seasonal and spatial pattern of lightning ignitions

Prevalence - Every year, approximately 30,000 lightning strikes occur within the GBMWHA, though this varies from 11,000 to 55,000. Between 1997 and 2007 there have been 373 ignitions caused by lightning, which is an average of 34 per year. In most years there were fewer than 20 ignitions, whereas three years stood out with high numbers 1997/8 (79 ignitions); 2002/3 (74) 2006/7 (89). 2006/7 was a year with high a strike rate, but 2002/3 was not (Figure 1.2).

Seasonality – Lightning strikes are highly seasonal events: 91% occur in the warmer half of the year (from November to April), and 65% in the Summer (Figure 1.3). Lightning ignitions are broadly in line with this seasonal pattern, with 80% of events occurring in the Summer months (Figure 1.2), but the peak appears to be two months earlier (in December rather than January). This is somewhat different to arson ignitions for which only 40% occurred in the Summer, and with the peak activity in September and October (47% of events) (Figure 1.2).

Figure 1.1: The Greater Blue Mountains World Heritage Area (GBMWHA) showing the ignitions used in this analysis.

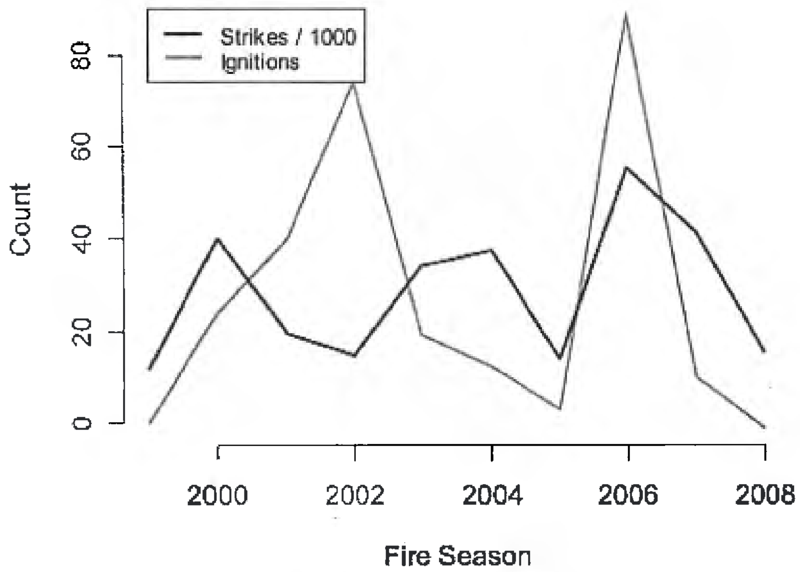


Figure 1.2: The annual pattern of lightning strikes and lightning ignitions in the GBMWHA.

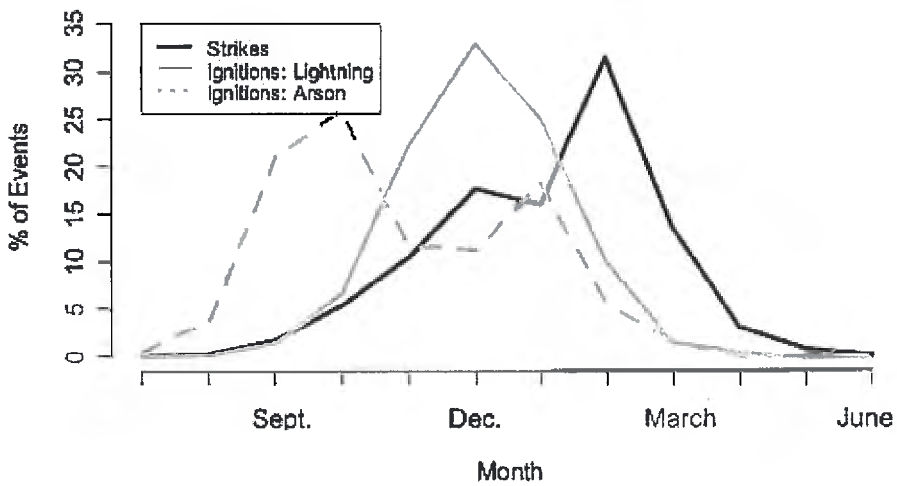


Figure 1.3: The seasonal pattern of lightning, lighting ignitions and arson ignitions. % of Events refers to the % of all events for the year that occurred in each month.

Spatial Pattern - The lighting strike data show a spatial pattern across the Greater Sydney region, with strikes being more prevalent in the Blue Mountains than in the areas to the east or west of them (Figure 1.4 a). There also appear to be three hotspots of activity within the mountains: one in the northeast (Yengo NP), one in the centre (Mt Wilson area) and one in the south (Nattai NP). However, even with ten years of data, it is possible that the pattern is biased to the tracks of individual large storms. The ignitions also show a spatial pattern (Figure 1.4 b), but it does not correspond to the strike pattern. There is a distinct tendency for more ignitions to occur in the northern section of the GBMWHA and a particular hotspot along the Capertee and Colo Rivers.

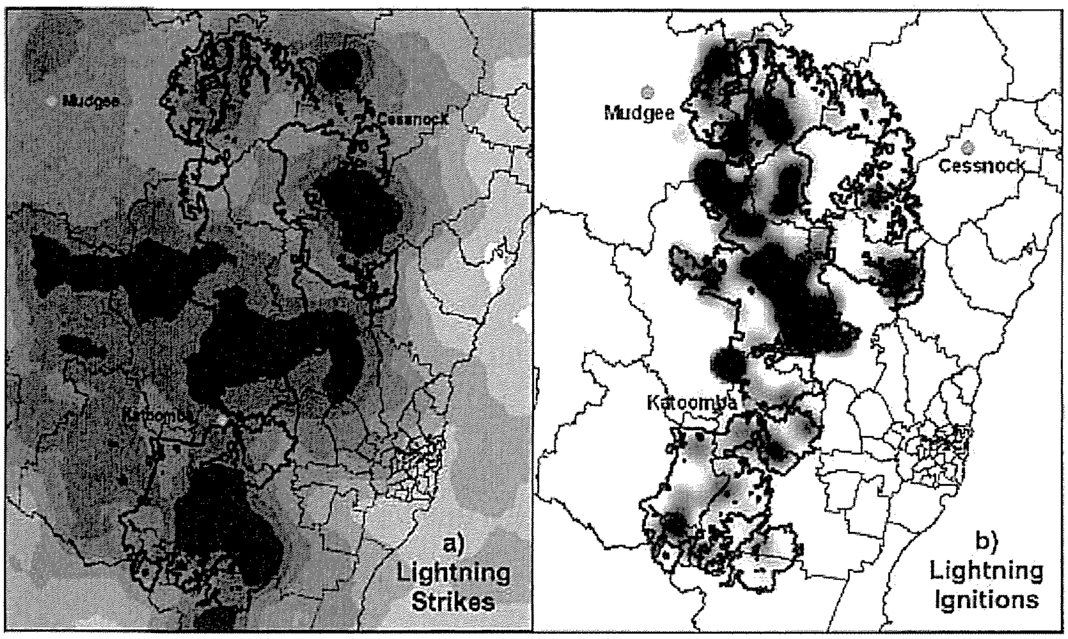


Figure 1.4: The spatial distribution of a) Lighting strikes from July 1999 to June 2009; and b) Lighting ignitions from 1997 to 2007. Both maps were generated by a kernel density algorithm applied to points. Notice that b) includes the GMBWHA only.

In order to investigate the prevalence of lightning ignitions over a range of environmental variables, we compared these variables at sites where lightning ignitions occurred and a similar number of randomly chosen locations within the World Heritage Area. Random points were selected by generating a grid of points 500 m apart across the region and then randomly selecting 315 of them for the sample.

Fire Weather - Most ignitions occurred on days when the Fire Danger Index was Moderate or Low (62%), with only 19% occurring when the Index was Very High or Extreme. However, in comparison to the distribution of FFDI across all days, lightning ignitions occurred at higher FFDI (Figure 1.5).

Topography - Although lightning ignitions do occur anywhere in the landscape, they are concentrated on ridges or upper slopes. This tendency is illustrated by comparing the distribution of topographic position values between lightning ignitions and random points (Figure 1.6). In comparison to the random points, there are more lightning ignitions in higher values of topographic position and fewer in the lower values. Topographic position values of 0 represent valley floors and 100 represents ridge tops.

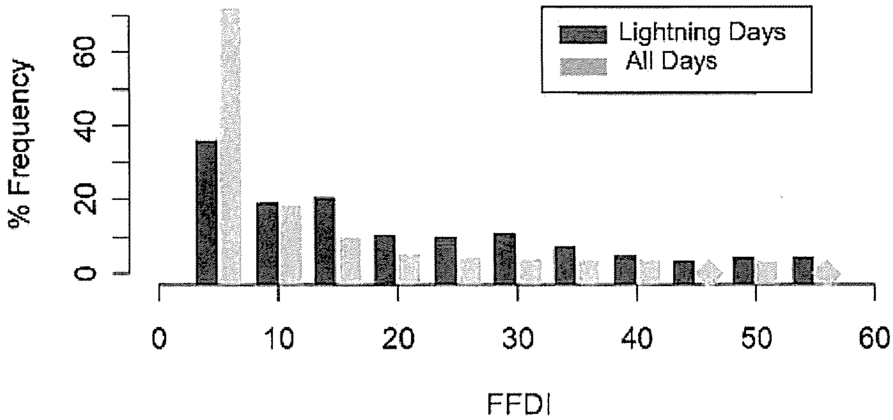


Figure 1.5: The frequency distribution of FFDI for lightning ignition days and all days.

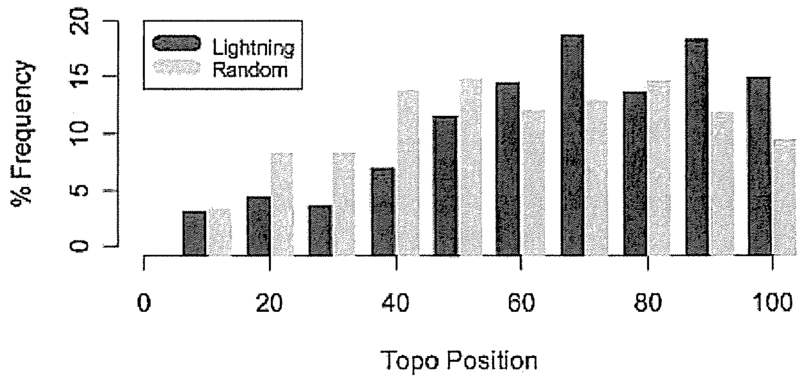


Figure 1.6: The frequency distribution of Topographic Position for lightning ignition days and randomly selected days.

Vegetation Type – Most ignitions occurred in woodlands and dry sclerophyll forests, both in approximately the same frequency that random points occurred in these vegetation types (Figure 1.7). However, ignitions were very rare in wet sclerophyll forests, accounting for only 3% of ignitions compared to 14% of random points.

Fuel Age – Ignitions have occurred in a wide range of fuel ages from zero to more than 30 years (Figure 1.8). However, ignitions occurred in fuels of three years or less at only half the frequency compared to random points.

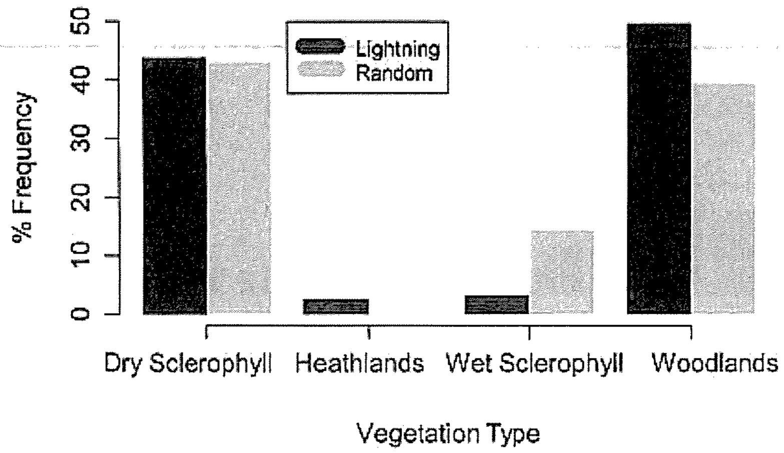


Figure 1.7: The frequency of lightning ignition days and randomly selected days in different vegetation types.

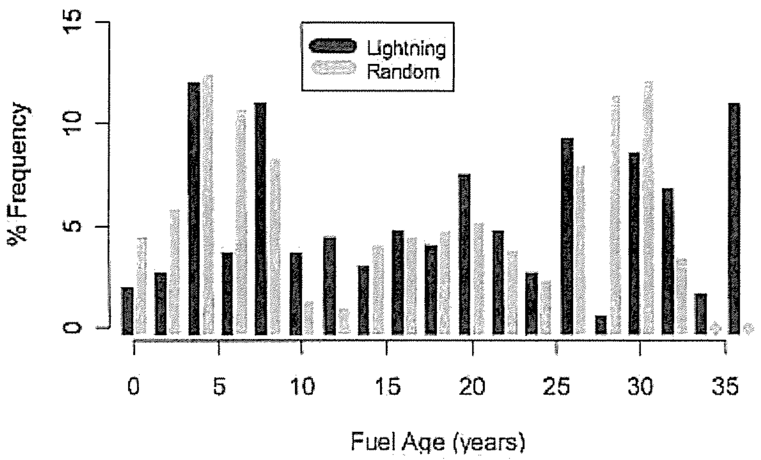


Figure 1.8: The frequency distribution of Fuel Age for lightning ignition days and randomly selected days.

A Statistical Model of Lighting Ignition

In order to determine whether certain aspects of lightning ignition could be predicted, we conducted statistical modelling of ignition against the environmental variables. The method used was generalised linear modelling with a binomial response and logit link function. This method uses a binomial response variable, meaning the variable to be predicted is either true or false. In this case, true values were the lightning ignitions, but there must be a set of false values for which we used the random locations. To interpret alternative models, we used Akaike's Information Criterion (AIC) to select the most informative model. First, we grouped the explanatory variables into themes that describe basic processes influencing ignitions and selected the best model for each group. Then we combined all of the variables selected in these models and identified the best overall model and supported alternatives (see Table 1.1 for results summary).

Fuel Variables – Exploratory analysis revealed that fuel age was best represented as the log of fuel age. This is because the effect of fuel age is greater at young ages. Also, vegetation types could usefully be grouped into Wet and Dry with Dry including Dry Sclerophyll Forest, Woodland and Heath, and Wet comprising Wet Sclerophyll Forest and Rainforest. We found that both variables were significantly related to ignition, but there is no interaction. The model with both variables was highly significant but explained a very small proportion of the variation ($r^2 = 0.06$). Ignitions are slightly more likely in older fuel and in dry vegetation types.

Topography – Of the four topographic variables, only Topographic Position was significant. There is a significant tendency for ignitions to be more likely on ridge-tops compared to valleys. However, like fuel, this was a very minor effect, with an r^2 of only 0.02.

Spatial Location – The spatial arrangement variables were Easting, Northing, Rainfall and Road Distance. For the analysis we included squared terms for Easting and Northing in order to identify humped distributions (for example higher ignition probabilities in the centre of the study area). The analysis revealed that ignition probability increases toward the north and west of the study area and where annual rainfall is higher. Road distance has no effect, and the squared terms were not selected. Again, this was a weak model, explaining only 4% of variation ($r^2 = 0.04$).

Fire Weather – Many of the weather variables are correlated with each other, and exploratory analysis showed that the best results are obtained when FFDI and Humidity were excluded from the modelling. The best model showed independent positive effects of Drought Factor, Temperature and Wind Speed. In comparison to the models for the other themes, the weather model was strong, with an r^2 of 0.36.

Final Combined Model – All of the variables from the theme models were selected in the combined model. This explained 44% of variation ($r^2 = 0.44$). We also derived a best combined model without weather variables. This was to produce a mappable model, and since weather values at the time of lighting events cannot be predicted, they could not be used. The mappable model captured only 10% of the variation.

Conclusion – While many environmental variables have a statistical relationship with ignition probability, most are extremely weak and therefore of limited use for prediction. Weather has a strong effect, but unfortunately cannot be predicted. For predictive purposes, we can conclude that ignitions are more likely on ridge tops, to the north and west of the study area, in areas with higher rainfall and where fuels are old. However, the mappable model is too weak to be of any practical purpose for siting fire-fighting resources.

Table 1.1. Statistical models for lightning ignition

Theme	Model Term	AIC	Deviance Captured	r^2	Prob
Fuel	-0.773 + 0.357 * Log(Fuel Age) – 1.767 (Veg = Wet)	758.74	38.82	0.06	<0.001
Topography*	-0.787 + 0.0133 * Topopos	781.55	14.01	0.02	<0.001
Spatial	-62.5 + 0.00997 * North – 0.0113 * East + 0.00276 * Rainfall	776.70	22.86	0.04	<0.001
Weather	-6.71 + 0.199 * Temp + 0.0472 * Wind Speed + 0.114 * DF	541.86	257.7	0.36	<0.001
Combined	-94.6 + 0.4027 * Log(Fuel Age) – 1.17 (Veg = Wet) + 0.01271 * Topopos – 0.0295 * East + 0.0141 * North + 0.00393 * Rainfall + 0.05287 * Wind Speed + 0.231 * Temp + 0.146 * DF	478.26	333.3	0.44	<0.001
Mappable	-50.6 + 0.359 * Log(Fuel Age) – 1.660 (Veg = Wet) + 0.0113 * Topopos – 0.00788 * East + 0.00777 * North + 0.00238 * Rainfall	741.11	64.45	0.10	<0.001

* The model Topopos + Aspect was an alternative supported model (AIC = 783.02).

Table 1.2. Statistical models for arson ignition

Theme	Model Term	AIC	Deviance Captured	r^2	Prob
Fuel	0.778 – 0.337 * Fuel Age	204.93	12.51	0.04	<0.01
Topography	1.765 – 0.0318 * Slope – 0.00221 * Elevation	215.64	23.26	0.13	<0.001
Spatial	-5.585 – 2.750 * Road Dist + 0.0273 * Easting	145.03	93.87	0.44	<0.001
Weather*	-3.927 + 0.0798 * Temperature + 0.0607 * Wind Speed + 0.124 * DF	202.98	37.92	20.20	<0.001
Combined	-2.312 + 0.126 * Temperature + 0.0488 * Wind Speed – 0.00301 * Road Distance	133.46	107.44	0.47	<0.001
Mappable	As Spatial model				

* The model Temperature + Wind Speed was an alternative supported model (AIC = 204.42)

A Statistical Model of Arson Ignition

The correlates of arson ignition were modelled statistically using the same method as for lightning ignitions. For arson, there were 84 fires with known locations, dates and weather records, and we also used 84 random points in the analysis. There is a very marked hotspot of arson ignition in the eastern edge of the Blue Mountains where the Western Highway meets the Nepean River (Figure 1.9a). There was a significant but weak negative effect of fuel age (explaining 4% of variation), and slightly stronger negative effects of slope and elevation on ignition likelihood (Table 1.2). Road distance showed a strong relationship and there was also a weak positive relationship with easting. Temperature and wind speed had strong positive relationships with ignition likelihood. When the models were combined into a single mode, road distance, temperature and wind speed were the important terms, together explaining 47% of variation. The slope, elevation and fuel age effects are probably artefacts that disappear once road distance is in the model. The best mappable model was the spatial model, which captured 44% of variation. This has sufficient discrimination to provide a practical map of ignition likelihood (Figure 1.9b).

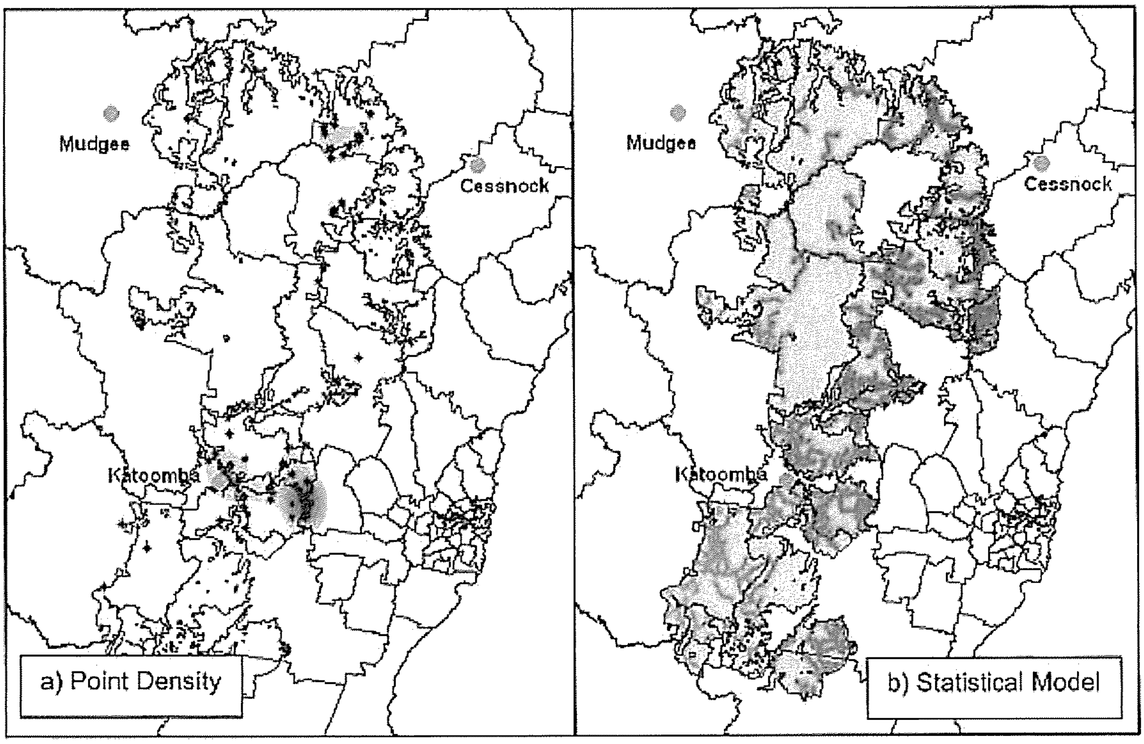


Figure 1.9: Arson ignitions in the GBMWHA: a) Point locations and kernel density map; b) Predictive statistical model (see Table 1.2).

Conclusion

Lighting strikes are spatially heterogeneous across the GBMWHA, and so are lightning ignitions, but the two distributions do not appear to match. Moreover, statistical analysis of lightning ignitions suggests that there is little that can be done to predict where lightning will occur. In contrast, arson ignition patterns follow a predictable pattern: arson is more common closer to roads and especially near the lower slopes of the Western Highway. Since lightning ignition is four times more common than arson, the potential for authorities to place resources in areas with high ignition density is very low.

2) The Wollemi 2006 Case Study

Introduction

The 2006 fire season in the Wollemi National Park in which 42 ignitions occurred (Figure 2.1) serves as an ideal case study to examine the merits of rapid attack strategies. In particular, nine ignitions occurred on 13th and 14th November 2006, which over the course of four weeks burned an area of 90,000 ha and cost over $4 m in direct resources. The cost figure is only for direct outlay on the fires, and does not include the cost of preparation. Rehabilitation, recovery or running Incident Management Teams. DECCW staff have reconstructed the events in terms of the resources deployed at each fire on each day, and the net outcomes. Hourly weather was also obtained for Nullo Mountain (BOM station 62100) and Mt Boyce (BOM station 63292).

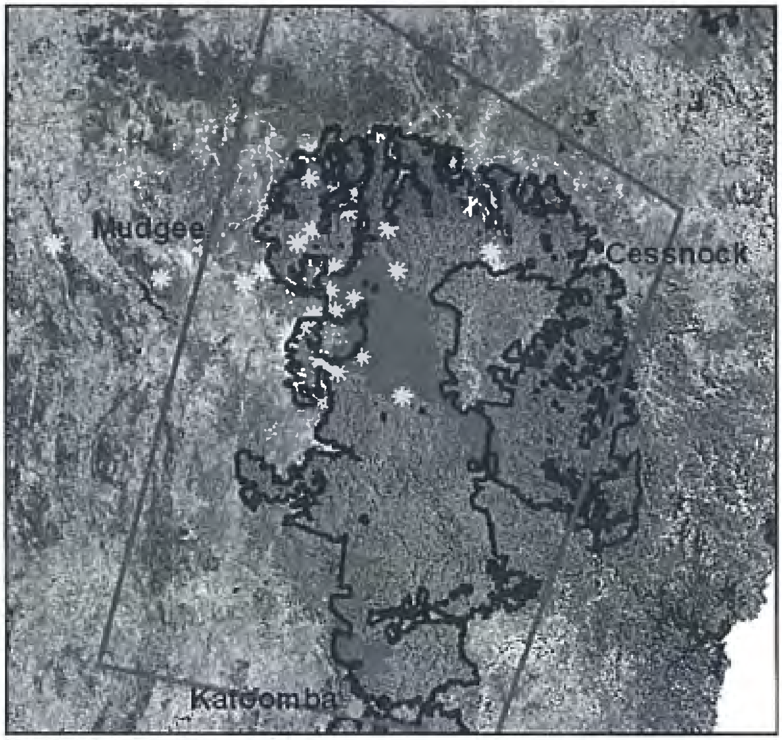


Figure 2.1: The ignitions and area burnt in the Wollemi section of the GBMWHA. The purple outline was used to calculate the current fire regime for the region.

The sequence of events

Lightning storms at midday on 13th November 2006 ignited nine fires in Wollemi National Park (and its immediate surrounds), mostly in inaccessible locations. The weather on the day was moderate in terms of fire danger, but wind hampered helicopter deployment. DECCW personnel from Mudgee and Bulga and RFS officers responded as quickly as possible. Two fires were attacked within two hours of reporting: the Dunns Swamp fire was attended by 8 DECCW ground crew accessing by vehicle with 2 hours of helicopter support; and the Dingo fire was water-bombed for 3 hours. Mt Kerrabee fire was attended after three hours by 6 RFS crew with helicopter support and the Gungalwa fire was water-bombed after 3 hours. The other five fires were not attacked, the major reason being that there were no other helicopters available (i.e. there was no shortage of crews). The reason that no helicopters were available was because they were deployed on fires elsewhere in the state.

By 14th November, Dunns Swamp and Gungalwa had been contained, Dingo and Mt Kerrabee were expanding, and four of the other five fires were attend of which two were contained to a size of about 50 ha or less (Numietta and Murrumbo). The other two fires not attacked on 13th (Ovens Creek and Corricudgy) expanded and eventually merged and burnt 74,000 ha with a combined cost of $4.7m. The combined fire (Wollemi Complex) was eventually contained by a combination of suppression, favourable weather and by low-fuel barriers from fires in the 2002/3 season. The ninth fire (Wirraba) was not attended for two days and eventually burnt 395 ha. The resources deployed to the fires expanded from a total cost of $18,000 on 13th to $112,000 on the 14th. From this date on, resources expanded, the weather became unfavourable for several days beginning on Nov 19th and a Section 44 fire emergency was declared on 20th November. The number of events and resources deployed for each day are summarised in Table 2.1.

On November 23rd, two more fires started, and both were attacked within three hours. Despite the fact that the weather was severe on this day (the Fire Danger was Very High for seven hours), both fires were contained to less than 10 ha, one with minimal water-bombing (Cox's Gap) and the other by a ground crew of 16 with air support (Stockyard Ck). 110 crew and 11 aircraft were operating on that day. On 28th November lighting ignited a further six fires. On this day 235 crew and 13 helicopters were on the fire-ground and crews could easily be diverted to the new ignitions. All of these ignitions were attended within three hours, and all except one was contained to less than 10 ha. The one exception (Springdale), which burnt 120 ha, was water-bombed and successfully contained, but subsequently expanded because the land-owner did not mop-up. The weather on this day was mild, and more favourable to suppression than the 13th.

Three more lightning fires started the following day (29th), all of which were attended within four hours and all of which were contained to less than 20 ha.

From December 1st onwards, the fire activity declined and resources were gradually drawn down until December 9th when the Section 44 was revoked. A further 20 ignitions were recorded up to the end of the fire season, but none of these caused serious problems. All were attended within 12 hours and only two exceeded 20 ha.

Table 2.1: Fire activity and resources deployed for the fires started on Nov 13th 2006.

Date	Active Fire Count	New Ignition Count	# of Crew	# of Helicopters	Heli. Hours	Total Cost ($)
Nov – 13 - 2006	3	9	14	3	5	16700
14	10	0	42	7	39	108500
15	10	0	56	9	56	151600
16	9	0	84	9	51	157800
17	7	0	97	10	77	222950
18	7	0	110	12	65	205700
19	8	0	89	13	92	256150
20	5	0	88	13	73	210400
21	6	0	118	14	83	245900
22	5	0	150	13	110	335500
23	5	2	110	12	53	182100
24	3	0	98	13	48	156900
25	3	0	165	14	80	258750
26	1	0	160	14	70	236000
27	1	0	266	14	65	265300
28	8	6	235	13	58	241850
29	7	0	227	12	65	259050
30	7	0	239	12	70	274650
Dec – 1 - 2007	8	0	202	11	76	273700
2	4	0	210	11	69	262500
3	3	0	119	11	71	226650
4	3	0	103	12	71	218450
5	1	0	89	11	60	187550
6	1	0	86	11	60	189100
7	1	0	62	11	54	156700
8	1	0	52	10	48	143200
9	1	0	40	7	42	118400
10	1	0	43	7	42	117050

The weather context of the events

Leading up to these events, the region was in drought with a Byram Keetch Drought Index of greater than 100 (Anon 2006). However, approximately 50 mm of rain had fallen at Nullo Mountain (Bureau of Meteorology station 62100) in the week starting November 3rd, and 35 mm had fallen at Mt Boyce (BOM station). The weather on the 13th began with a warm night (Figure 2.2). Temperatures fell and humidity increased during the day and the lightning storms occurred around midday. The storm was associated with a further decrease in temperature and a spike in humidity. The 14th saw a rise in the temperature to the same levels as early on the 13th and a reduction in humidity. The wind speed was between 20 and 30 km/hr for most of the daylight hours on the 13th and between 10 and 20 km/hr on the 14th. The Fire Danger Rating was moderate for all of the 13th but increased to high on the afternoon of the 14th (mostly due to the drop in humidity).

Since the weather record is from a station some distance from the ignitions (between 12 and 45 km), and at a higher elevation (1130 m, whereas all ignitions were below

800 m), there is uncertainty about the weather experienced at the fire ground. The Mt Boyce station, which is more remote (at least 80 km from all ignitions) showed a similar general pattern to Nullo Mountain, but there was a more pronounced spike due to the storm, which passed earlier, and the wind speed was consistently higher, peaking at 44 km/h on 13th and 46 km/h on the 14th. The Cessnock station is approximately 90 km from the ignition points and less than 100 m above sea level. Here, the weather pattern was similar, but the temperatures were an average of 4.2°C higher, and consequently, the fire danger was also much higher (Figure 2.3). In particular, at the time of the ignitions, before the storm hit Cessnock, the Fire Danger Rating was extreme (peaking at an FFDI of 69 at 12.30).

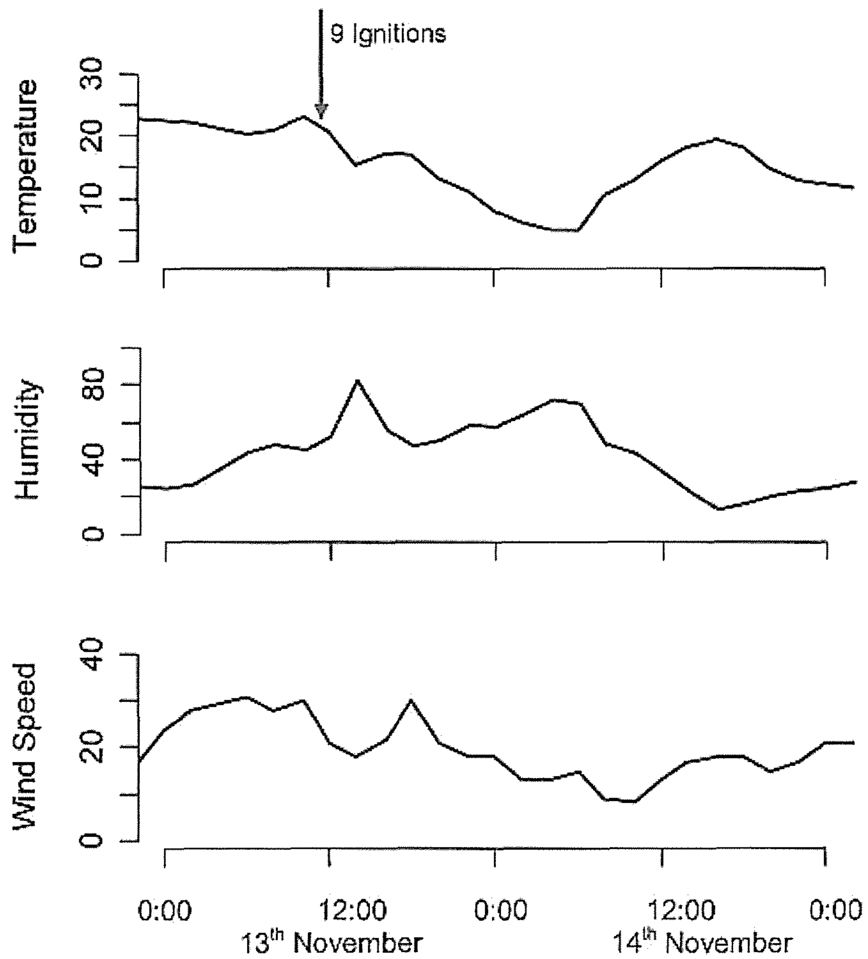


Figure 2.2: Weather conditions at Nullo Mountain during the 13th and 14th November 2006

The weather became more benign until the 18th when the temperature steadily increased and humidity decreased for several days. The Fire Danger Rating was High for most of the daytime, and for three days starting on the 21st peaked into Very High during the afternoons. Thereafter, the weather moderated, and became erratic with mostly cool humid weather, but with Fire Danger tipping occasionally into the Very High Category for a few hours. The weather trace for the duration of the emergency, plus the area burnt each day, is shown in Figure 2.3.

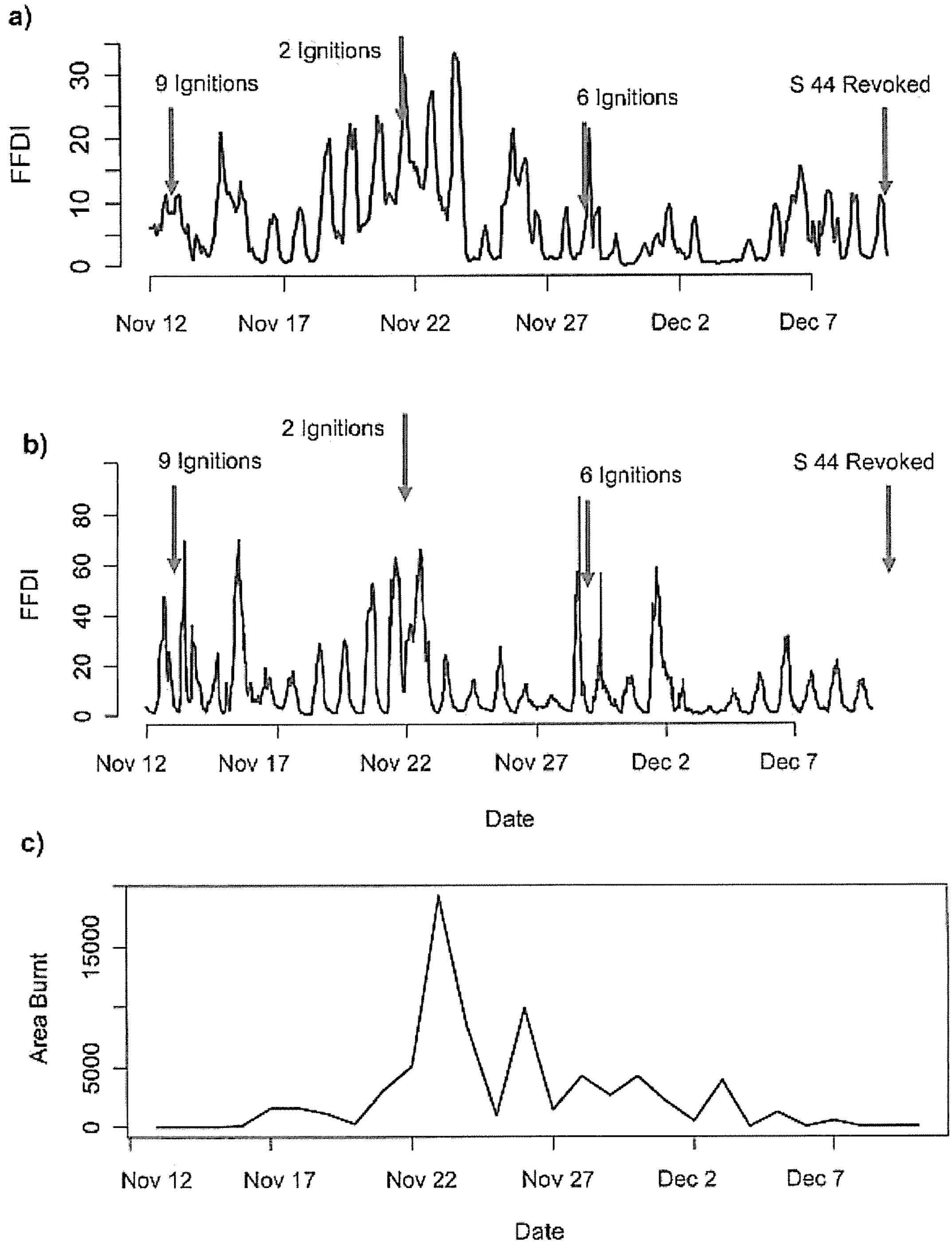


Figure 2.3: Weather trace (FFDI) for a) Nullo Mountain and b) Cessnock; and c) area burnt by the fires during the Section 44 emergency.

These weather events may be put into the context of how often conditions equally or more extreme occur by comparing the events with the distribution of FFDI over recent history (Figure 2.4). Based 3pm daily data for Nullo Mountain for the years 1994-2008, weather at least as extreme as occurred on 13th November occurs on 27% of days, meaning that this was a very ordinary day. It seems certain that the storm that caused the ignition moderated the weather for some hours, although the FFDI was not high at any time on that day (peaking at 10 am at 6.6. The weather in Cessnock was much less ordinary. Although the storm also depressed FFDI (to 6.4 at 3 pm), the FFDI of 69 at midday was so high that the 3 pm value exceeds this value on only 0.1% of days (about once every four years). Taking the evidence from all of the stations together, it seems as though the 13th was a relatively bad day before and some-time after the storm, but not during it.

Days as extreme as the 14th occur on only 3.1% of days at Nullo Mountain, which is about 11 days per year. Days as extreme as the 23rd of November (3pm FFDI = 30.6) occur on only 0.22% days, which is less than one day per year. Very High Fire Danger days are rare at Nullo Mountain occurring at 3 pm only 2.5 days per year on average. So the fact that this did occur on three successive days on November 21st to 23rd was a rare event indeed.

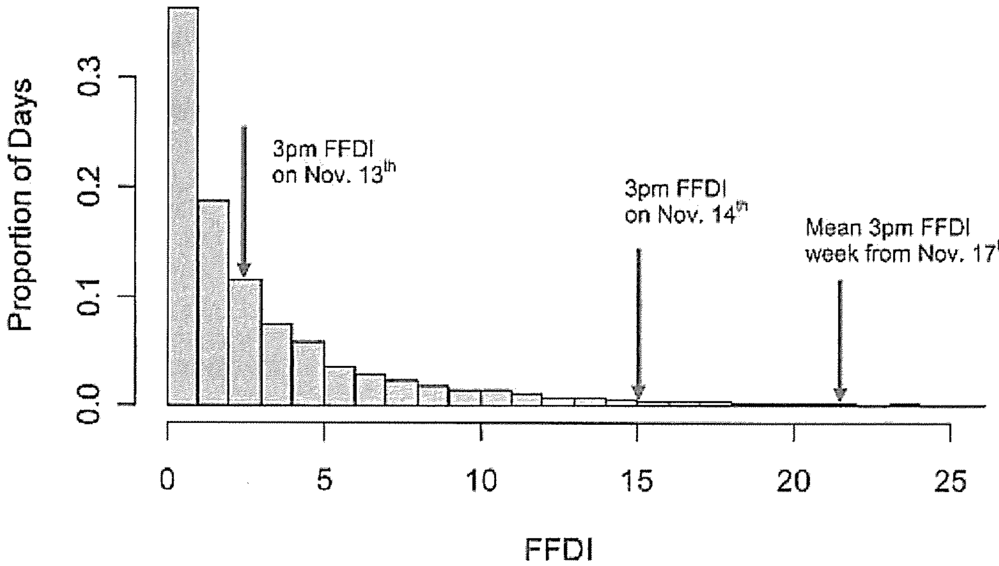


Figure 2.4: The Forest Fire Danger Index (FFDI) at Nullo Mountain on certain days in comparison to the distribution of daily values. 27% of days have an FFDI as high as Nov 13th, 3.1% of days are as high as Nov. 14th, and 1.1% are as high as the week of Nov. 17th.

To summarise, the nine ignitions occurred on a day of moderate fire danger, but reasonably strong winds. The conditions were somewhat worse on the following day but then improved for three more days. There then followed a week of much more severe weather. During this week the Fire Danger Rating regularly peaked at Very High, which is rare for the Blue Mountains region, but was probably a once in a decade phenomenon for the location. There was an opportunity to contain the fires on the first day, and then again during two or three days of mild weather. However, more severe weather on the second day, and delay in attendance meant this opportunity was lost. Once the severe weather beginning on 19th November occurred, probably nothing could be done to contain the fires, and very large areas burned.

Resources deployed to the fires

The Area DECCW offices at Rylestone and Bulga have approximately 20 crew available to fight fires (D. Crust, pers. comm.). On 13th November, eight of these were deployed to the fires, and they were supported with six staff from the Rural Fire Service Volunteers. Three helicopters were used to ferry crew and to water-bomb. Strong winds made it difficult to deploy crew by helicopter, and no more helicopters could be obtained. These two factors explain why the only fire directly attended by DECCW staff was the Dunns Swamp fire, which was accessible by vehicle and was successfully contained. The total deployment for the day was 14 crew and 5 helicopter hours.

It took until the following day (14th) for extra resources to be made available, which totalled 42 crew, and 7 helicopters flying 39 hours. Thereafter the resources increased steadily for a week, with a slight drop on 23rd and 24th (possibly because the weather was too severe) and a peak of 266 crew on the 27th November. Deployment then decreased gradually, but did not fall below 30 crew until the 16th December, and below 15 on January 15th 2007. There was a minor flare-up requiring a maximum of 48 crew starting on January 22nd but the details of this event are not considered further.

We have costed the deployment according to the rate table below.

Table 2.2

Item	Cost	Note
Aircraft	$2200 /hr	Mean wet rate of mix of helicopters
Plant	$1000 /day	Mean of mix of dozer, grader, excavator and water-cart
Crew	$550 /day	
Crew (IMT)	$730 /day	These are not included in costs
RFS volunteers	$350 /day	

The cost of the deployment was $16,700 on the 13th November, increased six fold to $108,500 on the following day and increased steadily. The maximum in any one day was $335,000 on 21st November. The total bill for the fire season was $7.6m or $8.1m if the Incident Management Team cost is included. $4.7m of the $7.6 m was deployed on the two fires that started on November 13th and were not contained (Oven's Creek and Corricudgy).

Statistical Analysis

The data for the 42 Wollemi fires from 2006/7 were analysed to determine whether there was a measurable effect of response time or the nature of deployment on the success at containment. We defined containment success as a fire with a final area no greater than 100 ha, rapid response as no more than 6 hours and we distinguished between fires where ground-crew were deployed to the fire on the first day from all others (i.e. fires where the response was longer than one day or the first day response was confined to water-bombing). The data are summarised in Table 2.3 below.

Table 2.3 mean percentage containment success for fires with rapid and slower responses (< or > 6 hours) and whether or not the fire was attended by ground crew on the first day (as opposed to water-bucketing only). All sample sizes were 5 or greater.

		Rapid	**Response**	
	% Success	Yes	No	**Total**
Crewed on Day 1	Yes	94	70	**89**
	No	81	30	**67**
	Total	**88**	**50**	

Of the 30 fires with a rapid response, only three (all from 13th November) were not contained, and in all three of these cases, lack of resources was considered to contribute to the failure. Two of the fires could not be attacked with the effort required due to competing resources and the third flared after initial containment because the private landholder did not mop up.

This data was analysed statistically* and we found that there was a significantly higher success for rapid responses ($p < 0.05$), but crewing on day 1 did not have a significant effect, and nor did the combination of the two factors. The rapid response factor explained only 9.8% of variation in containment success. If the two failures described above with too few resources were re-classified as long-response times, then the statistical model was highly significant ($p < 0.01$) and explained 25% of variation in success.

* The analysis used Generalised Linear Modelling where the dependent variable was containment success (0 or 1). As with the analysis for lightning ignition, this was a binomial model with logit link function.

Simulation Model of Containment Scenarios

One of the complicating factors when trying to quantify the costs and benefits of different fire management strategies is that the net area burnt is not simply a product of the number of ignitions. It is possible that two or more ignitions occurring close together may burn no larger an area than if only one had occurred. In the context of the Wollemi 2006 fires, it is possible that the net area burnt may have been similar if fire-fighters had contained none, half or all but one of the ignitions. To put it another way, it is possible that rapid attack is ineffective unless all of the ignitions are contained: if just one escapes then the effort was wasted. To explore this issue, we used the bushfire simulator Phoenix to test the consequences of successfully containing different combinations of the actual ignitions from November 13th.

The Phoenix fire-spread simulator – Phoenix is a bushfire behaviour simulator developed at the University of Melbourne as one part of a project funded by the Cooperative Research Centre for Bushfires ((Chong and Tolhurst, 2006; Tolhurst *et al.* 2007)). It represents a landscape as a grid with various attributes, including fuel loads at three strata (litter, bark and elevated), topography and barriers). Fires are propagated by applying the McArthur forest or the CSIRO grassland fire spread models to a large number of points around the current perimeter of the fire (the Huygens method, Finney 1999). The calculation takes into account the various factors that might increase or decrease the rate of spread for each point independently. This produces a series of small fire-spread ellipses that are then combined to create a new fire line. This process is repeated for 10 minute time-steps. A stream of actual or predicted weather variables are provided to Phoenix for a point or on a coarse resolution grid. Phoenix includes a sophisticated spotting model that can cause fires to spread more rapidly and jump barriers, given a combination of elevated fuels and strong winds. A variety of outputs can be viewed using GIS software. It is probably the most sophisticated and accurate simulator currently available. The developers have used it successfully to recreate several past fire events, including the recent Black Saturday fires in Victoria. However, an objective study of its performance on selected historical NSW fires found that it described the general magnitude of fire spread well, but was imprecise about the exact rate of spread and where the maximum spread would occur (Cook *et* al. 2009).

Parameterising Phoenix - Phoenix was used to examine the consequences had more or fewer of the ignitions on November been contained. To prepare the simulator, the topographic, vegetation, fire history and weather record were recreated for the Wollemi National Park. Hourly weather data was obtained for Nullo Mountain and Cessnock. Since Nullo Mountain is at a considerably higher altitude than the fire ground, and staff thought that the recent rainfall pattern was more similar to Cessnock than Nullo Mountain, a hybrid weather record was applied: Rainfall and Drought Factor from Cessnock; Wind Direction from Nullo Mountain; and all other variables were the mean of the two stations. The vegetation was assigned one of seven types based on the Vegetation Map for Wollemi National Park (see Table 2.4). Fuel totals and accumulation rates were obtained from published information (Conroy 1993) where available, or otherwise analogous values for similar Victorian vegetation types were used.

Table 2.4 Vegetation types used for Phoenix (with assumed maximum fuel loads).

Veg Class	% of Study Area	Max Surface Fuel	Max Elevated Fuel	Max Bark Fuel
Gum Woodland With Grass/Herbs	50.1	16.5	0.4	0.3
Forest with Shrub	28.9	15..8	6.1	5.4
Dry Heath	1.2	5.8	8.4	0
Wet Sclerophyll Forest	1.2	15.8	3.8	7
Rainforest	0.9	9.1	0.4	0.3
Temperate Grassland	0.1	5.1	0	0
Swamp Forest	0.1	2.6	0.2	0.5
No Vegetation	17.6	-	-	-

Base scenario – Corricudgy and Ovens – Before alternative scenarios can be investigated, it is important to determine whether Phoenix successfully recreates what did happen with the fires that were unattended. To do this we started the Corricudgy and Ovens fires at 12:00 midday on November 13th and allowed them to run until December 9th. These two fires are referred to as the core fires, and the other seven from that day as the non-core fires. It was assumed that no suppression was applied. Phoenix did reproduce the approximate dimensions of the actual fire, but only when the value for self extinction intensity was reduced from its default value of 120 kwm^{-1} to 60 kwm^{-1}. If this was not done, the fires tended to extinguish themselves before they reached 20 ha in size. The predicted fire is largely contained by recent fuels to the east and south in much the same pattern as the actual fire was (Figure 2.5). Phoenix predicted that the fire was mostly burning at low intensity, quite often so low that parts of the perimeter self-extinguished (presumably at night before flaring again in the following day). The total burnt area was 121,000 ha. This is somewhat larger than the actual fires (90,000 ha), but considering that no suppression was included in the simulation, this is a reasonable agreement.

If only one of the two had escaped containment – The Phoenix simulations suggest that a large area would have burnt if either of fires had escaped early containment (Figure 2.6). In fact, both fires were predicted to have burnt a larger area on their own than in conjunction with the other fire (181,000 ha for Corridudgy and 196,000 ha for Ovens Creek). This result illustrates some of the complexities in recreating fire events: whether or not an area burns depends not only on the active fire edge reaching that area but also on what the weather was like at the time. Sometimes an area does not burn if the fire arrives early, but does if it arrives later

Consequences of not containing other individual fires – The simulations predict that the Numietta fire would have been even larger than the two fires that did escape (200,000 ha, Fig 2.7a). Similarly, the Coorogooba fire would have been very large (215,000 ha, Fig. 2.7b). The Gungalwa would have expanded to a moderate size (38,000 ha, Fig. 2.7c). Dingo Creek would have been about 3000 ha in size. The other two (Dairy Mountain and Dunn Swamp) would probably have self-extinguished at small sizes (~ 100 ha).

If none of the 9 had been contained – Then the net result is predicted to be slightly smaller than if the Coorogooba fire alone had burnt. (Figure 2.8a). As above, this illustrates some of the problems with interpreting simulation models. This result does not burn the area at the extreme west of the Wollemi NP, presumably because the timing when it comes to this area was not suitable for further westward expansion. It is difficult to know whether this is realistic or not. Nevertheless, this results does reinforce the conclusion that sometimes a single fire will burn the same area as several.

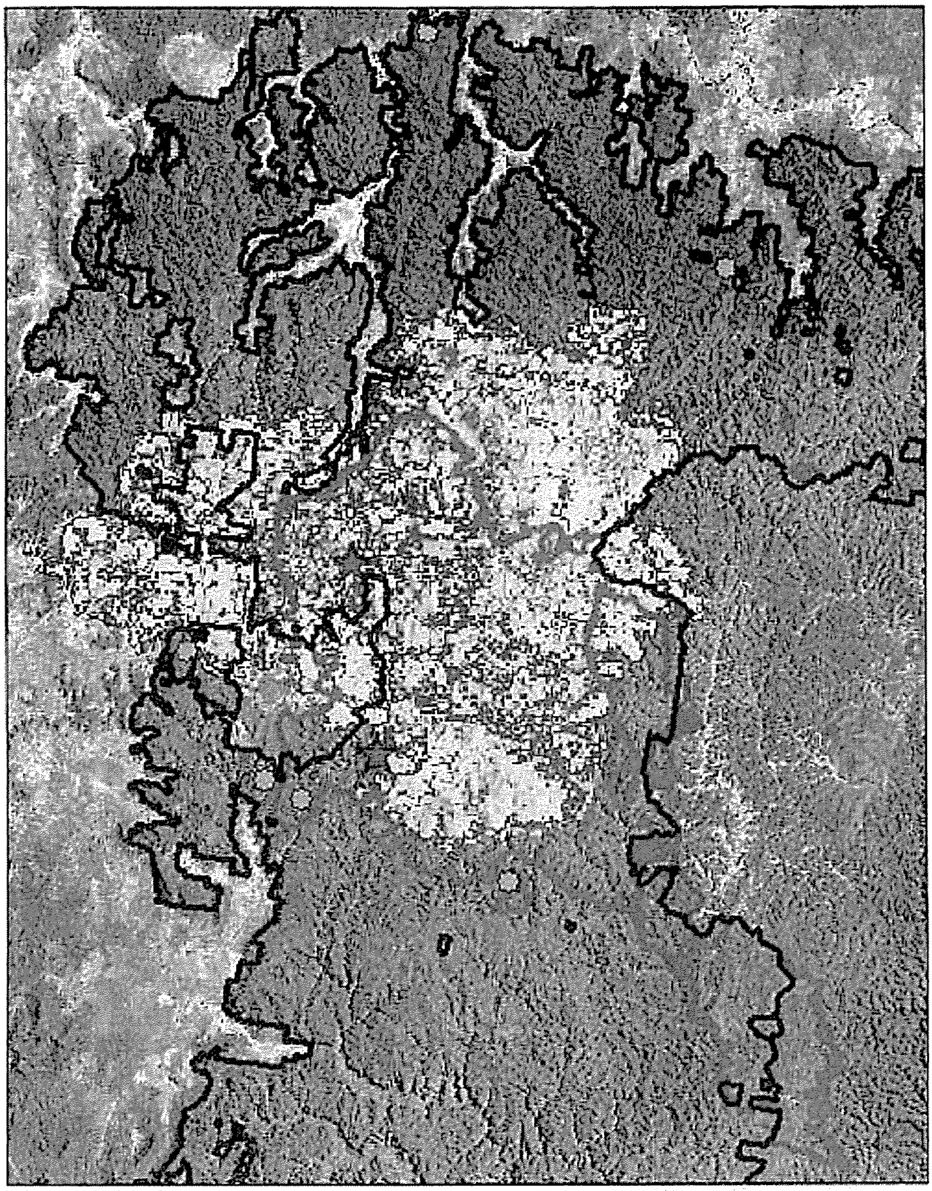


Figure 2.5: Phoenix output for the base scenario. Wollemi National Park is outlined in black, the actual fire boundaries are outlined in red, the two ignitions used in the scenario are red stars and other ignitions for the day are blue circles. The simulated fire is yellow and areas where the fire was predicted to self-extinguish are purple.

If the weather had been worse – When the weather record was adjusted by plus 3°C to account for the difference in altitude between Nullo Mountain and the majority of the National Park, there was little difference in the area burnt. None of the non-core fires expanded to a large area. When the weather for the week beginning December 24th 2001 was used instead of the actual weather record, the net result was very similar. This weather record caused the huge 2001/2 fire season that included the Mt Hall fire, Burragorang Complex, Royal National Park fire and many others in eastern NSW. However, it seems that while the weather for many stations was extreme, Nullo Mountain was something of an exception. 3 pm FFDI was 15.5 on December 24th and 17 on December 25th, compared to 34.6 and 45.7 at Mt Boyce. We then looked for the worst day of weather in the past 9 years of the Nullo Mountain record, which was the 10th November 2002, when FFDI peaked at 50.5 at 3.30 pm. Using a reconstructed week of weather consisting of this day repeated seven times, we found that the three core fires would have expanded to burn most of the northern part of the park (332,000 ha in total, Figure 2.8 b). If all 8 of the ignitions were used as starting points, then the burnt area was even larger (369,000 ha, Figure 2.8c), mostly because the Gungalwa fire expanded greatly. Notice that even under this extreme weather, the Dingo fire did not become huge, self extinguishing at 1500 ha. All of the other contained fires were engulfed by others in this scenario.

Sensitivity Analysis – As mentioned above, the spread of fire in Phoenix is sensitive to many of the parameters. To investigate why Phoenix gave the results it did, we changed several of the parameters and compared the results. Fires that Phoenix predicted would not establish, could be made to do so by one or more of six means: i) changing the Self Extinguishment threshold (i.e. to 40 or 80 kwm^{-1}); ii) substantially increasing the fuel load (e.g. giving Woodlands 6 tonnes of bark fuel); iii) using much different weather (either just Nullo Mountain or the most severe ever encountered); iv) using a smaller grid size for the simulation; v) moving the ignition point to a location further from barriers and/or recent burns (by as little as 70 m in the case of the Numietta fire); or vi) giving the fire an initial area at ignition (e.g. 10 ha). Some of these changes had major effects on the outcomes. In particular, using severe weather resulted in a huge area burnt whereas using the weather record directly from Nullo Mountain resulted in small areas burnt and most fires self-extinguished at less than 100 ha.

Conclusions – The results from the Phoenix simulator suggest that any one of the Numietta, Corricudgy, Ovens Creek, Coorogooba, Gungalwa or Wirraba fires could have burnt a large area if not suppressed. The final area burnt may not have been much different if anywhere between one and nine fires had not been contained. However, given the sensitivity of Phoenix to the input parameters, we cannot be certain about these conclusions.

Conclusions

The Wollemi fires of 2006 occurred during weather of slightly above average fire danger, but by no means during extreme weather. Containment was very successful if resources were deployed rapidly. The fact that nine ignitions started at once and resources could not be deployed to all of them rapidly (partly due to competing demands on helicopters and partly due to windy conditions), were the primary reasons that two fires eventually burned a large area. In order to have prevented the major fire event, six of the nine fires had to be contained: failure to contain any one of the six would have resulted in a large fire. However, it is unlikely that any of the other three fires would have become large even if they were not contained.

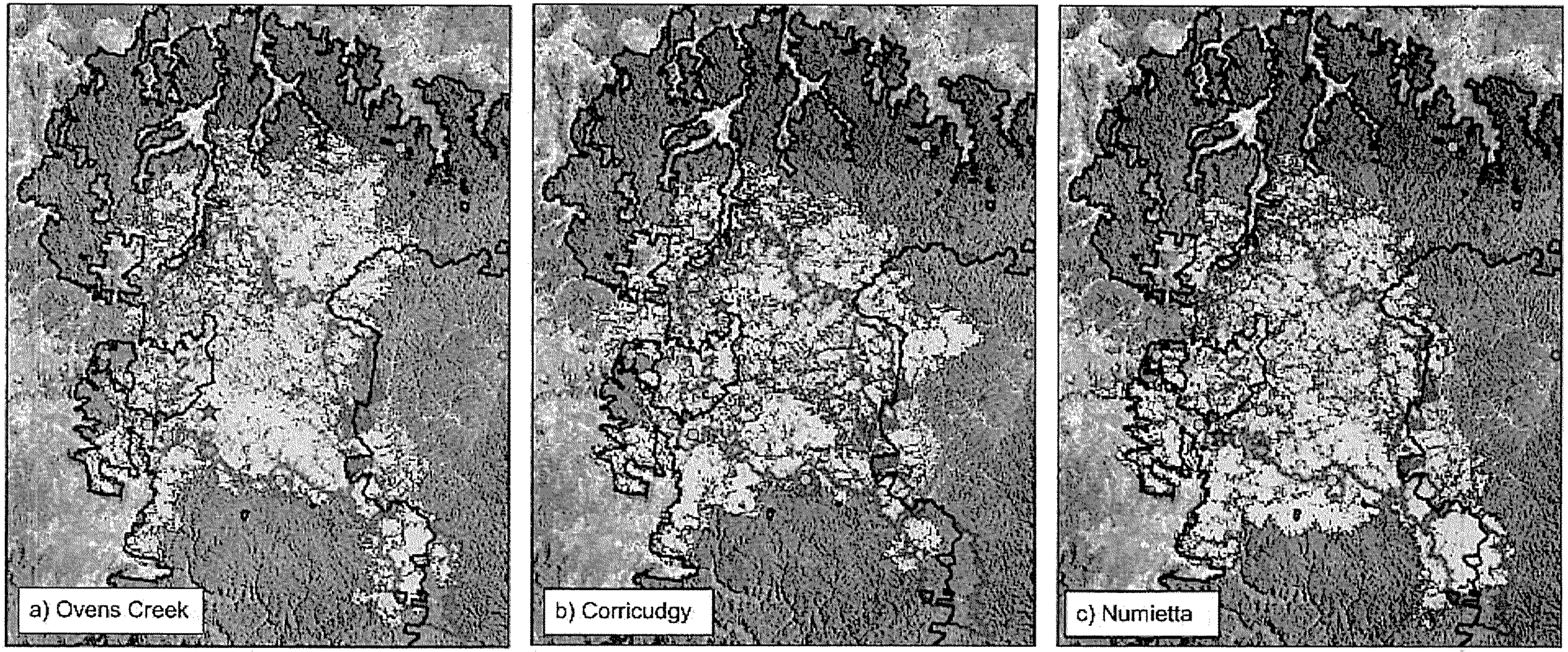


Figure 2.6: Phoenix simulation results for single ignition sources: a) Ovens Creek only; b) Corricudgy only; and c) Numietta only. In each case, the ignition point is indicated by the red star.

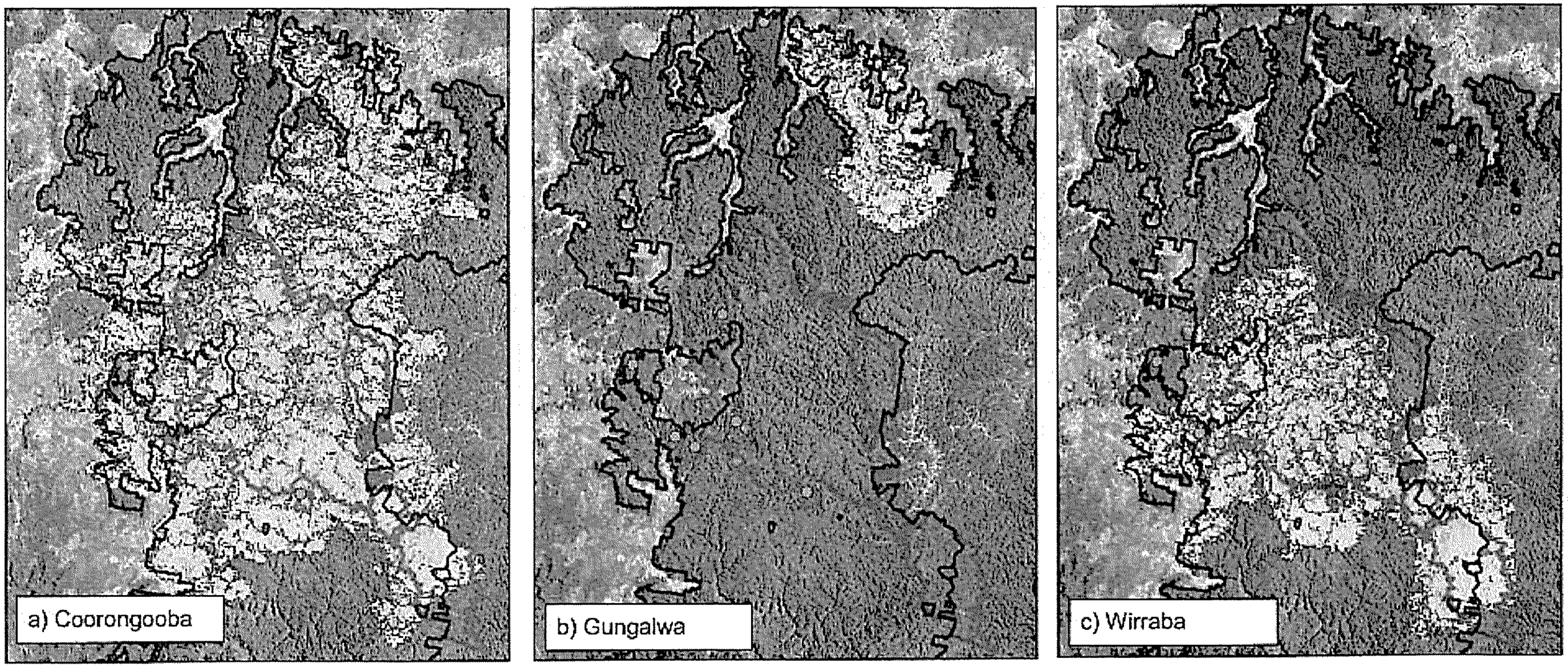


Figure 2.7: Phoenix simulation results for single ignition sources: a) Coorogooba only; b) Gungalwa only; and c) Wirraba only. In each case, the ignition point is indicated by the red star.

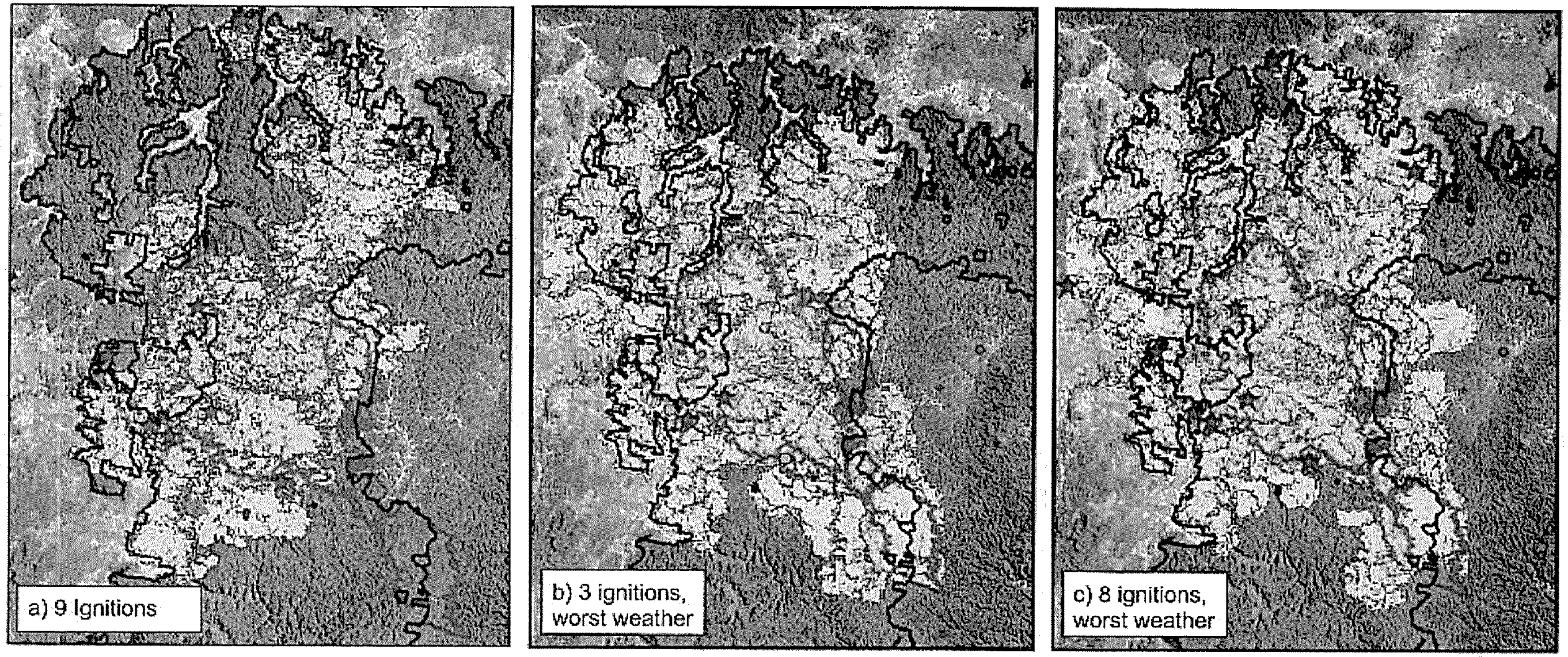


Figure 2.8: Phoenix simulation results for alternative scenarios: a) 9 ignitions; b) 3 ignitions with worst weather; and c) 8 ignitions with worst weather. In each case, the ignition points are indicated by red stars.

3) Cost-Benefit Analysis of Fire Strategies

Introduction

Given that almost all of the fires in the 2006/7 fire season were contained while still small, but that two fires escaped and caused a very costly fire season, it is worth examining whether this cost could have been avoided. Moreover, we may consider to what extent strategies that would have contained these two fires would be adequate for potential future scenarios. In order to fully evaluate the benefits that could be made from rapid attack, it is also necessary to consider that extra prescribed burning will be required to replace the areas that would have burned by wildfire. These issues are considered in this section.

Could Most Wildfires Be Contained?

Factors influencing containment success - The likelihood that any ignition can be successfully contained (i.e. to less than 100 ha) is determined by a combination of weather, resources and physical situation. The physical situation includes such factors as remoteness (difficulty of access), fuel load and topography. Topography is not amenable to management, and the analyses above have suggested that although it has an influence on ignition probability and containment success, the influence is small compared to other factors. Fuel may be managed via prescribed burning or by allowing wildfires to burn, but like topography, it has a minor influence on the spread of wildfire. Most of the fires in this region are remote, and DECCW uses RAFT teams to gain access to remote areas.

Weather and resources are the main influences on success. To describe the situation simply, when an ignition occurs, there must be sufficient resources to respond quickly. With more severe weather, the likelihood of ignitions increases and so does the difficulty of containment. This means that under severe weather, agencies require more resources at each fire, will attend more fires, and the need to respond quickly is even more important. However, severe weather may prevent crews from being deployed, either because of the risk of injury from the fire or because the helicopters cannot operate.

Re-examining resourcing on 13th November - There was a resourcing issue on 13th November due to competing demands for resources. It is very likely that the two fires that eventually became the Wollemi Complex could have been contained had they been attended early, and the state would have potentially saved $4.7 m in suppression costs. The success rate at attended fires on the same and subsequent days was very high (89% of 33 fires).

Examining all of the fires that were attended and contained (29 of the 42 fires), the mean total cost of the containment was $36,000. In all cases, this consisted of initial containment and a mop-up continuing for two or more extra days. This may be taken as an approximate cost of containing an ignition using RAFT teams, and we may assume that roughly half of this total is spent on the initial containment ($18,000). On 13th November, $17,000 of resources were deployed, which by this calculation was only enough to contain one fire. This is essentially what happened, although resources were spread across three fires. On 14th November, $108,000 of resources was deployed, which was enough to contain all of the burning fires. However, these were deployed one day too late. If the resources deployed on the 14th had been deployed on 13th, then it is very likely that the fire emergency would have been avoided. The deployment on 14th is itself less than half of the daily deployment at the height of the fire emergency. At the peak, there were 266 personnel and 14 helicopters working on the fire complex.

Clearly, major resources are available for fire fighting. There are two related challenges: one is to make resources available quickly and the other is to be able to deploy them. Both problems operated on November 13th: there were insufficient resources, particularly helicopters and those available could not operate well because the wind made it difficult to land crews. If more resources had been available on day 1, would the wind have prevented them being deployed? It is the opinion of the staff present at the time, that while the wind hampered operations, the presence of more helicopters would have enabled crews to be dropped into some of the fires, particularly some of those considered higher priorities than the ones that were actually attended. Also, more fires could have been water-bombed to prevent them spreading. So, more resources will lead to more fires being contained but no amount of resourcing can guarantee that all of them will be contained.

There are many models which deliver more rapid responses. For our analysis, we will focus on RAFT teams, for which costs are available

The economics of RAFT – From the 2000/1 fire season onwards, DECCW and the Sydney Catchment Authority have funded a RAFT team. The model centres on a team of 10-14 personnel hired during the fire season (6 months) and a dedicated helicopter leased for the same period. The cost of a team is $1.2 m per year. The team may be split to effectively contain two fires at once. A lower cost model has been proposed whereby six currently employed staff and six new contract staff are on call for fire-fighting for four months, with a four-month helicopter lease. The cost of this model is $490,000 per year. RAFT teams do work other than rapid attack: when there are no fires to respond to, they carry out other fire management tasks, including trail maintenance, hazard reduction burning, fire detection, equipment maintenance and routine park management tasks.

Had an additional team been available on 13th November, it would have effectively doubled the resources deployed that day, and so all of the ignitions would probably have been extinguished. To have been certain of containing them all, probably even more resources would have been needed. Thus, $4.7 m would have been saved. However, to calculate whether the outlay of $490,000 per year is a cost saving in the long term, we need to consider how often similar savings could have been made. It is also important to predict whether such a team would have been able to prevent some of the other past fire emergencies.

Could RAFT have prevented other fire emergencies? – We will assume that one RAFT team can contain three fires per day: two teams at one fire each and the support helicopter water-bombing one other. We use the GBMWHA as a study area and examine the ignitions over the past 11 years and weather over the past 30 years. How many of the fires that occurred over that period could have been contained, and how many would have escaped?

Taking the known ignitions from 1997 to 2007 (11 years), these were responsible for burning 1051,000 ha. We assume that the RAFT team could have contained all of the fires on days when three or less fires ignited. These accounted for 472 ignitions on 361 days and burned an area of 360,000 ha. The days that more than three ignitions occurred consisted of 308 ignitions on 40 days, which burned 691,000 ha. We assume that the RAFT team could contain three of these on each day and the area thus saved is the average fire size of those started on such days. The saving on those days is 268,000 ha and 423,000 of fire ha remain. Thus, the RAFT team could have prevented 628,000 ha of fires or 64% of the burnt area over 11 years.

However, this analysis is simplistic for two reasons related to weather. First, it does not account for days when wind prevented deployment, and second it assumes that RAFT crews can contain fires during even the most extreme weather events.

The relative success of RAFT teams on November 13th confirms that weather conditions equal to those on that day lead to containable fires. However fire events do occur under more severe weather. All of the significant events in the since 1997 are listed in Table 3.1. That is those where the weather was similar or more severe than 13th November 2006 and ignitions occurred. Of these, it seems that all of them had worse weather conditions than 13th November 2006, although it is very hard to gauge because the weather trace for these days vary greatly among stations and in any case none of the stations fully represent the weather on the fire-ground. The November 1997 event would have been very hard to contain with very high fire danger for several days. Likewise the two events in December 2001 occurred under severe weather according to the Section 44 reports, even though the conditions at Nullo Mountain were relatively mild. The conditions for the October 2002 and January 2003 fires appear to have been reasonably containable, with all of the stations recording generally moderate fire danger on the ignition days.

Table 3.1: Significant fire events in the greater Blue Mountains area, including 13th November 2006 (FFDI calculated at 3 pm at Nullo Mountain, Mt. Boyce and Cessnock).

Date	# of Ignitions	Area Burnt	FFDI on Day	FFDI Next day	FFDI on Day	FFDI Next day	FFDI on Day	FFDI Next day
			--Nullo Mountain--		----Mt. Boyce----		----Cessnock----	
26/11/1997	34 (23)	107,000	24.5	26.5	46.3	54.4	38.4	23.0
03/12/2001	41 (12)	114,000#	12.5	7.5	28.2	15.6	10.8	5.1
24/12/2001	13 (10)	191,000	15.5	17.0	34.6	45.7	52.4	28.0
05/10/2002	2 (2)	95,000	10.9	15.9	14.8	16.2	25.3	23.4
07/01/2003	14 (5)	79,000	11.8	23.9	7.3	24.1	21.1	36.0
13/11/2006	9 (2)	77,000	2.4	15.1	7.1	24.9	5.0	13.7

This figure includes 80,000 ha Burragorang complex that was not included in the data

If we assume that RAFT teams could have averaged one third of their potential success in these events (i.e. 1 fire contained per day), then the figures calculated above for the area of wildfire prevented need to be adjusted to account for an additional failure to contain two fires on each of the six days, which averages 74,000 ha, so the overall area prevented would be 554,000 or 53%. If we assume that on average they are able to contain two fires on these days, then the figures are adjusted by 37,000 ha to 591,000 ha or 56%.

Prescribed Burning to Replace Wildfires

If rapid attack is successful in most cases at preventing large wildfires, the net effect will be to reduce the fire frequency across the landscape. This will have negative consequences for biodiversity, since most of the vegetation types will be experiencing fire regimes outside their defined Threshold of Potential Concern. Also, fuel loads will tend to increase, thus increasing the risk of intense future wildfires occurring. It is unlikely that rapid attack can be developed to such an extent that all wildfire risk can be eliminated, so it is possible that rapid attack will increase rather than decrease the risk of damaging fires. This scenario is based on a large fuel build up that occasionally results in a wildfire so intense that it cannot be contained.

Analysis of fires in the greater Sydney region between 1977 and 2006 suggests that there is a relationship between the 5-year mean area burnt and the area burnt in the subsequent area burnt by wildfire with a slope of approximately -0.4 (Price and Bradstock, in review). This means that removing wildfire from the landscape will increase the area burnt by subsequent fire by about 0.4 ha for every ha removed. Of course, the assumption behind rapid attack is that this will not happen because the fires will be put out before they can fulfil their potential. Nevertheless, the relationship underscores the heightened risk of wildfire that will occur if much of the wildfire is removed from the landscape.

In order to prevent these negative consequences, it is necessary to replace the area prevented from being burnt by wildfires with a similar area of prescribed fires. Notice, however, that prescribed fires do not have the same effect either in ecological terms or in fuel reduction as wildfires. In particular, there are some vegetation communities that require periodic hot fires for some of their species to complete their lifecycles.

The forests of the Blue Mountains range north of Katoomba comprise the Wollemi NP, Yengo NP, Parr State Conservation area and the northern section of the Blue Mountains NP and cover an area of 948,000 ha. The long-term mean area burnt by wildfires between 1977 and 2006 is 5.86% per year (DECCW fire history mapping, unpublished). The equivalent area for prescribed burning is 0.40%. From 2000 onwards, the values are 7.89% by wildfire and 0.35 by prescribed fire. The great majority of fuel reduction in this region is done by wildfires. To replace all wildfire with prescribed fire will require an almost 15 fold increase over current levels to 59,000 ha per year. Whether it is desirable to completely replace the prevented wildfires depends on two factors: what is needed to provide a suitable ecological fire regime and the level of fuel management deemed necessary for risk minimisation. It may be argued that if the rapid attack approach is generally successful, then higher fuel loads in the landscape can be tolerated since the increased risk of major fires occurring is balanced by the increased likelihood that those fires would be contained quickly. Suitable ecological regimes are described by the concept of Thresholds of Potential Concern, which define an upper and lower acceptable inter-fire return interval for each vegetation type. For the dominant types, these are 7 year minimum and 30 year maximum. Using the figures above, the current mean interval is 16 years. It could be extended to 25 years without compromising ecological health. This would require 4% of the forests to be burnt each year. Given that 0.4% is already burnt by prescribed burning, an additional 3.6% would be required, which could be met by wildfires or prescribed burning. In the cost-benefit scenarios in the following section, we examine the cost-consequences of full replacement and this partial replacement.

The actual extent to which this would be necessary will be determined by the extent to which wildfire area is actually reduced by rapid attack over the long term. The costs of prescribed fire are considered in the following section.

The cost of prescribed burning – This depends on where in the landscape the burn takes place. Costing data for all of the prescribed fires for the central forests of NSW in 2007/8 were supplied by DECCW and RFS. Assuming that the DECCW implement landscape fires and RFS implement interface fires, then the mean cost of landscape fires was $27.5 per ha and the cost of interface fires was much higher ($731 per ha, or $622 if the single most costly fire is excluded). These costs include the personnel and plant costs, but not planning or other support. These are similar values to that provided for Victorian forests in the "Inquiry into the impact of public land management on bushfires in Victoria" (Anon, 2008). That report estimated the landscape cost at between $10 and $50 per ha, whereas urban interface costs were between $50 - $500.

Cost-Benefit Analysis of RAFT

Cost-benefit calculation

In order to estimate the economic benefit of additional RAFT teams, we need estimates of the following components:

1) The cost of suppression;
2) The cost of RAFT;
3) The area that RAFT prevents from needing suppression;
4) The area of prescribed burns that are needed to replace wildfire
5) The cost of prescribed burns

All of these, other than 1) have been addressed in previous sections. We can calculate the mean cost of wildfire containment by dividing the total outlay of the Wollemi Complex by its area, which comes to $63 per ha. Ellis *et al.* (2004) gives a comparable figure for the total outlay by NSW Government in the 2001/2 fire season ($81 per ha). In the thirty years from 1977/8 to 2006/7 for the Central Directorate of DECCW, wildfires burned an average of 110,000 ha per year. Using the cost figure for the Wollemi Complex fire, this would cost $6.9m per year on average.

We present several alternative scenarios to explore the possible savings given the uncertainties about how effective a RAFT team might be. The study area is the GBMWHA area, of which an average of 95,500 ha have burnt by wildfire each year. We include scenarios with one or two raft teams with differing success rates, both in general and on severe days. We also include two scenarios where the target for wildfire is 58,700 ha (reflecting 4% total burn area each year), and this must be met by prescribed fire where wildfires are less than this total

We assume that additional RAFT teams could have affected those historical fires that became large (>100 ha): the smaller ones were, by definition, dealt with the existing resources. So, large fires are the focus of the calculations.

For each scenario, the area that RAFT teams save is calculated according to the following logic:

Number of fires that RAFT can contain per day = c
Total number of large fires = n
Total area burnt by large fires = a
Sum of area burnt for days when $n <= c = a_s$
Sum of area burnt for days when $n > c = a_l$
Number of Large Fires on days when $n > c = n_l$
Number of Days when $n > c = d_l$

Area Contained $a_c = a_s + a_l * d_l * c / n_l$
Area Burnt $a_b = a_l * (n_l - d_l * c)/n_l$

There is a correction for severe events, which have happened six times in 11 years. This estimates the number of large fires that the previous calculated had assumed would be contained, but in actual fact would not have been.

Number of fires that cannot be contained during severe events, which otherwise could be contained = c_s
Number of large fires during severe events = 54
Number of days with severe events = 6
Area burnt during severe events = 663000 ha
Extra Area Burnt Correction = $663000 * (c_s * 6)/54$

Results and discussion

The results of the economic calculations for each of the scenarios are listed in Table 3.2. Most of the strategies can lead to savings of between \$1m and \$2 m per year. Given that the additional outlay for an extra RAFT team is approximately \$0.5 m, there is between a 2:1 to 4:1 net return on investment (3:1 to 5:1 gross return). The highest economic returns are gained by reducing the target for replacement of wildfire with prescribed fire (scenario 10). Of the scenarios where all of the prevented wildfire is replaced by prescribed fire, the highest cost savings were where a single team can extinguish four fires per day (scenario 5) and the least cost were where two teams were employed (scenario 8). The best value for money (saving compared to outlay cost is from employing half of a RAFT team (scenario 11). The largest reduction in wildfire area is when two teams are employed (even though this was not so cost effective). This is able to prevent 65% of wildfire area, leaving 35% remaining. The costings are sensitive to the relative difference in the cost of fire suppression and the cost of prescribed fire. In any scenario with full replacement, if the cost of prescribed burning is more than about $60 per ha, then there is a net cost rather than saving.

Notice that the benefits do not rise rapidly if the teams are more efficient. This is because most fires occur on their own, with no other ignitions, so teams of any efficiency will be able to contain them. At the other extreme, the really bad days with many ignitions are rare, but when they occur, there are more ignitions than can be contained, not matter how efficient the teams are. Notice also that these calculations do not factor in the benefit from the work RAFT teams do when they are not fighting fires.

This is not the first study to put an economic value on rapid attack. Bennetton *et al.* 1997 estimated that in Victoria in the year 1991/2 fire season, the 606 known fires would have burnt 2.1 m ha had fire-fighting been delayed by one day to all of them. They calculated a return-for-effort of $22 for each $1 spent. This is much higher than the return reported here, and may reflect somewhat overestimated assumptions about spread rates in the absence of suppression. Nevertheless, the conclusion is clear: rapid attack can deliver very good value for money.

Responding to Climate Change

National and international evidence points to a predicted increase in the severity of fire weather (i.e. increased average fire danger rating and incidence of extreme events) under a wide range of climate change scenarios. Both international and Australian modelling studies predict an increase in fire frequency and severity with global warming (Goldammer and Price 1998, Brown et al 2004, Hennessey et al 2005). The COAG Report of the National Inquiry on Bushfire Mitigation and Management (Ellis *et al.* 2004) stated "Climate change is likely to increase the frequency, intensity and size of bushfires in much of Australia in the future"

While we cannot be certain about the precise effects of climate change on fire regimes, there is reasonable agreement that temperatures and evaporation will increase. Several studies have concluded that wildfires will become more frequent, larger and more intense over the following 50 years (Hennessey *et al.* 2005). A recent simulation study focussed on the Sydney (Blue Mountains) region estimated that the burnt area will increase wildfire area by about 20%, and the impact of this may be countered by a large increase in prescribed fire area (Bradstock *et al.* 2008). This also has implications for rapid attack. Rapid attack could potentially be used in lieu of prescribed burning to contain the extra wildfire area, without the potential negative biodiversity consequences of increasing the average fire frequency. Also, in the scenarios outlined above, prescribed fire is applied to replace the area of wildfire that has been prevented. If the area of wildfire will increase under climate change, the same level of rapid attack as used in the scenarios will leave more residual wildfire in the future. This means that the area of prescribed fire that needs to be applied will be less. In other words, as the inherent area of wildfire increases, for the same level of rapid attack effort, less prescribed fire is needed, and so the cost is reduced. Of course, a better course of action might be to increase the level of rapid attack effort as the climate deteriorates.

Table 3.2. Results of scenarios to explore the economic benefits of RAFT teams

Scenario Number	# Of Raft Teams	# Fires Contained Per Day	# Fires Contained On Bad Days	% Replacement By Pb	% Wildfire Prevented	Wildfire Area (Ha)	Area Prevented (Ha)	Area Of Pb (Ha)	Cost ($M)	Cost Saving ($M)
0	0	0	0	0	0	95500			6.68	n/a
1	1	2	2	100	50	47800	47100	47100	5.11	1.57
2	1	2	1	100	42.9	54500	40400	40400	5.4	1.28
3	1	3	2	100	57	41200	53700	53700	4.83	1.85
4	1	3	1	100	49.9	47900	47000	47000	5.11	1.57
5	1	4	3	100	62	36500	58400	58400	4.62	2.06
6	1	4	2	100	54.9	43200	51700	51700	4.91	1.77
7	2	3	2	100	64.9	33800	61100	61100	5.00	1.68
8	2	3	1	100	50.7	47200	47700	47700	5.57	1.11
9	1	3	2	32.6	57	41200	53700	17500	3.85	2.83
10	1	3	1	23.0	49.9	47900	47000	10800	4.13	2.55
11	0.5	2	1	100	46.2	51400	43500	43500	5.02	1.66

Conclusion

If the resources deployed on November 14th could have been deployed on November 13th, the major fire could probably have been averted. RAFT teams provide one model for the delivery of fire-fighting resourced. One extra RAFT team could probably have lead to the containment of those fires. Many of the biggest fires in the region have occurred on days of worse fire weather and/or when more ignitions started on one day. some of these would not have been containable. Over the 11 year period, one additional RAFT team could have led to the prevention of between 50% and 62%, depending on the relative efficiency of the team. To prevent a higher proportion of wildfire area would require a different model, where even more resources can be deployed quickly on the very rare days when many ignitions occur during bad weather. RAFT fails on these occasions because a team can only contain a certain number of fires and cannot operate in strong winds.

At least some of the prevented wildfire area must be replaced with prescribed burning to keep fuels to acceptable levels and to maintain ecological health. The extent to which this is done has a large bearing on the cost-benefit of employing an additional RAFT team. Depending on the level of replacement, the level of success of the team and the relative costs of campaign suppression and prescribed fire, the addition of one RAFT team could yield a net saving of between $1 - $2 m per year for an outlay of $0.5 m per year, which is a very good return on investment. Deploying more than one team may not save money because most ignitions occur singly and the team is idle for most of the time. Rather, as mentioned above, a model where even more resources can be deployed quickly, but very rarely, would be needed to make further reductions in wildfire area.

Climate change will probably increase the risk of wildfire, which will make rapid attack a more attractive management solution. Also, it will become cheaper because less prescribed burning will be needed to replace lost wildfire area.

Conclusions and Recommendations

- There is little scope for siting resources near ignitions because the dominant source of ignitions (lightning) does not occur in predictable places. However, arson is concentrated on the lower parts of the Western Highway.
- The 2006 fires in the Wollemi National Park occurred during a time of moderate fire weather. If more resources had been available on the first ignition day, the largest of the fires could probably have been prevented, and several millions of dollars saved.
- The cost-benefit analysis suggest that this sort of scenario will happen again and that adding one RAFT team would yield an average economic benefit of between $1 – 2$ m per year (a 2 - 4 fold return on investment).
- Some fire events are worse than the 2006 Wollemi case study (more ignitions in worse weather), and additional RAFT teams cannot contain all ignitions. It is estimated that RAFT teams could prevent most ignitions, but only 53% of the area burnt by bushfires.
- Adding two RAFT teams would prevent more fires, but the return for investment is lower.
- If more ignitions are controlled, less area will be burnt by wildfire, so for environmental and risk-management purposes, some or all of the burnt area saved will need to be replaced by prescribed burning. This cost has been factored into the cost-benefit analysis.
- Climate change is likely to increase bushfire activity, and this will make Rapid Initial Attack an even more favourable option.

It is recommended that DECCW investigate options for increasing the resources invested into Rapid Initial Attack. The model should include an increase in prescribed burning to replace the area saved from wildfire.

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